Linearity Challenges of LTE-Advanced Mobile Transmitters: Requirements and Potential Solutions

In order to provide higher data rates and to improve radio spectrum utilization, 3GPP has introduced the concept of carrier aggregation (CA) in its Release 10 and onwards, commonly known as LTE-Advanced standard. The CA technology, in particular when applied in a noncontiguous manner, poses serious design and implementation challenges for radio transceivers, mainly due to the allowed flexibility in the transmitted signal characteristics and the nonlinear radio frequency (RF) components in the transmitter (TX) and receiver (RX) chains. As a consequence, substantial nonlinear distortion may occur that not only degrades the transmitted signal quality but can also affect the concurrent operation of the coexisting receiver, when operating in the frequency division duplex (FDD) mode. In this article, the key technical design challenges in terms of linearity requirements for LTE-Advanced mobile terminals are reviewed, and the corresponding self-interference problem related to the potential desensitization of the device’s own receiver is highlighted. Then, technical solutions to mitigate the self-interference at the RX band due to a nonlinear power amplifier (PA) in the transmitter chain are reviewed, with specific emphasis on digital self-interference cancellation methods. As demonstrated through simulation and actual RF measurement examples, the cancellation solutions can substantially mitigate the RX desensitization problem, thus relaxing the RF isolation requirements between the TX and RX chains. Such cancellation methods are one potential enabling technique towards the full exploitation of the fragmented RF spectrum and the CA technology in future LTE-Advanced and beyond mobile networks.

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Efficient fast-convolution based waveform processing for 5G physical layer

This paper investigates the application of fast-convolution (FC) filtering schemes for flexible and effective waveform generation and processing in 5th generation (5G) systems. FC based filtering is presented as a generic multimode waveform processing engine while, following the progress of 5G new radio (NR) standardization in 3rd Generation Partnership Project (3GPP), the main focus is on efficient generation and processing of subband-filtered cyclic prefix orthogonal frequency-division multiplexing (CP-OFDM) signals. First, a matrix model for analyzing FC filter processing responses is presented and used for designing optimized multiplexing of filtered groups of CP-OFDM physical resource blocks (PRBs) in a spectrally well-localized manner, i.e., with narrow guardbands. Subband filtering is able to suppress interference leakage between adjacent subbands, thus supporting independent waveform parametrization and different numerologies for different groups of PRBs, as well as asynchronous multiuser operation in uplink. These are central ingredients in the 5G waveform developments, particularly at sub-6 GHz bands. The FC filter optimization criterion is passband error vector magnitude minimization subject to a given subband band-limitation constraint. Optimized designs with different guardband widths, PRB group sizes, and essential design parameters are compared in terms of interference levels and implementation complexity. Finally, extensive coded 5G radio link simulation results are presented to compare the proposed approach with other subband-filtered CP-OFDM schemes and time-domain windowing methods, considering cases with different numerologies or asynchronous transmissions in adjacent subbands. Also the feasibility of using independent transmitter and receiver processing for CP-OFDM spectrum control is demonstrated.
Arguments of Innovative Antenna Design and Centralized Macro Sites for 5G
The evolution of mobile networks has been extremely fast during the last decade. However, the advancements in the technological ways of improving the system capacity are not enough for the data revolution we have witnessed in the last couple of years, and for the data traffic forecast made by the professionals for the next decade. Several recent technological enhancements may double the network capacity, or may even increase the system capacity 5–10 times, but still it is far away from the expected "need for a thousandfold more capacity". The fifth Generation (5G) of mobile networks with a slogan of thousandfold more capacity has compelled the research community to think in an “Innovative Way” and to think “Outside the box”. The aim of this article is first to show the limitations of recent technology solutions for the future demands, and thus to highlight the need for more innovative breakthrough solutions. The excellence of centralized macro sites is argued as a principal capacity layer instead of micro cells, small cells, or femto cells. Moreover, it is also argued that an ultimate need for innovative antenna solutions for macro sites is required instead of traditional antenna array technologies.

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Web of Science (2014): 0.653 0.648 3.1 0.104 0.00347 0.127
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Publication Forum (2012): 1
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Scopus rating (2010): 0.291 0.682
This paper presents an evaluation of a Heterogeneous Multicore Architecture (HMA) by implementing Orthogonal Frequency-Division Multiplexing (OFDM) receiver blocks as designs for the test of functionality. OFDM receiver consists of computationally intensive and general-purpose processing tasks that can provide maximum coverage to test and evaluate a massively-parallel as well as a general-purpose platform like the HMA. The blocks of the receiver are primarily designed by crafting template-based Coarse-Grained Reconfigurable Array (CGRA) devices and then arranging them in a sequence over a Network-on-Chip (NoC) structure along with a few RISC cores for complete OFDM processing. The OFDM blocks such as Fast Fourier Transform (FFT) and Time Synchronization are computationally intensive and require parallel processing. The OFDM receiver also contains tasks such as frequency offset estimation which require the processing of Taylor series and CORDIC algorithms that are serial in nature. Such a combination of serial and parallel algorithms can perform a thorough exploration and evaluation of almost all the design features of an HMA. The OFDM implementation has led to scale CGRAs to different dimensions, instantiate Processing Elements (PEs) as multiple arithmetic resources and to establish almost all possible ways of PE interconnections. It further explores time-multiplexed patterns for data placement in the CGRA memories. Nevertheless, the data can also be exchanged among different nodes over NoC structure simultaneously and independently by using direct memory access devices. In this experimental work, the performance of each CGRA, the collective performance of the whole platform and the NoC traffic are recorded in terms of the number of clock cycles and several high-level performance metrics. Today's HMAs are generally over or under resourced for the applications that they are designed for and thus not an optimal choice for the end user. Apart from the interesting comparisons to the other state-of-the-art, our experimental setup has provided important insight and guidelines that the designers can use to implement near-optimal solutions for their target applications.
Enhanced multicarrier techniques for narrowband and broadband PMR coexistence

The coexistence of broadband systems with currently deployed professional mobile radio (PMR) communication systems like public protection and disaster relief has gained much deserved attention. Recently, it has been shown that a conventional orthogonal frequency division multiplexing (OFDM)-based long-term evolution (LTE) system needs sufficient guard-band or additional filtering in order to coexist in a PMR band, even without considering the RF impairments of the transmitter. In practice, it is imperative to take into account the RF impairments in radio communication systems, such as the non-linear (NL) nature of a high power amplifier (PA). This paper aims at investigating some enhanced multicarrier techniques allowing the coexistence of narrowband and broadband PMR systems that can support asynchronism, have low latency and be able to be operated with NL devices. The simulation results show that a LTE-like post-OFDM broadband system working with NL PA devices can still co-exist with legacy PMR systems with high energy efficiency, when proper PA linearization techniques are applied in combination with effective peak-to-average power ratio reduction methods.

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Authors: Bulusu, S. S. K. C., Renfors, M., Yli-Kaakinen, J., Shaiek, H., Roviras, D.
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Web of Science (2015): 1.295 1.226 2.3 0.198 0.00142 0.4
Publication Forum (2015): 1
Publication Forum (2014): 1
A Survey on Wireless Transmitter Localization Using Signal Strength Measurements

Knowledge of deployed transmitters’ (Tx) locations in a wireless network improves many aspects of network management. Operators and building administrators are interested in locating unknown Txs for optimizing new Tx placement, detecting and removing unauthorized Txs, selecting the nearest Tx to offload traffic onto it, and constructing radio maps for indoor and outdoor navigation. This survey provides a comprehensive review of existing algorithms that estimate the location of a wireless Tx given a set of observations with the received signal strength indication. Algorithms that require the observations to be location-tagged are suitable for outdoor mapping or small-scale indoor mapping, while algorithms that allow most observations to be unlocated trade off some accuracy to enable large-scale crowdsourcing. This article presents empirical evaluation of the algorithms using numerical simulations and real-world Bluetooth Low Energy data.

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Authors: Nurminen, H., Dashti, M., Piché, R.
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Web of Science (2015): 0.922 1.165 8.4 0.154 0.00332 0.355
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Scopus rating (2014): 0.306 0.783
Web of Science (2014): 0.858 1.127 9.1 0.164 0.00397 0.403
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Scopus rating (2008): 0.561 0.905
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Scopus rating (2006): 0.596 0.893
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Modeling and Joint Mitigation of TX and RX Nonlinearity Induced Receiver Desensitization

In this article, we provide detailed modeling of the spurious intermodulation distortion (IMD) products appearing in the own receiver (RX) operating band as a result of coexisting transmitter (TX) and RX nonlinearities with noncontiguous carrier aggregation (CA) transmissions. Furthermore, an efficient baseband digital signal processing technique is proposed, which can flexibly mitigate the resulting receiver in-band self-interference caused either by individual or simultaneously coexisting TX and RX nonlinearities. The technique is based on accurately estimating the effective leakage channel that models the nonlinearities of the transmitter and receiver chains and the duplexer filters characteristics. In the parameter estimation stage, an observation receiver chain is adopted for separately estimating the TX passband leakage response, which facilitates efficient joint estimation and regeneration of the TX and RX induced self-interference. In the online digital cancellation, the actual transmit data is used in conjunction with the estimated channel responses to generate a replica of the overall nonlinear self-interference, which is subsequently suppressed by subtracting it from the actual observation. In general, the proposed technique can efficiently estimate and suppress the self-interference at arbitrary spurious sub-bands located at the RX band. The performance evaluations with comprehensive numerical simulations and practical RF measurements indicate that the proposed technique can achieve up to 28 dB of measured self-interference suppression.

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Web of Science (2014): 2.243 2.286 9.6 0.214 0.03802 1.174
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Scopus rating (2013): 1.705 2.589
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Scopus rating (2007): 2.584 2.888
Scopus rating (2006): 2.435 2.826
Scopus rating (2005): 2.286 3.098
Scopus rating (2004): 2.304 2.586
Scopus rating (2003): 2.401 2.521
Scopus rating (2002): 2.396 2.307
Scopus rating (2001): 2.106 2.152
Capacity Analysis of Joint Transmission CoMP With Adaptive Modulation

Joint transmission (JT)-based Coordinated Multipoint (CoMP) systems achieve high performance gains by allowing full coordination among multiple cells, transforming unwanted intercell interference into useful signal power. In this paper, we present an analytical model to perform adaptive modulation for a typical JT CoMP system, consisting of three transmission points, under a target bit error rate (BER) constraint. Probability density functions of the signal-to-interference-plus-noise ratio (SINR) are derived for different JT CoMP schemes, and based on them, closed-form expressions for the average spectral efficiency (ASE) are obtained when adopting continuous-rate adaptive modulation. The study of ASE is also extended for the case of discrete-rate modulations, where the performance comparison of different practical quantized modulation schemes is carried out.

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Scopus rating (2011): 1.168 2.393
Scopus rating (2010): 0.995 1.927
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Scopus rating (2008): 1.193 2.294
Scopus rating (2007): 1.463 2.8
Scopus rating (2006): 1.055 2.332
Scopus rating (2005): 1.004 1.885
Scopus rating (2004): 1.238 2.185
Scopus rating (2003): 1.283 2.267
Scopus rating (2002): 2.363 2.337
Scopus rating (2001): 1.677 2.108
Analytical performance estimation of network-assisted D2D communications in urban scenarios with rectangular cells

The aggressive spatial reuse of radio resources is considered today as one of the most promising avenues to achieve significant cellular capacity improvements in future fifth-generation networks. Accordingly, device-to-device (D2D) communications are an emerging paradigm that promises to offer these much expected gains without the need for additional investments into the network infrastructure. However, before this attractive technology can be deployed ubiquitously, the research community has to fully understand the extent of its potential performance benefits across typical scenarios of interest. In this work, we consider one such use case of rectangular cells (common for offices, shopping malls, dormitories, etc.) and develop the corresponding analytical methodology for D2D performance evaluation. As our target metric, we employ the signal-to-interference (SIR) ratio experienced by a D2D user. To this end, we propose two relatively simple approximations for SIR distribution and hence capture the related parameters, including user throughput. Further, we carefully investigate the most interesting numerical results by making important conclusions on the envisioned operation of our chosen scenario. In particular, we demonstrate that under certain conditions, the SIR behaviour is insensitive to the dimensions of cells, while different propagation exponents ‘scale’ its density function thus allowing to simplify the characterisation of SIR in a wide range of input parameters. Copyright © 2015 John Wiley & Sons, Ltd.

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Authors: Samuylov, A., Ometov, A., Begishev, V., Kovalchukov, R., Moltchanov, D., Gaidamaka, Y., Samouylov, K., Andreev, S., Koucheryavy, Y.
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Computing Platforms for Software-Defined Radio

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Authors: Hussain, W., Nurmi, J., Isoaho, J., Garzia, F.
Conclusions
Navigation and localization are nowadays an intrinsic part of the majority of wireless communication devices. They are also likely to play crucial roles in the new generations of communication devices, such as Device-to-Device (D2D), Internet of Things (IoT) and 5G.

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Authors: Lohan, E., Seco-Granados, G., Wymeersch, H., Nykänen, O., Nurmi, J.
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Design and Implementation of IEEE 802.11a/g Receiver Blocks on a Coarse-Grained Reconfigurable Array
This chapter presents the design and evaluation of template-based Coarse-Grained Reconfigurable Array (CGRA) generated accelerators that process Orthogonal Frequency-Division Multiplexing receiver blocks. The CGRA operates as a coprocessor with a Reduced Instruction-Set Computing (RISC) processor so that the overall system yields the benefits of general- and special-purpose processing. The accelerators are designed by crafting the CGRA template to the computational and communication requirements of the algorithms in an effort to minimize the resource utilization and power dissipation on the target Field Programmable Gate Array (FPGA) device. The performance of each CGRA is recorded in terms of the number of clock cycles and several multiple performance metrics. The power consumption is also estimated by simulating the postfit gate-level FPGA netlist of the accelerators.

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Design Transformation from a Single-Core to a Multi-Core Architecture Targeting Massively Parallel Signal Processing Algorithms

This chapter describes single-core and multi-core platforms that are reconfigurable and heterogeneous by design and are specifically targeted to accelerate computationally intensive signal processing algorithms mostly used in software-designed radio applications. The signal-core accelerator architectures are tightly integrated with a C programmable processor core while the backbone of communications and control in multi-core architecture is a network-on-chip. The platforms were instantiated multiple times for different proof-of-concept application scenarios. The single- and multi-core platforms were subjected to self-aware dynamic frequency scaling while being prototyped for a field programmable gate array device. The performance of the platforms was measured and estimated in terms of many basic and high-level metrics and comparisons with other state-of-the-art platform are established for design evaluation.

General information

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Authors: Hussain, W., Hoffmann, H., Ahonen, T., Nurmi, J.
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GNSS Vulnerabilities

Ionospheric effect, multipath, and interference are the three important error sources for satellite-based positioning. Ionospheric content interferes with GNSS signals, inducing errors for users calculating their position from such signals. Besides, since GNSS was designed to operate in ideal line-of-sight conditions, observables are highly influenced by the signals arriving to the receiver along multiple propagation paths in locations with high possibility of reflection or refraction of the signal, such as urban scenarios. Finally, due to their very low power at the Earth surface, GNSS signals are vulnerable to RF interference, which can severely degrade the receiver performance. The chapter will assess the effects of these impairments and will present the strategies to detect and correct them.

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ASJC Scopus subject areas: Electrical and Electronic Engineering
DOIs: 10.1007/978-3-319-50427-8_4
Introduction and Book Structure

Wireless positioning and navigation area is a prevalent area embroidered in the majority of wireless communication devices and applications. The number of technologies supporting wireless navigation has been continuously increasing in the last decade, from those based on classical satellite navigation systems to technologies employing inertial sensors, Wireless Local Area Networks (WLAN) and cellular systems, and even ultra-sound and visible light systems.

Mapping the Radio World to Find Us

Locating users in an indoor scenario is a challenging task. While there are several systems capable of tackling it, most of them are impractical to deploy in a worldwide scale due to the costs associated with its infrastructure. Therefore, this chapter guides the reader through a popular indoor positioning technique, fingerprinting, which relies on existing infrastructure to provide an estimation of the user's location. While any kind of signal can be used, such as acoustic and electromagnetic signals, the focus is put on wireless local area network signals, which are ubiquitous in most current buildings. Along the way, the chapter introduces path-loss models, advantages, disadvantages and a thorough description of the inner workings of this technique.

Multi-GNSS: Facts and Issues

The world of satellite navigation is experiencing an era of expansion, as the GNSS community is growing. Besides the two already operational systems, the United States of America's GPS and Russia's GLONASS, two additional constellations are currently under development and near to be completed: the Chinese BeiDou and the European Galileo. Within 2020, four systems are then expected to be fully operational and will offer immense possibilities to improve navigation performance in terms of availability, continuity, reliability and accuracy. This chapter focuses on current and future GNSS, giving an introduction to each system and pointing out advantages and challenges of the multi-constellation scenario.
MULTI-POS: Lessons Learnt from Fellows and Supervisors

The path to a successful and cooperative network is not always smooth. Marie Curie networks are, by definition, networks of people with various technical and cultural backgrounds and with different personalities, individual work and life targets, and personal ways of solving the challenges that each has to cope with. The larger a network is, the more likely it is that some conflicts or personality mismatches appear, but this is not necessarily a bad thing, and it can be used as a learning and growth lesson. This chapter addresses the various challenges that were encountered during the MULTI-POS implementation and it summarizes the lessons learnt by both the fellows and the supervisors. The goal of this chapter is to offer some generic guidelines in forming and running large international networks, such as the Marie Curie training networks, and to enable the people interested in such collaborations to pro-actively identify and tackle some of the inherent challenges in such networks.

MULTI-POS: Multi-Technology Positioning Professionals Training Network

This chapter presents an overview of the Marie Curie Initial Training Network MULTI-POS, whose fellows are the main authors of the rest of the book chapters. The motivation of creating this network is first presented, and then the network structure and some of its main realizations are overviewed.
Ninesilica: A Homogeneous MPSoC Approach for SDR Platforms

This chapter presents the study of Software Defined Radio applications on homogeneous multi-core architectures based on the Silicon Café template. Two instances of the template have been realized and implemented on an Altera Stratix IV FPGA device. Ninesilica, the first instance of the template, is a homogeneous 3 × 3 mesh of processing elements realizing a standalone cluster. The second instance of the template is a clustered architecture composed of four Ninesilica clusters. Significant kernels of WCDMA and OFDM kernels were ported on the architectures analyzing the platform performance in terms of computational power, algorithm scalability, energy consumption and efficiency, portability of the mapping and hardware scalability. The achieved results showed that the proposed approach offers a high flexibility and parallelization efficiency, making homogeneous solutions a good candidate for the implementation of SDR systems.

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Authors: Airoldi, R., Garzia, F., Ahonen, T., Nurmi, J.
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Publication date: 2017
Synchronization in NC-OFDM-Based Cognitive Radio Platforms

This chapter provides essential information with regard to the synchronization issues in Non-Contiguous Orthogonal Frequency Division Multiplexing (NC-OFDM)-based systems. It also provides a flexible timing synchronization scheme implemented on an Altera Stratix-V Field Programmable Gate Array (FPGA) device. The main component of the synchronizer is a reconfigurable module which calculates the Sum-of-Products (SoP) of the incoming signal with predefined coefficients. The SoP module performs as a multicorrelator on demand. Furthermore, different architectures of the SoP block and their respective performance evaluations are discussed in detail. Eventually, all developed architectures are compared to each other in terms of power consumption, silicon area, maximum frequency, etc.
The Future of Software-Defined Radio: Recommendations

An efficient Software-Defined Radio solution comes when all the aspects of system design are collectively addressed under application specifications and constraints. It includes all—the efforts to design wideband antennas, powerful software to process huge bandwidth of information, optimizations at hardware to maximize performance and nevertheless to mention compilers and operating systems. It is important that every engineer or a scientist working on a particular block of SDR should have a bare-minimum understanding of the entire design stack. There is a need to have clear vision about the targets to be achieved, trade-offs to be made, and a unified approach so that all the objectives are measurable to enable a qualitative and quantitative analysis.

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Organisations: Department of Electronics and Communications Engineering, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, University of Turku
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The Impact of Galileo Open Service on Location Based Services Markets

Many Location Based Services (LBS), such as navigation and tracking services, are using Global Satellite-based Navigation Systems (GNSS). GNSS is the most widely used positioning solution for LBS outdoors, therefore any improvement in the quality of GNSS positioning services will directly improve the quality of LBS and therefore it will generate more revenue and attract more users. One of the upcoming satellite navigation systems is Galileo, which is being deployed by the European Union (EU). Beside all political motivations behind Galileo, the availability of more satellites in view and a more accurate, reliable and continuous positioning service are some of the technological motivations of having yet another of GNSS on sky. Such improvement in positioning service and, as a result, in LBS applications will develop the market and attract more users. However, due to long delays, current powerful competitors which are making the GNSS market increasingly crowded, and also the cost of Galileo being covered by EU taxpayers only, there is a question if another of GNSS is really required and it is able to return all its cost in near future. This chapter assesses the financial aspects of Galileo at the time of writing the book, including increasing costs and impact of losing some parts of market and also its potential revenue and the economic impact of positioning and timing service improvement by Galileo, and finally the impact of Galileo on future markets of LBS is estimated.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Basiri, A., Lohan, E., Moore, T.
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Publication date: 2017
Understanding the GNSS Signal Model

The aim of this chapter is to guide anyone who is new to the Global Navigation Satellite System (GNSS) field through the basics of navigation signal modelling. The chapter explains the relation between the mathematical model and physical reality. It reveals some basic facts which are usually hidden in an advanced literature on signal processing in GNSS. In detail, it focuses on the noise modelling and it provides a recipe to properly set the noise level in a computer simulation to authentically reflect the real situation. It also provides an explanation of the Doppler effect and it discusses its overall impact on the received navigation signal.


Techniques for wireless energy harvesting (WEH) are being emerged as a fascinating set of solutions to extend the lifetime of energy-constrained wireless networks. They are commonly regarded as a key functional technique for almost perpetual communications. With the WEH technology, wireless devices are able to harvest energy from, e.g., different light sources or RF signals broadcast by ambient/dedicated wireless transmitters to support their operation and communications capabilities. The WEH technology will have increasingly wider range of use in upcoming applications for, e.g., wireless sensor networks, Machine-to-Machine (M2M) communications, and the Internet of Things. In this paper, the usability and fundamental limits of solar cell or photovoltaic harvesting based M2M communication systems are studied and presented. The derived theoretical bounds are in essence based on the Shannon capacity theorem, combined with selected propagation loss models, assumed additional link nonidealities, as well as the given energy harvesting and storage capabilities. Fundamental performance limits and available capacity of the communicating link are derived and analyzed, together with extensive numerical results evaluated in different practical scenarios, including realistic implementation losses and state-of-the-art printed supercapacitor performances. In particular, low power sensor type communication applications using passive wake-up radio (WuR) assisted operation are addressed in the study. The results show the benefits of using passive WuR, especially when the number of nodes is small. Moreover, the presented analysis principles and results establish clear feasibility regions and performance bounds for wireless energy harvesting based low rate M2M communications in the future IoT networks.
In preparation towards future cellular networks: the detailed analysis of macro and micro site densification and sector densification

The next generation of cellular networks is expected to provide huge capacity, and site densification is one of the possible solutions to increase the network capacity. The target of this paper is to show the impact of macro/micro site densification and higher order sectorization on signal strength, signal quality and throughput in LTE network. It also highlights the impact of site and sector densification on the cell overlapping and cell border areas. A detailed techno-economical analysis along with area power consumption and area spectral efficiency is also provided in this paper. In site densification, the intersite distance (ISD) between the base station sites is decreased, which results in strong inter cell interference. The results presented in this paper show that the spectral efficiency of the cell decreases with the site densification. However, the average area spectral efficiency increases due to a larger number of cells in the densified network. At the same time the number of cell border users overlapped by multiple servers also increases with the site and sector densification. It is shown that in one square kilometer, increasing the number of cells from 14 (3-sector site with 500 m ISD) to 693 (6-sector site with 100 m ISD) relatively improves the area spectral efficiency by 24.5 times at the cost of 49.5 times more number of cells. Almost identical power efficiency is provided with 3-, and 6-sector site. However, a higher order sectored site was found to be more cost efficient.

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Peer-reviewed: Yes
Monitoring intrusion in an area using WIFI-enabled devices

For monitoring an area, signal strength samples are obtained (S1) by sampling a data signal transmitted from at least one first device and received by at least one second device, and measuring a signal strength of the sampled data signal. The signal strength samples are processed (S2) by forming consecutive first groups of N consecutive signal strength samples, calculating first standard deviations for each of the consecutive first groups, forming consecutive second groups of N consecutive first standard deviations, and calculating second standard deviations for each of the consecutive second groups. Based on the second standard deviations, it is detected (S3) if a fluctuation in the data signal received by the second device has occurred that represents an intrusion in the area.

Active RF cancellation of nonlinear TX leakage in FDD transceivers

In frequency division duplex (FDD) transceivers, transmitter (TX) passband leakage induced self-interference can cause own receiver (RX) desensitization, due to limited isolation of the duplexer RX filter and nonlinear components in the RX front-end. In this paper, an active RF cancellation technique for TX passband leakage is proposed, to efficiently suppress the nonlinear leakage signal at the RX chain input. The technique is based on generating an RF replica of the leakage signal using an auxiliary transmitter branch, together with appropriate digital preprocessing of the known transmit data. This RF replica is then combined with the received signal at the LNA input in the RX chain, properly phased, such that the level of the TX leakage signal is reduced. The performance of the proposed solution is evaluated with simulations as well as practical RF measurements, demonstrating excellent suppression of the TX leakage signal for wideband signals at high transmission power levels. Such novel self-interference cancellation solutions can facilitate enhanced efficiency and flexibility of the RF spectrum use in the emerging 5G radio networks, especially at the lower carrier frequencies.
Digital predistortion for mitigating transmitter-induced receiver desensitization in carrier aggregation FDD transceivers

In frequency division duplexing (FDD) transceivers, the intermodulation distortion (IMD) created by a nonlinear transmit power amplifier can easily interfere with the receiver (RX) band. This is a particular concern in various carrier aggregation scenarios, and can cause severe own RX desensitization. In this paper, a spur-injection based sub-band digital predistortion (DPD) solution is proposed to mitigate this problem. Compared to earlier works, the proposed DPD parameter learning is performed using the main RX of the device, and thus it does not require an extra observation RX, which implies reduced costs and size. The proposed DPD is tested using computer simulations with practical models for the transmitter (TX) power amplifier and the TX/RX duplexer filters. The TX-induced IMD is suppressed by up to 25 dB at the own RX band, demonstrating a significant improvement in the RX signal-to-interference-and-noise-ratio (SINR).

Efficient Time-Domain Phase Noise Mitigation in cm-Wave Wireless Communications

The topic of this paper is low-complexity yet high-precision phase-noise mitigation in a realistic cm-wave radio link. The proposed algorithm for phase-noise induced intercarrier interference mitigation works in time domain. We propose a filtering solution that is computationally very simple to implement on silicon. Noise from initial phase-noise estimate is removed with cumulative sum filtering instead of a very high order complex-tap filter. The performance of the proposed algorithm is evaluated in realistic ITU-R Urban Microcell Non-Line-of-Sight channel as well as in white Gaussian noise channel, and with state-of-the-art phase-locked-loop oscillator generated phase noise. The obtained results show that highly-efficient phase-noise mitigation can be obtained using the proposed approach. For the example 5G case, the algorithm suppresses the phase noise so that the bit-error-rate performance is near the case without phase noise.
Fast-convolution filtered OFDM waveforms with adjustable CP length
This paper investigates the application of flexible and effective fast-convolution (FC) filtering scheme for multiplexing OFDM physical resource blocks (PRBs) in a spectrally well-localized manner. The scheme is able to suppress interference leakage between adjacent PRBs, thus supporting independent waveform parametrization for different PRBs, as well as asynchronous multiuser operation. These are considered as important features in the 5G waveform development. This contribution focuses on the parametrization alternatives and constraints, which are mostly due to the forward and inverse discrete Fourier transform (DFT/IDFT) lengths feasible for practical implementation. Special attention is on cyclic prefix (CP) OFDM system dimensioning with adjustable CP length while the overall symbol duration is fixed. It is demonstrated that a wide range of alternative CP-lengths are usually available through the FC-filtered OFDM scheme.

Methods for phase noise mitigation for DFT-S-OFDM waveforms
This paper addresses the problem of phase noise mitigation in communications links utilizing DFT-S-OFDM waveforms. The paper discusses use of two different pilot configurations to do the compensation of the common phase error part of the phase noise. The pilot configurations are inserting pilots as logical symbols before the DFT spreading and inserting frequency domain pilots as subcarriers as in OFDM waveforms. Then, based on the former pilot configuration, a computationally efficient intercarrier interference compensation algorithm is proposed. The pilot configurations and techniques are evaluated in terms of peak-to-average power ratio and phase noise mitigation performance with realistic numerology in numerical simulations.

Reference receiver enabled digital cancellation of nonlinear out-of-band blocker distortion in wideband receivers
This paper proposes digital cancellation of nonlinear distortion originating from out-of-band blocking carriers and induced by the analog front-end nonlinearities in direct-conversion receivers (RXs). The cancellation is enabled by employing an additional reference RX for capturing these blockers. In addition, cancellation of mirror-frequency interference is targeted. The feed-forward cancellation of nonlinear distortion is blindly adaptive without any a priori information of the received signal or the nonlinearity characteristics of the RX. The performance of this approach is demonstrated with laboratory RF measurements using state-of-the-art base-station hardware. With the distortion cancellation, blocker tolerance of the RX is improved by 7-8 dB.
Wireless Optogenetic Neural Dust for Deep Brain Stimulation
In recent years, numerous research efforts have been dedicated towards developing efficient implantable devices for Deep Brain Stimulation (DBS). However, there are limitations and challenges with the current technologies. Firstly, the stimulation of neurons currently is only possible through implantable electrodes which target a population of neurons. This results in challenges in the event that stimulation at the single neuron level is required. Secondly, a major hurdle still lies in developing miniature devices that can last for a lifetime in the patient's brain. Recently, the concept of neural dust has been introduced as a way to achieve single neuron monitoring and potentially actuation. In parallel to this, the field of optogenetics has emerged where the aim is to stimulate neurons using light, usually by means of optical fibers inserted through the skull. Obviously, this introduces many challenges in terms of user friendliness and biocompatibility. We address this shortcoming by proposing the wireless optogenetic neural dust (wi-opt neural dust). The wi-opt neural dust is equipped with a miniature LED that is able to stimulate the genetically engineered neurons, and at the same time harvest energy from ultrasonic vibrations. The simulation results presented in the paper investigates the behaviour of the light propagation in the brain tissue, as well as the performance of designed circuitry for the energy harvesting process. The results demonstrates the feasibility of utilizing wi-opt neural dust for long term implantation in the brain, and a new direction towards precise stimulation of neurons in the cortex.

FPGA Implementation Issues of a Flexible Synchronizer Suitable for NC-OFDM-Based Cognitive Radios
This paper presents a flexible timing synchronization scheme alongside the hardware implementation issues on an Altera Stratix-V Field Programmable Gate Array (FPGA) device. The core content of the synchronizer is based on Finite Impulse Response (FIR) filter which operates as a multicorrelator on demand. The term “flexibility” refers to a specific part of the synchronizer where the multicorrelator reconfigures its FIR filter block on-the-fly by employing Partial Reconfiguration (PR) feature. Moreover, different implementations have been evaluated for the multicorrelator, including Multiplier-Less (ML) approach (an approximate computing technique only for autocorrelation purpose) along with the Direct From as well as the Transposed, Parallel, and Pipelined-Parallel Direct Form FIR filters. All the developed architectures are compared to each other in terms of power consumption, silicon area, and maximum frequency. Preliminary synthesis results show that the ML approach achieves better performance (including 94% less power dissipation, 75% less logic utilization as well as 67%
fewer registers) than other architectures when performing autocorrelation function. Furthermore, the critical path is
analyzed and appropriate optimization techniques (such as DSP register packing and intermediate register insertion) are
applied to the best candidates of the architectures mentioned. As the best results, 2.83× speed-up, 56.57% less logic
utilization along with 38.86% fewer registers are achieved for different architectures. Accordingly, we discover that the
parallel form, as well as the pipelined-parallel one, achieve more interesting results than the transposed version in most of
the cases.

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Authors: Shamani, F., Airoldi, R., Fakour Sevom, V., Ahonen, T., Nurmi, J.
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ASJC Scopus subject areas: Electrical and Electronic Engineering

Energy Consumption and Outage Performance Analysis of Heterogeneous Network with Varying Inter-tier Dependence

General information
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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications
and Positioning, Beijing University of Posts and Telecommunications
Compact inband full-duplex relays with beyond 100 dB self-interference suppression: Enabling techniques and field measurements

In this paper, the self-interference channel and novel enabling techniques for a compact inband full-duplex relay are described and characterized in different operating environments. The full-duplex operation is based on a novel antenna design that uses wavetraps to provide passive isolation of up to 70 dB between the transmit and receive antenna ports. The passive isolation is complemented with novel active RF and digital cancellation stages that further suppress the residual SI to the receiver noise floor. Measurement results of a complete prototype implementation show that the proposed design can achieve an overall SI cancellation performance of over 100 dB even with an ambitious instantaneous bandwidth of 80 MHz. Similar results are obtained both in an anechoic chamber as well as in realistic multipath indoor environments.

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Scopus rating (2016): 1.362 2.033
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Web of Science (2015): 2.053 2.263 8.3 0.267 0.04319 0.829
Scopus rating (2014): 1.828 2.644
Web of Science (2014): 2.181 2.346 8.3 0.323 0.0446 0.889
Publication Forum (2014): 3
Scopus rating (2013): 1.536 2.256
Publication Forum (2013): 3
Scopus rating (2012): 1.471 2.237
Publication Forum (2012): 3
Scopus rating (2011): 1.366 2.16
Scopus rating (2010): 1.141 2.097
Scopus rating (2009): 1.505 2.188
Scopus rating (2008): 1.165 2.062
Scopus rating (2006): 2.074 2.669
Scopus rating (2005): 2.236 2.837
Scopus rating (2004): 1.709 2.481
Scopus rating (2003): 1.38 2.438
Scopus rating (2002): 1.689 2.338
Scopus rating (2001): 1.475 1.595
Scopus rating (2000): 1.167 1.674
Scopus rating (1999): 1.448 2.373
Low-Complexity Subband Digital Predistortion for Spurious Emission Suppression in Noncontiguous Spectrum Access

Noncontiguous transmission schemes combined with high power-efficiency requirements pose big challenges for radio transmitter and power amplifier (PA) design and implementation. Due to the nonlinear nature of the PA, severe unwanted emissions can occur, which can potentially interfere with neighboring channel signals or even desensitize the own receiver in frequency division duplexing transceivers. In this paper, to suppress such unwanted emissions, a low-complexity subband digital predistortion solution, specifically tailored for spectrally noncontiguous transmission schemes in low-cost devices, is proposed. The proposed technique aims at mitigating only the selected spurious intermodulation distortion components at the PA output, hence allowing for substantially reduced processing complexity compared with classical linearization solutions. Furthermore, novel decorrelation-based parameter learning solutions are also proposed and formulated, which offer reduced computing complexity in parameter estimation as well as the ability to track time-varying features adaptively. Comprehensive simulation and RF measurement results are provided, using a commercial LTE-Advanced mobile PA, to evaluate and validate the effectiveness of the proposed solution in real-world scenarios. The obtained results demonstrate that highly efficient spurious component suppression can be obtained using the proposed solutions.

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Authors: Abdelaziz, M., Anttila, L., Tarver, C., Li, K., Cavallaro, J. R., Valkama, M.
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Web of Science (2015): 2.284 2.36 9.9 0.256 0.02987 0.988
Publication Forum (2015): 2
Scopus rating (2014): 1.56 2.417
Web of Science (2014): 2.243 2.286 9.6 0.214 0.03802 1.174
Publication Forum (2014): 3
Scopus rating (2013): 1.705 2.589
Publication Forum (2013): 3
Scopus rating (2012): 1.371 2.043
Publication Forum (2012): 3
Scopus rating (2011): 1.223 1.764
Scopus rating (2010): 1.16 1.774
Scopus rating (2009): 1.687 2.478
Scopus rating (2008): 1.815 2.243
Scopus rating (2007): 2.584 2.888
Scopus rating (2006): 2.435 2.826
Scopus rating (2005): 2.286 3.098
Scopus rating (2004): 2.304 2.586
Scopus rating (2003): 2.401 2.521
Terahertz band communications: Applications, research challenges, and standardization activities

Terahertz frequency band, 0.1–10THz, is envisioned as one of the possible resources to be utilized for wireless communications in networks beyond 5G. Communications over this band will feature a number of attractive properties, including potentially terabit-per-second link capacities, miniature transceivers and, potentially, high energy efficiency. Meanwhile, a number of specific research challenges have to be addressed to convert the theoretical estimations into commercially attractive solutions. Due to the diversity of the challenges, the research on THz communications at its early stages was mostly performed by independent communities from different areas. Therefore, the existing knowledge in the field is substantially fragmented. In this paper, an attempt to address this issue and provide a clear and easy to follow introduction to the THz communications is performed. A review on the state-of-the-art in THz communications research is given by identifying the target applications and major open research challenges as well as the recent achievements by industry, academia, and the standardization bodies. The potential of the THz communications is presented by illustrating the basic tradeoffs in typical use cases. Based on the given summary, certain prospective research directions in the field are identified.

Feasibility and Fundamental Limits of Energy-Harvesting Based M2M Communications

Feasibility and Fundamental Limits of Energy-Harvesting Based M2M Communications

Feasibility and Fundamental Limits of Energy-Harvesting Based M2M Communications
**Integrating Printed and Silicon Electronics**

The Internet of Everything (IoE) is a vision for the connectivity of anything, at anytime and from anyplace. It will extend today’s internet to the physical world that surrounds us (things and objects). To reach the vision of IoE, technical innovation is required in a number of fields from hardware solutions to data management. Stick-it-on devices (SioDs) are one of the revolutionary innovations enabling the vision and bringing intelligence into today’s real world objects. SioDs are flexible, energy autonomous, interactive devices that can perform functions like sensing, actuating, computing, and/or communicating.

To incorporate low-power high-performance computing into the SioDs, it is necessary to integrate both flexible printed and silicon components. This presentation focuses on the integration of printed and conventional electronics. It will present progress in 1) SMD mounting, 2) flip-chip bonding, and 3) direct chip connections (e.g. replacement of wire-bonding).

**Location Based Beamforming in 5G Ultra-Dense Networks**

In this paper we consider transmit (Tx) and receive (Rx) beamforming schemes based on the location of the device. In particular, we propose a design methodology for the Tx/Rx beamforming weight-vectors that is based on the departure and arrival angles of the line-of-sight (LoS) path between accessnodes (ANds) and user-nodes (UNds). A network-centric extended Kalman filter (EKF) is also proposed for estimating and tracking the directional parameters needed for designing the Tx and Rx beamforming weights. The proposed approach is particularly useful in 5G ultra-dense networks (UDNs) since the high-probability of LoS condition makes it possible to design geometric beams at both Tx and Rx in order to increase the signal-to-interferenceplus-noise ratio (SINR). Moreover, relying on the location of the UNd relative to the ANds makes it possible to replace fullband uplink (UL) reference signals, commonly employed for acquiring the channel-state-information-at-transmitter (CSIT) in time-division-duplex (TDD) systems, by narrowband UL pilots. Also, employing the EKF for tracking the double-directional parameters of the LoS-path allows one to reduce the rate at which UL reference signals are transmitted. Consequently, savings in terms of time frequency resources are achieved compared to beamforming schemes based on full-band CSI. Extensive numerical results are included using a realistic ray-tracing based system-level simulator in ultra-dense 5G network context. Results show that position based beamforming schemes outperform those based on full-band CSI in terms of mean user-throughput even for highly mobile users.
Implementation and performance evaluation of graphene-based passive UHF RFID textile tags

In this paper, we investigate the fabrication and wireless performance of graphene-based passive UHF RFID textile tags. Two different graphene-based inks were used to fabricate identical antennas on a fabric substrate by doctor blading technique. The performance of the tags was evaluated with wireless measurements throughout the UHF RFID frequency band. Based on our results, the graphene-based tags showed attainable read ranges of 1.6 and 2.4 meters. According to these first results, these tags have a great potential in future wearable applications along with cost-effective and eco-friendly aspects.

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Random Triangle: A Baseline Model for Interference Analysis in Heterogeneous Networks

In emerging heterogeneous networks, a wide range of the underlying performance evaluation problems are related to wireless interference characterization and can be reduced to investigating the distribution of a side length in a random triangle. In this work, we address the task of calculating the side length distribution in such a triangle determined by the known distributions of its two other sides and the distribution of the angle between them. No restrictions on the distributions of input random variables are imposed except for their statistical independence. Our solution delivers a crucial building block for interference analysis in multi-tier and multi-radio heterogeneous networks, including mobile device-to-device communication as one of the most extreme interference-limited cases.

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Web of Science (2014): 1.978 2.483 5.2 0.305 0.03595 1.019
Publication Forum (2014): 3
Optimization of Flexible Filter Banks Based on Fast Convolution

Multirate filter banks can be implemented efficiently using fast-convolution (FC) processing. The main advantage of the FC filter banks (FC-FB) compared with the conventional polyphase implementations is their increased flexibility, that is, the number of channels, their bandwidths, and the center frequencies can be independently selected. In this paper, an approach to optimize the FC-FBs is proposed. First, a subband representation of the FC-FB is derived. Then, the optimization problems are formulated with the aid of the subband model. Finally, these problems are conveniently solved with the aid of a general nonlinear optimization algorithm. Several examples are included to demonstrate the proposed overall design scheme as well as to illustrate the efficiency and the flexibility of the resulting FC-FB.

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Scopus rating (2014): 0.292 1.0
Web of Science (2014): 0.6 0.675 3.9 0.086 0.00207 0.245
Publication Forum (2014): 1
Performance Considerations for Positioning with Signals of Opportunity
This paper presents a study on the benefit of observing several signals of opportunity for positioning purposes. Several static emitters are placed over a defined area where an user is moving and acquiring measurements to each of these emitters. The simulation considers that the user is capable of acquiring time of arrival measurements from several wireless protocols, such as WCDMA, 802.11b, 802.11g and 802.11ac. The variance in the measurements is modelled through the Crámer-Rao bound and a propagation model for each technology. As conclusions, this paper discusses the benefits of using multiple signals of opportunity in the context of positioning and how much the positioning performance is affected by considering different measurements combinations from several wireless technologies.

