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Executive Summary

This deliverable summarizes the dissemination and standardisation activities carried out during the whole duration of the CONCERTO project. This includes also demonstration activities and liaisons to other projects.

The dissemination of project results is mainly related to the project web page (including some partner's sites references to the project), publications in journals and magazines and participation to conferences, workshops, symposiums, other ICT project meetings, as well as the organization of workshops about eHealth. In addition, also demonstration events with the exhibition of CONCERTO technology and solutions as well as project collaborations/interactions and participation at other external events are reported.

The web page is the primary mean for collecting and disseminating the project information and outcomes. It publishes information about the main project objectives and the followed technical approach, but also reports the list of already published material. Publications are reported for the whole duration of the project. Different conferences (e.g., Future Networks and Mobile Summit 2013, IEEE Wireless Commnications and Networking Conference, IEEE Globecom) and journals (e.g., IEEE Journal on Selected Topics in Signal Processing and Signal Processing: Image Communications or IEEE Transactions on Vehicular Technology) have been addressed, even five book chapters have been written. The participation of project members at different conferences, workshops, etc., for which a descriptive table has been included, reflects how the dissemination of the project has been carried out, in particular considering the scope of the related events and the reached audience. Noticeably, the consortium decided to organize three project workshops in conjunction with international conferences, i.e., at Mobihealth 2012, IEEE Healthcom 2013, and MoWNet 2014.

Standardisation was mostly done by the industrial partners but also by one academic partner. NTUK was actively involved in 3GPP, where the project requirements have been taken into account in the definition of the requirements on the proximity services. TCS was participating at the Network Centric Operations Industry Consortium (NCOIC®) and in particular in the SAGM Real-Time Tactical Video Mobile Networking Technical Pattern that is devoted to the transmission of video over Private Mobile Radios for ambulances, fire fighters, and police forces. However, these activities have been suspended due to scarcity of clients funding the work. TCS also follows standardization activities in the MPEG group. SIEMENS was focusing its standardization activities on image/video compression at ISO/IEC MPEG and JCT-VC (a joint subgroup of MPEG and ITU-T SG16 WP3). Siemens was actively involved in standardization body meetings and contributed to the extension of the HEVC standard towards higher bit depth, which finally let to the definition of suitable profiles for the compression of monochrome medical image content. For this, Siemens also co-chaired an MPEG Ad-hoc Group on "Coding of non-camera-captured content". Finally, also Kingston University has collaborated with IEEE 1907.1 standardization group for **"**Network-Adaptive Quality of Experience (QoE) Management Scheme for Real-Time Mobile Video Communications".

CONCERTO has planned and organized also meetings and collaborations with other European projects, with the objective to share results and approaches to address common issues. Therefore, several events with ITSSv6 project, ENVISION, COMUNE, and MEDIVAL were held for information exchange on specific topics, e.g., Mobile IPv6, quality metrics in video applications, cross-layer approaches, etc. Furthermore, also results were shared and exploited across projects, e.g., in the area of multipath delivery of video streams and HTTP streaming. In addition, two CONCERTO project partners exploited project results in the context of a joint activity within the European Institute for Innovation and Technology (EIT) in order to demonstrate further the HTTP-based streaming technology, which was also investigated within CONCERTO.

Finally, CONCERTO technology was demonstrated at two international conventions, i.e., FIA 2014 and EuCNC 2014. There, the image/video streaming solution and the mobility management solution were showcased. Last not least, the full demonstration setup of the CONCERTO platform was shown at a convention at the Hospital of Perugia in 2015, which featured the main use case of "Ambulance and Emergency Area", demonstrating the transmission of visual information (i.e., ambient video and ultrasound image streams) from an ambulance to the hospital using LTE transmission and also a further routing of the streams within the hospital.

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1 Introduction

This deliverable summarizes the dissemination and standardization carried out by CONCERTO during the whole project life-time (i.e., December 2011 until February 2015). It mainly gives information on the project web page, partner's web-site relevant references, publications (in books, journals, conference proceedings, workshops, etc.), organization of dedicated workshops, participation at conferences, clustering, concertation and standardization meetings, achieved contributions to standardization, project liaisons, and demonstration events.

All partners have contributed to dissemination and standardization initiatives. Typically, universities and research centres are more involved in the former, while industrial partners in the latter. However a contribution to almost all the listed activities is supported by several project members in collaboration, though direct individual involvement is reasonable for standardization, where actual inclusion in standardization bodies is required. Finally, project clustering and concertation meeting are more suitable for the project main contractor. Though, some attempts for triggering collaborations with other EU funded projects have taken place being led by different partners in the project consortium.

Noticeably, some project activities (such as the organized workshops) represent opportunities to carry out dissemination, collaboration, and exploitation all together. This has demonstrated definitely helpful in acquiring feedbacks and suggestions for re-fining the project work (e.g., use-case detailed specification) during the whole lifetime of CONCERTO, especially towards the beginning of the project, when a higher degree of flexibility is present for tuning.

Last but not least, the projects achievements were demonstrated at several events, including two international conventions and a dedicated CONCERTO convention for showcasing the full CONCERTO solution.

2 Dissemination activities

A large number of research and technology institutes and organizations may be interested in the achievements of CONCERTO, which will be emphasized by dissemination activities. Moreover, CONCERTO benefits from the direct participation of the Clinical Engineering and Information Systems department of the hospital of Perugia and its visibility in the world of healthcare services: the presence of the end-user in the consortium will be exploited to directly disseminate the project results among the concerned professionals. Furthermore, test-bed or demos in the real-life, properly selected as addressing the more interesting use-cases, represent also a mean of further dissemination.

CONCERTO project dissemination is organized through different channels: publications, workshops, demonstrations, web page, collaborations and liaison with other projects, actions toward standardization and regulation. These activities are described below.

- A project home page has been opened. General information on CONCERTO scope, progress and partnership is given. Public project documents are published on this home page for dissemination purposes. In addition to such a home page, some partners have included general information about the project and links to their official web site (see Appendix A3) or disseminate project information using available social networks (see Appendix A4).
- Most partners, especially universities, plan to publish their work in different scientific forums, books, conferences and journals. Publications were written in the fields of telemedicine, video coding, joint source and channel coding, multimedia content adaptation, IP networking and Quality of Service, wireless transmissions and resource allocation. The scientific publications will be made in top press, journals and conferences of each of these fields to ensure that CONCERTO results will be well disseminated.
  - Articles in recognised journals, mainly IEEE journals, not neglecting other journals in the area of telemedicine and ICT for medical applications, such as the International Journal of Telemedicine and Applications.
  - Members of the consortium are journal editors and special issues on the topics of CONCERTO were envisaged. For instance Dr. Martini (Kingston University) is guest editor of a special issue series on "Healthcare Applications and Services in Converged Networking Environments" in the International Journal of Telemedicine and Applications, which was a suitable dissemination vehicle for CONCERTO results. A special issue on the topics addressed by CONCERTO will be organised in the IEEE MMTC E-Letter.
  - International conferences, such as IEEE International Conference on Image Processing (ICIP), IEEE International Conference on Multimedia and Expo (ICME), IEEE GLOBECOM, IEEE ICC, IEEE International Conference of Engineering in Medicine and Biology (EMBC), IEEE International Symposium on Biomedical Imaging (ISBI), IEEE Healthcom, ICST Mobihealth, Computers in Cardiology, Future Network & MobileSummit, and many others were the in the focus of the publication work.
  - Exhibitions, Workshops and Symposiums, such as Packet Video Workshop, Mobimedia, World of Health IT, etc. were further were opportunities for publication as well as Workshops organized by the EC like the NEM summit, the ICT Future Network & Mobile Summit, and EuCNC.
  - Press releases will be considered as well for the dissemination of the final results of the project to the general public.
- The results were also included in Ph.D. thesis related to CONCERTO's work. All scientific publications will be reported on the homepage.
- The teaching, given by university partners, will be typically based on the latest research results. Consequently, results from this project will be reflected in the courses offered to students. The information will be typically first included in the postgraduate courses and, in the later phases, the key topics will be included in undergraduate courses.

The following sections will give further details on the individual dissemination activities.

2.1 Project web site

The project website of CONCERTO is available under the domain *ict-concerto.eu*. This website is the primary tool to disseminate information about the project, its results and actual efforts publicly available to people all around the world,

and also to exchange private information between the project partners. In order to support the above goals, a TWiki engine was applied as the basis of the website allowing users to create, collaboratively edit or even delete pages via a common web browser and supporting concurrent editing and enhanced versioning. Thanks to the efficient toolset of the TWiki system the CONCERTO project website is easy to operate and maintain, while also able to play its essential role both in dissemination and inside project communication.

2.1.1 Link for news distribution: Events and News

Under the link *http://ict-concerto.eu/twiki/bin/view/Concerto/EventsAndNews* we created a page for distributing project related news and advertisements of professional events like workshops, etc. in regard of our work within CONCERTO.

2.1.2 Link for useful resources outside of the webpage: Useful links

In order to collect useful resources outside of the project website, the page Useful links was created under the link *http://ict-concerto.eu/twiki/bin/view/Concerto/UsefulLinks*. Currently the webpage of the predecessor project of FP7 ICT CONCERTO called FP7 ICT OPTIMIX is listed together with the separate website created for CONCERTO's mobility management framework called mip6d-ng (*http://www.mip6d-ng.net/*). mip6d-ng is a new implementation of Mobile IPv6 for Linux, specifically designed for CONCERTO's requirements. The plugin-based modular design ensures easy extension, and the wide-range of modules makes it a good choice for various applications. The mip6d-ng website offers a development mailing list, download possibilities for Linux sources and Android ROMs and a detailed documentation page about the installation and usage of the framework. The website also implements a News section operating in an efficient blog layout to help dissemination of novel results, current efforts and upcoming/past events in regard of efficient, fine-grained, and cross-layer optimized IPv6 mobility management topics.

2.1.3 Other online dissemination channels

In addition to the project webpage, the consortium used other channels to disseminate project events, concepts and results. In particular, a twitter account was created @ICTConcerto on which several project news and updates have been posted. Some videos of the project have also been posted on YouTube. Finally, the CONCERTO project has been advertised on web pages and LinkedIn accounts of some of the partners of the project.

2.2 Publications

2.2.1 Books or Book Chapter

[1] J. Kovacs, L. Bokor, Z. Kanizsai, and S. Imre. Intelligent Multimedia Technologies for Networking Applications: Techniques and Tools, chapter Review of Advanced Mobility Solutions for Multimedia Networking in IPv6, pages 25-47. Number Hershey, PA, USA. IGI Global, 2013.

Abstract: IPv6 is the new version of the Internet Protocol (IP), which is expected to be introduced for the wide audience in the forthcoming years. IPv6 comes with a huge amount of improvements compared to the currently widespread IP version (IPv4), while it keeps the same conceptual basics. For instance, IPv6 has a comprehensive and built-in scheme for mobility management with a great set of additional functionality, while IPv4 has only an extension for this purpose (and it is usually not implemented). Considering the evolution of telecommunication architectures toward a heterogeneous all-IP fixed-mobile convergent multimedia-provisioning system, it is now obvious that only the appearance of IPv6 could extend the infrastructure to cope with the emerging scenarios and use-cases. This chapter will provide a broad introduction of the advanced IPv6 features and will guide the readers from the basics of the new IP protocol family to its complex feature set and power to support multimedia communications in the mobility-centric Future Internet. Optimization techniques to further increase the adequacy of IPv6 for mobile multimedia are also presented along with the description of several research directions.
Relation with the project work: This work is related to WP5, as it studies different mobility management schemes built upon the Mobile IPv6 standards family in regard of their capabilities for advanced multimedia transmission and optimization.

[2] C.T. Hewage, M.G. Martini, H. Appuhami Ralalage and C. Politis, "Real-Time 3D QoE Evaluation of Novel 3D Media " in *Novel 3D Media Technologies*, Kondoz, A.; Dagiuklas, T., Eds., Springer, 2014, pp. 163-184.

Abstract: Recent wireless networks enable the transmission of high bandwidth multimedia data, including advanced 3D video applications. Such wireless multimedia systems should be designed with the purpose of maximizing the quality perceived by the users. For instance, quality parameters can be measured at the receiver-side and fed back to the transmitter for system optimization. Quality evaluation of impaired 3D video is critical in a number of scenarios, from

telemedicine and 3D tele-surgery to broadcasting. Measuring 3D video quality is a challenge due to a number of perceptual attributes associated with 3D video viewing (e.g., image quality, depth perception, naturalness). Subjective as well as objective metrics have been developed to measure 3D video quality against different artifacts. However most of these metrics are Full-Reference (FR) quality metrics and require the original 3D video sequence to measure the quality at the receiver-end. Therefore, these are not a viable solution for system monitoring/update "on the fly." This chapter presents a Near No-Reference (NR) quality metric for color plus depth 3D video compression and transmission using the extracted edge information of color images and depth maps. This work is motivated by the fact that the edges/contours of the depth map and of the corresponding color image can represent different depth levels and identify image objects/boundaries of the corresponding color image and hence can be used in quality evaluation. The performance of the proposed method is evaluated for different compression ratios and network conditions. The results obtained match well those achieved with its counterpart FR quality metric and with subjective tests, with only a few bytes of overhead for the original 3D image sequence as side-information.

Relation with the project work: This work is related to WP3.

[3] M.G. Martini, C.T. Hewage, M. M. Nasralla and O. Ognenoski, "QoE Control, Monitoring and Management Strategies" in *Multimedia Quality of Experience (QoE): Current Status and Future Requirements*, Atzori, L.; Dagiuklas, T.; Chatzimisios, P.; Chen, C., Eds., Wiley, 2014.

Abstract: In recent years, the concept of quality of service (QoS) has been extended to the new concept of quality of experience (QoE) reflecting the experience of the user accessing the provided service. Experience is user- and context-dependent. However, subjective QoE evaluation is time consuming and not suitable for use in closed loop adaptation, hence objective, rather than subjective, QoE evaluation enables optimal use of the available resources based on the defined objective utility index. The main aim of achieving a satisfactory QoE for the users of a system can be afforded at different layers of the protocol stack. This book chapter presents a review of recent strategies for QoE monitoring, control and management, including new solutions proposed by the authors.

Relation with the project work: The paper is related to WP3 , WP4 and WP5 and, following a detailed review of the topic, presents results achieved in the CONCERTO project in the areas of quality of experience evaluation (WP3), and quality of experience management strategies based on cross-layer design and content/context aware system adaptation.

[4] N. Khan and M.G. Martini, "Resource Allocation and Scheduling for Video Transmission over LTE/LTE-A Wireless Systems" in *Resource Management in Mobile Computing Environments*, Mavromoustakis, C.; Pallis, E.; Mastorakis, G., Eds., Springer, 2014.

Abstract: Quality of Service requirements for video streaming over LTE networks are quite stringent and must be met for all active flows. Hence, resource allocation and scheduling at the MAC layer of an LTE system becomes extremely important in determining the overall system performance. Different strategies can be adopted to share the resources among the users. Some of them assume knowledge of channel information and allocate more resources to users experiencing better channel conditions in order to maximise the cell throughput. However, for real time applications such schedulers are incapable of providing fairness among users. Achieving a good trade-off between efficiency and fairness is critical for scheduling strategies. This book chapter presents the different aspects of scheduling strategies for multimedia transmission on the downlink of LTE networks, highlighting how these tackle the aforementioned trade-off, and introduce solutions proposed by the authors to address it.

Relation with the project work: This work is related in particular to WP5.

[5] M.G. Martini, C.T. Hewage and M. M. Nasralla, "3D robotic surgery and training at a distance" in *3D Future Internet Media*, Kondoz, A.; Dagiuklas, T., Eds., Springer, 2013.

Abstract: The usage of 3D images and video in medical surgery and training applications contributes in the provision of more natural viewing conditions and improved diagnosis and operation. This is enabled by the recent advances in 3D video capturing and display technologies, as well as advances in robotics and network technologies. The latest advances in robotic surgery enable the performance of many surgical procedures; in particular, recent 3D endoscopes have improved the performance of minimally invasive surgical procedures. Based on these advances, performing or visualizing in real-time surgical procedures at a distance can be envisaged. In this chapter, we present a review of 3D robotic surgery and tele-surgery applications and a performance evaluation of 3D robotic tele-surgery and training over wireless networks based on the long term evolution (LTE) 3GPP standard. Different scheduling strategies are compared and results are analysed in term of the resulting quality of experience for the surgeon.

Relation with the project work: This chapters addresses the medical training use case and in particular the transmission of 3D surgical video to multiple users for training purposes.

2.2.2 Journals and magazines

[6] M. Razaak, M.G. Martini and K. Savino, "A Study on Quality Assessment for Medical Ultrasound Video Compressed via HEVC," *IEEE Journal of Biomedical and Health Informatics (J-BHI)*, vol. 18, no. 5, pp. 1552-1559, Sep 2014.

Abstract: The Quality of Experience (QoE) and Quality of Service (QoS) provided in the healthcare sector are critical in evaluating the reliable delivery of the healthcare services provided. Medical images and videos play a major role in modern e-health services and have become an integral part of medical data communication systems. The quality evaluation of medical images and videos is an essential process, and one of the ways of addressing it is via the use of quality metrics. In this paper, we evaluate the performance of seven state of the art video quality metrics with respect to compressed medical ultrasound video sequences. We study the performance of each video quality metric in representing the diagnostic quality of the video, by evaluating the correlation of each metric with the subjective opinions of medical experts. The results indicate that the Visual Information Fidelity (VIF), Structural Similarity Index Metric (SSIM), and Universal Quality Index (UQI) metrics show good correlation with the subjective scores provided by medical experts. The tests also investigate the performance of the emerging video compression standard, High Efficiency Video Coding (HEVC), for medical ultrasound video compression. The results show that, using HEVC, a diagnostically reliable compressed ultrasound video can be obtained for compression with values of the quantization parameter, QP, upto 35.

Relation with the project work: The article presents the results of the quality assessment studies performed by Kingston University and the medical doctors in the Hospital of Perugia on the cardiac ultrasound video sequences acquired in the Hospital. The work has been performed within WP3

[7] M.G. Martini, "Cross-layer Design for Quality-Driven Multi-user Multimedia Transmission in Mobile Networks ," *IEEE MMTC e-letters*, Mar 2013.

Abstract: A critical problem in next generation wireless multimedia networks is how to efficiently ensure good quality video streaming over a multiple access wireless channel with shared communications resources. The main aim of achieving a satisfactory Quality of Experience (QoE) for the users of the system can be afforded at different layers of the protocol stack. This paper presented the main aspects of quality-driven design for multimedia transmission over mobile networks, including cross layer-design strategies, signalling proposals, and quality assessment and utility design, also highlighting design issues and open points. Some recent results have been also presented.

Relation with the project work: The article presents some of the concepts elaborated within the CONCERTO project in WP3, WP4, and WP5.

[8] W. M. Gifford and A. Conti and M. Chiani and M. Z. Win, “On the SNR Penalties of Ideal and Non-ideal Subset Diversity Systems,” IEEE Transactions on Information Theory, vol. 58, n. 6, pp.3708-3724, June 2012.

Abstract: Subset diversity (SSD) techniques, which select and combine the signals from a subset of the available diversity branches, are important for practical wireless systems. This paper characterizes the performance loss, or signal-to-noise ratio (SNR) penalty, of one SSD system with respect to another. Both ideal and non-ideal channel estimation are considered, and the analysis is valid for the important case of arbitrary two-dimensional signal constellations. Expressions are given for the asymptotic SNR penalty, for both small and large SNR, for all the comparisons considered. Additionally, we develop bounds and approximations to quantify the performance of one system in terms of another for all SNRs of interest. Furthermore, for some signal constellations, we derive the exact SNR penalty of a non-ideal system with respect to an ideal system, as well as the exact penalty associated with two non-ideal systems with varying degrees of estimation energy. The SNR penalty enables the assessment of system sensitivity to channel estimation energy, combining architecture, and signal constellation.

Relation with the project work: This work is related to WP5, as it studies the impact of channel estimation accuracy on the performance of subset diversity systems, currently applied to modern wireless communication standards.

[9] S. Cicalò, A. Haseeb and V. Tralli, “Fairness-oriented multi-stream rate adaptation using scalable video coding,” Signal Processing: Image Communication, Elsevier, vol. 7, n. 8, pp. 800-813, Sep. 2012.

Abstract: In the delivery of video services like video on-demand, IP-TV, sport broadcasting, as well as real-time streaming, the end-user expectation is to receive the best feasible quality independently of the particular video complexity, even in the presence of packet losses. In this scenario, rate adaptation is required to optimize the overall quality, whereas fairness is an important issue that has to be addressed. In this paper we propose a multi-stream rate adaptation framework with reference to the scalable video coding (SVC) extension of the H.264/AVC standard with medium grain scalability (MGS). We first define a general discrete multi-objective problem with the aim to maximize the sum of assigned rates, while minimizing the differences among the expected distortions, under a total bit-rate constraint. A single-objective problem formulation is then derived by applying a continuous relaxation. Finally, a simplified continuous semi-analytical model that accurately estimates the rate–distortion relationship for both error-free channel and packet-erasure channel is also proposed, which allows us to derive an optimal and low-complexity procedure to solve the relaxed problem. Unequal erasure protection (UXP) is also considered and designed to suitably shape the rate–distortion relationship for different values of RTP packet-loss rate. The numerical results show the goodness of our framework in terms of error gap between the relaxed and its related discrete solution, and the significant performance improvement achieved with respect to an equal-rate adaptation scheme.

Relation with the project work: This work is related to both WP4 and WP5, as it concerns the problem of rate adaptation for scalable video in the context of wireless transmission.

[10] A. Zanella and M. Chiani, "Reduced Complexity Power Allocation Strategies for MIMO systems with Singular Value Decomposition," Vehicular Technology, IEEE Transactions on, vol. 61, n. 9, pp. 4031-4041, Nov. 2012.

Abstract: We consider wireless multiple-input-multiple-output (MIMO) systems in fading environments, with frequency flat fading, channel state information at both transmitter and receiver sides, and linear precoding based on singular value decomposition (SVD). The optimal solution for these MIMO SVD systems, in terms of achievable rate, requires water filling to optimally allocate power to the different channel eigenmodes. Alternatively, reduced complexity power allocation methods can be employed. We propose two power allocation techniques that only require statistical knowledge of the channel matrix coefficients and do not need knowledge of the instantaneous values of the channel state. To study these power allocation methods, we introduce a new expression for the exact distribution of the eigenvalues of Wishart matrices, where the probability density function of the lth largest eigenvalue is given as a sum of terms of the form xβe-x δ. The expression is here used, in the context of MIMO SVD systems, to obtain the achievable rate for both zero-outage and nonzero-outage strategies. We show that low-complexity methods have performance very similar to water-filling methods.

Relation with the project work: This work is related to WP5, as it studies low-complexity power allocation techniques for MIMO communication systems. Low-complexity terminals having just statistical information on the radio channel can benefit from such a power allocation strategy, since it allows achieving quasi-optimal performance in terms of throughput.

[11] Liva, G.; Pulini, P.; Chiani, M., "On-Line Construction of Irregular Repeat Accumulate Codes for Packet Erasure Channels," *Wireless Communications, IEEE Transactions on* , vol.12, no.2, pp.680,689, February 2013.

Abstract: In many applications erasure correcting codes are used to recover packet losses at high protocol stack layers. The objects (e.g. files) to be transmitted often have variable sizes, resulting in a variable number of packets to be encoded by the packet-level encoder. In this paper, algorithms for the (on-line) flexible design of parity-check matrices for irregular-repeat-accumulate codes are investigated. The proposed algorithms allow designing in fast manner parity-check matrices that are suitable for low-complexity maximum-likelihood decoding. The code ensembles generated by the algorithms are analyzed via extrinsic information transfer charts. Numerical results show how the designed codes can attain codeword error rates as low as 10^{-5} without appreciable losses w.r.t. the performance of idealized maximum-distance separable codes. Finally, we apply the proposed codes to the upcoming aeronautical communication standard, showing large performance improvements and proving the efficiency and the flexibility of the developed method.

Relations with the project work: This work is related to WP4 (T4.3), as it concerns packet-level protection techniques to be implemented at the upper layers of the communication stack to recover from packet losses. These techniques are particularly suitable in delay-sensitive applications where retransmissions are not appropriate.

[12] C. La Palombara, V. Tralli, B. Masini and A. Conti, "Relay-Assisted Diversity Communications," IEEE Transactions on Vehicular Technology, vol. 62, n. 1, pp. 415-421, Jan. 2013

Abstract: Relaying and diversity methods improve wireless communications by jointly exploiting the benefits of node cooperation, multiple-channel reception, and distributed processing. We develop a framework for design and analysis of relay-assisted diversity communications accounting for: 1) node positions; 2) link characterization; 3) diversity methods; 4) distributed coding and constellation signaling; and 5) power allocation. The framework is built on a simple model for assessing the frame error probability (FEP) as a function of radio-link characteristics, and it enables a clear understanding of how the aforementioned aspects affect the performance. A novel FEP-optimal power allocation is developed and compared with other allocation techniques such as uniform, destination-balanced (D-balanced), and relay-balanced (R-balanced) power allocations. Results show the effectiveness of the novel power allocation technique for various distributed codings and provide insights into the operation of relay-assisted diversity systems.

Relations with the project work: This work is related to WP5 (T.5.3), as it proposes an analytical framework to optimize the performance of MIMO wireless communications with relaying. Applications with strict requirements in terms of delay and throughput (e.g. real-time videos and interactive communications) can benefit from the proposed approach.

[13] Chao Xu, S. Sugiura, Soon Xin Ng and L. Hanzo, "Spatial Modulation and Space-Time Shift Keying: Optimal Performance at a Reduced Detection Complexity", in *IEEE Transactions on Communications,* vol.61, no.1, pp.206-216, January 2013.

Abstract: In this paper, we propose a comprehensive reduced-complexity detector both for hard-decision-aided as well as for the soft-decision-assisted Spatial Modulation (SM)/Space-Time Shift Keying (STSK). More explicitly, the detection of the SM scheme, which activates a single one out of M antennas to transmit a single LPSK/QAM symbol, may be carried out by detecting the antenna activation index m and the LPSK/QAM symbol s_t separately, so that the detection complexity may be reduced from the order of $O(M \cdot L)$ to the lower bound of $O(M + \log_2 L)$. However, the QAM aided STSK hard detection proposed in [1] results in a performance loss. Furthermore, the Max-Log-MAP algorithm proposed for soft STSK detection in [2] only takes into account the maximum a posteriori probabilities, which also imposed a performance degradation. Therefore, in this paper, we propose a novel solution for hard-decision-aided SM/STSK detection, which retains its optimal performance, despite its reduced detection complexity, when either LPSK or LQAM is employed. Furthermore, we propose the reduced-complexity Approx-Log-MAP algorithm conceived for the soft-decision-aided SM/STSK detector, in order to replace the suboptimal Max-Log-MAP algorithm.

Relation with the project work: This is related to the ongoing work on complexity reduction in WP5.

[14] J. Hu, L. Yang and L. Hanzo, "Maximum Average Service Rate and Optimal Queue Scheduling of Delay-Constrained Hybrid Cognitive Radio in Nakagami Fading Channels", IEEE Transactions on Vehicular Technology.

Abstract: As a promising technique of improving the achievable bandwidth efficiency, cognitive radio (CR) has attracted substantial research attention from both the academic and industrial communities. In order to improve the performance attained by the secondary user (SU), a novel hybrid CR system is proposed, which combines the conventional interweave and underlay paradigms for enhancing the chance of the SU to access the spectrum. Queuing theory is invoked in this paper for analysing the impact of the primary users (PU) maximum tolerable delay on the performance of the SU. Multiple queues are assumed for the SU, who is engaged in video communication. Apart from the Poisson traffic generation, we also model the classic Nakagamim fading channel as a Poisson service process by utilizing the outage probability in the presence of cochannel interference. We optimize both the hybrid interweave/underlay procedure for maximizing the average service rate ìS,max of the SU, and the queues scheduling scheme, for the sake of minimizing the overall average delay. As a result, the overall average delay of the SU is reduced by up to 27% and 20% compared to the proportion and round-robin schemes, respectively.

Relation with the project work: This work is part of the recent developments in Cognitive Radio, which is being dealt within Task 5.3.

[15] Li Li, Li Wang and L. Hanzo, "Differential Interference Suppression Aided Three-Stage Concatenated Successive Relaying", IEEE Transactions on Communications, vol.60, no.8, pp.2146-2155, August 2012.

Abstract: Conventional single-relay aided two-phase cooperative networks employing coherent detection algorithms incur a significant 50% throughput loss. Furthermore, it is unrealistic to expect that in addition to the task of relaying, the relay-station would dedicate further precious resources to the estimation of the source-to-relay channel in support of coherent detection, which would consume extra energy expended in power-hungry channel estimation. In order to circumvent these problems, we propose successive relaying employing noncoherent detection schemes. A crucial challenge in this context is that of suppressing the successive relaying induced interference, despite dispensing with any channel state information (CSI). We overcome this challenge by introducing a novel adaptive Newton algorithm based

multiple-symbol differential interference suppression (MS-DIS) scheme. We demonstrate that our system is capable of near-error-free transmissions at low signal-to-noise ratios.

Relation with the project work: This work is related to WP5. More specifically, it deals with the successive relaying schemes, which we are developing for cooperative networks in Task 5.3.

[16] L. Li, L. Wang and L. Hanzo, "Successive AF/DF Relaying in the Cooperative DS-CDMA Uplink: Capacity Analysis and Its System Architecture", in IEEE Transactions on Vehicular Technology, vol.62, no.2, pp.655-666, Feb. 2013.

Abstract: A successive-relaying-aided network (SRAN) is designed for a multiuser spread-spectrum scenario conceived for noncoherent (NC) detection to convert the typical 50% half-duplex relaying induced throughput loss to a potential user-load reduction of the code-division multiple-access (CDMA) system, where the NC allows us to avoid the extra power consumption imposed by channel estimation. We commence by evaluating the NC discrete-input–continuous-output memoryless channel (DCMC) capacity of both the amplify-and-forward-based (AF) and decode-and-forward-based (DF) SRANs in the direct-sequence CDMA (DS-CDMA) uplink (UL). While NC detection has the added benefit of eliminating both the pilot overhead and the power-hungry channel estimation, it tends to form an error floor at high Doppler frequencies. We mitigate this problem using multiple-symbol detection, which increases the detection complexity upon extending the detection window. Finally, a relay-aided soft-input–soft-output multiple-symbol differential sphere detection (SISO-MSDSD) CDMA regime is proposed, which significantly reduces the system's complexity without sacrificing its performance.

Relation with the project work: This is related to Task 5.3.

[17] Hoang Anh Ngo, Sohail Ahmed, Lie-Liang Yang, L. Hanzo, "Non-Coherent Cooperative Communications Dispensing with Channel Estimation Relying on Erasure Insertion Aided Reed-Solomon Coded SFH M-ary FSK Subjected to Partial-Band Interference and Rayleigh Fading", IEEE Transactions on Communications, vol.60, no.8, pp.2177-2186, August 2012.

Abstract: The rationale of our design is that although much of the literature of cooperative systems assumes perfect coherent detection, the assumption of having any channel estimates at the relays imposes an unreasonable burden on the relay station. Hence, non-coherently detected Reed-Solomon (ReS) coded Slow Frequency Hopping (SFH) assisted M-ary Frequency Shift Keying (FSK) is proposed for cooperative wireless networks, subjected to both partial-band interference and Rayleigh fading. Erasure insertion (EI) assisted ReS decoding based on the joint maximum output-ratio threshold test (MO-RTT) is investigated in order to evaluate the attainable system performance. Compared to the conventional error-correction-only decoder, the EI scheme may achieve an E_b/N_0 gain of approximately 3 dB at the Codeword Error Probability, P_w, of 10^{-4}, when employing the ReS(31,20) code combined with 32-FSK modulation. Additionally, we evaluated the system's performance, when either equal gain combining (EGC) or selection combining (SC) techniques are employed at the destination's receiver. The results demonstrated that in the presence of one and two assisting relays, the EGC scheme achieves gains of 1.5 dB and 1.0 dB at the P_w of 10^{-6}, respectively, compared to the SC arrangement. Furthermore, we demonstrated that for the same coding rate and packet size, the ReS(31,20) code using EI decoding is capable of outperforming convolutional coding, when 32-FSK modulation is considered, whilst LDPC coding had an edge over the above two schemes.