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Authors: Figueiredo e Silva, P., Lohan, E.
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Links:
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Research output: Scientific - peer-review › Conference contribution

Multilevel outphasing power amplifier system with a transmission-line power combiner
This paper presents a multilevel outphasing power amplifier (PA) system consisting of eight class-D unit PAs on 28 nm CMOS and an off-chip transmission-line power combiner. The combiner, implemented on PCB with microstrip lines, was designed to operate at 1.8 GHz frequency and filter out the third and fifth harmonics generated by the PAs. The combiner layout was designed so that the line spacing increases towards the output to reduce coupling, while the lines are equal in length. The simulated maximum output power is 32.3 dBm (1.71 W) with an efficiency of 34.4%. With 20 MHz and 100 MHz LTE signals, average efficiencies of 15.2% and 15.1% were achieved, respectively.
Analysis and Augmented Spatial Processing for Uplink OFDMA MU-MIMO Receiver With Transceiver I/Q Imbalance and External Interference

This paper addresses receiver (RX) signal processing in multiuser multiple-input multiple-output (MU-MIMO) systems. We focus on uplink orthogonal frequency-division multiple access (OFDMA)-based MU-MIMO communications under in-phase/quadrature (I/Q) imbalance in the associated radio frequency electronics. It is shown in the existing literature that transceiver I/Q imbalances cause cross-talk of mirror-subcarriers in OFDM systems. As opposed to typically reported single-user studies, we extend the studies to OFDMA-based MU-MIMO communications, with simultaneous user multiplexing in both frequency and spatial domains, and incorporate also external interference from multiple sources at RX input, for modeling challenging conditions in increasingly popular heterogeneous networks. In the signal processing developments, we exploit the augmented subcarrier processing, which processes each subcarrier jointly with its counterpart at the image subcarrier, and jointly across all RX antennas. Furthermore, we derive an optimal augmented linear RX in terms of minimizing the mean-squared error. The novel approach integrates the I/Q imbalance mitigation, external interference suppression, and data stream separation of multiple UEs into a single processing stage, thus avoiding separate transceiver calibration. Extensive analysis and numerical results show the signal-to-interference-plus-noise ratio (SINR) and symbol-error rate (SER) behavior of an arbitrary data stream after RX spatial processing as a function of different system and impairment parameters. Based on the results, the performance of the conventional per-subcarrier processing is heavily limited under transceiver I/Q imbalances, and is particularly sensitive to external interferers, whereas the proposed augmented subcarrier processing provides a high-performance signal processing solution being able to detect the signals of different users as well as suppress the external interference efficiently. Finally, we also extend the studies to massive MIMO framework, with very large antenna systems. It is shown that, despite the huge number of RX antennas, the conventional linear processing methods still suffer heavily from I/Q imbalances while the augmented approach does not have such limitations.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Hakkarainen, A., Werner, J., Dandekar, K. R., Valkama, M.
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Publication date: 9 May 2016
Peer-reviewed: Yes
Performance and Cramer-Rao Bounds for DoA/RSS Estimation and Transmitter Localization Using Sectorized Antennas

Using collaborative sensors or other observing devices equipped with sectorized antennas provides a practical and low-cost solution to direction of arrival (DoA) and received signal strength (RSS) estimation, as well as non-cooperative transmitter localization. In this paper, we study the performance and theoretical bounds of DoA/RSS estimation and localization using sectorized antennas. We first show that the sector-power measurements at an individual sensor form a sufficient statistic for DoA/RSS estimation and transmitter localization. Motivated by that, we then derive the Cramer-Rao bound (CRB) on DoA/RSS estimation based on sector-powers and study its asymptotic behavior. Moreover, we derive an analytical expression for the mean squared error of a practical sectorized-antenna based DoA estimator, compare its performance to the derived CRB and study its asymptotic properties. Next, we derive the CRB for localization based on sector-powers. The resulting CRB is a lower bound for a localization system where the DoA/RSS estimates, obtained from sector-powers at individual sensors, are fused together into a location estimate. Moreover, the CRB also covers the more general case of a localization system where sector-powers from individual nodes are directly fused together, without an intermediate DoA/RSS estimation step. We compare the obtained CRB to a localization approach employing an intermediate DoA/RSS estimation step, and observe that skipping this intermediate processing step may result in a substantially improved localization performance. Finally, we study the influence of various important system parameters, like the number of sensors, sectors and measurement samples, on the achievable estimation and localization performance. Overall, this paper demonstrates and quantifies the achievable DoA/RSS estimation and localization performance of sectorized antennas, and provides comprehensive design guidelines for sector-power based low-complexity localization systems.
3GPP LTE-A offers new technologies such as non-contiguous carrier allocation for improving radio spectrum utilization. However, implementation of these technologies is challenging because of intermodulation distortion caused by non-linearity of components. Digital Predistortion (DPD) offers a way for compensating for these nonlinearities by modifying the digital baseband signal. As most consumer-oriented mobile devices are equipped with powerful Graphics Processing Units (GPUs), it has become possible to implement DPD functionality to such devices with no additional hardware cost. In this paper, we propose data-parallel, reconfigurable predistortion and measure its performance on mobile GPUs: Qualcomm Adreno 330 and ARM Mali T628.
Sub-band Digital Predistortion for Noncontiguous Transmissions: Algorithm Development and Real-Time Prototype Implementation

This article proposes a novel, reduced complexity, block-adaptive digital predistortion (DPD) technique for mitigating the spurious emissions that occur when amplifying spectrally noncontiguous signals with a nonlinear power amplifier (PA). The introduced DPD solution is designed for real-time scenarios where a loop delay exists in the DPD system. By a proper choice of the DPD parameters, the technique is shown to be robust against arbitrarily long loop delays while not sacrificing DPD linearization performance and convergence speed. Moreover, the proposed DPD solution has lower complexity compared to previously proposed solutions in the literature while giving excellent linearization performance in terms of mitigating the spurious emissions. Real-time implementations of the algorithm on the WARP platform are developed, including considerations for several key trade-offs in the hardware design to balance the robustness, performance and complexity. The simulations and real-time FPGA experiments evidence excellent and robust performance in real-life situations with highly nonlinear PAs and arbitrary loop delays.

Analysis of a receiver-based reliable broadcast approach for vehicular networks

The Intelligent Transportation Systems concept provides the ground to enable a wide range of applications to improve traffic safety and efficiency. Innovative communication systems must be proposed taking into account, on the one hand, unstable characteristics of vehicular communications and, on the other hand, different requirements of applications. In this paper a reliable (geo-)broadcasting scheme for vehicular ad-hoc networks is proposed and analyzed. This receiver-based technique aims at fulfilling the received message integrity yet keeping the overhead at a reasonably low level. The results are compared to simulation studies carried out in the Network Simulator-3 (NS-3) simulation environment demonstrating good agreement with each other. The analysis shows that in a single-hop scenario, receiver-based reliable broadcasting can provide good reliability, while giving very little overhead for high number of receivers.
An efficient indoor positioning particle filter using a floor-plan based proposal distribution

We present a novel floor-plan and PDR (pedestrian dead reckoning) based proposal distribution for indoor positioning particle filtering. Including floor-plan information in the proposal distribution makes the particle filtering more efficient than using the map only in the measurement model, because the proposal distribution becomes more accurate and the measurement model less accurate. The method uses offline-computed distances from each point of a regular grid to the closest wall in each direction. Our simulations show that the novel proposal distribution combined with a floor-plan and PDR based motion model improves the positioning accuracy with small numbers of particles and noisy PDR compared to the particle filters that use the floor-plan only for particle weighting.

General information

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Authors: Nurminen, H., Raitoharju, M., Piche, R.
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Publication date: 2016

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Publisher: IEEE
Digitally Enhanced Wideband I/Q Downconversion Receiver With 2-Channel Time-Interleaved ADCs

The interesting concept of employing in-phase/quadrature (I/Q) downconversion together with time-interleaved analog-to-digital converters allows digitizing very wide instantaneous radio-frequency (RF) bandwidths (BW) and grants enhanced flexibility in accessing and processing the RF spectrum. Such a structure also inevitably suffers from performance degradation due to the analog components' nonidealities, e.g., frequency response mismatches (FRMs), that ultimately lead to spurious mismatch components that limit the system's dynamic range. Available solutions developed for I/Q mismatches or time-interleaving mismatches alone are not compatible for correcting the FRM spurs in such joint I/Q time-interleaved converter (IQ-TIC) architecture. This brief proposes novel blind FRM identification and correction solutions that are able to suppress all the associated spurs in the considered wideband IQ-TIC architecture. The proposed digital correction solutions are tested and verified using measured hardware data obtained from an experimental platform, exhibiting good FRM spur correction performance with instantaneous BW on the order of 800 MHz. These developments pave the way toward 5G radio communication devices and systems where instantaneous BWs on the order of 1 GHz are envisioned at centimeter- and millimeter-wave frequency bands.

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Publication Forum (2015): 2
Scopus rating (2014): 0.688 1.551
Web of Science (2014): 1.234 1.546 7.8 0.131 0.01104 0.751
Publication Forum (2014): 2
Scopus rating (2013): 0.855 1.805
Publication Forum (2013): 2
Scopus rating (2012): 0.801 1.628
Publication Forum (2012): 2
Scopus rating (2011): 0.794 1.484
Hybrid Renewable Energy Routing for ISP Networks

The ICT industry has come under criticism as being one of the major energy consumers to exacerbate high global carbon emissions. Meanwhile, using renewable energy to power ICT infrastructure is becoming an attractive solution and is gaining its momentum due to the recent breakthroughs of converting solar and wind energies as power sources at competitive costs. Although significant amounts of fossil fuel based-energy can be saved by allowing network devices (e.g., routers and line-cards) to be set to sleep, this optimization approach comes at a price of degrading routing performance, i.e., the quality of service. This paper addresses the problem of minimizing fossil fuel consumption in large Internet Service Provider (ISP) networks, by utilizing a novel gradient-based routing protocol, which favors forwarding packets along routers powered by the highest quantity of renewable energies. Besides favoring renewable energy, the proposed routing protocol can support putting routers to sleep in order to optimize energy consumption while ensuring a minimum degradation in routing performance. Through our evaluation utilizing real meteorological data, our proposed solution has demonstrated a massive reduction of fossil fuel usage by the network (> 70%) while maintaining the routing performance to a similar level when no energy optimization is applied.

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Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, University of Helsinki, University of Cambridge
Authors: Mineraud, J., Wang, L., Balasubramaniam, S., Kangasharju, J.
Publication date: 2016

IEEE 802.11ac MIMO Transceiver Baseband Processing on a VLIW Processor

Wireless standards are evolving rapidly due to the exponential growth in the number of portable devices along with the applications with high data rate requirements. Adaptable software based signal processing implementations for these devices can make the deployment of the constantly evolving standards faster and less expensive. The flagship technology from the IEEE WLAN family, the IEEE 802.11ac, aims at achieving very high throughputs in local area connectivity scenarios. This article presents a software based implementation for the Multiple Input and Multiple Output (MIMO) transmitter and receiver baseband processing conformance to the IEEE 802.11ac standard which can achieve transmission bit rates beyond 1Gbps. This work focuses on the Physical layer frequency domain processing. Various configurations, including 2×2 and 4×4 MIMO are considered for the implementation. To utilize the available data and instruction level parallelism, a DSP core with vector extensions is selected as the implementation platform. Then, the feasibility of the presented software-based solution is assessed by studying the number of clock cycles and power consumption of the different scenarios implemented on this core. Such Software Defined Radio based approaches can potentially offer more flexibility, high energy efficiency, reduced design efforts and thus shorter time-to-market cycles in comparison with the conventional fixed-function hardware methods.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Joint 3D Positioning and Network Synchronization in 5G Ultra-Dense Networks Using UKF and EKF

It is commonly expected that future fifth generation (5G) networks will be deployed with a high spatial density of access nodes (ANs) in order to meet the envisioned capacity requirements of the upcoming wireless networks. Densification is beneficial not only for communications but it also creates a convenient infrastructure for highly accurate user node (UN)
positioning. Despite the fact that positioning will play an important role in future networks, thus enabling a huge amount of location-based applications and services, this great opportunity has not been widely explored in the existing literature. Therefore, this paper proposes an unscented Kalman filter (UKF)-based method for estimating directions of arrival (DoAs) and times of arrival (ToA) at ANs as well as performing joint 3D positioning and network synchronization in a network-centric manner. In addition to the proposed UKF-based solution, a similar extended Kalman filter (EKF)-based method is proposed by extending the existing 2D EKF-based approach to cover also realistic 3D scenarios. Building on the premises of 5G ultradense networks (UDNs), the performance of both methods is evaluated and analysed in terms of DoA and ToA estimation as well as positioning and clock offset estimation accuracy, using the METIS map-based ray-tracing channel model and 3D trajectories for vehicles and unmanned aerial vehicles (UAVs) through the Madrid grid. Based on the comprehensive numerical evaluations, both proposed methods can provide the envisioned one meter 3D positioning accuracy even in the case of unsynchronized 5G network while simultaneously tracking the clock offsets of network elements with a nanosecond-scale accuracy.

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Research output: Scientific - peer-review » Conference contribution

Multicarrier modulation for HF communications
High-frequency (HF) communications can be flexibly realized using multicarrier modulation techniques. This paper compares the performance of three widely utilized MCM techniques, namely, orthogonal frequency-division multiplexing (OFDM), filter bank multicarrier/offset-QAM (FBMC/OQAM), and filtered multitone (FMT) in HF communications. The performance of these systems is simulated using commonly adopted HF-channel models. It is shown that the simulated uncoded bit-error rate of OFDM is slightly better than that of FBMC/OQAM and FMT. However, with pilot based channel estimation FMT outperforms FBMC/OQAM and OFDM systems in achievable coded frame error rate in case of selective channel models.

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Authors: Yli-Kaakinen, J., Renfors, M., Tuomivaara, H.
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Research output: Scientific - peer-review » Conference contribution

Optimization of parallel processing intensive digital front-end for IEEE 802.11ac receiver
Modern computing platforms offer increasing levels of parallelism for the fast execution of different signal processing tasks. In this paper a digital front-end concept is developed, where the parallel processing is utilized for dividing the inherent structure of IEEE 802.11ac waveform to two or more parallel signals and by processing the resulting signals further e.g., using legacy IEEE 802.11n digital receiver chains. Two multirate channelization architectures are developed with the corresponding filter coefficient optimization. The full radio link performance simulations with commonly adopted indoor WiFi channel profiles are provided, verifying the overall link performance with the proposed channelization architectures.
Parallel processing intensive digital front-end for IEEE 802.11ac receiver

Modern computing platforms offer increasing levels of parallelism for fast execution of different signal processing tasks. In this paper, we develop and elaborate on a digital front-end concept for an IEEE 802.11ac receiver with 80 MHz bandwidth where parallel processing is adopted in multiple ways. First, the inherent structure of the 802.11ac waveform is utilized such that it is divided, through time-domain digital filtering and decimation, to two parallel 40 MHz signals that can be processed further in parallel using smaller-size FFTs and, e.g., legacy 802.11n digital receiver chains. This filtering task is very challenging, as the latency and the cyclic prefix budget of the receiver cannot be compromised, and because the number of unused subcarriers in the middle of the 80 MHz signal is only three, thus necessitating very narrow transition bandwidth in the deployed filters. Both linear and circular filtering based multirate channelization architectures are developed and reported, together with the corresponding filter coefficient optimization. Also, full radio link performance simulations with commonly adopted indoor WiFi channel profiles are provided, verifying that the channelization does not degrade the overall link performance. Then, both C and OpenCL software implementations of the processing are developed and simulated for comparison purposes on an Intel CPU, to demonstrate that the parallelism provided by the OpenCL will result in substantially faster realization. Furthermore, we provide complete software implementation results in terms of time, number of clock cycles, power, and energy consumption on the ARM Mali GPU with half precision floating-point arithmetic along with the ARM Cortex A7 CPU.

Performance Evaluation of Cyclostationary Based Cooperative Sensing Using Field Measurements

This paper focuses on evaluating the gains obtained through cooperative spectrum sensing in real-world while using cyclostationary based mobile sensors. In cooperative sensing (CS), different secondary users (SUs) in a geographical neighborhood cooperate to detect the presence of a primary user (PU). As compared to single-user sensing, cooperation provides diversity gains in the face of multipath fading and shadowing. The effectiveness of the CS is demonstrated by analyzing data acquired in two extensive field measurement campaigns. The first measurement campaign (MC-I) focuses on measurements at fixed locations while the second measurement campaign (MC-II) focuses on a scenario where measurements are taken inside a moving car. These measurements are carried out for DVB-T channels in Finland’s
Capital Region, which consists of urban and suburban environments. Hard decision rules such as OR, AND, MAJORITY and soft decision rule such as SUM (sum of cyclostationary test statistics) are employed and their detection performances are compared to a cyclostationary based single-user detector. A performance parameter of relative increase in probability of detection (RIPD) is used to efficiently demonstrate the cooperation gain obtained relative to local sensing. It is shown that cooperation can significantly improve the performance of a sensor severely affected by fading and shadowing effects. Furthermore, it is shown that increasing the number of collaborating users beyond few users (5-8) does not in practice bring significant improvement in terms of the expected RIPD. The performances of CS schemes evaluated from MC-I are also compared to the corresponding simulated CS results using empirical channel models and terrain data for the same experimental parameters. It is shown that the use of empirical or theoretical models may result in detection errors in practical conditions and measurements should be used to improve the accuracy in such scenarios.

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Scopus rating (2010): 0.995 1.927
Scopus rating (2009): 1.074 2.009
Scopus rating (2008): 1.193 2.294
Scopus rating (2007): 1.463 2.8
Scopus rating (2006): 1.055 2.332
Scopus rating (2005): 1.004 1.885
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Scopus rating (2003): 1.283 2.267
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Power amplifier effects on frequency localized 5G candidate waveforms

One important direction in advanced communication waveform studies for future wireless communications is improved spectrum localization, i.e., minimization of the power leakage outside very narrow guardbands around the useful signal band. This helps to improve the spectrum efficiency, especially in difficult radio access scenarios, like cognitive radio and dynamic spectrum access. In contrast to basic OFDM based waveforms, this allows dense frequency-division multiple access without need for precise synchronization of users. Various multicarrier and single-carrier waveforms with effective spectrum localization are available, but their spectral characteristics have so far been investigated mostly in the digital processing domain. For practical deployment, it is necessary to study the effects of practical transmitter power amplifiers (PAs) on the waveform characteristics, together with power amplifier linearization and peak-to-average power ratio (PAPR) reduction methods. This paper focuses on these issues, deriving PA backoff requirements using the soft envelope limiter model, corresponding to an ideally linearized PA, together with a generic PAPR reduction method based on windowed clipping. It is demonstrated that this method, when applied with well-linearized PA, helps to significantly reduce the required power amplifier backoff for both single-carrier and multicarrier waveforms, with the potential of reaching extremely low out-of-band radiation with realistic backoff values. The results are generally applicable to all spectrally localized waveforms.

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Authors: Renfors, M., Yli-Kaakinen, J., Valkama, M.
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Organisations: Department of Electronics and Communications Engineering, Research group: Laboratory for Future Electronics
Authors: Mäntysalo, M., Vuorinen, T., Suikkola, J.
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Research output: Scientific » Paper, poster or abstract

Private cloud deployment model in open-source mobile robots ecosystem

The focus of this paper is on secure cloud service platform for mobile robots ecosystem. Especially the emphasis is based on the scope of open-source software frameworks such as Apache Hadoop which offers numerous possibilities to employ open-source designing tools and deployment models for private cloud computing planning. This paper presents implementation of the OpenCRP (Open CloudRobotic Platform) locally-operated private cloud infrastructure and configuration methods by using Hadoop distributed file system (HDFS) for easing the ecosystem communications set-up in its entirety. For robot teleoperation, ROS (Robot Operating System) is used. The presented ecosystem utilizes security features for autonomous cloud robotic platform, software tools to manage user authentication and methods for large-scale robot-based data management and analysis. In addition to robot trial set-up of robot data storage and sharing, an ecosystem built with two low-cost mobile robots is presented.

General information
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Ministry of Education publication type: A4 Article in a conference publication
Remotely Powered Piezoresistive Pressure Sensor: Toward Wireless Monitoring of Intracranial Pressure

This paper presents the results of pressure measurements taken after the successful activation of an implantable piezoresistive pressure sensor. The sensor was activated using inductive power transmission for an Intracranial Pressure (ICP) monitoring application. This generated sufficient power (4.47 mW) and voltage (1.894 V) at the sensor input to monitor the pressure changes. Although the changes in voltage were monitored through wires, the required electronics for wireless voltage transfer and measurement in a biological environment are planned in the future. The simulated and measured results of the wireless link, along with the measured changes in pressure are presented. The results are the first step towards a wirelessly powered implant for ICP monitoring.

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Authors: Khan, M. W. A., Björninen, T., Sydänheimo, L., Ukkonen, L.
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Publication Forum (2015): 2
Scopus rating (2014): 1.199 1.974
Web of Science (2014): 1.703 1.766 6.1 0.152 0.01786 0.974
Publication Forum (2014): 2
Short range HF radio channel measurements: Search for one path channels

High frequency (HF) radio channel is diverse since it could be a single path channel or a multipath channel. However, there is lack of information about what is the ratio between these. Herein, results from a measurement campaign in Finland for ground wave and near vertical incidence skywave (NVIS) paths are reported. It was observed that one path channels are rather widely available and in ground waves they dominate. This means that channels for high modulation orders (high data rate HF) are available and should be searched for during the link establishment process. Unfortunately, the current link establishment processes do not support that such that maybe it is time for improvements. Another observation was that if channels are available at all, then usually there are multiple channels available. This means that recently introduced wideband (up to 24 kHz) and multiband (several 3 kHz bands) HF communications have room.

General information

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Saarnisaari, H., Hovinen, V., Tuomivaara, H., Yli-Kaakinen, J.
Number of pages: 6
Publication date: 2016

Statistical Trilateration with Skew-t Distributed Errors in LTE Networks

Localization accuracy of trilateration methods in Long Term Evolution (LTE) cellular networks, which are based on time-of-arrival (ToA), may be highly degraded due to multipath and non-line of sight (NLoS) conditions in urban and indoor environments. Multipath mitigation techniques usually involve a high computational burden and require wideband signals to be effective, which limit their adoption in certain low-cost and low-power mobile applications using narrow-band signals. As an alternative to these conventional techniques, this paper analyzes an Expectation Maximization (EM) localization algorithm that considers the skewness introduced by multipath in the LTE ranging error distribution. The EM algorithm is extensively studied with realistic emulated LTE signals of 1.4 MHz bandwidth. The EM method is compared to a standard Nonlinear Least Squares (NLS) algorithm under ideal simulated conditions and using realistic outdoor measurements from a laboratory testbed. The EM method outperforms the NLS method when the ranging errors in the training and test stages have similar distributions.
The Possibilities of Graphene-Based Passive RFID Tags in High humidity Conditions

In this paper, we study the wireless response and reliability of graphene-based passive UHF RFID tags in high humidity conditions. The functional graphene ink is deposited directly on cardboard substrate to fabricate the RFID tag and the tag performance is evaluated through wireless tag measurements before and after high humidity conditions. Initially the peak read range of the tag is about 2.7 meters, which increases to 3.2 meters in high humidity conditions. Additionally, after drying, the performance of the tag returns back to normal. The results show that this low-cost and eco-friendly graphene RFID tag has a remarkable and unique response to moisture and has a strong potential to be used in future humidity sensor applications.
Unified Analysis of Cooperative Spectrum Sensing over Composite and Generalized Fading Channels

In this paper, we investigate the performance of cooperative spectrum sensing (CSS) with multiple-antenna nodes over generalized and composite fading channels. To this end, we approximate the probability density function (pdf) of the signal-to-noise ratio (SNR) of various fading channels using the mixture Gamma (MG) distribution. Based on this, we derive an exact closed-form expression and a generic infinite series representation for the corresponding probability of energy detection, along with a finite upper bound for the involved truncation error. Both expressions have a relatively simple algebraic form that gives them convenience in handling both analytically and numerically. Furthermore, the composite effect of multipath fading and shadowing scenarios in CSS is mitigated by applying an optimal fusion rule that minimizes the total error rate (TER), where the optimal number of nodes is derived under the Bayesian criterion, assuming erroneous feedback channels. We also extend the derived average detection probability to include diversity reception techniques, namely, maximal-ratio combining, square-law combining, and square-law selection (SLS). For the SLS, we demonstrate the existence of an error rate floor as the number of antennas of the cognitive radio nodes increases in erroneous decision feedback channels. Accordingly, we derive the optimal rule for the number of antennas that minimizes the TER in the SLS framework. Monte Carlo simulations are presented to corroborate the analytical results and to provide illustrative performance comparisons and insights between different composite fading channels.
Using Competing Bacterial Communication to Disassemble Biofilms

In recent years, bacterial infections have become a major public health concern due to their ability to cooperate between single and multiple species resisting to various forms of treatments (e.g., antibiotics). One form of protection is through biofilms, where the bacteria produce a protective medium known as the Extracellular Polymeric Substances (EPS). Researchers are pursuing new multi-disciplinary approaches to treating and curb the evolving process of these infections through the biofilms, to lower the humans' antibiotic dependence that can result in the so-called "super-bugs". Although various solutions have been proposed to break biofilms, they are based on applying drugs or using nanoparticles. In this paper, we propose an alternative approach, where bacteria will cooperate and surround the biofilms to consume the nutrients. By hijacking the nutrients in the environment and blocking the flow from reaching the biofilms, this will lead to starvation, forcing them to break their structure. Preliminary simulations show that a small action radius of quorum sensing molecules is needed to maximise bacteria attraction to a particular location and create the protective wall. Therefore, this formation is capable of speeding up biofilm dispersal process by two hours.

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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Waterford Institute of Technology
Authors: Martins, D., Barros, M., Balasubramaniam, S.
Publication date: 2016

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Article number: 18
ISBN (Electronic): 978-1-4503-4061-8
DOIs: 10.1145/2967446.2967463
Research output: Scientific - peer-review » Conference contribution

Energy cooperation for throughput optimization based on save-then-transmit protocol in wireless communication system

Green communication and energy saving have been a critical issue in modern wireless communication systems. The concepts of energy harvesting and energy transfer are recently receiving much attention in academic research field. In this paper, we study energy cooperation problems based on save-then-transmit protocol and propose two energy cooperation schemes for different system models: two-node communication model and three-node relay communication model. In both models, all of the nodes transmitting information have no fixed energy supplies and gain energy only via wireless energy harvesting from nature. Besides, these nodes also follow a save-then-transmit protocol. Namely, for each timeslot, a fraction (referred to as save-ratio) of time is devoted exclusively to energy harvesting while the remaining fraction is used for data transmission. In order to maximize the system throughput, energy transfer mechanism is introduced in our schemes, i.e., some nodes are permitted to share their harvested energy with other nodes by means of wireless energy transfer. Simulation results demonstrate that our proposed schemes can outperform both the schemes with half-allocate save-ratio and the schemes without energy transfer in terms of throughput performance, and also characterize the dependencies of system throughput, transferred energy, and save-ratio on energy harvesting rate.
Context Awareness for Navigation Applications
This thesis examines the topic of context awareness for navigation applications and asks the question, “What are the benefits and constraints of introducing context awareness in navigation?” Context awareness can be defined as a computer’s ability to understand the situation or context in which it is operating. In particular, we are interested in how context awareness can be used to understand the navigation needs of people using mobile computers, such as smartphones, but context awareness can also benefit other types of navigation users, such as maritime navigators. There are countless other potential applications of context awareness, but this thesis focuses on applications related to navigation. For example, if a smartphone-based navigation system can understand when a user is walking, driving a car, or riding a train, then it can adapt its navigation algorithms to improve positioning performance.

We argue that the primary set of tools available for generating context awareness is machine learning. Machine learning is, in fact, a collection of many different algorithms and techniques for developing “computer systems that automatically improve their performance through experience” [1]. This thesis examines systematically the ability of existing algorithms from machine learning to endow computing systems with context awareness. Specifically, we apply machine learning techniques to tackle three different tasks related to context awareness and having applications in the field of navigation:
(1) to recognize the activity of a smartphone user in an indoor office environment, (2) to recognize the mode of motion that a smartphone user is undergoing outdoors, and (3) to determine the optimal path of a ship traveling through ice-covered waters. The diversity of these tasks was chosen intentionally to demonstrate the breadth of problems encompassed by the topic of context awareness.

During the course of studying context awareness, we adopted two conceptual “frameworks,” which we find useful for the purpose of solidifying the abstract concepts of context and context awareness. The first such framework is based strongly on the writings of a rhetorician from Hellenistic Greece, Hermagoras of Temnos, who defined seven elements of “circumstance.” We adopt these seven elements to describe contextual information. The second framework, which we dub the “context pyramid” describes the processing of raw sensor data into contextual information in terms of six different levels. At the top of the pyramid is “rich context”, where the information is expressed in prose, and the goal for the computer is to mimic the way that a human would describe a situation.

We are still a long way off from computers being able to match a human’s ability to understand and describe context, but this thesis improves the state-of-the-art in context awareness for navigation applications. For some particular tasks, machine learning has succeeded in outperforming humans, and in the future there are likely to be tasks in navigation where computers outperform humans. One example might be the route optimization task described above. This is an example of a task where many different types of information must be fused in non-obvious ways, and it may be that computer algorithms can find better routes through ice-covered waters than even well-trained human navigators. This thesis provides only preliminary evidence of this possibility, and future work is needed to further develop the techniques outlined here. The same can be said of the other two navigation-related tasks examined in this thesis.

A Comparison of Received Signal Strength Statistics between 2.4 GHz and 5 GHz bands for WLAN-based Indoor Positioning
In this paper we study a fingerprinting-based multi-storey indoor positioning system using Received Signal Strength (RSS) measurements. The presented system analysis is based on an extensive measurement campaign including 6 large multi-storey buildings from two different European countries. First, RSS measurement statistics at two different frequency bands, 2.4 GHz and 5 GHz, are compared. The RSS statistics are studied especially from the positioning point of view, including both floor-wise and inter-floor radio propagation analysis. Based on the obtained results, it is shown that the RSS measurements at the 5 GHz band have significantly higher propagation losses especially in the vertical direction compared to the measurements at the 2.4 GHz band. The difference of positioning performance between the 2.4 GHz and 5 GHz bands is then studied as the average 3D positioning error and the floor detection probability and results are provided separately for each considered building. The results imply that the positioning performance at the 2.4 GHz is still considerably better compared to the 5 GHz band, but with possible coverage improvements in the future, the 5 GHz band seems to suit well for the positioning purposes.
Hybrid Cooperative Positioning in Harsh Environments

Hybrid cooperative positioning involves the combination of satellite pseudoranges with measurements based on terrestrial radio signals, with the aim to improve both coverage and accuracy. This paper presents a theoretical analysis of hybrid cooperative positioning in low signal-to-noise ratio environments, explicitly accounting for scenarios where receivers can receive signals but cannot decode navigation messages. We propose an extended pseudorange model, suitable for evaluation of measurements made by the receiver in these scenarios, as well as extended cooperation across agents attempting to enable satellite navigation functionality of receivers operating below signal-to-noise ratio threshold required for proper message decoding. The advantages of such extended cooperation are illustrated on a realistic scenario by means of the Cramer-Rao lower bound.

Characterization of Two-Turns External Loop Antenna with Magnetic Core for Efficient Wireless Powering of Cortical Implants

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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Identification and Sensing Systems Research Group
Authors: Khan, M. W. A., Björninen, T., Sydänheimo, L., Ukkonen, L.
Number of pages: 4
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Publication Forum (2017): 2
Scopus rating (2016): 1.257 1.803
Publication Forum (2016): 2
Comparative End-to-End Analysis of Ca2+-Signaling-Based Molecular Communication in Biological Tissues

Calcium (Ca2+)-signaling-based molecular communication is a short-range communication process that diffuses and propagates ions between the cells of a tissue. The communication process is initiated via stimulation and amplification of the production of Ca2+ ions within a cell; these ions then diffuse through a physical connection between cells called a gap junction. Ca2+ signaling can be found in different classes of cell. In excitable cells, initiation of the Ca2+-signaling process is accompanied by an electrical component; for nonexcitable cell types, the electrical component is absent; while hybrid cells exhibit both behaviors. This paper provides a comparison and analysis of the communication behavior in tissues comprised three specific cell types that utilize Ca2+ signaling: epithelium cells (nonexcitable), smooth muscle cells (excitable), and astrocytes (hybrid). The analysis focuses on spatiotemporal Ca2+ concentration dynamics and how they are influenced by the intracellular signaling process, the molecular diffusion delay, the gain and capacity of the communication channel, as well as intracellular signaling interference. This analysis of the communication behavior in the context of tissues provides insights useful for, inter alia, the design of nanomachines that are situated within tissues and that use analysis of the communication channel to infer tissue health.
Deployment of wireless sensor network in dispersed renewable energy sources for increasing efficiency of power distribution networks

In this work, a novel performance analysis method for evaluating the robustness of emerging power distribution networks (PDNs), which involve deployable renewable energy sources, is proposed. This is realized with the aid of the outage probability (OP) criterion in the context of cooperative communications, which is widely considered in modern wireless communication systems. The main usefulness of this method is that it allows the involved components to communicate to each other by means of a robust and flexible wireless sensor network architecture. In this context, any conventional medium voltage (MV) bus of the PDN is represented as a wireless relay node where data signals gathered from each MV bus can be forwarded reliably to a control station for the subsequent processing. The received signals at wireless nodes are decoded and then forwarded to ensure minimal errors and maximal robustness at the receiving site. The considered OP analysis denotes the probability that the power of a received information signal drops below a pre-defined threshold which satisfies the acceptable Quality of Service requirements of a reliable signal reception. To this end, simple closed-form expressions are proposed for the OP of a regenerative cooperative-based PDN in the presence of various multipath fading effects, which degrade information signals during wireless transmission. The offered results are rather simple and provide meaningful insights for the design and deployment of smart grid systems.
Emerging Technologies, Applications, and Standardizations for Connecting Vehicles: [From the Guest Editors]

General information
State: Published
Ministry of Education publication type: B1 Article in a scientific magazine
Organisations: Department of Electronics and Communications Engineering, IEEE Magnetics Society, Inst Informat Transmiss Problems
Authors: Zhuang, W., Jamalipour, A., Bai, F., Vinel, A.
Number of pages: 3
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Ratings:
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Scopus rating (2016): 0.97 1.933
Publication Forum (2016): 1
Scopus rating (2015): 0.762 1.694
Web of Science (2015): 2.783 1.994 4.4 0.37 0.0025 1.071
Publication Forum (2015): 1
Scopus rating (2014): 0.841 1.479
Web of Science (2014): 1.75 1.669 4.6 0.31 0.00275 1.081
Publication Forum (2014): 1
Scopus rating (2013): 0.75 1.357
Publication Forum (2013): 1
Scopus rating (2012): 0.549 1.359
Publication Forum (2012): 1
Scopus rating (2011): 0.418 1.141
Scopus rating (2010): 0.507 1.163
Scopus rating (2009): 0.69 2.222
Scopus rating (2008): 0.317 1.86
Scopus rating (2007): 0.213 1.022
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Source: WOS
Source-ID: 000366665800006
**Impact of Power Amplifier Nonlinearities in Multi-user Massive MIMO Downlink**

In this paper, we investigate the impact of power amplifier (PA) nonlinear distortion in pre-coded multi-user large antenna or massive MIMO downlink systems. First, detailed signal and system models are derived for the received signal at single-antenna user equipment (UE) under channel-aware linear precoding in the base-station combined with behavioral models for the individual PA units, covering both single-carrier and multi-carrier modulation schemes. Based on the derived models, it is shown that the PA-induced nonlinear distortion can also combine coherently in the channel, depending on the relative differences between the phase characteristics of the different PA units and the corresponding distortion terms. Furthermore, it is also shown that the impact of nonlinear PAs and the resulting linear and nonlinear multi-user interference, quantified in terms of the received signal-to-interference-plus-noise ratio (SINR), is largely dependent on the effective or observable linear gain in the UE receiver demodulation stage. By observing only the instantaneous direct linear gain, the PA-induced nonlinear distortion has a substantial impact on the effective SINR, even if very large number of TX antennas is adopted relative to the number of spatially multiplexed UEs. On the other hand, if the statistically averaged linear gain can be observed, the impact of nonlinear PAs is far less severe. These findings give thus new insight, not only to the core impact of nonlinear PAs in massive MIMO systems but also to the downlink reference signal design, radio frame design and radio resource management in time, in order to facilitate the estimation of the statistically averaged linear gains in the receivers within the scheduled transmission and processing blocks.

**General information**

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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Zou, Y., Raeesi, O., Anttila, L., Hakkarainen, A., Vieira, J., Tufvesson, F., Cui, Q., Valkama, M.
Publication date: Dec 2015

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Links: http://globecom2015.ieee-globecom.org/
Research output: Scientific - peer-review › Conference contribution

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**Joint User Node Positioning and Clock Offset Estimation in 5G Ultra-Dense Networks**

It is commonly expected that network densification will play an important role in achieving the capacity demands of 5G communication networks. While densification is introduced to improve the spectral efficiency and area-capacity, it also results in an infrastructure that is perfectly suitable for user node (UN) positioning. However, so far this compelling opportunity has not been clearly recognized in the literature. In this paper, we therefore propose to make "always on" positioning an integral part of 5G networks such that highly accurate user location estimates are available at any given moment but without draining the UN batteries. We furthermore propose an extended Kalman filter (EKF) that tracks the user location based on the fusion of direction of arrival (DoA) and time of arrival (ToA) estimates obtained at the access nodes (ANs) of the 5G network. Since ToA estimates are typically not useful for positioning unless the UN is synchronized with the network, we include a realistic clock model within the DoA/ToA EKF. This addition makes it possible to estimate the offset of the imperfect UN clock, along with the UN position. In an extensive analysis that is based on specific 5G simulation models, we then quantify the enormous potential of high accuracy positioning in 5G networks, in general, and the proposed DoA/ToA EKF, in particular. Moreover, we demonstrate that the proposed DoA/ToA EKF substantially outperforms the classical DoA-only EKF and is furthermore also able to handle practically extremely relevant situations where the DoA-only EKF fails to position the UN.

**General information**

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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Werner, J., Costa, M. J., Hakkarainen, A., Leppänen, K., Valkama, M.
Publication date: Dec 2015

**Host publication information**

Title of host publication: IEEE Global Communications Conference (GLOBECOM) 2015
Publisher: IEEE
A New Approach to Sign-Bit-Based Parameter Estimation in OFDM Receivers

This article combines algorithm development, thorough analysis and implementation of sign-bit (SB) estimation techniques for symbol timing, carrier frequency offset (CFO) and signal-to-noise ratio (SNR) in orthogonal frequency division multiplexing receivers. The SB estimation is compared in terms of performance and hardware complexity to an equivalent implementation with higher quantization. The techniques are demonstrated by simulation of a SB time/frequency and SB-SNR estimator for 3rd Generation Partnership Project long-term evolution (LTE) cell search in 65-nm technology operating at nominal voltage of 1.2 V. According to post-layout power simulations with toggling information, the architecture estimates the corresponding CFO and SNR for as little as \$479\,\mu W\$ average power for LTE-R8/10, while occupying a silicon area as small as \$0.03\,\text{mm}^2\$. Even though SB estimation experiences some relative performance penalty when compared to 8-bit quantization, this paper demonstrates various advantages and the potential of employing these techniques in low-complexity terminals.

General Information

State: Published
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Lund Univ, Lund University, Ericsson Research
Authors: Diaz, I., Wilhelmsson, L. R., Sofotasios, P. C., Miao, Y., Tan, S., Edfors, O., Öwall, V.
Keywords: (CFO, LTE, OFDM, Receiver design, SNR, Symbol timing, Time synchronization)
Number of pages: 30
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Peer-reviewed: Yes
ASJC Scopus subject areas: Signal Processing, Applied Mathematics

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Publication Forum (2017): 1
Scopus rating (2016): 0.563 1.004
Publication Forum (2016): 1
Scopus rating (2015): 0.511 0.875
Web of Science (2015): 1.178 1.18 3.6 0.228 0.00275 0.262
Publication Forum (2015): 1
Scopus rating (2014): 0.481 0.936
Web of Science (2014): 1.118 1.142 3.7 0.167 0.00217 0.255
Publication Forum (2014): 1
Scopus rating (2013): 0.473 1.112
Publication Forum (2013): 1
Scopus rating (2012): 0.486 0.829
Publication Forum (2012): 1
Scopus rating (2011): 0.513 0.955
Scopus rating (2010): 0.41 0.746
Scopus rating (2009): 0.379 0.626
Scopus rating (2008): 0.438 0.619
Scopus rating (2007): 0.379 0.414
Scopus rating (2006): 0.307 0.79
Scopus rating (2005): 0.238 0.813
Scopus rating (2004): 0.216 0.541
Scopus rating (2003): 0.269 0.62
Scopus rating (2002): 0.306 0.484
Directional Antenna System-Based DoA/RSS Estimation, Localization and Tracking in Future Wireless Networks: Algorithms and Performance Analysis

Location information plays an important role in many emerging technologies such as robotics, autonomous vehicles, and augmented reality. Already now the majority of smartphone owners use their devices' localization capabilities for a broad range of location-based services. Currently, location information in smartphones is mostly obtained in a device-centric approach, where the device to be localized, here referred to as the target node (TN), estimates its own location using, for example, the global positioning system (GPS). However, TNs with wireless communication capabilities can be localized based on their transmitted signals by a third party. In particular, localization can be implemented as a functionality of a wireless network. Depending on the application area and implementation, this network-centric approach has several advantages compared to device-centric localization, such as reducing the energy consumption within the TNs, enabling localization of non-cooperative TNs, and making location information available in the network itself. Current generation wireless networks are already capable of coarse localization. However, these existing localization capabilities do not suffice for the challenging demands of future applications. The majority of approaches moreover does not exploit the fact that an increasing number of base stations (BSs) and user devices are equipped with directional antennas. However, directional antennas enable direction of arrival (DoA) estimation that can, in turn, serve as the basis for advanced localization and location tracking. In this thesis, we thus study the application of directional antennas for localization and location tracking in future generation wireless networks. The contributions of this thesis can be grouped into two topics.

First, this thesis provides a detailed study of DoA/received signal strength (RSS) estimation and localization with a group of directional antennas herein denoted as sectorized antennas. This group of antennas is of particular interest as it encompasses a broad range of directional antennas that can be implemented with a single RF front-end. Thus, the hardware complexity of sectorized antennas is low in comparison to the conventionally used antenna arrays that require multiple transceiver branches. However, at the same time this means that DoA estimation with sectorized antennas has to be implemented in a fundamentally different way. In order to address these differences, the study of sectorized antennas in this thesis includes the derivation of Cramer-Rao bounds (CRBs) for DoA/RSS estimation and localization, the proposal of three different DoA/RSS estimators, as well as numerical and analytical performance evaluations of DoA/RSS estimation and localization using sectorized antennas.

Second, this thesis deals with localization based on the fusion of DoA and RSS estimates as well as DoA and time of arrival (ToA) estimates. It is shown that the combination of these estimates can result in a much increased localization performance compared to a localization based on one of these estimates alone. For the localization based on DoA/RSS estimates, a mechanism explaining this improvement is revealed by means of a CRB analysis. Thereafter, DoA/RSS-based fusion is further studied using an extended Kalman filter (EKF) as an example location tracking algorithm. Finally, an EKF is proposed that tracks the location of a TN by fusing DoA and ToA estimates. Apart from a significantly improved tracking performance, this joint DoA/ToA-EKF moreover provides estimates for the TN device clock offset and is able to localize the TN in situations where a classical DoA-only EKF fails to provide a location estimate altogether.

Overall, this thesis thus provides insights into benefits of localization and location tracking using directional antennas, accompanied by specific DoA/RSS estimation, localization and location tracking solutions, as well as design guidelines for implementing localization systems in future generation wireless networks.
Combined architecture for multi-dimensional signal quality enhancements in GNSS receivers

Multipath, interference and ionospheric distortions are three of the main error sources in satellite-based positioning. As Global Navigation Satellite Systems (GNSS) were designed to operate in perfect line-of-sight conditions, the GNSS observables are highly influenced by the signals arriving to the receiver along multiple propagation paths in locations with increased possibility of reflection or refraction of the signal, such as urban scenarios. Furthermore, due to their very low power at the Earth surface, GNSS signals are vulnerable to Radio Frequency Interference (RFI), which can severely degrade the receiver performance. Finally, ionosphere is another important error source in single frequency positioning. Taking into account these three main error sources and some of the most promising detection and mitigation methods, we propose a combined architecture for future GNSS receivers including advanced multipath detection for integrity assessment, jamming interference detection, and a Data Driven (DD) framework for long term near real time ionospheric modeling.

Biotelemetric wireless intracranial pressure monitoring: an in vitro study

Assessment of intracranial pressure (ICP) is of great importance in management of traumatic brain injuries (TBIs). The existing clinically established ICP measurement methods require catheter insertion in the cranial cavity. This increases the risk of infection and hemorrhage. Thus, noninvasive but accurate techniques are attractive. In this paper, we present two wireless, battery-less and minimally invasive implantable sensors for continuous ICP monitoring. The implants comprise ultra-thin (50 µm) flexible spiral coils connected in parallel to a capacitive microelectromechanical systems (MEMS) pressure sensor. The implantable sensors are inductively coupled to an external on-body reader antenna. The ICP variation can be detected wirelessly through measuring the reader antenna’s input impedance. This paper also proposes a novel implant placement to improve the efficiency of the inductive link. In this study, the performance of the proposed telemetry system was evaluated in a hydrostatic pressure measurement setup. The impact of the human tissues on the inductive link was simulated using a 5-mm layer of pig skin. The results from the in vitro measurement proved the capability of our developed sensors to detect ICP variations ranging from 0 to 70 mmHg at 2.5-mmHg intervals.
Investigations on mobility models and their impact on indoor positioning

This paper proposes a new mobility model more suitable for a user that moves in a 3D indoor space. A fingerprinting method is used to compare the performance of the new model with another feasible one found in literature.

General information
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Host publication information
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Investigations on mobility models and their impact on indoor positioning
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Links:
http://urn.fi/URN:NBN:fi:ttv-201603013603

Bibliographical note
Versio ja lupa ok 12.1.2016 /KK
Research output: Scientific - peer-review › Conference contribution
On the Impact of Intra-System Interference for Ranging and Positioning with Bluetooth Low Energy
This paper focuses on the study of intra-system interference for ranging and positioning applications using Blue- tooth Low Energy (BLE). While BLE tries to avoid inter- ference with other protocols in the same frequency band, such as Wi-Fi, the intra-system interference is unavoidable, either due to multipath or simultaneous transmissions in the same channel. This study shows that intra-system interfer- ence contributes with a deviation of approximately 5 dBm in the Received Signal Strength (RSS) and by taking this into account the ranging and positioning accuracy can be significantly improved. The study uses data collected from two different environments.

General information
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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), The University of Nottingham, Nottingham Geospatial Institute
Authors: Figueiredo e Silva, P., Basiri, A., Lohan, E., Pinchin, J., Hill, C., Moore, T.
Publication date: 3 Nov 2015

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BLE Intra-System Interference
DOIs:
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Links:
http://urn.fi/URN:NBN:fi:tty-201603013601

Bibliographical note
Versio ja lupa ok 12.1.2016 KK
Research output: Scientific - peer-review › Conference contribution

Room-level indoor positioning with Wi-Fi and RFID fingerprints
This paper shows the advantages and limitations of combining RFID and Wi-Fi technology for estimating the location of a user in an indoor environment. The paper builds on on a simulated environment, with one or several RFID read- ers being deployed inside a room and several Wi-Fi devices spread, exclusively, around the surrounding area. The parameters of the simulated environment were drawn from a real measurement experiment.