Relation with the project work: This is also part of the extensive work which we are conducting on cooperative communications under the framework of WP5, particularly Task 5.3.

[18] M.I. Kadir, S. Sugiura, Jiayi Zhang, Sheng Chen and L. Hanzo, "OFDMA/SC-FDMA Aided Space–Time Shift Keying for Dispersive Multiuser Scenarios", IEEE Transactions on Vehicular Technology, vol.62, no.1, pp.408-414, Jan. 2013.

Abstract: Motivated by the recent concept of space-time shift keying (STSK), which was developed for achieving a flexible diversity versus multiplexing gain tradeoff, we propose a novel orthogonal frequency-division multiple access (OFDMA)/single-carrier frequency-division multiple-access (SC-FDMA)-aided multiuser STSK scheme for frequency-selective channels. The proposed OFDMA/SC-FDMA STSK scheme can provide an improved performance in dispersive channels while supporting multiple users in a multiple-antenna-aided wireless system. Furthermore, the scheme has the inherent potential of benefitting from the low-complexity single-stream maximum-likelihood detector. Both an uncoded and a sophisticated near-capacity-coded OFDMA/SC-FDMA STSK scheme were studied, and their performances were compared in multiuser wideband multiple-input-multiple-output (MIMO) scenarios. Explicitly, OFDMA/SC-FDMA-aided STSK exhibits an excellent performance, even in the presence of channel impairments due

to the frequency selectivity of wideband channels, and proves to be a beneficial choice for high-capacity multiuser MIMO systems.

Relation with the project work: This is related to WP5.

[19] Y. Huo, C. Zhu and L. Hanzo, "Spatio-Temporal Iterative Source-Channel Decoding Aided Video Transmission" IEEE Transactions on Vehicular Technology.

Abstract: Low-complexity uncompressed video transmission meets the requirements of home networking and quality/delay-sensitive medical applications. Hence it attracted research-attention in recent years. The redundancy inherent in the uncompressed video signals may be exploited by joint source-channel decoding for improving the attainable error resilience. Hence in this treatise we study the application of iterative joint source-channel decoding aided uncompressed video transmission, where correlation inherent in the video signals is modelled by a first-order Markov process. Firstly, we propose a spatio-temporal joint source-channel decoding system using a recursive systematic convolutional codec, where both the horizontal and the vertical intra-frame correlations as well as the inter-frame correlations are exploited by the receiver, hence relying on three-dimensional (3D) information exchange. This scheme may be combined with arbitrary channel codecs. Then we analyze the three-stage decoder's convergence behavior using 3D EXIT charts. Finally, we benchmark the attainable system performance against a couple of video communication systems, including our previously proposed 2D scheme, where only intra-frame correlations were exploited without invoking a channel codec. Our simulation results show that substantial Eb /N0 improvements are attainable by the proposed technique.

Relation with the project work: This study is a continuation of the ongoing work on ithe terative joint source-channel decoding aided uncompressed video transmission, which is part of Task 3.1.

[20] C.T. Hewage and M.G. Martini, "Quality of Experience for 3D video streaming," *IEEE Communications Magazine*, May 2013.

Abstract: In this article we present and discuss in detail how artefacts introduced during 3D video streaming affect the end user perception and how we could use real-time quality evaluation methodologies to overcome these effects. The observations presented can underpin the design of future QoE-aware 3D video streaming systems.

Relation with the project work: This work is related to WP3.

[21] C.T. Hewage and M.G. Martini, "Edge based Reduced-Reference Quality Metric for 3D Video Compression and Transmission," *IEEE Journal of Selected Topics in Signal Processing*, vol. 6, no. 5, pp. 471-482, 2012.

Abstract: 3-D video applications are delivered over a range of different transmission systems. In order to provide demanding customers with a better service over unreliable communication channels, compression and transmission system parameters can be changed "on the fly." For interactive 3-D video services, video compression can be adapted (e.g., it can be made more robust and/or rate adaptive) based on the quality measured at the receiver. It has been shown that measuring the (3-D) video quality at the receiver-side, and using this information as a feedback to fine tune the system parameters result in improved performance in such systems. However, measuring 3-D video quality using Full-Reference (FR) quality metrics is not feasible due to the need of the original 3-D video sequence at the receiver-side for comparison. Therefore, this paper proposes a Reduced-Reference (RR) quality metric for color plus depth 3-D video compression and transmission, using the extracted edge information of color plus depth map 3-D video. This work is motivated by the fact that the edges/contours of the depth map can represent different depth levels and this can be considered for measuring structural degradations. Since depth map boundaries are also coincident with the corresponding color image object boundaries, edge information of the color image and of the depth map is compared to obtain a quality index (structural degradation) for the corresponding color image sequence. The performance of the method is evaluated for different compression ratios and network conditions. The proposed method achieves good results compared to its counterpart FR quality metric, with a lower overhead for side-information.

Relation with the project work: This work is related to WP3. Note that this work started prior to CONCERTO kick-off.

[22] M.G. Martini, B. Villarini and F. Fiorucci, "A reduced-reference perceptual image and video quality metric based on edge preservation," *Eurasip Journal on Advances in Signal Processing*, vol. 66, 2012.

Abstract: Objective image/video quality metrics which accurately represent the subjective quality of processed images are of paramount importance for the design and assessment of an image compression and transmission system. In some scenarios, it is also important to evaluate the quality of the received image with minimal reference to the transmitted one. For instance, for closed-loop optimization of a transmission system, the image quality measure can be evaluated at

the receiver and provided as feedback information to the system controller. The original image – prior to compression and transmission – is not usually available at the receiver side, and it is important to rely at the receiver side on an objective quality metric that does not need reference or needs minimal reference to the original image. The observation that the human eye is very sensitive to edge and contour information of an image underpins the proposal of our reduced reference (RR) quality metric, which compares edge information between the distorted and the original image. Results highlight that the metric correlates well with subjective observations, also in comparison with commonly used full-reference metrics and with a state-of-the-art reduced reference metric.

Relation with the project work: This work is related to WP3.

[23] M.G. Martini, C.T. Hewage and B. Villarini, "Image Quality Assessment based on Edge Preservation," *Signal Processing: Image Communication*, vol. 27, no. 8, pp. 875–882, Sep 2012.

Abstract: This work presents an alternative to the video quality metric designed in [22] where the displacement of edges in the corrupted images is considered. This metric provides better performance than [22] at the cost of a slightly higher complexity. Results highlight that the metric correlates well with subjective observations for the different image databases considered, also in comparison with commonly used full-reference metrics and with a state-of-the-art reduced reference metric.

Relation with the project work: This work is related to WP3.

[24] [96] E. Piri and H. Schulzrinne, ”Scaling Network Information Services to Support HetNets and Dynamic Spectrum Access”, in *Journal of Communications and Networks*, vol. 16 no. 2, April 2014.

Abstract: Wireless network information services allow end systems to discover heterogeneous networks and spectrum available for secondary use at or near their current location, helping them to cope with increasing traffic and finite spectrum resources. We propose a unified architecture that allows end systems to find nearby base stations that are using either licensed, shared or unlicensed spectrum across multiple network operators. Our study evaluates the performance and scalability of spatial databases storing base station coverage area geometries. The measurement results indicate that the current spatial databases perform well even when the number of coverage areas is very large. A single logical spatial database would likely be able to satisfy the query load for a large national cellular network. We also observe that coarse geographic divisions can significantly improve query performance.

Relation with the project work: This work is related to WP2 and WP5.

[25] N. Varga, L. Bokor, A. Takács, Android-based Testbed and Demonstration Environment for Cross-layer Optimized Flow Mobility, LECTURE NOTES OF THE INSTITUTE FOR COMPUTER SCIENCES SOCIAL-INFORMATICS AND TELECOMMUNICATIONS ENGINEERING (ISSN: 1867-8211) (eISSN: 1867-822X) 137: pp. 282-292, 2014.

Abstract: Nowadays, the spreading and development of multi-access mobile devices together with the proliferation of different radio access technologies make possible to users to actively benefit from the advances of heterogeneous and overlapping wireless networks. This fact and the varying characteristics of mobile applications in means of the required network resources and Quality of Service parameters invoke elaboration of effective flow-based mobility handling algorithms and their cross-layer optimization. Aiming to help research and development in the above topic, we propose an advanced, Android-based testbed and demonstration environment incorporating a cross-layer optimization platform and a flow-aware, client-based mobility management scheme. The testbed relies on MIP6D-NG, which is a client-based, multi-access Mobile IPv6 implementation with different extensions (e.g., Multiple Care-of Addresses registration, Flow Bindings etc.) and an advanced cross-layer communication API. We also introduce an adaptive flow handover system for multi-access environments based on cross-layer information transfer between the applications and the MIP6D-NG core, all implemented and evaluated in the proposed testbed.

Relation with the project work: This work is related to WP2 and WP5.

[26] N. Varga, L. Bokor, S. Bouroz, B. Lecroart, A. Takács, Client-based and Cross-layer Optimized Flow Mobility for Android Devices in Heterogeneous Femtocell/Wi-Fi Networks*, Procedia Computer Science, Volume 40, 2014, Pages 26-36, ISSN 1877-0509, http://dx.doi.org/10.1016/j.procs.2014.10.028.

Abstract: The number of subscribers accessing Internet resources from mobile and wireless devices has been increasing continually since i-mode, the first mobile Internet service launched in 1999. The handling and support of dramatic growth of mobile data traffic create serious challenges for the network operators. Due to the spreading of WLAN

networks and the proliferation of multi-access devices, offloading from 3G to Wi-Fi seems to be a promising step towards the solution. To solve the bandwidth limitation and coverage issues in 3G/4G environments, femtocells became key players. These facts motivate the design and development of femtocell/Wi-Fi offloading schemes. Aiming to support advanced offloading in heterogeneous networks, in this paper we propose a client-based, cross-layer optimized flow mobility architecture for Android devices in femtocell/Wi-Fi access environments. The paper presents the design, implementation and evaluation details of the aforementioned mechanisms.

Relation with the project work: This work is related to WP2 and WP5.

[27] N. Varga, L. Bokor, A. Takács, Context-aware IPv6 Flow Mobility for Multi-sensor Based Mobile Patient Monitoring and Tele-consultation, Procedia Computer Science, Volume 40, 2014, Pages 222-229, ISSN 1877-0509, http://dx.doi.org/10.1016/j.procs.2014.12.030.

Abstract: Recently, the rapid growth of multi-access mobile devices interconnected with different wearable biosignal sensors via Body Area Network (BAN) play an increasingly important role in healthcare systems and provide significant solutions for scenarios of home healthcare, real-time remote/mobile patient monitoring and ubiquitous tele-consultation. The proliferation of different radio access technologies make possible mobile healthcare (mHealth) services to actively benefit from the advances of heterogeneous and overlapping wireless networks. The varying characteristics of mHealth applications (particularly different real-time monitoring solutions) in means of the required network resources and Quality of Services parameters invoke elaboration of effective flow-based mobility management algorithms. Aiming to provide a transparent and efficient mobility infrastructure for the mHealth field we designed and developed a context-aware IPv6 flow mobility management scheme for Android focusing on mobile patient monitoring and tele-consultation use-cases in a multi-sensor environment. The proposed solution incorporates a cross-layer optimization platform and relies on MIP6D-NG, which is a client-based, multi-access, flow-aware Mobile IPv6 implementation. We have implemented a real-life multi-sensor testbed architecture where the proposed system with its adaptive flow handover scheme was evaluated.

Relation with the project work: This work is related to WP2 and WP5.

[28] Kara, P.A.; Bokor, L.; Imre, S., Analysis of assessment alteration phenomena of subjective quality of experience measurements in 2D and 3D mobile video services, INFOCOMMUNICATIONS JOURNAL VI:(2) pp. 1-11. 2014.

Abstract: The growing importance of Quality of Experience over Quality of Service demands precise results in the monitoring of experienced quality; empirical assessment of subjective QoE measurement on perceived quality is expected to deliver accurate reflection of reality. The goal of this paper is to highlight potential errors in existing subjective QoE measurement methodologies. Our approach focuses on a special topic of distortions caused by preconceptions based on prior technical knowledge of evaluation measurement test subjects. The paper presents two series of measurements where the test subjects were aware of the service parameters during the evaluation of the given services. The paper specifies the identified distortion phenomenon and shows how cognitive dissonance played a role in the formation of evaluation patterns and the distortion of the Mean Opinion Score.

Relation with the project work: This work is related to WP3.

[29] Cicalo, S.; Tralli, V., "Distortion-Fair Cross-Layer Resource Allocation for Scalable Video Transmission in OFDMA Wireless Networks," in *IEEE Transactions on Multimedia*, vol. 16, no. 3, pp. 848,863, April 2014.

Abstract: The design of optimized video delivery to multiple users over a wireless channel is a challenging task, especially when the objectives of maximizing the spectral efficiency and providing a fair video quality have to be jointly considered. In this paper we propose a novel cross-layer optimization framework for scalable video delivery over OFDMA wireless networks. It jointly addresses rate adaptation and resource allocation with the aim of maximizing the sum of the achievable rates while minimizing the distortion difference among multiple videos. After having discussed the feasibility of the optimization problem, we consider a “vertical” decomposition of it and propose the iterative local approximation (ILA) algorithm to derive the optimal solution. The ILA algorithm requires a limited information exchange between the application and the MAC layers, which independently run algorithms that handle parameters and constraints characteristic of a single layer. In order to reduce the overall complexity and the latency of the optimal algorithm, we also propose suboptimal strategies based on the first-step of the ILA algorithm and on the use of stochastic approximations at the MAC layer. Our numerical evaluations show the fast convergence of the ILA algorithm and the resulting small gap in terms of efficiency and video quality fairness between optimal and suboptimal strategies. Moreover, significant individual PSNR gains, up to 7 dB for high-complexity videos in the investigated scenario, are obtained with respect to other state-of-the-art frameworks with similar complexity.

Relation with the project work (T5.2): The transmission of real-time multiple videos over a common wireless channel with a limited and time-varying capacity is one of the main issues addressed by the CONCERTO project for the delivery of MSHTM services. This paper proposes an optimization framework for the downlink scenario, which has been extended to the uplink case of the CONCERTO scenarios to also consider different priorities among the transmitted video sequences (see D5.3). Specifically, the proposed distortion-fair rate adaptation algorithm has been implemented in the CONCERTO simulator as it enables real-time adaptation of the video sequences according to the content characteristic and to the channel condition of the user equipment. The results have shown significant enhancement in the perceived QoE for both diagnostic and ambient delivered video sequences.

[30] Cicalò, S.; Tralli, V., "Adaptive Resource Allocation With Proportional Rate Constraints for Uplink SC-FDMA Systems," in *IEEE Communications Letters*, vol. 18, no. 8, pp. 1419,1422, Aug. 2014.

Abstract: In this letter, we address the problem of ergodic sum-rate maximization under proportional rate constraints for the uplink of single-carrier frequency-division multiple-access (SC-FDMA) systems. Finding optimal solution generally requires high computational complexity, because SC-FDMA imposes the contiguous allocation of the available frequency resources. To reduce complexity, we propose a novel suboptimal algorithmic solution, based on Lagrangian relaxation of the rate constraints, which exploits a simple but effective estimation of the average number of the resources to allocate in order to reduce the search space. The complexity of the resulting algorithm increases only linearly with the number of users and the number of resources, whereas the performance gap to optimal solution is limited to the 10% of the sum-rate.

Relation with the project work (T5.2): In most of the CONCERTO scenario (e.g. emergency area, ambulance) health-related video information are delivered through uplink wireless connection of 3GPP LTE. The stringent constraints in terms of high data-rate and low delay, especially for high-quality diagnostic video, require efficient radio resource exploitation and QoS support, which may not be guaranteed with classical radio resource allocation algorithm, e.g., proportional fair. The RRA algorithm proposed in this contribution is well suited to cope with this requirement, as it combines efficient multiuser and frequency diversity exploitation with minimum rate requirement support and low computational complexity. The algorithm has been implanted in the 4G radio resource management module of the CONCERTO simulator.

[31] Liva, G.; Paolini, E.; Chiani, M., "Bounds on the Error Probability of Block Codes over the q-Ary Erasure Channel," *Communications, IEEE Transactions on* , vol.61, no.6, pp.2156,2165, June 2013.

Abstract: In this paper, tight bounds on the block error probability of linear block codes over order-q finite fields for the q-ary erasure channel, under maximum-likelihood (ML) decoding, are developed. Upper bounds are obtained for uniform parity-check ensembles, sparse parity-check ensembles, general parity-check ensembles (e.g., Gallager regular nonbinary low-density parity-check ensembles), and for any given linear code with known distance spectrum. The tightness of the upper bounds is confirmed both by the comparison with simple lower bounds and, for Gallager low-density parity-check ensembles, by extensive Monte Carlo simulations. Exploiting the derived bounds, it is shown how already for short blocks and small q>2 sparse ensembles attain block error probabilities close to those of idealized maximum distance separable (MDS) codes, down to low error probabilities, whereas in the same regime binary codes show visible losses with respect to the Singleton bound. Thanks to the accurate performance estimates, the developed bounds can support the design of near-optimum erasure correcting codes with short and moderate lengths.

Relation with the project work (T4.3): The above paper addresses the problems of design and analysis of packet erasure LDPC codes constructing on finite fields of order q>2 and decoded using a maximum likelihood decoder. These codes have been used in CONCERTO in the packet-level forward error correction (PL-FEC) module in order to cope with packet losses introduced by both wireless links, network congestion situations and buffer overflows.

[32] Liva, G.; Paolini, E.; Matuz, B.; Scalise, S.; Chiani, M., "Short Turbo Codes over High Order Fields," *Communications, IEEE Transactions on* , vol.61, no.6, pp.2201,2211, June 2013.

Abstract: Two classes of turbo codes constructed on high-order finite fields are introduced. The codes are derived from a particular protograph sub-ensemble of the (2,3) regular low-density parity-check (LDPC) code ensemble. The first construction results in a parallel concatenation of two non-binary, time-variant accumulators. The second construction consists of the serial concatenation of a non-binary time-variant differentiator with a non-binary time-variant accumulator, and provides a highly structured flexible encoding scheme for (2,4) LDPC codes. A cycle graph representation is also provided. The proposed codes can be decoded efficiently either as LDPC codes (via belief propagation decoding on their bipartite graphs) or as turbo codes (via the forward-backward algorithm applied to the

component code trellises) by means of the fast Fourier transform. The proposed codes provide remarkable coding gains (more than 1 dB at a codeword error rate 10^{-4}) over binary LDPC and turbo codes in the moderate-short block length regime.

Relation with the project work (T5.2): The above paper deals with non-binary LDPC codes (i.e., constructed on finite fields of order q>2) analogous to the ones constructed in CONCERTO for packet erasure correction applications, but used at the physical layer to correct bit errors. In these papers it is shown how nonbinary LDPC codes may also been favourably applied at physical layer, performing close to the theoretical limits.

[33] Liva, G.; Paolini, E.; Chiani, M., "On Optimum Decoding of Certain Product Codes," Communications Letters, IEEE , vol.18, no.6, pp.905,908, June 2014.

Abstract: Optimum decoding of a class of product codes is investigated. The class is the one given by the serial concatenation of a binary single-parity-check code with a low-dimension binary linear block code. It was proved by Wolf that maximum likelihood decoding for this class of product codes can be efficiently performed through the Viterbi algorithm over a compact trellis representation of the code. In this letter, it is showed that the decoding complexity can be further reduced by formulating the decoding problem as a symbol-wise maximum-a-posteriori decision problem. Results illustrated for suitably designed codes show that the proposed algorithm significantly outperforms conventional iterative decoders. Finally, a generalization of the code construction, enjoying the same low-complexity decoding principle is presented and analyzed, achieving tangible coding gains at moderate error rates.

Relation with the project work (T5.2): The above paper deals with non-binary LDPC codes (i.e., constructed on finite fields of order q>2) analogous to the ones constructed in CONCERTO for packet erasure correction applications, but used at the physical layer to correct bit errors. In these papers it is shown how nonbinary LDPC codes may also been favourably applied at physical layer, performing close to the theoretical limits.

[34] Flanagan, M.F.; Paolini, E.; Chiani, M.; Fossorier, M.P.C., "Spectral Shape of Doubly-Generalized LDPC Codes: Efficient and Exact Evaluation," *Information Theory, IEEE Transactions on* , vol.59, no.11, pp.7212,7228, Nov. 2013.

Abstract: This paper analyzes the asymptotic exponent of the weight spectrum for irregular doubly-generalized LDPC (D-GLDPC) codes. In the process, an efficient numerical technique for its evaluation is presented, involving the solution of a 4×4 system of polynomial equations. The expression is consistent with previous results, including the case where the normalized weight or stopping set size tends to zero. The spectral shape is shown to admit a particularly simple form in the special case where all variable nodes are repetition codes of the same degree, a case which includes Tanner codes; for this case it is also shown how certain symmetry properties of the local weight distribution at the CNs induce a symmetry in the overall weight spectral shape function. Finally, using these new results, weight and stopping set size spectral shapes are evaluated for some example generalized and doubly-generalized LDPC code ensembles.

Relation with the project work (T4.3): The performances of error correcting codes under maximum likelihood decoding (such as the codes adopted in CONCERTO to recover from packet losses) depend on their weight enumerating function. This paper develops a technique to calculate the asymptotic exponent of the weight distribution, to infer is a linear code will offer good performance or not.

[35] Matuz, B.; Liva, G.; Paolini, E.; Chiani, M.; Bauch, G., "Low-Rate Non-Binary LDPC Codes for Coherent and Blockwise Non-Coherent AWGN Channels," Communications, IEEE Transactions on , vol.61, no.10, pp.4096,4107, October 2013.

Abstract: Low-rate non-binary low-density parity-check (LDPC) codes for coherent and blockwise non-coherent additive white Gaussian noise (AWGN) channels are developed. The proposed construction is based on the concatenation of non-binary outer LDPC codes with inner binary codes. In case the binary codes are chosen to be Hadamard or Reed-Muller (RM) codes, the complexity of the decoding scheme is considerably reduced. An asymptotic analysis of the concatenation with help of composite capacity considerations anddensity evolution (DE) is provided, from which guidelines on the choice of both inner and outer codes are devised. Finite length designs presented in this work confirm the excellent performance of the proposed codes.

Relation with the project work (T5.2): This paper presents an analysis of a concatenated coding scheme composed of an outer nonbinary code with an inner binary one. The outer nonbinary code is an LDPC code over a finite field of order q>2 analogous to the ones developed in CONCERTO, but used at the physical layer. It is shown how the concatenated scheme performs close to the theoretical limit even over a block-wise non-coherent channel.

[36] Pulini, Paola; Liva, Gianluigi; Chiani, Marco, "Unequal Diversity LDPC Codes for Relay Channels," Wireless Communications, IEEE Transactions on , vol.12, no.11, pp.5646,5655, November 2013

Abstract: A novel protograph-based construction of low-density parity-check (LDPC) codes for the relay channel is proposed, which provides an enhanced unequal error protection property named unequal diversity. The focus is on quasi-static fading channels and on the high-code-rate (R>1/2) regimes, for which (according to the Singleton bound) no full diversity can be achieved. In the proposed construction, some nodes (and the corresponding codeword fragment) associated with the code graph enjoy the diversity provided by the relay, whereas the remaining nodes do not experience any diversity. The proposed approach can be thus tailored to transmit information blocks with different priority levels. An extrinsic information transfer (EXIT) analysis is developed, which allows an accurate performance prediction over the considered channel model, and more in general over block-fading channels.

Relation with the project work (T5.3): This work develops an unequal error protection scheme for handling messages and data flows characterized by different priorities. This is an important issue within the CONCERTO project, in which some data flows may be marked as high priority data due to the better quality of experience they guarantee to the final user.

[37] E. Paolini, Č. Stefanović, G. Liva, P. Popovski, "Coded Random Access: Applying Codes on Graphs to Design Random Access Protocols," IEEE Communications Magazine, accepted.

Abstract: The rise of machine-to-machine communications has rekindled the interest in random access protocols as a support for a massive number of uncoordinatedly transmitting devices. The legacy ALOHA approach is developed under a collision model, where slots containing collided packets are considered as waste. However, if the common receiver (e.g., base station) is capable to store the collision slots and use them in a transmission recovery process based on successive interference cancellation, the design space for access protocols is radically expanded. We present the paradigm of *coded random access*, in which the structure of the access protocol can be mapped to a structure of an erasure-correcting code defined on graph. This opens the possibility to use coding theory and tools for designing efficient random access protocols, offering markedly better performance than ALOHA. Several instances of coded random access protocols are described, as well as a case study on how to upgrade a legacy ALOHA system using the ideas of coded random access.

Relation with the project work (T5.2): Massive uncoordinated access based on successive interference cancellation has been considered in the CONCERTO project, as an alternative for multiple access in certain scenarios in which the number of devices in the emergency area (medical equipment, cameras, etc.) is time variant and not a priori known. This paper surveys the most recent developments in this field.

[38] Hong Chen, Maunder, R.G. and Hanzo, L., "A Survey and Tutorial on Low-Complexity Turbo Coding Techniques and a Holistic Hybrid ARQ Design Example," IEEE *Communications Surveys & Tutorials*, vol.15, no.4, pp.1546-1566, Fourth Quarter 2013.

Abstract: Hybrid Automatic Repeat reQuest (HARQ) has become an essential error control technique in communication networks, which relies on a combination of arbitrary error correction codes and retransmissions. When combining turbo codes with HARQ, the associated complexity becomes a critical issue, since conventionally iterative decoding is immediately activated after each transmission, even though the iterative decoder might fail in delivering an error-free codeword even after a high number of iterations. In this scenario, precious battery-power would be wasted. In order to reduce the associated complexity, we will present design examples based on Multiple Components Turbo Codes (MCTCs) and demonstrate that they are capable of achieving an excellent performance based on the lowest possible memory octally represented generator polynomial (2, 3). In addition to using low-complexity generator polynomials, we detail two further techniques conceived for reducing the complexity. Firstly, an Early Stopping (ES) strategy is invoked for curtailing iterative decoding, when its Mutual Information (MI) improvements become less than a given threshold. Secondly, a novel Deferred Iteration (DI) strategy is advocated for the sake of delaying iterative decoding, until the receiver confidently estimates that it has received sufficient information for successful decoding. Our simulation results demonstrate that the MCTC aided HARQ schemes are capable of significantly reducing the complexity of the appropriately selected benchmarkers, which is achieved without degrading the Packet Loss Ratio (PLR) and throughput.

Relation with the project work: This work presents a survey on HARQ, which constitutes an efficient means of enhancing the transmission reliability of communication networks, which falls in the domain of WP5.

[39] Dandan Liang, Soon Xin Ng and Hanzo, L., "Near-Capacity Turbo Coded Soft-Decision Aided DAPSK/Star-QAM for Amplify-and-Forward Based Cooperative Communications," *IEEE Transactions on Communications*, vol.61, no.3, pp.1080-1087, March 2013.

Abstract: Multilevel Differential Amplitude and Phase-Shift Keying (DAPSK) schemes do not require any channel estimation, which results in low complexity. In this treatise we derive the soft-output probability formulas required for a soft-decision based demodulation of high-order DAPSK, in order to facilitate iterative detection by exchanging extrinsic information with an outer Turbo Code (TC). Furthermore, when the TC block size is increased, the system operates closer to the channel capacity. Compared to the identical-throughput TC assisted 64-ary Differential Phase-Shift Keying (64-DPSK) scheme, the 4-ring based TC assisted 64-ary DAPSK arrangement has a power-efficiency improvement of 2.3 dB at a bit error rate (BER) of 10^{-5}. Furthermore, when the TC block size is increased, the system operates closer to the channel capacity. More specifically, when using a TC block length of 400 modulated symbols, the 64 DAPSK (4, 16) scheme is 7.56 dB away from its capacity curve, while it had a reduced gap as low as 2.25 dB, when using a longer TC block length of 40 000 modulated symbols. Finally, as a novel application example, the soft-decision M-DAPSK scheme was incorporated into an Amplify-and-Forward (AF) based cooperative communication system, which attains another 4.5 dB SNR improvement for a TC block length of 40 000 modulated symbols.

Relation with the project work: In this contribution a soft-decision M-DAPSK aided AF based cooperative scheme is proposed, which is in line with the objectives of Task 5.3.

[40] Maunder, Robert G., Zhang, Wenbo, Wang, Tao and Hanzo, Lajos, "A Unary Error Correction Code for the Near-Capacity Joint Source and Channel Coding of Symbol Values from an Infinite Set," *IEEE Transactions on Communications*, vol.61, no.5, pp.1977-1987, May 2013.

Abstract: A novel Joint Source and Channel Code (JSCC) is proposed, which we refer to as the Unary Error Correction (UEC) code. Unlike existing JSCCs, our UEC facilitates the practical encoding of symbol values that are selected from a set having an infinite cardinality. Conventionally, these symbols are conveyed using Separate Source and Channel Codes (SSCCs), but we demonstrate that the residual redundancy that is retained following source coding results in capacity loss. This loss is found to have a value of 1.11 dB in a particular practical scenario, where Quaternary Phase Shift Keying (QPSK) modulation is employed for transmission over an uncorrelated narrowband Rayleigh fading channel. By contrast, the proposed UEC code can eliminate this capacity loss, or reduce it to an infinitesimally small value. Furthermore, the UEC code has only a moderate complexity, facilitating its employment in practical low-complexity applications.

Relation with the project work: In this paper, a UEC code is conceived for JSCC, which overcomes the capacity loss associated with SSCCs. This work is related to Task 3.1.

[41] Thomas, V.A., Ghafoor, S., El-Hajjar, M. and Hanzo, L., "A Full-Duplex Diversity-Assisted Hybrid Analogue/Digitized Radio Over Fibre for Optical/Wireless Integration," IEEE Communications Letters, vol.17, no.2, pp.409-412, February 2013.

Abstract: A duplex Radio Over Fibre (ROF) ring architecture is proposed taking into account the constraints imposed by the cost of fibre laying and of the optical/electronic components, as well as the spectral efficiency and the duplex link performance. It has been shown that relying on Analogue ROF (AROF) and state-of-the-art Digitized ROF (DROF) architectures for downlink and uplink transmission, respectively, attains a high-integrity duplex performance. A sophisticated amalgam of Optical Carrier Suppression (OCS), Code Division Multiplexing (CDM), optical frequency multiplexing, Optical Carrier Reuse (OCR) and distributed antennas is conceived.

Relation with the project work: In line with WP5, in this contribution a wireless campus network architecture has been proposed, which efficiently utilises the optical bandwidth and minimizes the implementation cost, while maintaining robust duplex performance.

[42] Chao Xu, Dandan Liang, Soon Xin Ng and Hanzo, L., "Reduced-Complexity Noncoherent Soft-Decision-Aided DAPSK Dispensing With Channel Estimation," IEEE Transactions on Vehicular Technology, vol.62, no.6, pp.2633-2643, July 2013.

Abstract: Differential Amplitude Phase Shift Keying (DAPSK), which is also known as star-shaped QAM has implementational advantages not only due to dispensing with channel estimation, but also as a benefit of its low signal detection complexity. It is widely recognized that separately detecting the amplitude and the phase of a received DAPSK symbol exhibits a lower complexity than jointly detecting the two terms. However, since the amplitude and the

phase of a DAPSK symbol are affected by the correlated magnitude fading and phase-rotations, detecting the two terms completely independently results in a performance loss, which is especially significant for soft-decision-aided DAPSK detectors relying on multiple receive antennas. Therefore, in this contribution, we propose a new soft-decision-aided DAPSK detection method, which achieves the optimum DAPSK detection capability at a substantially reduced detection complexity. More specifically, we link each a priori soft input bit to a specific part of the channel's output, so that only a reduced subset of the DAPSK constellation points has to be evaluated by the soft DAPSK detector. Our simulation results demonstrate that the proposed soft DAPSK detector exhibits a lower detection complexity than that of independently detecting the amplitude and the phase, while the optimal performance of DAPSK detection is retained.
Relation with the project work: In this contribution, a soft-decision-aided DAPSK detection method is proposed, which may be particularly beneficial for cooperative communications systems of Task 5.3.

[43] Chao Xu, Dandan Liang, Sugiura, S., Soon Xin Ng and Hanzo, L., "Reduced-Complexity Approx-Log-MAP and Max-Log-MAP Soft PSK/QAM Detection Algorithms," IEEE Transactions on Communications, vol.61, no.4, pp.1415-1425, April 2013.

Abstract: In this paper, we propose to reduce the complexity of both the Approx-Log-MAP algorithm as well as of the Max-Log-MAP algorithm conceived for generalized PSK/QAM detection, where only a reduced-size subset of the PSK/QAM constellation points is taken into account for producing a single soft-bit output. Although the detectors of Gray-labelled low-order PSK/QAM schemes generally produce near-horizontal EXIT curves, our proposed detectors exploit the a priori LLRs gleaned from a channel decoder in order to retain the optimum detection capability for all PSK/QAM constellations. Furthermore, we demonstrate in this paper that the widely applied MIMO schemes including V-BLAST and STBC, which invoke the proposed soft PSK/QAM detectors may also benefit from our reduced-complexity design. Our simulation results confirm that a near-capacity performance may be achieved by the proposed detectors at a substantially reduced detection complexity.

Relation with the project work: This work is part of WP5, where a new method of reducing the complexity of the soft PSK/QAM detection algorithms was proposed, and its advantages in V-BLAST system and in Alamouti's G2 STBC system were demonstrated.

[44] Cheung, K.T.K., Shaoshi Yang and Hanzo, L., "Achieving Maximum Energy-Efficiency in Multi-Relay OFDMA Cellular Networks: A Fractional Programming Approach," IEEE Transactions on Communications, vol.61, no.7, pp.2746-2757, July 2013.

Abstract: In this paper, the joint power and subcarrier allocation problem is solved in the context of maximizing the energy-efficiency (EE) of a multi-user, multi-relay orthogonal frequency division multiple access (OFDMA) cellular network, where the objective function is formulated as the ratio of the spectral-efficiency (SE) over the total power dissipation. It is proven that the fractional programming problem considered is quasi-concave so that Dinkelbach's method may be employed for finding the optimal solution at a low complexity. This method solves the above-mentioned master problem by solving a series of parameterized concave secondary problems. These secondary problems are solved using a dual decomposition approach, where each secondary problem is further decomposed into a number of similar subproblems. The impact of various system parameters on the attainable EE and SE of the system employing both EE maximization (EEM) and SE maximization (SEM) algorithms is characterized. In particular, it is observed that increasing the number of relays for a range of cell sizes, although marginally increases the attainable SE, reduces the EE significantly. It is noted that the highest SE and EE are achieved, when the relays are placed closer to the BS to take advantage of the resultant line-of-sight link. Furthermore, increasing both the number of available subcarriers and the number of active user equipment (UE) increases both the EE and the total SE of the system as a benefit of the increased frequency and multi-user diversity, respectively. Finally, it is demonstrated that as expected, increasing the available power tends to improve the SE, when using the SEM algorithm. By contrast, given a sufficiently high available power, the EEM algorithm attains the maximum achievable EE and a suboptimal SE.
Relation with the project work: In line with the objectives of Task 5.3, in this contribution, we have solved the joint power and subcarrier allocation problem, which was formulated for maximizing the EE in a multi-relay aided multi-user OFDMA cellular network.

[45] Zhang, Peichang, Chen, Sheng and Hanzo, Lajos, "Reduced-Complexity Near-Capacity Joint Channel Estimation and Three-Stage Turbo Detection for Coherent Space-Time Shift Keying," IEEE Transactions on Communications, vol.61, no.5, pp.1902-1913, May 2013.

Abstract: We propose a low-complexity joint channel estimation (CE) and three-stage iterative demapping-decoding scheme for near-capacity coherent space-time shift keying (CSTSK) based multiple-input multiple-output (MIMO) systems. In the proposed scheme, only a minimum number of space-time shift keying training blocks are employed for

generating an initial least square channel estimate, which is then used for initial data detection. As usual, the detected soft information is first exchanged a number of times within the inner turbo loop between the unity-rate-code (URC) decoder and the CSTSK soft-demapper, and the information gleaned from the inner URC decoder is then iteratively exchanged with the outer decoder in the outer turbo loop. Our CE scheme is embedded into the outer turbo loop, which exploits the a posteriori information produced by the CSTSK soft-demapper to select a sufficient number of high-quality decisions only for CE. Since the CE is embedded into the iterative three-stage demapping-decoding process, no additional iterative loop is required for exchanging information between the decision-directed channel estimator and the three-stage turbo detector. Hence, the computational complexity of the proposed joint CE and three-stage turbo detection remains similar to that of the three-stage turbo detection-decoding scheme with the given channel estimate. Moreover, our proposed low-complexity semi-blind scheme is capable of approaching the optimal maximum likelihood turbo detection performance attained with the aid of perfect channel state information, with the same low number of turbo iterations as the latter, as confirmed by our extensive simulation results.

Relation with the project work: In this paper, a low-complexity semi-blind block-of-bits selection based joint channel estimation and three-stage data demapping-decoding scheme has been proposed for near-capacity CSTSK systems, which is related to Task 5.3 in particular.

[46] Babar, Z., Soon Xin Ng and Hanzo, L., "Reduced-Complexity Syndrome-Based TTCM Decoding," IEEE Communications Letters, vol.17, no.6, pp.1220-1223, June 2013.

Abstract: The iterative decoder of Turbo Trellis Coded Modulation (TTCM) exchanges extrinsic information between the constituent TCM decoders, which imposes a high computational complexity at the receiver. Therefore we conceive the syndrome-based block decoding of TTCM, which is capable of reducing the decoding complexity by disabling the decoder, when syndrome becomes zero. Quantitatively, we demonstrate that a decoding complexity reduction of at least 17% is attained at high SNRs, with at least 20% and 45% reduction in the 5^{th} and 6^{th} iterations, respectively.
Relation with the project work: This paper focuses on the complexity reduction of TTCM decoding, which is relevant to WP5.

[47] El-Hajjar, M. and Hanzo, L., "EXIT Charts for System Design and Analysis," IEEE Communications Surveys & Tutorials, vol.16, no.1, pp.127-153, First Quarter 2014.

Abstract: Near-capacity performance may be achieved with the aid of iterative decoding, where extrinsic soft information is exchanged between the constituent decoders in order to improve the attainable system performance. Extrinsic information Transfer (EXIT) charts constitute a powerful semi-analytical tool used for analysing and designing iteratively decoded systems. In this tutorial, we commence by providing a rudimentary overview of the iterative decoding principle and the concept of soft information exchange. We then elaborate on the concept of EXIT charts using three iteratively decoded prototype systems as design examples. We conclude by illustrating further applications of EXIT charts, including near-capacity designs, the concept of irregular codes and the design of modulation schemes.

Relation with the project work: This is a survey paper on EXIT charts, which assist in designing near-capacity iteratively decoded systems, which falls in the domain of WP5.

[48] El-Hajjar, M. and Hanzo, L., "A Survey of Digital Television Broadcast Transmission Techniques," IEEE Communications Surveys & Tutorials, vol.15, no.4, pp.1924-1949, Fourth Quarter 2013

Abstract: This paper is a survey of the transmission techniques used in digital television (TV) standards worldwide. With the increase in the demand for High-Definition (HD) TV, video-on-demand and mobile TV services, there was a real need for more bandwidth-efficient, flawless and crisp video quality, which motivated the migration from analogue to digital broadcasting. In this paper we present a brief history of the development of TV and then we survey the transmission technology used in different digital terrestrial, satellite, cable and mobile TV standards in different parts of the world. First, we present the Digital Video Broadcasting standards developed in Europe for terrestrial (DVB-T/T2), for satellite (DVB-S/S2), for cable (DVB-C) and for hand-held transmission (DVB-H). We then describe the Advanced Television System Committee standards developed in the USA both for terrestrial (ATSC) and for hand-held transmission (ATSC-M/H). We continue by describing the Integrated Services Digital Broadcasting standards developed in Japan for Terrestrial (ISDB-T) and Satellite (ISDB-S) transmission and then present the International System for Digital Television (ISDTV), which was developed in Brazil by adopteding the ISDB-T physical layer architecture. Following the ISDTV, we describe the Digital Terrestrial television Multimedia Broadcast (DTMB) standard developed in China. Finally, as a design example, we highlight the physical layer implementation of the DVB-T2 standard.

Relation with the project work: This is a survey paper on the transmission techniques used in digital TV standards, which is related to WP5 in general.

[49] Yongkai Huo, El-Hajjar, M. and Hanzo, L., "Inter-Layer FEC Aided Unequal Error Protection for Multilayer Video Transmission in Mobile TV," *IEEE Transactions on Circuits and Systems for Video Technology*, vol.23, no.9, pp.1622-1634, Sept. 2013.

Abstract: Layered video coding creates multiple layers of unequal importance that enables us to progressively refine the reconstructed video quality. When the base layer (BL) is corrupted or lost during transmission, the enhancement layers (ELs) must be dropped, regardless of whether they are perfectly decoded or not, which implies that the transmission power assigned to the ELs is wasted. In this treatise, we propose an inter-layer forward error correction (FEC) coded video transmission scheme for mobile TV. At the transmitter, the proposed interlayer (IL) coding technique implants the systematic information of the BL into the ELs by using exclusive-OR operations. At the receiver, the implanted bits of the ELs may be utilized for assisting in decoding the BL. Furthermore, the data partition mode of H.264 video coding is utilized as the source encoder, where the type B and type C partitions will assist in protecting the type A partition. The IL coded bitstream will then be modulated and transmitted over a multifunctional multiple input multiple output (MF-MIMO) scheme for the sake of improving the system's performance in mobile environments. The proposed system may be readily combined with the traditional unequal error protection (UEP) technique, where extrinsic mutual information (MI) measurements are used for characterizing the performance of our proposed technique. Finally, our simulation results show that the proposed system model outperforms the traditional UEP aided system by about 2.5 dB of E_b/N_0 or 3.4 dB of peak signal-to-noise ratio (PSNR) at the cost of a 21% complexity increase, when employing a recursive systematic convolutional code. Furthermore, unlike the traditional UEP strategies, where typically stronger FEC-protection is assigned to the more important layer, employing our proposed IL coding technique requires weaker FEC to the more important layer. For example, the system relying on channel coding rates of 0.85, 0.44, and 0.44 for t-e type A, type B, and type C H.264 video partitions, respectively, achieves the best system performance when employing a recursive systematic convolutional (RSC) code.

Relation with the project work: In line with Task 3.1, this paper an inter-layer FEC coded video transmission scheme is proposed for wireless video transmission.

[50] Yongkai Huo, Tao Wang, Maunder, R.G. And Hanzo, L., "Iterative source and channel decoding relying on correlation modelling for wireless video transmission," IET Communications, vol.7, no.14, pp.1465-1475, September 24 2013.

Abstract: Since joint source-channel decoding is capable of exploiting the residual redundancy in the source signals for improving the attainable error resilience, it has attracted substantial attention. In this treatise, the authors study iterative source-channel decoding (ISCD) aided video communications, where the video signal redundancy is modelled by a first-order Markov process. Firstly, the authors derive reduced-complexity formulas for the first-order Markov modelling (FOMM) aided source decoding. Then they propose a bit-based iterative horizontal-vertical scanline model (IHVSM) aided source decoding algorithm, where a horizontal and a vertical source decoder are employed for exchanging their extrinsic information using the iterative decoding philosophy. The iterative IHVSM aided decoder is then employed in a forward error correction (FEC) encoded uncompressed video transmission scenario, where the IHVSM and the FEC decoder exchange softbit-information for performing turbo-like ISCD for the sake of improving the reconstructed video quality. Finally, the authors benchmark the attainable system performance against a near-lossless H.264/AVC video communication system and the existing FOMM-based softbit source decoding scheme. The authors simulation results show that E_b/N_0 improvements in excess of 2.8 dB are attainable by the proposed technique in uncompressed video applications.

Relation with the project work: This work is a continuation of our previous work on JSCC, which is related to Task 3.1. More specifically, this paper focuses on iterative source-channel decoding for video transmission.

[51] Kadir, M.I., Li Li, Sheng Chen and Hanzo, L., "Successive-Relaying-Aided Decode-and-Forward Coherent Versus Noncoherent Cooperative Multicarrier Space–Time Shift Keying," *IEEE Transactions on Vehicular Technology*, vol.62, no.6, pp.2544-2557, July 2013.

Abstract: Successive-relaying-aided (SR) cooperative multicarrier (MC) space-time shift keying (STSK) is proposed for frequency-selective channels. We invoke SR to mitigate the typical 50% throughput loss of conventional half-duplex relaying schemes and MC code-division multiple access (MC-CDMA) to circumvent the dispersive effects of wireless

channels and to reduce the SR-induced interference. The distributed relay terminals form two virtual antenna arrays (VAAs), and the source node (SN) successively transmits frequency-domain (FD) spread signals to one of the VAAs, in addition to directly transmitting to the destination node (DN). The constituent relay nodes (RNs) of each VAA activate cyclic-redundancy-checking-based (CRC) selective decode-and-forward (DF) relaying. The DN can jointly detect the signals received via the SN-to-DN and VAA-to-DN links using a low-complexity single-stream-based joint maximum-likelihood (ML) detector. We also propose a differentially encoded cooperative MC-CDMA STSK scheme to facilitate communications over hostile dispersive channels without requiring channel estimation (CE). Dispensing with CE is important since the relays cannot be expected to altruistically estimate the SN-to-RN links for simply supporting the source. Furthermore, we propose soft-decision-aided serially concatenated recursive systematic convolutional (RSC) and unity-rate-coded (URC) cooperative MC STSK and investigate its performance in both coherent and noncoherent scenarios.

Relation with the project work: In this paper, a novel cooperative MC STSK scheme using selective DF and SR to recover the half-duplex multiplexing loss is proposed, which is related to Task 5.3.

[52] Thomas, Varghese Antony, Ghafoor, Salman, El-Hajjar, Mohammed and Hanzo, Lajos, "Baseband Radio over Fiber Aided Millimeter-Wave Distributed Antenna for Optical/Wireless Integration," *IEEE Communications Letters*, vol.17, no.5, pp.1012-1015, May 2013.

Abstract: A Baseband Radio Over Fiber (BROF) architecture is proposed, where upto four Radio Frequency (RF) carriers can be generated, while using the heterodyne photo-detection of only two optical signals. This proposed BROF architecture has a star-like structure and it is composed of six Radio Access Units (RAUs), where data is transmitted from the Central Unit (CU) to the Base Station (BS) and from the BS to the RAU over a distance of 20 Km and 0.3 Km, respectively, at a rate of 768 Mbps. The performance of the system supporting four carrier frequencies drops by at most 1dB, at a BER of 10^{-9}, compared to conventional heterodyne photo-detection.

Relation with the project work: Within the domain of WP5, a novel technique for varying the carrier frequency of the signal, which is generated by heterodyne photo-detection of 2 given optical signals, is proposed.

[53] Jin, Fan, Zhang, Rong and Hanzo, Lajos, "Fractional Frequency Reuse Aided Twin-Layer Femtocell Networks: Analysis, Design and Optimization," *IEEE Transactions on Communications*, vol.61, no.5, pp.2074-2085, May 2013.

Abstract: Femtocells constitute an economical solution conceived for improving the indoor coverage, which are capable of achieving a high network capacity. In order to guarantee a high Spectral Efficiency (SE), femtocells have to reuse the spectrum of macrocells. As a result, the performance of both the femtocells and macrocells may suffer owing to the near-far effects. In this paper, we study a twin-layer cellular networks, where the Macrocell Base Stations (MBSs) employing Fractional Frequency Reuse (FFR) host the Femtocell Base Stations (FBSs). This paper investigates the design, performance analysis and optimization problems of this FFR aided twin-layer network. We firstly assume that the femtocells opt for full spectrum access (FSA). The per-layer outage probability (OP) is derived and the network is optimized for maximizing the macrocell's throughput. We found that the advantage of FFR eroded in dense femtocell-scenarios and the optimized network tends to become a Unity Frequency Reuse (UFR) aided system. We then propose a spectrum swapping access (SSA) strategy for protecting the macrocell's performance and for overcoming the typical near-far problem. Our analysis demonstrates that both the OP of femtocell users in the Cell Centre Region (CCR) and that of the macrocell users in the Cell Edge Region (CER) will be reduced by the proposed SSA. The optimized network using our SSA is more robust to the detrimental impact of femtocells.

Relation with the project work: This work focuses on the analysis, design and optimization of FFR-aided femtocell networks, which is related to WP5.

[54] Jing Zuo, Chen Dong, Hung Viet Nguyen, Soon Xin Ng, Lie-liang Yang and Hanzo, L., "Cross-Layer Aided Energy-Efficient Opportunistic Routing in Ad Hoc Networks," IEEE Transactions on Communications, vol.62, no.2, pp.522-535, February 2014.

Abstract: Most of the nodes in ad hoc networks rely on batteries, which requires energy saving. Hence, numerous energy-efficient routing algorithms have been proposed for solving this problem. In this paper, we exploit the benefits of cross-layer information exchange, such as the knowledge of the Frame Error Rate (FER) in the physical layer, the maximum number of retransmissions in the Medium Access Control (MAC) layer and the number of relays in the network layer. Energy-consumption-based Objective Functions (OF) are invoked for calculating the end-to-end energy consumption of each potentially available route for both Traditional Routing (TR) and for our novel Opportunistic Routing (OR), respectively. We also improve the TR and the OR with the aid of efficient Power Allocation (PA) for

further reducing the energy consumption. For the TR, we take into account the dependencies amongst the links of a multi-hop route, which facilitates a more accurate performance evaluation than upon assuming the links that are independent. Moreover, two energy-efficient routing algorithms are designed based on Dijkstra's algorithm. The algorithms based on the energy OF provide the theoretical bounds, which are shown to be close to the bound found from exhaustive search, despite the significantly reduced complexity of the former. Finally, the end-to-end throughput and the end-to-end delay of this system are analyzed theoretically and a new technique of characterizing the delay distribution of OR is proposed. The simulation results show that our energy-efficient OR outperforms the TR and that their theoretical analysis accurately matches the simulation results.

Relation with the project work: In this contribution, cross-layer optimized routing is conceived for ad hoc nerworks, which is relevant to the broad framework of WP5.

[55] Jiao Feng, Rong Zhang, Hanzo, L. and Soon Xin Ng, "Cooperative Medium Access Control Based on Spectrum Leasing," *IEEE Transactions on Vehicular Technology*, , vol.63, no.1, pp.297-307, Jan. 2014.

Abstract: Based on cooperative spectrum leasing, a distributed “win-win” (WW) cooperative framework is designed to encourage the licensed source node (SN) to lease some part of its spectral resources to the unlicensed relay node (RN) for the sake of simultaneously improving the SN's achievable rate and for reducing the energy consumption (EC). The potential candidate RNs carry out autonomous decisions concerning whether to contend for a cooperative transmission opportunity, which could dissipate some of their battery power, while conveying their traffic in light of their individual service requirements. Furthermore, a WW cooperative medium-access-control (MAC) protocol is designed to implement the proposed distributed WW cooperative framework. Simulation results demonstrate that our WW cooperative MAC protocol is capable of providing both substantial rate improvements and considerable energy savings for the cooperative spectrum leasing system.

Relation with the project work: This contribution focuses on a cooperaitive MAC protocol, which is related to Task 5.3 in particular.

[56] Wei Liang, Soon Xin Ng and Hanzo, L., "Cooperative communication between cognitive and primary users," IET Communications, vol.7, no.17, pp.1982-1992, Nov. 26 2013.

Abstract: The active cooperation between a primary user (PU) and a cognitive user (CU) has the potential of leading to a transmission power reduction and transmission rate increase for both the PU and the CU. Alternatively, the required bandwidth may be reduced and the freed bandwidth may be leased to a group of CUs for their secondary communications. More explicitly, our cooperative protocol allows a CU to serve as a relay node (RN) for relaying the signal of the first PU, which is a source node (SN), to the second PU, which is a destination node (DN). Furthermore, we conceived adaptive turbo trellis coded modulation (ATTCM) for appropriately adjusting both the code rate and the modulation mode according I to the near-instantaneous channel conditions. More specifically, we propose an ATTCM aided two-way relaying cooperative CR scheme that maximises the CU's own data rate and improves the exploitation of the bandwidth released by the PUs. Our numerical and simulation results show that the bandwidth reduction attained by the proposed two-way relay based CR scheme is more than 80% of the PU's bandwidth.

Relation with the project work: This is a continuation of our work on cooperative networks within the framework of Task 5.3. More specifically, a practical ATTCM aided one-way relaying CR scheme, where adaptive coding and modulation were invoked according to the instantaneous channel conditions, is proposed.

[57] Peichang Zhang; Sheng Chen; Hanzo, L., "Embedded Iterative Semi-Blind Channel Estimation for Three-Stage-Concatenated MIMO-Aided QAM Turbo Transceivers," IEEE Transactions on Vehicular Technology, vol.63, no.1, pp.439,446, Jan. 2014.

Abstract: The lack of accurate and efficient channel estimation (CE) for multiple-input-multiple-output (MIMO) channel state information (CSI) has long been the stumbling block of near-MIMO-capacity operation. We propose a semi-blind joint CE and three-stage iterative detection/decoding scheme for near-capacity MIMO systems. The main novelty is that our decision-directed (DD) CE exploits the a posteriori information produced by the MIMO soft demapper within the inner turbo loop to select a “just sufficient number” of high-quality detected soft bit blocks or symbols for DDCE, which significantly improves the accuracy and efficiency of DDCE. Moreover, our DDCE is naturally embedded into the iterative three-stage detection/decoding process, without imposing an additional external iterative loop between the DDCE and the three-stage turbo detector/decoder. Hence, the computational complexity of our joint CE and three-stage turbo detector/decoder remains similar to that of the three-stage turbo detection/decoding scheme associated with the perfect CSI. Most significantly, the mean square error (MSE) of our DD channel estimator

approaches the Cramér-Rao lower bound (CRLB) associated with the optimal-training-based CE, whereas the bit error rate (BER) of our semi-blind scheme is capable of achieving the optimal maximum-likelihood (ML) performance bound associated with the perfect CSI.

Relation with the project work (WP5): We have proposed a novel semi-blind joint BBSB-SCE and stage turbo detection/decoding scheme for near-capacity MIMO systems.

[58] Aljohani, A.J.; Soon Xin Ng; Maunder, R.G.; Hanzo, L., "EXIT-Chart-Aided Joint Source Coding, Channel Coding, and Modulation Design for Two-Way Relaying," IEEE Transactions on Vehicular Technology, , vol.62, no.6, pp.2496,2506, July 2013.

Abstract: In this paper, we have proposed and investigated an attractive joint source coding, channel coding, and modulation (JSCM) scheme for a two-way relaying system. We commence by quantifying the achievable capacity of the corresponding two-way relay channel before proposing low-complexity source coding schemes for concatenation with band-width-and power-efficient coded modulation schemes. Extrinsic information transfer (EXIT) charts are used to investigate the decoding convergence of the joint source and channel decoder and for the overall system design. The quality of the decoded source signals is quantified using the bit error ratio (BER) metric. It is found that the two-way-relay-based JSCM scheme is capable of attaining a combined coding and relaying gain of 5.7 dB over the conventional noncooperative JSCM scheme when communicating over uncorrelated Rayleigh fading channels in an outdoor environment.

Relation with the project work (WP3): In this paper, we have proposed a practical jointly optimized end-to-end source coding, channel coding, and modulation scheme, which was assisted by a two-way relaying scheme.

[59] Li Wang; Li Li; Chao Xu; Dandan Liang; Soon Xin Ng; Hanzo, L., "Multiple-Symbol Joint Signal Processing for Differentially Encoded Single- and Multi-Carrier Communications: Principles, Designs and Applications," Communications Surveys & Tutorials, IEEE , vol.16, no.2, pp.689,712, Second Quarter 2014.

Abstract: Bypassing the potentially excessive-complexity and yet inaccurate channel estimation, differentially encoded modulation in conjunction with low-complexity non-coherent detection constitutes a viable candidate for future multiple-antenna aided systems, where estimating all the links may become unrealistic, especially in high-speed environments. Upon exploiting the correlation between the phase distortions experienced by the consecutively transmitted symbols and/or based on mutually and iteratively utilizing the increasingly improved bit reliability information among the associated multiple symbols in the context of differentially modulated systems using channel code aided iterative receivers, the joint processing on consecutively received multiple symbols improves the system's performance. For example, an increased robustness against rapid channel fluctuation, improved flexibility in the system's performance-complexity compromise as well as a reduced performance loss is achieved in comparison to its coherent detection aided counterpart. In order to stimulate further research on differentially modulated systems and on the associated multiple-symbol signal processing based advanced receiver design, a comprehensive review on their related concepts and fundamental principles is carried out in this treatise, followed by a number of potential challenges encountered in their practical implementations in future high-spectral-efficiency wireless transmissions, such as their applications in high-order differentially modulated systems and in differential interference suppression of spatial-division multiplexing/multiple access scenarios.

Relation with the project work (WP5): Multiple-symbol joint signal processing techniques, which are capable of exploiting the fading channel’s memory, were advocated in this treatise as an appealing, practically implementable candidate for differentially modulated systems dispensing with the potentially excessive-complexity and yet inaccurate channel estimation.

[60] Hu Jie; Yang Lieliang; Hanzo, L., "Mobile social networking aided content dissemination in heterogeneous networks," Communications, China , vol.10, no.6, pp.1,13, June 2013.

Abstract: Since more and more mobile applications are based on the proliferation of social information, the study of Mobile Social Networks (MSNs) combines social sciences and wireless communications. Operating wireless networks more efficiently by exploiting social relationships between MSN users is an appealing but challenging option for network operators. An MSN-aided content dissemination technique is presented as a potential extension of conventional cellular wireless networks in order to satisfy growing data traffic. By allowing the MSN users to create a self-organized ad hoc network for spontaneously disseminating contents, the network operator may be able to reduce the operational costs and simultaneously achieve an improved network performance. In this paper, we first summarize the basic

features of the MSN architecture, followed by a survey of the factors which may affect MSN-aided content dissemination. Using a case study, we demonstrate that one can save resources of the Base Station (BS) while substantially lowering content dissemination delay. Finally, other potential applications of MSN-aided content dissemination are introduced, and a range of future challenges are summarized.

Relation with the project work (WP5): In this article, we present the principles of MSN-aided content dissemination, where the MSN users rely on self-organization and ad hoc networking for disseminating the desired content across the community.

[61] Aljohani, A.J.; Soon Xin Ng; Hanzo, L., "TTCM-Aided Rate-Adaptive Distributed Source Coding for Rayleigh Fading Channels," IEEE Transactions on Vehicular Technology, , vol.63, no.3, pp.1126,1134, March 2014.

Abstract: Adaptive turbo-trellis-coded modulation (TTCM)-aided asymmetric distributed source coding (DSC) is proposed, where two correlated sources are transmitted to a destination node. The first source sequence is TTCM encoded and is further compressed before it is transmitted through a Rayleigh fading channel, whereas the second source signal is assumed to be perfectly decoded and, hence, to be flawlessly shown at the destination for exploitation as side information for improving the decoding performance of the first source. The proposed scheme is capable of reliable communications within 0.80 dB of the Slepian-Wolf/Shannon (SW/S) theoretical limit at a bit error rate (BER) of 10-5. Furthermore, its encoder is capable of accommodating time-variant short-term correlation between the two sources.

Relation with the project work (WP3): In this paper, we have proposed a novel DSTTCMs scheme for a SW-distributed coding system.

[62] Yongkai Huo; Tao Wang; Maunder, R.; Hanzo, L., "Two-Dimensional Iterative Source-Channel Decoding for Distributed Video Coding," Communications Letters, IEEE , vol.18, no.1, pp.90,93, January 2014.

Abstract: Motivated by the Joint Source-Channel Decoding (JSCD) principle of exploiting the source redundancy, in this treatise we study the application of iterative source-channel decoding (ISCD) conceived for distributed video coding (DVC), where the video signal is modelled by our Iterative Horizontal-Vertical Scanline Model (IHVSM) relying on a first-order Markov process. The IHVSM technique is combined with the classic forward error correction (FEC) codecs employed in the state-of-the-art DVC systems for the sake of reducing the bitrate. Our simulation results show that up to 21.5% bitrate reductions are achieved by employing the proposed ISCD technique in a DVC scheme. Alternatively, a peak signal-to-noise ratio (PSNR) gain of 2.2 dB is achieved at a bitrate of 4.5 Mbps when considering the Foreman sequence.

[63] Yongkai Huo; Tao Wang; Maunder, R.; Hanzo, L., "Two-Dimensional Iterative Source-Channel Decoding for Distributed Video Coding," Communications Letters, IEEE , vol.18, no.1, pp.90,93, January 2014.

Abstract: Motivated by the Joint Source-Channel Decoding (JSCD) principle of exploiting the source redundancy, in this treatise we study the application of iterative source-channel decoding (ISCD) conceived for distributed video coding (DVC), where the video signal is modelled by our Iterative Horizontal-Vertical Scanline Model (IHVSM) relying on a first-order Markov process. The IHVSM technique is combined with the classic forward error correction (FEC) codecs employed in the state-of-the-art DVC systems for the sake of reducing the bitrate. Our simulation results show that up to 21.5% bitrate reductions are achieved by employing the proposed ISCD technique in a DVC scheme. Alternatively, a peak signal-to-noise ratio (PSNR) gain of 2.2 dB is achieved at a bitrate of 4.5 Mbps when considering the Foreman sequence.

Relation with the project work (WP3): In this paper, we conceived an iterative source-channel decoding technique for Wyner-Ziv video coding, where the IHVSM was combined with the turbo decoder for the sake of reducing the required bitrate.

[64] Yongkai Huo; Tao Wang; Maunder, R.G.; Hanzo, L., "Motion-Aware Mesh-Structured Trellis for Correlation Modelling Aided Distributed Multi-View Video Coding," Image Processing, IEEE Transactions on , vol.23, no.1, pp.319,331, Jan. 2014.

Abstract: A joint source-channel coding has attracted substantial attention with the aim of further exploiting the residual correlation residing in the encoded video signals for the sake of improving the reconstructed video quality. In our previous paper, a first-order Markov process model was utilized as an error concealment tool for exploiting the intra-frame correlation residing in the Wyner--Ziv (WZ) frame in the context of pixel-domain distributed video coding. In this contribution, we exploit the inter-view correlation with the aid of an inter-view motion search in distributed multi-view video coding (DMVC). Initially, we rely on the system architecture of WZ coding invoked for multi-view video.