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Figueiredo e Silva, P., Lohan, E.
Keywords: (Wi-Fi, RFID, fingerprinting)
Publication date: 3 Nov 2015

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Room-level indoor positioning with Wi-Fi and RFID fingerprints
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Links:
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Bibliographical note
Versio ja lupa ok 12.1.2016 /KK
Research output: Scientific - peer-review › Conference contribution
Entropy and Channel Capacity under Optimum Power and Rate Adaptation over Generalized Fading Conditions

Accurate fading characterization and channel capacity determination are of paramount importance in both conventional and emerging communication systems. The present work addresses the non-linearity of the propagation medium and its effects on the channel capacity. Such fading conditions are first characterized using information theoretic measures, namely, Shannon entropy, cross entropy and relative entropy. The corresponding effects on the channel capacity with and without power adaptation are then analyzed. Closed-form expressions are derived and validated through computer simulations. It is shown that the effects of nonlinearities are significantly larger than those of fading parameters such as the scattered-wave power ratio, and the correlation coefficient between the in-phase and quadrature components in each cluster of multipath components.

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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: Wireless Communications and Positioning, Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO), Department of Electrical Engineering and Computer Science, Aristotle University of Thessaloniki, Department of Electronic Engineering, Khalifa University, Centre for Communication Systems Research, University of Surrey, University of Leeds, International University of Rabat
Authors: Sofotasios, P. C., Muhaidat, S., Valkama, M., Ghogho, M., Karagiannidis, G. K.
Keywords: (Adaptation policies, channel capacity, entropy)
Number of pages: 5
Pages: 2162-2166
Publication date: 1 Nov 2015
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ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing, Applied Mathematics

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Scopus rating (2016): 0.942 1.805
Publication Forum (2016): 2
Scopus rating (2015): 0.872 1.887
Web of Science (2015): 1.661 1.852 6.3 0.449 0.01578 0.862
Publication Forum (2015): 2
Scopus rating (2014): 0.902 1.993
Web of Science (2014): 1.751 1.926 6.7 0.234 0.01523 0.827
Publication Forum (2014): 2
Scopus rating (2013): 0.876 2.111
Publication Forum (2013): 2
Scopus rating (2012): 0.97 1.883
Publication Forum (2012): 2
Scopus rating (2011): 0.774 1.604
Scopus rating (2010): 0.981 1.728
Scopus rating (2009): 0.926 1.75
Scopus rating (2008): 1.048 1.951
Scopus rating (2007): 1.0 2.006
Scopus rating (2006): 0.84 1.895
Scopus rating (2005): 0.921 1.965
Scopus rating (2004): 1.029 2.606
Scopus rating (2003): 1.214 1.888
Scopus rating (2002): 1.145 1.652
Scopus rating (2001): 1.088 1.263
Scopus rating (2000): 1.139 1.358
Scopus rating (1999): 0.813 1.205
Original language: English
Sectorized antenna-based DoA estimation and localization: Advanced algorithms and measurements

Sectorized antennas are a promising class of antennas for enabling direction-of-arrival (DoA) estimation and successive transmitter localization. In contrast to antenna arrays, sectorized antennas do not require multiple transceiver branches and can be implemented using a single RF front-end only, thus reducing the overall size and cost of the devices. However, for good localization performance the underlying DoA estimator is of uttermost importance. In this paper, we therefore propose a novel high performance DoA estimator for sectorized antennas that does not require cooperation between the transmitter and the localizing network. The proposed DoA estimator is broadly applicable with different sectorized antenna types and signal waveforms, and has low computational complexity. Using computer simulations, we show that our algorithm approaches the respective Cramer-Rao lower bound for DoA estimation variance if the signal-to-noise ratio (SNR) is moderate to large and also outperforms the existing estimators. Moreover, we also derive analytical error models for the underlying DoA estimation principle considering both free space as well as multipath propagation scenarios. Furthermore, we also address the fusion of the individual DoA estimates into a location estimate using the Stansfield algorithm and study the corresponding localization performance in detail. Finally, we show how to implement the localization in practical systems and demonstrate the achievable performance using indoor RF measurements obtained with practical sectorized antenna units.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Electrical Engineering Department, University of California, Los Angeles (UCLA), Drexel University


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Scopus rating (2011): 2.903 4.68


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SPMA: An innovative solution for future smart networks in macrocellular suburban environment

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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning, Tampere University of Technology
Authors: Sheikh, M. U., Naghdi, S., Lempiäinen, J.
Keywords: (Antenna radiation patterns, Buildings, Directive antennas, Interference, Needles, Three-dimensional displays, 3D ray tracing, 5G, Antenna Beamwidth, Antenna Tilting, High Order Sectorization, SPMA)
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Modeling and Digital Mitigation of Transmitter Imperfections in Radio Communication Systems
To satisfy the continuously growing demands for higher data rates, modern radio communication systems employ larger bandwidths and more complex waveforms. Furthermore, radio devices are expected to support a rich mixture of standards such as cellular networks, wireless local-area networks, wireless personal area networks, positioning and navigation systems, etc. In general, a "smart" device should be flexible to support all these requirements while being portable, cheap, and energy efficient. These seemingly conflicting expectations impose stringent radio frequency (RF) design challenges which, in turn, call for their proper understanding as well as developing cost-effective solutions to address them. The direct-conversion transceiver architecture is an appealing analog front-end for flexible and multi-standard radio systems. However, it is sensitive to various circuit impairments, and modern communication systems based on multi-carrier waveforms such as Orthogonal Frequency Division Multiplexing (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA) are particularly vulnerable to RF front-end non-idealities.

This thesis addresses the modeling and digital mitigation of selected transmitter (TX) RF impairments in radio communication devices. The contributions can be divided into two areas. First, new modeling and digital mitigation techniques are proposed for two essential front-end impairments in direct-conversion architecture-based OFDM and OFDMA systems, namely inphase and quadrature phase (I/Q) imbalance and carrier frequency offset (CFO). Both joint and de-coupled estimation and compensation schemes for frequency-selective TX I/Q imbalance and channel distortions are proposed for OFDM systems, to be adopted on the receiver side. Then, in the context of uplink OFDMA and Single Carrier FDMA (SC-FDMA), which are the air interface technologies of the 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) and LTE-Advanced systems, joint estimation and equalization techniques of RF impairments and channel distortions are proposed. Here, the challenging multi-user uplink scenario with unequal received power levels
is investigated where I/Q imbalance causes inter-user interference. A joint mirror subcarrier processing-based minimum mean-square error (MMSE) equalizer with an arbitrary number of receiver antennas is formulated to effectively handle the mirror sub-band users of different power levels. Furthermore, the joint channel and impairments filter responses are efficiently approximated with polynomial-based basis function models, and the parameters of basis functions are estimated with the reference signals conforming to the LTE uplink sub-frame structure. The resulting receiver concept adopting the proposed techniques enables improved link performance without modifying the design of RF transceivers.

Second, digital baseband mitigation solutions are developed for the TX leakage signal-induced self-interference in frequency division duplex (FDD) transceivers. In FDD transceivers, a duplexer is used to connect the TX and receiver (RX) chains to a common antenna while also providing isolation to the receiver chain against the powerful transmit signal. In general, the continuous miniaturization of hardware and adoption of larger bandwidths through carrier aggregation type noncontiguous allocations complicates achieving sufficient TX-RX isolation. Here, two different effects of the transmitter leakage signal are investigated. The first is TX out-of-band (OOB) emissions and TX spurious emissions at own receiver band, due to the transmitter nonlinearity, and the second is nonlinearity of down-converter in the RX that generates second-order intermodulation distortion (IMD2) due to the TX in-band leakage signal. This work shows that the transmitter leakage signal-induced interference depends on an equivalent leakage channel that models the TX path non-idealities, duplexer filter responses, and the RX path non-idealities. The work proposes algorithms that operate in the digital baseband of the transceiver to estimate the TX-RX non-idealities and the duplexer filter responses, and subsequently regenerating and canceling the self-interference, thereby potentially relaxing the TX-RX isolation requirements as well as increasing the transceiver flexibility.

Overall, this thesis provides useful signal models to understand the implications of different RF non-idealities and proposes compensation solutions to cope with certain RF impairments. This is complemented with extensive computer simulations and practical RF measurements to validate their application in real-world radio transceivers.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Kiayani, A.
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Awarding institution:Tampere University of Technology
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Research output: Collection of articles › Doctoral Thesis

**Novel Methods for Personal Indoor Positioning**

Currently, people are used to getting accurate GNSS based positioning services. However, in indoor environments, the GNSS cannot provide the accuracy and availability comparable to open outdoor environments. Therefore, alternatives to GNSS are needed for indoor positioning. In this thesis, methods for pedestrian indoor positioning are proposed. With these novel methods, the mobile unit performs all the required positioning measurements and no dedicated positioning infrastructure is required.

This thesis proposes novel radio map configuration methods for WLAN fingerprinting based on received signal strength measurements. These methods with different model parameters were studied in field tests to identify the best models with reasonable positioning accuracy and moderate memory requirements. A histogram based WLAN fingerprinting model is proposed to aid IMU based pedestrian dead reckoning that is obtained using a gyro and a 3-axis accelerometer, both
based on MEMS technology. The sensor data is used to detect the steps taken by a person on foot and to estimate the step length and the heading change during each step.

For the aiding of the PDR with WLAN positioning, this thesis proposes two different configurations of complementary extended Kalman filters. The field tests show that these configurations produce equivalent position estimates. Two particle filters are proposed to implement the map aided PDR: one filter uses only the PDR and map information, while the other uses also the WLAN positioning. Based on the field tests, map aiding improves the positioning accuracy more than WLAN positioning.

Novel map checking algorithms based on the sequential re-selection of obstacle lines are proposed to decrease the computation time required by the indoor map matching. To present the map information, both unstructured and structured obstacle maps are used. The feasibility of the proposed particle filter algorithms to real time navigation were demonstrated in field tests.

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Organisations: Department of Automation Science and Engineering
Authors: Leppäkoski, H.
Number of pages: 129
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Research output: Monograph › Doctoral Thesis

**Nonlinear Distortion in Wideband Radio Receivers and Analog-to-Digital Converters: Modeling and Digital Suppression**
Emerging wireless communications systems aim to flexible and efficient usage of radio spectrum in order to increase data rates. The ultimate goal in this field is a cognitive radio. It employs spectrum sensing in order to locate spatially and temporally vacant spectrum chunks that can be used for communications. In order to achieve that, flexible and reconfigurable transceivers are needed. A software-defined radio can provide these features by having a highly-integrated wideband transceiver with minimum analog components and mostly relying on digital signal processing. This is also desired from size, cost, and power consumption point of view. However, several challenges arise, from which dynamic range is one of the most important. This is especially true on receiver side where several signals can be received simultaneously through a single receiver chain. In extreme cases the weakest signal can be almost 100 dB weaker than the strongest one. Due to the limited dynamic range of the receiver, the strongest signals may cause nonlinear distortion which deteriorates spectrum sensing capabilities and also reception of the weakest signals. The nonlinearities are stemming from the analog receiver components and also from analog-to-digital converters (ADCs). This is a performance bottleneck in many wideband communications and also radar receivers. The dynamic range challenges are already encountered in current devices, such as in wideband multi-operator receiver scenarios in mobile networks, and the challenges will have even more essential role in the future.

This thesis focuses on aforementioned receiver scenarios and contributes to modeling and digital suppression of nonlinear distortion. A behavioral model for direct-conversion receiver nonlinearities is derived and it jointly takes into account RF, mixer, and baseband nonlinearities together with I/Q imbalance. The model is then exploited in suppression of receiver nonlinearities. The considered method is based on adaptive digital post-processing and does not require any analog hardware modification. It is able to extract all the necessary information directly from the received waveform in order to suppress the nonlinear distortion caused by the strongest blocker signals inside the reception band.
In addition, the nonlinearities of ADCs are considered. Even if the dynamic range of the analog receiver components is not limiting the performance, ADCs may cause considerable amount of nonlinear distortion. It can originate, e.g., from undeliberate variations of quantization levels. Furthermore, the received waveform may exceed the nominal voltage range of the ADC due to signal power variations. This causes unintentional signal clipping which creates severe nonlinear distortion. In this thesis, a Fourier series based model is derived for the signal clipping caused by ADCs. Furthermore, four different methods are considered for suppressing ADC nonlinearities, especially unintentional signal clipping. The methods exploit polynomial modeling, interpolation, or symbol decisions for suppressing the distortion. The common factor is that all the methods are based on digital post-processing and are able to continuously adapt to variations in the received waveform and in the receiver itself. This is a very important aspect in wideband receivers, especially in cognitive radios, when the flexibility and state-of-the-art performance is required.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning

Authors: Allen, M.

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**Signal strength readout and miniaturised antenna for metal-mountable UHF RFID threshold temperature sensor tag**

A new method for the wireless monitoring of a battery-free threshold temperature sensor based on a passive ultra-high-frequency radiofrequency identification (RFID) tag integrated with a bimetal thermostat switch is presented. The strategic placement of the switch brings about a strong modification in the tag antenna impedance as the temperature crosses over a threshold value. Optimisation of the narrow-band tag antenna to operate at the edges of the 902-928 MHz frequency-hopping spread spectrum RFID in the different switch states provides separate sub-bands for the readout above and below a threshold temperature. The results show that this enables an unambiguous sensor readout by monitoring the backscattered signal strength.

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Ministry of Education publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Identification and Sensing Systems Research Group, Sensing Systems for Wireless Medicine (MediSense), Tsinghua University

Authors: Björninen, T., Yang, F.

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Pages: 1734-1736

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ASJC Scopus subject areas: Electrical and Electronic Engineering

**Publication information**

Journal: Electronics Letters

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Recent data analytics from the mobile broadband networks have revealed an exponentially rising trend of mobile data traffic for the past five years. It is predicted that by 2020 the overall data traffic will increase by a factor of 1000x. This traffic growth is caused both by the increased adoption of smartphones and tablets, and by the increased usage of multimedia rich services, such as video streaming. Furthermore, most of this demand is likely to come from indoor users.

In order to be able to meet the increased capacity needs, network densification has been identified as a viable pathway for mobile operators to evolve their networks. Network densification can be achieved by either densifying the existing legacy deployments, e.g. by deploying more macrocell sites or street-level microcells, or by deploying new indoor low-power sites, or both. Furthermore, different distributed antenna solutions offer an additional interesting aspect in network densification and deployments.

This doctoral dissertation addresses network densification from alternative deployment strategies’ perspective, in particular, when individual densification solutions are pushed to their capacity limits, such that all the network elements operate at full load. It evaluates and compares the performance of different deployment strategies in terms of capacity-, energy- and cost-efficiency perspectives, through realistic power consumption and investment cost models. The energy-efficiency aspects are seen particularly important when moving towards the era of green communications, under clear trends and incentives to save energy at all levels of society. Furthermore, the analysis integrates some of the recent findings related to substantially increased building penetration losses, through the use of more energy-efficient building materials.

The obtained results indicate that the indoor femtocell-based solutions with densely deployed femto-cells are much more
spectrally-, energy- and cost efficient approach to address the enormous indoor capacity demands of the 5G era and beyond, compared to densifying the outdoor legacy deployment solutions, when the network is pushed to the extreme limit. This is particularly so when the building penetration losses are high, as has been recently observed in actual field measurements. Furthermore, the dynamic outdoor DAS concept, studied also in this thesis, offers an efficient and capacity-adaptive solution to provide outdoor capacity, on-demand, in urban areas. In general, this thesis work provides tools, results, understanding, and insight of both technical and techno-economical aspects of long-term evolutionary perspectives of different mobile network deployment and densification solutions, which can be used by network vendors, operators, and device manufacturers.

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**3GPP LTE-assisted Wi-Fi-direct: Trial implementation of live D2D technology**
This paper is a first-hand summary on our comprehensive live trial of cellular-assisted device-to-device (D2D) communications currently being ratified by the standards community for next-generation mobile broadband networks. In our test implementation, we employ a full-featured 3GPP LTE network deployment and augment it with all necessary support to provide realtime D2D connectivity over emerging Wi-Fi-Direct (WFD) technology. As a result, our LTE-assisted WFD D2D system enjoys the required flexibility while meeting the existing standards in every feasible detail. Further, this paper provides an account on the extensive measurement campaign conducted with our implementation. The resulting real-world measurements from this campaign quantify the numerical effects of D2D functionality on the resultant system performance. Consequently, they shed light on the general applicability of LTE-assisted WFD solutions and associated operational ranges.

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Authors: Pyattaev, A., Hosek, J., Johnsson, K., Krkos, R., Gerasimenko, M., Masek, P., Ometov, A., Andreev, S., Sedy, J., Novotny, V., Koucheryavy, Y.
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ASJC Scopus subject areas: Electrical and Electronic Engineering, Computer Science(all), Electronic, Optical and Magnetic Materials
A non-repudiable negotiation protocol for security service level agreements

Security service level agreements (SSLAs) provide a systematic way for end users at home or in the office to guarantee sufficient security level when doing business or exchanging sensitive personal or organizational data with an online service. In this paper, we propose an SSLA negotiation protocol that implements non-repudiation with cryptographic identities and digital signatures and includes features that make it resistant to denial of service attacks. The basic version of the protocol does not rely on the use of a trusted third party, and it can be used for all kinds of simple negotiations. For the negotiation about SSLAs, the protocol provides an option to use an external knowledge base that may help the user in the selection of suitable security measures. We have implemented a prototype of the system, which uses JSON Web Signature for the message exchange and made some performance tests with it. The results show that the computational effort required by the cryptographic operations of the negotiation protocol remains at a reasonable level.
Solutions to integrals involving the marcum Q-function and applications

Novel analytic solutions are derived for integrals that involve the generalized Marcum Q-function, exponential functions and arbitrary powers. Simple closed-form expressions are also derived for specific cases of the generic integrals. The offered expressions are both convenient and versatile, which is particularly useful in applications relating to natural sciences and engineering, including wireless communications and signal processing. To this end, they are employed in the derivation of the average probability of detection in energy detection of unknown signals over multipath fading channels as well as of the channel capacity with fixed rate and channel inversion in the case of correlated multipath fading and switched diversity.

General information

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Department of Electrical and Computer Engineering, Khalifa University, Centreor Communication Systems Research, Department of Electronic Engineering, University of Surrey, Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki
Analytic Hierarchy Process for assessing e-health technologies for elderly indoor mobility analysis

Accidental falls and reduced mobility are major risk factors in later life. Changes in a person’s mobility patterns can be related with personal well-being and with the frequency of memory lapses and can be used as risk detectors of incipient neuro-degenerative diseases. Thus, developing technologies for fall detection and indoor localization and novel methods for mobility pattern analysis is of utmost importance in e-health. Choosing the right technology is not only a matter of cost and performance, but also a matter of user acceptability and the perceived ease-of-use by the end user. In this paper, we employ an Analytic Hierarchy Process (AHP) to assess the best fit-to-purpose technology for fall detection and user mobility estimation. Our multi-criteria decision making process is based on the survey results collected from 153 elderly volunteers from 5 EU countries and on 10 emerging e-health technologies for fall detection and indoor mobility pattern estimation. Our analysis points out towards a Bluetooth Low Energy wearable solution as the most suitable solution.
Model-based design and implementation of an adaptive digital predistortion filter

Dataflow models of computation are widely used for modeling signal processing systems. These models have inherent concurrency and the task (actor) execution depends only on the availability of the input data (tokens). This property of dataflow models can be exploited for dynamic power management by automatically switching off the actors with no available input tokens. This idea is applied in this paper for efficient modeling and implementation of an adaptive Digital Predistortion (DPD) filter. The DPD filter is required to operate with different profiles under varying operation scenarios, hence requiring a methodology to manage power dynamically. The paper presents a dataflow model for Adaptive Digital Predistortion based on the Core Functional Dataflow (CFDF) model of computation using the Light Weight Dataflow (LWDF) programming methodology. The paper also provides a methodology for dynamic power management under the dataflow paradigm. To the authors’ best knowledge, this work is the first to integrate dataflow-based power management systematically in the context of adaptive DPD implementation.

Achievable transmission rates and self-interference channel estimation in hybrid full-duplex/half-duplex MIMO relaying

This paper investigates the achievable throughput of a multi-antenna two-hop relay link under hybrid full/half-duplex operation. The analysis is facilitated by realistic waveform simulations, which explicitly model all the essential circuit impairments occurring in the relay transceiver together with degrading channel estimation and self-interference cancellation. The obtained results indicate that pure full-duplex operation does not ensure optimal performance but additional half-duplex transmission periods are usually needed to maximize the end-to-end throughput. Especially, it is
shown that the estimation of the self-interference channel within the relay should be performed when the source is not transmitting anything while also the source should be allowed to transmit alone to avoid making the first hop a bottleneck. These findings form a solid basis for optimizing the full-duplex MIMO relay deployments in future mobile networks.

Abstracting Application Development for Resource Constrained Wireless Sensor Networks

Ubiquitous computing is a concept whereby computing is distributed across smart objects surrounding users, creating ambient intelligence. Ubiquitous applications use technologies such as the Internet, sensors, actuators, embedded computers, wireless communication, and new user interfaces. The Internet-of-Things (IoT) is one of the key concepts in the realization of ubiquitous computing, whereby smart objects communicate with each other and the Internet. Further, Wireless Sensor Networks (WSNs) are a sub-group of IoT technologies that consist of geographically distributed devices or nodes, capable of sensing and actuating the environment.

WSNs typically contain tens to thousands of nodes that organize and operate autonomously to perform application-dependent sensing and sensor data processing tasks. The projected applications require nodes to be small in physical size and low-cost, and have a long lifetime with limited energy resources, while performing complex computing and communications tasks. As a result, WSNs are complex distributed systems that are constrained by communications, computing and energy resources. WSN functionality is dynamic according to the environment and application requirements. Dynamic multitasking, task distribution, task injection, and software updates are required in field experiments for possibly thousands of nodes functioning in harsh environments.

The development of WSN application software requires the abstraction of computing, communication, data access, and heterogeneous sensor data sources to reduce the complexities. Abstractions enable the faster development of new applications with a better reuse of existing software, as applications are composed of high-level tasks that use the services provided by the devices to execute the application logic.

The main research question of this thesis is: What abstractions are needed for application development for resource constrained WSNs? This thesis models WSN abstractions with three levels that build on top of each other: 1) node abstraction, 2) network abstraction, and 3) infrastructure abstraction. The node abstraction hides the details in the use of the sensing, communication, and processing hardware. The network abstraction specifies methods of discovering and accessing services, and distributing processing in the network. The infrastructure abstraction unifies different sensing technologies and infrastructure computing platforms.

As a contribution, this thesis presents the abstraction model with a review of each abstraction level. Several designs for each of the levels are tested and verified with proofs of concept and analyses of field experiments. The resulting designs consist of an operating system kernel, a software update method, a data unification interface, and all abstraction levels combining abstraction called an embedded cloud.

The presented operating system kernel has a scalable overhead and provides a programming approach similar to a desktop computer operating system with threads and processes. An over-the-air update method combines low overhead and robust software updating with application task dissemination. The data unification interface homogenizes the access to the data of heterogeneous sensor networks. A unification model is used for various use cases by mapping everything as measurements. The embedded cloud allows resource constrained WSNs to share services and data, and expand resources with other technologies. The embedded cloud allows the distributed processing of applications according to the available services. The applications are implemented as processes using a hardware independent description language that can be executed on resource constrained WSNs. The lessons of practical field experimenting are analyzed to study the importance of the abstractions. Software complexities encountered in the field experiments highlight the need for suitable abstractions.

The results of this thesis are tested using proof of concept implementations on real WSN hardware which is constrained by computing power in the order of a few MIPS, memory sizes of a few kilobytes, and small sized batteries. The results
will remain usable in the future, as the vast amount, tight integration, and low-cost of future IoT devices require the combination of complex computation with resource constrained platforms.

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Authors: Laukkarinen, T.
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**Frequency Response Mismatches in 4-channel Time-Interleaved ADCs: Analysis, Blind Identification, and Correction**
This article proposes a novel adaptive architecture for blind identification and compensation of frequency response mismatches in 4-channel time-interleaved analog-to-digital-converters (TI-ADCs). Detailed frequency response mismatch modeling is first carried out elaborating in detail the interleaving mismatch spurs characteristics. Stemming from the established mirror-frequency crosstalk nature of the different mismatch spurs, the interleaving mismatch identification process is then carried out using complex second-order statistics based methods. The developed learning algorithm performs the mismatch identification and learns the mismatch compensation filter parameters in a blind manner for almost the full digital bandwidth of the 4 TI-ADC system. The proposed solution's efficiency and performance are verified and demonstrated using state-of-the-art RF-sampling TI-ADC hardware measurements with GHz range instantaneous bandwidth. In addition to this, the relationship between a four-channel TI-ADC and an I/Q sampling 2-channel TI-ADC is explored and an interesting link between the two is established in this work.

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Authors: Singh, S., Anttila, L., Epp, M., Schlecker, W., Valkama, M.
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High-Efficiency Device Localization in 5G Ultra-Dense Networks: Prospects and Enabling Technologies

The deployment of future 5G ultra-dense small cell networks provides unprecedented opportunities to create an advanced localization system that meets the demands of future location-based services and functionalities. In this paper, we present technical enablers for obtaining location information of user nodes (UNs) in a network-centric manner. More specifically, we focus on signal properties, access node (AN) hardware and AN deployments in the envisioned 5G systems. Moreover, we provide illustrative examples of the expected localization performance and indicate how to efficiently predict the UN location. Finally, we offer insights into the utilization of location-awareness and location prediction, and show that it provides substantial benefits compared to existing radio networks.

Securing Network-Assisted Direct Communication: The Case of Unreliable Cellular Connectivity

Network-assisted device-to-device (D2D) communication is a next-generation wireless technology enabling direct connectivity between proximate user devices under the control of cellular infrastructure. It couples together the centralized and the distributed network architectures, and as such requires respective enablers for secure, private, and trusted data exchange especially when cellular control link is not available at all times. In this work, we conduct the state-of-the-art overview and propose a novel algorithm to maintain security functions of proximate devices in case of unreliable cellular connectivity, whether a new device joins the secure group of users or an existing device leaves it. Our proposed solution and its rigorous mathematical implementation detailed in this work open door to a novel generation of secure proximity-based services and applications in future wireless communication systems.
You are AllRing too Much: Assessing the Privacy of Users in Crowdsourcing Environmental Data

With the availability of inexpensive sensors, the attractiveness of participatory sensing has increased tremendously in the last decade. However, when sensing is performed with devices owned by individuals, it raises several privacy issues with respect to the data producers, and hence reduces the incentive to contribute to the services. In this paper, we evaluate the extent to which a malicious server in a crowdsourcing air quality monitoring service can track the locations of users that contribute to the service. The participants periodically send information, such as temperature, relative humidity, carbon monoxide, and luminosity of their surrounding, using an off-the-shelf sensor connected to their mobile phones. The participants also send their coarse-grain location (i.e., disclosing the ID of the cell tower to which their mobile is coupled) along with the air quality data. We evaluate the precision with which the attacker can track the participants using only air quality data and location of the cell tower. We perform a thorough analysis of the privacy attack and show that it can accurately discover the destination of the users with a precision of more than 85% (up to 97%), if at least five consecutive samples are provided by the participants. We also discovered that the precision drops when the environmental sensors are affected by outside conditions (e.g., exposition to direct sunlight) but remains significant (54.5% for 20 consecutive samples).

Transceiver I/Q Imbalance and Widely-Linear Spatial Processing in Large Antenna Systems

In order to keep the total device costs low, large antenna systems require affordable radio frequency (RF) electronics. Unfortunately, this requirement results in RF impairments and may thus cause performance degradations. In this paper, we show how one of these impairments, namely in-phase/quadrature (I/Q) imbalance, distorts the received signals in an uplink multiuser multiple-input multiple-output (MU-MIMO) system where multiple users are spatially multiplexed into the same time-frequency resource. In addition, we present three receiver (RX) post-processing methods and analyze their performance with different multicarrier scenarios under transceiver I/Q imbalances. The results clearly show that the simple maximum ratio combining (MRC) based RX processing suffers heavily from the presence of multiple spatially
multiplexed users, especially in case of I/Q imbalances, and cannot necessarily provide sufficient performance even with the number of RX antennas approaching infinity. In contrast, the linear minimum mean-square error (LMMSE) processing offers more flexible and efficient operation characteristics but is also shown to suffer from performance degradations due to I/Q imbalances. To overcome this problem, we formulate a widely-linear (WL) variant of the MMSE method, called WL-MMSE, which provides good performance also under I/Q imbalances in different multiple access scenarios, and is thus a good candidate for future software defined radios where flexibility is a key concern.

**General information**
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Drexel University, Philadelphia, USA
Authors: Hakkarainen, A., Werner, J., Renfors, M., Dandekar, K. R., Valkama, M.
Number of pages: 5
Pages: 651-655
Publication date: Aug 2015

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DOI: 10.1109/ISWCS.2015.7454428
Research output: Scientific - peer-review > Conference contribution

**Evaluation of SPMA and higher order sectorization for homogeneous SIR through macro sites**
This paper highlights the performance of single path multiple access (SPMA) and discusses the performance comparison between higher order sectorization and SPMA in a macrocellular environment. The target of this paper is to emphasize the gains and significance of the novel concept of SPMA in achieving better and homogeneous SIR and enhanced system capacity in a macrocellular environment. This paper also explains the algorithm of SIR computation in SPMA. The results presented in this paper are based on sophisticated 3D ray tracing simulations performed with real world 3D building data and site locations from Seoul, South Korea. Macrocellular environment dominated with indoor users was considered for the research purpose of this paper. It is found that by increasing the order of sectorization, SIR along with spectral efficiency degrades due to the increase in inter-cell interference. However, as a result of better area spectral efficiency due to increased number of sectors (cells), the higher order sectorization offers more system capacity compared to the traditional 3-sector site. Furthermore, SPMA shows an outstanding performance and significantly improves the SIR for the individual user over the whole coverage area, and also remarkably increases the system capacity. In the environment under consideration, the simulation results reveal that SPMA can offer approximately 424 times more system capacity compared to the reference case of 3-sector site.

**General information**
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning
Authors: Sheikh, M. U., Säe, J., Lempiäinen, J.
Keywords: (3D ray tracing, 5G, High order sectorization, Macro cell, SPMA, System performance)
Publication date: 16 Jul 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Electrical and Electronic Engineering, Computer Networks and Communications, Information Systems

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Scopus rating (2016): 0.402 0.969
Publication Forum (2016): 1
Scopus rating (2015): 0.378 1.084
Web of Science (2015): 1.006 1.167 7.0 0.163 0.00354 0.364
Publication Forum (2015): 1
Performance analysis of IoT-enabling IEEE 802.11ah technology and its RAW mechanism with non-cross slot boundary holding schemes

IEEE 802.11ah task group is working on a new amendment of the IEEE 802.11 standard, suitable for high density WLAN networks in the sub 1 GHz band. It is expected to be the prevalent standard in many Internet of Things (IoT) and Machine to Machine (M2M) applications where it will support long-range and energy-efficient communication in dense network environments. Therefore, significant changes in the legacy 802.11 standards have been proposed to improve the network performance in high contention scenarios, most important of which is the Restricted Access Window (RAW) mechanism described in the amendment. In this paper we analyze the performance of the RAW mechanism in the Non-Cross Slot Boundary case under various possible holding schemes. We propose new holding schemes as well as a new grouping scheme for RAW mechanism based on backoff states of the stations. The proposed schemes are shown to improve the saturation throughput and energy efficiency of the network through extensive simulations. These schemes can therefore be adapted in practical deployment scenarios of the IEEE 802.11ah use cases to improve the overall network performance. Overall, these advanced features make 802.11ah standard a true IoT-enabling technology towards seamless integration of massive amount of connected devices in the future.
Molecular Communication Modeling of Antibody-Mediated Drug Delivery Systems

Antibody-mediated Drug Delivery Systems (ADDS) are emerging as one of the most encouraging therapeutic solutions for treating several diseases such as human cancers. ADDS use small molecules (antibodies) that propagate in the body and bind selectively to their corresponding receptors (antigens) expressed at the surface of the diseased cells. In this paper, the Molecular Communication (MC) paradigm, where information is conveyed through the concentration of molecules, is advocated for the engineering of ADDS and modeling their complex behavior, to provide a realistic model without the over-complication of system biology models, and the limitations of experimental approaches. The peculiarities of antibodies, including their anisotropic transport and complex electrochemical structure, are taken into account to develop an analytical model of the ADDS transport and antigen-binding kinetics. The end-to-end response of ADDS, from the drug injection to the drug absorption, is mathematically derived based on the geometry of the antibody molecule, the electrochemical structure of the antibody-antigen complex, and the physiology of the patient. The accuracy of the MC model is validated by finite-element (COMSOL) simulations. The implications of the complex interplay between the transport and kinetics parameters on the performance of ADDS are effectively captured by the proposed MC model. The MC model of ADDS will enable the discovery and optimization of drugs in a versatile, cost-efficient, and reliable manner.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Wireless Communications and Positioning (WICO), Georgia Institute of Technology
Authors: Chahibi, Y., Akyildiz, I. F., Balasubramaniam, S., Koucheryavy, Y.
Keywords: (molecular communication, pharmacokinetics, protein-protein interactions, Targeted drug delivery systems)
Number of pages: 13
Pages: 1683-1695
Publication date: 1 Jul 2015
Peer-reviewed: Yes
ASJC Scopus subject areas: Biomedical Engineering

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Journal: IEEE Transactions on Biomedical Engineering
Volume: 62
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Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 1.214 1.995
Publication Forum (2016): 1
Scopus rating (2015): 1.132 2.083
Web of Science (2015): 2.468 2.719 8.9 0.625 0.02454 0.888
Publication Forum (2015): 1
Scopus rating (2014): 0.84 1.973
Web of Science (2014): 2.347 2.567 8.7 0.519 0.02257 0.761
Publication Forum (2014): 2
Scopus rating (2013): 1.081 2.073
Publication Forum (2013): 2
Scopus rating (2012): 0.816 1.706
Publication Forum (2012): 2
Scopus rating (2011): 0.7 1.715
Scopus rating (2010): 0.686 1.637
Scopus rating (2009): 0.81 1.94
Scopus rating (2008): 0.826 1.719
Scopus rating (2007): 1.144 2.187
Scopus rating (2006): 1.317 2.426
Scopus rating (2005): 1.023 2.252
Scopus rating (2004): 0.73 1.689
Scopus rating (2003): 0.849 1.367
Prioritized centrally-controlled resource allocation in integrated multi-RAT HetNets

Given the importance of multi-radio heterogeneous networks (HetNets) in delivering more throughput and better connectivity experience to today's wireless users, we investigate the prioritized centrally-controlled resource allocation mechanisms in such systems. First, we theoretically formulate the problem of assisted rate allocation across multiple radio access technologies (RATs) as a special case of relative max-min fairness problem with bifurcated (splittable) traffic flows, which can then be solved by employing the standard linear optimization techniques. Our proposed solution delivers certain minimum guarantees to all the network users, while the rest of system resources are divided proportionally to the preset priority of the users. The priorities in our system may correspond to different subscription/pricing plans of a network operator. Finally, we demonstrate the practical benefits of the proposed resource allocation scheme with system-level simulations, as well as discuss its implementation within a testbed prototype based on the OpenFlow architecture.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Tampere University of Technology,
Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Wireless Communications and Positioning (WICO), Intel Corporation
Authors: Gerasimenko, M., Moltchanov, D., Florea, R., Himayat, N., Andreev, S., Koucheryavy, Y.
Number of pages: 7
Publication date: 1 Jul 2015

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ASJC Scopus subject areas: Electrical and Electronic Engineering, Computer Science Applications, Applied Mathematics
DOIs: 10.1109/VTCSpring.2015.7146031

Bibliographical note
AUX=elt,"Florea, Roman"
Source: Scopus
Source-ID: 84940398708
Research output: Scientific - peer-review › Conference contribution

Wideband self-adaptive RF cancellation circuit for full-duplex radio: Operating principle and measurements

This paper presents a novel RF circuit architecture for self-interference cancellation in inband full-duplex radio transceivers. The developed canceller is able to provide wideband cancellation with waveform bandwidths in the order of 100 MHz or beyond and contains also self-adaptive or self-healing features enabling automatic tracking of time-varying self-interference channel characteristics. In addition to architecture and operating principle descriptions, we also provide actual RF measurements at 2.4 GHz ISM band demonstrating the achievable cancellation levels with different bandwidths and when operating in different antenna configurations and under low-cost highly nonlinear power amplifier. In a very challenging example with a 100 MHz waveform bandwidth, around 41 dB total cancellation is obtained while the corresponding cancellation figure is close to 60 dB with the more conventional 20 MHz carrier bandwidth. Also, efficient tracking in time-varying reflection scenarios is demonstrated.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Tampere University of Technology,
Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Intel Corporation
Electro-textiles – The enabling technology for wearable antennas in wireless body-centric sensing systems

General information
State: Published
Authors: Koski, K., Moradi, E., Hasani, M., Virkki, J., Björninen, T., Rahmat-Samii, Y., Ukkonen, L.
Pages: 1203-1204
Publication date: Jul 2015

Incorporating Bacterial Properties for Plasmid Delivery in Nano Sensor Networks
The new paradigm of molecular communication aims to utilize biological components and systems for developing communication systems. One promising candidate for molecular communication is the use of bacteria to carry information between different nanomachines. However, there is a lack of connection between molecular communication and the design of nanomachines for payload delivery. Utilizing molecular communication to support the transport of payload will further ensure high reliability of delivery to the targeted location. In this paper, we propose the use of bacteria to carry information (which is encoded into plasmids) for a nano sensor network application. We base the structure of the sensor nanomachine compartments on solutions that have been developed and experimentally validated, and utilize a number of bacterial properties to pick up the plasmids and deliver them to a target. This paper presents the analytical and numerical models for the each of the processes as well as their combination, in particular focusing on the end-to-end delay and reliability for the transfer of information. Extensive analysis have been conducted for the proposed approach by varying a number of parameters (e.g., quantity of bacteria, area of deployment, and number of target sites) to determine the overall system performance.

General information
State: Published
Authors: Petrov, V., Molchanov, D., Balasubramaniam, S., Koucheryavy, Y.
Keywords: (Nano and molecular communications, bacterial nanonetworks, nanomachines, ESCHERICHIA-COLI, COMMUNICATION, NANOVALVES)
Number of pages: 10
Pages: 751-760
Publication date: Jul 2015
Peer-reviewed: Yes
This paper proposes a solution for human indoor positioning utilizing the embroidered passive Radio Frequency Identification (RFID) tag. The performance of the on-body RFID tag for indoor positioning applications is compared with the existing Wireless LAN solutions. As a proof of concept, we conducted both training and positioning phase of the fingerprinting method which relies upon the measurement of the Received Signal Strength (RSS) of the RFID tag and the WLAN access points (APs). The comparison of RFID with WLAN results shows very valuable achievements utilizing RFID technology in term of the accuracy especially for small distance error.
Digital Self-Interference Cancellation under Nonideal RF Components: Advanced Algorithms and Measured Performance

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Korpi, D., Huusari, T., Choi, Y. S., Anttila, L., Talwar, S., Valkama, M.
Number of pages: 5
Pages: 286-290
Publication date: 28 Jun 2015

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Indoor Positioning Technology Assessment using Analytic Hierarchy Process for Pedestrian Navigation Services
Indoor positioning is one of the biggest challenges of many location-based applications and services. Providing users with accurate, reliable, cheap or free-to-use, low power consuming to calculate and continuously available positional data becomes even more challenging when pedestrians are the target users. People spend most of their time in roofed areas, such as houses, offices, airports, shopping centres and in general indoors. There are some positioning technologies that can be applied as stand-alone indoor positioning technologies. They include WLAN, BLE, UWB, RFID passive and active, tactile floor and high sensitivity GNSS. This paper evaluate the practicality and fitness-to-the-purpose of pedestrian navigation of each of these stand-alone positioning technology to identify the best one for the purpose of indoor pedestrian navigation. In this regard, the most important criteria defining a suitable positioning service for pedestrian navigation are identified and prioritised. They include accuracy, availability, cost, power consumption and privacy. Then, each technology is evaluated according to each criterion using Analytic Hierarchy Process (AHP) and finally the combination of all weighted criteria and technologies are being processed to identify the most suitable solution.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), The University of Nottingham, Nottingham Geospatial Institute
Authors: Basiri, A., Peltola, P., Figueiredo e Silva, P., Lohan, E. S., Moore, T., Hill, C.
Publication date: 23 Jun 2015

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Electronic versions:
Indoor Positioning Technology Assessment using Analytic Hierarchy Process for Pedestrian Navigation Services
DOIs: 10.1109/ICL-GNSS.2015.7217157

Bibliographical note
Versio ja lupa kunnossa 12.1.2016 /KK
Research output: Scientific - peer-review → Conference contribution
Received Signal Strength models for WLAN and BLE-based indoor positioning in multi-floor buildings

This paper investigates the similarities and differences of the signal strength fluctuations and positioning accuracy in indoor scenarios for three types of wireless area networks: two Wireless Local Area Networks (WLANs) at 2.4 GHz and 5 GHz frequency, respectively, and one Wireless Personal Area Network (WPAN), namely the Bluetooth Low Energy (BLE). Two path-loss models based on weighted centroids and non-negative least squares estimation are presented: one including a floor loss factor, and the other one ignoring the floor losses, and the three signal types are compared in terms of the path-loss parameters, channel fluctuations and positioning accuracy, namely the distance errors and floor detection probabilities. The comparison is done based on real-field measurement data collected from a university building in Tampere, Finland. It is shown that all these three signal types have similar shadowing variances and close path-loss parameter values, and that a path-loss model considering floor losses gives the best floor detection probability, but not necessarily the smallest distance error.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Lohan, E., Talvitie, J., Figueiredo e Silva, P., Nurminen, H., Ali-Löytty, S., Piche, R.
Number of pages: 6
Publication date: 23 Jun 2015

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Links:
http://urn.fi/URN:NBN:fi:tty-201603013609

Bibliographical note
ORG=elt,0.7
ORG=ase,0.2
ORG=mat,0.1
Research output: Scientific - peer-review + Conference contribution

Receiver Architecture for Cognitive Positioning with CDMA and OFDM signals

This paper proposes a cognitive positioning architecture to determine which signals are present in the surrounding spectrum of a receiver. These signals are used by the cognitive positioning engine to acquire time of arrival measurements. The spectrum content is determined by a cyclostationary method and this information is used by the cognitive positioning engine to retrieve information from the adequate loops. This architecture provides a fast mechanism to infer the contents of the spectrum and improve the efficiency of the resources by allowing the cognitive positioning engine to control the acquisition and tracking loops. The performance of the spectrum sensing and positioning blocks is evaluated by considering the presence of CDMA and OFDM signals. First, the spectrum sensing block is evaluated using different input scenarios, such as presence of both, one or only noise. Cyclostationary features are used to classify the spectral contents and derive a probability of detection for each scenario. Second, the performance level of the cognitive positioning engine is discussed by considering an hypothetical scenario where several CDMA and OFDM emitters are used for determining the position of an user through a maximum likelihood approximation method.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Universitat Autonoma de Barcelona, Spain
Authors: Figueiredo e Silva, P. M., Granados, G. S., Lohan, E.
Number of pages: 6
Publication date: 23 Jun 2015

Host publication information
Systematic search for design contradictions in systems' architecture: Toward a computer aided analysis

Time pressure imposed to the engineering design process is one fundamental constraint pushing engineers to rush into known solutions, to avoid analysing properly the environment of a design problem, to avoid modelling design problems and to take decision based on isolated evidences. Early phases in particular have to be kept short despite the large impact of decisions taken at this stage. Significant efforts are currently spent within different engineering communities to develop a model-based design approach adapted to conceptual stages. Developing such type of models is also challenging due to the fuzziness of the information and due to the complexity of the concepts and processes manipulated at this stage. Currently few support tools are really capable of really supporting an analysis of the early design concepts and architectures. Simultaneously the approach should be fast, easy to use and should provide a real added-value to efficiently support the decision and the design process. The present article is presenting a framework based on a progressive transformation of the design concepts. The final material generated by this transformation process is an oriented graph with different types of classified variables. This graph can be processed as described in the article to automatically exhibit the conflicts or contradictions present in the design concept architecture. The article is proposing two main contributions which are a real move toward model development at conceptual stage and the possibility to process those models to detect solution weaknesses. The discussion is presenting further developments and possibilities associated with this method.
Feasibility study of the THz band for communications between wearable electronics

Emerging wearable nano sensor networks enable a set of valuable applications in biomedical and environmental fields. At the same time, the current state of communication technologies significantly limits the processing capabilities of prospective nanomachines. Consequently, implying that all the analysis of collected data needs to be performed on a macro device. Therefore, to effectively enable long-awaited applications of nanonetworks their seamless integration into existing networking infrastructure is required, leading to the concept of Internet of Nano Things. In this paper, the interoperability between already deployed macro networks and emerging nano networks is preliminary investigated. The solution for this problem is nontrivial, as the existing macro wireless networks use primarily the carrier-based electromagnetic communications, while nanomachines must rely on ultra-low-power pulse-based EM radiation or inherently mobile objects as information carriers. Thus, the direct interaction between macro and nano networks is currently not feasible, forcing using special gateway nodes. Moreover, the modern solutions for nano communications have to be rapidly improved to enable construction of large-scale networks on top of existing link level techniques. Numerous theoretical questions are to be addressed to achieve this goal, ranging from the design of a proper modulation and coding technique to mitigation of noise and interference effects.
Performance comparison of selected wired and wireless networks on chip architectures

In this paper we compare performance intra-core communications in network on chips. We consider two alternative architectures, wired and wireless. The wired on is based on a common bus (ring) with all the cores attached to it. We compare it to the mesh (point-to-point) architecture based on THz wireless links operating in 0.1-0.54 frequency band.

Using reference latencies of inter-core communications in modern CPUs we perform an applicability assessment of considered schemes. As performance metrics of interest we consider both delay and capacity. Our results indicate that the latter architecture outperforms the former by a significant margin. The proposed system can be realized implementing directional antennas at all cores and ensuring that cores are placed on a chip such that there is no interference between them.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Tampere University of Technology, Department of Electronics and Communications Engineering, P.G. Demidov Yaroslavl State University
Authors: Komar, M.
Number of pages: 7
Pages: 68-74
Publication date: 3 Jun 2015

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Title of host publication: 2015 17TH Conference of Open Innovations Association (FRUCT)
ASJC Scopus subject areas: Computer Science(all), Electrical and Electronic Engineering

A molecular noise model for THz channels

The recent interest in the use of THz band, 0:1-10THz, for communications purposes stimulates development of new models for performance assessment of prospective technologies. One of the unique properties of this band is molecular noise generated by water vapor in response to absorption of electromagnetic radiation. In this paper we specify a model capturing the behavior of the molecular noise in the frequency domain and propose the associated parameters fitting algorithm. The model has a simple structure and can be used as a building block for bit error rate (BER) performance assessment.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Boronin, P., Moltchanov, D., Koucheryavy, Y.
Keywords: (electromagnetic wave absorption, error statistics, frequency-domain analysis, noise measurement, terahertz waves, BER performance assessment, THz band, bit error rate performance assessment, electromagnetic radiation absorption, frequency 0.1 THz to 10 THz, frequency domain, molecular noise model, parameters fitting algorithm, water vapor, Absorption, Bit error rate, Mathematical model, Millimeter wave communication, Modulation, Noise, Probability density function)
Number of pages: 6
Pages: 1286-1291
Publication date: 1 Jun 2015

Host publication information
Distributed power allocation over indoor multi-pico stations

A low-complexity distributed power allocation algorithm is proposed to reduce the interference and improve the transmitting rate of edge users. Different scenarios are considered and user experience of indoor communication is promoted. The simulation results prove the effectiveness of our algorithm. The proposed power control scheme ensures that more users can achieve their required rate and the fairness of different users is improved. Besides, more than 50% energy can be saved without loss in outage ability, and energy efficiency is also promoted. In addition, the proposed algorithm can be extended to scenarios that the required rates of pico stations can be changed periodically.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, School of Information and Electronics, Beijing Institute of Technology
Authors: Fei, Z. S., Gao, Q., Fu, Y., Isotalo, T., Niemelä, J.
Keywords: (Distributed power allocation, Indoor communication, Multi-pico stations)
Number of pages: 6
Pages: 227-232
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Peer-reviewed: Yes
ASJC Scopus subject areas: Engineering(all)

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Volume: 24
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ISSN (Print): 1004-0579
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Scopus rating (2016): 0.137 0.121
Publication Forum (2016): 0
Scopus rating (2015): 0.154 0.165
Publication Forum (2015): 0
Scopus rating (2014): 0.127 0.259
Scopus rating (2013): 0.163 0.23
Scopus rating (2012): 0.173 0.38
Scopus rating (2011): 0.149 0.273
Scopus rating (2010): 0.116 0.218
Scopus rating (2009): 0.144 0.239
Scopus rating (2008): 0.114 0.117
Scopus rating (2007): 0.207 0.206
Scopus rating (2006): 0.128 0.234
Scopus rating (2005): 0.128 0.262
Scopus rating (2004): 0.33 0.183
Scopus rating (2003): 0.284 0.286
Scopus rating (2002): 0.188 0.026
Scopus rating (2001): 0.16 0.0
Scopus rating (2000): 0.207
Scopus rating (1999): 0.109
Original language: English
DOIs:
10.15918/j.bit1004-0579.201524.0214
Efficient Wireless Microphone sensing: Subband energy detector principle and measured performance

Spectrum scarcity has become a critical concern in wireless communication systems due to the limited availability of frequency spectrum. Hence, cognitive radio (CR) has been introduced as a solution for more effective use of the spectrum resources. Spectrum sensing (SS) is one of the key elements in the implementation of effective and reliable CR systems. Energy detection (ED) based SS is the most common sensing algorithm due to its low complexity. The main drawback of ED based SS is that it is highly dependent on the precise knowledge of the receiver noise variance. Hence, the performance of the ED algorithm is degraded significantly, when there is noise uncertainty in the estimation of the noise variance. In this study, we apply a recently proposed enhanced ED based algorithm to the sensing of Wireless Microphone (WM) signals, demonstrating robustness to noise uncertainty in real-time testing with actual WM signals. This so-called Max-Min ED algorithm is based on subband division of a wideband signal using an analysis filter bank (AFB) and utilizing the difference of maximum and minimum subband energies as the test statistic. Following the introduction of analytical models and scenarios of ED based SS algorithms, the sensing algorithms are implemented and tested using National Instruments (NI) Universal Software Radio Peripheral (USRP) and the NI-LabVIEW software platform, together with the necessary toolboxes.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Dikmese, S., Zheng, Z., Sofotasios, P. C., Renfors, M., Valkama, M.
Keywords: (channel bank filters, cognitive radio, microphones, minimax techniques, radio receivers, radio spectrum management, signal detection, telecommunication network reliability, AFB, CR system reliability, analysis filter bank, efficient wireless microphone sensing performance measurement, energy detection, frequency spectrum scarcity, maxmin ED algorithm, receiver noise variance estimation, spectrum sensing, subband energy detector principle, wideband signal subband division, wireless communication system, Channel models, Mathematical model, Sensors, Signal to noise ratio, Uncertainty, Wireless communication, Cognitive radio, GNU radio, LabView, USRP, noise uncertainty, wireless microphone)
Number of pages: 6
Pages: 7480-7485
Publication date: 1 Jun 2015

Host publication information
Title of host publication: 2015 IEEE International Conference on Communications (ICC)
Publisher: IEEE
ISBN (Print): 978-1-4673-6432-4
DOIs: 10.1109/ICC.2015.7249522

Bibliographical note
AUX=elt, "Zheng, Zhenyu"
Source: Bibtex
Source-ID: urn:3110ca71ca4ca77eaa6181492b7baf3d3
Research output: Scientific › peer-review › Conference contribution

Frequency response mismatch analysis in time-interleaved analog I/Q processing and ADCs

This brief examines a novel method to increase the usable analog bandwidth (BW) of an analog-to-digital interface through the use of in-phase/quadrature (I/Q) downconversion or homodyne architecture, followed by time-interleaved analog-to-digital converters (TI-ADCs) in both I and Q branches. The increased analog BW comes with the inherent drawback of various spurious components, due to analog components’ frequency response mismatches, which ultimately limit the dynamic range. In this brief, the impacts of different mismatch sources are modeled and analyzed. Actual measured hardware data of the considered time-interleaved homodyne architecture are also presented, verifying the modeling and analysis results. The analysis and modeling results of this brief thus provide new insight into the joint impact of different mismatch mechanisms and pave the way for future contributions on the correction of these mismatches, building on the derived composite behavioral model of the overall time-interleaved I/Q processing.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Airbus Defence and Space
On feasibility of coding-based 3GPP LTE coverage enhancements for MTC

As machine-type communications (MTC) penetrate deeper into our everyday life, alternative access models are considered for them. In particular, instead of a traditional multi-hop mesh topology (a.k.a. capillary network), recent works have suggested the use of a cellular network to cover massive numbers of MTC devices with a one-hop deployment (specifically, 3GPP LTE). This significantly reduces the need for relays at the cost of bitrate. On the other hand, reaching certain locations such as basements may be difficult in a single hop, and thus coverage enhancement features have been proposed for LTE. In this work, we evaluate the feasibility and applicability of the proposed coverage enhancements relying on the application of coding gain in the uplink channels. We perform radio network planning for representative neighborhoods with massive deployments of smart meters, and compute the key performance indicators. We conclude with discussion on applicability of the coverage enhancements in various conditions.
5G Multi-RAT LTE-WiFi Ultra-Dense Small Cells: Performance Dynamics, Architecture, and Trends

The ongoing densification of small cells yields an unprecedented paradigm shift in user experience and network design. The most notable change comes from cellular rates being comparable to next-generation WiFi systems. Cellular-to-WiFi off-loading, the standard modus operandi of recent years, is therefore shifting towards a true integration of both technology families. Users in future 5G systems will thus likely be able to use 3GPP, IEEE, and other technologies simultaneously, so as to maximize their quality of experience. To advance this high-level vision, we perform a novel performance analysis specifically taking the system-level dynamics into account and thus giving a true account on the uplink performance gains of an integrated multi radio access technology (RAT) solution versus legacy approaches. Further, we advocate for an enabling architecture that embodies the tight interaction between the different RATs, as we lay out a standardization roadmap able to materialize the envisaged design. 3GPP-compliant simulations have also been carried out to corroborate the rigorous mathematical analysis and the superiority of the proposed approach.

General information

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Ministry of Education publication type: A1 Journal article-refereed
Authors: Galinina, O., Pyattaev, A., Andreev, S., Dohler, M., Koucheryavy, Y.
Keywords: (Network densification, cellular offloading, 5G architecture, integrated LTE-WiFi small cells, system-level dynamics, performance analysis, HETEROGENEOUS CELLULAR NETWORKS, WIRELESS COMMUNICATIONS, HETNETS, TIER, ASSOCIATION, EVOLUTION, DESIGN)
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ISSN (Print): 0733-8716
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Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.098
Web of Science (2014): 3.453 3.822 7.9 0.524 0.03251 2.192
Publication Forum (2014): 3
Scopus rating (2013): 2.843 4.106
Publication Forum (2013): 3
Scopus rating (2012): 2.747 3.9
Are all the Access Points necessary in WLAN-based indoor positioning?
Wireless Local Area Networks are widely used for indoor localization purposes based on Received Signal Strength-based positioning algorithms, due to the increasing demands for Location-based Services indoors. A huge number of hearable Access Points can however increase the complexity of the positioning system and the difficulty of location estimation, since not all of the available Access Points carry useful or significant information. This paper focuses on Wireless Local Area Networks-based indoor location by taking into account the contribution of each hearable Access Point in the location estimation. Several criteria for Access Point selection are examined, and we will show what is the permissible reduction factor without a large deterioration in positioning performance and which criterion is optimal for use in Access Point removal. The fingerprinting estimation method and the deconvolution based path loss positioning approach are both addressed, and the results are based on a large measurement campaign covering five different buildings with several floors each, in two countries.

General information
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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Laitinen, E., Lohan, E.
Number of pages: 6
Publication date: Jun 2015

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Links:
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Research output: Scientific - peer-review » Conference contribution

Applicability of Frequency Selective Surfaces to Enhance Mobile Network Coverage in Future Energy-Efficient Built Environments
Modern houses and constructions use energy efficient building materials, like metal shielding and energy saving windows, to improve the thermal insulation and efficiency. However, such energy efficient building materials not only block the thermal radiation but also substantially increase the building penetration losses of the radio signals, forming thus a challenging problem in mobile cellular networks where majority of network elements are still located outdoors while more and more of the mobile data use takes place indoors. In this article, the use of frequency selective surface (FSS) is studied as one potential means to reduce the penetration loss while still maintaining high thermal insulation of the buildings. FSS structures build on a combination of either conducting patches or apertures in a thin conducting sheet arranged periodically in one or two dimensional array, and can be etched on the metal coating of energy saving windows that behave as electromagnetic filter. Thus, such energy saving windows incorporating FSS structures can potentially allow transmission of radio signals while still essentially retaining its major thermal insulation properties. The aim of this paper is to investigate the applicability of such FSS structures in realworld scenarios with actual field measurements in real mobile networks. First, a double square-loop FSS structure which is transparent to GSM 900MHz and UMTS/HSPA 2100MHz frequency bands is developed and analyzed. The developed FSS structure is then fabricated using aluminum foil and tested and measured in both laboratory conditions as well as in real mobile networks and real buildings. In the mobile network measurements, the developed FSS prototype shows substantial improvements of the indoor signal strengths, in the order of 8-13 dB for GSM 900MHz band and 2-5 dB for UMTS/HSPA 2100MHz frequency band, compared to the uniform metal coating. This indicates that FSS structures can provide useful and feasible means to enhance -he indoor signal levels in future energy efficient built environments, and thus substantially enhance the indoor coverage and capacity of wireless networks.

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Asp, A., Baniya, A., Yunas, S., Niemelä, J., Valkama, M.
Number of pages: 8
Pages: 1-8
Publication date: 22 May 2015

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Title of host publication: Proceedings of 21th European Wireless Conference : European Wireless 2015
Publisher: VDE Verlag GmbH
ISBN (Print): 978-3-8007-3976-9
Research output: Scientific - peer-review › Conference contribution

Technologies for Ambient Assisted Living: Ambient Communication and Indoor Positioning
In all industrialised countries, the population is aging rapidly as the average life expectancy continues to rise and the number of younger age groups grows smaller. Hence, due to economical and practical reasons, the elders of the near future will likely live longer in their own apartments, particularly because institutionalization is significantly expensive and there is not room for the entire elderly population in currently existing nursing homes. Even more important, nearly all people would choose to live independently as long as possible before moving into an assisted-living facility.

A longer period of independent living for elders can be enabled by technical solutions. In this work, two technology areas for assisted living are studied. First, the prevention of feelings of loneliness in elders living alone is studied, and a solution for social inclusion and remote presence is presented. The results of long-lasting field trials are presented and analysed. Secondly, as information regarding the location of the inhabitant in the apartment can be used to provide several assistive services, indoor positioning systems are also studied in this work. Several technologies for indoor positioning are presented and compared. Furthermore, a new system based on capacitive measurement and the results of testing of the system are introduced.

Technologies and systems developed here have been implemented into actual systems, and real end users have tested them over long periods of time. Thus, these technologies can be developed into commercial products with reasonable effort. Moreover, in this work it has been proven that the systems developed can actually be used to support the independent living of elders.

General information
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Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Electronics and Communications Engineering
Authors: Kivimäki, T.
Number of pages: 54
Publication date: 22 May 2015

Publication information
Publisher: Tampere University of Technology
Recent advances in antenna design and interference cancellation algorithms for in-band full duplex relays

In-band full-duplex relays transmit and receive simultaneously at the same center frequency, hence offering enhanced spectral efficiency for relay deployment. In order to deploy such full-duplex relays, it is necessary to efficiently mitigate the inherent self-interference stemming from the strong transmit signal coupling to the sensitive receive chain. In this article, we present novel state-of-the-art antenna solutions as well as digital self-interference cancellation algorithms for compact MIMO fullduplex relays, specifically targeted for reduced-cost deployments in local area networks. The presented antenna design builds on resonant wavetraps and is shown to provide passive isolations on the order of 60-70 dB. We also discuss and present advanced digital cancellation solutions, beyond classical linear processing, specifically tailored against nonlinear distortion of the power amplifier when operating close to saturation. Measured results from a complete demonstrator system, integrating antennas, RF cancellation, and nonlinear digital cancellation, are also presented, evidencing close to 100 dB of overall self-interference suppression. The reported results indicate that building and deploying compact full-duplex MIMO relays is already technologically feasible.
In this paper, novel blind identification and compensation architectures for the frequency response mismatch of a two-channel time-interleaved analog-to-digital-converter (TI-ADC) are proposed. First, detailed modeling of the frequency response mismatch is carried out, establishing a direct connection and similarity to the well-known in-phase/quadrature mismatch problem. Stemming from this modeling, the proposed blind mismatch identification and compensation architectures are then developed building on complex statistical signal processing. Compared to the existing methods in the literature, the proposed solutions can identify and correct the frequency response mismatch in a fully blind manner for the full digital bandwidth (BW) of the ADC system, and are also applicable in sub-sampling TI-ADC devices and RF sampling. The efficiency of the proposed solutions is verified and demonstrated using comprehensive measurements of actual RF-sampling TI-ADC hardware with gigahertz-scale instantaneous BW.
Achievable rate regions and self-interference channel estimation in hybrid full-duplex/half-duplex radio links

This article investigates the achievable rates of a bidirectional full-duplex radio link between a base station and a mobile user in a cellular network. In particular, we analyze the relationship between accurate self-interference channel estimation, which is required for effective digital interference cancellation, and spectral-efficient simultaneous two-way data transmission and reception, which is the objective for developing the full-duplex technology in the first place. Channel estimation and data transmission are inherently coupled due to a trade-off arising from the facts that the former benefits
from half-duplex slots during which there is no distortion from the data signal of interest while the latter needs full-duplex slots for approaching the anticipated ideal-case doubled spectral efficiency in comparison to plain half-duplex operation. The analysis is conducted by deriving expressions for the achievable data rates and calculating the corresponding rate regions with the help of realistic waveform simulations for incorporating transceiver hardware impairments, which render residual self-interference despite effective cancellation. The findings indicate that increased flexibility in the form of half-duplex communication periods of adjustable lengths results in an increased overall throughput. Thereby, hybrid half/full-duplex operation is not only useful for improving the performance of digital self-interference cancellation but also for supporting varying unbalanced downlink-uplink traffic ratios.

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Columbia University in the City of New York
Authors: Korpi, D., Riihonen, T., Valkama, M.
Publication date: 15 Apr 2015

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Source: Scopus
Source-ID: 84929192013
Research output: Scientific - peer-review » Conference contribution

Spectrum Sensing under RF Non-Linearities: Performance Analysis and DSP-Enhanced Receivers
Intermodulation products arise as a result of low noise amplifier (LNA) and mixer non-linearities in wideband receivers. In the presence of strong blockers, the intermodulation distortion can deteriorate the spectrum sensing performance by causing false alarms and degrading the detection probability. We theoretically analyze the impact of third-order non-linearities on the detection and false alarm probabilities for both energy detectors and cyclostationary detectors under front-end LNA non-linearities. We show that degradation of the detection performance due to non-linearities of both energy and cyclostationary detection is strongly dependent on the modulation type of the blockers. We then propose two DSP-enhanced receiver architectures to compensate the impact of non-linearities. The first approach is a post-processing technique which compensates for non-linearities effect on the test statistic by adapting the sensing time and detection threshold. The second approach is a pre-processing method that compensates by correcting received samples prior to computing the test statistic. This approach is based on adaptively estimating the intermodulation distortion, weighting it by a scalar constant and subtracting it from the subband of interest. We propose a method to adaptively compute the optimal weighting coefficient and show that it depends on the power and modulation of the blockers. Our results show that the pre-processing sample-based compensation method is more effective and that clear dynamic range extension can be obtained by using intermodulation compensation without resorting to increasing the sensing time. We also study the impact of uncertainties about the knowledge or estimates for nonlinearity parameters.

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), University of California, Los Angeles (UCLA), Qualcomm Research, Maxlinear
Authors: Rebeiz, E., Hagh Ghadam, A. S., Valkama, M., Cabric, D.
Keywords: (Cognitive radios, cyclostationary detection, energy detection, intermodulation, nonlinear distortion, nonlinearity compensation, sensing receiver, wideband sensing)
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ASJC Scopus subject areas: Electrical and Electronic Engineering, Signal Processing

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Measuring angular information by inertial unit arranged to wheel

General information
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Ministry of Education publication type: H1 Granted patent
Organisations: Department of Pervasive Computing, Research area: Computer engineering
Authors: Collin, J.
Publication date: 4 Apr 2015

Publication information
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Patent number: FI125167
Priority date: 3/10/13
Original language: English
Research output: Scientific › Patent

Bit error rate of underlay decode-and-forward cognitive networks with best relay selection
This paper provides an analytic performance evaluation of the bit error rate (BER) of underlay decode-and-forward
cognitive networks with best relay selection over Rayleigh multipath fading channels. A generalized BER expression valid
for arbitrary operational parameters is firstly presented in the form of a single integral, which is then employed for
determining the diversity order and coding gain for different best relay selection scenarios. Furthermore, a novel and
highly accurate closed-form approximate BER expression is derived for the specific case where relays are located
relatively close to each other. The presented results are rather convenient to handle both analytically and numerically,
while they are shown to be in good agreement with results from respective computer simulations. In addition, it is shown that as in the case of conventional relaying networks, the behaviour of underlay relaying cognitive networks with best relay selection depends significantly on the number of involved relays.

**General information**

State: Published

Ministry of Education publication type: A1 Journal article-refereed

Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Aristotle University of Thessaloniki, Department of Informatics, Department of Telecommunications Engineering, HoChiMinh City University of Technology, Athens Information Technology-AIT, University of Leeds

Authors: Ho-Van, K., Sofotasios, P. C., Alexandropoulos, G. C., Freear, S.

Keywords: (Bit error rate (BER), Cognitive radios, Cooperative relaying, Rayleigh fading, Relay selection, Underlay communication)

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Peer-reviewed: Yes

ASJC Scopus subject areas: Computer Networks and Communications, Information Systems

**Publication information**

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Ratings:

- Scopus rating (2017): 1
- Scopus rating (2016): 0.452 1.233
- Scopus rating (2015): 0.406 1.051
- Web of Science (2015): 0.92 0.983 3.7 0.029 0.00271 0.508
- Scopus rating (2014): 0.318 0.853
- Web of Science (2014): 1.007 0.779 3.5 0.071 0.00191 0.349
- Scopus rating (2013): 0.264 0.405
- Scopus rating (2012): 0.295 0.473
- Scopus rating (2011): 0.232 0.332
- Scopus rating (2010): 0.167 0.376
- Scopus rating (2009): 0.214 0.289
- Scopus rating (2008): 0.21 0.307
- Scopus rating (2007): 0.29 0.464
- Scopus rating (2006): 0.523 0.679
- Scopus rating (2005): 0.54 0.856
- Scopus rating (2004): 0.642 0.801
- Scopus rating (2003): 0.796 1.584
- Scopus rating (2002): 1.169 0.995
- Scopus rating (2001): 0.999 0.905
- Scopus rating (2000): 0.311 0.332

Original language: English

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Source-ID: 84929406652

Research output: Scientific - peer-review › Article

This paper builds on a recent method, chain routing with even energy consumption (CREEC), for designing a wireless sensor network with chain topology and for scheduling the communication to ensure even average energy consumption in the network. In here a new suboptimal design is proposed and compared with the CREEC design. The chain topology in CREEC is reconfigured after each group of n converge-casts with the goal of making the energy consumption along the new paths between the nodes in the chain as even as possible. The new method described in this paper designs a single near-optimal Hamiltonian circuit, used to obtain multiple chains having only the terminal nodes different at different converge-casts. The advantage of the new scheme is that for the whole life of the network most of the communication takes place between same pairs of nodes, therefore keeping topology reconfigurations at a minimum. The optimal scheduling of the communication between the network and base station in order to maximize network lifetime, given the chosen minimum length circuit, becomes a simple linear programming problem which needs to be solved only once, at the initialization stage. The maximum lifetime obtained when using any combination of chains is shown to be upper bounded by the solution of a suitable linear programming problem. The upper bounds show that the proposed method provides near-optimal solutions for several wireless sensor network parameter sets.

General information
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Authors: Tabus, V., Moltchanov, D., Koucheryavy, Y., Tabus, I., Astola, J.
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Publication Forum (2017): 1
Scopus rating (2016): 0.452 1.233
Publication Forum (2016): 1
Scopus rating (2015): 0.406 1.051
Web of Science (2015): 0.92 0.983 3.7 0.029 0.00271 0.508
Publication Forum (2015): 1
Scopus rating (2014): 0.318 0.853
Web of Science (2014): 1.007 0.779 3.5 0.071 0.00191 0.349
Publication Forum (2014): 1
Scopus rating (2013): 0.264 0.405
Publication Forum (2013): 1
Scopus rating (2012): 0.295 0.473
Publication Forum (2012): 1
Scopus rating (2011): 0.232 0.322
Scopus rating (2010): 0.167 0.376
Scopus rating (2009): 0.214 0.289
Scopus rating (2008): 0.21 0.307
Scopus rating (2007): 0.29 0.464
Scopus rating (2006): 0.523 0.679
Scopus rating (2005): 0.54 0.856
Scopus rating (2004): 0.642 0.801
Scopus rating (2003): 0.796 1.584
Scopus rating (2002): 1.169 0.995
Scopus rating (2001): 0.999 0.905
Context-awareness and the smart grid: Requirements and challenges

New intelligent power grids (smart grids) will be an essential way of improving efficiency in power supply and power consumption, facilitating the use of distributed and renewable resources on the supply side and providing consumers with a range of tailored services on the consumption side. The delivery of efficiencies and advanced services in a smart grid will require both a comprehensive overlay communications network and flexible software platforms that can process data from a variety of sources, especially electronic sensor networks. Parallel developments in autonomic systems, pervasive computing and context-awareness (relating in particular to data fusion, context modelling, and semantic data) could provide key elements in the development of scalable smart grid data management systems and applications that utilise a multi-technology communications network. This paper describes: (1) the communications and data management requirements of the emerging smart grid, (2) state-of-the-art techniques and systems for context-awareness and (3) a future direction towards devising a context-aware middleware platform for the smart grid, as well as associated requirements and challenges.
The internet of Bio-Nano things

The Internet of Things (IoT) has become an important research topic in the last decade, where things refer to interconnected machines and objects with embedded computing capabilities employed to extend the Internet to many application domains. While research and development continue for general IoT devices, there are many application domains where very tiny, concealable, and non-intrusive Things are needed. The properties of recently studied nanomaterials, such as graphene, have inspired the concept of Internet of NanoThings (IoNT), based on the interconnection of nanoscale devices. Despite being an enabler for many applications, the artificial nature of IoNT devices can be detrimental where the deployment of NanoThings could result in unwanted effects on health or pollution. The novel paradigm of the Internet of Bio-Nano Things (IoBNT) is introduced in this paper by stemming from synthetic biology and nanotechnology tools that allow the engineering of biological embedded computing devices. Based on biological cells, and their functionalities in the biochemical domain, Bio-NanoThings promise to enable applications such as intra-body sensing and actuation networks, and environmental control of toxic agents and pollution. The IoBNT stands as a paradigm-shifting concept for communication and network engineering, where novel challenges are faced to develop efficient and safe techniques for the exchange of information, interaction, and networking within the biochemical domain, while enabling an interface to the electrical domain of the Internet.

General information

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Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno, Wireless Communications and Positioning (WICO), University of Nebraska, Georgia Institute of Technology
Authors: Akyildiz, I. F., Pierobon, M., Balasubramaniam, S., Koucheryavy, Y.
Number of pages: 9
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Peer-reviewed: Yes
ASJC Scopus subject areas: Electrical and Electronic Engineering, Computer Science Applications, Computer Networks and Communications

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Publication Forum (2016): 2
Web of Science (2015): 5.125 5.194 4.9 0.729 0.04043 2.538
Publication Forum (2015): 2
Scopus rating (2014): 2.678 4.808
Web of Science (2014): 4.007 4.756 5.3 0.901 0.0384 2.428
Publication Forum (2014): 3
LTE indoor MIMO performances field measurements

Long-term evolution (LTE) and multiple input multiple output (MIMO) have earned reputations to be a cutting-edge technology, which can boost significantly wireless communication performances. The paper aims at providing LTE MIMO performances in indoor environments and, therefore, guidelines for network operators can be proposed. Medium access control throughput (MAC TP) and some system parameters in LTE network that are linked with MAC TP, such as Channel Quality Indicator (CQI), Modulation and Coding Scheme (MCS), Ranking Indicator (RI), Pre-coding Matrix Indicator (PMI), as well as MIMO utilization, are analysed. Effects of indoor propagation, Line of Sight (LoS), No-line of Sight (NLoS), strong and weak signal levels on Signal to Noise Ratio (SNR) strength and MIMO utilization are clarified. In this paper, the performances of MIMO transmission mode over transmit diversity (TxDiv, Multiple Input-Single Output-MISO) and single antenna (Single Input Multiple Output-SIMO) modes are also analyzed and compared at overall manner and at channel-specific manners.

General information

State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Tampere University of Technology, Department of Electronics and Communications Engineering, Department of Electronics and Communication Engineering, Electrical and Electronics Engineering Department, Department of Electric-Electronics Engineering, Ho Chi Minh City University of Technology, Industrial University of Ho Chi Minh City, Ho Chi Minh City University of Food Industry
Authors: Nguyen-Thanh, D., Le-Tien, T., Bui-Thu, C., Le-Thanh, T.
Keywords: (Field measurements, LTE, MIMO, MISO, OFDM, Rayleigh channel, Rician channel)
Number of pages: 6
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ASJC Scopus subject areas: Computer Networks and Communications, Hardware and Architecture, Software
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Bibliographical note

INT=elt,"Nguyen-Thanh, Duc"
Enhanced Spectrum Sensing Techniques for Cognitive Radio Systems

Due to the rapid growth of new wireless communication services and applications, much attention has been directed to frequency spectrum resources. Considering the limited radio spectrum, supporting the demand for higher capacity and higher data rates is a challenging task that requires innovative technologies capable of providing new ways of exploiting the available radio spectrum. Cognitive radio (CR), which is among the core prominent technologies for the next generation of wireless communication systems, has received increasing attention and is considered a promising solution to the spectral crowding problem by introducing the notion of opportunistic spectrum usage. Spectrum sensing, which enables CRs to identify spectral holes, is a critical component in CR technology. Furthermore, improving the efficiency of the radio spectrum use through spectrum sensing and dynamic spectrum access (DSA) is one of the emerging trends. In this thesis, we focus on enhanced spectrum sensing techniques that provide performance gains with reduced computational complexity for realistic waveforms considering radio frequency (RF) impairments, such as noise uncertainty and power amplifier (PA) non-linearities. The first area of study is efficient energy detection (ED) methods for spectrum sensing under non-flat spectral characteristics, which deals with relatively simple methods for improving the detection performance. In realistic communication scenarios, the spectrum of the primary user (PU) is non-flat due to non-ideal frequency responses of the devices and frequency selective channel conditions. Weighting process with fast Fourier transform (FFT) and analysis filter bank (AFB) based multi-band sensing techniques are proposed for overcoming the challenge of non-flat characteristics. Furthermore, a sliding window based spectrum sensing approach is addressed to detect a re-appearing PU that is absent in one time and present in other time. Finally, the area under the receiver operating characteristics curve (AUC) is considered as a single-parameter performance metric and is derived for all the considered scenarios. The second area of study is reduced complexity energy and eigenvalue based spectrum sensing techniques utilizing frequency selectivity. More specifically, novel spectrum sensing techniques, which have relatively low computational complexity and are capable of providing accurate and robust performance in low signal-to-noise ratio (SNR) with noise uncertainty, as well as in the presence of frequency selectivity, are proposed. Closed-form expressions are derived for the corresponding probability of false alarm and probability of detection under frequency selectivity due the primary signal spectrum and/or the transmission channel. The offered results indicate that the proposed methods provide quite significant saving in complexity, e.g., 78% reduction in the studied example case, whereas their detection performance is improved both in the low SNR and under noise uncertainty. Finally, a new combined spectrum sensing and resource allocation approach for multicarrier radio systems is proposed. The main contribution of this study is the evaluation of the CR performance when using wideband spectrum sensing methods in combination with water-filling and power interference (PI) based resource allocation algorithms in realistic CR scenarios. Different waveforms, such as cyclic prefix based orthogonal frequency division multiplexing (CP-OFDM), enhanced orthogonal frequency division multiplexing (E-OFDM) and filter bank based multicarrier (FBMC), are considered with PA nonlinearity type RF impairments to see the effects of spectral leakage on the spectrum sensing and resource allocation performance. It is shown that AFB based spectrum sensing techniques and FBMC waveforms with excellent spectral containment properties have clearly better performance compared to the traditional FFT based spectrum sensing techniques with the CP-OFDM. Overall, the investigations in this thesis provide novel spectrum sensing techniques for overcoming the challenge of noise uncertainty with reduced computational complexity. The proposed methods are evaluated under realistic signal models.
Communication challenges in high-density deployments of wearable wireless devices

Wearable wireless devices are very likely to soon move into the mainstream of our society, led by the rapidly expanding multibillion dollar health and fitness markets. Should wearable technology sales follow the same pattern as those of smartphones and tablets, these new devices (a.k.a. wearables) will see explosive growth and high adoption rates over the next five years. It also means that wearables will need to become more sophisticated, capturing what the user sees, hears, or even feels. However, with an avalanche of new wearables, we will need to find ways to supply them with low-latency high-speed data connections to enable truly demanding use cases such as augmented reality. This is particularly true for high-density wearable computing scenarios, such as public transportation, where existing wireless technology may have difficulty supporting stringent application requirements. In this article, we summarize our recent progress in this area with a comprehensive review of current and emerging connectivity solutions for high-density wearable deployments, their relative performance, and open communication challenges.
Coarse-grained model of protein interaction for bio-inspired nano-communication

Bio-inspired nano-communication enables nanoscale devices to exchange information with each other by various natural mechanisms of data transfer. One of the most perspective way in bio-inspired communications is using the protein interactions, which refer from various proteins conformation states. In this paper, we describe our new coarse-grained model for protein conformation estimation based on fast transport task solving, developed algorithm and software which implement this model are provided.

Enhanced OFDM for fragmented spectrum use in 5G systems

Most of the recent and emerging wireless systems have selected orthogonal frequency division multiplexing (OFDM) scheme as the basis for the physical layer due to its flexibility and robustness. OFDM is commonly considered also as the first candidate technology for advanced cognitive radio, dynamic spectrum use and fragmented coexistence scenarios, including the 5G system development. Nevertheless, OFDM has the problem of high-power spectral sidelobes around the active subcarriers, which limit its feasibility in fragmented spectrum use and asynchronous frequency division multiple access operation. Therefore, various sidelobe suppression techniques have been proposed in the literature to mitigate these effects. This paper investigates four different suppression techniques: time-domain windowing, cancellation carrier method, subcarrier weighting and polynomial cancellation coding, as well as their combinations. These methods are elaborated for a practical heterogeneous fragmented spectrum use scenario based on 5-MHz 3GPP Long-Term Evolution (LTE), proposing various enhancements to achieve effective suppression in narrow gaps with affordable complexity. In addition to the spectral characteristics, also, the possible side effects are evaluated in details, considering peak-to-average power ratio characteristics, error rate performance, computational complexity and resources usage.
Social behavior in bacterial nanonetworks: Challenges and opportunities

Molecular communication holds the promise to enable communication between nanomachines with a view to increasing their functionalities and opening up new possible applications. Due to some of the biological properties, bacteria have been proposed as a possible information carrier for molecular communication, and the corresponding communication networks are known as bacterial nanonetworks. The biological properties include the ability for bacteria to mobilize between locations and carry the information encoded in deoxyribonucleic acid molecules. However, similar to most organisms, bacteria have complex social properties that govern their colony. These social characteristics enable the bacteria to evolve through various fluctuating environmental conditions by utilizing cooperative and non-cooperative behaviors. This article provides an overview of the different types of cooperative and non-cooperative social behavior of bacteria. The challenges (due to non-cooperation) and the opportunities (due to cooperation) these behaviors can bring to the reliability of communication in bacterial nanonetworks are also discussed. Finally, simulation results on the impact of bacterial cooperative social behavior on the end-to-end reliability of a single-link bacterial nanonetwork are presented. The article concludes by highlighting the potential future research opportunities in this emerging field.
To tackle the 1000× mobile data challenge, the research towards the 5th generation of mobile cellular networks is currently ongoing. One clear enabler toward substantially improved network area capacities is the increasing level of network densification at different layers of the overall heterogeneous radio access system. Ultra-dense deployments, or DenseNets, seek to take network densification to a whole new level, where extreme spatial reuse is deployed. This article looks into DenseNets from the perspectives of different deployment strategies, covering the densification of the classical macro layer, extremely dense indoor femto layer, as well as outdoor distributed antenna system (DAS), which can be dynamically configured as a single microcell or multiple independent microcells. Also, the potential of a new indoor-to-outdoor service provisioning paradigm is examined. The different deployment solutions are analyzed from the network area spectral and network energy efficiency perspectives, with extreme densification levels, including both indoor and outdoor use scenarios. The obtained results indicate that dedicated indoor solutions with densely deployed femtocells are much more spectrumand energy-efficient approaches to address the enormous indoor capacity demands compared to densifying the outdoor macro layer, when the systems are pushed to their capacity limits. Furthermore, the dynamic outdoor DAS concept offers an efficient and capacity-adaptive solution to provide outdoor capacity, on demand, in urban areas.

**Spectral and energy efficiency of ultra-dense networks under different deployment strategies**

To tackle the 1000× mobile data challenge, the research towards the 5th generation of mobile cellular networks is currently ongoing. One clear enabler toward substantially improved network area capacities is the increasing level of network densification at different layers of the overall heterogeneous radio access system. Ultra-dense deployments, or DenseNets, seek to take network densification to a whole new level, where extreme spatial reuse is deployed. This article looks into DenseNets from the perspectives of different deployment strategies, covering the densification of the classical macro layer, extremely dense indoor femto layer, as well as outdoor distributed antenna system (DAS), which can be dynamically configured as a single microcell or multiple independent microcells. Also, the potential of a new indoor-to-outdoor service provisioning paradigm is examined. The different deployment solutions are analyzed from the network area spectral and network energy efficiency perspectives, with extreme densification levels, including both indoor and outdoor use scenarios. The obtained results indicate that dedicated indoor solutions with densely deployed femtocells are much more spectrumand energy-efficient approaches to address the enormous indoor capacity demands compared to densifying the outdoor macro layer, when the systems are pushed to their capacity limits. Furthermore, the dynamic outdoor DAS concept offers an efficient and capacity-adaptive solution to provide outdoor capacity, on demand, in urban areas.

**General information**

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Yunas, S., Valkama, M., Niemelä, J.
Number of pages: 11
Pages: 90-100
A Capacity Bound for mmWave-based Channel Access in Ultra-Dense Wearable Deployments

In this paper, we address mmWave (millimeter-wave) channel access protocols operating in extremely high frequency bands. We argue that the anticipated mass use of wearable wireless devices over such protocols is likely to soon produce ultra-dense personal network deployments, especially in commuter scenarios. To this end, this work primarily focuses on a specific area of interest, where wearable devices all hear each other. By introducing an adequate mmWave-based protocol abstraction model, we are interested in characterizing the system capacity bound for the entire class of possible channel access schemes. In particular, we establish a lower bound on system operation by thoroughly investigating a decentralized random-access model. Given that its asymptotic behavior is determined by a simple and elegant expression, the obtained performance estimate may serve as a useful reference for subsequent performance optimization. Therefore, our results constitute an important building block, which allows accounting for more realistic directional antenna patterns, as well as aids in future protocol design.
Acquisition of E5 Galileo signals in Matlab

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: Wireless Communications and Positioning, Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Stepanova, E., Kudryavtsev, I., Lohan, E.
Number of pages: 7
Pages: 36-42
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: Procedia Engineering
Volume: 104
ISSN (Print): 1877-7058
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.282 0.697
Publication Forum (2016): 1
Scopus rating (2015): 0.238 0.568
Scopus rating (2014): 0.275 0.679
Scopus rating (2013): 0.217 0.464
Scopus rating (2012): 0.191 0.396
Scopus rating (2011): 0.237 0.586
Scopus rating (2010): 0.219 0.434
Original language: English
DOIs:
10.1016/j.proeng.2015.04.094
Research output: Scientific - peer-review › Article

Adaptive equalization and Successive self-Interference Cancellation (SIC) methods: The European Commission 7th Framework Programme (FP7) project ICT-318362-EMPhAtiC deliverable D3.2

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Nedic, S., Josilo, S., Stanivuk, V., Narandžić, M., Renfors, M., Yli-Kaakinen, J., Kofidis, E., Beikos, A., Zakaria, R.
Number of pages: 91
Publication date: 2015

Publication information
Publisher: ICT-EMPhAtiC

This article investigates novel adaptive self-interference cancellation solutions and the total integrated cancellation performance of a mobile single-antenna inband full-duplex transceiver. First, novel self-adaptive digital self-interference cancellation algorithms are described, with an emphasis on tracking of time-varying self-interference coupling channel in a mobile device as well as on structural ability to suppress also nonlinear self-interference with highly nonlinear mobile power amplifiers. This leads to an advanced self-adaptive nonlinear digital canceller which utilizes a novel orthogonalization procedure for nonlinear basis functions, together with low-cost LMS-based parameter learning. The achievable self-interference cancellation performance is then evaluated with actual RF measurements using mobile device scale RF components, in particular a highly nonlinear PA. The measurements also incorporate a novel self-adaptive RF cancellation circuit in order to realistically assess the total integrated cancellation performance. The reported results show that highly efficient self-interference cancellation can be achieved also in a mobile device, despite a heavily nonlinear PA and limited computing and hardware resources. The proposed cancellation solutions, when integrated together, show that 100 dB of self-interference can be cancelled using a 20 MHz LTE waveform, while the SI can be attenuated by over 110 dB with a narrower bandwidth of 1.4 MHz, all measured at 2.4 GHz ISM band. Furthermore, these results are achieved using a highly nonlinear transmitter power amplifier and fully adaptive canceller structures which can track a rapidly changing coupling channel in a mobile full-duplex device.
Analysis and Design Specifications for Full-Duplex Radio Transceivers under RF Oscillator Phase-Noise with Arbitrary Spectral Shape

In this correspondence, the effects of oscillator phase-noise with arbitrary spectral characteristics on self-interference cancellation capability of a full-duplex radio transceiver are addressed, and design considerations for optimized PLL design in full-duplex radio are given. The paper first presents a full-duplex transceiver model that inherently mitigates most of the phase-noise effects from the self-interference signal. The remaining effect of the phase noise is then analysed and closed-form expressions for the self-interference power are derived. In the simulations part, a practical phase-locked loop type oscillator is used, which is based on the arbitrary mask phase-noise model. Analytical derivations are verified with the simulations, and the self-interference cancellation performance is thoroughly studied with various parameters. Design considerations are finally given for oscillator design in full-duplex radio transceivers, with the help of tangible parameters of the phase-locked loop type oscillators.
Analysis of Cognitive Cooperative Networks with Best Relay Selection and Diversity Reception

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Ho-Van, K., Sofotasios, P. C., Que Son, V., Thanh Tra, L., Hong Lien, P.
Number of pages: 6
Pages: 651-656
Publication date: 2015

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Title of host publication: 2015 International Conference on Advanced Technologies for Communications (ATC)
Publisher: IEEE
ISBN (Print): 978-1-4673-8374-5
DOIs:
10.1109/TVT.2015.2480338

Analysis of Galileo E1 Receiver Performance with a Power-controlled Front-end

Power consumption is an important figure of merit for Global Navigation Satellite Systems (GNSS) receiver design. Low power consumption is essential in mass-market GNSS receivers which depend upon a battery for a power source. To achieve the reduction in the power consumption, the front-end of the receiver can be powered down for a fraction of time, but in a continuous manner so that the baseband can still keep track of the signals. This method can reduce the average power while still continuously tracking. However, its effects on the receiver performance have not been studied much in the literature. In this article, the authors analyze the receiver performance in terms of detection probability, code tracking error and bit error rate with different power switching time intervals. The analysis is performed both from the theoretical point of view and via signal simulations. Our results show that the performance of a power-controlled GNSS receiver is meaningfully degraded when power-blanking is applied. According to the obtained results, there is a loss of around 3 dB in terms of Carrier-to-Noise-density ratio (C/N0) of the received signal in both acquisition and tracking while compared with the traditional receiver without having any power reduction.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: Wireless Communications and Positioning, Department of Electronics and Communications Engineering, FGI, Magister
Authors: Zhang, J., Bhuiyan, Z., Lohan, E.
Analysis of Noise Uncertainty and Frequency Selectivity Effects in Wideband Multimode Spectrum Sensing

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Dikmese, S., Sofotasios, P. C., Renfors, M., Valkama, M., Ghogho, M.
Publication date: 2015

Host publication information
Title of host publication: Proceedings of IEEE Global Communications Conference (IEEE GLOBECOM 2015)
ISBN (Electronic): 978-1-4799-5951-8
Links:
http://globecom2015.ieee-globecom.org/
Research output: Scientific - peer-review › Conference contribution

Analytical Performance Evaluation of Cooperative and Multi-Radio Concepts in Emerging Wireless Networks

General information
State: Published
Ministry of Education publication type: G5 Doctoral dissertation (article)
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Galinina, O.
Number of pages: 124
Publication date: 2015

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Place of publication: Tampere
Publisher: Tampere University of Technology
Original language: English

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Name: Tampere University of Technology. Publication
Publisher: Tampere University of Technology
Volume: 1320
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Bibliographical note
Analytic Symbol Error Rate Evaluation of M-PSK Based Regenerative Cooperative Networks Over Generalized Fading Channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Fikadu, M. K., Sofotasios, P. C., Valkama, M., Cui, Q., Muhaidat, S., Karagiannidis, G. K.
Number of pages: 8
Pages: 704-711
Publication date: 2015

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Publisher: IEEE
ISBN (Print): 978-1-4673-7701-0
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Research output: Scientific - peer-review > Conference contribution

Analyzing Assisted Offloading of Cellular User Sessions onto D2D Links in Unlicensed Bands

For the past years, the analysts have been predicting a tremendous and continuous increase in mobile traffic, causing much of industry and academia to seek out any and all methods to increase wireless network capacity. In this paper, we investigate one such method, cellular data offloading onto direct connections between proximate user devices, which has been shown to provide significant wireless capacity gains. To do so, we formulate a new system model that couples a cellular network in licensed bands and a device-to-device (D2D) network in unlicensed bands. We propose that devices be continually associated with the cellular base station and use this connectivity to help manage their direct connections in unlicensed spectrum. In particular, we demonstrate that assisted offloading of cellular user sessions onto the D2D links improves the degree of spatial reuse and reduces the impact of interference. In this study, a session is a real-time flow of data from one user to another, which adheres to a Poisson point process (PPP). By contrast to a throughput- or capacity-centric system view, the application of PPP enables formulations where entire user sessions, rather than singular data packets, are arriving at random and leaving the system after being served. The proposed methodology is flexible enough to accommodate practical offloading scenarios, network selection algorithms, quality of service measures, and advanced wireless technologies. In this study, we are primarily interested in evaluating the data session blocking probability in dynamically loaded cellular and D2D networks, but given the importance of energy efficiency for mobile devices, we are also interested in characterizing the energy expenditure of a typical data session in these different networks. First with our advanced analytical methodology and then with our detailed system-level simulator, we evaluate the performance of network-assisted data session offloading from cellular to D2D connections under a variety of conditions. This analysis represents a useful tool in the development of practical offloading schemes and ongoing standardization efforts.