Then, we construct a novel mesh-structured pixel-correlation model from the inter-view motion vectors and derive its decoding rules for joint source-channel decoding. Finally, we benchmark the attainable system performance against the existing pixel-domain WZ coding based DMVC scheme, where the classic turbo codec is employed. Our simulation results show that substantial bitrate reductions are achieved by employing the proposed motion-aware mesh-structured correlation modelling technique in a DMVC scheme.

Relation with the project work (WP3): In this paper, we firstly extended the WZ coding techniques for monoscopic video into a Wyner-Ziv coded multi-view video system.

[65] Babar, Z.; Soon Xin Ng; Hanzo, L., "Near-Capacity Code Design for Entanglement-Assisted Classical Communication over Quantum Depolarizing Channels," Communications, IEEE Transactions on , vol.61, no.12, pp.4801,4807, December 2013.

Abstract: We have conceived a near-capacity code design for entanglement-assisted classical communication over the quantum depolarizing channel. The proposed system relies on efficient near-capacity classical code designs for approaching the entanglement-assisted classical capacity of a quantum depolarizing channel. It incorporates an Irregular Convolutional Code (IRCC), a Unity Rate Code (URC) and a soft-decision aided Superdense Code (SD), which is hence referred to as an IRCC-URC-SD arrangement. Furthermore, the entanglement-assisted classical capacity of an N-qubit superdense code transmitted over a depolarizing channel is invoked for benchmarking. It is demonstrated that the proposed system operates within 0.4 dB of the achievable noise limit for both 2-qubit as well as 3-qubit SD schemes. More specifically, our design exhibits a deviation of only 0.062 and 0.031 classical bits per channel use from the corresponding 2-qubit and 3-qubit capacity limits, respectively. The proposed system is also benchmarked against the classical convolutional and turbo codes.

Relation with the project work (WP3): we have designed a superdense coding based near-capacity code for entanglement-assisted classical communication over the quantum depolariz-ing channel.

[66] Botsinis, P.; Soon Xin Ng; Hanzo, L., "Quantum Search Algorithms, Quantum Wireless, and a Low-Complexity Maximum Likelihood Iterative Quantum Multi-User Detector Design," Access, IEEE , vol.1, no., pp.94, 122-2013.

Abstract: The high complexity of numerous optimal classic communication schemes, such as the maximum likelihood (ML) multiuser detector (MUD), often prevents their practical implementation. In this paper, we present an extensive review and tutorial on quantum search algorithms (QSA) and their potential applications, and we employ a QSA that finds the minimum of a function in order to perform optimal hard MUD with a quadratic reduction in the computational complexity when compared to that of the ML MUD. Furthermore, we follow a quantum approach to achieve the same performance as the optimal soft-input soft-output classic detectors by replacing them with a quantum algorithm, which estimates the weighted sum of a function's evaluations. We propose a soft-input soft-output quantum-assisted MUD (QMUD) scheme, which is the quantum-domain equivalent of the ML MUD. We then demonstrate its application using the design example of a direct-sequence code division multiple access system employing bit-interleaved coded modulation relying on iterative decoding, and compare it with the optimal ML MUD in terms of its performance and complexity. Both our extrinsic information transfer charts and bit error ratio curves show that the performance of the proposed QMUD and that of the optimal classic MUD are equivalent, but the QMUD's computational complexity is significantly lower.

Relation with the project work (WP5): We have conceived an improved QMA resulting in the QWSA, which is employed for designing a quantum-assisted MUD relying on soft inputs and providing soft outputs.

[67] Bo Zhang; El-Hajjar, M.; Hanzo, L., "Opportunistic Relay Selection for Cooperative Relaying in Cochannel Interference Contaminated Networks," IEEE Transactions on Vehicular Technology, vol.63, no.5, pp.2455-2461, June 2014.

Abstract: A multiple-relay assisted cooperative automatic-repeat-request (CARQ) system is proposed in interference-limited scenario, where multiple-user detection (MUD) receivers using successive interference cancellation (SIC) are employed at the relay nodes (RNs) and the destination node (DN) to combat cochannel interference (CCI). We analyze the outage performance and propose a novel best effort-detection-based opportunistic relay selection (BED-ORS) scheme, which achieves significantly better outage performance than the traditional highest SNR-based ORS scheme offered in the literature. Moreover, considering the effects of the outdated channel state information (CSI), an improved-BED-ORS (I-BED-ORS) scheme is proposed to enhance the robustness against CSI imperfections.
Relation with the project work (WP5): In this paper, we have considered two CARQ systems adopting MUD-SIC receivers at the DN, namely, the MUD-SIC-aided CARQ and SUD-aided CARQ schemes.

[68] Botsinis, Panagiotis, Ng, Soon Xin and Hanzo, Lajos, "Fixed-Complexity Quantum-Assisted Multi-User Detection for CDMA and SDMA," IEEE Transactions on Communications, vol.62, no.3, pp.990-1000, March 2014.

Abstract: In a system supporting numerous users the complexity of the optimal Maximum Likelihood Multi-User Detector (ML MUD) becomes excessive. Based on the superimposed constellations of K users, the ML MUD outputs the specific multi-level K-user symbol that minimizes the Euclidean distance with respect to the faded and noise-contaminated received multi-level symbol. Explicitly, the Euclidean distance is considered as the Cost Function (CF). In a system supporting K users employing M-ary modulation, the ML MUD uses M^K CF evaluations (CFE) per time slot. In this contribution we propose an Early Stopping-aided Durr-Ho yer algorithm-based Quantum-assisted MUD (ES-DHA QMUD) based on two techniques for achieving optimal ML detection at a low complexity. Our solution is also capable of flexibly adjusting the QMUD's performance and complexity trade-off, depending on the computing power available at the base station. We conclude by proposing a general design methodology for the ES-DHA QMUD in the context of both CDMA and SDMA systems.

Relation with the project work: Quantum-assisted ML MUD is conceived for CDMA and SDMA networks, which falls in the domain of WP5.

[69] Yongkai Huo, El-Hajjar, M., Maunder, R.G. and Hanzo, L., "Layered Wireless Video Relying on Minimum-Distortion Inter-Layer FEC Coding," IEEE Transactions on Multimedia, vol.16, no.3, pp.697-710, April 2014.

Abstract: Layered video coding is capable of progressively refining the reconstructed video quality with the aid of multiple layers of unequal importance. When the base layer (BL) is corrupted or lost due to channel impairments, the enhancement layers (ELs) must be discarded by the video decoder, regardless whether they are perfectly decoded or not, which implies that the transmission power assigned to the ELs is wasted. To circumvent this problem, we proposed a bit-level inter-layer forward error correction (IL-FEC) scheme for layered video transmission in our previous work, which implanted the systematic bits of the BL into the systematic bits of the ELs using exclusive-OR operations (XOR). This allowed the receiver to exploit the implanted bits of the ELs for assisting the BL's decoding and hence improved the overall system performance of our IL-FEC aided layered video scheme. In this treatise, we find the specific FEC coding rates in a real-time on-line fashion for the sake optimizing the overall system performance. The proposed procedure is widely applicable to diverse wireless transceivers and FEC codecs. Our simulation results show that the proposed optimized IL-FEC system outperforms the traditional optimal UEP by about 1.9 dB of Eb/N_0 at a peak signal-to-noise ratio (PSNR) of 38 dB. Viewing the improvements in terms of the video quality, 3.3 dB of PSNR improvement is attained at an $Eb/N_0$of 10 dB, when employing a recursive systematic convolutional (RSC) code.

Relation with the project work: In line with the objectives of Task 3.1, a layer video coding scheme is proposed.

[70] Kadir, M.I., Sheng Chen, Hari, K.V.S., Giridhar, K. and Hanzo, L., "OFDM-Aided Differential Space–Time Shift Keying Using Iterative Soft Multiple-Symbol Differential Sphere Decoding," IEEE Transactions on Vehicular Technology, vol.63, no.8, pp.4102-4108, Oct. 2014.

Abstract: Soft-decision multiple-symbol differential sphere decoding (MSDSD) is proposed for orthogonal frequency-division multiplexing (OFDM)-aided differential space-time shift keying (DSTSK)-aided transmission over frequency-selective channels. Specifically, the DSTSK signaling blocks are generated by the channel-encoded source information and the space-time (ST) blocks are appropriately mapped to a number of OFDM subcarriers. After OFDM demodulation, the DSTSK signal is noncoherently detected by our soft-decision MSDSD detector. A novel soft-decision MSDSD detector is designed, and the associated decision rule is derived for the DSTSK scheme. Our simulation results demonstrate that an SNR reduction of 2 dB is achieved by the proposed scheme using an MSDSD window size of $N_w = 4$ over the conventional soft-decision-aided differential detection benchmarker, while communicating over dispersive channels and dispensing with channel estimation (CE).

Relation with the project work: This is part of the work pertaining to WP5. A soft-decision-MSDSD-aided multicarrier DSTSK scheme for communications over wideband channels. The OFDM-aided DSTSK provides a flexible diversity versus multiplexing gain tradeoff by spreading the source information across both the spatial and time dimensions, while mitigating the potential performance degradation imposed by the frequency selectivity of the channel.

[71] Wei Liang, Soon Xin Ng, Jiao Feng and Hanzo, L., "Pragmatic Distributed Algorithm for Spectral Access in Cooperative Cognitive Radio Networks," IEEE Transactions on Communications, vol.62, no.4, pp.1188-1200, April 2014.

Abstract: A pragmatic distributed algorithm (PDA) is proposed for supporting the efficient spectral access of multiple Primary Users (PUs) and Cognitive Users (CUs) in cooperative Cognitive Radio (CR) networks. The novelty of our PDA is that the PUs negotiate with the CUs concerning the specific amount of relaying and transmission time, the CU is granted, which the CU will either accept or decline. The CUs may serve as relay nodes for relaying the signal received from the PUs to their destinations, while both the PUs' and the CUs' minimum rate requirements are satisfied. This will reduce the required transmission power and/or increase the transmission rate of the PU. Our results show that the proposed scheme performs better than the benchmarker, despite its significantly lower overhead and complexity. Moreover, we show that the cooperative spectral access based on our PDA reaches an equilibrium, when it is repeated for a sufficiently long duration. These benefits are achieved, because the PUs are motivated to cooperate by the incentive of achieving a higher PU rate, whilst non-cooperation can be discouraged with the aid of a limited-duration punishment. Furthermore, we invoke an attractive practical adaptive Turbo Trellis Coded Modulation (ATTCM) scheme, which appropriately adjusts the code rate and the modulation mode according to the near-instantaneous channel conditions. It was found that the joint design of coding, modulation and user-cooperation may lead to significant mutual benefits for all the PUs and the CUs.

Relation with the project work: In this contribution, PU/CU matching algorithms are conceived for spectral access in a cooperative regime. This is related to the work on cooperative communications of Task 5.3.

[72] Jiankang Zhang, Bo Zhang, Sheng Chen, Xiaomin Mu, El-Hajjar, M. and Hanzo, L., "Pilot Contamination Elimination for Large-Scale Multiple-Antenna Aided OFDM Systems," IEEE Journal of Selected Topics in Signal Processing, vol.8, no.5, pp.759-772, Oct. 2014.

Abstract: Pilot contamination constitutes a particularly significant impairment in large-scale multi-cell systems. We propose an effective pilot contamination elimination scheme for multi-cell time division duplexing based orthogonal frequency division multiplexing systems, by carefully designing a sophisticated amalgam of downlink (DL) training and `scheduled' uplink (UL) training. During the DL training stage, each base station (BS) transmits the DL pilot symbols (PSs) to its mobile stations (MSs) for them to estimate their frequency-domain channel transfer functions (FDCHTFs), which are then embedded in the UL PSs by `predistorting' the PSs with the estimated FDCHTFs. During the scheduled UL training, each BS's UL receiver in turn extracts the FDCHTFs of its MSs from their received PSs by eliminating the pilot contamination imposed by the simultaneously transmitted UL PSs of all other cells. Our simulation results demonstrate that the pilot contamination is completely eliminated by the proposed scheme, even for the network consisting of a large number of unity frequency reuse cells. Most significantly, unlike many existing pilot contamination reduction schemes, our scheme does not rely on the assumption that each BS knows the second-order statistics of all the interfering UL channels.

Relation with the project work: In this paper, a novel pilot contamination elimination scheme has been proposed for multi-cell TDD and OFDM based massive MIMO systems, which relies on the two stages of the DL training and the scheduled UL training, which falls in the broad scope of WP5.

[73] Babar, Z., Ng, S.X. and Hanzo, L., "EXIT-Chart Aided Near-Capacity Quantum Turbo Code Design," IEEE Transactions on Vehicular Technology, vol.PP, no.99, pp.1-1.

Abstract: High detection complexity is the main impediment in future Gigabit-wireless systems. However, a quantum-based detector is capable of simultaneously detecting hundreds of user signals by virtue of its inherent parallel nature. This in turn requires near-capacity quantum error correction codes for protecting the constituent qubits of the quantum detector against the undesirable environmental decoherence. In this quest, we appropriately adapt the conventional non-binary EXtrinsic Information Transfer (EXIT) charts for quantum turbo codes by exploiting the intrinsic quantum-to-classical isomorphism. The EXIT chart analysis not only allows us to dispense with the time-consuming Monte-Carlo simulations, but also facilitates the design of near-capacity codes without resorting to the analysis of their distance spectra. We have demonstrated that our EXIT chart predictions are in line with the Monte-Carlo simulations results. We have also optimized the entanglement-assisted QTC using EXIT charts, which outperforms the existing distance spectra based QTCs. More explicitly, the performance of our optimized QTC is as close as 0.3 dB to the corresponding hashing bound.

Relation with the project work: This work is falls in the domain of Task 5.3, whereby near-capacity quantum codes are designed for assisting the quantum-assisted multi-user detectors employed in CDMA and SDMA networks.

[74] Botsinis, P., Alanis, D., Ng, S.X. and Hanzo, L., "Low-Complexity Soft-Output Quantum-Assisted Multiuser Detection for Direct-Sequence Spreading and Slow Subcarrier-Hopping Aided SDMA-OFDM Systems," IEEE Access , vol.2, no., pp.451-472, 2014.

Abstract: Low-complexity suboptimal multiuser detectors (MUDs) are widely used in multiple access communication systems for separating users, since the computational complexity of the maximum likelihood (ML) detector is potentially excessive for practical implementation. Quantum computing may be invoked in the detection procedure, by exploiting its inherent parallelism for approaching the ML MUDs performance at a substantially reduced number of cost function evaluations. In this contribution, we propose a soft-output (SO) quantum-assisted MUD achieving a near-ML performance and compare it to the corresponding SO ant colony optimization MUD. We investigate rank deficient direct-sequence spreading (DSS) and slow subcarrier-hopping aided (SSCH) spatial division multiple access orthogonal frequency division multiplexing systems, where the number of users to be detected is higher than the number of receive antenna elements used. We show that for a given complexity budget, the proposed SO-Du□rr-Høyer algorithm (DHA) QMUD achieves a better performance. We also propose an adaptive hybrid SO-ML/SO-DHA MUD, which adapts itself to the number of users equipped with the same spreading sequence and transmitting on the same subcarrier. Finally, we propose a DSS-based uniform SSCH scheme, which improves the system's performance by 0.5 dB at a BER of 10-5, despite reducing the complexity required by the MUDs employed.

Relation with the project work: A low complexity MUD is conceived for SDMA-OFDM systems, which is related to Task 5.3.

[75] Cheung, K.T.K., Shaoshi Yang and Hanzo, L., "Spectral and Energy Spectral Efficiency Optimization of Joint Transmit and Receive Beamforming Based Multi-Relay MIMO-OFDMA Cellular Networks," IEEE Transactions on Wireless Communications, vol.13, no.11, pp.6147-6165, Nov. 2014.

Abstract: We first conceive a novel transmission protocol for a multi-relay multiple-input-multiple-output orthogonal frequency-division multiple-access (MIMO-OFDMA) cellular network based on joint transmit and receive beamforming. We then address the associated network-wide spectral efficiency (SE) and energy spectral efficiency (ESE) optimization problems. More specifically, the network's MIMO channels are mathematically decomposed into several effective multiple-input-single-output (MISO) channels, which are essentially spatially multiplexed for transmission. Hence, these effective MISO channels are referred to as spatial multiplexing components (SMCs). For the sake of improving the SE/ESE performance attained, the SMCs are grouped using a pair of proposed grouping algorithms. The first is optimal in the sense that it exhaustively evaluates all the possible combinations of SMCs satisfying both the semi-orthogonality criterion and other relevant system constraints, whereas the second is a lower-complexity alternative. Corresponding to each of the two grouping algorithms, the pair of SE and ESE maximization problems are formulated, thus the optimal SMC groups and optimal power control variables can be obtained for each subcarrier block. These optimization problems are proven to be concave, and the dual decomposition approach is employed for obtaining their solutions. Relying on these optimization solutions, the impact of various system parameters on both the attainable SE and ESE is characterized. In particular, we demonstrate that under certain conditions the lower-complexity SMC grouping algorithm achieves 90% of the SE/ESE attained by the exhaustive-search based optimal grouping algorithm, while imposing as little as 3.5% of the latter scheme's computational complexity.

Relation with the project work: This paper falls under Task 5.3 focusing on the joint optimization of transmit and receive beamforming for multi-relay MIMO-OFDMA networks.

[76] Jie Zhang, Fan Jin, Rong Zhang, Guangjun Li and Hanzo, L., "Analysis and Design of Distributed Antenna-Aided Twin-Layer Femto- and Macrocell Networks Relying on Fractional Frequency Reuse," IEEE Transactions on Vehicular Technology, vol.63, no.2, pp.763-774, Feb. 2014.

Abstract: Distributed antenna systems (DASs) and FemtoCells (FCs) are capable of improving the attainable performance in the cell-edge area and in indoor residential areas, respectively. To achieve high spectral efficiency (SE), both the distributed antenna elements (DAEs) and FC base stations (FBSs) may have to reuse the spectrum of the macrocellular network. As a result, the performance of both outdoor MacroCell (MC) users (OMU) and indoor FC users (IFUs) suffers from CoChannel Interference (CCI). Hence, in this paper, heterogenous cellular networks are investigated, where the DAS-aided MCs and FCs coexist within the same area. Both the outage probability (OP) and the spatially averaged throughput are derived, and the network is optimized either to minimize the OP or to maximize the MC's throughput. Our analysis demonstrates that surprisingly, the unity frequency-reuse (UFR)-based macrocellular system can be optimized in isolation, without considering the impact of FCs. We found that the

MCs relying on fractionalfrequency reuse (FFR) tend to be converted to several small cells, illuminated by the DAEs, when the density of FCs becomes high.

Relation with the project work: This work focuses on femoto- and macrocell networks, which is related to Task 5.3.

[77] Zhang, R., Yang, Lie-Liang and Hanzo, L., "Energy Pattern Aided Simultaneous Wireless Information and Power Transfer," IEEE Journal on Selected Areas in Communications, vol.PP, no.99, pp.1,1.

Abstract: In echoing Varshney's seminal concept of jointly transmitting information and energy, we propose the concept of an energy pattern aided Simultaneous Wireless Information and PowerTransfer (SWIPT) system, where in addition to power transfer, information is conveyed both by the specific Receive Antenna (RA) indices to which the power is delivered as well as by the particular intensity of the power assigned to that particular RA pattern. By embedding information into energy patterns rather than imposing it by modulating classic radio waveforms, our proposed solution is capable of operating both in an integrated receiver mode and in a power-split mode, whilst relying on a low-complexity two-stage non-coherent detection algorithm. Both our analysis and simulations show that our energy pattern aided SWIPT system exhibits a beneficial immunity to any potential performance degradation imposed by power-conversion. Moreover, the achievable rate versus power conversion trade-off bounds are characterized, demonstrating that our proposed energy pattern aided SWIPT system leads to a beneficial wireless information and power transfer convergence.

Relation with the project work: This paper is pertaining to WP5, with particular emphasis on Task 5.3. A novel energy pattern aided SWIPT system is proposed, where both RA index-based information transfer as well as intensity-based information transfer were employed in the context of both the integrated receiver mode and the power-split mode.

[78] Rong Zhang, Lie-liang Yang and Hanzo, L., "Error Probability and Capacity Analysis of Generalised Pre-Coding Aided Spatial Modulation," IEEE Transactions on Wireless Communications, vol.14, no.1, pp.364-375, Jan. 2015.

Abstract: The recently proposed multiple input multiple output (MIMO) transmission scheme termed asgeneralized pre-coding aided spatial modulation (GPSM) is analyzed, where the key idea is that a particular subset of receive antennas is activated and the specific activation pattern itself conveys useful implicit information. We provide the upper bound of both the symbol error ratio (SER) and bit error ratio (BER) expression of the GPSM scheme of a low-complexity decoupled detector. Furthermore, the corresponding discrete-input continuous-output memoryless channel (DCMC) capacity as well as the achievable rate is quantified. Our analytical SER and BER upper bound expressions are confirmed to be tight by our numerical results. We also show that our GPSM scheme constitutes a flexible MIMO arrangement and there is always a beneficial configuration for our GPSM scheme that offers the same bandwidth efficiency as that of its conventional MIMO counterpart at a lower signal to noise ratio (SNR) per bit.

Relation with the project work: This paper is related to WP5 in general, whereby the concept of our GPSM scheme is introduce, followed by its theoretical analysis in terms of both its DCMC capacity as well as its achievable rate relying on our analytical upper bound of the SER and the BER expressions, when a low-complexity decoupled detector is employed.

[79] Alanis, D.; Botsinis, P.; Soon Xin Ng; Hanzo, L., "Quantum-Assisted Routing Optimization for Self-Organizing Networks," IEEE Access, vol.2, no., pp.614-632, 2014.

Abstract: Self-organizing networks act autonomously for the sake of achieving the best possible performance. The attainable routing depends on a delicate balance of diverse and often conflicting quality-of-service requirements. Finding the optimal solution typically becomes an mono-polynomial-hard problem, as the network size increases in terms of the number of nodes. Moreover, the employment of user-defined utility functions for the aggregation of the different objective functions often leads to suboptimal solutions. On the other hand, Pareto optimality is capable of amalgamating the different design objectives by providing an element of elitism. Although there is a plethora of bio-inspired algorithms that attempt to address this optimization problem, they often fail to generate all the points constituting the optimal Pareto front. As a remedy, we propose an optimal multi-objective quantum-assisted algorithm, namely the non-dominated quantum optimization algorithm (NDQO), which evaluates the legitimate routes using the concept of Pareto optimality at a reduced complexity. We then compare the performance of the NDQO algorithm to the state-of-the-art evolutionary algorithms, demonstrating that the NDQO algorithm achieves a near-optimal performance. Furthermore, we analytically derive the upper and lower bounds of the NDQO algorithmic complexity, which is of the order of O(N) and O(N$\sqrt{}$(N)) in the best and worst case scenario, respectively. This corresponds to a substantial complexity reduction of the NDQO from the order of O(N2) imposed by the brute-force method.

Relation with the project work(Task 5.3): We have proposed an optimal algorithm for multi-objective routing in SONs using Pareto Optimality. The theoretical upper and lower complexity bounds of the NDQO algorithm have been analytically derived, yielding a complexity between O(N)) and O(N√N). This implies a significant CFE reduction compared to the classical BF method, which exhibits a complexity on the order of O(N2) in the worst case scenario.

[80] Yongkai Huo; El-Hajjar, M.; Hanzo, L., "Wireless Video: An Interlayer Error-Protection-Aided Multilayer Approach," IEEE Vehicular Technology Magazine, vol.9, no.3, pp.104-112, Sept. 2014.

Abstract: Video clips captured from real world scenes exhibit intra-frame correlation among their pixels. This correlation can be removed by applying video compression to reduce the required the storage space, transmission bandwidth, bitrate, and power. Layered video coding separates the video sequence into partitions having unequal importance, hence allowing the decoder to progressively refine the reconstructed video quality, when an increased bandwidth is available. On the other hand, compressed video signals are sensitive to channel errors. Therefore, forward error correction (FEC) must be applied when communicating over hostile wireless channels. In addition, based on the fact that the different layers have unequal importance, different-rate FEC codes may be applied to the different layers, leading to unequal error protection (UEP). We propose an interlayer (IL) FEC coding technique combined with UEP, where the lower-importance layers are used for protecting the higher-importance layers in the data-partitioned mode of H.264/advanced video coding (AVC). Explicitly, our simulation results show that the IL coded system outperforms the traditional UEP system by providing a better video quality for transmission over a wireless channel having Eb /N0 of 0 dB, when using our multifunctional multiple-input, multiple-output (MIMO) array.

Relation with the project work (Task 5.2): In this article, a brief description of novel protection arrangements conceived for layered video coding was presented. It was shown how UEP can be utilized for enhancing the video quality at the receiver. Furthermore, we described our proposed IL coding technique that can be combined with UEP in layered video coding to further improve the attainable system performance.

[81] Zhang, B.; Hu, J.; Huang, Y.; El-Hajjar, M.; Hanzo, L., "Outage Analysis of Superposition-Modulation-Aided Network-Coded Cooperation in the Presence of Network Coding Noise," IEEE Transactions on Vehicular Technology, vol.64, no.2, pp.493,501, Feb. 2015.

Abstract: We consider a network, where multiple source–destination (S–D) pairs communicate with the aid of a half-duplex relay node (RN), which adopts decode-and-forward (DF) relaying and superposition modulation (SPM) for combining the signals transmitted by the source nodes (SNs) and then forwards the composite signal to all the destination nodes (DNs). Each DN extracts the signals transmitted by its own SN from the composite signal by subtracting the signals overheard from the unwanted SNs. We derive tight lower bounds for the outage probability for transmission over Rayleigh fading channels and invoke diversity combining (DC) at the DNs, which is validated by simulation for both the symmetric and the asymmetric network configurations. For the high signal-to-noise ratio regime, we derive both an upper bound and a lower bound for the outage performance and analyze the achievable diversity gain. It is revealed that a diversity order of 2 is achieved, regardless of the number of SN–DN pairs in the network. We also highlight the fact that the outage performance is dominated by the quality of the worst overheated link because it contributes most substantially to the network coding (NC) noise. Finally, we use the lower bound for designing a relay selection scheme for the proposed SPM-based network-coded cooperative communication (SPM-NC-CC) system.

Relation with the project work (Task 5.3): In this paper, a cooperative network was considered, where multiple SN–DN pairs communicate with the aid of a single RN. The lower bounds of the outage probability were derived, which matches tightly with the simulation results. The results explicitly quantified the detrimental effects of NC noise imposed on SPM-NC-CC schemes. Additionally, we designed a relay selection approach for our SPM-NC-CC scheme using the closed-form outage expression derived in (11), which avoids the excessive computational burden required by Monte Carlo simulations.

[82] Jin, F.; Zhang, R.; Hanzo, L., "Resource Allocation Under Delay-Guarantee Constraints for Heterogeneous Visible-Light and RF Femtocell," IEEE Transactions on Wireless Communications, vol.14, no.2, pp.1020,1034, Feb. 2015.

Abstract: The resource-allocation (RA) problems of mobile terminals (MTs) are investigated in a heterogeneous wireless network, where both a visible light communication system and an RF femtocell system are deployed in a room. We consider diverse quality-of-service requirements in terms of the data rate, fairness, and statistical delay requirements. Inspired by the concept of effective capacity, we formulate our optimization problems applying α-proportional fairness while satisfying specific statistical delay constraints. Two types of MTs, namely, multihoming MTs and multimode MTs, are considered, where multihoming MTs have the capability of aggregating resources from

different networks, whereas the multimode MTs always select a single network for their connection. Our optimization procedure solves the RA probability problem for multihoming MTs with the aid of a decentralized algorithm. By contrast, our optimization problem involves both network selection and RA probability optimization for multimode MTs, which may be regarded as a mixed-integer nonlinear problem. Since this problem is computationally intractable, a suboptimal decentralized method is proposed for solving it. Simulation results are also presented for clarifying the performance of the proposed algorithm. It is shown that the multimode MTs are capable of achieving similar performance to that of the multihoming MTs when the statistical delay requirements are loose. However, as expected, the multihoming MTs attain a better performance when we tighten the delay requirements.

Relation with the project work(Task 5.2): In this paper, we studied the resource allocation problems of mobile terminals (MTs) in a HetNet under diverse QoS requirements in terms of the data rate, fairness to MTs and the statistical delay requirements, where a hybrid VLC and RF femto-cell system was considered. The objective functions relied upon were proven to be concave. Then we proposed decentralized algorithms for solving the associated RA problem. The optimal RA for each iteration of the dual decomposition algorithm were presented and simulations were performed for validating the algorithm.

[83] Peichang Zhang; Sheng Chen; Hanzo, L., "Two-Tier Channel Estimation Aided Near-Capacity MIMO Transceivers Relying on Norm-Based Joint Transmit and Receive Antenna Selection," IEEE Transactions on Wireless Communications, vol.14, no.1, pp.122-137, Jan. 2015.

Abstract: We propose a norm-based joint transmit and receive antenna selection (NBJTRAS) aided near-capacity multiple-input-multiple-output (MIMO) system relying on the assistance of a novel two-tier channel estimation scheme. Specifically, a rough estimate of the full MIMO channel is first generated using a low-complexity, low-training-overhead minimum mean square error based channel estimator, which relies on reusing a modest number of radio frequency (RF) chains. NBJTRAS is then carried out based on this initial full MIMO channel estimate. The NBJTRAS aided MIMO system is capable of significantly outperforming conventional MIMO systems equipped with the same modest number of RF chains while dispensing with the idealized simplifying assumption of having perfectly known channel state information (CSI). Moreover, the initial subset channel estimate associated with the selected subset MIMO channel matrix is then used for activating a powerful semi-blind joint channel estimation and turbo detector-decoder, in which the channel estimate is refined by a novel block-of-bits selection based soft-decision aided channel estimator (BBSB-SDACE) embedded in the iterative detection and decoding process. The joint channel estimation and turbo detection-decoding scheme operating with the aid of the proposed BBSB-SDACE channel estimator is capable of approaching the performance of the near-capacity maximum-likelihood (ML) turbo transceiver associated with perfect CSI. This is achieved without increasing the complexity of the ML turbo detection and decoding process.

Relation with the project work (Task 5.3): In this paper, we have proposed a novel TTCE assisted and NBJTRAS aided three-stage turbo coded MIMO system, and our contribution has been twofold. Firstly, we have developed a low-complexity yet effective NBJTRAS aided near-capacity three-stage turbo coded MIMO system, which significantly outperforms the conventional MIMO system having the same number of RF chains and operating without AS, in terms of the achievable BER performance and throughput. Secondly, we have proposed a new TTCE scheme relying on a low training overhead for assisting the NBJTRAS aided MIMO system to approach the optimal MIMO performance bound associated with perfect CSI, which maintains a high system effective throughput while imposing a low computational complexity.

[84] Zhang, W.; Jia, Y.; Meng, X.; Brejza, M.F.; Maunder, R.G.; Hanzo, L., "Adaptive Iterative Decoding for Expediting the Convergence of Unary Error Correction Codes," IEEE Transactions on Vehicular Technology, vol.64, no.2, pp.621,635, Feb. 2015.

Abstract: Multimedia encoders typically generate symbols having a wide range of legitimate values. In practical mobile wireless scenarios, the transmission of these symbols is required to be bandwidth efficient and error resilient, motivating both source coding and channel coding. However, separate source and channel coding (SSCC) schemes are typically unable to exploit the residual redundancy in the source symbols, which cannot be totally reduced by finite-delay finite-complexity schemes, hence resulting in a capacity loss. Until recently, none of the existing joint source and channel codes (JSCCs) were suitable for this application since their decoding complexity rapidly increases with the size of the symbol alphabet. Motivated by this, we proposed a novel JSCC referred to as the unary error correction (UEC) code, which is capable of exploiting all residual redundancy and eliminating any capacity loss, while imposing only a moderate decoding complexity. In this paper, we show that the operation of the UEC decoder can be dynamically adapted to strike an attractive tradeoff between its decoding complexity and its error correction capability. Furthermore, we conceive the corresponding 3-D EXtrinsic Information Transfer (EXIT) charts for controlling this dynamic adaptation, as well as the decoder activation order, when the UEC code is serially concatenated with a turbo code. In

this way, we expedite iterative decoding convergence, facilitating a gain of up to 1.2 dB compared with both SSCC and to its nonadaptive UEC benchmarkers, while maintaining the same transmission bandwidth, duration, energy, and decoding complexity.