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Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Andreev, S., Galinina, O., Pyattaev, A., Johnsson, K., Koucheryavy, Y.
Number of pages: 14
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Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 33
Issue number: 1
ISSN (Print): 0733-8716
Ratings: Publication Forum (2017): 3
An Analytical Approach to SINR Estimation in Adjacent Rectangular Cells

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Begishev, V., Kovalchukov, R., Samuylov, A., Ometov, A., Moltchanov, D., Gaidamaka, Y., Andreev, S.
Number of pages: 13
Pages: 446-458
Publication date: 2015

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Title of host publication: Internet of Things, Smart Spaces, and Next Generation Networks and Systems: 15th International Conference, NEW2AN 2015, and 8th Conference, ruSMART 2015, St. Petersburg, Russia, August 26-28, 2015, Proceedings
Publisher: Springer International Publishing
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Name: Lecture Notes in Computer Science
Volume: 9247
A Novel Transform for Secret Key Generation in Time-varying TDD Channel under Hardware Fingerprint Deviation

Channel reciprocity can be used for providing sufficient key generation in time division duplex (TDD) system. However, in practice, its application is limited by the hardware fingerprint deviation (HFD) problem. In this paper, we propose a novel real-time transform that can cope with this problem in time-varying TDD channel without any calibration period or feedback loops. More specifically, a log-domain differential (LDD) transform is developed and the resulting performance is analyzed in terms of mean square error (MSE) between receptions at Alice and Bob and effective signal to error ratio (ESER). The analysis shows that the proposed transform can eliminate the impact of HFD, yet its performance is very sensitive to channel noise and moving speed. For this purpose, an enhanced version is proposed including an efficient noise reduction technique and the impact of mobility on parameter design is also analyzed. Numerical results show that the proposed LDD advanced transform provides performance comparable to the ideal case without HFD, and thus, can be used to form a simple, practical and flexible solution for secret key generation in time-varying TDD channel.

Antennas in Body-Centric Sensor Network Devices

Application of the nonuniform filterbank for spectrum sensing in a cognitive radio: The European Commission 7th Framework Programme (FP7) project ICT-318362-EMPhAtiC deliverable D8.1
Area under ROC Curve of Energy Detection over Generalized Fading Channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Bagheri, A., Sofotasios, P. C., Tsiftsis, T. A., Shahzadi, A., Freear, S., Valkama, M.
Number of pages: 6
Pages: 1005-1010
Publication date: 2015

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Publisher: IEEE
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Research output: Scientific - peer-review › Conference contribution

A Spectrum Sensing Algorithm for Constant Modulus Primary Users Signals
In this letter, a spectrum sensing technique is proposed for constant modulus primary users signals. A new metric, namely the normalized variance, is introduced as a function of the second and fourth order moment of the received signal. Then, it is used as the testing variable for detecting the primary user signal. Theoretical analysis and simulations in the presence of noise uncertainty evaluate the performance of the proposed technique, in comparison with the conventional energy detection. The results evidence the efficiency of our method for fast and reliable primary users’ detection in cognitive radio systems.

General information
State: Published
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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Benedetto, F., Giunta, G., Renfors, M.
Keywords: (Spectrum sensing, cognitive communications, constant modulus signals, energy detector, noise uncertainty)
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Scopus rating (2016): 0.628 1.234
Publication Forum (2016): 2
Scopus rating (2015): 0.764 1.542
Web of Science (2015): 1.291 1.4 4.6 0.136 0.02439 0.647
Publication Forum (2015): 2
Scopus rating (2014): 0.807 1.402
Web of Science (2014): 1.268 1.342 5.0 0.125 0.02226 0.615
Assisted Handover Based on Device-to-Device Communications in 3GPP LTE Systems

The ever-increasing demand in mobile data traffic, fueled by the fast proliferation of bandwidth-hungry wireless applications and services, has imposed new challenges on data rate requirements in emerging 5G systems. To meet these demanding expectations, the mainstream direction for the network operators is to deploy a higher density of various cellular infrastructure. Along these lines, this paper seeks to augment future handover operation by employing the recent Device-to-Device (D2D) communications technology. The underlying rationale behind our proposal is to equip the mobile users with better-quality direct links and thus improve the resulting service perception under the typical 3GPP LTE handover procedures. The proposed D2D-assisted handover scheme is able to efficiently offer the attractive energy efficiency, data rate, and packet delivery ratio benefits. By utilizing the tools from stochastic geometry, we derive the main performance metrics of interest for our solution, such as the distribution of signal-to-noise ratio experienced by a user entering the zone of overlapping coverage and the amount of time it remains in contact with a chosen D2D partner. The gains on top of the standard LTE handover procedures for all the considered parameters are further confirmed by extensive system-level simulations in video streaming and multimedia content downloading scenarios.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Orsino, A., Gapeyenko, M., Militano, L., Moltchanov, D., Andreev, S., Koucheryavy, Y., Araniti, G.
Publication date: 2015

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Research output: Scientific - peer-review » Conference contribution

AUC study of energy detection based spectrum sensing over η-μ and α-μ fading channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Cache storage attacks
Covert channels are a fundamental concept for cryptanalytic side-channel attacks. Covert timing channels use latency to carry data, and are the foundation for timing and cache-timing attacks. Covert storage channels instead utilize existing system bits to carry data, and are not historically used for cryptanalytic side-channel attacks. This paper introduces a new storage channel made available through cache debug facilities on some embedded microprocessors. This channel is then extended to a cryptanalytic side-channel attack on AES software.

General information
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Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Pervasive Computing, Research area: Information security, Intelligent dexterity for secure networked infrastructure and applications (IDSNIA)
Authors: Brumley, B. B.
Keywords: (Cache-timing attacks, Covert channels, Side-channel attacks, Storage channels, Timing attacks)
Number of pages: 13
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Source: Scopus
Source-ID: 84930422577
Research output: Scientific - peer-review › Conference contribution

Channel Estimation and Equalization in Multi-User Uplink OFDMA and SC-FDMA Systems Under Transmitter RF Impairments
Single-carrier frequency division multiple access (SC-FDMA), a modified form of orthogonal frequency division multiple access (OFDMA), has been adopted as the uplink physical layer radio access technique for the 3GPP Long Term Evolution (LTE) and LTE-Advanced. Radio transceiver implementations for such OFDM-based systems with the direct-conversion architecture are desirable to enable small size, low-cost and low power consumption terminals. However, the associated circuit impairments stemming from the processing of analog radio frequency (RF) signals, such as in-phase and quadrature phase (I/Q) imbalance and carrier frequency offset (CFO) errors, can severely degrade the obtainable link performance. In this paper, we analyze the effects of these radio impairments in multi-user SC-FDMA uplink system, and present digital signal processing (DSP)-based methods for the joint estimation and equalization of impairments and channel distortions on the receiver side with arbitrary number of receiver antennas. For the equalization, linear equalizers such as the zero-forcing (ZF) and the minimum mean-square error (MMSE) equalizers that utilize pairs of mirror subcarriers are formulated, and the MMSE equalizer is developed to effectively handle mirror sub-band users with different power levels. Furthermore, for reduced computational complexity, the joint channel and impairments filter
responses are efficiently approximated with polynomial-based basis function models. The parameters of the basis functions are then estimated by exploiting the time multiplexed reference symbols in the LTE uplink sub-frame structure. The performance of the proposed estimation and equalization methods is assessed with extensive multi-user link simulations, with both single-antenna and dual-antenna base station receivers, and the results show that the proposed algorithms are able to significantly reduce the impact of channel distortions and radio impairments. The resulting receiver implementation with the proposed techniques enables improved uplink link performance even when the mobile terminals fulfill their emission requirements, in terms of I/Q images, without any changes in the LTE standard's frame and pilot structures.

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State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Kiayani, A. Q., Anttila, L., Zou, Y., Valkama, M.
Keywords: (Channel estimation, OFDM, I/Q imbalance, CFO, long term evolution (LTE), single-carrier frequency-division multiple access (SC-FDMA), user interference (IUI))
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Scopus rating (2016): 0.855 1.91
Publication Forum (2016): 2
Scopus rating (2015): 0.97 2.325
Web of Science (2015): 2.243 2.631 5.5 0.377 0.03526 1.092
Publication Forum (2015): 2
Scopus rating (2014): 1.063 2.567
Web of Science (2014): 1.978 2.483 5.2 0.305 0.03595 1.019
Publication Forum (2014): 3
Scopus rating (2013): 1.599 3.031
Publication Forum (2013): 3
Scopus rating (2012): 1.542 2.852
Publication Forum (2012): 3
Scopus rating (2011): 1.168 2.393
Scopus rating (2010): 0.995 1.927
Scopus rating (2009): 1.074 2.009
Scopus rating (2008): 1.193 2.294
Scopus rating (2007): 1.463 2.8
Scopus rating (2006): 1.055 2.332
Scopus rating (2005): 1.004 1.885
Scopus rating (2004): 1.238 2.185
Scopus rating (2003): 1.283 2.267
Scopus rating (2002): 2.363 2.337
Scopus rating (2001): 1.677 2.108
Scopus rating (2000): 1.739 1.631
Scopus rating (1999): 1.059 2.012
Original language: English
DOIs:
10.1109/TVT.2015.2397277
Research output: Scientific - peer-review › Article
Characterizing Fading in Wearable Communications Channels using Composite Models

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: L. Cotton, S., Ki Yoo, S., Sofotasios, P.
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE Asilomar Conference on Signals, Systems and Computers (Asilomar '15)
Publisher: IEEE
ISBN (Print): 978-1-4673-8574-9
Research output: Scientific - peer-review › Conference contribution

Coexistence of LTE and WLAN in Unlicensed Bands: Full-Duplex Spectrum Sensing

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Syrjälä, V., Valkama, M.
Number of pages: 10
Pages: 725-734
Publication date: 2015

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Title of host publication: Cognitive Radio Oriented Wireless Networks : 10th International Conference, CROWNCOM 2015, Doha, Qatar, April 21-23, 2015, Revised Selected Papers
Publisher: Springer
ISBN (Print): 978-3-319-24539-3
ISBN (Electronic): 978-3-319-24540-9
Research output: Scientific - peer-review › Conference contribution

Combined Electricity and Mobile Network Situation Awareness System for Disturbance Management

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electrical Engineering, Research area: Power engineering, Department of Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning
Authors: Krohns-Välimäki, H., Haapanen, J., Verho, P., Sää, J., Lempiäinen, J.
Publication date: 2015

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Title of host publication: 2015 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia)
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Electronic): 978-1-5090-1237-4
DOIs: 10.1109/ISGT-Asia.2015.7387099
Research output: Scientific - peer-review › Conference contribution

Bibliographical note
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ORG=elt,0.3
Research output: Scientific - peer-review › Conference contribution
Comparison of Detection Techniques for Multipath Propagation of Pseudolite Signals Used in Dense Industrial Environments

Modern industrial environments with automated production machinery often require special indoor positioning and localization techniques, due to the presence of objects and the infrastructure that may obstruct the line-of-sight propagation or interfere with the behaviour of electromagnetic waves. These challenges are difficult to overcome by the widely employed GNSS positioning system designed for use in outdoor areas. One of existing indoor positioning systems are the pseudolites, which transmit positioning signals similar to the ones used by GNSS systems. One of the sources of errors for pseudolites is the multipath propagation. Our paper compares the performances of several multipath propagation detection techniques, using Binary Offset Carrier (BOC) navigation signal and determines that errors increases sharply when the receiver uses navigation signals that have multipath propagation. The techniques that we present improve the positioning accuracy, which leads to more precise industrial processes.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Authors: Alexandru, R., Lohan, E.
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Scopus rating (2015): 0.238 0.568
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Scopus rating (2011): 0.237 0.586
Scopus rating (2010): 0.219 0.434
Original language: English
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Compressive Identification of Active OFDM Subcarriers in Presence of Timing Offset

In this paper we study the problem of identifying active subcarriers in an OFDM signal from compressive measurements sampled at sub-Nyquist rate. The problem is of importance in Cognitive Radio systems when secondary users (SUs) are looking for available spectrum opportunities to communicate over them while sensing at Nyquist rate sampling can be costly or even impractical in case of very wide bandwidth. We first study the effect of timing offset and derive the necessary and sufficient conditions for signal recovery in the oracle-assisted case when the true active sub-carriers are assumed known. Then we propose an Orthogonal Matching Pursuit (OMP)-based joint sparse recovery method for identifying active subcarriers when the timing offset is known. Finally we extend the problem to the case of unknown timing offset and develop a joint dictionary learning and sparse approximation algorithm, where in the dictionary learning phase the timing offset is estimated and in the sparse approximation phase active subcarriers are identified. The obtained results demonstrate that active subcarrier identification can be carried out reliably, by using the developed framework.

General information
State: Published
Cooperative Radio Resource Management in Heterogeneous Cloud Radio Access Networks

Responding to the unprecedented challenges imposed by the 5G communications ecosystem, emerging heterogeneous network architectures allow for improved integration between multiple radio access technologies. When combined with advanced cloud infrastructures, they bring to life a novel paradigm of heterogeneous cloud radio access network (H-CRAN). The novel H-CRAN architecture opens door to improved network-wide management, including coordinated cross-cell radio resource allocation. In this paper, emphasizing the lack of theoretical performance analysis, we specifically address the problem of cooperative radio resource management in H-CRAN by providing a comprehensive mathematical methodology for its real-time performance optimization. Our approach enables flexible balance between throughput and fairness metrics, as may be desired by the network operator, and demonstrates attractive benefits when compared against the state-of-the-art multiradio resource allocation strategies. The resulting algorithms are suitable for efficient online implementation, which principal feasibility is confirmed by our proof-of-concept prototype.
Covariance-based OFDM spectrum sensing with sub-Nyquist samples

In this paper, we propose a feature-based method for spectrum sensing of OFDM signals from sub-Nyquist samples over a single band. We exploit the structure of the covariance matrix of OFDM signals to convert an underdetermined set of covariance-based equations to an overdetermined one. The statistical properties of sample covariance matrix are analyzed and then based on that an approximate Generalized Likelihood Ratio Test (GLRT) for detection of OFDM signals from sub-Nyquist samples is derived. The method is also extended to the frequency-selective channels.
Data Rate Performance of Droplet Microfluidic Communication System

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Wirdatmadja, S., Moltchanov, D., Bolcos, P., Väliaho, J., Kreutzer, J., Kallio, P., Koucheryavy, Y.
Pages: 5:1-5:6
Publication date: 2015

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Source: Bibtex
Source-ID: urn:04611a69237f0b418864f7c31d126c53
Research output: Scientific - peer-review » Conference contribution

Delayed key exchange for constrained smart devices
In the Internet of Things some nodes, especially sensors, can be constrained and sleepy, i.e., they spend extended periods of time in an inaccessible sleep state. Therefore, the services they offer may have to be accessed through gateways. Typically this requires that the gateway is trusted to store and transmit the data. However, if the gateway cannot be trusted, the data needs to be protected end-to-end. One way of achieving end-to-end security is to perform a key exchange, and secure the subsequent messages using the derived shared secrets. However, when the constrained nodes are sleepy this key exchange may have to be done in a delayed fashion. We present a novel way of utilizing the gateway in key exchange, without the possibility of it influencing or compromising the exchanged keys. The paper investigates the applicability of existing protocols for this purpose. Furthermore, due to a possible need for protocol translations, application layer use of the exchanged keys is examined.

General information
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Organisations: Department of Pervasive Computing, Research area: Information security, Intelligent dexterity for secure networked infrastructure and applications (IDSNIA), Ericsson Research
Authors: Kannisto, J., Heikkinen, S., Slavov, K., Harju, J.
Number of pages: 15
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ASJC Scopus subject areas: Computer Science(all), Theoretical Computer Science

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Name: Lecture Notes in Computer Science
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Design and Implementation of a Power-aware FFT Core for OFDM-based DSA-enabled Cognitive Radios

This research work presents the design and the physical implementation of a power aware FFT core for OFDM-based, dynamic spectrum access (DSA) enabled cognitive radios. The FFT core is equipped with a pruning engine that allows the run-time removal of dummy operations (e.g. multiplications by a zero term) related to the pruning of sub-carriers of the communication systems. The pruning algorithm introduced by this research work utilizes a reduced size configuration matrix, which limits the memory requirements' overhead. Finally, the physical implementation of the FFT on a 45 nm technology node showed that, for a 8 % area overhead, the total power saving settles around 10 % when in the presence of a medium to high pruning level, justifying the silicon area overhead introduced by the pruning unit.

General information
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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Wireless Communications and Positioning (WICO), Simon Fraser University, Sch Engn Sci
Authors: Airoldi, R., Campi, F., Cucchi, M., Revanna, D., Anjum, O., Nurmi, J.
Keywords: (Cognitive radios, Dynamic spectrum access, OFDM, FFT pruning, Low power design, WIRELESS ACCESS, ALGORITHM, TECHNOLOGY, SYSTEMS)
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Scopus rating (2015): 0.228 0.639
Web of Science (2015): 0.508 0.525 4.6 0.087 0.0189 0.234
Publication Forum (2015): 1
Scopus rating (2014): 0.292 1.0
Web of Science (2014): 0.6 0.675 3.9 0.086 0.00207 0.245
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Publication Forum (2013): 1
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Publication Forum (2012): 1
Scopus rating (2011): 0.252 0.717
Scopus rating (2010): 0.288 0.829
Scopus rating (2009): 0.293 0.849
Scopus rating (2008): 0.314 0.661
Scopus rating (2007): 0.34 1.021
Scopus rating (2006): 0.261 0.688
Scopus rating (2005): 0.379 0.914
Scopus rating (2004): 0.384 1.05
Design of a Hybrid Multicore Platform for High Performance Reconfigurable Computing

Digital correction of frequency response mismatches in 2-channel time-interleaved ADCs using adaptive I/Q signal processing

Digital Mitigation of Transmitter-Induced Receiver Desensitization in Carrier Aggregation FDD Transceivers

Carrier aggregation transmissions in frequency division duplexing devices reduce the duplexing distance between the transmitter (TX) and receiver (RX) bands. As a consequence, the spurious intermodulation distortion products created by the nonlinear RF front-end of the TX may easily extend over to the RX band, potentially causing own RX desensitization. In this paper, we propose an efficient and computationally feasible adaptive digital identification and cancellation technique to mitigate the RX desensitization. We first show that the spurious leakage signal at own RX band depends on an equivalent leakage channel that models the overall signal leakage path including the TX nonlinearities, duplexer filter responses, and RX path. The parameters of the equivalent leakage channel can be efficiently estimated with the least squares or the recursive least squares algorithm, using the actual digital transmit data as a reference, and then used to regenerate and cancel the leakage interference from the received signal. The performance of the proposed technique is evaluated with extensive computer simulations, as well as with practical real-world RF measurements, demonstrating excellent calibration properties with up to 19-dB improvement in signal-to-interference plus noise ratio of the desired received signal.

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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Kiayani, A., Abdelaziz, M., Anttila, L., Lehtinen, V., Valkama, M.
Keywords: (Baseband, Interference, Long Term Evolution, Noise, Nonlinear distortion, Radio frequency, Transceivers, Carrier aggregation (CA), frequency division duplexing (FDD), in-phase-quadrature (I/Q) imbalance, interference cancellation, intermodulation distortion (IMD), long-term evolution (LTE)-Advanced, spurious emissions)
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Volume: 63
Digital Signal Transmission in Magnetic Induction Based Wireless Underground Sensor Networks

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Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Distance-based Interpolation and Extrapolation Methods for RSS-based Localization with Indoor Wireless Signals

Wireless Local Area Network (WLAN) based fingerprinting using Received Signal Strengths (RSS) has been considered as one solution for indoor positioning. However, one widely recognized problem in fingerprinting is the collection and maintenance of a proper fingerprint database. In this paper we consider having an incomplete fingerprint database with realistic coverage gaps and we study the performance of several interpolation and extrapolation methods for recovering the missing fingerprint data. For this purpose, we have collected an extensive set of data at 2.4GHz and 5GHz frequency bands from one university building with four floors. The accuracy of the interpolation and extrapolation methods is studied by artificially removing fingerprints from the database using a randomized procedure, and by comparing the estimated fingerprints with the original ones. The average RSS estimation error of different interpolation and extrapolation methods is shown for various percentages of missing fingerprints. In addition, a cumulative RSS error distribution is studied in order to reveal the dispersion of the error statistics, which affect the user positioning accuracy. Here, the user positioning accuracy is defined in terms of horizontal positioning error and floor detection probability. The user positioning accuracy is also compared in four cases, namely when using the original fingerprints, the partial fingerprints, the interpolated fingerprints, and the interpolated and extrapolated fingerprints. It is shown that both the horizontal positioning accuracy and the floor detection probability can be improved with proper interpolation and extrapolation methods. However, it is also illustrated that the best positioning performance is not necessarily achieved with the best average interpolation and extrapolation accuracy, but it is important to avoid certain type of errors in the interpolation and extrapolation process.
Dynamic and Flexible Spectrum Use with Frequency Localized Waveforms under Transmitter Nonidealities

Filter bank multicarrier (FBMC) is considered as one of the strong 5G waveform candidates due to better spectral containment compared to orthogonal frequency division multiplexing (OFDM). However, when considering the spectral leakage effects appearing in practical devices due to transmitter non-idealities, such as power amplifier (PA) nonlinearity and inphase-quadrature (I/Q) imbalance, the nice spectral properties of FBMC may be severely degraded, thus questioning the additional complexity needed to generate such waveforms in baseband. In this paper, digital pre-distortion (DPD) is investigated as a practical solution for both of these problems. We extend the study also to potential applications of spectrum sensing based cognitive radio in future wireless communications. We utilize the benefits of the analysis filter bank of FBMC receiver in wideband multichannel spectrum sensing. In this context, the power leakage due to transmitter non-idealities also makes it difficult to identify spectral gaps amongst relatively strong primary transmissions. It is demonstrated that effective DPD greatly facilitates both spectrum sensing and spectrum utilization functions and thus enhances the overall spectral efficiency in opportunistic dynamic spectrum use scenarios.
Efficient Energy Detection Methods for Spectrum Sensing under Non-Flat Spectral Characteristics

Cognitive radio is an emerging wireless technology that is capable of efficiently coordinating the use of the currently scarce spectrum resources, and spectrum sensing constitutes its most crucial operation. This paper proposes wideband multichannel spectrum sensing methods utilizing fast Fourier transform or filter-bank-based methods for spectrum analysis. Fine-grained spectrum analysis facilitates optimal energy detection in practical scenarios where the transmitted signal, channel frequency response, and/or receiver frequency response do not follow the commonly assumed boxcar model, which typically assumes, among other things, narrow-band communications with flat spectral characteristics. Such sensing schemes can be tuned to the spectral characteristics of the target primary user signals, allowing simultaneous sensing of multiple target primary signals with low additional complexity. This model is also extended to accounting for the specific scenario of detecting a reappearing primary user during secondary transmission, as well as in spectrum sensing scenarios where the frequency range of a primary user is unknown. Novel analytic expressions are derived for the corresponding probability of false alarm and probability of detection in each case, while the useful concept of the area under the receiver operating characteristics curve is additionally introduced as a single scalar metric for evaluating the overall performance of the proposed spectrum sensing algorithms and scenarios. The derived expressions have a rather simple algebraic representation, which renders them convenient to handle both analytically and numerically. The offered results are also extensively validated through comparisons with respective results from computer simulations and are subsequently employed in evaluating each technique analytically, which provides meaningful insights that are anticipated to be useful in future deployments of cognitive radio systems.

General information

Efficient Energy Detection Methods for Spectrum Sensing under Non-Flat Spectral Characteristics

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General information

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General information
Efficient Fast-Convolution Implementation of Filtered CP-OFDM Waveform Processing for 5G

This paper investigates the use of effective and flexible fast-convolution (FC) filtering scheme for multiplexing OFDM resource blocks (RBs) in a spectrally well-localized manner. The scheme is able to effectively suppress interference leakage between adjacent RBs, thus supporting asynchronous operation and independent waveform parametrization of RBs. This is considered as an important feature in 5G waveform development for effectively supporting diversified service characteristics. Our approach is applicable for cyclic prefix or zero prefix based OFDM and the corresponding OFDM based single-carrier (SC-FDMA) waveforms. It is also possible to generate and process traditional Nyquist pulse shaping based single-carrier waveforms and filter bank multicarrier waveforms using the same FC processing engine, accommodating different waveforms simultaneously in different RBs. Our case study is based on proposed numerology for 5G cm-wave communications utilizing flexible time-division duplexing principle. While using RBs of 160 OFDM subcarriers, it is enough to deactivate 3 to 5 subcarriers out of each RB as guardbands to effectively suppress interference leakage between RBs.

Embroidered Textile Antennas for Wireless Body-Centric Communication and Sensing

This paper presents a review and analysis of embroidered textile antennas for wireless body-centric communication systems. Especially, the paper concentrates on recent advancements in embroidered on-body radio frequency identification (RFID) antennas and wireless brain machine interface (BMI) systems and their specific antenna and wireless power transfer challenges.
Energy and delay performance of machine-type communications (MTC) in long-term evolution-advanced (LTE-A)

Abstract In this chapter, the authors conduct an integrated simulation–analytical performance evaluation of machine-type communications (MTC) in long-term evolution-advanced (LTE-A) systems. First, the analytic tools and simulation methodologies to be used throughout the chapter are introduced. Next, the approach is validated against the simulation methodology proposed by the 3GPP (3rd Generation Partnership Project). Finally, some numerical results for access latency, collision probability, and power consumption in overload conditions are presented. This allows a number of energy and delay performance trade-offs of MTC in LTE-A systems to be analyzed.

General information
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Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Gerasimenko, M., Galinina, O., Andreev, S., Koucheryavy, Y.
Keywords: (Machine-type communications (MTC), LTE-A, MTC overload, Power consumption, RACH)
Number of pages: 21
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Publication date: 2015

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Source: RIS
Source-ID: urn:A20344ED82D0DCA003A79F8C9DFBEAE2
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Energy Detection of Unknown Signals over Cascaded Fading Channels

General information
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Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Sofotasios, P., Mohjazi, L., Muhaiderat, S., Al-Qutayri, M., Karagiannidis, G.
Keywords: (Computers, Diversity methods, Electronic mail, Rayleigh channels, Sensors, Signal to noise ratio, Energy detection, cascaded fading, diversity)
Number of pages: 4
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Peer-reviewed: Yes

Publication information
Energy-Efficiency Analysis of Regenerative Cooperative Systems Under Spatial Correlation

Energy efficiency and its optimization constitute critical tasks in the design of low-power wireless networks. This paper is devoted to the error rate analysis and energy efficiency
optimization of regenerative cooperative networks in the presence of multipath fading under spatial correlation. To this end, exact and asymptotic analytic expressions are first derived for the symbol error rate (SER) of M-ary quadrature amplitude and M-ary phase-shift keying modulations (M-QAM and M-PSK), respectively, assuming a dual-hop decode-and-forward (DF) relay system, spatially correlated Nakagami-m multipath fading, and maximum ratio combining (MRC) at the destination. The derived expressions are subsequently employed in quantifying the energy consumption of the considered system, incorporating both transmit energy and the energy consumed by the transceiver circuits, and in deriving the optimal power allocation (OPA) formulation for minimizing energy consumption under certain quality-of-service (QoS) requirements. A relatively harsh path-loss (PL) model, which also accounts for realistic device-to-device communications, is adopted in numerical evaluations, and various useful insights are provided for the design of future low-energy wireless networks deployments. Indicatively, it is shown that, depending on the degree of spatial correlation, severity of fading, transmission distance, relay location, and power allocation strategy, target performance can be achieved with much overall energy reduction compared with direct transmission (DT) reference.

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Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Fikadu, M., Sofotasios, P., Valkama, M., Cui, Q., Karagiannidis, G.
Keywords: (Correlation, Energy consumption, Fading, Optimization, Quadrature amplitude modulation, Relays, Wireless communication, asymptotic analysis, cooperative communications, energy efficiency, error rate, maximum ratio combining, multipath fading, optimization, power allocation, quality-of-service, regenerative relaying, spatial correlation)
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Journal: IEEE Transactions on Vehicular Technology
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Scopus rating (2016): 0.855 1.91
Publication Forum (2016): 2
Scopus rating (2015): 0.97 2.325
Web of Science (2015): 2.243 2.631 5.5 0.377 0.03526 1.092
Publication Forum (2015): 2
Scopus rating (2014): 1.063 2.567
Web of Science (2014): 1.978 2.483 5.2 0.305 0.03595 1.019
Publication Forum (2014): 3
Scopus rating (2013): 1.599 3.031
Publication Forum (2013): 3
Scopus rating (2012): 1.542 2.852
Publication Forum (2012): 3
Scopus rating (2011): 1.168 2.393
Scopus rating (2010): 0.995 1.927
Scopus rating (2009): 1.074 2.009
Scopus rating (2008): 1.193 2.294
Scopus rating (2007): 1.463 2.8
Scopus rating (2006): 1.055 2.332
Scopus rating (2005): 1.004 1.885
Fast-convolution implementation of filter bank multicarrier waveform processing

This paper investigates the use of effective and flexible fast-convolution (FC) implementation for two main types of filter bank multicarrier (FBMC) waveforms, FBMC/OQAM and filtered multitone (FMT). The generated waveforms are spectrally well-contained, with very small power leakage to adjacent frequencies, and are thus good candidates for opportunistic and heterogeneous spectrum use scenarios. On the receiver side, the FC filter bank (FC-FB) approach can be used for simultaneously processing multiple channels with individually tunable bandwidths, center frequencies, and timing offsets, supporting asynchronous multi-user operation. FC-FB implementations are compared with traditional polyphase designs in terms of spectral characteristics and computational complexity.

Faster Binary Curve Software: A Case Study

This paper presents a case study on the implementation of faster binary curve software, focusing on the efficiency and performance improvements achieved through optimized algorithms and computational techniques. The study is relevant for applications requiring secure and efficient data processing, particularly in the context of networked infrastructure and applications. The authors discuss the technical challenges and the strategies employed to enhance the speed and reliability of binary curve computations, which are fundamental in various cryptographic and digital communication systems.
Feasibility analysis of ITU-T P.1201 Amd.2 standard for video on demand services

Flexible Digital Predistortion for Future Spectrally-Agile Waveforms and 5G Radio Systems

In this article, we focus on the RF and digital frontend design and implementation challenges associated with future 5G radio access systems with special emphasis on spectrally contained waveforms and small-cell system scenarios. In general, filter bank based multicarrier (FBMC) type of techniques have various potential benefits due to their excellent spectral containment compared to classical OFDM(A). However, these spectrally contained waveforms lose their intriguing spectral properties when power amplifier (PA) nonlinearities are considered. Flexible and efficient digital predistortion (DPD) algorithms are thus considered an interesting solution in order to restore the spectral containment of such advanced 5G waveforms. Noncontiguous spectrally-agile transmission is another key feature of future 5G systems for increasing data rates and spectral allocation flexibility. However, the PA nonlinearities impose even more severe challenges in such noncontiguous transmission scenarios due to the resulting spurious intermodulation emissions that can easily violate the emission limits or even desensitize the own receiver in frequency division duplexing based systems. Furthermore, at the network deployment level, different small-cell concepts are expected to play a major role in future 5G networks. Unlike the ordinary macro base-stations, the digital computing capabilities in small-cell base-stations are much more limited. They should also adopt lower-cost and small-size analog RF components, while still maintaining high energy-efficiency. The afore-mentioned constraints, along with advanced 5G waveforms, call for flexible and low-complexity DPD solutions, a challenge addressed in this article. We report novel DPD methods with built-in capability to direct the linearization performance to pre-defined frequencies or subbands in a flexible manner, and demonstrate their good performance and complexity benefits in the context of non-contiguous FBMC transmission.
Flexible fast-convolution implementation of single-carrier waveform processing for 5G

This paper proposes and analyzes the use of effective and flexible fast-convolution (FC) implementation for single-carrier (SC) waveforms with very small roll-offs to reach high spectrum efficiency and significantly lower peak-to-average power ratio (PAPR) than corresponding multicarrier schemes. The generated waveforms are spectrally well-contained, with very small power leakage to adjacent frequencies, and are thus good candidates for opportunistic and heterogeneous spectrum use scenarios. The SC-waveforms are found to exhibit similar PAPR characteristics as the OFDM based SC-FDMA scheme. On the receiver side, fast-convolution filter bank (FC-FB) approach supports effective frequency-domain equalization with low complexity. It can be used for simultaneous processing of multiple SC channels with individually tunable bandwidths, center frequencies and timing offsets. This solution enables different terminals to operate with different roll-offs and hence with different PAPR. The approach supports well asynchronous multi-user operation, which is considered as an important element in 5G networks.

Hybrid WLAN-RFID Indoor Localization Solution Utilizing Textile Tag

This letter presents a novel hybrid configuration for indoor positioning, utilizing the passive radio frequency identification (RFID) and wireless local area network (WLAN). Our architecture is based on a mobile device with a WLAN receiver, a textile RFID tag, and one or several RFID readers communicating with the mobile. The proposed passive textile RFID tag provides a very cost effective, power efficient, and easily implemented solution for human positioning and tracking applications. In addition, the joint utilization of two technologies increases the accuracy of the indoor positioning service. Our main contribution comes from the innovative RFID-WLAN hybrid architecture based on received signal strengths and able to improve the localization accuracy compared to pure RFID and pure WLAN location solutions. The proposed algorithm is tested with real-field measurements.
Implementation of IEEE-802.11a/g receiver blocks on a coarse-grained reconfigurable array

This paper presents the implementation of Orthogonal Frequency-Division Multiplexing receiver blocks as accelerators using a template-based Coarse-Grained Reconfigurable Array (CGRA) device. The CGRA operates with a Reduced Instruction-Set Computing (RISC) processor so that the overall system yields the benefits of general-and special-purpose processing. The accelerators are designed by crafting the CGRA template to the computational and communication requirements of the algorithms in an effort to minimize the resource utilization and power dissipation on the target Field Programmable Gate Array (FPGA) device. The accelerators are also evaluated for performance in terms of the number of clock cycles, resource utilization, synthesis frequency, power and energy estimation. The implementation results show that the designed accelerators give speed-up of 2.8X to 9.3X in comparison with a RISC software implementation.

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Authors: Nouri, S., Hussain, W., Nurmi, J.
Publication date: 2015

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Research output: Scientific - peer-review » Conference contribution

Interference Analysis and Performance Evaluation of 5G Flexible-TDD based Dense Small-Cell System
The projected growth of mobile data traffic requires the 5G wireless systems to support at least 1000× larger area throughput than the existing 4G solutions. This requires ultradense local area networks combined with fast and flexible time division duplex based access to provide wide bandwidths for multi-gigabit peak data rates. In this paper, we focus on the system level performance characterization and evaluations of the recently proposed 5GETLA radio interface for centimeter-wave communications. We study the effects of interference tiers on the throughput and SINR distributions and show that broadcasted, omnidirectional information should be minimized and preferably combined with learning spectral reuse and interference canceling receivers. We also demonstrate the low latency provided by the new 5G radio interface design.
Interference and SINR in Dense Terahertz Networks

Over the last decade short-range communications in the terahertz band have been extensively studied as a technology-enabler for dense and ultra-dense wireless networks. Recent advances in miniaturized terahertz transceivers design promise wireless connectivity and simultaneous interaction between thousands of devices. However, the feasibility of network-wide communications is still an open issue due to specific features of the terahertz band and inherent properties of dense deployments. We address this issue developing an analytical model for interference and SINR assessment in dense terahertz networks obtaining the first two moments and density functions for both metrics. Our results demonstrate that the presence of molecular noise does not qualitatively affect the behavior of SINR, while its quantitative effect is of secondary importance compared to interference. The presented approach provides the so-far missing building block for performance analysis of prospective dense terahertz networks.
K-Means Fingerprint Clustering for Low-Complexity Floor Estimation in Indoor Mobile Localization

Indoor localization in multi-floor buildings is an important research problem. Finding the correct floor, in a fast and efficient manner, in a shopping mall or an unknown university building can save the users' search time and can enable a myriad of Location Based Services in the future. One of the most widely spread techniques for floor estimation in multi-floor buildings is the fingerprinting-based localization using Received Signal Strength (RSS) measurements coming from indoor networks, such as WLAN and BLE (Bluetooth Low Energy). The clear advantage of RSS-based floor estimation is its ease of implementation on a multitude of mobile devices at the Application Programming Interface (API) level, because RSS values are directly accessible through API interface. However, the downside of a fingerprinting approach, especially for large-scale floor estimation and positioning solutions, is their need to store and transmit a huge amount of fingerprinting data. The problem becomes more severe when the localization is intended to be done on mobile devices (smart phones, tablets, etc.) which have limited memory, power, and computational resources. An alternative floor estimation method, which has lower complexity and is faster than the fingerprinting is the Weighted Centroid Localization (WCL) method. The trade-off is however paid in terms of a lower accuracy than the one obtained with traditional fingerprinting with Nearest
Neighbour (NN) estimates. In this paper a novel K-means-based method for floor estimation via fingerprint clustering of WiFi and various other positioning sensor outputs is introduced. Our method achieves a floor estimation accuracy close to the one with NN fingerprinting, while significantly improves the complexity and the speed of the floor detection algorithm. The decrease in the database size is achieved through storing and transmitting only the cluster heads (CH's) and their corresponding floor labels. The performance of the proposed methods is evaluated using real-life indoor measurements taken from four multi-floor buildings. The numerical results show that the proposed K-means-based method offers an excellent trade-off between the complexity and performance.

Low-Complexity Digital Correction of 4-Channel Time-Interleaved ADC Frequency Response Mismatch using Adaptive I/Q Signal Processing

This paper proposes a novel fully blind frequency response mismatches correction architecture for a four-channel time interleaved ADC (TI-ADC) using digital signal processing. By generating appropriate complex valued signals from the real valued TI-ADC output, a mapping of the TI-ADC problem into a mirror frequency interference problem is obtained, which allows using in-phase/quadrature (I/Q) mismatch correction techniques, e.g., circularity, for the frequency response mismatch identification. Compared to the existing methods in the literature, the proposed method allows for blind frequency response mismatch identification throughout the whole digital bandwidth and has substantially lower computational complexity while maintaining similar correction performance, hence making it suitable for an on-chip implementation. The compensation architecture is implemented, demonstrated and tested using real RF-sampling four-channel TI-ADC hardware data, achieving a multitone spur reduction below 80 dBFS.

Low-profile head-worn antenna with a monopole-like radiation pattern

We present a low-profile antenna derived from a center-fed circular patch to provide uniform spatial coverage around a human head in 5.8 GHz ISM band. With the thickness of only 7 mm, it provides a compelling solution for a beacon-like radiator or harvester embedded in a smart headgear or in an in/off body communication relay-station. Below, we will first outline the development of an ellipsoid head model for numerically efficient optimization of the antenna and then detail the antenna development based on full-wave simulations. The results are validated using an anatomical head model and measurements both in air and in head-worn configuration. The measured results show that the antenna achieves a 0-dBi
gain in the spatial angles around the head. The simulated radiation efficiency is 76% and SAR is well below ICNIRP and
FCC limits even with 100 mW antenna power.

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: Wireless Identification and Sensing Systems Research Group, Department of Electronics
and Communications Engineering
Authors: Björninen, T., Yang, F.
Number of pages: 4
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Peer-reviewed: Yes
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Journal: IEEE Antennas and Wireless Propagation Letters
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Scopus rating (2016): 1.257 1.803
Publication Forum (2016): 2
Scopus rating (2015): 1.572 1.925
Web of Science (2015): 1.751 1.806 4.3 0.288 0.02613 0.843
Publication Forum (2015): 2
Scopus rating (2014): 1.517 1.927
Web of Science (2014): 1.579 1.727 4.2 0.176 0.02589 0.843
Publication Forum (2014): 2
Scopus rating (2013): 1.202 1.703
Publication Forum (2013): 2
Scopus rating (2012): 1.005 1.517
Publication Forum (2012): 2
Scopus rating (2011): 0.926 1.54
Scopus rating (2010): 0.736 1.25
Scopus rating (2009): 1.083 1.582
Scopus rating (2008): 0.794 1.256
Scopus rating (2007): 1.421 2.221
Scopus rating (2006): 1.599 1.911
Scopus rating (2005): 1.943 1.839
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Scopus rating (2003): 0.918 1.391
Original language: English
Electronic versions:
AWPL_head-worn_ant
DOIs:
10.1109/LAWP.2015.2475158
Links:
http://urn.fi/URN:NBN:fi: tty-201603013590
Research output: Scientific - peer-review › Article

**LTE Performance Analysis Using Queuing Systems with Finite Resources and Random Requirements**
Heavy traffic load in current LTE networks calls for effective radio resource allocation methods and tools for performance
evaluation. In this work, we provide an analytical framework for LTE resource allocation in terms of queuing theory. We
consider a multiservice queuing system with a finite amount of resources of several types, and allow the customers
occupy a random amount of resources upon their arrival. Random resource requirements lead to more accurate
performance evaluation compared to conventional multiservice models. For the considered model, we prove that the
stationary probability distribution has a multiplicative form. Our findings are illustrated with a numerical example.
MIMO channel estimation and data detection: The European Commission 7th Framework Programme (FP7) project ICT-318362-EMPhAtiC deliverable D4.2

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Naumov, V., Samouylov, K., Yarkina, N., Sopin, E., Andreev, S., Samuylov, A.
Number of pages: 4
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Title of host publication: 2015 7th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT)
Publisher: IEEE
ISBN (Print): 978-1-4673-9282-2
DOI: 10.1109/ICUMT.2015.7382412
Research output: Scientific - peer-review ▶ Conference contribution

Mobile GPU Accelerated Digital Predistortion on a Software-defined Mobile Transmitter
We present the design exploration and the performance evaluation of a mobile transmitter digital predistortion (DPD) module on a mobile GPU. Digital predistortion is a widely used technique for suppressing the spurious spectrum emission caused by the imperfection of power amplifier and radio frequency (RF) circuits in a real wireless transmitter. Considering the parallel architecture, numerous computing cores and programmability of GPU, in this work, a DPD design based on augmented parallel Hammerstein structure is implemented on a mobile GPU integrated in an Nvidia Jetson TK1 mobile development board, targeting at a mobile transmitter. The algorithm level and data level parallelism are carefully explored for efficient mapping of the DPD algorithm and full utilization of the mobile GPU resources. We analyze the throughput and timing performance of our implementation and verify the functionality of DPD experimentally on a novel software-defined mobile terminal. The results show that our proposed mobile GPU driven digital predistortion design not only achieves real-time high performance, but also offers programmability and reconfigurability for design upgrading and extension.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Mavrokefalidis, C., Kofidis, E., Rontogiannis, A., Beikos, A., Renfors, M., Yli-Kaakinen, J., Louveaux, J.
Number of pages: 66
Publication date: 2015

Publication information
Publisher: ICT-EMPhAtiC
Original language: English
Research output: Professional ▶ Commissioned report

Mobile GPU Accelerated Digital Predistortion on a Software-defined Mobile Transmitter
We present the design exploration and the performance evaluation of a mobile transmitter digital predistortion (DPD) module on a mobile GPU. Digital predistortion is a widely used technique for suppressing the spurious spectrum emission caused by the imperfection of power amplifier and radio frequency (RF) circuits in a real wireless transmitter. Considering the parallel architecture, numerous computing cores and programmability of GPU, in this work, a DPD design based on augmented parallel Hammerstein structure is implemented on a mobile GPU integrated in an Nvidia Jetson TK1 mobile development board, targeting at a mobile transmitter. The algorithm level and data level parallelism are carefully explored for efficient mapping of the DPD algorithm and full utilization of the mobile GPU resources. We analyze the throughput and timing performance of our implementation and verify the functionality of DPD experimentally on a novel software-defined mobile terminal. The results show that our proposed mobile GPU driven digital predistortion design not only achieves real-time high performance, but also offers programmability and reconfigurability for design upgrading and extension.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Li, K., Ghazi, A., Boutellier, J., Abdelaziz, M., Anttila, L., Juntti, M., Valkama, M., Cavallaro, J. R.
Pages: 756-760
Publication date: 2015

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ISBN (Electronic): 978-1-4799-7590-7
DOI: 10.1109/GlobalSIP.2015.7380208
Research output: Scientific - peer-review ▶ Conference contribution
Multi-Antenna Interference Cancellation for Black Space Cognitive Radio Communications

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Srinivasan, S., Dikmese, S., Menegazzo, D., Renfors, M.
Publication date: 2015

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Title of host publication: Proceedings of IEEE Global Communications Conference (IEEE GLOBECOM 2015)
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DOI:
10.1109/GLOCOMW.2015.7414136
Research output: Scientific - peer-review › Conference contribution

Multimode, non-uniform filterbank: The European Commission 7th Framework Programme (FP7) project ICT-318362-EMPhAtiC deliverable D2.2

General information
State: Published
Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Rakic, D., Martinod, L., Medjahdi, Y., Le Ruyet, D., Bader, F., Petrov, D., Nedic, S., Yli-Kaakinen, J., Renfors, M.
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Publication date: 2015

Publication information
Publisher: ICT-EMPhAtiC
Original language: English
Links:
Research output: Professional › Commissioned report

Network-Assisted Device-to-Device Connectivity: Contemporary Vision and Open Challenges

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Andreev, S., Moltchanov, D., Galinina, O., Pyattaev, A., Ometov, A., Koucheryavy, Y.
Number of pages: 8
Pages: 227-234
Publication date: 2015

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Title of host publication: Proceedings of European Wireless 2015; 21th European Wireless Conference
Publisher: VDE
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Research output: Scientific - peer-review › Conference contribution

Novel Indoor Positioning Mechanism via Spectral Compression
Received Signal Strength (RSS) measurements are important in indoor location solutions based on WiFi, cellular networks or Bluetooth. RSS-based positioning involves two phases, namely learning and estimation. The database sizes required both for the learning and for the estimation phases grow rapidly as the network coverage areas and the number of Access Points number increase. Achieving large-scale/global localization solutions would be possible if the database size bottlenecks were solved. We present here an innovative approach based on spectral compression, which allows a tremendous reduction in the database sizes in both learning and estimation phases. We introduce the new concept of
compressed RSS images. We show how, through an astute 2-D frequency analysis, only a fraction of the transform-domain components need to be stored and transferred to/from the mobiles. Our idea is validated with WiFi real-life measurements from five multi-storey buildings. We show that our method is able to provide comparable results with the traditional fingerprinting approach, but with up to 80% reduction in the database sizes.

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State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Talvitie, J., Renfors, M., Lohan, E.
Number of pages: 4
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Scopus rating (2016): 0.628 1.234
Publication Forum (2016): 2
Scopus rating (2015): 0.764 1.542
Web of Science (2015): 1.291 1.4 4.6 0.136 0.02439 0.647
Publication Forum (2015): 2
Scopus rating (2014): 0.807 1.402
Web of Science (2014): 1.268 1.342 5.0 0.125 0.02226 0.615
Publication Forum (2014): 1
Scopus rating (2013): 1.077 1.71
Publication Forum (2013): 1
Scopus rating (2012): 0.987 1.593
Publication Forum (2012): 1
Scopus rating (2011): 0.824 1.58
Scopus rating (2010): 0.858 1.488
Scopus rating (2009): 1.11 1.633
Scopus rating (2008): 1.271 1.777
Scopus rating (2007): 1.368 1.813
Scopus rating (2006): 1.3 1.803
Scopus rating (2005): 1.731 2.283
Scopus rating (2004): 2.141 2.636
Scopus rating (2003): 2.656 2.447
Scopus rating (2002): 2.949 2.056
Scopus rating (2001): 2.028 1.678
Scopus rating (2000): 1.47 1.1
Scopus rating (1999): 0.684 0.971
Original language: English
DOIs:
10.1109/LCOMM.2015.2504097
Research output: Scientific - peer-review » Article

**On capacity of active relaying in magnetic induction based wireless underground sensor networks**

**General information**
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
On Capturing Spatial Diversity of Joint M2M/H2H Dynamic Uplink Transmissions in 3GPP LTE Cellular System

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Authors: Ahmadian, A., Galinina, O., Gudkova, I. A., Andreev, S., Shorgin, S., Samouylov, K.
Pages: 407-421
Publication date: 2015

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ISBN (Electronic): 978-3-319-23126-6

Publication series
Name: Lecture Notes in Computer Science
Volume: 9247
ISSN (Print): 0302-9743
DOIs: 10.1007/978-3-319-23126-6_36
Research output: Scientific - peer-review › Conference contribution

On Predicting Video Quality Expectations of Mobile Users

Mobile network operators are currently seeking for simple but accurate methods to predict the levels of satisfaction for their customers using the on-line multimedia applications, such as YouTube. Even though the ultimate user demands are known to be influenced by multiple factors, there is one clear trend - people require an increasingly higher quality of mobile video services. To this end, modeling the corresponding quality of experience (QoE) constitutes a non-trivial task and calls for a careful balance between the key underlying aspects, while maintaining the overall complexity as low as possible. This should in turn deliver the much needed usability of the resulting model across many real-world scenarios, and in this work we develop a novel QoE prediction model based on our extensive user experience investigation of the YouTube service. Our proposed solution allows network operators to estimate the degrees of video quality and thus predict the associated mobile user expectations in their deployments. The design principles behind our methodology, its accuracy evaluation, as well as the obtained numerical results are reported in the course of this paper.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Hosek, J., Kovac, D., Uhlir, D., Galinina, O., Andreev, S., Koucheryavy, Y., Ries, M.
Number of pages: 6
Pages: 110-115
Publication date: 2015

Host publication information
On the Effects of UE Transceiver Non-Reciprocity in Coordinated TDD Multi-Cell MIMO Network

In this paper, we study the effects of effective channel non-reciprocity in coordinated TDD multi-cell MIMO network based on weighted sum rate (WSR) maximization. More specifically, we focus on UE transceiver non-reciprocity while the base stations (BS) are assumed to be perfectly calibrated, and both centralized and decentralized beamforming schemes are considered. In the centralized scheme, the cost function is constructed in a central controller using antenna specific UL pilots for channel estimation from all the connected BSs in the network. Then, even though the transceiver frequency response (FR) mismatches at the UE side corrupt the effective channel reciprocity, it is shown to have only a trivial impact on the WSR objective in such centralized case. However, when decentralized beamforming is deployed, the optimization is carried out in each BS and the corresponding cost function and optimization process depend on information acquired by over-the-air signaling between the BSs and all the users using precoded UL pilots. In this case, it is then shown that the transceiver FR mismatches at the UE side can cause severe performance degradation and even influence the convergence properties of the sum-rate optimization process. Further insight is provided for improving the performance by modifying the weight calculations in the optimization process and connecting users with good cell separations. Then a convergence-aware processing algorithm is also proposed to improve the performance of the decentralized scheme under UE transceiver non-reciprocity. Numerical experiments demonstrate that efficient processing algorithms for calibrating UE transceiver mismatches to be less than -30dB to -35dB are, in general, required in the decentralized system in order to achieve performance close to the ideal case without any RF imperfections.

On the efficiency of spatial channel reuse in ultra-dense THz networks

Wireless communications in the terahertz (THz) frequency band, 0.1-10THz, promises a rapid increase of channel capacity in next-generation networks. However, the advantages of this technology depend not only on the single link performance, but also on the possibility of several THz links to coexist in the same area. Thus, the efficiency of spatial channel reuse has to be studied. Due to the presence of specific effects in the THz band, such as molecular absorption and molecular noise, existing performance evaluation techniques are not straightforwardly applicable. In this paper, the approach for network-level analysis of THz wireless communications is proposed. This approach is based on the tools of stochastic geometry and takes into account the specific signal propagation features of the THz frequency band. The presented technique is used to derive the distribution of SINR and spectral efficiency as well as to estimate the optimal distance between receiving nodes and maximize the area capacity.
On the RSS biases in WLAN-based indoor Positioning

Fluctuations in the Received Signal Strength, caused for example by temporal propagation dynamics or various mobile types, can decrease the positioning accuracy in WLAN-based indoor fingerprinting. In this paper, the effect of an offset between Received Signal Strength values in the training and estimation phases is investigated. Our study is based on a huge measurement campaign that covers in total eight different buildings with several floors each, in two countries.

Different offset types and offset values are studied on a large scale, in terms of 3D positioning accuracy and floor detection probability. We will show that biases between $-20$ dB and $+10$ dB do not affect the positioning results in a significant way and that such biases could be also tolerated without calibration.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Laitinen, E., Talvitie, J., Lohan, E.
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Electronic versions: ICC_Elina_cameraready
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Research output: Scientific - peer-review › Conference contribution

On the Solution of the Steiner Tree NP-Hard Problem via Physarum BioNetwork

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Caleffi, M., Akyildiz, I., Paura, L.
Number of pages: 15
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Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: IEEE/ACM Transactions on Networking
Volume: 23
Issue number: 4
ISSN (Print): 1063-6692
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.055 2.241
Publication Forum (2016): 3
Web of Science (2015): 2.186 2.661 7.3 0.374 0.01537 1.381
In this paper we investigate the time-frequency localization tradeoffs in practical implementation of filter bank multicarrier (FBMC) waveforms in short burst transmission. Frequency localization is considered as an important characteristic for future wireless communication systems, including 5G, but it comes with the cost of not-so-good time localization. This appears in the form of relatively long 'tails' of the generated transmission burst. Truncation of the burst tails is an obvious choice for reducing the time-overheads in short burst based multiple access or duplexing schemes, but it introduces transients in the inband interference and out-of-band radiation characteristics. We study the burst truncation effects while utilizing a flexible FBMC waveform generation scheme based on fast-convolution processing. Also a novel method to optimize the used symbol waveform taking into account the truncation effects is developed.
Outage Probability Analysis of Dual-hop Full-Duplex Decode-and-Forward Relaying over Generalized Multipath Fading Conditions

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Fikadu, M. K., Sofotasios, P. C., Valkama, M., Muhaidat, S., Cui, Q., Karagiannidis, G. K.
Number of pages: 8
Pages: 414-421
Publication date: 2015

Host publication information
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Publisher: IEEE
ISBN (Print): 978-1-4673-7701-0
DOIs: 10.1109/WiMOB.2015.7347992
Research output: Scientific - peer-review › Conference contribution

Outage Probability Analysis of Full-Duplex Regenerative Relaying over Generalized Asymmetric Fading Channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Fikadu, M. K., Sofotasios, P. C., Valkama, M., Cui, Q., Muhaidat, S., Karagiannidis, G. K.
Publication date: 2015

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ISBN (Electronic): 978-1-4799-5951-8
DOIs: 10.1109/GLOCOM.2014.7417396
Links: http://globecom2015.ieee-globecom.org/
Research output: Scientific - peer-review › Conference contribution

Parameterized Sets of Dataflow Modes And Their Application to Implementation of Cognitive Radio Systems
Cognitive radio networks present challenges at many levels of design, including configuration, control, and cross-layer optimization. To meet requirements of bandwidth, flexibility and reconfigurability, systematic methods to model and analyze cognitive radio designs on signal processing platforms are desired. To help address these challenges, we present in this paper a novel dataflow modeling technique, called parameterized set of modes (PSM). PSMs allow efficient representation, manipulation and application of related groups of processing configurations for functional design components in signal processing systems. PSMs lead to more concise formulations of actor behavior, and a unified modeling methodology for applying a variety of techniques for efficient implementation. We develop the formal foundations of PSM-based modeling, and demonstrate its utility through two case studies involving the mapping of reconfigurable wireless communication functionality into efficient implementations.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Signal Processing Research Community (SPRC), Wireless Communications and Positioning (WICO)
Authors: Lin, S., Wang, L., Vosoughi, A., Cavallaro, J. R., Juntti, M., Boutellier, J., Silven, O., Valkama, M., Bhattacharyya, S. S.
The present paper is devoted to the evaluation of energy detection based spectrum sensing over different multipath fading and shadowing conditions. This is realized by means of a unified and versatile approach that is based on the particularly flexible mixture gamma distribution. To this end, novel analytic expressions are firstly derived for the probability of detection over MG fading channels for the conventional single-channel communication scenario. These expressions are subsequently employed in deriving closed-form expressions for the case of square-law combining and square-law selection diversity methods. The validity of the offered expressions is verified through comparisons with results from respective computer simulations. Furthermore, they are employed in analyzing the performance of energy detection over multipath fading, shadowing and composite fading conditions, which provides useful insights on the performance and design of future cognitive radio based communication systems.
Relaxed direct position estimation as strategy for open-loop GNSS receivers

Direct Position Estimation (DPE) approach fully exploits geometrical relationships between receiver and observable global navigation satellite system satellites. In this paper, we present a novel method based on this approach especially suitable for navigation receivers implemented on the open-loop batch signal processing architecture. In contrast to DPE, the method brings benefits in terms of computational complexity whereas the position accuracy degradation is minimal. We make a performance comparison using an extensive Monte Carlo simulation that includes navigation signals buried in additive white Gaussian noise, as well as a realistic satellite constellation.

Resource Management Schemes for Network Assisted Device-to-Device Communication for an Integrated OFDMA Cellular System

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Xing, H., Renfors, M.
Number of pages: 6
Pages: 1520-1525
Publication date: 2015
Host publication information
Title of host publication: 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC): Mobile and Wireless Networks
Publisher: IEEE
ISBN (Print): 978-1-4673-6782-0
DOI: 10.1109/PIMRC.2015.7343539
Research output: Scientific - peer-review » Conference contribution
Simultaneous Transmission and Spectrum Sensing in OFDM Systems Using Full-Duplex Radios

This paper studies the idea and performance of cyclostationary spectrum sensing in cognitive full-duplex radios, when secondary transmission and spectrum sensing are done simultaneously at the same channel. The paper starts by briefly introducing the ideas of cognitive full-duplex radio and the cyclostationary spectrum sensing in the presence of self-interference. The idea of changing the cyclic features of the secondary signal is then proposed and its impact on the spectrum sensing under self-interference is analysed. The cyclic features can be changed by changing the length of the cyclic prefix of the OFDM signal or by changing the amount of subcarriers. The effects of both approaches are evaluated with comprehensive performance simulations. It is shown that changing the cyclic features of the secondary signal can provide significant improvements in the sensing results of the primary signal, and that in general, reliable inchannel spectrum sensing while transmitting is feasible. This can enable enhance coexistence mechanisms, e.g., for LTE-Unlicensed technology at ISM band.
Smart home gateway system over Bluetooth low energy with wireless energy transfer capability

As billions of sensors and smart meters connect to the Internet of Things (IoT), current wireless technologies are taking decisive steps to ensure their sustainable operation. One popular IoT scenario features a smart home service gateway, which becomes the central point of user's home environment facilitating a multitude of tasks. Given that most IoT devices connected to residential gateway are small-scale and battery-powered, the key challenge is to extend their lifetime without recharging/replacing batteries. To this end, a novel radio technology named Bluetooth low energy (BLE) has recently been completed to enable energy-efficient data transfer. Another inspiring innovation is the capability of sensors to harvest wireless energy in their local environment. In this work, we envision a scenario where many in-home sensors are communicating with a smart gateway over the BLE protocol, while at the same time harvesting RF energy transmitted from the gateway wirelessly via a dedicated radio interface. We thoroughly investigate performance limitations of such wireless energy transfer interface (WETI) with dynamic analytical model and with important practical considerations. Our methodology delivers the upper bound on WETI operation coupled with BLE-based communication, which characterizes ultimate system performance over the class of practical radio and energy resource management algorithms.
Software simulations and experiments: The European Commission 7th Framework Programme (FP7) project ICT-318362-EMPhAtiC deliverable D9.2

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Ministry of Education publication type: D4 Published development or research report or study
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Laurent, M., Rakic, D., Bartzoudis, N., Font-Bach, O., Petrov, D., Yli-Kaakinen, J.
Number of pages: 61
Publication date: 2015

Publication information
Publisher: European Commission
Original language: English
Links:
Research output: Professional › Commissioned report

Spectrum sensing in generalized multipath fading conditions using square-law combining

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Bagheri, A., Sofotasios, P. C., Tsiftsis, T. A., Shahzadi, A., Valkama, M.
Number of pages: 6
Pages: 7528-7533
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE International Conference on Communications (ICC)
Publisher: IEEE
ISBN (Print): 978-1-4673-6432-4
Research output: Scientific - peer-review › Conference contribution

Start-up and Frequency Stability Analysis using Time-Varying Root Locus
Undesired points of operation i.e. real pole in the right half of s-plane causes relaxation oscillation, especially in GHz-range of monolithic oscillators. They also prove to be "hard" target for most of the very powerful circuit simulators, like SpecterRF for example. Since the behavior is best described by the Eigen values of characteristic polynomial, then we settle on investigating the operating points using the time varying root locus (TVRL) method. The numerical QZ algorithm has been practiced to compute the characteristic roots relative to periodic steady-state (PSS). The circuit is modified to avoid relaxation process and it confirms the proper sinusoidal operation of oscillator.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: RF Integrated Circuits
Authors: Jain, S., Tchamov, N.
Publication date: 2015
Peer-reviewed: Yes
Statistical Sensor Fusion of Ultra Wide Band Ranging and Real Time Kinematic Satellite Navigation

Real Time Kinematic (RTK) Global Positioning System (GPS) uses carrier phase measurement from GPS signal and it has a high accuracy but has integer ambiguity resolution problem which causes cycle slips and requires good satellite visibility as well. RTK was originally developed for applications such as surveying; in our case the target application is the tracking and the control of a robot hexacopter. The main issue in RTK is the determination of the number of cycles, called integer ambiguity, between the receiver and each satellite. Once the ambiguity is solved, it remains constant as long as the receiver maintains a phase lock on the satellite signals. However, the hexacopter maneuvers or the satellite visibility obstructions can cause the loss of phase lock, and the integer ambiguity needs to be solved again which result in degradation of RTK GPS positioning. This paper presents fusion of Ultra-Wide Band (UWB) and RTK GPS positions through loosely coupled approach in Kalman filter to overcome this issue. Measurement results show that the fusion of UWB and RTK GPS positioning solutions have better performance compared to stand-alone RTK GPS solution.
Study of the Duty Cycle Challenges for Short Range Devices Deployment Based on the IEEE 802.11ah in M2M and IoT Network

General information
State: Published
Ministry of Education publication type: B1 Article in a scientific magazine
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning
Authors: Hazmi, A., Qutab-Ud-Din, M., Bahidi, B., Amin, P., Felipe Del Carpio, L., Larmo, A., Valkama, M.
Number of pages: 4
Pages: 21-24
Publication date: 2015
Peer-reviewed: No

Publication information
Journal: Internet of Things Finland
Issue number: 1
ISSN (Print): 2342-6551
Original language: English
Research output: Scientific › Article

Subband Energy Based Reduced Complexity Spectrum Sensing under Noise Uncertainty and Frequency-Selective Spectral Characteristics

The present work proposes a subband energy detection method that performs efficiently under noise uncertainty (NU) and frequency selective channels. The critical impact of detrimental modeling uncertainties, such as NU, is analytically quantified and it is shown that the introduced method is robust to both NU and frequency selectivity conditions. This is also the case for eigenvalue based sensing techniques, in contrast to traditional energy detector based sensing. Connections of the subband energy based approach and existing eigenvalue based methods are established analytically which leads to a novel reduced complexity processing technique based on the difference between maximum and minimum subband energies. The proposed method is capable of providing accurate and robust performance with low signal-to-noise ratios (SNR) in the presence of NU. Closed-form expressions are derived for the corresponding probability of false alarm and probability of detection under frequency selectivity due to the primary signal spectrum and/or the transmission channel. The validity of the offered expressions is justified through comparisons with respective results from computer simulations. The sensing performance is evaluated in different communication scenarios, with different frequency selective channel models and primary user waveforms. The offered results indicate that the proposed methods provide quite significant savings in complexity, e.g., 78% reduction in the considered example case, while also improving the detection performance at low SNRs and in the presence of NU.

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: Wireless Communications and Positioning, Department of Electronics and Communications Engineering
Authors: Dikmese, S., Sofotasios, P., Renfors, M., Valkama, M.
Keywords: (Computational complexity, Detectors, Eigenvalues and eigenfunctions, Noise, Uncertainty, Cognitive radio, eigenvalue based sensing, extreme Gumbel distribution, frequency selectivity, noise uncertainty, random matrix theorem, spectrum sensing, subband energy based detector)
Pages: 131-145
Publication date: 2015
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Signal Processing
Techno-Economical Comparison of Dynamic DAS and Legacy Macrocellular Densification: Capacity and Cost-Efficiency
Analysis of Alternative Deployment Solutions for Outdoor Service Provisioning

In order to support anywhere and anytime services of Beyond 4G networks, new deployment solutions will be required that can cost-effectively address the capacity demand of the future and also offer consistently high bit rates and decent quality of service throughout the network coverage area. In this article we look into an advanced outdoor distributed antenna system (DAS) concept, dynamic DAS, that offers on-demand outdoor capacity in urban areas by dynamically configuring the remote antenna units to either act as individual small cells or distributed nodes of a common central cell. The performance of the investigated DAS solution is evaluated and compared with legacy macrocellular deployment in a dense urban environment. Furthermore, the analysis covers the performance evaluation, mainly from an outdoor perspective. The obtained results indicate superior performance of dynamic DAS concept in terms of coverage and SINR, network capacity and cost-efficiency as compared to legacy macrocellular network deployments.

General information

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO), Elisa Corporation
Authors: Yunas, S. F., Valkama, M., Niemelä, J.
Keywords: (Capacity efficiency, Cost efficiency, Dynamic DAS, Macrocellular densification, Outdoor service provisioning, Techno-economics)
Pages: 312-326
Publication date: 2015
The effects of RF impairments in Vehicle-to-Vehicle Communications

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Boulogeorgos, A. A., Sofotasios, P. C., Muhaidat, S., Valkama, M., Karagiannidis, G. K.
Number of pages: 6
Pages: 960-965
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC)
Publisher: IEEE
The η − µ / Inverse Gamma Composite Fading Model
In this paper we propose a new composite fading model which assumes that the mean signal power of an η - µ signal envelope follows an inverse gamma distribution. The inverse gamma distribution has a simple relationship with the gamma distribution and can be used to model shadowed fading due to its semi heavy-tailed characteristics. To demonstrate the utility of the new η - µ / inverse gamma composite fading model, we investigate the characteristics of the shadowed fading behavior observed in body centric communications channels which are known to be susceptible to shadowing effects, particularly generated by the human body. It is shown that the η - µ / inverse gamma composite fading model provided an excellent fit to the measurement data. Moreover, using Kullback-Leibler divergence, the η - µ / inverse gamma composite fading model was found to provide a better fit to the measured data than the k - µ / inverse gamma composite fading model, for the communication scenarios considered here.

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Ki Yoo, S., Sofotasios, P. C., L. Cotton, S., Matthaiou, M., Valkama, M., Karagiannidis, G. K.
Number of pages: 5
Pages: 978-982
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC)
Publisher: IEEE
ISBN (Print): 978-1-4673-6781-3
DOIs:
10.1109/PIMRC.2015.7343288
Research output: Scientific - peer-review › Conference contribution

The κ − µ / Inverse Gamma Fading Model
Statistical distributions have been extensively used in modeling fading effects in conventional and modern wireless communications. In the present work, we propose a novel κ - µ composite shadowed fading model, which is based on the valid assumption that the mean signal power follows the inverse gamma distribution instead of the lognormal or commonly used gamma distributions. This distribution has a simple relationship with the gamma distribution, but most importantly, its semi heavy-tailed characteristics constitute it suitable for applications relating to modeling of shadowed fading. Furthermore, the derived probability density function of the κ - µ / inverse gamma composite distribution admits a rather simple algebraic representation that renders it convenient to handle both analytically and numerically. The validity and utility of this fading model are demonstrated by means of modeling the fading effects encountered in body centric communications channels, which have been known to be susceptible to the shadowing effect. To this end, extensive comparisons are provided between theoretical and respective real-time measurement results. It is shown that these comparisons exhibit accurate fitting of the new model for various measurement set ups that correspond to realistic communication scenarios.

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Ki Yoo, S., L. Cotton, S., Sofotasios, P. C., Matthaiou, M., Valkama, M., Karagiannidis, G. K.
Number of pages: 5
Pages: 949-953
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC)
Publisher: IEEE
ISBN (Print): 978-1-4673-6781-3
DOIs:
10.1109/PIMRC.2015.7343336
Understanding Practical Limitations of Network Coding for Assisted Proximate Communication

In next-generation wireless networks, device-to-device (D2D) communication represents a feasible way for mobile users to offload their cellular traffic demand without extra costs for deploying additional infrastructure from the network operators. Cellular (e.g., 3GPP LTE) network assistance can automate user/service discovery and connection establishment procedures, as well as enable secure D2D connectivity between proximate users. Currently, assisted direct connectivity is only available in the form of unlicensed-band protocols (e.g., WiFi Direct), which motivates research on understanding its practical limitations with realistic distributions of users and content. Whereas there are concerns that D2D communication alone may not be efficient due to limited content availability, in this paper, we advocate the use of network coding to upgrade assisted proximate communication and make it realize its full potential. In particular, we demonstrate that even simpler network coding techniques are capable to significantly improve the degrees of content availability for communicating users and thus enhance offloading performance under realistic constraints. Inspired by the recent popularity of wireless content distribution systems over D2D caches, we contribute a practical methodology for assisted data caching and distribution, mindful of the state-of-the-art D2D technology.
Understanding the IoT connectivity landscape: a contemporary M2M radio technology roadmap  
This article addresses the market-changing phenomenon of the Internet of Things (IoT), which relies on the underlying paradigm of machine-to-machine (M2M) communications to integrate a plethora of various sensors, actuators, and smart meters across a wide spectrum of businesses. Today the M2M landscape features an extreme diversity of available connectivity solutions which, due to the enormous economic promise of the IoT, need to be harmonized across multiple industries. To this end, we comprehensively review the most prominent existing and novel M2M radio technologies, as well as share our first-hand real-world deployment experiences, with the goal to provide a unified insight into enabling M2M architectures, unique technology features, expected performance, and related standardization developments. We pay particular attention to the cellular M2M sector employing 3GPP LTE technology. This work is a systematic recollection of our many recent research, industrial, entrepreneurial, and standardization efforts within the contemporary M2M ecosystem.
Unified Analysis of Cooperative Spectrum Sensing over Generalized Multipath Fading Channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Mohjazi, L., Dawoud, D., Sofotasios, P. C., Muhaidat, S., Dianati, M., Valkama, M., Karagiannidis, G. K.
Number of pages: 5
Pages: 966-971
Publication date: 2015

Host publication information
Title of host publication: 2015 IEEE 26th International Symposium on Personal, Indoor and Mobile Radio Communications - (PIMRC)
Publisher: IEEE
ISBN (Print): 978-1-4673-6781-3
Research output: Scientific - peer-review › Conference contribution

User’s happiness in numbers: Understanding mobile YouTube quality expectations

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Number of pages: 5
Pages: 607-611
Publication date: 2015

Host publication information
WarmPie: A bare-bones implementation of message passing interface for embedded many-cores
In this paper we present a message-passing based interface, WarmPie, to simplify data communication and management on a Multi-Processor System-on-Chip (MPSoC). WarmPie defines a subset of Message Passing Interface (MPI) library routines. We provide C language implementation of those routines on a 9-core MPSoC. WarmPie offers an abstract view of the MPSoC to facilitate effortless integration of software to hardware. In one use case study of developing a ring communication program on the MPSoC, software development effort is reduced by a factor of 3.75 due to using WarmPie. The application using WarmPie is fully compatible with a reference MPI environment on Linux. WarmPie has a small memory footprint of 7.3KB per core. Although data transmission latency has increased due to using the interface, the overhead is amortized when transferring a bigger payload in one message.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: System-on-Chip for GNSS, Wireless Communications and Cyber-Physical Embedded Computing, Department of Pervasive Computing, Research area: Computer engineering, Wireless Communications and Positioning (WICO)
Authors: Wang, K., Salminen, E., Nurmi, J., Ahonen, T.
Number of pages: 4
Pages: 33-36
Publication date: 2015

Host publication information
Title of host publication: 2015 11th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME)
Publisher: IEEE
DOIs:
10.1109/PRIME.2015.7251087

Bibliographical note
ORG=elt,0.75
ORG=tie,0.25
Research output: Scientific - peer-review › Conference contribution

Wireless Authentication using OPACITY Protocol
Authentication using wireless keys simplifies the user daily life and opens the door to a number of promising applications in the area of pervasive computing, Internet of Things and Tactile Internet. However, this approach raises several research challenges, including but not limited to: which communication technology to use, how to guarantee the relevant security level, and, last but not the least, how to integrate the wireless authentication systems into already deployed authorization solutions. In this paper, we address the above mentioned questions by proposing a wireless authentication solution based on the NFC-capable smartphone and using OPACITY authentication protocol that is compatible with existing access control mechanisms in OS Windows 8. We start with qualitative comparison of Bluetooth, RFID and NFC technologies in terms of applicability for wireless authentication. We then describe the OPACITY protocol in general, and its adaptation to wireless authentication scenario. We finally present the high-level architecture of our solution and highlight some Windows OS specifics we faced during the reference implementation. We believe that demonstrated interoperability between wireless authentication solution and existing access control mechanisms in modern OS provides an important step towards further development of advanced authentication methods, based on wireless keys.

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Emerging Technologies for Nano-Bio-Info-Cogno
Authors: Petrov, V., Bezzateev, S., Zybin, V.
Pages: 253-258
Publication date: 2015

Host publication information
Title of host publication: 2015 7th International Congress on Ultra Modern Telecommunications and Control Systems and Workshops (ICUMT)
Vehicle Positioning
The invention relates to an inertial unit for being attached to a rotatable part of a vehicle, the rotatable part being coupled to a power equipment of the vehicle, the inertial unit comprising: at least one acceleration sensor and/or at least one magnetometer arranged to detect a tilting angle of the rotatable part, and/or at least one counter device arranged to detect rotations of the rotatable part, and at least one gyroscope arranged to detect directions at a rim level of the rotatable part for providing angular information for positioning.

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Pervasive Computing, Research area: Computer engineering
Authors: Collin, J.
Publication date: 15 Dec 2014

Efficient User, Service, or Content Representation for Device Communication
Embodiments described herein relate generally to efficient network-assisted communication between user equipment ("UE"). A first UE may be adapted to determine a plurality of hash values associated with provision of a resource by the first UE. The first UE may further determine a port at which the resource is available to be provided. The first UE may communicate this information to a server. Where a second UE wishes to consume the resource, the second UE may determine a plurality of hash values that correspond to those determined by the first UE. The second UE may transmit these determined hash values to the server. In response, the server may transmit the port and an IP address associated with the first UE to the second UE. The server may further facilitate D2D communication between the UEs for provision of the resource. Other embodiments may be described and/or claimed.

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Authors: Pyattaev, A., Johnsson, K., Andreev, S., Koucheryavy, Y.
Publication date: 4 Dec 2014

Precoded Massive MU-MIMO Uplink Transmission under Transceiver I/Q Imbalance

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Hakkarainen, A., Werner, J., Dandekar, K. R., Valkama, M.
Number of pages: 7
Method and Apparatus for Communicating with Smart Objects

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Pervasive Computing, Research area: Information security, Nokia Technologies
Authors: Savolainen, T., Reunamäki, J., Silverajan, B.
Publication date: 9 Oct 2014

Publication information
Patent number: 20140304381
Original language: English
Research output: Scientific › Patent

Method and apparatus for determining environmental context utilizing features obtained by multiple radio receivers
A method, apparatus and computer program product are provided to facilitate the determination of the environmental context of a mobile terminal. In this regard, the method, apparatus and computer program product may utilize the features obtained by a plurality of different types of radio receivers in order to more precisely determine the environmental context of the mobile terminal. The performance of the mobile terminal including applications executed by the mobile terminal may correspondingly be more accurately tailored to the current environmental context of the mobile terminal.

General information
State: Published
Ministry of Education publication type: H1 Granted patent
Organisations: Department of Pervasive Computing, Research area: Computer engineering
Authors: Eronen, A., Leppänen, J., Collin, J., Parviainen, J., Bojja, J.
Publication date: 16 Sep 2014

Publication information
IPC: H04B17/00
Patent number: US8838147
Priority date: 28/02/13
Priority number: US201113222708
Original language: English
Research output: Scientific › Patent

Interference suppression with antenna arrays in OFDM systems under transceiver I/Q imbalance

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Hakkarainen, A., Werner, J., Dandekar, K., Valkama, M.
Number of pages: 7
Pages: 278-284
Publication date: Jun 2014
Reconfigurable antenna based DOA estimation and localization in cognitive radios: Low complexity algorithms and practical measurements

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Hakkarainen, A., Werner, J., Gulati, N., Patron, D., Pfeil, D., Paaso, H., Mammela, A., Dandekar, K., Valkama, M.
Number of pages: 6
Pages: 454-459
Publication date: Jun 2014

Co-modeling of embedded networks using SystemC and SDL: From theory to practice
This chapter gives an overview of a modeling application in the general embedded systems design flow and presents two general approaches for the embedded networks simulation: network modeling and protocol stack modeling. The authors select two widely used modeling languages, which are SDL and SystemC. The analysis shows that both languages have a number of advantages that could be combined by the joint use of SystemC and SDL. Thus, the authors propose an approach for the SystemC and SDL co-modeling. This approach can be used in practice to perform protocol stack simulation as well as simulation of network operation. Therefore, the authors give examples of co-modeling practical applications.

General information
State: Published
Ministry of Education publication type: A3 Part of a book or another research book
Organisations: Department of Electronics and Communications Engineering, St. Petersburg State University of Aerospace Instrumentation, Nokia
Authors: Olenev, V., Rabin, A., Lavrovskaya, I., Balandin, S., Morozkin, P., Gillet, M.
Number of pages: 28
Pages: 206-233
Publication date: 30 Apr 2014
A blind frequency response mismatch correction algorithm for 4-channel Time-Interleaved ADC

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Singh, S., Epp, M., Vallant, G., Valkama, M., Anttila, L.
Number of pages: 4
Pages: 1304-1307
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Symposium on Circuits and Systems (ISCAS), 1-5 June 2014
ISBN (Print): 978-1-4799-3431-7
DOIs: 10.1109/ISCAS.2014.6865382

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-08-27
Source: researchoutputwizard
Source-ID: 1514
Research output: Scientific - peer-review › Conference contribution

Adaptive mobile tracking in unknown non-line-of-sight conditions with application to digital TV networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Research group: MAT Positioning, Department of Automation Science and Engineering, Research group: Positioning, Wireless Communications and Positioning (WICO)
Authors: Chen, L., Piche, R., Kuusniemi, H., Chen, R.
Number of pages: 10
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Eurasip Journal on Advances in Signal Processing
Volume: 2014
Article number: UNSP 22
ISSN (Print): 1687-6172
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.313 0.78
Publication Forum (2016): 1
Scopus rating (2015): 0.279 0.592
Web of Science (2015): 0.928 0.94 6.4 0.22 0.00612 0.341
Publication Forum (2015): 1
Scopus rating (2014): 0.229 0.54
Web of Science (2014): 0.777 0.941 6.4 0.104 0.00657 0.343
Publication Forum (2014): 1
Scopus rating (2013): 0.267 0.506
Publication Forum (2013): 1
Analysis and Rate Optimization of OFDM-Based Cognitive Radio Networks Under Power Amplifier Nonlinearity

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Baghani, M., Mohammadi, A., Majidi, M., Valkama, M.
Number of pages: 10
Pages: 3410-3419
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Communications
Volume: 62
Issue number: 10
ISSN (Print): 0090-6778
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Web of Science (2015): 2.298 2.192 8.6 0.34 0.03521 1.187
Scopus rating (2014): 1.312 1.99
Web of Science (2014): 1.992 1.973 9.7 0.212 0.03482 1.055
Publication Forum (2014): 3
Scopus rating (2013): 1.856 2.479
Publication Forum (2013): 3
Scopus rating (2012): 1.856 2.138
Publication Forum (2012): 3
Scopus rating (2011): 1.233 1.859
Analytic Expressions and Bounds for Special Functions and Applications in Communication Theory

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Sofotasios, P. C., Tsiftsis, T. A., Brychkov, Y. A., Freear, S., Valkama, M., Karagiannidis, G. K.
Number of pages: 26
Pages: 7798-7823
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Information Theory
Volume: 60
Issue number: 12
ISSN (Print): 0018-9448
Ratings:
Analytic performance evaluation of M-QAM based decode-and-forward relay networks over enriched multipath fading channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Fikadu, M. K., Sofotasios, P. C., Valkama, M., Cui, Q.
Number of pages: 6
Pages: 194-199
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE 10th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), 8-10 October 2014, Larnaca, Cyprus
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-5041-6
DOIs:
10.1109/WiMOB.2014.6962170

Bibliographical note
Analytic solutions to a Marcum Q-function-based integral and application in energy detection of unknown signals over multipath fading channels

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Sofotasios, P. C., Valkama, M., Tsiftsis, T. A., Brychkov, Y. A., Freear, S., Karagiannidis, G. K.
Number of pages: 6
Pages: 260-265
Publication date: 2014

Host publication information
Title of host publication: 2014 9th International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM), 2-4 June 2014, Oulu, Finland
Publisher: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
ISBN (Print): 978-1-63190-003-7
DOIs: 10.4108/icst.crowncom.2014.255383

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-07-18<br/>Publisher name: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
Source: researchoutputwizard
Source-ID: 1528
Research output: Scientific - peer-review › Conference contribution

Analyzing Impacts of Coexistence between M2M and H2H Communication on 3GPP LTE System

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Gudkova, I., Samouylov, K., Buturlin, I., Borodakiy, V., Gerasimenko, M., Galinina, O., Andreev, S.
Number of pages: 13
Pages: 162-174
Publication date: 2014

Host publication information
Publisher: Springer International Publishing
ISBN (Print): 978-3-319-13173-3
ISBN (Electronic): 978-3-319-13174-0

Publication series
Name: Lecture Notes in Computer Science
Volume: 8458
ISSN (Print): 0302-9743
DOIs: 10.1007/978-3-319-13174-0_13

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-15<br/>Publisher name: Springer International Publishing
Source: researchoutputwizard
Source-ID: 372
Analyzing the overload of 3GPP LTE system by diverse classes of connected-mode MTC devices

**General information**
State: Published  
Ministry of Education publication type: A4 Article in a conference publication  
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)  
Authors: Dementev, O., Galinina, O., Gerasimenko, M., Tirronen, T., Torsner, J., Andreev, S., Koucheryavy, Y.  
Number of pages: 4  
Pages: 309-312  
Publication date: 2014

**Host publication information**
Title of host publication: 2014 IEEE World Forum on Internet of Things (WF-IoT), 6-8 March 2014, Seoul, South Korea  
Publisher: Institute of Electrical and Electronics Engineers IEEE  
ISBN (Print): 978-1-4799-3459-1  
DOIs:  
10.1109/WF-IoT.2014.6803178

**Bibliographical note**
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-05-12<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE  
Source: researchoutputwizard  
Source-ID: 255  
Research output: Scientific - peer-review › Conference contribution

Antibody-based molecular communication for targeted drug delivery systems

**General information**
State: Published  
Ministry of Education publication type: A4 Article in a conference publication  
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author  
Authors: Chahibi, Y., Akyildiz, I., Song, S.  
Pages: 5707-5710  
Publication date: 2014

**Host publication information**
Title of host publication: Proceedings of IEEE EMBC 2014  
DOIs:  
10.1109/EMBC.2014.6944923  
Links:  
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84929485695&partnerID=40&md5=aa38edcdeba314660de1e5243c85ecd2d

**Bibliographical note**
cited By 2  
Source: Bibtex  
Source-ID: urn:84b5730ba82c4d21bcb3e68f02f1bdef  
Research output: Scientific - peer-review › Conference contribution

A PET project from Finland: Automating GNSS receiver testing

**General information**
State: Published  
Ministry of Education publication type: B1 Article in a scientific magazine  
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)  
Authors: Thombre, S., Raasakka, J., Paakki, T., Rosa, F., Valkama, M., Ruotsalainen, L., Kuusniemi, H., Nurmi, J.  
Number of pages: 6  
Pages: 45-50  
Publication date: 2014
A roadmap for traffic engineering in software defined networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Akyildiz, I., Lee, A., Wang, P., Luo, M., Chou, W.
Number of pages: 30
Pages: 1-30
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Computer Networks
Volume: 71
ISSN (Print): 1389-1286
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.652 1.694
Publication Forum (2016): 2
Scopus rating (2015): 0.585 1.84
Web of Science (2015): 1.446 1.903 6.9 0.277 0.01334 0.671
A routing framework for energy harvesting wireless nanosensor networks in the Terahertz Band

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Jornet, J., Akkari, N., Almasri, S., Akyildiz, I.
Number of pages: 15
Pages: 1169-1183
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Wireless Networks
Volume: 20
Issue number: 5
ISSN (Print): 1022-0038
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.402 0.969
Publication Forum (2016): 1
Scopus rating (2015): 0.378 1.084
Web of Science (2015): 1.006 1.167 7.0 0.163 0.00354 0.364
Publication Forum (2015): 1
A statistical-physical model of interference in diffusion-based molecular nanonetworks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Number of pages: 11
Pages: 2085-2095
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Communications
Volume: 62
Issue number: 6
ISSN (Print): 0090-6778
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Web of Science (2015): 2.298 2.192 8.6 0.34 0.03521 1.187
Scopus rating (2014): 1.312 1.99

Bibliographical note
cited By 14
Source: Bibtext
Source-ID: urn:6d68619fe2f9c6fc8a24057a75c44718
Research output: Scientific - peer-review › Article

DOI:
10.1007/s11276-013-0665-y
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84903819270&partnerID=40&md5=39f6ae115f1369d79ae5aaa062e7fcbd
Capturing Spatial Randomness of Heterogeneous Cellular/WLAN Deployments With Dynamic Traffic

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Galinina, O., Andreev, S., Gerasimenko, M., Koucheryavy, Y., Himayat, N., Yeh, S., Talwar, S.
Number of pages: 17
Pages: 1083-1099
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 32
Issue number: 6
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.098
Cell planning for outdoor distributed antenna systems in dense urban areas

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Yunas, S. F., Valkama, M., Niemelä, J.
Number of pages: 7
Pages: 1-7
Publication date: 2014

Host publication information
Title of host publication: 2014 16th International Telecommunications Network Strategy and Planning Symposium (Networks), 17-19 September 2014, Funchal, Portugal
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-6515-1
DOIs:
10.1109/NETWKS.2014.6959264

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-11-25<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1829
Research output: Scientific - peer-review › Conference contribution

Cellular traffic offloading onto network-assisted device-to-device connections

General information
Closed-form Analysis of Channel Non-Reciprocity Due to Transceiver and Antenna Coupling Mismatches in Multi-user Massive MIMO Network
Delivering uniform connectivity and service experience to converged 5G wireless networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Andreev, S.
Number of pages: 2
Pages: 323-324
Publication date: 2014
Dense Small-Cell Networks: Rethinking the Radio Interface Beyond LTE-Advanced

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Levanen, T., Pirskanen, J., Valkama, M.
Publication date: 2014

Deployment strategies and performance analysis of Macrocell and Femtocell networks in suburban environment with modern buildings

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Yunas, S. F., Asp, A., Niemelä, J., Valkama, M.
Number of pages: 9
Pages: 643-651
Publication date: 2014
Digital post-processing based wideband receiver linearization for enhanced spectrum sensing and access

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Allen, M., Marttila, J., Valkama, M., Grimm, M., Thomä, R.
Number of pages: 6
Pages: 520-525
Publication date: 2014

Host publication information
Title of host publication: 2014 9th International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM), 2-4 June 2014, Oulu, Finland
Publisher: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
ISBN (Print): 978-1-63190-003-7
Electronic versions:
crowncom2014_postprint
DOIs:
10.4108/icst.crowncom.2014.255428
Links:
http://urn.fi/URN:NBN:fi:ttty-201603183706