Relation with the project work (Task 3.1): In this paper, we have demonstrated that the number of trellis states employed by a UEC decoder can be dynamically adapted to strike an attractive tradeoff between its decoding complexity and its error correction capability. Furthermore, we have proposed the employment of 3-D EXIT charts for controlling this dynamic adaptation, as well as for controlling the decoder activation order. This has been demonstrated for the scenario where the UEC code is serially concatenated with

[85] Yetgin, H., Cheung, K. t. K., El-Hajjar, M. & Hanzo, L. 'Cross-layer network lifetime optimisation considering transmit and signal processing power in wireless sensor networks', in *IET Wireless Sensor Systems*, 4, 176-182, 2014.

Abstract: Maintaining high energy efficiency is essential for increasing the lifetime ot wireless sensor networks (WSNs), where the battery of the sensor nodes cannot be routinely replaced. Nevertheless, the energy budget of the WSN strictly relies on the communication parameters, where the choice of both the transmit power as well as of the modulation and coding schemes (MCSs) plays a significant role in maximising the network lifetime (NL). In this paper, we optimise the NL of WNSs by analysing the impact of the physical layer parameters as well as of the signal processing power (SPP) P_{sp} on the NL. We characterise the underlying trade-offs between the NL and bit error ratio (BER) performance for a predetermined set of target signal-to-interference-plus-noise ratio (SINR) values and for different MCSs using periodic transmit-time slot (TS) scheduling in interference-limited WSNs. For a per-link target BER requirement (PLBR) of 10^{-3}, our results demonstrate that a `continuous-time' NL in the range of 0.58 - 4.99 years is achieved depending on the MCSs, channel configurations, and SPI.

Relation with the project work (WP5): We evaluated the NL for both Scenario 1, where we consider the required transmit power only, and for Scenario 2, where we considered an additional SPP, against the BER target of WSNs for a fi xed rate of different MCSs for both AWGN and Rayleigh fading channels.

[86] G. Panza and S. Grilli, "An IP cross-layer scheduler with closed-loop control for QoS provisioning in NGNs", to be published in Springer Wireless Networks journal in 2015 (extended version of the work presented at IEEE MoWNet 2014 – 1st CONCERTO Workshop).

Abstract: Next-Generation Networks (NGNs) will support Quality of Service (QoS) over a mixed wired and wireless IP-based infrastructure. A relative model of service differentiation in Differentiated Services architecture is a scalable solution for delivering multimedia traffic. However, the dynamic nature of radio channels makes it difficult to achieve the target quality provisioning working at the IP and lower layers separately as in the classical approach.
In this work, an IP cross-layer scheduler with feedback control able to support a Proportional Differentiation Model (PDM) for delay guarantees also over wireless is described. The key idea is to leverage feedbacks about the actual delays experienced by packets at the lower layers and the errors with respect to the ideal support of the PDM in order to tune at run-time the priority of the IP queues with the objective of supporting a PDM at the network interface on the whole across multiple layers.
A simulation analysis demonstrates the reliability and robustness of the proposal in achieving consistent results even with highly time-variant performance of the LTE 3GPP MAC and PHY layers, differently from the classical approach. Furthermore, considerations on the required additional functionality and likely deployment scenarios highlight the scalability and backward compatibility of the designed solution.

Relations with the project work: the article reports the results achieved in WP5, about the design and development of an IP content-aware cross-layer scheduler. It gives a complete vision of the work done, because it contains a complete description of the adopted models, of the made assumptions and the complete report of the achieved results, including a comparison with the IP scheduler without the cross layer solution. The contribution has been included in D5.3. Providing QoS guarantees in a reliable, robust, scalable and backward compatible way on the basis of media content to be delivered is key to the project.

[87] A. Weinlich, P. Amon, A. Hutter, and A. Kaup, "Probability Distribution Estimation for Autoregressive Pixel-predictive Image Coding", submitted to *IEEE Transactions on Image Processing*.

Abstract: Pixel-wise linear prediction using backward adaptive least-squares or weighted least-squares estimation of prediction coefficients is currently among the state-of-the-art methods for lossless image compression. While current research is focused on mean intensity prediction of the pixel to be transmitted, best compression requires occurrence

probability estimates for all possible intensity values. Apart from common heuristic approaches, we show how prediction error variance estimates can be derived from the (weighted) least-squares training region and how a complete probability distribution can be built based on an autoregressive image model. The analysis of image stationarity properties further allows deriving a novel formula for weight computation in weighted least-squares proofing and generalizing ad-hoc equations from literature. For sparse intensity distributions in non-natural images a modified image model is presented. Evaluations were done in the newly developed C++ framework Vanilc (Volumetric, artificial, and natural image lossless coder), which can compress a wide range of images, including 16-bit medical 3-D volumes or multi-channel data. A comparison with several of the best available lossless image codecs proofs that the method can achieve very competitive compression ratios. In terms of reproducible research, the source code of Vanilc will be made public.

Relation with the project work: This work is part of WP 3, Task 3.1, related to lossless compression of images, especially also for medical image data (e.g., computed tomography images).

2.2.3 Conference, symposium or workshop proceedings

[88] G. Panza and S. Grilli, "Cross-layer scheduling with feedback for QoS support", IEEE MoWNet 2014 – 1st CONCERTO Workshop.

Abstract: Next-Generation Networks (NGNs) will support Quality of Service (QoS) over a mixed wired and wireless IP-based infrastructure. A relative model of service differentiation in Differentiated Services architecture is a scalable solution for delivering multimedia traffic. However, the dynamic nature of radio channels makes it difficult to achieve the target quality provisioning working at the IP and lower layers separately as in the classical approach.
In this work, an IP cross-layer scheduler with feedback control able to support a Proportional Differentiation Model (PDM) for delay guarantees also over wireless is described. The key idea is to leverage feedbacks about the actual delays experienced by packets at the lower layers and the errors with respect to the ideal support of the PDM in order to tune at run-time the priority of the IP queues with the objective of supporting a PDM at the network interface on the whole across multiple layers.
A simulation analysis demonstrates the reliability and robustness of the proposal in achieving consistent results even with highly time-variant performance of the LTE 3GPP MAC and PHY layers, differently from the classical approach. Furthermore, considerations on the required additional functionality and likely deployment scenarios highlight the scalability and backward compatibility of the designed solution.

Relations with the project work: the article reports the results achieved in WP5, about the design and development of an IP content-aware cross-layer scheduler. It gives a complete vision of the work done, because it contains a complete description of the adopted models, of the made assumptions and the complete report of the achieved results, including a comparison with the IP scheduler without the cross layer solution. the contribution has been included in D5.3. Providing QoS guarantees in a reliable, robust, scalable and backward compatible way on the basis of media content to be delivered is key to the project.

[89] G. Panza and S. Grilli, "QoS provisioning by cross-layer feedback control", IEEE Symposium on Communications and Vehicular Technology, (SCVT 2014).

Abstract: Next-Generation Networks (NGNs) will support Quality of Service (QoS) over a mixed wired and wireless IP-based infrastructure. A relative model of service differentiation in Differentiated Services architecture is a scalable solution for delivering multimedia traffic. However, the dynamic nature of radio channels makes it difficult to achieve the target quality provisioning working at the IP and lower layers separately as in the classical approach.
In this work, an IP cross-layer scheduler with feedback control able to support a Proportional Differentiation Model (PDM) for delay guarantees also over wireless is described. The key idea is to leverage feedbacks about the actual delays experienced by packets at the lower layers and the errors with respect to the ideal support of the PDM in order to tune at run-time the priority of the IP queues with the objective of supporting a PDM at the network interface on the whole across multiple layers.
A simulation analysis demonstrates the reliability and robustness of the proposal in achieving consistent results over the IEEE 802.11g MAC and PHY layers, differently from the classical approach. Furthermore, considerations on the required additional functionality and likely deployment scenarios highlight the scalability and backward compatibility of the designed solution.

Relations with the project work: the article reports the results achieved in WP5, about the design and development of an IP content-aware cross-layer scheduler. It gives a complete vision of the work done, because it contains a complete

description of the adopted models, of the made assumptions and the complete report of the achieved results, including a comparison with the IP scheduler without the cross layer solution. the contribution has been included in D5.3. Providing QoS guarantees in a reliable, robust, scalable and backward compatible way on the basis of media content to be delivered is key to the project.

[90] S. Cicalò and V. Tralli, "Cross-Layer Algorithms for Distortion-Fair Scalable Video Delivery over OFDMA Wireless Systems," in Proc. of IEEE Globecom Workshop on Quality of Experience for Multimedia Communications 2012, Anaheim, California (USA), Dec. 2012

Abstract: Optimizing video delivery to multiple users over OFDMA wireless systems is a challenging task, especially when the objective of maximizing the spectral efficiency has to be jointly considered with the objective of providing a fair video quality. In this paper a novel cross-layer optimization framework is proposed. It jointly addresses rate adaptation and resource allocation, aiming at maximizing the sum of the achievable rates while minimizing the distortion difference among multiple videos. After having discussed its feasibility, the optimization problem is vertically decomposed into two sub-problems, and a novel efficient Iterative Local Approximation (ILA) algorithm is proposed to evaluate the global solution. ILA algorithm requires a limited information exchange between the application and the MAC layers, which independently run algorithms that handle parameters and constraints characteristic of a single layer. The numerical evaluations show the fast convergence of the ILA algorithm and demonstrate the significant video quality improvement of the proposed strategy with respect to other optimization frameworks.

Relations with the project work: This work is related to WP5, as it deals with a cross-layer iterative technique for transmission of scalable video over OFDMA wireless links. The objective of the rate adaptation and radio resource allocation is to deliver different video contents to different users, while guaranteeing fairness in terms of video distortion.

[91] M. Chiani, G. Liva and E. Paolini, "The Marriage Between Random Access and Codes on Graphs: Coded Slotted Aloha," in Proc. of the IEEE First European Conference on Satellite Telecommunications (AESS) 2012, Rome (Italy), Oct. 2012.

Abstract: We present some recent results on a scheme, named Coded Slotted Aloha, where the theory of codes on graphs is used to obtain a random access protocol that does not require retransmissions. The scheme is based on the use of erasure correcting codes for the recovery of packet segments that are lost in collisions, and on successive interference subtraction for resolving collisions. The proposed protocol achieves reliable communication in the asymptotic setting and attains capacities close to 1 packet/slot. Some remarks and results for practical implementation of the access scheme are presented.

Relations with the project work: This work is related to WP4 (T4.3) and WP5, as it concerns an uncoordinated multiple access scheme that can be useful, e.g., in emergency areas where multiple data and video streams are transmitted toward a unique destination.

[92] G. Liva, B. Matuz, E. Paolini and M. Chiani, "Short Low-Rate Non-Binary Turbo Codes," IEEE 7th International Symposium on Turbo Codes & Iterative Information Processing (ISTC), Gothenburg (Sweden), Aug. 2012.

Abstract: A serial concatenation of an outer non-binary turbo code with different inner binary codes is introduced and analyzed. The turbo code is based on memory-1 time-variant recursive convolutional codes over high order fields. The resulting codes possess low rates and capacity-approaching performance, thus representing an appealing solution for spread spectrum communications. The performance of the scheme is investigated on the additive white Gaussian noise channel with coherent and noncoherent detection via density evolution analysis. The proposed codes compare favorably w.r.t. other low rate constructions in terms of complexity/performance trade-off. Low error floors and performances close to the sphere packing bound are achieved down to small block sizes (k=192 information bits).

Relations with the project work: This work is mainly related to WP5, as it concerns the design of forward error correction schemes for low-delay applications, e.g. real-time video transmission over wireless networks.

[93] E. Paolini, G. Liva and M. Chiani, "Random Access on Graphs: A Survey and New Results," Proc. of 46th Annual Asilomar Conference on Signals, Systems, and Computers, Pacific Groove, CA (USA), Nov. 2012.

Abstract: This paper overviews the recently proposed coded slotted ALOHA (CSA) random access scheme and illustrates some new results in this area. In CSA, a randomly picked linear block code is employed by each user to encode segments of its bursts prior to transmission, where the choice of the code is performed with no coordination with the other users. On the receiver side iterative interference cancellation combined with decoding of the local codes is performed to recover from collisions. This process may be represented as an iterative decoding algorithm over a sparse bipartite graph.

Relations with the project work: This work is related to WP4 (T4.3) and WP5, as it concerns an uncoordinated multiple access scheme that can be useful, e.g., in emergency areas where multiple data and video streams are transmitted toward a unique destination.

[94] B. Matuz, G. Liva, E. Paolini, M. Chiani and G. Bauch, "Blockwise Noncoherent AWGN Channel: Concatenated Codes and Composite Capacity," 9th International ITG Conference on Systems, Communications and Coding (SCC2013), Munich, Germany, Jan. 2013.

Abstract: We consider binary phase shift keying (BPSK) over an additive white Gaussian noise (AWGN) channel with constant, but unknown carrier phase over blocks of nI channel symbols and a concatenated coding scheme. The composite capacity of the channel constrained to specific binary inner codes, i.e. codes with good minimum distance properties, is derived. The outer code is chosen from the ensemble of non-binary regular $(2, d_c)$ low-density parity-check (LDPC) codes with fixed variable node degree of 2 and check node degree d_c. Iterative decoding thresholds obtained by means of density evolution are provided for several concatenations of inner and outer codes and are compared with capacity results.

Relations with the project work: This work is mainly related to WP5, as it concerns the design of forward error correction schemes for low-delay applications, e.g. real-time video transmission over wireless networks.

[95] B. Matuz, G. Liva, E. Paolini and M. Chiani, "Verification-Based Decoding with MAP Erasure Recovery," 9th International ITG Conference on Systems, Communications and Coding (SCC2013), Munich, Germany, Jan. 2013.

Abstract: Verification-based decoding (VBD) is a simple yet powerful iterative (IT) decoding technique for codes operating on packets (vector-symbols) and channels that introduce packet- wise errors. An example is given by the q-ary symmetric channel (qSC) for which a simple improvement of the VBD algorithm is proposed. It consists of performing a Gaussian elimination (GE)-based erasure decoding stage whenever VBD fails, i.e., whenever $\beta > 0$ packets remain unverified. The modified decoder may recover the β unverified packets with a complexity of $O(\beta \text{ ^3})$ by making use of the inherent code structure. Numerical results on low-density parity-check (LDPC) codes and analytical expressions for the block error probability of linear random block codes show the benefit of the proposed algorithm.

Relations with the project work: This work is related to WP4 (T4.3), as it concerns packet-level protection techniques to be implemented at the upper layers of the communication stack to recover from packet losses. These techniques are particularly suitable in delay-sensitive applications where retransmissions are not appropriate.

[96] Li Li, Li Wang and L. Hanzo, "Successive DF relaying: MS-DIS aided interference suppression and three-stage concatenated architecture design", in 2012 *IEEE International Conference on Communications (ICC), Ottawa, Canada*, 10-15 June 2012.

Abstract: Conventional single-relay aided two-phase cooperative networks employing coherent detection algorithms incur a significant 50% throughput loss. Furthermore, it is unrealistic to expect that in addition to the task of relaying, the relay-station would dedicate further precious resources to the estimation of the source-relay channel in support of coherent detection. In order to circumvent these problems, we propose decode-and-forward (DF) based successive relaying employing noncoherent detection schemes. A crucial challenge in this context is that of suppressing the successive relaying induced interference, despite dispensing with any channel state information (CSI). We overcome this challenge by introducing a novel adaptive Newton algorithm based multiple-symbol differential interference suppression (MS-DIS) scheme. Correspondingly, a three-stage concatenated transceiver architecture is devised. We demonstrate that our proposed system is capable of near-error-free transmissions at low signal-to-noise ratios.

Relations with the project work: In this work, a decode-and-forward based successive relaying scheme has been proposed for cooperative networks, which is related to Task 5.3.

[97] Chao Xu, Dandan Liang, S. Sugiura, Soon Xin Ng and L. Hanzo, "Reduced-Complexity Soft-Decision Aided PSK Detection", in 2012 IEEE *Vehicular Technology Conference (VTC Fall),* Quebec, Canada, 3-6 Sept. 2012

Abstract: In this paper, we propose to reduce the complexity of both the Approx-Log-MAP algorithm as well as of the Max-Log-MAP algorithm, which were designed for soft-decision aided PSK detectors. First of all, we extend the shown a posteriori PSK symbol probability formula and streamline it by eliminating its unnecessary calculations in the context of the Approx-Log-MAP algorithm. Secondly, we reduce the complexity of the Max-Log-MAP algorithm, where the maximum a posteriori symbol probability may be obtained without evaluating and comparing all the candidate symbol probabilities. Furthermore, we apply our new soft detection arrangement to a variety of coded systems. Our simulation results demonstrate that a significant detection complexity reduction was achieved by our design without any performance loss. For example, a factor two complexity reduction was achieved by the proposed Max-Log-MAP algorithm, when it was invoked for detecting QPSK symbols, which is expected to be significantly higher, when invoked for 16QAM.

Relations with the project work: This is related to WP5, focussing primarily on Task 5.3.

[98] M. Driusso, F. Babich, M.I. Kadir and L. Hanzo, "OFDM Aided Space-Time Shift Keying for Dispersive Downlink Channels", in 2012 IEEE *Vehicular Technology Conference (VTC Fall), Quebec, Canada,* 3-6 Sept. 2012.

Abstract: The performance of a Space-Time Shift Keying (STSK) scheme was shown to degrade in frequency-selective fading channels. Hence, we propose Orthogonal Frequency Division Multiplexing (OFDM) combined with STSK for frequency-selective broadband channels. Furthermore, we consider both an uncoded and a near-capacity coded scenario. Our results show that a STSK system combined with OFDM is capable of overcoming the impairments of dispersive channels, hence approaching the same performance as in a flat- fading channel.

Relation with the project work: This work deals with WP5.

[99] Hua Sun, Soon Xin Ng, and L. Hanzo, "Superposition Coded Modulation for Cooperative Communications," in 2012 IEEE *Vehicular Technology Conference (VTC Fall), Quebec, Canada,* 3-6 Sept. 2012.

Abstract: A Turbo Trellis-Coded Modulation (TTCM) aided superposition modulation scheme is conceived for a Decode-and-Forward (DAF) based cooperative communication system. More specifically, two source nodes communicate simultaneously with the same destination node via a relay node. Superposition modulation is invoked at the relay node in order to combine and simultaneously transmit the two source signals to the destination node. Hence two timeslots are used to transmit two source signals. Extrinsic Information Transfer (EXIT) charts and power sharing techniques are employed in our design. The performance of the proposed scheme is investigated for transmission over uncorrelated Rayleigh fading channels, which is within about 2 dB of the corresponding capacity.

Relation with the project work: In this work, a TTCM-aided superposition modualtion scheme has been proposed for DAF-based cooperative communications, which is related to WP5.

[100] Chao Xu, Dandan Liang, S. Sugiura, Ng, Soon Xin Ng, and L. Hanzo, “Reduced-complexity soft STBC detection”, in *2012 IEEE Global Communications Conference, Anaheim, US, 03 - 07 Dec 2012.*

Abstract: In this paper, we propose to reduce the complexity of both the Approx-Log-MAP algorithm as well as of the Max-Log-MAP algorithm, which were designed for soft-decision-aided Space-Time Block Code (STBC) detectors. First of all, we review the STBC design, which enables regular L-PSK/QAM detectors to be invoked in order to detect STBCs on a symbol-by-symbol basis. Secondly, we propose to operate the L-PSK/QAM aided STBC detection on a bit-by-bit basis, so that the complexity may be reduced from the order of O(L) to O(BPS). Our simulation results demonstrate that a near-capacity performance may be achieved by the proposed detectors at a substantially reduced detection complexity. For example, a factor six complexity reduction was achieved by the proposed algorithms, when they were invoked for detecting Alamouti's Square 16QAM aided G2 scheme.

Relation with the project work: This work is related to WP5.

[101] Shaoshi Yang and L. Hanzo, “Iterative detection and decoding using approximate Bayesian theorem based PDA method over MIMO Nakagami-m fading channels”, in *2012 IEEE Global Communications Conference (IEEE GLOBECOM 2012), Anaheim, US, 03 - 07 Dec 2012.*

Abstract: In this paper, the design of iterative detection and decoding (IDD) schemes relying on a low-complexity probabilistic data association (PDA) aided method is conceived for turbo-coded multiple-input multiple-output (MIMO) systems communicating over Nakagami-m fading channels. The known PDA based MIMO detectors typically operate purely in the probability-domain. We show that the classic relationship where the extrinsic LLRs are given by subtracting the a priori LLRs from the a posteriori LLRs does not hold for the existing PDA based MIMO detectors. Therefore, the PDA method is not readily applicable to the IDD receiver. To overcome this predicament, we propose an approximate Bayesian theorem based log-domain PDA (AB-Log-PDA) detector, as well as a novel simple approach of calculating the bit-wise extrinsic LLRs for the AB-Log-PDA, which makes the AB-Log-PDA well-suited for employment in IDD receivers. It is shown that the proposed AB-Log-PDA based IDD scheme is capable of achieving a comparable performance to that of the optimal maximum a posteriori (MAP) detector based IDD receiver, while imposing a much lower computational complexity in the scenarios considered.

Relation with the project work: This paper falls under the on-going work of WP5.

[102] Jie Hu, Lie-Liang Yang and L. Hanzo, Lajos, "Optimal Queue Scheduling for Hybrid Cognitive Radio Maintaining Maximum Average Service Rate Under Delay Constraints", in, *2012 IEEE Global Communications Conference (GLOBECOM), Anaheim, US, 03 - 07 Dec 2012.*

Abstract: As a promising technique of improving the attainable bandwidth e□ciency, cognitive radio (CR) has attracted substantial attention from both the academic and industrial communities. In order to improve the performance of the secondary user (SU), a novel hybrid CR system is introduced, which combines the conventional interweave and underlay paradigms for enhancing the chances of the SU to access the spectrum. Queuing theory is invoked in this paper for analysing the impact of the primary user's (PU) delay tolerance on the performance of the SU. Multiple queues are assumed for the SU engaging in video communication. Besides the Poisson tra□c generation, we model a Rayleigh fading channel as a Poisson service process with the aid of the outage probability in the presence of cochannel interferences. Two valuable goals are achieved, namely that of maximizing the average service rate and minimizing the overall average delay of the SU's multiple queues. As our numerical results demonstrate, the overall average delay of the SU becomes 27% and 34% lower than that of the Proportional as well as that of the Round-Robin schemes respectively.

Relation with the project work: This work addresses the issue of improving the performance of secondary users cognitive radio; thus, addressing Task 5.3.

[103] Dandan Linag, Xinyi Xu, Soon Xin Ng and L. Hanzo, "Turbo-coded star-QAM for cooperative wireless and optical-fiber communications", in *3rd International Conference on Photonics, Penang, Malaysia, 01 - 03 Oct 2012.*

Abstract: A low-complexity cooperative wireless and optical-fiber communication scheme is proposed for uplink communication in a Fractional Frequency Reuse (FFR) based multicell, multiuser system. The FFR principle is invoked for improving the cell-edge performance without reducing the throughput of the cell-center. Each cell is illuminated with the aid of six Remote Antennas (RAs), which are connected to the central base-station with the aid of realistically modelled imperfect optical-fiber links. When a Mobile Station (MS) is located at the cell-edge, the two nearest RAs can be invoked to detect and forward the user's signal to the base-station, based on the Single-Input Multiple-Output (SIMO) principle. Furthermore, we design a Turbo Coded (TC) 16-level Star-Quadrature Amplitude Modulation (StQAM) scheme for supporting optical-fiber-aided cooperative wireless transmission, where the receiver does not have to estimate the channel state information. Hence, a lower detection complexity can be achieved when compared to coherently detected schemes, albeit naturally, at a 3 dB power-loss. We also investigated the effect of phase-rotation imposed by imperfect optical-fiber links. We found that our noncoherent TC-StQAM scheme is robust to both wireless and optical-fiber imperfections

Relation with the project work: This work is part of the ongoing work on WP5. Here a novel cooperative wireless and optical-fiber communication scheme has been developed for the uplink transmission.

[104] J. Nagler, P. Amon, and L. Demaret. Hybrid downscaling of DCT-compressed images, in *Proc. of IEEE Germany Student Conference (GSC) 2012*, Passau, Germany, Nov. 2012.

Abstract: We introduce an efficient downscaling methods with arbitrary downscaling factors for images that are transformed to DCT blocks as in the compression standard JPEG. Our hybrid approach combines the low complexity of DCT domain downscaling with the high image quality of B-spline based downscaling methods. A scalable parameter allows to adjust the trade-off between computational costs and image quality. Results from numerical experiments

demonstrate the superiority of the new method in terms of efficiency compared to the existing methods. Furthermore, our method results in a scalable trade-off between the image quality and the computational costs.

Relation with the project work: This work is part of WP 3, Task 3.1. In some medical applications, multiple image streams (e.g., ultrasound streams) need to be transmitted to and displayed by a client device simultaneously. Therefore, efficient downscaling algorithms are needed, e.g., to be applied on server-side.

[105] A. Weinlich, P. Amon, A. Hutter, and A. Kaup. Edge modeling prediction for computed tomography images, in *Proc. of Visual Communications and Image Processing (VCIP) 2012*, San Diego, CA, USA, Nov. 2012.

Abstract: Predictive coding is applied in many state-of-the-art lossless image compression algorithms like JPEG-LS, CALIC, or least-squares-based methods. We propose a new approach for accurate intensity prediction in pixel-predictive coding of computed tomography (CT) images. Exploiting their particular edge characteristic, the method only relies on a small twelve-pixel context. It does neither require adaptation to larger-region image characteristics nor the transmission of side-information and therefore may be particularly suitable for compression of small images like in region-of interest coding. While applying simple linear prediction with fixed weights in homogeneous regions, a Gauss error model function is fit to given contexts in edge regions and then sampled at the position corresponding to the pixel to be predicted in order to obtain prediction values. By the example of CALIC, it is shown that for CT data the edge modeling prediction (EMP) approach can yield an even smaller prediction error than other methods relying on context modeling.

Relation with the project work: This work is part of WP 3, Task 3.1, related to high-quality (i.e., lossless) compression of medical image data (i.e., computed tomography images).

[106] A. Weinlich, P. Amon, A. Hutter, A. Kaup, "Near-lossless compression of computed tomography images using predictive coding with distortion optimization", in *Proceedings of SPIE Medical Imaging 2013*, Orlando, Florida, FL, USA, February 2013.

Abstract: This paper presents a method for iterative minimization of combined residual and prediction error for near-lossless compression of medical computed tomography acquisitions using pixel-wise least-squares prediction. While most other lossy state-of-the-art image compression systems like JPEG 2000 make use of transform-based coding, in lossless coding higher compression ratios can be achieved with plain predictive algorithms like JPEG-LS because of their non-linear data adaptive energy reduction. Yet, applying these algorithms in lossy coding, simple quantization usually leads to error propagation and therefore serious quality loss or rate increase, as prediction accuracy of a pixel value and thus data rate depends on the previously reconstructed image region. The proposed minimization approach modifies the original image to be coded in a way such that the edge-directed prediction method from literature may achieve better predictions while introducing only a minimum amount of distortion. Compared to transform-based coding methods, the distortion introduced by the proposed scheme mostly consists in noise reduction instead of blurring or the introduction of artificial structures. The method also prevents error propagation due to the consideration of all pixel dependencies of the prediction. It is shown that, combined with a context-adaptive arithmetic coder, in high-fidelity coding (i. e., PSNR higher than 55 dB) the proposed method can achieve higher compression ratios than the transform-based approaches JPEG 2000, H.264/AVC, and HEVC intra coding.

Relation with the project work: This work is part of WP 3, Task 3.1, related to high-quality compression (i.e., near-lossless) of medical image data (i.e., computed tomography images).

[107] A. Weinlich, J. Rehm, A. Hutter, A. Kaup, "Massively parallel lossless compression of medical images using least-squares prediction and arithmetic coding", in *Proceedings of IEEE International Conference on Image Processing (ICIP) 2013*, Melbourne, Australia, September 2013.

Abstract: Medical imaging in hospitals requires fast and efficient image compression to support the clinical work flow and to save costs. Least-squares autoregressive pixel prediction methods combined with arithmetic coding constitutes the state of the art in lossless image compression. However, a high computational complexity of both prevents the application of respective CPU implementations in practice. We present a massively parallel compression system for medical volume images which runs on graphics cards. Image blocks are processed independently by own processing threads. After pixel prediction with specialized border treatment, prediction errors are entropy coded with an adaptive binary arithmetic coder. Both steps are designed to match particular demands of the parallel hardware architecture. Comparisons with current image and video coders show efficiency gains of 3.3–13.6% while compression times can be reduced to a few seconds.

Relation with the project work: This work is part of WP 3, Task 3.1. This work is based on the previously developed lossless image coding algorithm. It provides a parallel design of this algorithm for practical hardware-supported (GPU-accelerated) implementations.

[108] E. Wige, P. Amon, A. Hutter, A. Kaup, "Pixel-based averaging predictor for HEVC lossless coding", submitted to IEEE International Conference on Image Processing (ICIP) 2013, Melbourne, Australia, September 2013.

Abstract: This paper presents an intra-frame prediction scheme designed for lossless coding using HEVC. The proposed coding method comprises a pixel-wise prediction based on original samples. It is realized as a separate intra prediction mode, which replaces the PLANAR mode. In order to perform the prediction, a four-sample template around the pixel that is to be predicted is compared to the respective template of a four-pixel neighborhood. For each reference template, the sum of absolute differences (SAD) is determined. A table look-up of the SAD value gives the respective weighting factor for each neighborhood pixel. The predictor for the current pixel is calculated as the weighted average of the neighborhood pixels. In comparison to the unmodified HEVC Test Model HM-9.1 configured for lossless coding by disabling/bypassing transformation, quantization, and in-loop filters, the proposed method provides average bitrate savings up to 10.88% for intra-only coding at similar computational complexity.

Relation with the project work: This work is part of WP 3, Task 3.1, related to generic lossless coding of images and video sequences. This work is the basis for a standardization contribution to the Joint Collaborative Team on Video Coding (JCT-VC), a joint working group of ISO//IEC MPEG and ITU-T VCEG.

[109] A. Weinlich, M. Bätz, P. Amon, A. Hutter, A. Kaup, "Volumetric Deformation Compensation in CUDA for Coding of Dynamic Cardiac Images", in *Proceedings of Picture Coding Symposium (PCS) 2013*, San Jose, CA, USA, Dec. 2013.

Abstract: A new approach for volumetric deformation compensation in temporally predictive coding of dynamic medical heart images is presented. Instead of using conventional vectors, motion is represented by deformation values to model 3-D muscle contractions. In this way, estimated motion is more homogeneous among the image domain and predictions do not contain disturbing blocking artifacts making the approach suitable also for non-block-based transform coding. It is shown that with equal numbers of motion values the method can achieve prediction accuracies similar to cube-based motion estimation. The run time of the described parallel implementation in Nvidia CUDA is shown to be shorter than for an equivalent implementation of cube-based motion estimation.

Relation with the project work: This work is part of WP 3, Task 3.1, related to high-quality compression (i.e., near-lossless) of medical image data (i.e., computed tomography images).

[110] E. Wige, G. Yammine, P. Amon, A. Hutter, A. Kaup, "Sample-Based Weighted Prediction with Directional Template Matching for HEVC Lossless Coding", in *Proceedings of Picture Coding Symposium (PCS) 2013*, San Jose, CA, USA, Dec. 2013.

Abstract: The recently introduced High Efficiency Video Coding (HEVC) standard is currently further investigated for potential use in professional applications. The considered Range Extensions should on the one hand introduce higher bit depths and additional color formats, and on the other hand the coding efficiency of HEVC for high fidelity compression as well as lossless compression is to be improved. In this paper we investigate and improve the recently introduced Sample-based Weighted Prediction (SWP) for HEVC lossless coding. Although being very efficient for natural video content, the SWP algorithm can be further improved for screen content by using a directional template predictor in cases where the SWP algorithm yields worse prediction. The mainly introduced predictor improves the lossless coding results by up to 9.9% compared to the unmodified HEVC reference software for lossless compression.

Relation with the project work: This work is part of WP 3, Task 3.1, related to generic lossless coding of images and video sequences. This work is the basis for a standardization contribution to the Joint Collaborative Team on Video Coding (JCT-VC), a joint working group of ISO/IEC MPEG and ITU-T VCEG.

[111] A. Takacs and L. Bokor. A distributed dynamic mobility architecture with integral cross-layered and context-aware interface for reliable provision of high bitrate mhealth services. In Proc. of 3rd International Conference on Wireless Mobile Communication and Healthcare (MobiHealth 2012), Paris, France, Nov. 2012.

Abstract: Mobile health (mHealth) has been receiving more and more attention recently as an emerging paradigm that brings together the evolution of advanced mobile and wireless communication technologies with the vision of "connected health" aiming to deliver the right care in the right place at the right time. However, there are several

cardinal problems hampering the successful and widespread deployment of mHealth services from the mobile networking perspective. On one hand, issues of continuous wireless connectivity and mobility management must be solved in future heterogeneous mobile Internet architectures with ever growing traffic demands. On the other hand, Quality of Service (QoS) and Quality of Experience (QoE) must be guaranteed in a reliable, robust and diagnostically acceptable way. In this paper we propose a context- and content-aware, jointly optimized, distributed dynamic mobility management architecture to cope with the future traffic explosion and meet the medical QoS/QoE requirements in varying environments.

Relation with the project work: This work is part of WP2, WP5, related to the architecture (as it defines the components for advanced and scalable mobility management) and to the network layered multi-flow multimedia transmission supporting schemes aiming to transmit layered media content to the end users over heterogenuous networks.

[112] P.A. Kara, L. Bokor, and S. Imre. Distortions in qoe measurements of ubiquitous mobile video services caused by the preconceptions of test subjects. In Applications and the Internet (SAINT), 2012 IEEE/IPSJ 12th International Symposium on, pages 409 -413, July 2012.

Abstract: In telecommunication services, alongside QoS, QoE provision has become essential, thus performance and quality evaluation measurement results need to reflect reality as much as possible. Our goal is to enhance QoE evaluation schemes and enable improved QoE provision for video applications and services anytime and anywhere. In order to eliminate potential erroneous conclusions of QoE assessment techniques, our paper reveals a novel topic of distortions caused by preconceptions based on prior technical knowledge of QoE measurement test subjects. In our analysis we introduce the differences from genuine QoE measurement results in 3G ubiquitous mobile video service scenarios where test subjects were aware of the service parameters during measurements. We show how subjects' evaluations were affected and investigate the identified phenomenon in terms of Mean Opinion Score deviations and the overall QoE result distortion.

Relation with the project work: This work is part of WP 3, related to the studies of Quality of Experience evaluation methods for image/video (medical) applications.

[113] Gabor Feher, "The Price of Secure Mobile Streaming", accepted to 8th IEEE International Workshop on the Performance Analysis and Enhancement of Wireless Networks, March 25-28, 2013, Barcelona, Spain

Abstract: The cryptographic algorithms providing unquestionable security are usually complex. From this point of view, it is reasonable that high bitrate secure live video streams require significant processing power from the end devices. To cope with the demands, there are many publications suggesting a kind of selective video encryption that reduce the burden by ciphering only a part of the video stream. As a tradeoff, the security level decreases. On the other hand, recently the retail price of the efficient hardware based cryptographic chips is dropped and devices became more and more resourceful. This is true for the mobile sector as well. In this article, based on measurements, we prove that the fully encrypted high bitrate mobile video streaming is possible today, moreover there are certain scenarios where it is advised to be used. The resource barrier is no longer the processing capacity, but the network link.

Relation with the project work: This work summarizes the results of the security related work carried out in WP3.

[114] H. Saki, M.G. Martini and M. Shikh-Bahaei, "Multi-user Scalable Video Transmission over Cognitive Radio Networks" in *IEEE International Conference on Communications (ICC 2015)*, London, UK, Jun 8-12 2015.

Abstract: Abstract—We propose an optimal radio resource allocation (RRA) scheme for scalable H.264/SVC multi-user video transmission over downlink orthogonal frequency division multiple Access (OFDMA)-based cognitive radio (CR) networks. Our framework adopts a new probabilistic approach to mitigate the total imposed interference by cognitive users on the licensed spectrum. We consider two fundamental network service objectives, i.e., number of satisfied users and the overall transmitted video quality. We devised the 3-dimensional scalable quality of the H.264/SVC video transmission for an OFDMA-based CR network and develop efficient suboptimal algorithms to solve the probabilistic constrained mixed discrete-continuous non-linear programming (MDCNLP) problem. Simulation results indicate that the proposed quality-aware scheme can achieve up to 1.3 dB increase in the average peak signal-to-noise ratio (PSNR) per user over the conventional non-quality-aware RRA algorithms.

Relation with the project work: This work is related to WP5.

[115] H. Saki, A. Shojaeifard and M.G. Martini, "Stochastic Resource Allocation for Hybrid Spectrum Access OFDMA-Based Cognitive Radios" in *IEEE International Conference on Communications (ICC 2015)*, London, UK, Jun 8-12 2015.

Abstract: A stochastic radio resource allocation (RRA) algorithm is designed to maximize the total transmission rate of orthogonal frequency-division multiple access (OFDMA) cognitive radios (CRs) with hybrid (i.e., joint underlay and overlay) spectrum access strategy. Our novel solution incorporates the probabilities of channel availability obtained through spectrum sensing for allocating power and subcarrier in a multi-user multi-band environment. In order to protect the licensed users from harmful intervention under imperfect sensing information, stochastic transmit and interference power constraints are imposed on the CRs. The performance of the proposed RRA algorithm and advantages over the conventional hard-decision based approaches are demonstrated using simulation results.

Relation with the project work: This work is related to WP5.

[116] H. Appuhami Ralalage, C.T. Hewage and M.G. Martini, "Using 3D Structural Tensors in Quality Evaluation of Stereoscopic Video" in *IEEE Visual Communications and Image Processing (IEEE VCIP 2014) Conference*, Malta, Dec 7-10 2014.

Abstract: Recent advancements in 3D imaging, coding, compression, storage, transmission, and error concealment techniques enable wide usage of 3D video/image applications. Transmission of 3D video over wireless networks is enabled in particular by the latest wireless systems, such as LTE and LTE-A. Video quality assessment plays a major role in improving the perceived quality at the receiver side, since such information can be used at the transmitter or in the different network nodes for system optimization 'on-the-fly'. Most of the objective quality metrics in use are Full-Reference (FR), requiring the original video sequence for comparison. In the case of quality assessment for stereoscopic video, both left and right views need to be considered. In this paper, we introduce a novel Reduced-Reference (RR) quality metric for stereoscopic video using 3D structural tensors, based on the fact that the Human Visual System (HVS) is more sensitive to the structural information present in the scene. 3D structural tensors represent the predominant direction of the energy distribution in a neighbourhood of a point using local gradient. This method incorporates a new saliency detection method by considering spatial and temporal aspects of the video sequence. The Correlation Coefficient (CC) calculated for the obtained results shows that the values of the derived metric are well correlated with the corresponding subjective test results.

Relation with the project work: The work presents a novel quality metric for stereoscopic video. This can be used in the 3D surgery scenario and is relevant to WP3.

[117] C.T. Hewage, M.G. Martini and H. Appuhami Ralalage, "Quality evaluation of compressed 3D surgical video" in *In Proc. IEEE Healthcom 2014 - Workshop on Service Science for e-Health*, IEEE, Natal, Brazil, Oct 2014, pp. 5.

Abstract: 3D medical video was forecasted to be one of the groundbreaking 3D video applications. These range from tele-consultation to 3D robotics surgery. Enabling 3D video in e-health applications results in the provision of more natural viewing conditions, improved diagnosis and accurate interventions in surgical procedures. The deployment of 3D video services in healthcare is made possible to some extent by the advanced capturing devices (e.g., 3D endoscopes), recent advances in wireless communication technologies (e.g., LTE-Advanced(LTE-A)) and 3D video display technologies. Remote robotic assisted surgery and surgery training (education for surgeons) can benefit in particular from 3D video technologies due to the added dimension of depth. This paper analyses the quality of compressed 3D surgical video. Moreover, asymmetric encoding of 3D medical video without compromising the medical quality of experience (M-QoE) is investigated in this paper. The quality of the compressed 3D medical video with the proposed method is evaluated using a comprehensive subjective quality evaluation test involving 12 medical surgeons. The results show a slightly better perception with the proposed asymmetric coding method compared to reference symmetric compression method, however the difference is statistically insignificant.

Relation with the project work: The work addresses the 3D surgery CONCERTO scenario and is relevant to WP3.

[118] M. M. Nasralla, C.T. Hewage and M.G. Martini, "Subjective and Objective Evaluation and Packet Loss Modeling for 3D Video Transmission over LTE Networks" in *International conference on Telecommunications and Multimedia (TEMU)*, IEEE, Crete, Greece, July 28-30 2014.

Abstract: The recent Long-Term Evolution (LTE) standard, thanks to the provision of high data rates, will enable bandwidth demanding multimedia applications like Three Dimensional (3D) video streams over wireless. In this paper, we study the transmission of 3D video sequences over LTE networks by modeling an LTE wireless network, which uses the best performing downlink packet scheduling strategy (Modified Largest Weighted Delay First (M-LWDF)) for delay sensitive applications, through the well-known Gilbert-Elliot Channel Model (GE). Also, we perform subjective and objective quality evaluation of the received 3D video sequences. The perceived video sequences are impaired with six packet loss rates produced by the corresponding LTE network. The three major contributions of the paper are: 1) GE parameters that represent real statistics of an LTE network 2) a subjective study on 3D video transmission over an LTE system modelled as a GE channel for different levels of impairments and 3) the provision of a publicly available database with 3D video sequences affected by packet losses distributed according to a GE model and associated Mean Opinion Score (MOS) values, to enable researchers to test their video quality evaluation algorithms.

Relation with the project work: The article presents a subjective evaluation study of 3D video over LTE networks and reports the relevant work performed within WP3 and WP5.

[119] O. Ognenoski, M. Razaak, M.G. Martini and P. Amon, "Medical Video Streaming Utilizing MPEG-DASH" in *IEEE Healthcom - Mobile Medical Imaging Workshop (MMIW)*, Lisbon, Portugal, Oct 9-12 2013.

Abstract: This paper presents an analysis of medical video streaming based on the Dynamic Adaptive Streaming over HTTP (DASH) standard from the Moving Picture Experts Group (MPEG).We propose two adaptation approaches at the client and evaluate parameters of the Quality of Experience (QoE), i.e., the quality perceived by the users, by investigating the number and duration of re-buffering events, the added time in the playout, and the Peak Signal-to-Noise Ratio (PSNR) of the medical video frames. The results show that the selection of MPEG-DASH related parameters and the adaptation approach at the client result in improved quality of the medical video streaming. In the end, we discuss how the elaborated approaches and results could be utilized to facilitate and enhance telemedicine applications.

Relation with the project work: The work addresses the tele-consultation CONCERTO scenario in particular and has been performed within WP4.

[120] M. Razaak and M.G. Martini, "Medical Image and Video quality assessment in e-health Applications and Services" in *SSH: IEEE International Workshop on Service Science for eHealth*, IEEE, Lisbon, Portugal, October 9-12 2013.

Abstract: Healthcare services are increasingly using medical images and video in their applications. Quality assessment can be performed via image quality evaluation metrics. However, due to the specific nature of the associated data, quality evaluation of medical images poses several issues. In this paper, we provide an insight into medical image quality evaluation, by discussing the issues faced and the current trends in the literature. Based on the analysis of the medical and technical literature, three broad categories of quality evaluation metrics are presented. The different methodologies are compared in different environments and services and recommendations for future research are provided.

Relation with the project work: The work has been performed within WP3 and also in preparation for WP6, in order to select a suitable image and video quality metric for medical images and video.

[121] M. Razaak and M. G. Martini, “Rate-distortion and Rate-quality Performance Analysis of HEVC Compression of Medical Ultrasound Videos”, in *Fourth International Conference on Selected Topics in Mobile & Wireless Networking, Volume 40, Rome, 2014.*

Abstract: The emerging video compression standard High Efficiency Video Coding (HEVC) promises to provide bitrate savings of up to 50% compared to its predecessor H.264 standard. Due to its remarkable compression performance, HEVC is expected to be extensively used for telemedicine applications. Therefore, it is important to analyse the compression performance of HEVC and its impact on the diagnostic and perceptual quality of medical videos. In this paper, medical ultrasound video sequences compressed via HEVC were subjectively assessed by medical experts and non-experts and the subjective scores obtained were then used to analyse the compression performance of HEVC in terms of acceptable diagnostic and perceptual video quality. The rate-distortion and rate-quality performance of HEVC with respect to medical ultrasound videos is presented. The bitrate and the Quantization Parameter (QP) range at which HEVC can provide acceptable diagnostic and perceptual quality for medical ultrasound videos are discussed.

Relation with the project work: The work has been performed within WP3 and also in preparation for WP6, in order to select a suitable image and video quality metric for medical images and video.

[122] C.T. Hewage, H. Appuhami Ralalage, M.G. Martini, R Smith, I Jourdan and T Rockall, "'Quality Evaluation of Asymmetric Compression for 3D Surgery Video" in *2013 IEEE 15th International Conference on e-Health Networking, Applications and Services (Healthcom)*, IEEE, Lisbon, Portugal, Oct 9-12 2013.

Abstract: Enabling 3D video in e-health applications results in the provision of more natural viewing conditions and improved diagnosis. Recent advances in wireless communications, network technologies and 3D video capture/display mechanisms enable the replacement of 2D video applications of current healthcare services with 3D video, to provide improved perception and diagnosis. Remote surgery and surgery training can benefit in particular from 3D video due to the added dimension of depth. This paper envisages a wireless health system which transmits 3D surgical video over next generation wireless networks. Asymmetric coding of 3D video to provide effective medical services over band limited wireless networks is investigated in this paper. The quality of the compressed 3D medical video with the proposed method is measured both objectively and subjectively for a range of compression levels.

Relation with the project work: The work addresses the tele-surgery and training scenarios and has been performed within WP3.

[123] M. M. Nasralla and M.G. Martini, "A Downlink Scheduling Approach for Balancing QoS in LTE Wireless Networks" in *24th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications*, IEEE, London, UK, Sep 8-11 2013.

Abstract: In this paper, we propose a strategy for resource allocation for different traffic classes at the Medium Access Control (MAC) layer of wireless systems based on Orthogonal Frequency Division Multiple Access (OFDMA), such as the recent Long-Term Evolution (LTE) wireless standard. In order to achieve inter-class fairness, we propose a modification of the Virtual Token Modified Largest Weighted Delay First (VT-M-LWDF) and Modified Largest Weighted Delay First (M-LWDF) rules. Through simulation, we show that the proposed scheduler introduces remarkable multi-objective improvement of the Quality of Service (QoS) performance parameters, i.e., Packet Loss Rate (PLR), average throughput, fairness index and system spectral efficiency, among different classes of traffic such as video, VoIP and best-effort.

Relation with the project work: The work addresses scheduling video traffic over LTE and is relevant to WP5.

[124] O. Ognenoski, M.G. Martini and P. Amon, "Segment-based Teletraffic Model for MPEG-DASH" in *15th IEEE International Workshop on Multimedia Signal Processing* , IEEE, Pula (Sardinia), Italy, Sept. 30 - Oct. 2 2013.

Abstract: This paper proposes a novel segment-based teletraffic model for dynamic adaptive video streaming over HTTP (DASH), based on the MPEG-DASH standard. The functionality of the standard's framework is mapped on the proposed model for which the probabilities of buffer overflow, empty buffer and active buffer are adopted as relevant performance metrics. These metrics describe the MPEG-DASH streaming process from the teletraffic viewpoint and are observed for different segment sizes of the encoded video at the server and different buffer sizes at the client. The results show that small segment sizes of the encoded video increase the probabilities of empty buffer and active buffer, while decreasing the probability of buffer overflow, whereas large segment sizes are suitable for decreasing the probabilities of empty buffer and active buffer, while increasing the probability of buffer overflow. Regardless of the segment sizes, the performance metrics are further improved when the buffer size at the client is increased.

Relation with the project work: The work studies MPEG-DASH streaming for (medical) video and has been performed within WP4.

[125] B. M. Isawhe and M.G. Martini, "Optimum Frame Synchronization over Binary Symmetric Channel for Data with Known, Unequal Distribution" in *14th IEEE International Workshop on Signal Processing Advances in Wireless Communications*, Darmstadt, Germany, Jun 16 - 19 2013.

Abstract: Based on hypothesis testing and using the likelihood ratio test (LRT), optimum frame synchronization metrics have been recently proposed for data transmission over an additive white Gaussian noise (AWGN) channel for frames which are of unknown, variable lengths. The derived metrics addressed the cases where data symbols have an equiprobable distribution, where the distribution of the data symbols is unknown, and where data symbols have a known, unequal distribution. In this paper, following a similar approach, a frame synchronization metric is proposed for transmission over a binary symmetric channel (BSC), where frames are of unknown, variable lengths and with data symbols which have a known, unequal distribution. This is the case, for instance, for medical video transmitted over a wireless channel. The performance of this metric is compared via simulation with the commonly used hard correlation

(HC) metric. The obtained receiver operating characteristic (ROC) curves show that an evident performance improvement can be obtained with the use of the proposed metric.

Relation with the project work: The work has been performed within WP5, and addresses content/source-aware frame synchronisation.

[126] C.T. Hewage, J Wang, M.G. Martini and P Le Callet, "Visual saliency driven error protection for 3D video" in *Proc. of IEEE Int. Conference on Multimedia and Expo (ICME) - Workshop on Hot Topics in 3D*, IEEE Communication Society, San Jose, USA, July 15-19 2013.

Abstract: Viewers tend to focus into specific regions of interest in an image. Therefore visual attention is one of the major aspects to understand the overall Quality of Experience (QoE) and user perception. Visual attention models have emerged in the recent past to predict user attention in images, videos and 3D video. However, the usage of these models in quality assessment and quality improvement has not been thoroughly investigated to date. This paper investigates 3D visual attention model driven quality assessment and improvement methods for 3D video services. Moreover, a visual saliency driven error protection mechanism is proposed and evaluated in this paper. Both objective and subjective results show that the proposed method has significant potential to provide improved 3D QoE for end users.

Relation with the project work: The work has been performed within WP3.

[127] M.G. Martini, C.T. Hewage, M. M. Nasralla, R Smith, I Jourdan and T Rockall, "3-D Robotic Tele-Surgery and Training over Next Generation Wireless Networks" in *35th Annual International IEEE EMBC Conference*, Osaka, Japan , July 3-7 2013.

Abstract: The latest advances on robotic surgery enable the performance of many surgical procedures by utilizing minimally invasive techniques. In particular, recent 3-D endoscopes have improved the performance of minimally invasive surgical procedures. Based on these advances, performing or visualizing in real-time surgical procedures at a distance can be envisaged. In this paper, we present a performance evaluation of 3-D robotic tele-surgery and training over next generation wireless networks, namely wireless networks based on the long term evolution (LTE) 3GPP standard. Different scheduling strategies are compared and results are analysed in term of the resulting quality of experience (QoE) for the surgeon.

Relation with the project work: The work addresses the tele-surgery and training CONCERTO scenario and has been performed within WP5.

[128] M. Razaak and M.G. Martini, "Rate-Distortion and Rate-Quality Performance Analysis of HEVC compression of Medical Ultrasound Videos" in *First International Workshop On Wireless Solutions For Healthcare Applications (Concerto 2014)*, Rome, Italy, Sep 8-9 2014, pp. 95-101.

Abstract: The emerging video compression standard High Efficiency Video Coding (HEVC) promises to provide bitrate savings of up to 50\% compared to its predecessor H.264 standard. Due to its remarkable compression performance, HEVC is expected to be extensively used for telemedicine applications. Therefore, it is important to analyse the compression performance of HEVC and its impact on the diagnostic and perceptual quality of medical videos. In this paper, medical ultrasound video sequences compressed via HEVC are subjectively assessed by medical experts and non-experts. The subjective scores are then used to analyse the compression performance of HEVC in terms of acceptable diagnostic and perceptual video quality. The rate-distortion and rate-quality performance of HEVC with respect to medical ultrasound videos is also presented. The bitrate and the Quantization Parameter (QP) range at which HEVC can provide acceptable diagnostic and perceptual quality medical videos are discussed.

Relation with the project work: This work is related to WP3 and to most of the CONCERTO use cases (emergency and tele-consultation in particular).

[129] C.T. Hewage, M.G. Martini, M. B. Brandas and D.V.S.X. De Silva, "A Study on the Perceived Quality of 3-D Video subject to Packet Losses" in *IEEE International Conference on Communications 2013 - Workshop on Immersive & Interactive Multimedia Communications over the Future Internet*, Budapest Hungary, June 9-13 2013.

Abstract: 3D video quality evaluation received much attention from researchers due to the demand from the industry and to the complex nature of true 3D video perception. The availability of public 3D video databases provides an opportunity for researchers and developers to evaluate novel objective 3D video quality evaluation metrics. In this paper, a stereoscopic 3D video database for the evaluation of visual quality assessment metrics is described. The effects

of random packet losses on the overall 3D perception (i.e., distortions due to different packet loss rates) are considered in this research. The database presented here contains 54 test stimuli from 9 reference test video sequences corresponding to 6 different packet loss rates, including the uncorrupted 3D video sequence. In order to obtain true 3D video perception, about 1730 individual human quality observations (Opinion Scores (OS) of subjects) are considered for this database. The obtained Differential Mean Opinion Scores (DMOS) can be effectively used for evaluating 3D video quality metrics, as well as for designing new 3D video quality evaluation methods. Together with DMOS values, we provide the corresponding objective quality measurements using several objective quality metrics. The designed 3D video database will be freely available for download and use in scientific research.

Relation with the project work: This work is related to WP3.

[130] M. M. Nasralla, O. Ognenoski and M.G. Martini, "Bandwidth Scalability and Efficient 2D and 3D Video Transmission over LTE Networks" in *IEEE ICC'13 - Workshop on Immersive & Interactive Multimedia Communications over the Future Internet* , Budapest, Hungary, June 9-13 2013.

Abstract: The recent Long-Term Evolution (LTE) standard, thanks to the provision of high data rates, will enable future immersive and interactive multimedia applications over wireless.
In this paper, we study the performance of 2D and 3D video transmission over LTE networks. The LTE standard bandwidth ranges are considered in order to explore the impact of the LTE bandwidth scalability on the transmission of 2D and 3D video traffic to the end users. This dependency is investigated through the packet loss ratio (PLR) and average throughput as user-oriented metrics, and the cell spectral efficiency as a system-oriented metric. Furthermore, a PLR-based Admission Control (AC) strategy is introduced in the system for which the achieved trade-off between the system resource utilization and the quality level provided to the different users is investigated. The simulation results provide guidelines for combining bandwidth scalability and admission control strategies in LTE networks in order to achieve high system resource utilization and video quality for the LTE users.

Relation with the project work: This work is related to WP5.

[131] A. Haseeb, M.G. Martini, V. Tralli and S. Cicalo', "Rate and Distortion Modeling for Real-time MGS Coding and Adaptation" in *IEEE Wireless Advanced (WiAd 2012)*, London, June 25-27 2012.

Abstract: Scalable Video Coding (SVC) is the extension of the Advanced Video Coding standard (H.264/AVC) providing video compression with spatial, temporal and quality scalability. Scalability can be exploited in order to provide a better video quality for the end user in video transmission over wireless networks. In this paper we develop a parametric Rate Distortion (R-D) model for Medium Grain Scalability (MGS) SVC depending only on two indexes describing the spatial and temporal complexity of video sequences. The two indexes can be easily obtained from the original raw video, thus enabling real time video adaptation for transmission over channels with variable bandwidth such as wireless channels. The results from simulations show that the use of the proposed model for rate adaptation of multiple-videos sharing a common channel results in an end user video quality comparable to that obtained by using a more accurate non-real time rate distortion model

Relation with the project work: This work is related to WP5.

[132] H. Appuhami Ralalage, M.G. Martini and C.T. Hewage, "Channel and Content aware 3D Video Scheduling with Prioritized Queuing" in *IEEE Wireless Advanced (Formerly SPWC) 2012*, London, UK, Jun 25-27 2012.

Abstract: In this paper we address 3D video delivery over wireless systems based on Orthogonal Frequency Division Multiple Access (OFDMA), by considering a medium access control (MAC) layer scheduling method combined with a prioritized queuing mechanism to prioritize the most important video components/layers with the goal of improving the perceived quality of 3D video at the receiver. We consider colour plus depth 3D video and we exploit its properties in terms of importance of the different components for the perceived quality. The priority values of the scalable video coding (SVC) encoded 3D video are signalled from the Application Layer to the MAC layer via cross-layer signalling. All the users attached to a Base Station feedback their sub-channel gain to the Base Station periodically via partial channel state information (CSI) and this information is used in the sub-channel allocation process at the scheduler. Thereby, the proposed scheduler always guarantees that the most important layers are scheduled over the sub channels with higher gain at each time slot of an OFDMA frame. Furthermore, we have established a Packet Loss Ratio (PLR) threshold which is used by the scheduler to drop video layers too much affected by packet losses to save scarce radio resources. Simulation results show that the MAC layer Packet Drop Ratio (PDR) is improved in the prioritized

colour/depth layers at the cost of slight increase in PDR in the low prioritized layers. This results in a global quality improvement for the prioritized case

Relation with the project work: This work is related to WP4.

[133] M. Uitto and J. Vehkaperä, "Enhanced quality adaptation strategies for scalable video", in *Proceedings of 13th IEEE International Symposium on Signal Processing and Information Technology*. ISSPIT 2013, Athens, 12 - 15 Dec. 2013.

Abstract: Technology today favors tightly compressed, but still extremely high quality video transmitted wireless to mobile devices. Users want to access the video data anytime, anywhere, which sets challenges in the highly-loaded network to provide best possible video quality for the end user. Naturally, in the era of high-definition, users want to experience high quality from their mobile devices even when the channel capacity fluctuates drastically due to congestion. Video adaptation to bandwidth fluctuations plays an important role in modern video transmission in order to maximize the best available video quality, but again to use available bandwidth efficiently. In this paper, we aim to find the best strategy for how the adaptation should be performed, to find sufficient adaptation period and number of layers that maximize the compression efficiency, usage of channel resources and objective quality in video streaming. For the compression, we utilize Scalable Video Coding (SVC), which provides layered video structure and enables video adaptation to bandwidth fluctuations. The results indicate that long adaptation period with complex content encoded for two enhancement layers brings essential channel savings while also maintaining the compression efficiency and objective quality in adequate level.

Relation with the project work: This work is related to WP3.

[134] T. Ojanperä, M. Uitto and J. Vehkaperä, " QoE-based Management of Medical Video Transmission in Wireless Networks", in *IEEE/IFIP 2nd IEEE/IFIP International Workshop on Quality of Experience Centric Management (QCMan14)*. Krakow, Poland, May 5-9, 2014.

Abstract: The prevalence of broadband wireless networks offering nearly ubiquitous Internet connectivity today has opened new possibilities for utilizing wireless and mobile services also in eHealth applications. However, such services often involve transmission of critical multimedia data, thus having stringent requirements for network Quality of Service (QoS) that are not supported in current networks. In this paper, we propose means for implementing enhanced QoS support for medical video transmission in wireless networks. Our solution extends existing wireless network QoS architectures with support for differentiating multiple flows and packets of the same service type based on their impact on the Quality of Experience (QoE). The paper also presents an experimental evaluation of the solution in a simulation environment. The simulation results indicate that our solution can enhance the QoE significantly and therefore improve the availability of critical medical data services.

Relation with the project work: This work is related to WP3, WP4 and WP5.

[135] E. Piri, "Cell Coverage Area Information Service to Improve Mobility in HetNets," in *Proc. the 11th Annual IEEE Consumer Communications & Networking Conference (CCNC)*, Las Vegas, USA, January 2014.

Abstract: Information services providing diverse information about networks and their services have been widely cited as one of the key factors to better utilize the heterogeneous network environment. However, the current information services do not properly enable determining the base stations that reside within the range and close-by of a mobile device. The serving range of base stations can only be roughly estimated. Moreover, large variations in cell sizes bring additional challenges with respect to mobility management. In this study, a network information service allowing mobile devices to query for information about base station cells near their location is utilized in cell selection. A spatial database is used to store the coverage area geometries of base stations and the base station coverage area and distance information is utilized in cell selection. The paper presents a clustering method for grouping the cells found in the vicinity of a mobile terminal based on the coverage area and their distance to the terminal, which improves the handover target discovery in a dense cell environment. In pedestrian mobility, mobile network operators likely prefer the use of cells with short range for traffic load balancing purposes. Favoring large cells in the high-speed vehicular mobility, the results show that the number of handovers can be significantly decreased, even cut to half from that attained with the conventional cell selection scheme.

Relation with the project work: This work is related toWP2 and WP5.

[136] E. Piri, ”Road Based Mobility with Network Information Services”, in *Proc. Fourth International Conference on Selected Topics in Mobile &Wireless Networking workshops (MoWNet)*, Rome, Italy, September, 2014.

Abstract: Increasing traffic demand and mobility pose many challenges for wireless networks. Lack of sufficient wireless resources and attempts to fix the problem by equipping networks with more small cell base stations challenge mobility managers. Network information services have been widely cited to help mobile users and networks cope with increasingly dense heterogeneous network environment. In this paper, an information service enhanced with information about base station coverage areas and expected driving routes of end systems are used as basis to improve mobility. Especially, emergency and other high-priority vehicles with pre-known driving routes could benefit from the proactive selection of base stations and their configuration to guarantee quality of service throughout the traversed path. The results indicate that the demanded quality is likely not met when networks suffer from congestion. Moreover, cell selection based on the known route can decrease the number of handovers even almost by half compared to the traditional algorithm using signal strength measurements as basis for the handover target selection.

Relation with the project work: This work is related to WP2 and WP5.

[137] E. Piri, M. Varela and J. Prokkola, ”A Network Information Service for Quality-Driven Mobility”, in *Proc. 12th Annual IEEE Consumer Communications & Networking Conference (CCNC)*, Las Vegas, USA, January 2015.

Abstract: Fast growing data traffic over mobile networks pose many challenges for both end systems and networks to satisfy the required service levels of different applications. For end-users, the quality of experience (QoE), and consequently the underlying quality of service (QoS) are the most meaningful criteria for triggering handovers and selecting target base stations. However, difficulties in reliably measuring quality real-time have resulted in many QoS/QoE based mobility solutions being impractical. We propose a network information service that allows mobile devices to find suitable nearby base stations by indicating their capability to satisfy the required service level. Information services allow end systems to discover heterogeneous networks at or near their location. However, the current solutions do not enable assessing base station availability and their quality of service in different locations reliably enough. In our solution, end system performed QoS measurement (and possibly QoE estimation) results are stored in a spatial database within the information service as polygon geometries. Through a single query to the information service end systems can find a sufficient amount of information about base stations in range to make handover target decisions on quality of service basis. We observe that the solution can achieve quality improvements of up to 50% in dense heterogeneous networks.