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-07-18<br/>Publisher name: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
Source: researchoutputwizard
Source-ID: 95
Research output: Scientific - peer-review › Conference contribution

Digital Suppression of Power Amplifier Spurious Emissions at Receiver Band In FDD Transceivers

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Kiayani, A., Anttila, L., Valkama, M.
Number of pages: 5
Pages: 69-73
Publication date: 2014
Peer-reviewed: Yes

Publication information
Volume: 21
Issue number: 1
ISSN (Print): 1070-9908
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.942 1.805
Publication Forum (2016): 2
Scopus rating (2015): 0.872 1.887
Web of Science (2015): 1.661 1.852 6.3 0.449 0.01578 0.862
Publication Forum (2015): 2
Scopus rating (2014): 0.902 1.993
Web of Science (2014): 1.751 1.926 6.7 0.234 0.01523 0.827
Publication Forum (2014): 2
Scopus rating (2013): 0.876 2.111
Publication Forum (2013): 2
Scopus rating (2012): 0.97 1.883
Distance-aware multi-carrier (DAMC) modulation in Terahertz Band communication

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Han, C., Akyildiz, I.
Pages: 5461-5467
Publication date: 2014

Host publication information
Title of host publication: Proceedings of IEEE ICC 2014
DOIs: 10.1109/ICC.2014.6884190
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84907000429&partnerID=40&md5=ccdcdede9e114c41368ddfb693bc5eab8

Bibliographical note
cited By 5
Source: Bibtex
Source-ID: urn:19e093d4a53b1639ea54dfe34b0c6863
Research output: Scientific - peer-review › Conference contribution

DSP-Based Suppression of Spurious Emissions At RX Band in Carrier Aggregation FDD Transceivers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Kiayani, A., Abdelaziz, M., Anttila, L., Lehtinen, V., Valkama, M.
Number of pages: 5
Pages: 591-595
Publication date: 2014
Effects of Radio Front-end PLL Phase Noise on GNSS Baseband Correlation

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Thombre, S., Tchamov, N. N., Lohan, S., Valkama, M., Nurmi, J.
Number of pages: 9
Pages: 13-21
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Navigation
Volume: 61
Efficient Estimation and Compensation of Transceiver Non-Reciprocity in Precoded TDD Multi-User MIMO-OFDM Systems

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Zou, Y., Raeesi, O., Valkama, M.
Number of pages: 7
Pages: 1-7
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE 80th Vehicular Technology Conference (VTC Fall), 14-17 September 2014, Vancouver, BC, Canada
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-4449-1
DOIs: 10.1109/VTCFall.2014.6965954
Efficient Estimation and Pilot-Free Online Re-Calibration of I/Q Imbalance in Broadband Direct-Conversion Transmitters

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Luo, J., Kortke, A., Keusgen, W., Valkama, M.
Number of pages: 15
Pages: 2506-2520
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Vehicular Technology
Volume: 63
Issue number: 6
Article number: 6691960
ISSN (Print): 0018-9545
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.855 1.91
Publication Forum (2016): 2
Scopus rating (2015): 0.97 2.325
Web of Science (2015): 2.243 2.631 5.5 0.377 0.03526 1.092
Publication Forum (2015): 2
Scopus rating (2014): 1.063 2.567
Web of Science (2014): 1.978 2.483 5.2 0.305 0.03595 1.019
Publication Forum (2014): 3
Scopus rating (2013): 1.599 3.031
Publication Forum (2013): 3
Scopus rating (2012): 1.542 2.852
Publication Forum (2012): 3
Scopus rating (2011): 1.168 2.393
Scopus rating (2010): 0.995 1.927
Scopus rating (2009): 1.074 2.009
Scopus rating (2008): 1.193 2.294
Scopus rating (2007): 1.463 2.8
Scopus rating (2006): 1.055 2.332
Scopus rating (2005): 1.004 1.885
Scopus rating (2004): 1.238 2.185
Scopus rating (2003): 1.283 2.267
Scopus rating (2002): 2.363 2.337
Scopus rating (2001): 1.677 2.108
Scopus rating (2000): 1.739 1.631
Scopus rating (1999): 1.059 2.012
Original language: English
DOIs:
10.1109/TVT.2013.2295940
End-to-end propagation noise and memory analysis for molecular communication over microfluidic channels

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Bicen, A., Akyildiz, I.
Number of pages: 12
Pages: 2432-2443
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Communications
Volume: 62
Issue number: 7
ISSN (Print): 0090-6778
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Web of Science (2015): 2.298 2.192 8.6 0.34 0.03521 1.187
Scopus rating (2014): 1.312 1.99
Web of Science (2014): 1.992 1.973 9.7 0.212 0.03482 1.055
Publication Forum (2014): 3
Scopus rating (2013): 1.856 2.479
Publication Forum (2013): 3
Scopus rating (2012): 1.856 2.138
Publication Forum (2012): 3
Scopus rating (2011): 1.233 1.859
Scopus rating (2010): 1.343 1.893
Scopus rating (2009): 1.779 2.42
Scopus rating (2008): 2.455 2.683
Scopus rating (2007): 2.727 3.018
Scopus rating (2006): 2.533 3.018
Scopus rating (2005): 3.072 3.817
Scopus rating (2001): 3.951 3.014
Scopus rating (2000): 1.871 2.343
Scopus rating (1999): 1.215 1.609
Original language: English
DOI: 10.1109/TCOMM.2014.2323293
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84904813641&partnerID=40&md5=ffed4fac5e8ff7766615067c1b8563

Bibliographical note
cited By 7
Source: Bibtex
Source-ID: urn:6d6542805e5c7b64cc315e954f5598f2
Full-Duplex Transceiver System Calculations: Analysis of ADC and Linearity Challenges

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Korpi, D., Riihonen, T., Syrjälä, V., Anttila, L., Valkama, M., Wichman, R.
Number of pages: 16
Pages: 3821-3836
Publication date: 2014
Peer-reviewed: Yes
Graphene-based plasmonic nano-transceiver for terahertz band communication

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Pages: 492-496
Publication date: 2014

Host publication information
Title of host publication: Proceedings of EuCAP 2014
DOI:
10.1109/EuCAP.2014.6901799
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84908626621&partnerID=40&md5=f16f12e4f60f0ec079d9754f6bba114f

Bibliographical note
cited By 7
Source: Bibtex
Source-ID: urn:896185e23dabc92be3f56e16f52d6c96
Research output: Scientific - peer-review » Conference contribution
IEEE 802.11ac MIMO Receiver Baseband Processing on Customized VLIW Processor

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Department of Pervasive Computing, Wireless Communications and Positioning (WICO)
Authors: Aghababaeetafreshi, M., Lehtonen, L., Levanen, T., Valkama, M., Takala, J.
Number of pages: 6
Pages: 1-6
Publication date: 2014

Host publication information
Title of host publication: SIPS 2014. 2014 IEEE Workshop on Signal Processing Systems, October 20th - 22nd 2014, Belfast, UK
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-14799-6578-8
DOIs: 10.1109/SIPS.2014.6986092

Bibliographical note
Contribution: organisation=elt,FACT1=0.5<br />
Portfolio EDEND: 2014-12-19<br />
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 54
Research output: Scientific - peer-review › Conference contribution

Impact of modern construction materials on radio signal propagation: Practical measurements and network planning aspects

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Asp, A., Sydorov, Y., Kesikikastari, M., Valkama, M., Niemelä, J.
Number of pages: 7
Pages: 1-7
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE 79th Vehicular Technology Conference (VTC2014-Spring), 18-21 May 2014, Seoul, Korea
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-4482-8

Bibliographical note
Contribution: organisation=elt,FACT1=1<br />
Portfolio EDEND: 2014-12-19<br />
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 119
Research output: Scientific - peer-review › Conference contribution

Impact of received signal on self-interference channel estimation and achievable rates in in-band full-duplex transceivers
In this paper we analyze the effect of the calibration period, or lack of, on self-interference channel estimation in the digital domain of in-band full-duplex radio transceivers. In particular, we consider a scenario where the channel estimation must be performed without a separate calibration period, which means that the received signal of interest will act as an additional noise source from the estimation perspective. We will explicitly analyze its effect, and quantify the increase in the parameter estimation variance, or sample size, if similar accuracy for the self-interference channel estimate is to be achieved as with a separate calibration period. In addition, we will analyze how the calibration period, or its absence, affects the overall achievable rates. Full waveform simulations are then used to determine the validity of the obtained results, as well as to provide numerical results regarding the achievable rates. It is shown that, even though a substantial increase in the parameter sample size is required if there is no calibration period, the achievable rates are still comparable for the two scenarios.
Impact of VANET-Based V2X Communication Using IEEE 802.11p on Reducing Vehicles Traveling Time in Realistic Large Scale Urban Area

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning, Wireless Communications and Positioning (WICO)
Authors: Korpi, D., Anttila, L., Valkama, M.
Number of pages: 8
Pages: 975-982
Publication date: 2014

Host publication information
Title of host publication: 2014 48th Asilomar Conference on Signals, Systems and Computers
Publisher: IEEE COMPUTER SOCIETY PRESS
ISBN (Print): 9781479982974
ASJC Scopus subject areas: Computer Networks and Communications, Signal Processing
DOIs:
10.1109/ACSSC.2014.7094599
Source: Scopus
Source-ID: 84940485442
Research output: Scientific - peer-review » Conference contribution

Improving network connectivity in the presence of heavy-tailed interference

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Noori, H., Valkama, M.
Number of pages: 8
Pages: 654-661
Publication date: 2014

Host publication information
Title of host publication: 2013 International Conference on Connected Vehicles and Expo (ICCVE), 2-6 December 2013, Las Vegas, NV, USA
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/ICCVE.2013.6799873
Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-04-29<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1154
Research output: Scientific - peer-review » Conference contribution

Publication information
Journal: IEEE Transactions on Wireless Communications
Volume: 13
Issue number: 10
Number of pages: 13
Pages: 5427-5439
Publication date: 2014
Peer-reviewed: Yes
Intelligent access network selection in converged multi-radio heterogeneous networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Andreev, S., Gerasimenko, M., Galinina, O., Koucheryavy, Y., Himayat, N., Yeh, S., Talwar, S.
Number of pages: 14
Pages: 86-96
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Wireless Communications
Volume: 21
Issue number: 6
ISSN (Print): 1536-1284
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 2.561 3.744
Publication Forum (2016): 2
Lifetime analysis of wireless sensor nodes in different smart grid environments

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Eris, C., Saimler, M., Gungor, V., Fadel, E., Akyildiz, I.
Number of pages: 10
Pages: 2053-2062
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Wireless Networks
Volume: 20
Issue number: 7
ISSN (Print): 1022-0038
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.402 0.969
Publication Forum (2016): 1
Scopus rating (2015): 0.378 1.084
Web of Science (2015): 1.006 1.167 7.0 0.163 0.00354 0.364
Publication Forum (2015): 1
Scopus rating (2014): 0.411 1.417
Web of Science (2014): 0.961 1.068 7.9 0.075 0.00309 0.355
Publication Forum (2014): 1
Scopus rating (2013): 0.448 1.574
Publication Forum (2013): 1
Scopus rating (2012): 0.514 1.394
Publication Forum (2012): 1
Scopus rating (2011): 0.514 1.237
Scopus rating (2010): 0.728 1.586
Scopus rating (2009): 0.732 1.69
Scopus rating (2008): 1.105 2.593
Scopus rating (2007): 0.911 2.549
Scopus rating (2006): 0.982 2.436
Scopus rating (2005): 1.49 2.824
Scopus rating (2004): 2.372 3.201
Scopus rating (2003): 1.596 2.931
Scopus rating (2002): 1.086 1.402
Scopus rating (2001): 1.338 1.683
Scopus rating (2000): 0.819 1.312
Scopus rating (1999): 0.68 0.873
Original language: English
DOIs:
10.1007/s11276-014-0723-0
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84921068102&partnerID=40&md5=b0e46219ada099f6d22eb76e7f58056b

Bibliographical note
Cited By 2
Source: Bibtex
Source-ID: urn:6180f49e9fd58584280921aac1b7efaa
LOS and NLOS channel modeling for terahertz wireless communication with scattered rays

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Moldovan, A., Ruder, M., Akyildiz, I., Gerstacker, W.
Pages: 388-392
Publication date: 2014

Host publication information
Title of host publication: Proceedings of IEEE GLOBECOM 2014 workshops
DOIs: 10.1109/GLOCOMW.2014.7063462
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84946688511&partnerID=40&md5=a30898610971e9df5caaf8257d8bd191

Bibliographical note
cited By 4
Source: Bibtex
Source-ID: urn:d310e01c77dca06f51b2552dfc6bf8c
Research output: Scientific - peer-review › Conference contribution

Low-complexity digital predistortion for reducing power amplifier spurious emissions in spectrally-agile flexible radio

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Signal Processing Research Community (SPRC), Wireless Communications and Positioning (WICO)
Authors: Abdelaziz, M., Anttila, L., Cavallaro, J. R., Bhattacharyya, S. S., Mohammadi, A., Ghannouchi, F., Juntti, M., Valkama, M.
Number of pages: 6
Pages: 323-328
Publication date: 2014

Host publication information
Title of host publication: 2014 9th International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM), 2-4 June 2014, Oulu, Finland
Publisher: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
ISBN (Print): 978-1-63190-003-7
DOIs: 10.4108/icst.crowncom.2014.255387

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-07-18<br/>Publisher name: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
Source: researchoutputwizard
Source-ID: 41
Research output: Scientific - peer-review › Conference contribution

Low latency radio interface for 5G flexible TDD local area communications

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Levanen, T., Pirskanen, J., Koskela, T., Talvitie, J., Valkama, M.
Number of pages: 7
Low power implementation of digital predistortion filter on a heterogeneous application specific multiprocessor

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Signal Processing Research Community (SPRC), Wireless Communications and Positioning (WICO)
Number of pages: 5
Pages: 8336-8340
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Conference on Communications Workshops (ICC), 10-14 June 2014, Sydney, NSW
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOI:
10.1109/ICCW.2014.6881164

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-11-25<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 927
Research output: Scientific - peer-review › Conference contribution

LTE-Advanced and the evolution to Beyond 4G (B4G) systems

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Number of pages: 30
Pages: 31-60
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Physical Communication
Volume: 10
ISSN (Print): 1874-4907
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.422 0.951
Publication Forum (2016): 1
Maximum-minimum energy based spectrum sensing under frequency selectivity for Cognitive Radios

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Dikmese, S., Sofotasios, P. C., Renfors, M., Valkama, M.
Number of pages: 6
Pages: 347-352
Publication date: 2014

Host publication information
Title of host publication: 2014 9th International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CROWNCOM), 2-4 June 2014, Oulu, Finland
Publisher: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
ISBN (Print): 978-1-63190-003-7
DOIs: 10.4108/icst.crowncom.2014.255376

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-07-18<br/>Publisher name: Institute for Computer Sciences, Social Informatics and Telecommunications Engineering ICST
Source: researchoutputwizard
Source-ID: 261
Research output: Scientific - peer-review » Conference contribution

M/D[y]/1 Periodically gated vacation model and its application to IEEE 802.16 network

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering
Authors: Saffer, Z., Andreev, S., Koucheryavy, Y.
Number of pages: 24
Pages: 1-24
Publication date: 2014
Measurement campaign for collaborative sensing using cyclostationary based mobile sensors

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Chaudhari, S., Kosunen, M., Mäkinen, S., Cardenas-Gonzales, A., Koivunen, V., Ryynänen, J., Laatta, M., Valkama, M.
Number of pages: 8
Pages: 283-290
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Symposium on Dynamic Spectrum Access Networks (DYSPAN), 1-4 April 2014, McLean, VA
Publisher: Institute of Electrical and Electronics Engineers IEEE
Modeling and Efficient Cancellation of Nonlinear Self-Interference in MIMO Full-Duplex Transceivers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Anttila, L., Korpi, D., Antonio-Rodriguez, E., Wichman, R., Valkama, M.
Number of pages: 7
Pages: 862-868
Publication date: 2014

Host publication information
Title of host publication: GLOBECOM 2014, IEEE Global Communications Conference, 8-12 December 2014, Austin, TX, USA
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7701-7

Modeling contention-based M2M transmissions over 3GPP LTE cellular networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Ahmadian, A. A., Galinina, O., Andreev, S., Koucheryavy, Y.
Number of pages: 7
Pages: 441-447
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Conference on Communications Workshops (ICC), 10-14 June 2014, Sydney, NSW
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/ICCW.2014.6881238
Modeling Unreliable LSA Operation in 3GPP LTE Cellular Networks

Presently, we observe an unprecedented growth of traffic volumes in modern cellular networks. Consequently, to effectively meet the impeding capacity crunch, current spectrum bands can be extended by using LSA (Licensed Shared Access) - the promising technology that allows an operator to lease additional frequency bands in order to satisfy the increasing data rate requirements. This technology is naturally suitable for the state-of-the-art 3GPP LTE cellular networks, since it allows to flexibly control resource allocation across the network users. Owing to that, the operator can employ the LSA band whenever desired to improve area capacity and increase data rate. However, due to the fact that the LSA band may be unexpectedly revoked by its original owner, there exists a certain chance of degradation in system performance and user service quality. This paper focuses on studying a one-cell 3GPP LTE system over the LSA technology, with both analysis and simulations, by proposing a baseline methodology to model the unreliable operation of an LSA frequency band.

Molecular communication noise and capacity analysis for particulate drug delivery systems

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO)
Authors: Chahibi, Y., Akyildiz, I.
Number of pages: 13
Pages: 3891-3903
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Communications
Volume: 62
Issue number: 11
ISSN (Print): 0090-6778
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Web of Science (2015): 2.298 2.192 8.6 0.34 0.03521 1.187
Multi-channel energy detection under phase noise: analysis and mitigation

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Gokceoglu, A., Zou, Y., Valkama, M., Sofotasios, P. C.
Number of pages: 14
Pages: 473-486
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Mobile Networks and Applications
Volume: 19
Issue number: 4
ISSN (Print): 1383-469X
Ratings:
Scopus rating (2017): 1
Scopus rating (2016): 0.681 1.799
Publication Forum (2016): 1
Scopus rating (2015): 0.562 1.717
Web of Science (2015): 1.538 1.532 6.5 0.301 0.00252 0.529
Publication Forum (2015): 1
Multi-radio heterogeneous networks: Architectures and performance

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Himayat, N., Yeh, S., Panah, A. Y., Talwar, S., Gerasimenko, M., Andreev, S., Koucheryavy, Y.
Number of pages: 7
Pages: 252-258
Publication date: 2014

Host publication information
Title of host publication: 2014 International Conference on Computing, Networking and Communications (ICNC), 3-6 February 2014, Honolulu, HI, USA
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-2358-8
DOIs: 10.1109/ICCNC.2014.6785341

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-05-13<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 478
Research output: Scientific - peer-review › Conference contribution

Multiuser frequency allocation with wideband power amplifier models

General information
Network-Assisted D2D Communications: Implementing a Technology Prototype for Cellular Traffic Offloading

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Pyattaev, A., Johnsson, K., Surak, A., Florea, R., Andreev, S., Koucheryavy, Y.
Number of pages: 6
Pages: 3266-3271
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE Wireless Communications and Networking Conference (WCNC), 6-9 April 2014, Istanbul, Turkey
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
ISBN (Print): 978-1-4799-3083-8
DOI: 10.1109/WCNC.2014.6953070

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-11-25<br/>Publisher name: Institute of Electrical and Electronics Engineers (IEEE)
Source: researchoutputwizard
Source-ID: 1318
Research output: Scientific - peer-review › Conference contribution

Network-Assisted D2D Over WiFi Direct

General information
State: Published
Ministry of Education publication type: A3 Part of a book or another research book
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Pyattaev, A., Galinina, O., Johnsson, K., Surak, A., Florea, R., Andreev, S., Koucheryavy, Y.
Number of pages: 54
Pages: 165-218
Publication date: 2014

Host publication information
Title of host publication: Smart Device to Smart Device Communication
Publisher: Springer
Editors: Mumtaz, S., Rodriguez, J.
ISBN (Print): 978-3-319-04962-5
ISBN (Electronic): 978-3-319-04963-2
DOI: 10.1007/978-3-319-04963-2_7

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-15<br/>Publisher name: Springer
Source: researchoutputwizard
Source-ID: 1316
Research output: Scientific - peer-review › Chapter

New Spectrally and Energy Efficient Flexible TDD Based Air Interface for 5G Small Cells

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Levanen, T., Talvitie, J., Pirskanen, J., Valkama, M.
Number of pages: 7
On modulation for magnetic induction based transmission in wireless underground sensor networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Akyildiz, I., Gerstacker, W.
Pages: 71-76
Publication date: 2014

Host publication information
Title of host publication: Proceedings of IEEE ICC 2014
DOI:
10.1109/ICC.2014.6883297
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84907005752&partnerID=40&md5=2f91f589ff9307d9740c73623d3b204f

Bibliographical note
cited By 1
Source: Bibtex
Source-ID: urn:11324c80280a60d5a5d805d0391d16d7
Research output: Scientific - peer-review › Conference contribution

On receiver design for diffusion-based molecular communication

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Meng, L., Yeh, P., Akyildiz, I.
Number of pages: 13
Pages: 6032-6044
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Signal Processing
Volume: 62
Issue number: 22
ISSN (Print): 1053-587X
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.591 2.587
Publication Forum (2016): 3
Scopus rating (2015): 1.756 2.783
Web of Science (2015): 2.624 3.157 7.8 0.462 0.06262 1.528
Web of Science (2014): 2.787 3.435 7.4 0.429 0.06161 1.473
Web of Science (2013): 2.504 3.349
Web of Science (2012): 2.404 3.552
Web of Science (2011): 1.957 3.005
Web of Science (2010): 2.201 2.925
Web of Science (2009): 2.034 2.929
Web of Science (2008): 1.912 2.751
Web of Science (2005): 2.399 3.964
Web of Science (2004): 2.165 3.661
Web of Science (2002): 1.545 1.876
Web of Science (2001): 1.21 1.716
Web of Science (1999): 0.564 1.521
Scopus rating (2015): 3
Scopus rating (2014): 1.867 2.925
Scopus rating (2013): 2.504 3.349
Scopus rating (2012): 2.404 3.552
Scopus rating (2011): 1.957 3.005
Scopus rating (2010): 2.201 2.925
Scopus rating (2009): 2.034 2.929
Scopus rating (2008): 1.912 2.751
Scopus rating (2006): 2.033 3.36
Scopus rating (2005): 2.399 3.964
Scopus rating (2004): 2.165 3.661
Scopus rating (2002): 1.545 1.876
Scopus rating (2001): 1.21 1.716
Scopus rating (2000): 1.125 2.623
Scopus rating (1999): 0.564 1.521
Original language: English
DOIs: 10.1109/TSP.2014.2359644
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84908432899&partnerID=40&md5=a6d89cbe2c8056c31bb201f04638d3ba

Bibliographical note
cited By 11
Source: Bibtex
Source-ID: urn:50649ba393cb771bf6bdc1f5b1d5db85
Research output: Scientific - peer-review › Article


General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Shorgin, S., Samouylov, K., Gudkova, I., Galinina, O., Andreev, S.
Number of pages: 4
Pages: 151-154
Publication date: 2014

Host publication information
Title of host publication: SDN & NFV: Next Generation of Computational Infrastructure. 2014 International Science and Technology Conference, Modern Networking Technologies (MoNeTec), Moscow, Russia, October 27-29, 2014, Proceedings
Publisher: MOCKBA
ISBN (Print): 978-5-317-04829-7

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/><br/>Portfolio EDEND: 2014-12-30<br/><br/>Publisher name: MOCKBA
Source: researchoutputwizard
On the Optimal Assisted Rate Allocation in N-Tier Multi-RAT Heterogeneous Networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Moltchanov, D., Gerasimenko, M., Wang, Q., Andreev, S., Koucheryavy, Y.
Number of pages: 6
Pages: 1525-1530
Publication date: 2014

Host publication information
Title of host publication: 25th IEEE international symposium on personal, indoor and mobile radio communications (PIMRC), September 2-5, 2014, Washington, DC, USA
ISBN (Print): 978-1-4799-4912-0
DOIs: 10.1109/PIMRC.2014.7136410

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-19
Source: researchoutputwizard
Source-ID: 1093
Research output: Scientific - peer-review › Conference contribution

Optimal energy-throughput efficiency for magneto-inductive underground sensor networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Lin, S., Akyildiz, I., Wang, P., Sun, Z.
Pages: 22-27
Publication date: 2014

Host publication information
Title of host publication: Proceedings of IEEE BlacSeaCom 2014
DOIs: 10.1109/BlackSeaCom.2014.6848997
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84904540312&partnerID=40&md5=ed0416f12d954031626f7c231949856

Bibliographical note
cited By 0
Source: Bibtex
Source-ID: urn:68c05231f61db136f92806f9e7218e09
Research output: Scientific - peer-review › Conference contribution

Optimized Power Allocation and Spectrum Sharing in Device to Device underlaying Cellular Systems

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Han, J., Cui, Q., Yang, C., Valkama, M., Tao, X.
Number of pages: 6
Pages: 1332-1337
Publication date: 2014
Optimizing energy efficiency of a multi-radio mobile device in heterogeneous beyond-4G networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Galinina, O., Andreev, S., Turlikov, A., Koucheryavy, Y.
Number of pages: 24
Pages: 18-41
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Performance Evaluation
Volume: 78
ISSN (Print): 0166-5316
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.563 1.242
Publication Forum (2016): 2
Scopus rating (2015): 0.499 1.472
Web of Science (2015): 0.944 1.091 9.0 0.191 0.00283 0.584
Publication Forum (2015): 2
Scopus rating (2014): 0.617 1.628
Web of Science (2014): 1.25 1.312 8.1 0.119 0.0036 0.728
Publication Forum (2014): 2
Scopus rating (2013): 0.628 1.848
Publication Forum (2013): 2
Scopus rating (2012): 0.533 1.737
Publication Forum (2012): 2
Scopus rating (2011): 0.461 1.423
Scopus rating (2010): 0.651 2.2
Scopus rating (2009): 0.804 2.093
Scopus rating (2008): 0.784 1.641
Scopus rating (2007): 0.675 1.13
Scopus rating (2006): 0.816 1.424
Scopus rating (2005): 0.591 1.316
Scopus rating (2004): 0.686 1.567
Scopus rating (2003): 0.634 1.178
Scopus rating (2002): 0.817 1.307
Scopus rating (2001): 0.547 1.194
Scopus rating (2000): 0.395 0.853
Scopus rating (1999): 0.572 0.739
Performance evaluation of IEEE 802.11ah and its restricted access window mechanism

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Raeesi, O., Pirskanen, J., Hazmi, A., Levanen, T., Valkama, M.
Number of pages: 7
Pages: 460-466
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Conference on Communications Workshops (ICC), 10-14 June 2014, Sydney, NSW
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs: 10.1109/ICCW.2014.6881241

Bibliographical note
Contribution: organisation=elt,FACT1=1
Portfolio EDEND: 2014-11-25
Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1323
Research output: Scientific - peer-review › Conference contribution

Performance evaluation of MDT assisted LTE RF fingerprint framework

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering
Authors: Mondal, R., Turkka, J., Ristaniemi, T., Henttonen, T.
Number of pages: 5
Pages: 33-37
Publication date: 2014

Host publication information
Article number: 6799054
ISBN (Print): 978-1-4799-2231-4
DOIs: 10.1109/ICMU.2014.6799054

Bibliographical note
Contribution: organisation=elt,FACT1=1
Portfolio EDEND: 2015-01-22
Source: researchoutputwizard
Phase noise mitigation in OFDMA uplink

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Samara, L., Syrjälä, V., Hamila, R., Valkama, M.
Number of pages: 4
Pages: 344-347
Publication date: 2014

Host publication information
Title of host publication: 2014 6th International symposium on communications, control and signal processing (ISCCSP), 21-23 May 2014, Athens
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-2890-3
DOI:
10.1109/ISCCSP.2014.6877884

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-09-15<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1445
Research output: Scientific - peer-review › Conference contribution

Predicting user QoE satisfaction in current mobile networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Number of pages: 6
Pages: 1088-1093
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE International Conference on Communications (ICC), 10-14 June 2014, Sydney, NSW
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOI:
10.1109/ICC.2014.6883466

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-09-30<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 502
Research output: Scientific - peer-review › Conference contribution

Radio Interface Design for Ultra-Low Latency Millimeter-Wave Communications in 5G Era

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Radio Interface Evolution towards 5G and Enhanced Local Area Communications

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Levanen, T., Pirskanen, J., Koskela, T., Talvitie, J., Valkama, M.
Pages: 1005-1029
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: IEEE Access
Volume: 2
ISSN (Print): 2169-3536
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.801 1.927
Publication Forum (2016): 1
Scopus rating (2015): 0.735 3.404
Web of Science (2015): 1.249 1.254 1.8 20.0 0.00198 0.706
Publication Forum (2015): 1
Scopus rating (2014): 0.961 2.218
Original language: English
DOIs:
10.1109/ACCESS.2014.2355415

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-09-15<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 928
Research output: Scientific - peer-review › Article

Reduced-complexity power amplifier linearization for carrier aggregation mobile transceivers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Abdelaziz, M., Anttila, L., Mohammadi, A., Ghannouchi, F., Valkama, M.
Number of pages: 5
Reference Receiver Based Digital Self-Interference Cancellation in MIMO Full-Duplex Transceivers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Korpi, D., Anttila, L., Valkama, M.
Number of pages: 7
Pages: 1099-1105
Publication date: 2014

Host publication information
Title of host publication: GLOBECOM 2014, IEEE Global Communications Conference, 8-12 December 2014, Austin, TX, USA
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-7701-7

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-09<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 767
Research output: Scientific - peer-review › Conference contribution

Signature-assisted rendezvous in OFDM-based cognitive networks using sub-Nyquist samples

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Razavi, A., Valkama, M., Cabric, D.
Number of pages: 4
Pages: 401-404
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE 8th Sensor Array and Multichannel Signal Processing Workshop (SAM), 22-25 June 2014, A Coruna, Spain
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-1481-4
DOIs: 10.1109/SAM.2014.6882427
Spectral Efficiency of Dynamic DAS with Extreme Down-tilt Antenna Configuration

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Yunas, S. F., Valkama, M., Niemelä, J.
Number of pages: 6
Publication date: 2014

Host publication information
Title of host publication: 7th International WDN Workshop on Cooperative and Heterogeneous Cellular Networks (WDN-CN2014), IEEE 25th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), September 2-5, 2014, Washington, DC
ISBN (Print): 9781479949120
DOIs: 10.1109/PIMRC.2014.7136535

Techno-economic analysis and comparison of legacy and ultra-dense small cell networks

General information
State: Published
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Yunas, S. F., Niemelä, J., Valkama, M., Isotalo, T.
Number of pages: 9
Publication date: 2014

Host publication information
Title of host publication: 2014 IEEE 39th Conference on Local Computer Networks Workshops (LCN Workshops), 8-11 Sept. 2014, Edmonton, AB, Canada
ISBN (Print): 978-1-4799-3782-0
DOIs: 10.1109/LCNW.2014.6927733

Terahertz band: Next frontier for wireless communications

General information
State: Published
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
The Area Under a Receiver Operating Characteristic Curve Over Enriched Multipath Fading Conditions

The Area Under a Receiver Operating Characteristic Curve Over Enriched Multipath Fading Conditions

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Sofotasios, P., Fikadu, M., Ho-Van, K., Valkama, M., Karagiannidis, G. K.
Number of pages: 6
Pages: 4327-4332
Publication date: 2014

Host publication information
Title of host publication: GLOBECOM 2014, IEEE Global Communications Conference, 8-12 December 2014, Austin, TX, USA
Publisher: Institute of Electrical and Electronics Engineers IEEE
ISBN (Print): 978-1-4799-3511-6

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-19<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Transmitter-side channel estimation in magnetic induction based communication systems

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Akyildiz, I., Gerstacker, W.
Pages: 16-21
Publication date: 2014

Host publication information
Title of host publication: Proceedings of IEEE BlacSeaCom 2014
DOIs:
10.1109/BlackSeaCom.2014.6848996
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84904576166&partnerID=40&md5=8530501c4e37ba69eeeb3b1bf19ac86c7

Bibliographical note
cited By 2
Source: Bibtex
Source-ID: urn:5be155a874e8292957eb70bcc0826021
Research output: Scientific - peer-review › Conference contribution

Two Approaches to Analyzing Dynamic Cellular Networks with Limited Resources

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Naumov, V., Samouylov, K., Sopin, E., Andreev, S.
Number of pages: 4
Pages: 585-588
Publication date: 2014

Host publication information
Title of host publication: ICUMT 2014, 6th International Congress on Ultra Modern Telecommunications and Control Systems, October 6-8, 2014, St. Petersburg, Russia
Publisher: Institute of Electrical and Electronics Engineers IEEE
DOIs:
10.1109/ICUMT.2014.7002149

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-12-19<br/>Publisher name: Institute of Electrical and Electronics Engineers IEEE
Source: researchoutputwizard
Source-ID: 1127
Research output: Scientific - peer-review › Conference contribution

User Guided Energy and Capacity Optimization In UMTS Mobile Networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Research group: Laboratory of Radio Network Planning, Wireless Communications and Positioning (WICO)
Authors: Säe, J., Lempiäinen, J.
Number of pages: 5
Pages: 861-865
Publication date: 2014
A cross-layer communication module for the Internet of Things

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Han, C., Jornet, J., Fadel, E., Akyildiz, I.
Number of pages: 12
Pages: 622-633
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Computer Networks
Volume: 57
Issue number: 3
ISSN (Print): 1389-1286
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.652 1.694
Publication Forum (2016): 2
Scopus rating (2015): 0.585 1.84
Web of Science (2015): 1.446 1.903 6.9 0.277 0.01334 0.671
Publication Forum (2015): 2
Scopus rating (2014): 0.639 2.011
Web of Science (2014): 1.256 1.714 6.7 0.573 0.01228 0.64
Publication Forum (2014): 2
Scopus rating (2013): 0.722 2.682
Publication Forum (2013): 2
Scopus rating (2012): 0.755 2.307
Publication Forum (2012): 2
A differential coding-based scheduling framework for wireless multimedia sensor networks

State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Dai, R., Akyildiz, I.
Number of pages: 14
Pages: 684-697
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Multimedia
Volume: 15
Issue number: 3
ISSN (Print): 1520-9210
Ratings:
Advanced self-interference cancellation and multiantenna techniques for full-duplex radios

General information

State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Korpi, D., Venkatasubramanian, S., Riihonen, T., Anttila, L., Otewa, S., Icheln, C., Haneda, K., Tretyakov, S., Valkama, M., Wichman, R.
Number of pages: 6
Pages: 3-8
Publication date: 2013

Host publication information
Title of host publication: 2013 Asilomar Conference on Signals, Systems and Computers, 3-6 November 2013, Pacific Grove, CA, USA
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
DOIs: 10.1109/ACSSC.2013.6810217
A molecular communication system model for particulate drug delivery systems

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Chahibi, Y., Pierobon, M., Song, S., Akyildiz, I.
Number of pages: 16
Pages: 3468-3483
Publication date: 2013
Peer-reviewed: Yes

Publication Information
Journal: IEEE Transactions on Biomedical Engineering
Volume: 60
Issue number: 12
ISSN (Print): 0018-9294
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 1.214 1.995
Publication Forum (2016): 1
Scopus rating (2015): 1.132 2.083
Web of Science (2015): 2.468 2.719 8.9 0.625 0.02454 0.888
Publication Forum (2015): 1
Scopus rating (2014): 0.84 1.973
Web of Science (2014): 2.347 2.567 8.7 0.519 0.02257 0.761
Publication Forum (2014): 2
Scopus rating (2013): 1.081 2.073
Publication Forum (2013): 2
Scopus rating (2012): 0.816 1.706
Publication Forum (2012): 2
Scopus rating (2011): 0.7 1.715
Scopus rating (2010): 0.686 1.637
Scopus rating (2009): 0.81 1.94
Scopus rating (2008): 0.826 1.719
Scopus rating (2007): 1.144 2.187
Scopus rating (2006): 1.317 2.426
Scopus rating (2005): 1.023 2.252
Scopus rating (2004): 0.73 1.689
Scopus rating (2003): 0.849 1.367
Scopus rating (2002): 0.888 1.428
Scopus rating (2001): 0.767 1.578
Scopus rating (2000): 0.942 1.505
Scopus rating (1999): 0.613 2.187
Original language: English
DOI:
10.1109/TBME.2013.2271503
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84889601358&partnerID=40&md5=07f662009e19fdcd4bb753d8438f136

Bibliographical note
Asymptotic queuing analysis for dynamic spectrum access networks in the presence of heavy tails

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Akyildiz, I.
Number of pages: 9
Pages: 514-522
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 31
Issue number: 3
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.098
Web of Science (2014): 3.453 3.822 7.9 0.524 0.03251 2.192
Publication Forum (2014): 3
Scopus rating (2013): 2.843 4.106
Publication Forum (2013): 3
Scopus rating (2012): 2.747 3.9
Publication Forum (2012): 3
Scopus rating (2011): 2.903 4.68
Scopus rating (2008): 3.316 4.527
Scopus rating (2007): 2.955 4.5
Scopus rating (2006): 2.852 4.803
Scopus rating (2005): 3.769 5.814
Scopus rating (2004): 4.221 4.958
Scopus rating (2003): 3.538 4.93
Scopus rating (2002): 5.527 4.293
Scopus rating (2000): 2.454 2.689
Scopus rating (1999): 1.919 2.668
Original language: English
DOIs:
10.1109/JSAC.2013.130316
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84876401863&partnerID=40&md5=296924e2c3c51da5452a7d1545a6380c

Bibliographical note
Cited By 32
Source: Bibtex
Blackseacom 2013, communications and networking in the land of "Golden Fleece"

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Akyildiz, I., Ulema, M.
Number of pages: 2
Pages: 14-15
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Communications Magazine
Volume: 51
Issue number: 12
ISSN (Print): 0163-6804
Ratings:
Publication Forum (2017): 2
Publication Forum (2016): 2
Web of Science (2015): 5.125 5.194 4.9 0.729 0.04043 2.538
Publication Forum (2014): 3
Scopus rating (2014): 2.678 4.808
Web of Science (2014): 4.007 4.756 5.3 0.901 0.0384 2.428
Publication Forum (2013): 3
Scopus rating (2013): 2.584 5.643
Publication Forum (2012): 3
Scopus rating (2012): 2.867 5.416
Publication Forum (2011): 2.242 5.121
Scopus rating (2010): 2.29 3.65
Scopus rating (2009): 1.817 3.976
Scopus rating (2008): 1.893 3.918
Scopus rating (2007): 2.331 4.411
Scopus rating (2006): 2.085 4.483
Scopus rating (2005): 2.788 5.649
Scopus rating (2000): 2.945 3.261
Scopus rating (1999): 1.974 2.863
Original language: English
DOIs:
10.1109/MCOM.2013.6685748
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84891612023&partnerID=40&md5=97d35ec125eef54cca225006329964d0

Bibliographical note
cited By 0
Source: Bibtex
Source-ID: urn:d18e3b72cf91862590c97c1634d5bffb
Research output: Scientific - peer-review › Article
Cancellation of power amplifier induced nonlinear self-interference in full-duplex transceivers

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Anttila, L., Korpi, D., Syrjälä, V., Valkama, M.
Number of pages: 6
Pages: 1193-1198
Publication date: 2013

Host publication information
Title of host publication: 2013 Asilomar Conference on Signals, Systems and Computers, 3-6 November 2013, Pacific Grove, CA, USA
Publisher: Institute of Electrical and Electronics Engineers, IEEE
DOIs: 10.1109/ACSSC.2013.6810482

Bibliographical note
Contribution: organisation=elt,FACT1=1<br/>Portfolio EDEND: 2014-05-09<br/>Publisher name: Institute of Electrical and Electronics Engineers, IEEE
Source: researchoutputwizard
Source-ID: 1930
Research output: Scientific - peer-review > Conference contribution

Capacity of a diffusion-based molecular communication system with channel memory and molecular noise

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Number of pages: 13
Pages: 942-954
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Information Theory
Volume: 59
Issue number: 2
ISSN (Print): 0018-9448
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.678 2.004
Publication Forum (2016): 3
Scopus rating (2015): 1.796 2.317
Web of Science (2015): 1.737 2.35 >10.0 0.329 0.05441 1.379
Scopus rating (2014): 1.944 2.544
Web of Science (2014): 2.326 3.002 9.7 0.46 0.05797 1.447
Publication Forum (2014): 3
Scopus rating (2013): 3.012 3.29
Publication Forum (2013): 3
Scopus rating (2012): 2.838 3.078
Publication Forum (2012): 3
Scopus rating (2011): 2.779 3.313
Scopus rating (2010): 3.17 2.952
Channel capacity of magnetic induction based Wireless Underground Sensor Networks under practical constraints

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Gerstacker, W., Schober, R., Sun, Z., Akyildiz, I.
Pages: 2603-2608
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE WCNC 2013
DOIs: 10.1109/WCNC.2013.6554972
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84881561114&partnerID=40&md5=17f0dd393fc33d9f53504e310f607c

Bibliographical note
cited By 75
Source: Bibtex
Source-ID: urn:289edec3915c5650f182e91dda6b0876
Research output: Scientific - peer-review › Article

Characterization and exploitation of heterogeneous OFDM primary users in cognitive radio networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Vizziello, A., Akyildiz, I., Agusti, R., Favalli, L., Savazzi, P.
Number of pages: 13
Pages: 1073-1085
Publication date: 2013
Peer-reviewed: Yes

Publication information
Cognitive radio resource management exploiting heterogeneous primary users and a radio environment map database

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Vizziello, A., Akyildiz, I., Agustí, R., Favalli, L., Savazzi, P.
Number of pages: 14
Pages: 1203-1216
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Wireless Networks
Volume: 19
Enabling next generation small cells through femtorelays

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Akyildiz, I., Chavarria-Reyes, E., Gutierrez-Estevez, D., Balakrishnan, R., Krier, J.
Number of pages: 15
Pages: 1-15
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Physical Communication
Volume: 9
ISSN (Print): 1874-4907
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.422 0.951
Publication Forum (2016): 1
Scopus rating (2015): 0.46 0.898
Publication Forum (2015): 1
Scopus rating (2014): 0.84 0.935
Publication Forum (2014): 1
Scopus rating (2013): 1.2 1.325
Publication Forum (2013): 1
Scopus rating (2012): 0.913 0.981
Publication Forum (2012): 1
Scopus rating (2011): 0.896 1.566
Scopus rating (2010): 0.869 1.97
Scopus rating (2009): 0.557 1.378
Original language: English
DOIs:
10.1016/j.phycom.2013.04.001
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84878807376&partnerID=40&md5=9d630337c3e9bf30b85db122cdf82734
Energy and spectrum-aware MAC protocol for perpetual wireless nanosensor networks in the Terahertz Band

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Jornet, J., Abbas Malik, M., Akkari, N., Akyildiz, I.
Number of pages: 15
Pages: 2541-2555
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Ad Hoc Networks
Volume: 11
Issue number: 8
ISSN (Print): 1570-8705
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.724 2.115
Publication Forum (2016): 2
Scopus rating (2015): 0.731 2.194
Web of Science (2015): 1.66 2.151 4.9 0.374 0.00699 0.742
Publication Forum (2015): 2
Scopus rating (2014): 0.673 2.161
Web of Science (2014): 1.53 2.109 5.3 0.232 0.00634 0.71
Publication Forum (2014): 2
Scopus rating (2013): 0.66 2.559
Publication Forum (2013): 2
Scopus rating (2012): 1.164 3.817
Publication Forum (2012): 2
Scopus rating (2011): 1.147 3.443
Scopus rating (2010): 1.105 2.589
Scopus rating (2009): 1.026 2.537
Scopus rating (2008): 1.38 2.918
Scopus rating (2006): 1.817 4.186
Scopus rating (2005): 1.563 4.829
Scopus rating (2004): 2.04 3.044
Original language: English
DOIs: 10.1016/j.adhoc.2013.07.002
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84885316083&partnerID=40&md5=8e83b04ef98a77cb8bb954cc5bd982cd

Bibliographical note
cited By 30
Source: Bibtex
Source-ID: urn:5ddb89bd4385b3dc0c41f5072c5fb978
Research output: Scientific - peer-review › Article
Fundamentals of diffusion-based molecular communication in nanonetworks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Number of pages: 147
Pages: 1-147
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Foundations and Trends in Networking
Volume: 8
Issue number: 1-2
Original language: English
DOIs: 10.1561/1300000033
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84899424213&partnerID=40&md5=9ae824f1710ae6450959acabc1939c3b

Bibliographical note
cited By 2
Source: Bibtex
Source-ID: urn:8ed8f30e09dec3d2d94a0778667fd2f3
Research output: Scientific - peer-review › Article