Relation with the project work: This work is related to WP2 and WP5.

[138] Kulik, I.; Kara, P.A.; Trinh, T.A.; Bokor, L., "Attributes unmasked: Investigation of service aspects in subjective evaluation of wireless 3D multimedia," *Informatics and Applications (ICIA), 2013 Second International Conference on* , vol., no., pp.270,275, 23-25 Sept. 2013.

Abstract: Multimedia services achieved unexpected penetration over wireless networks during the last few years. Provisioning of 3D video stream-based applications and transferring 3D movies - also becoming significant within the wireless domain - is a big challenge for Internet Service Providers (ISP). Only scarce empirical results are known about the user perceived quality of such kind of services. In this paper, we attempt to tackle this challenge by carrying out a real network scenario where 3D multimedia streams are provided through a GPON-based transport network and an IEEE 802.11n standard based Wi-Fi access is available for video delivery at the customer side. 20 test cases were distinguished by video samples suffering various Quality of Service (QoS) degradations, Wi-Fi TX-Power changing and alteration between secure and not secure data transport. 90 participants took part in this investigation, who evaluated perceived visual quality by Mean Opinion Score (MOS). QoE was also influenced by other factors like channel interference in the Wi-Fi network, acceptance of 3D technology, and personal prior technical knowledge/experience of participants (Level of Comprehension, LoC). The goal was to investigate relationships between combinations of the previously mentioned service parameters and their effects on perceived quality. It was also examined how the available environmental information during measurement scenarios affected evaluator behavior.

Relation with the project work: This work is related to WP3.

[139] Kulik, I.; Kara, P.A.; Tuan Anh Trinh; Bokor, L., "Analysis of the relationship between quality of experience and service attributes for 3D future internet multimedia," *Cognitive Infocommunications (CogInfoCom), 2013 IEEE 4th International Conference on* , vol., no., pp.641,646, 2-5 Dec. 2013. doi: 10.1109/CogInfoCom.2013.6719181

Abstract: Provisioning 3D video stream-based services online in an acceptable quality, even in a wireless access environment, is a big challenge for Future Internet service providers. Only few empirical results are known about the user perceived quality of these kinds of services. In this paper we describe a statistical analysis of the relationship between Quality of Experience and service attributes for active 3D live streaming, which was carried out in a real home scenario via an IEEE 802.11n standard based Wi-Fi access available for transferring data at the customer side. 90 participants took part in this investigation who watched 20 test cases of the full reference based subjective quality test suffering Quality of Service degradations, Wi-Fi TX-Power value changing and existence of secure and not secure (i.e., with and without IPsec) 3D video delivery. QoE was also affected by human factors like acceptance rate of 3D technology by the participants and their prior technical knowledge and experience, which could cause dissonant states of cognitions. The investigation presented here could help in the design of future QoE-aware 3D video streaming systems.

Relation with the project work: This work is related to WP3.

[140] Kara, P.A.; Bokor, L.; Imre, S., "Distortions in QoE assessment of 3D multimedia services on multi-access mobile devices," *Wireless and Mobile Computing, Networking and Communications (WiMob), 2013 IEEE 9th International Conference on* , vol., no., pp.311,318, 7-9 Oct. 2013. doi: 10.1109/WiMOB.2013.6673378

Abstract: Continuous monitoring of performance is a necessary tool for the maintenance and improvement of service quality. This applies to the rapidly developing 3D multimedia applications, where acceptability and user experience are the ultimate determinants of value. Satisfying demands in order to achieve high level Quality of Experience is challenging due to Quality of Service requirements and sensitivity of 3D services, especially in case of multi-access devices capable to benefit from wired, wireless and mobile network technologies. Feedback procedures relying on human evaluators are considered to be one of the most important industrial inputs of QoE monitoring. Distortions regarding this input necessitate additional attention due to their ability of making measurement results considerably inaccurate and misleading. This paper aims to observe and analyze the effect of specific environmental information, which is commonly public to the evaluators. The performed series of measurements demonstrates how the awareness of the type of connection can make constant objective quality to result in a rather varying subjective quality. It is also revealed how cognitive dissonance played a role during the evaluation of streaming services on a portable 3D terminal. In order to support understanding evaluator behavior, measurement subjects were distinguished by Level of Comprehension, based on prior technical knowledge and experience.

Relation with the project work: This work is related to WP3.

[141] Kara, P.A.; Bokor, L.; Imre, S., Seeing is believing and vice versa: Investigation of the altered perception during subjective assessment of streaming multimedia, In proc. of Tenth International Conference on Signal-Image Technology & Internet-Based Systems (SITIS 2014), Marrakech, Morocco, 2014.11.23-2014.11.27.2014. pp. 539-545.

Abstract: Quality of Experience is one of the most important components in the definition of service value. The primary role of the subjective evaluation of multimedia service quality is to reflect the true satisfactory of users. However, these reflections may not carry the desired level of accuracy under specific circumstances. This paper presents how basic information regarding the service not only distorts mean QoE results, but also manipulates perception itself. The research utilized 7 different measurement scales for subjective assessment of the perceived quality. A total of 90 participants evaluated the streaming multimedia, but while 30 performed blind tests, a group of 60 were given minimal information regarding the type of connection and transmission security. The results contain the scoring patterns of the participants and also our findings on the expressive power of scales.

Relation with the project work: This work is related to WP3.

[142] Cicalo, S.; Mazzotti, M.; Moretti, S.; Tralli, V.; Chiani, M., "Cross-layer optimization for m-health SVC multiple video transmission over LTE uplink," *e-Health Networking, Applications & Services (Healthcom), 2013 IEEE 15th International Conference on* , vol., no., pp.212,217, 9-12 Oct. 2013.

Abstract: M-health services are expected to become increasingly relevant in the management of emergency situations, enabling real-time support of remote medical experts. In this context, the transmission of health-related information from an ambulance to a remote hospital is a challenging task, due to the variability and the limitations of the mobile radio link. In particular, the transmission of multiple video streams can improve the efficacy of the tele-consultation service, but requires a large bandwidth to meet the desired quality, not always guaranteed by the mobile network. In this paper we propose a novel cross-layer adaptation strategy for multiple SVC videos delivered over a single LTE channel,

which dynamically adjusts the overall transmitted throughput to meet the actual available bandwidth, while being able to provide high quality to diagnostic video sequences and lower (but fair) quality to less critical ambient videos. After having introduced a realistic LTE uplink scenario, including an advanced resource allocation strategy, we show through numerical simulations that the proposed solution is capable to achieve an optimal end-to-end video quality for both the diagnostic and the ambient videos.

Relation with the project work (T4.2, T5.2): In many CONCERTO use cases, the presence of a 3G/4G radio access network can be exploited to establish a communication link between the emergency area and a remote hospital, enabling real-time and interactive tele-consultation. The possibility to jointly adapt multiple video streams to the current transmission conditions becomes particularly important in the context of emergency m-health, because mobile links are usually characterized by limited and variable bandwidth. Most of the techniques described in the paper have been included in the CONCERTO simulator and the most significant numerical results have been reported in D6.3.

[143] Moretti, S.; Cicalò, S.; Mazzotti, M.; Tralli, V.; Chiani, M.; "Content/Context-aware Multiple Camera Selection and Video Adaptation for the Support of m-Health Services," Procedia Computer Science, Volume 40, 2014, Pages 206-213.

Abstract: In this paper we focus on the problem of delivering multiple health-related real-time video streams from an emergency scenario to a remote hospital by exploiting the uplink of an LTE wireless access network, in order to support efficient m-health tele-consultation services. In this context, the transmission of health-related information is a challenging task, due to the variability and the limitations of the mobile radio link, the different qualities of the visual representations of the cameras and the heterogeneous end-to-end quality requirements of the contents to be delivered. We propose a solution based on: (i) a context-aware camera selection algorithm, which selects among the cameras deployed in the emergency scenario one or more video sources taking into account specific ranking criteria mainly related to the quality of the visual representation of the object of interest; (ii) a content-aware technique for the transmission of multiple scalable videos that jointly considers video aggregation and adaptation at the application layer of the transmitting equipment and takes into account the different quality requirements of diagnostic and ambient videos. Numerical results show that the proposed strategy permits to achieve a good end-to-end quality for both the diagnostic and the ambient videos even in the presence of rate limitations and fluctuations in the wireless link, due to the channel variations and the traffic load inside the LTE cell. When the wireless link capacity decreases, the proposed strategy appropriately discards the videos coming from the cameras providing the lowest visual quality, according to the camera ranking results, and, at the same time, adapts the rate of the transmitted videos to provide the requested quality with priority to diagnostic content.

Relation with the project work (T4.2, T5.2): This work extends the cross-layer optimization framework for m-Health SVC multiple Video Transmission over LTE Uplink introduced in **Erreur ! Source du renvoi introuvable.**]. In particular, a multi-source ranking algorithm implemented within the CONCERTO Coordination Center (CC) is applied to jointly adapt a multi-stream transmission from a stationary ambulance within an emergency area to a remote hospital. A part of the proposed techniques have been integrated in the OMNet++ simulation platform and their benefits have been evaluated within WP6, as reported in D6.3.

[144] Matuz, B.; Toscano, G.; Liva, G.; Paolini, E.; Chiani, M., "A robust pulse position coded modulation scheme for the Poisson channel," Communications (ICC), 2014 IEEE International Conference on , vol., no., pp.2118,2123, 10-14 June 2014.

Abstract: A coded modulation scheme for the Poisson channel is investigated. The scheme relies on the serial concatenation of an outer low-density parity-check (LDPC) code over an order-q finite field and a q-ary pulse position modulation (PPM). Due to the matching between code and modulation symbols, no iterative message exchange between the decoder and the modulator is required. The PPM capacity limit serves as a reference to evaluate the efficiency of the proposed scheme in the asymptotic setting via density evolution. A simplified form of the Gallager random coding bound (RCB) is also developed and used as a reference for the finite-length performance of the coded modulation scheme. The optimization via density evolution is performed on a surrogate (erasure) channel, yielding excellent iterative decoding thresholds for a wide range of channel parameters. The proposed coded modulation technique performs close to the theoretical bounds not only asymptotically, but also for moderate block lengths. It turns to represent a viable solution for deep-space direct detection optical links, for which the Poisson channel is adopted as a model.

Relation with the project work (T5.2): The above paper illustrates how most of the developments on nonbinary LDPC codes over the erasure channel, performed in CONCERTO, may be used to analyse optical communications with pulse position modulation (PPM), assuming a little amount of background noise. This work is only partially related to the

topics specifically addressed in CONCERTO and demonstrates how the techniques developed in the project may be applied to different communication scenarios.

[145] Zabini, F.; Matuz, B.; Liva, G.; Paolini, E.; Chiani, M., "The PPM Poisson channel: Finite-length bounds and code design," Turbo Codes and Iterative Information Processing (ISTC), 2014 8th International Symposium on , vol., no., pp.193,197, 18-22 Aug. 2014.

Abstract: This work investigates finite-length block error probability for the pulse position modulation (PPM) Poisson channel. Amongst, expressions for the Gallager random coding bound (RCB) and the Polyanskiy-Poor-Verdu' converse bound are derived. Likewise, we introduce an erasure channel (EC) approximation that allows the application of known EC bounds to the PPM Poisson channel by matching the channel capacities. We show that the derived bounds are not only simple to compute, but also accurate. Additionally, the design of protograph-based non-binary low-density parity-check (LDPC) codes for the (PPM) Poisson channel is addressed. The order q of the finite field is directly matched to the PPM order, so that no iterative message exchange between the decoder and the modulator is required. The suggested design turns out to be robust w.r.t. different channel parameters, yielding performances within 0.5 dB from theoretical bounds.

Relation with the project work (T5.2): The above paper illustrates how most of the developments on nonbinary LDPC codes over the erasure channel, performed in CONCERTO, may be used to analyse optical communications with pulse position modulation (PPM), assuming a little amount of background noise. This work is only partially related to the topics specifically addressed in CONCERTO and demonstrates how the techniques developed in the project may be applied to different communication scenarios.

[146] Cicalò S.; Tralli V., “Cross-Layer Algorithms for Distortion-Fair Scalable Video Delivery over OFDMA Wireless Networks,” Technical Document TD(13)06064, 6th COST IC 1004 meeting, Malaga (Spain) Feb. 2013

Abstract: Optimizing video delivery to multiple users over a wireless channel is a challenging task, especially when the objective of maximizing the spectral efficiency has to be jointly considered with the objective of providing a fair video quality. In this paper a novel cross-layer optimization framework for scalable video delivery over OFDMA wireless systems is proposed, aiming at maximizing the sum of the achievable rates while minimizing the distortion difference among multiple videos. Layering as optimization decomposition is considered to vertically decompose the problem and a novel efficient iterative local approximation (ILA) approach is proposed to evaluate the global solution. The ILA algorithm requires a limited information exchange between the application and the MAC layers, which independently run algorithms that handle parameters and constraints characteristic of a single layer. The numerical evaluations show the fast convergence of the ILA algorithm and demonstrate the significant video quality improvement of the proposed strategy with respect to optimizations based on rate fairness.

Relation with the project work (T5.2): The transmission of real-time multiple videos over a common wireless channel with a limited and time-varying capacity is one of the main issues addressed by the CONCERTO project for the delivery of MSHTM services. This preliminary work proposes an optimization framework for the downlink scenario, which has been extended to the uplink case of the CONCERTO scenarios to also consider different priorities among the transmitted video sequences (see D5.3).

[147] Jemin Lee; Conti, A.; Rabbachin, A.; Win, M.Z., "Distributed secrecy in multilevel wireless networks," Communications (ICC), 2013 IEEE International Conference on , vol., no., pp.6300,6305, 9-13 June 2013.

Abstract: Secrecy is a key enabler for various wireless applications in which distributed confidential information is communicated in a multilevel network from sources to destinations. Network secrecy can be accomplished by exploiting the intrinsic properties of multilevel wireless networks (MWNs). This paper introduces the concept of distributed network secrecy (DNS) and develops a framework for design and analysis of confidential MWNs. Our framework accounts for node distribution, network configuration, propagation medium, and communication protocol. This research offers the foundation of DNS and quantifies the impact of network configuration on DNS for self-organizing MWNs.

Relation with the project work (T5.3): In the emergency scenario where some ambient and diagnostic videos are first collected at the ambulance through wireless connections and then delivered to the hospital by using a LTE wireless access network, confidential transmission becomes crucial to ensure privacy. This work preliminarily investigates distributed secrecy where dislocated confidential information is communicated in a multilevel network from sources to destinations.

[148] Rabbachin, A.; Conti, A.; Win, M.Z., "Interference engineering for network secrecy in Nakagami fading channels," Communications (ICC), 2013 IEEE International Conference on , vol., no., pp.5052,5056, 9-13 June 2013.

Abstract: The demand of communication confidentiality in wireless network is rapidly increasing. The level of confidentiality can be enhanced by physical layer techniques exploiting intrinsic properties of a wireless network. We develop a framework for design and analysis of wireless network with secrecy that accounts for node distribution, propagation medium, and intentional interference. The framework enables the quantification of how intentional interference generated via legitimate network resources engineering mitigates the capability of the eavesdropping network. This research provides insight on the opportunistic use of legitimate network resources for enhancing network secrecy.

Relation with the project work (T5.3): Similarly to the contribution in **Erreur ! Source du renvoi introuvable.**], the framework proposed in this paper further analyze wireless network with secrecy, where confidentiality of, e.g., diagnostic/ambient video information delivered in the CONCERTO solutions must be ensured.

[149] Cicalò, S.; Tralli, V., "Resource Allocation in Relay-Assisted Uplink SC-FDMA Systems," EuCNC 2014, Bologna (Italy), June 2014.

Abstract: In this preliminary work we address the problem of maximizing the weighted sum-rate in the uplink of single-carrier frequency division multiple access (SC-FDMA) systems by considering both the in-band Type 1 and Type 1b relay transmission schemes to enhance the performance of cell-edge users. Since the evaluation of optimal solutions generally requires high computational complexity, low-complexity heuristic algorithmic solutions are proposed and investigated. Comparisons of in-band relaying schemes using optimal and heuristic algorithmic solutions are finally presented.

Relation with the project work (T5.3): In most of the CONCERTO scenario health-related video information are delivered through the uplink of 4G LTE cellular network. Even though not specifically considered in the CONCERTO project, relay-assisted transmission are de facto part of the LTE standard. This contribution preliminarily investigates the resource allocation optimization of the relay-assisted uplink LTE networks. In the CONCERTO scenario, this research allows to understand the benefits of an improved RRA when, as an example, the ambulance in emergency scenario is close to the cell edge and exploits a relay-assisted communication.

[150] Garrammone, G.; Paolini, E.; Matuz, B.; Liva, G.; Chiani, M., "Non-binary low-density parity-check codes for the q-ary erasure channel," *Communications (ICC), 2013 IEEE International Conference on* , vol., no., pp.3258,3263, 9-13 June 2013.

Abstract: The finite-length design of non-binary low-density parity-check (LDPC) codes for the q-ary erasure channel under maximum a posteriori (MAP) decoding is considered. A low-complexity MAP decoding algorithm is reviewed for which a code design strategy is proposed. In particular, it is illustrated how a judicious code design permits to find a trade-off between performance in terms of codeword error rate (CER) and decoding complexity. As an example, the performance curve of a short (400, 200) code on the memoryless 4-ary erasure channel tightly approaches the Singleton bound down to a CER of 10^{-8}.

Relation with the project work (T4.3): The above paper addresses the problems of design and analysis of packet erasure LDPC codes constructing on finite fields of order q>2 and decoded using a maximum likelihood decoder. These codes have been used in CONCERTO in the packet-level forward error correction (PL-FEC) module in order to cope with packet losses introduced by both wireless links, network congestion situations and buffer overflows.

[151] Yongkai Huo, El-Hajjar, M., Butt, M.F.U. and Hanzo, L., "Inter-layer-decoding aided self-concatenated coded scalable video transmission," *IEEE Wireless Communications and Networking Conference (WCNC)*, pp.4600-4605, 7-10 April 2013.

Abstract: In this treatise, we investigate an inter-layer (IL) decoded self-concatenated coded system conceived for scalable video coding (SVC). In SVC, when the base layer (BL) is corrupted due to channel-induced decoding errors, the enhancement layers (ELs) are discarded by the SVC decoder. The proposed IL coding technique implants the systematic information of the BL into the systematic bits of the ELs using exclusive-OR (XOR) operations. The IL coding is combined with a self-concatenated code, which is a near-capacity iterative detection aided channel codec using a single encoder and a single decoder. At the receiver, the IL decoding technique is activated for correcting the errors residing in the error-infested BL. In our experiments, the proposed system is combined with a number of the

traditional unequal error protection (UEP) arrangements for benchmarking the system performance. Our simulation results demonstrate that the proposed technique is capable of further improving the system performance of the traditional UEP assisted system by an E_b/N_0 of about 3 dB at a peak signal-to-noise ratio (PSNR) of 36 dB. When viewed from a different perspective, the attainable gain can be quantified as a PSNR improvement of 2.9 dB at E_b/N_0 = -5 dB, while imposing a marginal complexity increase of 1.5%.

Relation with the project work: In this contribution, an IL-SECCC coded video streaming scheme relying on a novel multi-functional MIMO technique was proposed, which is related to Task 3.1.

[152] Zhang, Wenbo, Maunder, Robert G. and Hanzo, Lajos, "On the complexity of Unary Error Correction codes for the near-capacity transmission of symbol values from an infinite set," IEEE *Wireless Communications and Networking Conference (WCNC)*, vol., no., pp.2795-2800, 7-10 April 2013.

Abstract: Unary Error Correction (UEC) codes have recently been proposed for the near-capacity Joint Source and Channel Coding (JSCC) of symbol values that are selected from a set having an infinite cardinality. In this paper, we characterize the computational complexity of UEC decoders and use complexity analysis for striking a desirable trade-off between the contradictory requirements of low complexity and near-capacity operation. We investigate a wide range of application scenarios and offer a deep insight into their beneficial parameterizations. In particular, we introduce puncturing for controlling the scheme's throughput and for facilitating fair comparisons with a Separate Source and Channel Coding (SSCC) benchmarker. The UEC scheme is found to offer almost 1.3 dB gain, when operating within 1.6 dB of the capacity bound. This is achieved without any increase in transmission energy, bandwidth, transmit duration or decoding complexity.

Relation with the project work: This is a continuation of our previous of on UEC, which is being carried out Task 3.1. We have characterized the computational complexity of UEC decoders and used this for striking a desirable trade-off between the contradictory requirements of low complexity and near-capacity operation.

[153] Hua Sun, Yiru Shen, Soon Xin Ng and Hanzo, Lajos, "Turbo Trellis Coded hierarchical modulation for cooperative communications," *IEEE Wireless Communications and Networking Conference (WCNC)*, pp.2789-2794, 7-10 April 2013.

Abstract: A cooperative communication system assisted by Turbo Trellis-Coded Modulation (TTCM) relying on Hierarchical Modulation (HM) is proposed, which invokes iterative soft decoding. Our results demonstrated that the performance of the single-relay aided cooperative system can be improved by at least 4 dB at a BER of 10^{-5}.

Relation with the project work: In line with our previous work on cooperative communications of Task 5.3, this paper presents a TTCHM aided cooperative communication scheme.

[154] Jie Zhang; Fan Jin, Rong Zhang, Guangjun Li and Hanzo, L., "Distributed Antenna aided twin-layer femto-and macro-cell networks relying on fractional Frequency-Reuse," IEEE Wireless Communications and Networking Conference (WCNC), pp.1586-1591, 7-10 April 2013.

Abstract: Distributed Antenna Systems (DAS) and femtocells are capable of improving the attainable performance in the cell-edge area and in indoor residential areas, respectively. In order to achieve a high spectral efficiency, both the Distributed Antenna Elements (DAEs) and Femtocell Base Stations (FBSs) may have to reuse the spectrum of the macrocellular network. As a result, the performance of both outdoor macrocell users and indoor femtocell users suffers from Co-Channel Interference (CCI). Hence in this paper, heterogenous cellular networks are investigated, where the DAS-aided macrocells and femtocells coexist within the same area. The outage probability is derived and the network is optimised for minimising the outage probability. Our analysis demonstrates that surprisingly, the Unity Frequency Reuse (UFR) based macrocellular system can be optimised in isolation, without considering the impact of femtocells. We found that the macrocells relying on hard-FFR as well as on soft-FFR tend to migrate to several small cells, illuminated by the DAEs, when the density of femtocells becomes high.

Relation with the project work: Within the domain of WP5, this paper analyses DAS-aided twin layer cellular networks and presents a genetic algorithm based near-optimal design.

[155] Peichang Zhang, Sheng Chen and Hanzo, L., "Near-capacity joint channel estimation and three-stage turbo detection for MIMO systems," *IEEE Wireless Communications and Networking Conference (WCNC)*, pp.3986-3991, 7-10 April 2013.

Abstract: We propose a novel joint channel estimation and three-stage iterative detection/decoding scheme for near-capacity MIMO systems. In our scheme, as usual, the detected soft information is first exchanged a number of times within the inner turbo loop between the unity-rate-code (URC) decoder and the MIMO soft-demapper, and the information gleaned from the inner URC decoder is then iteratively exchanged with the outer decoder in the outer turbo loop. Our channel estimator however exploits the a posteriori information produced by the MIMO soft-demapper to select a sufficient blocks of high-quality detected soft bits, and it is naturally embedded into the original iterative three-stage detection/decoding process, without introducing the costly iterative loop between the decision-directed channel estimator and the three-stage turbo detector/decoder. Hence, the computational complexity of our joint channel estimation and three-stage turbo detection is similar to that of the three-stage turbo detection/decoding scheme associated with the perfect CSI. Moreover, our reduced-complexity semi-blind scheme is capable of achieving the optimal maximum-likelihood turbo detection performance attained under the perfect CSI, with the same number of turbo iterations.

Relation with the project work: Within the framework of WP5, this paper presents a novel joint channel estimation and three-stage iterative detection/decoding scheme for near-capacity MIMO systems.

[156] Kadir, M.I., Sugiura, S., Sheng Chen and Hanzo, L., "MC-CDMA aided multi-user space-time shift keying in wideband channels," *IEEE Wireless Communications and Networking Conference (WCNC)*, pp.2643-2648, 7-10 April 2013.

Abstract: In this paper, we propose multi-carrier code division multiple access (MC-CDMA)-aided space-time shift keying (STSK) for mitigating the performance erosion of the classic STSK scheme in dispersive channels, while supporting multiple users. The codewords generated by the STSK scheme are appropriately spread in frequency-domain (FD) and transmitted over a number of parallel frequency-flat subchannels. We propose a new receiver architecture amalgamating the single-stream maximum-likelihood (ML) detector of the STSK system and the multiuser detector (MUD) of the MC-CDMA system. The performance of the proposed scheme is evaluated for transmission over frequency-selective channels in both uncoded and channel-coded scenarios. The results of our simulations demonstrate that the proposed scheme overcomes the channel impairments imposed by wideband channels and exhibits near-capacity performance in a channel-coded scenario.

Relation with the project work: Within the domain of WP5, in this contribution, an MC-CDMA aided STSK system is conceived.

[157] Aljohani, A.J., Soon Xin Ng, Maunder, R.G. and Hanzo, L., "Joint TTCM-VLC-Aided SDMA for Two-Way Relaying Aided Wireless Video Transmission," *IEEE Vehicular Technology Conference (VTC Fall)*, pp.1-5, 2-5 Sept. 2013.

Abstract: An iterative Joint Source and Channel Coded Modulation (JSCCM) scheme is proposed for robust video transmission over two-way relaying channels. The system advocated was designed for improving the throughput, reliability and coverage area compared to that of conventional one-way relaying schemes. We consider a two-user communication system, where the users exchange their information with the aid of a twin-antenna Relay Node (RN). For each user the proposed lossless video scheme is comprised of a Variable Length Code (VLC) encoder and two Turbo Trellis Coded Modulation (TTCM) encoders one at the Source Node (SN) and one at the RN. The spatio-temporal redundancy of the video sequence is exploited for reducing the iterative decoding complexity. The decoding convergence behaviour of the decoder as well as the power sharing ratio between the two SNs and the RN are characterized with the aid of EXtrinsic Information Transfer (EXIT) charts. Our proposed scheme exhibits an SNR gain of 9 dB compared to the non-cooperative scheme, when communicating over Rayleigh fading channels.

Relation with the project work: Within the domain of Task 3.1, this contribution proposes a JSCCM scheme for reliable video transmission.

[158] Aljohani, A.J.; Soon Xin Ng; Maunder, R.G.; Hanzo, L., "Joint TTCM-VLC-Aided SDMA for Two-Way Relaying Aided Wireless Video Transmission," Vehicular Technology Conference (VTC Fall), 2013 IEEE 78th , vol., no., pp.1,5, 2-5 Sept. 2013.

Abstract: An iterative Joint Source and Channel Coded Modulation (JSCCM) scheme is proposed for robust video transmission over two-way relaying channels. The system advocated was designed for improving the throughput, reliability and coverage area compared to that of conventional one-way relaying schemes. We consider a two-user communication system, where the users exchange their information with the aid of a twin-antenna Relay Node (RN). For each user the proposed lossless video scheme is comprised of a Variable Length Code (VLC) encoder and two Turbo Trellis Coded Modulation (TTCM) encoders one at the Source Node (SN) and one at the RN. The spatio-temporal redundancy of the video sequence is exploited for reducing the iterative decoding complexity. The decoding convergence behaviour of the decoder as well as the power sharing ratio between the two SNs and the RN are characterized with the aid of EXtrinsic Information Transfer (EXIT) charts. Our proposed scheme exhibits an SNR gain of 9 dB compared to the non-cooperative scheme, when communicating over Rayleigh fading channels.

Relation with the project work: Within the domain of Task 3.1, this contribution proposes a Joint TTCM-VLC-Aided SDMA scheme for reliable video transmission.

[159] Botsinis, P., Soon Xin Ng and Hanzo, L., "Low-complexity iterative quantum multi-user detection in SDMA systems," IEEE International Conference on Communications (ICC), vol., no., pp.5592-5597, 10-14 June 2014.

Abstract: The potentially excessive complexity of the Maximum Likelihood Multi-User Detector (ML MUD) in large-scale Spatial Division Multiple Access (SDMA) systems dictates the employment of low-complexity sub-optimal MUDs in the context of conventional systems. However, this limitation was circumvented by the recently proposed Du□rr-Høyer Algorithm (DHA)-aided QuantumWeighted Sum Algorithm (QWSA)-based Quantum Multi-User Detector (QMUD) employed for performing optimal ML iterative detection in SDMA systems. Focusing our attention on the QWSA, we analyse the QMUD and the evolution of the quantum system with the aid of a simpleSDMA uplink scenario. We characterize the performance of the DHA-QWSA QMUD advocated, which is capable of matching the performance of the ML MUD both in terms of its EXIT charts and BER curves.

Relation with the project work: Within the framework of Task 5.3, low-complexity quantum-assisted MUD is conceived for SDMA systems.

[160] Chen Dong, Lie-liang Yang, Jing Zuo, Soon Xin Ng and Hanzo, L., "Maximum Throughput Adaptive Rate Transmission scheme for multihop diversity aided multihop links," IEEE International Conference on Communications (ICC), vol., no., pp.221-226, 10-14 June 2014.

Abstract: In multihop diversity aided multihop links, the number of bits transmitted in each Time Slot (TS) is affected by both the Channel Quality (CQ) and the Buffer Fullness (BF), when adaptivemodulation is employed. We assume that every node has buffers for temporarily storing its received packets for further transmission at instances of good CQ. For the sake of improving thethroughput, a Maximum Throughput Adaptive Rate Transmission (MTART) scheme was proposed, where the specific hop having the capability of transmitting the highest number of bits (packets) will be activated. If more than one hops are capable of transmitting the same number of bits, the particular hop having the highest CQ (reliability) is activated. We demonstrate that the MTART scheme has 8 dB gain at the Outage Probability (OP) of 10-3 and has 3 dB gain in terms of the throughput attained in comparison to the conventional adaptive modulation aided scheme.

Relation with the project work: This paper is part of Task 5.3. In this contribution, the MTART scheme has been proposed for supporting delay-tolerant adaptive rate transmission of data over multihop links.

[161] Chen Dong, Jing Zuo, Lie-liang Yang, Yongkai Huo, Soon Xin Ng and Hanzo, L., "Energy-efficient buffer-aided relaying relying on non-linear channel probability space division," IEEE Wireless Communications and Networking Conference (WCNC), vol., no., pp.1979-1984, 6-9 April 2014.

Abstract: A buffer-aided two hop link is studied, where the RN is capable of temporarily storing the received packets. We commerce by defining the concept of a two-dimensional Channel Probability Space (CPS) based on the source-relay and relay-destination channel. Specifically, a non-linear CPS division method is proposed, which partitions the CPS into several regions representing the quality of the specific channels plus an outage region. Then the best channel is activated for the sake of minimizing the system's energy dissipation. Finally, the proposed buffer-aided transmission

scheme relying on our non-linear CPS division regime is investigated and the results show that at given average end-to-end energy dissipation, the outage probability was reduced by 33.5% compared to the benchmark scheme.

Relation with the project work: Within the framework of Task 5.3, a non-linear CPS scheme is proposed for buffer-aided transmission, which reduces the outage probability.