Graphene-based plasmonic nano-antenna for terahertz band communication in nanonetworks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Number of pages: 10
Pages: 685-694
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 31
Issue number: 12
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.098
Web of Science (2014): 3.453 3.822 7.9 0.524 0.03251 2.192
Publication Forum (2014): 3
Scopus rating (2013): 2.843 4.106
Publication Forum (2013): 3
Scopus rating (2012): 2.747 3.9
Publication Forum (2012): 3
Scopus rating (2011): 2.903 4.68
Increasing the capacity of magnetic induction communications in RF-challenged environments

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I., Kisseleff, S., Gerstacker, W.
Number of pages: 10
Pages: 3943-3952
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Communications
Volume: 61
Issue number: 9
ISSN (Print): 0090-6778
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.386 1.915
Publication Forum (2016): 3
Scopus rating (2015): 1.358 2.235
Web of Science (2015): 2.298 2.192 8.6 0.34 0.03521 1.187
Scopus rating (2014): 1.312 1.99
Web of Science (2014): 1.992 1.973 9.7 0.212 0.03482 1.055
Publication Forum (2014): 3
Scopus rating (2013): 1.856 2.479
Publication Forum (2013): 3
Scopus rating (2012): 1.856 2.138
Publication Forum (2012): 3
Scopus rating (2011): 1.233 1.859
Scopus rating (2010): 1.343 1.893
Interference polarization in magnetic induction based Wireless Underground Sensor Networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Akyildiz, I., Gerstacker, W.
Pages: 71-75
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE PIMRC 2013
DOIs: 10.1109/PIMRCW.2013.6707839
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84893568113&partnerID=40&md5=e1e3d7ec9c35d80debac0e68899a273d

Mobile transmitter digital predistortion: Feasibility analysis, algorithms and design exploration

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Signal Processing Research Community (SPRC), Wireless Communications and Positioning (WICO)
Authors: Abdelaziz, M., Ghazi, A., Anttila, L., Boutellier, J., Lähteensuo, T., Lu, X., Cavallaro, J. R., Bhattacharyya, S. S., Juntti, M., Valkama, M.
Number of pages: 8
Pages: 2046-2053
Publication date: 2013
Molecular transport in microfluidic channels for flow-induced molecular communication

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Bicen, A., Akyildiz, I.
Pages: 766-770
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE ICC 2013
DOIs: 10.1109/ICCW.2013.6649336
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-8489081076&partnerID=40&md5=09e0ad2da25d36ca9fb6df78bb222c8

Bibliographical note
cited By 2
Source: Bibtex
Source-ID: urn:2abb298727353fcc3e6f389d32f8cd4d
Research output: Scientific - peer-review › Conference contribution

Multiuser resource allocation optimization using bandwidth-power product in cognitive radio networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Tachwali, Y., Lo, B., Akyildiz, I., Agusti, R.
Number of pages: 13
Pages: 451-463
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 31
Issue number: 3
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
On the throughput of Wireless Underground Sensor Networks using magneto-inductive waveguides

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Gerstacker, W., Sun, Z., Akyildiz, I.
Pages: 322-328
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE GLOBECOM 2013
DOIs:
10.1109/GLOCOM.2013.6831091

Bibliographical note
cited By 49
Source: Bibtex
Source-ID: urn:6f22ff55b0103c2b2512ca97ac3369f7
Research output: Scientific - peer-review › Article

On the throughput of Wireless Underground Sensor Networks using magneto-inductive waveguides

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kisseleff, S., Gerstacker, W., Sun, Z., Akyildiz, I.
Pages: 322-328
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE GLOBECOM 2013
DOIs:
10.1109/GLOCOM.2013.6831091

Bibliographical note
cited By 3
Source: Bibtex
Source-ID: urn:2ae971347735c326e41984b768880002
Research output: Scientific - peer-review › Conference contribution
Radio access network energy minimization in multi-layer heterogeneous wireless systems

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Chavarria-Reyes, E., Akyildiz, I.
Pages: 3259-3263
Publication date: 2013
Reinforcement learning for cooperative sensing gain in cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Lo, B., Akyildiz, I.
Number of pages: 14
Pages: 1237-1250
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: Wireless Networks
Volume: 19
Issue number: 6
ISSN (Print): 1022-0038
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.402 0.969
Publication Forum (2016): 1
Scopus rating (2015): 0.378 1.084
Web of Science (2015): 1.006 1.167 7.0 0.163 0.00354 0.364
Publication Forum (2015): 1
Scopus rating (2014): 0.411 1.417
Web of Science (2014): 0.961 1.068 7.9 0.075 0.00309 0.355
Publication Forum (2014): 1
Scopus rating (2013): 0.448 1.574
Publication Forum (2013): 1
Scopus rating (2012): 0.514 1.394
Publication Forum (2012): 1
Scopus rating (2011): 0.514 1.237
Scopus rating (2010): 0.728 1.586
Scopus rating (2009): 0.732 1.69
Scopus rating (2008): 1.105 2.593
Scopus rating (2007): 0.911 2.549
Scopus rating (2006): 0.982 2.436
Scopus rating (2005): 1.49 2.824
Scopus rating (2004): 2.372 3.201
Scopus rating (2003): 1.596 2.931
Scopus rating (2002): 1.086 1.402
Scopus rating (2001): 1.338 1.683
Scopus rating (2000): 0.819 1.312
Scopus rating (1999): 0.68 0.873
System-theoretic analysis and least-squares design of microfluidic channels for flow-induced molecular communication

**General information**
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Bicen, A., Akyildiz, I.
Number of pages: 14
Pages: 5000-5013
Publication date: 2013
Peer-reviewed: Yes

**Publication information**
Journal: IEEE Transactions on Signal Processing
Volume: 61
Issue number: 20
ISSN (Print): 1053-587X
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.591 2.587
Publication Forum (2016): 3
Scopus rating (2015): 1.756 2.783
Web of Science (2015): 2.624 3.157 7.8 0.462 0.06262 1.528
Scopus rating (2014): 1.867 2.925
Web of Science (2014): 2.787 3.435 7.4 0.429 0.06161 1.473
Publication Forum (2014): 3
Scopus rating (2013): 2.504 3.349
Publication Forum (2013): 3
Scopus rating (2012): 2.404 3.552
Publication Forum (2012): 3
Scopus rating (2011): 1.957 3.005
Scopus rating (2010): 2.201 2.925
Scopus rating (2009): 2.034 2.929
Scopus rating (2008): 1.912 2.751
Scopus rating (2006): 2.033 3.36
Scopus rating (2005): 2.399 3.964
Scopus rating (2004): 2.165 3.661
Scopus rating (2002): 1.545 1.876
Scopus rating (2001): 1.21 1.716
Scopus rating (2000): 1.125 2.623
Scopus rating (1999): 0.564 1.521

Original language: English
DOIs: 10.1007/s11276-012-0530-4
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84880306616&partnerID=40&md5=2095996d5cb2b9b1965758e186649b4d

Bibliographical note
cited By 9
Source: Bibtext
Source-ID: urn:aeff62762b45a4f67b8eb785000c0e9c
Research output: Scientific - peer-review › Article
TCP CRAHN: A transport control protocol for cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Chowdhury, K., Di Felice, M., Akyildiz, I.
Number of pages: 14
Pages: 790-803
Publication date: 2013
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Mobile Computing
Volume: 12
Issue number: 4
ISSN (Print): 1536-1233
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.146 2.835
Publication Forum (2016): 3
Web of Science (2015): 2.456 3.145 5.1 0.413 0.01713 1.398
Web of Science (2014): 2.543 3.011 5.1 0.367 0.01544 1.353
Publication Forum (2014): 2
Scopus rating (2013): 1.706 4.22
Publication Forum (2013): 2
Scopus rating (2012): 1.836 3.747
Publication Forum (2012): 2
Scopus rating (2011): 1.671 4.089
Scopus rating (2010): 1.789 3.735
Scopus rating (2009): 2.01 3.843
Scopus rating (2008): 1.859 3.761
Scopus rating (2007): 1.859 3.948
Scopus rating (2006): 2.477 5.185
Scopus rating (2005): 3.149 5.678
Scopus rating (2004): 2.785 8.08
Scopus rating (2003): 1.146 4.604
Original language: English
DOIs:
10.1109/TMC.2012.59
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84874584381&partnerID=40&md5=e7c77f6733a49afe7d3f5d30011cd6d5

Bibliographical note
Traffic-aware utility based QoS provisioning in OFDMA hybrid smallcells

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Balakrishnan, R., Canberk, B., Akyildiz, I.
Pages: 6464-6468
Publication date: 2013

Host publication information
Title of host publication: Proceedings of IEEE ICC 2013
DOIs: 10.1109/ICC.2013.6655647
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84891368915&partnerID=40&md5=cc2fc5c12eaf8e1eaca0e8a4e619a71

Bibliographical note
cited By 0

A complete femtocell network modeling and development platform

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Reyes, E., Gutierrez-Estevez, D., Akyildiz, I.
Pages: 5142-5147
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE GLOBECOM 2012
DOIs: 10.1109/GLOCOM.2012.6503936
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84877677440&partnerID=40&md5=6c495280c87a61aedee5e4e17c511650

Bibliographical note
cited By 0

A diffusion-based binary digital communication system

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Meng, L., Yeh, P., Chen, K., Akyildiz, I.
Pages: 4985-4989
Publication date: 2012
A receiver architecture for pulse-based electromagnetic nanonetworks in the Terahertz Band

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Cid-Fuentes, R., Jornet, J., Akyildiz, I., Alarcon, E.
Pages: 4937-4942
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE ICC 2012
DOI: 10.1109/ICC.2012.6364476
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84871951865&partnerID=40&md5=371743b1eb7e45d5383dd72d534d31e5
Bibliographical note
cited By 5
Source: Bibtex
Source-ID: urn:756f599a95ccc585c1f69abd4794c4d5
Research output: Scientific - peer-review › Conference contribution

Correlation-aware QoS routing with differential coding for wireless video sensor networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Dai, R., Wang, P., Akyildiz, I.
Number of pages: 11
Pages: 1469-1479
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Multimedia
Volume: 14
Issue number: 5
ISSN (Print): 1520-9210
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 1.49 2.583
Publication Forum (2016): 2
Scopus rating (2015): 1.216 2.592
Web of Science (2015): 2.536 2.695 4.8 0.211 0.01196 1.141
Publication Forum (2015): 2
Correlation-aware user selection for cooperative spectrum sensing in cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Cacciapuoti, A., Akyildiz, I., Paura, L.
Number of pages: 10
Pages: 297-306
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 30
Issue number: 2
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.408
Web of Science (2014): 3.453 3.822 7.9 0.524 0.03251 2.192

Original language: English
DOIs: 10.1109/TMM.2012.2194992
Links:
hhttps://www.scopus.com/inward/record.uri?eid=2-s2.0-84866503492&partnerID=40&md5=8a8c5ca4d123cbb0c2df4c052ec00d2f

Bibliographical note
cited By 23
Source: Bibtex
Source-ID: urn:5c40c07460da4e53ccb1381f4952c81c
Research output: Scientific - peer-review › Article
Dynamic cooperator selection in cognitive radio networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Vučević, N., Akyildiz, I., Pérez-Romero, J.
Number of pages: 14
Pages: 789-802
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Ad Hoc Networks
Volume: 10
Issue number: 5
ISSN (Print): 1570-8705
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.724 2.115
Publication Forum (2016): 2
Scopus rating (2015): 0.731 2.194
Web of Science (2015): 1.66 2.151 4.9 0.374 0.00699 0.742
Publication Forum (2015): 2
Scopus rating (2014): 0.673 2.161
Web of Science (2014): 1.53 2.109 5.3 0.232 0.00634 0.71
Publication Forum (2014): 2
Scopus rating (2013): 0.66 2.559
Publication Forum (2013): 2
Scopus rating (2012): 1.164 3.817
Interference effects on modulation techniques in diffusion based nanonetworks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kuran, M., Yilmaz, H., Tugcu, T., Akyildiz, I.
Number of pages: 9
Pages: 65-73
Publication date: 2012
Intersymbol and co-channel interference in diffusion-based molecular communication

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Pages: 6126-6131
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE ICC 2012
DOI:
10.1109/ICC.2012.6364970

Bibliographical note
cited By 12
Source: Bibtex
Source-ID: urn:ab446119062db0bc19366c345384a663
Research output: Scientific - peer-review › Conference contribution

Joint energy harvesting and communication analysis for perpetual wireless nanosensor networks in the terahertz band

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Number of pages: 11
Pages: 570-580
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Nanotechnology
MIMO communications based on molecular diffusion

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Meng, L., Yeh, P., Chen, K., Akyildiz, I.
Pages: 5380-5385
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE GLOBECOM 2012
DOI:
10.1109/GLOCOM.2012.6503976
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84877645616&partnerID=40&md5=69ad51184b8385370061e3b2d900b90a

Bibliographical note
cited By 9
Monaco: Fundamentals of molecular nano-communication networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Akyildiz, I., Fekri, F., Sivakumar, R., Forest, C., Hammer, B.
Number of pages: 7
Pages: 12-18
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Wireless Communications
Volume: 19
Issue number: 5
ISSN (Print): 1536-1284
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 2.561 3.744
Publication Forum (2016): 2
Scopus rating (2015): 2.114 4.443
Web of Science (2015): 4.148 5.234 4.8 0.779 0.01527 2.747
Publication Forum (2015): 2
Scopus rating (2014): 2.618 3.467
Web of Science (2014): 5.417 5.381 4.4 0.568 0.01696 3.132
Publication Forum (2014): 2
Scopus rating (2013): 3.093 5.4
Publication Forum (2013): 2
Scopus rating (2012): 1.841 4.129
Publication Forum (2012): 2
Scopus rating (2011): 1.482 3.298
Scopus rating (2009): 1.833 3.49
Scopus rating (2008): 2.36 4.411
Scopus rating (2007): 2.87 6.552
Scopus rating (2006): 2.639 5.809
Scopus rating (2005): 3.008 4.739
Scopus rating (2004): 3.363 5.223
Scopus rating (2002): 5.573 5.193
Scopus rating (2001): 5.836 6.702
Scopus rating (2000): 2.508 2.981
Scopus rating (1999): 2.146 3.77
Original language: English
DOIs: 10.1109/MWC.2012.6339467
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84879218699&partnerID=40&md5=552b943fbc30e834f40e66b7a86be230

Bibliographical note
cited By 42
Source: Bibtex
Source-ID: urn:ceaff7f0faaa8ffa141c1ffebea704907
Multiagent jamming-resilient control channel game for cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Lo, B., Akyildiz, I.
Pages: 1821-1826
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE ICC 2012
DOI:
10.1109/ICC.2012.6364117
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84872001756&partnerID=40&md5=fd0d323e8b947a3dfd081072fe24e280

Bibliographical note
cited By 8
Source: Bibtex
Source-ID: urn:e3650b7090f7d9323374b78baddad83
Research output: Scientific - peer-review » Conference contribution

Network stability of cognitive radio networks in the presence of heavy tailed traffic

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Akyildiz, I.
Pages: 165-173
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE SECON 2012
DOI:
10.1109/SECON.2012.6275773
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84867969264&partnerID=40&md5=a5e9a178fd738d1b36e586e3b222064

Bibliographical note
cited By 3
Source: Bibtex
Source-ID: urn:65618e9876f5de367a81b3d66a805b7d
Research output: Scientific - peer-review » Conference contribution

On capacity of magnetic induction-based wireless underground sensor networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I.
Pages: 370-378
Publication date: 2012

Host publication information
Title of host publication: Proceedings of IEEE INFOCOM 2012
DOI:
On the origins of heavy-tailed delay in dynamic spectrum access networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Akyildiz, I.
Number of pages: 14
Pages: 204-217
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Mobile Computing
Volume: 11
Issue number: 2
ISSN (Print): 1536-1233
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.146 2.835
Publication Forum (2016): 3
Web of Science (2015): 2.456 3.145 5.1 0.413 0.01713 1.398
Web of Science (2014): 2.543 3.011 5.1 0.367 0.01544 1.353
Publication Forum (2014): 2
Scopus rating (2013): 1.706 4.22
Publication Forum (2013): 2
Scopus rating (2012): 1.836 3.747
Publication Forum (2012): 2
Scopus rating (2011): 1.671 4.089
Scopus rating (2010): 1.789 3.735
Scopus rating (2009): 2.01 3.843
Scopus rating (2008): 1.859 3.761
Scopus rating (2007): 1.859 3.948
Scopus rating (2006): 2.477 5.185
Scopus rating (2005): 3.149 5.678
Scopus rating (2004): 2.785 8.08
Scopus rating (2003): 1.146 4.604
Original language: English
DOIs:
10.1109/TMC.2011.187

Bibliographical note
cited By 11
Source: Bibtex
Source-ID: urn:8f9b45219996bc4ea3b7ad7bbcf3a5e
Research output: Scientific - peer-review › Conference contribution
OPERA: Optimal routing metric for cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Caleffi, M., Akyildiz, I., Paura, L.
Number of pages: 11
Pages: 2884-2894
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Wireless Communications
Volume: 11
Issue number: 8
ISSN (Print): 1536-1276
Ratings:
Publication Forum (2017): 3
Publication Forum (2016): 3
Scopus rating (2015): 1.86 2.745
Web of Science (2015): 2.925 3.16 5.4 0.451 0.05843 1.594
Scopus rating (2014): 1.671 2.335
Web of Science (2014): 2.496 2.82 5.4 0.352 0.05447 1.326
Publication Forum (2014): 3
Scopus rating (2013): 2.442 3.024
Publication Forum (2013): 3
Scopus rating (2012): 2.496 3.108
Publication Forum (2012): 3
Scopus rating (2011): 2.019 2.934
Scopus rating (2010): 1.902 2.45
Scopus rating (2009): 1.827 2.473
Scopus rating (2008): 2.041 2.576
Scopus rating (2007): 2.282 2.853
Scopus rating (2006): 2.179 3.043
Scopus rating (2005): 2.291 3.101
Scopus rating (2004): 2.654 4.856
Scopus rating (2003): 2.067 3.471
Original language: English
DOIs:
10.1109/TWC.2012.061912.111479
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84865386522&partnerID=40&md5=1886b4fdb1c5d4a7a7e91311049d858b

Bibliographical note
cited By 35
Source: Bibtex
Source-ID: urn:d20493821c177488bfaac1a17aa0ec1
Research output: Scientific - peer-review » Article

Optimal detection for diffusion-based communications in the presence of ISI

General information
State: Published
QoS-aware user Cohabitation Coordinator in Cognitive Radio Networks

Spatio-temporal estimation for interference management in femtocell networks

General information
Spectrum-aware mobility management in cognitive radio cellular networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Lee, W., Akyildiz, I.
Number of pages: 14
Pages: 529-542
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Mobile Computing
Volume: 11
Issue number: 4
ISSN (Print): 1536-1233
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.146 2.835
Publication Forum (2016): 3
Web of Science (2015): 2.456 3.145 5.1 0.413 0.01713 1.398
Web of Science (2014): 2.543 3.011 5.1 0.367 0.01544 1.353
Publication Forum (2014): 2
Scopus rating (2013): 1.706 4.22
Publication Forum (2013): 2
Scopus rating (2012): 1.836 3.747
Publication Forum (2012): 2
Scopus rating (2011): 1.671 4.089
Scopus rating (2010): 1.789 3.735
Scopus rating (2009): 2.01 3.843
Scopus rating (2008): 1.859 3.761
Scopus rating (2007): 1.859 3.948
Scopus rating (2006): 2.477 5.185
Scopus rating (2005): 3.149 5.678
Scopus rating (2004): 2.785 8.08
Scopus rating (2003): 1.146 4.604
Original language: English
DOIs: 10.1109/TMC.2011.69

Bibliographical note

cited By 6
Source: Bibtex
Source-ID: urn:0439637957553063caefe7179c49986a
Research output: Scientific - peer-review › Conference contribution

Terahertz channel modeling of underground sensor networks in oil reservoirs

General information
State: Published
The internet of multimedia Nano-Things

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Number of pages: 10
Pages: 242-251
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Nano Communication Networks
Volume: 3
Issue number: 4
ISSN (Print): 1878-7789
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.364 0.736
Publication Forum (2016): 1
Scopus rating (2015): 0.487 0.973
Publication Forum (2015): 1
Scopus rating (2014): 0.592 0.696
Scopus rating (2013): 0.932 0.972
Scopus rating (2012): 0.783 2.549
Scopus rating (2011): 0.283 1.686
Original language: English
DOIs:
10.1016/j.nancom.2012.10.001
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84870246513&partnerID=40&md5=92cab3f7caa6600ab0dc111b821016b8

Bibliographical note
cited By 14
Source: Bibtex
Source-ID: urn:2663dcd4289bf9cf00a9ad540592fe6b
Research output: Scientific - peer-review › Article
The internet of multimedia nano-things in the terahertz band

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Publication date: 2012

Host publication information
Title of host publication: Proceedings of European Wireless 2012
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84907075478&partnerID=40&md5=e84e6f840dc1ad241dd0de70b57dd78b

Bibliographical note
 cited By 0
Source: Bibtex
Source-ID: urn:9117b1330d755b4b2819cd373fe291
Research output: Scientific - peer-review › Conference contribution

A mode-based approach for channel modeling in underground tunnels under the impact of vehicular traffic flow

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I.
Number of pages: 10
Pages: 3222-3231
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Wireless Communications
Volume: 10
Issue number: 10
ISSN (Print): 1536-1276
Ratings:
Publication Forum (2017): 3
Publication Forum (2016): 3
Scopus rating (2015): 1.86 2.745
Web of Science (2015): 2.925 3.16 5.4 0.451 0.05843 1.594
Scopus rating (2014): 1.671 2.335
Web of Science (2014): 2.496 2.82 5.4 0.352 0.05447 1.326
Publication Forum (2014): 3
Scopus rating (2013): 2.442 3.024
Publication Forum (2013): 3
Scopus rating (2012): 2.496 3.108
Publication Forum (2012): 3
Scopus rating (2011): 2.019 2.934
Scopus rating (2010): 1.902 2.45
Scopus rating (2009): 1.827 2.473
Scopus rating (2008): 2.041 2.576
Scopus rating (2007): 2.282 2.853
Scopus rating (2006): 2.179 3.043
Scopus rating (2005): 2.291 3.101
Scopus rating (2004): 2.654 4.856
A spatial correlation-based image compression framework for wireless multimedia sensor networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Dai, R., Akyildiz, I.
Number of pages: 14
Pages: 388-401
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Multimedia
Volume: 13
Issue number: 2
ISSN (Print): 1520-9210
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 1.49 2.583
Scopus rating (2015): 1.216 2.592
Web of Science (2015): 2.536 2.695 4.8 0.211 0.01196 1.141
Publication Forum (2015): 2
Scopus rating (2014): 0.972 2.759
Web of Science (2014): 2.303 2.467 5.5 0.303 0.01014 1.011
Publication Forum (2014): 2
Scopus rating (2013): 1.009 2.826
Publication Forum (2013): 2
Scopus rating (2012): 0.907 2.721
Publication Forum (2012): 2
Scopus rating (2011): 0.843 2.691
Scopus rating (2010): 0.935 2.425
Scopus rating (2009): 0.98 2.539
Scopus rating (2008): 1.219 2.799
Scopus rating (2007): 1.235 2.804
Scopus rating (2005): 1.019 3.448
Scopus rating (2004): 0.974 3.79
Scopus rating (2003): 2.099 4.141
Scopus rating (2002): 2.87 5.051
Scopus rating (2001): 2.509 5.741
Scopus rating (2000): 0.819 2.397
Original language: English
DOIs:
A spectrum decision framework for cognitive radio networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Lee, W., Akyildiz, I.
Number of pages: 14
Pages: 161-174
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Mobile Computing
Volume: 10
Issue number: 2
ISSN (Print): 1536-1233
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.146 2.835
Publication Forum (2016): 3
Web of Science (2015): 2.456 3.145 5.1 0.413 0.01713 1.398
Web of Science (2014): 2.543 3.011 5.1 0.367 0.01544 1.353
Publication Forum (2014): 2
Scopus rating (2013): 1.706 4.22
Publication Forum (2013): 2
Scopus rating (2012): 1.836 3.747
Publication Forum (2012): 2
Scopus rating (2011): 1.671 4.089
Scopus rating (2010): 1.789 3.735
Scopus rating (2009): 2.01 3.843
Scopus rating (2008): 1.859 3.761
Scopus rating (2007): 1.859 3.948
Scopus rating (2006): 2.477 5.185
Scopus rating (2005): 3.149 5.678
Scopus rating (2004): 2.785 8.08
Scopus rating (2003): 1.146 4.604
Original language: English
DOIs:
10.1109/TMM.2010.2100374
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-79952958296&partnerID=40&md5=5e55abed9a41f150b2d14977de4d9863

Bibliographical note
cited By 23
Source: Bibtex
Source-ID: urn:1b9ff05369d98557defe146b028f66be
Research output: Scientific - peer-review › Article
Automata modeling of Quorum Sensing for nanocommunication networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Abadal, S., Akyildiz, I.
Number of pages: 10
Pages: 74-83
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Nano Communication Networks
Volume: 2
Issue number: 1
ISSN (Print): 1878-7789
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.364 0.736
Publication Forum (2016): 1
Scopus rating (2015): 0.487 0.973
Publication Forum (2015): 1
Scopus rating (2014): 0.592 0.696
Scopus rating (2013): 0.932 0.972
Scopus rating (2012): 0.783 2.549
Scopus rating (2011): 0.283 1.686
Original language: English
DOIs:
10.1016/j.nancom.2011.04.004
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-79956189035&partnerID=40&md5=2decfe160c954c93d4124b9029330607

Bio-inspired synchronization for nanocommunication networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Abadal, S., Akyildiz, I.
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE Globecom 2011
DOIs:
10.1109/GLOCOM.2011.6133931
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-84857212953&partnerID=40&md5=e1fe311472931e2761373491392c0134
BorderSense: Border patrol through advanced wireless sensor networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Number of pages: 10
Pages: 468-477
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Ad Hoc Networks
Volume: 9
Issue number: 3
ISSN (Print): 1570-8705
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.724 2.115
Publication Forum (2016): 2
Scopus rating (2015): 0.731 2.194
Web of Science (2015): 1.66 2.151 4.9 0.374 0.00699 0.742
Publication Forum (2015): 2
Scopus rating (2014): 0.673 2.161
Web of Science (2014): 1.53 2.109 5.3 0.232 0.00634 0.71
Publication Forum (2014): 2
Scopus rating (2013): 0.66 2.559
Publication Forum (2013): 2
Scopus rating (2012): 1.164 3.817
Publication Forum (2012): 2
Scopus rating (2011): 1.147 3.443
Scopus rating (2010): 1.105 2.589
Scopus rating (2009): 1.026 2.537
Scopus rating (2008): 1.38 2.918
Scopus rating (2006): 1.817 4.186
Scopus rating (2005): 1.563 4.829
Scopus rating (2004): 2.04 3.044
Original language: English
DOIs:
10.1016/j.adhoc.2010.09.008
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-78651354776&partnerID=40&md5=d95c68ba2dbbd4b9d4805179711b1d04

Bibliographical note
cited By 0
Source: Bibtex
Source-ID: urn:e86bf17e17096a74a7dcee9d57764bb3
Research output: Scientific - peer-review › Conference contribution
Can dynamic spectrum access induce heavy tailed delay?

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Akyildiz, I.
Pages: 197-207
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE DySPAN 2011
DOIs: 10.1109/DYSPAN.2011.5936206
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-79960691653&partnerID=40&md5=3f617f7a3ca79c171bbcb87537f11da4

Bibliographical note
cited By 3
Source: Bibtex
Source-ID: urn:2e148124817dc4d37f14caff0a715200
Research output: Scientific - peer-review › Conference contribution

Capacity and outage analysis of MIMO and cooperative communication systems in underground tunnels

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I., Hancke, G.
Number of pages: 11
Pages: 3793-3803
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Wireless Communications
Volume: 10
Issue number: 11
ISSN (Print): 1536-1276
Ratings:
Publication Forum (2017): 3
Publication Forum (2016): 3
Scopus rating (2015): 1.86 2.745
Web of Science (2015): 2.925 3.16 5.4 0.451 0.05843 1.594
Scopus rating (2014): 1.671 2.335
Web of Science (2014): 2.496 2.82 5.4 0.352 0.05447 1.326
Publication Forum (2014): 3
Scopus rating (2013): 2.442 3.024
Publication Forum (2013): 3
Scopus rating (2012): 2.496 3.108
Publication Forum (2012): 3
Scopus rating (2011): 2.019 2.934
Scopus rating (2010): 1.902 2.45
Scopus rating (2009): 1.827 2.473
Scopus rating (2008): 2.041 2.576
Scopus rating (2007): 2.282 2.853
Channel modeling and capacity analysis for electromagnetic wireless nanonetworks in the terahertz band

**General information**

State: Published

Ministry of Education publication type: A1 Journal article-refereed

Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author

Authors: Jornet, J., Akyildiz, I.

Number of pages: 11

Pages: 3211-3221

Publication date: 2011

Peer-reviewed: Yes

**Publication information**

Journal: IEEE Transactions on Wireless Communications

Volume: 10

Issue number: 10

ISSN (Print): 1536-1276

Ratings:

- Publication Forum (2017): 3
- Publication Forum (2016): 3
- Scopus rating (2015): 1.86 2.745
- Web of Science (2015): 2.925 3.16 5.4 0.451 0.05843 1.594
- Scopus rating (2014): 1.671 2.335
- Web of Science (2014): 2.496 2.82 5.4 0.352 0.05447 1.326
- Publication Forum (2014): 3
- Scopus rating (2013): 2.442 3.024
- Publication Forum (2013): 3
- Scopus rating (2012): 2.496 3.108
- Publication Forum (2012): 3
- Scopus rating (2011): 2.019 2.934
- Scopus rating (2010): 1.902 2.45
- Scopus rating (2009): 1.827 2.473
- Scopus rating (2008): 2.041 2.576
- Scopus rating (2007): 2.282 2.853
- Scopus rating (2006): 2.179 3.043
- Scopus rating (2005): 2.291 3.101
- Scopus rating (2004): 2.654 4.856

Original language: English

**DOIs:**

10.1109/TWC.2011.080611.102077

Links:

https://www.scopus.com/inward/record.uri?eid=2-s2.0-8355176089&partnerID=40&md5=936db0575174db60d2f2e5d2d10ceaeb

Bibliographical note

cited By 10

Source: Bibtex

Source-ID: urn:f73d89625353eab1ddcf4d45ff44d9

Research output: Scientific - peer-review › Article
Cooperative spectrum sensing in cognitive radio networks: A survey

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Former organisation of the author
Authors: Akyildiz, I., Lo, B., Balakrishnan, R.
Number of pages: 23
Pages: 40-62
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Physical Communication
Volume: 4
Issue number: 1
ISSN (Print): 1874-4907
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.422 0.951
Publication Forum (2016): 1
Scopus rating (2015): 0.46 0.898
Publication Forum (2015): 1
Scopus rating (2014): 0.84 0.935
Publication Forum (2014): 1
Scopus rating (2013): 1.2 1.325
Publication Forum (2013): 1
Scopus rating (2012): 0.913 0.981

Scopus rating (2013): 0.722 2.682
Publication Forum (2013): 2
Scopus rating (2012): 0.755 2.307
Publication Forum (2012): 2
Scopus rating (2011): 0.808 2.446
Scopus rating (2010): 0.764 2.2
Scopus rating (2009): 0.873 1.992
Scopus rating (2008): 0.906 1.889
Scopus rating (2007): 0.969 1.948
Scopus rating (2006): 0.921 1.724
Scopus rating (2005): 1.053 2.091
Scopus rating (2004): 1.073 2.024
Scopus rating (2003): 0.749 1.878
Scopus rating (2002): 0.765 1.387
Scopus rating (2001): 0.424 0.872
Scopus rating (2000): 0.382 0.809
Scopus rating (1999): 0.311 0.64

Original language: English
DOIs:
10.1016/j.comnet.2010.12.026
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-78651360090&partnerID=40&md5=2d875aa7624c20c7d9893014009dacb7

Bibliographical note
 cited By 0
Source: Bibtex
Source-ID: urn:89129ab6937e9a50ac37ca7fb52a07b1
Research output: Scientific - peer-review › Article
CRP: A routing protocol for cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Chowdhury, K., Akyildiz, I.
Number of pages: 11
Pages: 794-804
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Journal on Selected Areas in Communications
Volume: 29
Issue number: 4
ISSN (Print): 0733-8716
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 2.28 3.408
Publication Forum (2016): 3
Scopus rating (2015): 2.322 3.975
Web of Science (2015): 3.672 4.149 7.6 0.647 0.03652 2.468
Scopus rating (2014): 2.128 3.098
Web of Science (2014): 3.453 3.822 7.9 0.524 0.03251 2.192
Publication Forum (2014): 3
Scopus rating (2013): 2.843 4.106
Publication Forum (2013): 3
Scopus rating (2012): 2.747 3.9
Publication Forum (2012): 3
Scopus rating (2011): 2.903 4.68
Scopus rating (2008): 3.316 4.527
Scopus rating (2007): 2.955 4.5
Scopus rating (2006): 2.852 4.803
Scopus rating (2005): 3.769 5.814
Scopus rating (2004): 4.221 4.958
Scopus rating (2003): 3.538 4.93
Scopus rating (2002): 5.527 4.293
Diffusion-based noise analysis for molecular communication in nanonetworks

**General information**

State: Published

Ministry of Education publication type: A1 Journal article-refereed

Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author

Authors: Pierobon, M., Akyildiz, I.

Number of pages: 16

Pages: 2532-2547

Publication date: 2011

Peer-reviewed: Yes

**Publication information**

Journal: IEEE Transactions on Signal Processing

Volume: 59

Issue number: 6

ISSN (Print): 1053-587X

Ratings:

Publication Forum (2017): 3

Scopus rating (2016): 1.591 2.587

Publication Forum (2016): 3

Scopus rating (2015): 1.756 2.783

Web of Science (2015): 2.624 3.157 7.8 0.462 0.06262 1.528


Scopus rating (2014): 1.867 2.925

Web of Science (2014): 2.787 3.435 7.4 0.429 0.06161 1.473

Publication Forum (2014): 3

Scopus rating (2013): 2.504 3.349

Publication Forum (2013): 3

Scopus rating (2012): 2.404 3.552

Publication Forum (2012): 3

Scopus rating (2011): 1.957 3.005

Scopus rating (2010): 2.201 2.925

Scopus rating (2009): 2.034 2.929

Scopus rating (2008): 1.912 2.751


Scopus rating (2006): 2.033 3.36

Scopus rating (2005): 2.399 3.964

Scopus rating (2004): 2.165 3.661


Scopus rating (2002): 1.545 1.876

Scopus rating (2001): 1.21 1.716
Dynamic connectivity in wireless underground sensor networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I., Hancke, G.
Number of pages: 11
Pages: 4334-4344
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Wireless Communications
Volume: 10
Issue number: 12
ISSN (Print): 1536-1276
Ratings:
Publication Forum (2017): 3
Publication Forum (2016): 3
Scopus rating (2015): 1.86 2.745
Web of Science (2015): 2.925 3.16 5.4 0.451 0.05843 1.594
Scopus rating (2014): 1.671 2.335
Web of Science (2014): 2.496 2.82 5.4 0.352 0.05447 1.326
Publication Forum (2014): 3
Scopus rating (2013): 2.442 3.024
Publication Forum (2013): 3
Scopus rating (2012): 2.496 3.108
Publication Forum (2012): 3
Scopus rating (2011): 2.019 2.934
Scopus rating (2010): 1.902 2.45
Scopus rating (2009): 1.827 2.473
Scopus rating (2008): 2.041 2.576
Scopus rating (2007): 2.282 2.853
Scopus rating (2006): 2.179 3.043
Scopus rating (2005): 2.291 3.101
Scopus rating (2004): 2.654 4.856
Scopus rating (2003): 2.067 3.471
Original language: English
DOIs:
10.1109/TSP.2011.2114656
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-79957457576&partnerID=40&md5=d075c2b30c496b34c0ba50a5c32b0a39
Information capacity of diffusion-based molecular communication in nanonetworks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Pages: 506-510
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE INFOCOM 2011
DOIs: 10.1109/INFCOM.2011.5935214
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-79960860252&partnerID=40&md5=c18e4650c6a31aa2db937c646115de09

Bibliographical note
cited By 16
Source: Bibtex
Source-ID: urn:37e2bbd044568a23debd85bfcdfc71fd9
Research output: Scientific - peer-review › Conference contribution

Information capacity of pulse-based Wireless Nanosensor Networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Pages: 80-88
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE SECON 2011
DOIs: 10.1109/SAHCN.2011.5984951
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-80052792156&partnerID=40&md5=f2da3aad1b9cd6d3e2af8a5efacbd053

Bibliographical note
cited By 22
Source: Bibtex
Source-ID: urn:40b9d45fa7390477d790a33d85796c01
Research output: Scientific - peer-review › Conference contribution

Low-weight channel coding for interference mitigation in electromagnetic nanonetworks in the terahertz band

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Jornet, J., Akyildiz, I.
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE ICC 2011
DOIs:
MISE-PIPE: Magnetic induction-based wireless sensor networks for underground pipeline monitoring

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Number of pages: 10
Pages: 218-227
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Ad Hoc Networks
Volume: 9
Issue number: 3
ISSN (Print): 1570-8705

Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.724 2.115
Publication Forum (2016): 2
Scopus rating (2015): 0.731 2.194
Web of Science (2015): 1.66 2.151 4.9 0.374 0.00699 0.742
Publication Forum (2015): 2
Scopus rating (2014): 0.673 2.161
Web of Science (2014): 1.53 2.109 5.3 0.232 0.00634 0.71
Publication Forum (2014): 2
Scopus rating (2013): 0.66 2.559
Publication Forum (2013): 2
Scopus rating (2012): 1.164 3.817
Publication Forum (2012): 2
Scopus rating (2011): 1.147 3.443
Scopus rating (2010): 1.105 2.589
Scopus rating (2009): 1.026 2.537
Scopus rating (2008): 1.38 2.918
Scopus rating (2006): 1.817 4.186
Scopus rating (2005): 1.563 4.829
Scopus rating (2004): 2.04 3.044

Original language: English
DOIs:
10.1109/icc.2011.5962987

Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-80052137988&partnerID=40&md5=ddb174e3ffbd582a016a1a280f7225b7

Bibliographical note
cited By 2
Source: Bibtex
Source-ID: urn:67ad9d6222df4d2ce7ead5e4c30a175b
Research output: Scientific - peer-review » Conference contribution

Bibliographical note
cited By 64
Mobile relay and group mobility for 4G WiMAX networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Balakrishnan, R., Yang, X., Venkatachalam, M., Akyildiz, I.
Pages: 1224-1229
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE WCNC 2011
DOIs:
10.1109/WCNC.2011.5779334
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-79959295116&partnerID=40&md5=da4ef7bf7f653818f6a344f90b4ea8a7

Bibliographical note
cited By 6
Source: Bibtex

Modulation techniques for communication via diffusion in nanonetworks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Kuran, M., Yilmaz, H., Tugcu, T., Akyildiz, I.
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE ICC 2011
DOIs:
10.1109/icc.2011.5962989
Links:
https://www.scopus.com/inward/record.uri?eid=2-s2.0-80052174766&partnerID=40&md5=f623a721065276957b0eb22b851b4582

Bibliographical note
cited By 3
Source: Bibtex

Nanonetworks: A new frontier in communications

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Akyildiz, I., Jornet, J., Pierobon, M.
Number of pages: 6
Pages: 84-89
Publication date: 2011
Peer-reviewed: Yes
Noise analysis in ligand-binding reception for molecular communication in nanonetworks

General Information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Pierobon, M., Akyildiz, I.
Number of pages: 15
Pages: 4168-4182
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Signal Processing
OFDM-based common control channel design for cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Chowdhury, K., Akyildiz, I.
Number of pages: 11
Pages: 228-238
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE Transactions on Mobile Computing
Volume: 10
Issue number: 2
On network connectivity of wireless sensor networks for sandstorm monitoring

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Number of pages: 8
Pages: 1150-1157
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Computer Networks
Volume: 55
Issue number: 5
ISSN (Print): 1389-1286
Ratings:
Publication Forum (2017): 2
Scopus rating (2016): 0.652 1.694
Publication Forum (2016): 2

Bibliographical note
cited By 55
Source: Bibtex
Source-ID: urn:ebe05b5d2ab6c0293a885732256044b2
Research output: Scientific - peer-review › Article

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79951575692&partnerID=40&md5=c4eb40c2f91d2708f94d8a7814605e66
Scopus rating (2015): 0.585 1.84
Web of Science (2015): 1.446 1.903 6.9 0.277 0.01334 0.671
Publication Forum (2015): 2
Scopus rating (2014): 0.639 2.011
Web of Science (2014): 1.256 1.714 6.7 0.573 0.01228 0.64
Publication Forum (2014): 2
Scopus rating (2013): 0.722 2.682
Publication Forum (2013): 2
Scopus rating (2012): 0.755 2.307
Publication Forum (2012): 2
Scopus rating (2011): 0.808 2.446
Scopus rating (2010): 0.764 2.2
Scopus rating (2009): 0.873 1.992
Scopus rating (2008): 0.906 1.889
Scopus rating (2007): 0.969 1.948
Scopus rating (2006): 0.921 1.724
Scopus rating (2005): 1.053 2.091
Scopus rating (2004): 1.073 2.024
Scopus rating (2003): 0.749 1.878
Scopus rating (2002): 0.765 1.387
Scopus rating (2001): 0.424 0.872
Scopus rating (2000): 0.382 0.809
Scopus rating (1999): 0.311 0.64
Original language: English
DOIs: 10.1016/j.comnet.2010.11.008
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-79952453661&partnerID=40&md5=2d292e8d1ecfe4f57195cc331fe1a058

Bibliographical note
cited By 20
Source: Bibtex
Source-ID: urn:5c644f36a5176bf3994490dbb5f60d13
Research output: Scientific - peer-review › Article

Percolation theory based connectivity and latency analysis of cognitive radio ad hoc networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Akyildiz, I., Al-Dhelaan, A.
Number of pages: 11
Pages: 659-669
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Wireless Networks
Volume: 17
Issue number: 3
ISSN (Print): 1022-0038
Ratings:
Publication Forum (2017): 1
Scopus rating (2016): 0.402 0.969
Publication Forum (2016): 1
Scopus rating (2015): 0.378 1.084
Primary user activity modeling using first-difference filter clustering and correlation in cognitive radio networks

General information
State: Published
Ministry of Education publication type: A1 Journal article-refereed
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Canberk, B., Akyildiz, I., Oktug, S.
Number of pages: 14
Pages: 170-183
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: IEEE/ACM Transactions on Networking
Volume: 19
Issue number: 1
ISSN (Print): 1063-6692
Ratings:
Publication Forum (2017): 3
Scopus rating (2016): 1.055 2.241
Publication Forum (2016): 3
Web of Science (2015): 2.186 2.661 7.3 0.374 0.01537 1.381
Primary-user mobility impact on spectrum sensing in cognitive radio networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Department of Electronics and Communications Engineering, Wireless Communications and Positioning (WICO)
Authors: Cacciapuoti, A., Akyildiz, I., Paura, L.
Pages: 451-456
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE PIMRC 2011
DOIs:
10.1109/PIMRC.2011.6140001

Bibliographical note
cited By 20
Source: Bibtex
Source-ID: urn:4c28518a67ddea48044b462f34452cf6
Research output: Scientific - peer-review › Conference contribution

Spatial correlation and mobility-aware traffic modeling for wireless sensor networks

General information
General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Sun, Z., Akyildiz, I.
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE Globecom 2011
DOIs: 10.1109/GLOCOM.2011.6134436
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84863421722&partnerID=40&md5=6cfcf4828a64d3b59d214dfdc2574932

Bibliographical note
cited By 0
Source: Bibtex
Source-ID: urn:31da336fe6ca9f98c64ac69ab6b9bc95
Research output: Scientific - peer-review › Conference contribution

Topological analysis of wireless sensor networks for sandstorm monitoring

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Publication date: 2011

Host publication information
Title of host publication: Proceedings of IEEE ICC 2011
DOIs: 10.1109/icc.2011.5963393
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-80052137956&partnerID=40&md5=b32b9ebcb693f5bded177bf003e398

Bibliographical note
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Source: Bibtex
Source-ID: urn:8dcb3bda0b7be93a555dc0a72ebda50
Research output: Scientific - peer-review › Conference contribution

Visual correlation-based image gathering for wireless multimedia sensor networks

General information
State: Published
Ministry of Education publication type: A4 Article in a conference publication
Organisations: Wireless Communications and Positioning (WICO), Former organisation of the author
Authors: Wang, P., Dai, R., Akyildiz, I.
Pages: 2489-2497
Publication date: 2011

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Title of host publication: Proceedings of IEEE INFOCOM 2011
DOIs: 10.1109/INFCOM.2011.5935072
Links: https://www.scopus.com/inward/record.uri?eid=2-s2.0-79960883038&partnerID=40&md5=c43e726abf5337dbd2e5fd260ad8bf2d

Bibliographical note
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