[162] Jie Hu, Lie-liang Yang and Hanzo, L., "Throughput and delay analysis of wireless multicast in distributed mobile social networks based on geographic social relationships," IEEE Wireless Communications and Networking Conference (WCNC), vol., no., pp.1874-1879, 6-9 April 2014.

Abstract: Since mobile communications exhibit strong social characteristics, based on the potential common interests of mobile users, mobile social networks (MSNs) are capable of mitigating the tele-traffic bottleneck. By multicasting the content of common interest from a content owner to content seekers within the owner's transmission range, a distributed MSNs architecture is proposed, which is capable of mitigating the tele-traffic imposed on network operators. In this contribution, the social relationship between a pair of MSN users is defined according to their geographic characteristics. By jointly considering the geographic social relationships and the wireless propagation environment, we derive the closed-form equations for evaluating both the throughput and delay of the social unicast/multicast transmissions. Simulation results are provided, both for supporting our theoretical analysis, as well as for investigating the impact of social relationships on the achievable network performance. Based on the results presented, we conclude that a more socially-minded content owner is particularly efficient in multicasting the content of common interest to content seekers.

Relation with the project work: This is related to WP5. More specifically, the geographic social relationships and the wireless propagation environment are jointly considered for evaluating the throughput as well as the delay of the social unicast/multicast transmissions.

[163] Jie Hu, Lie-liang Yang and Hanzo, L., "Cooperative multicast aided picocellular hybrid information dissemination in mobile social networks: Delay/energy evaluation and relay selection," IEEE Wireless Communications and Networking Conference (WCNC), vol., no., pp.3207-3212, 6-9 April 2014.

Abstract: A novel hybrid information dissemination scheme is proposed for picocellular systems. At the first stage of our scheme, some of the mobile users (MUs) successfully receive the information of common interest via BS-aided multicast. At the second stage, the information is cooperatively multicast (co-multicast) by the information owners (IOs) in a self-organized ad hoc network until all the MUs receive it. Since limited resources are provided for the second stage of the spontaneous co-multicast, some of the IOs are appointed for relaying the information to the hitherto unserved MUs. Several relay selection protocols are conceived for the sake of improving the performance of our hybrid information dissemination scheme. The simulation results demonstrate that our scheme may reduce the average dissemination delay and the average energy dissipation by 20% and 70%, respectively, when compared to the conventional BS aided single-hop multicast. Furthermore, we demonstrate that relying on the IOs associated with the best links plays a crucial role in facilitating spontaneous information dissemination.

Relation with the project work: This paper is pertaining to cooperative networks of Task 5.3.

[164] Chen Dong, Jing Zuo, Lie-liang Yang, Yongkai Huo, Soon Xin Ng and Hanzo, L., "On Buffer-Assisted Opportunistic Routing Relying on Linear Transmission Activation Probability Space Partitioning for Relay-Aided Networks," IEEE 80th Vehicular Technology Conference (VTC Fall), vol., no., pp.1-5, 14-17 Sept. 2014.

Abstract: In this paper buffer-aided Opportunistic Routing (OR) was designed with the aid of the novel concept of linear Transmission Activation Probability Space (TAPS) partitioning invoked for relay-assisted networks, which combines the benefits of both OR [1] and of buffer-aided transmissions [2]. More specifically, a packet may be transmitted from the Source Node (SN) to the Destination Node (DN) either directly or indirectly via one of the M Relay Nodes (RNs), depending on the instantaneous channel qualities. The above-mentioned linear multi-dimensional TAPS partitioning concept is proposed for partitioning the transmission space into (2M+1) transmission regions plus an outage region, while ensuring that the number of input packets is equal to the number of output packets at each RN's buffer. The benefit of having a buffer and tolerating the associated delay is that the best channel is activated for transmission based on our linear TAPS partitioning method.

Relation with the project work: A routing scheme is conceived for the relaying-assisted networks of Task 5.3.

[165] Wei Liang, Soon Xin Ng, Bayat, S., Yonghui Li and Hanzo, L., "Opportunistic Spectral Access in Cooperative Cognitive Radio Networks," IEEE 80th Vehicular Technology Conference (VTC Fall), vol., no., pp.1-5, 14-17 Sept. 2014.

Abstract: A pragmatic distributed algorithm (PDA) is proposed for supporting the efficient spectral access of multiple Primary Users (PUs) and Cognitive Users (CUs) in cooperative Cognitive Radio (CR)networks. The CUs may serve as relay nodes for relaying the signal received from the PUs to their destinations, while both the PUs' and the CUs' minimum rate requirements are satisfied. The key idea of our PDA is that the PUs negotiate with the CUs concerning the specific amount of relaying and transmission time, whilst reducing the required transmission power or increasing the transmission rate of the PU. Our results show that the cooperative spectral access based on our PDA reaches an equilibrium, when it is repeated for a sufficiently long duration. These benefits are achieved, because the PUs are motivated to cooperate by the incentive of achieving a higher PU rate, whilst non-cooperation can be discouraged with the aid of a limited-duration punishment.

Relation with the project work: This work focuses on the efficiency of the spectral access in cooperative cognitive radio networks, which falls in the domain of Task 5.3.

[166] Liang, D., Thomas, V.A., Xinyi Xu, Soon Xin Ng, El-Hajjar, M. and Hanzo, L., "Adaptive Soft-Decision Aided Differential Modulation for Cooperative Uplink Transmission Relying on Radio-Over-Fiber Backhaul," IEEE 80th Vehicular Technology Conference (VTC Fall), vol., no., pp.1-5, 14-17 Sept. 2014.

Abstract: A novel adaptive turbo-coded soft-decision aided differential detection (ATSDD) scheme is proposed for cooperative uplink wireless and Radio-over-fiber (ROF) transmission in a Fractional Frequency Reuse (FFR) based multicell, multiuser system. More specifically, the ATSDD scheme is employed by the Mobile Station (MS) for reliably conveying the source bits to a pair of Remote Antennas (RAs) by appropriately adjusting the modulation mode according to the near-instantaneous wireless and ROF channel conditions. The ATSDD switching thresholds are specifically adjusted for ensuring that the Bit Error Ratio (BER) remains below 10^(-5). We also investigated the effect of phase-rotations, which is routinely inflicted by practical imperfect ROF links. We demonstrate that our ATSDD scheme increases the overall throughput.

Relation with the project work: In this paper, a radio-over-fiber backhaul is used for the cooperative schemes of Task 5.3.

[167] Aljohani, A.J., Soon Xin Ng and Hanzo, L., "TTCM-Assisted Distributed Source-Channel Coding for Nakagami-m Fading Channels," IEEE 80th Vehicular Technology Conference (VTC Fall), vol., no., pp.1-5, 14-17 Sept. 2014.
Abstract: Asymmetric Distributed Source-Channel coding (DSC) is considered, where a pair of correlated sources are transmitting to a central node. The distributed scheme is based on Turbo TrellisCoded Modulation (TTCM), where the first source will be channel encoded and then compressed before it is sent over Nakagami-m fading channels. The second source signal, however, is assumed to be available flawlessly at the destination for exploitation as side information for improving the decoding performance of the first source. A wide range of fading scenarios were considered, where reliable communications approaching the Slepian-Wolf Shannon (SW/S) limit were exhibited. Finally, the scheme is capable of adapting to the time-variant short-term correlation between the two sources.

Relation with the project work: This work deals with Task 3.1, whereby we investigated the performance of a reduced-complexity adaptive DSCM scheme communicating over a variety of realistic Nakagami-m fading channels.

[168] Babar, Z., Soon Xin Ng and Hanzo, L., "EXIT-Chart Aided Code Design for Symbol-Based Entanglement-Assisted Classical Communication over Quantum Channels," IEEE 80th Vehicular Technology Conference (VTC Fall), vol., no., pp.1-5, 14-17 Sept. 2014.

Abstract: Quantum-based transmission is an attractive solution conceived for achieving absolute security. In this quest, we have conceived an EXtrinsic Information Transfer (EXIT) chart aided channelcode design for symbol-based entanglement-assisted classical communication over quantumdepolarizing channels. Our proposed concatenated code design incorporates a Convolutional Code (CC), a symbol-based Unity Rate Code (URC) and a soft-decision aided 2-qubit Superdense Code (2SD), which is hence referred to as a CC-URC-2SD arrangement. We have optimized our design with the aid of non-binary EXIT charts. Our proposed design operates within 1 dB of the

achievable capacity, providing attractive performance gains over its bit-based counterpart. Quantitatively, the bit-based scheme requires 60% more iterations than our symbol-based scheme for the sake of achieving perfect decoding convergence. Furthermore, we demonstrate that the decoding complexity can be reduced by using memory-2 and memory-3 convolutional codes, while still outperforming the bit-based approach.

Relation with the project work: This work focuses on the near-capacity code designs for quantum channels, which falls within the domain of WP5.

[169] Hung Viet Nguyen, Zunaira Babar, Soon Xin Ng, Matteo Mazzotti, Lorenzo Iacobelli, Lajos Hanzo, "Network Coded MIMO Aided Cooperative Communications in the Ambulance-and-emergency Area", Procedia Computer Science, Volume 40, 2014, Pages 214-221, ISSN 1877-0509

Abstract: In this contribution, a novel network coding (NC) aided multi-input multi-output (MIMO) scheme is proposed for providing reliable transmission from an ambulance assisting in an emergency situation by cooperating with relaying devices at an emergency scene. Our system is constituted by an Irregular Convolutional Coded Unity Rate Coded Space Time Trellis Coded M-ary Phase Shift Keying (IrCC-URC-STTC-MPSK) scheme invoked for exploiting the benefits of MIMO systems. The system is designed with the aid of Extrinsic Information Transfer (EXIT) charts for approaching the corresponding channel capacity in fast fading environments. The proposed scheme exhibits substantial benefits over conventional MIMO systems in hostile wireless channels.

Relation with the project work (Task 5.3): In this contribution, we proposed the network coding aided multi-input multi-output systems for our IRCC-URC-STTC$_{2\times1}$-MPSK scheme invoked by the USER, RELAYs and BS. Network coding was invoked for cooperative communications amongst the USER, RELAYs and BS.

2.2.4 Non-scientific publications

The dissemination of project concepts and results went also through the dissemination in non-specialized publications and on newspapers and blogs.
An article about CONCERTO was published on "Net-tech future" with the title "CONCERTO: Saving lives with real-time e-health".
Following the final CONCERTO convenction organized in February 2015 in Perugia, several articles appeared on italian newspapers and CONCERTO was also advertised on regional television. More details are reported in Section 4.4.
Interviews were also released to italian local televisions and to the regional news of italian public television RAI [175].
Finally, an interview was also published on the italian online magazine "Tipi Tosti" [176] and an article on the website of the TV emission "Dottor Salute" [177].

2.3 Participation at conferences, symposiums and workshops

The following table lists the dissemination events, i.e. conferences, symposiums and workshops, in which the above mentioned topics were or will be presented, detailing also the audience type and scale.

Dates	Conference, symposium, or workshop	Type of audience	Countries addressed	Size of audience	Partner(s) involved
July 2012	Future Networks and Mobile Summit 2012	Research and Business	World	~1500	CEFRIEL
June 2012	IEEE International Conference on Communications 2012 (IEEE ICC'12)	Research and Business	World	~2000	UOS
June 2012	IEEE Wireless Advanced 2012	Research and Business	London, UK	~150	KU, CNIT
June 2012	Dagstuhl seminar on Future Internet for eHealth	Research, Business, End users	Dagstuhl, Germany	~50	KU
Aug 2012	IEEE 7th International Symposium on Turbo Codes & Iterative Information Processing (ISTC)	Research and Business	World	~500	CNIT

Sep 2012	2012 IEEE 76th Vehicular Technology Conference (VTC2012-Fall)	Research and Business	World	~1500	UOS
Oct 2012	IEEE 3rd International Conference on Photonics		World	~800	UOS
Oct 2012	IEEE First European Conference on Satellite Telecommunications (AESS) 2012	Research and Business	World	~200	CNIT
Nov 2012	46th Annual Asilomar Conference on Signals, Systems, and Computers	Research and Business	World	~500	CNIT
Nov 2012	IEEE Germany Student Conference (GSC)	Research	Germany	~100	Siemens
Nov 2012	Visual Communications and Image Processing (VCIP)	Research	World	~150	Siemens
Dec 2012	IEEE 2012 Global Communications Conference	Research and Business	World	~2000	UOS, CNIT
Jan 2013	9th International ITG Conference on Systems, Communications and Coding (SCC2013)	Research and Business	World	~150	CNIT
Feb 2013	SPIE Medical Imaging	Research and Business	World	~1100	Siemens
Feb 2013	6th COST IC 1004 Meeting	Research and Business	World	~300	CNIT
April 2013	WCNC2013	Research and Business	World	~800	UOS
June 2013	IEEE SPAWC 2013	Research	World	~300	KU
June 2013	IEEE ICC 2013	Research and Business	World	~1000	KU, CNIT, UOS
June 2013	VTC2013-Spring	Research and Business	World	~500	UOS
Sep 2013	IEEE International Conference on Image Processing	Research	World	~1000	Siemens
Sep 2013	IEEE PIMRC 2013	Research and Business	World	~1000	KU
Sep 2013	VTC2013-Fall	Research and Business	World	~500	UOS
Oct 2013	IEEE Healthcom 2013	Research	World	~1000	KU, CNIT
Dec 2013	GLOBECOM 2013	Research and Business	World	~2000	CEFRIEL, UOS
Dec 2013	IEEE ISSPIT 2013	Research and business	World	~100	VTT
Dec 2013	Picture Coding Symposium	Research	World	200	Siemens
Jan 2014	IEEE CCNC 2014	Research and Business	World	~1000	VTT
March 2014	IEEE PerCom 2014	Research and Business	World	~1000	BME

April 2014	WCNC2014	Research and Business	World	~800	UOS
May 2014	IEEE/IFIP QCMan 2014	Research and Business	World	~100	VTT
May 2014	IEEE 39th International Conference on Acoustic, Speech and Signal Processing (ICASSP 2014)	Research and Business	World	~1000	CNIT
May 2014	VTC2014-Spring	Research and Business	World	~500	UOS
June 2014	European Conference on Networks and Communications (EuCNC 2014)	Research and Business	Europe	~500	CNIT
June 2014	IEEE International Conference on Cummunications (ICC 2014)	Research and Business	World	~1000	CNIT, UOS
July 2014	IEEE TEMU 2014	Research and Business	World	~200	KU
Sep 2014	Mownet 2014	Research and Business	World	~150	KU, Thales, Siemens, UOS, CNIT, BME,…
Sep 2014	VTC2014-Fall	Research and Business	World	~500	UOS
Oct 2014	IEEE Healthcom 2014 (paper presented)	Research	World	~1000	KU
Nov. 2014	IEEE Symposium on Communications and Vehicular Technologies (SCVT) 2014	Research and Business	World	~100	CEFRIEL
Dec 2014	IEEE VCIP 2014	Research and Business	World	~400	KU
Dec 2014	GLOBECOM 2013	Research and Business	World	~2000	UOS
Jan 2015	IEEE CCNC 2015	Research and Business	World	~1000	VTT

3 Standardization Activities

3.1 3GPP

3GPP stand for "3rd Generation Partnership". It unites 6 key telecom standards bodies of Asia, Europe and USA. 3GPP was created at the end of 1998, with the aim of building from the GSM standards a 3rd Generation of wireless network system. Following the development of wireless technologies as W-CDMA, HDPA and LTE and its associated core network, 3GPP has defined in its Release 10, the main technologies that are recognised by the ITU as "4G" or IMT-Advanced Technologies.

3.1.1 Standardisation strategy

The project expectation was to follow and possibly influence the standardisation with project outcomes. The timescale of the 3GPP standardisation is defined by the 3GPP itself and it is not necessarily aligned with the project. The standardisation process is built over three stages: the definition of the requirements (Stage 1), the definition of the architecture (Stage 2) and the definition of the protocols (Stage 3). At the beginning of the CONCERTO, it was identified that the introduction of public safety features in the 3GPP standard, and in particular the proximity services, was an opportunity for disseminating some project outcomes. A regular tracking of the standardization progress has been carried on all along the project. The proximity services, introduced for supporting public safety services, and the RAN user plane congestion management were identified to be relevant for CONCERTO and could offer opportunity to promote some project results. A tracking of the SA4 group in charge of the codec and multimedia was also performed.

3.1.2 Standardisation results

The tracking of the 3GPP standardization progress, related to public safety features, and more specifically on the proximity services, and related to the user plane congestion and multimedia, has allowed to identify a forecast plan on the standardization activities for the timescale of the project. The target objective was the 3GPP release 12 that was initially expected to be completed in 2014, but which was postponed several times and it is currently planned for March 2015. The key evolution of this release with respect to CONCERTO activities is the introduction in the standard of proximity services, which will ease the use of LTE in public safety and for PMR market (which is one of the most promising markets for the exploitation of CONCERTO solutions).

During the phase related to the identification of the requirements on the proximity services, the tracking of 3GPP activities allowed ensuring that the requirements identified by CONCERTO were taken into account. Based on the requirements for the ambulance and emergency area scenario, a contribution was done to extend the usability of network during local absence of network infrastructure by introducing a traffic relay capabilities in mobile devices. All along the project, NTUK participated to 3GPP meetings, reporting feedbacks to the full consortium.
In the table below are listed the 3GPP meetings to which CONCERTO was represented.

Dates	Meeting	Partner(s) involved
August 2012	3GPP SA1#59 Ad hoc on Public Safety	NTUK
January 2013	3GPP SA1#60 & 3GPP SA2#95	NTUK
April 2013	3GPP Meeting SA2#96	NTUK
May 2013	3GPP Meeting SA2#97	NTUK
July 2013	3GPP Meeting SA2#98	NTUK
September 2013	3GPP Meeting SA2#99	NTUK
November 2013	3GPP Meeting SA2#100	NTUK
January 2014	3GPP Meeting SA2#101	NTUK
February 2014	3GPP Meeting SA2#102	NTUK

The following contributions were made to the 3GPP standardization group.

Partner		Title of contribution and standardisation group	Date	Location	Concerned technical domain (Task, WP)
4	NTUK	Contribution document, describing a use case and associated requirements for extending 3GPP network coverage by using a user terminal acting as a relay node. Contribution to the 3GPP SA1 #59 Meeting, for the work item ProSe (Proximity services)	30/7 to 3/8 2012	Chicago, Illinois, USA	WP2/WP7
4	NTUK	"ProSe Discovery modes", 3GPP Meeting SA2#97	27/5/2013	Busan, Korea	WP5/WP7
4	NTUK	"Update to key issue on Relays", SA2#97	27/5/2013	Busan, Korea	WP5/WP7
4	NTUK	"ProSe Configuration", SA2#98	15/7/2013	Valencia, Spain	WP5/WP7
4	NTUK	"L2 ProSe UE-to-Network Relay alternative", SA2#99	23/9/2013	Xiamen, China	WP5/WP7
4	NTUK	"Evaluation of solution P2 on ProSe configuration", Contribution to 3GPP meeting SA2#100	11/11/2013	San Francisco, USA	WP5/WP7
4	NTUK	"ProSe configuration in EPC", Contribution to 3GPP meeting SA2#100	11/11/2013	San Francisco, USA	WP5/WP7
4	NTUK	"ProSe configuration in EPC", Contribution to 3GPP meeting SA2#101	20/1/2014	Taipei, Taiwan	WP5/WP7

3.2 ISO/IEC MPEG AND ITU-T VCEG

The JCT-VC is a joint working group of ISO/IEC MPEG and ITU-T VCEG. The JCT-VC was established in April 2010, when it had its first meeting in Dresden. The JCT-VC is working on the standardization project on High Efficiency Video Coding (HEVC). HEVC can be seen as the successor of the H.264/AVC standard. The goal for HEVC is the improvement of compression efficiency by 50%. A first version of the standard (FDIS status, Final Draft International Standard) has been completed in January 2013.

3.2.1 Standardisation strategy

Within image/video coding, CONCERTO focuses on the standardization of high-quality compression, i.e., lossless and near-lossless coding, as already described in the DoW. Therefore, especially the co-called "Range Extension" work as part of version 2 of High Efficiency Video Coding (HEVC/H.265) is relevant. In this context Siemens made several proposal to support high-quality compression of high-bit-depth image data like computed tomography (CT) imagery and magnetic resonance imaging (MRI) data.

3.2.2 Standardization results

Siemens actively participates at the standardisation meetings of MPEG, VCEG, and JCT-VC as can be seen from the table below. TCS as well attended some MPEG meeting

Dates	Meeting	Partner(s) involved
February 2012	JCT-VC#8, MPEG#99, and VCEG#44 standardization meetings (San Jose, CA, USA)	Siemens
April/May 2012	JCT-VC#9, MPEG#100, and SG16/VCEG standardization meetings (Geneva Switzerland)	Siemens
July 2012	JCT-VC#10, MPEG#101, and VCEG#45 standardization meetings (Stockholm, Sweden)	Siemens
October 2012	JCT-VC#11, MPEG#102, and VCEG#46 standardization meetings (Shanghai, China)	Siemens
January 2013	JCT-VC#12 and SG16/VCEG standardization meetings (Geneva, Switzerland)	Siemens

Dates	Meeting	Partner(s) involved
February 2012	JCT-VC#8, MPEG#99, and VCEG#44 standardization meetings (San Jose, CA, USA)	Siemens
April/May 2012	JCT-VC#9, MPEG#100, and SG16/VCEG standardization meetings (Geneva Switzerland)	Siemens
April 2013	JCT-VC#13, MPEG#104, and VCEG#47 standardization meetings (Incheon, Korea)	Siemens
July/August 2013	JCT-VC#14, MPEG#105, and VCEG#48 standardization meetings (Vienna, Austria)	Siemens
October/November 2013	JCT-VC#15 and MPEG#106 standardization meetings (Geneva, Switzerland)	Siemens, TCS
January 2014	JCT-VC#16, MPEG#107, and VCEG#49 standardization meetings (San Jose, CA, USA)	Siemens
March/April 2014	JCT-VC#17, MPEG#108, and VCEG#50 standardization meetings (Valencia, Spain)	Siemens, TCS
October 2014	JCT-VC#18, MPEG#109, and VCEG#51 standardization meetings (Strasbourg, France)	Siemens, TCS
February 2015	JCT-VC#19 and MPEG#110 standardization meetings (Geneva, Switzerland)	Siemens, TCS

The following contributions were made to the MPEG and JCT-VC working groups, respectively.

Partner		Title of contribution and standardisation group	Date	Location	Concerned technical domain (Task, WP)
2	Siemens	G. Bäse, “Editors input on 23000-10 2nd edition PDAM1 Conformance and reference software”, ISO/IEC JTC1/SC29/WG1 (MPEG), document M27007	Oct. 2012	Shanghai, China	WP3, Task 3.1 on file format
2	Siemens	P. Amon, A. Hutter, E. Wige, A. Kaup, “Intra prediction for lossless coding” (proposal, document JCTVC-L0161/M27497)	Jan. 2013	Geneva, Switzerland	WP3, Task 3.1 on video compression
2	Siemens	W. Gao, M. Zhou, P. Amon, S. Lee, “HEVC Range Extensions Core Experiment 2 (RCE2): Intra Prediction for Lossless Coding” (CE description, document JCTVC-L1122/M28403)	Jan. 2013	Geneva, Switzerland	WP3, Task 3.1 on video compression
2	Siemens	P. Amon, A. Hutter, E. Wige, A. Kaup, “RCE2: Complexity-reduced sample-based weighted intra prediction for lossless coding”, JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M0052/m28487	Apr. 2013	Incheon, Korea	WP3, Task 3.1 on video compression
2	Siemens	Eugen Wige, Peter Amon, Sunil Lee, I.-K. Kim, C. Kim,“ RCE2: Experimental results for Test 6 – combination of RDPCM and SWP for HEVC lossless coding”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M0053/m28488	Apr. 2013	Incheon, Korea	WP3, Task 3.1 on video compression
2	Siemens	P. Amon, A. Hutter, U.-E. Martin, N. Wirsz, A. Klingler, “Requirements for medical imaging applications”, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M0190/M28643	Apr. 2013	Incheon, Korea	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling

2	Siemens	P. Amon, A. Hutter, U.-E. Martin," Medical imaging sequences for HEVC development", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M0191/M28644	Apr. 2013	Incheon, Korea	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	P. Amon, A. Hutter, E. Wige, A. Kaup," Non-RCE2: Improved sample-based weighted intra prediction for lossless coding", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M0193/M28646	Apr. 2013	Incheon, Korea	WP3, Task 3.1 on video compression
2	Siemens	R. Joshi, P. Amon, R. Cohen, S. Lee, M. Naccari, "HEVC Range Extensions Core Experiment 2 (RCE2): Prediction and coding techniques for transform-skip and transform-bypass blocks", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-M1122/m29534	Apr. 2013	Incheon, Korea	WP3, Task 3.1 on video compression
2	Siemens	R. Joshi, P. Amon, R. Cohen, S. Lee, M. Naccari, "RCE2: Summary report on HEVC Range Extensions Core Experiment 2 (RCE2) on prediction and coding techniques for transform-skip and transform-bypass blocks", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0035/m30417	July/Aug. 2013	Vienna, Austria	WP3, Task 3.1 on video compression
2	Siemens	P. Amon, A. Hutter, E. Wige, A. Kaup, "RCE2: Simplified sample-based weighted prediction (Test C.3)", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0071/m29675	July/Aug. 2013	Vienna, Austria	WP3, Task 3.1 on video compression
2	Siemens	P. Amon, A. Hutter, E. Wige, A. Kaup, "RCE2-related: Variants of simplified sample-based weighted prediction", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0072/m29676	July/Aug. 2013	Vienna, Austria	WP3, Task 3.1 on video compression
2	Siemens	E. Wige, P. Amon, R. Joshi, "RCE2-related: Variants of simplified sample-based weighted prediction", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0073/m29677	July/Aug. 2013	Vienna, Austria	WP3, Task 3.1 on video compression
2	Siemens	E. Wige, A. Kaup, P. Amon, A. Hutter, "RCE2: Cross-check results for Test C.4 (JCTVC-N0053)", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0164/m29791	July/Aug. 2013	Vienna, Austria	WP3, Task 3.1 on video compression

2	Siemens	P. Amon, A. Hutter, U.-E. Martin, N. Wirsz, "HEVC profiles for medical imaging applications", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0178/m29809	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Peter Amon, Andreas Hutter, Uwe-Erik Martin, "Selected medical imaging sequences for HEVC development", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-N0179/m29810	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	H. Yu, K. McCann, R. Cohen, P. Amon, "Draft requirements for future extensions of HEVC in coding non-camera-captured content" (requirements discussion, document MPEG2013/M30477)	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	H. Yu, K. McCann, R. Cohen, P. Amon, "WG11 AHG on Coding Non-camera-captured Content", (Ad-hoc Group, document MPEG2013/M30478)	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	H. Yu, K. McCann, R. Cohen, P. Amon, "Draft requirements for future extensions of HEVC in coding screen content and medical visual content" (requirements discussion, document MPEG2013/N13828)	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	H. Yu, K. McCann, R. Cohen, P. Amon, "Draft call for proposals for coding of screen content and medical visual content" (document MPEG2013/N13829)	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	H. Yu, K. McCann, R. Cohen, P. Amon, "AHG on coding screen content and medical visual content" (document MPEG2013/N13834)	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Haoping Yu, Ken McCann, Robert Cohen, Peter Amon, "AHG report on coding non-camera-captured content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/M30478, Vienna, Austria, July/August 2013.	July/Aug. 2013	Vienna, Austria	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	P. Amon, A. Hutter, U.-E. Martin, B. Heigl, "AHG22: Sequences with medical mixed content and medical visual content with bit depth beyond 10 bits for HEVC development", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-O0172/m30934	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	P. Amon, A. Hutter, U.-E. Martin, N. Wirsz, "Coding of medical mixed content and medical visual content with bit depth beyond 10 bits", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-O0172/m30934	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling

2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "AHG report on coding non-camera-captured content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/M31660	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "AHG on coding screen content and medical visual content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/N14081	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "Draft requirements for future extensions of HEVC in medical visual content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/N14088	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "Draft requirements for future extensions of HEVC in screen content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/N14089	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "Draft call for proposals for coding of screen content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2013/N14090	Oct./Nov. 2013	Geneva, Switzerland	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	P. Amon, P. Wojaczek, A. Hutter, U.-E. Martin, N. Wirsz, "AHG5: Tools for lossless coding of medical image/video content in RExt profiles", Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11, document JCTVC-P0107/m31989	Jan. 2014	San Jose, CA, USA	WP3, Task 3.1 on video compression
2	Siemens	Haoping Yu, K. McCann, R. Cohen, P. Amon, "AHG report on coding screen content and medical visual content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2014/m31779	Jan. 2014	San Jose, CA, USA	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling
2	Siemens	P. Amon, H. Yu, K. McCann, R. Cohen, "Requirements for an extension of HEVC for the coding of medical visual content", ISO/IEC JTC 1/SC 29/WG 11, document MPEG2014/n14173	Jan. 2014	San Jose, CA, USA	WP7, Task 7.3 on standardization, especially HEVC requirements and profiling

Major efforts were devoted into the definition of profiles for the compression of medical image content, specially monochrome content with 12 bits and 16 bits. Therefore, in the course of the HEVC standardization process, the requirements were set in MPEG, the parent body of the JVC-VC. Also medical test sequences were provided to stress the importance of this type of content. The discussions were organized in a respective MPEG Ad-hoc Group (AhG) on "coding of non-camera-captured content". Within JCT-VC, the relevant profiles for high-bit depths profiles were proposed, which finally let to the definition of the Monochrome, Monochrome 12 and Monochrome 16 profiles. Earlier work and proposals on lossless compression was finally not continued, since lossless compression was not within the mandates of the work towards Range Extensions (RExt) for High Efficiency Video Coding (HEVC).

3.3 NCOIC

The Network Centric Operations Industry Consortium (NCOIC®) is a not-for-profit international corporation established in August 2004, with the aim of integrating existing and emerging open standards into a common global framework for the global deployment of network-centric applications. Defense companies, educational institutions, government agencies, information technology providers, service providers, etc compose this consortium.

Several teams and working groups have been established, lists on NCOIC web-site:

- **Building Blocks Team**: Identifies a wide variety of elements that help enable interoperability.
- **Integrated Project Teams (IPTs)**: these are customer teams whose role is to aggregate the NCOIC technical deliverables in support of specific customer domains.
- **Network Centric Attributes Functional Team**: Develops tools used by systems engineers to determine the level of net centricity that has been achieved in systems.
- **NIF® Architecture Concepts Functional Team**: Develops enabling guidance that systems engineers may use to develop systems-of-systems capabilities.
- **Requirements Validation Functional Team**: Develops and promotes models and practices useful to customers and member companies for validating requirements in a network centric environment.
- **Systems Engineering and Integration Functional Team**: Integrates the efforts and promote the deliverables of NCOIC Functional Teams for the accomplishment of NCOIC goals and objectives. The team recommends and supports the application of systems engineering and education methodologies and develops tools such as an integrated technical roadmap and a lexicon.

NCOIC products are: analyses, lexicon of Terms, an Interoperability Framework (NIF), a Network Centric Analysis Tool, Frameworks Recommendations, Systems Engineering Best Practices and Processes, Training and Educational Materials.

3.3.1 Mobile Networks Working Group (MNWG)

The Mobile Networks Working Group (MNWG) is evaluating and recommending mobile networking solutions for network centric systems.

The MNWG has focused on issues with mobile and transportable nodes and networks, their interactions with fixed network infrastructure, and scenarios with mobile infrastructure. Impacts of wireless links including satellite links are considered. A wide range of use cases exist, including humanitarian disasters ranging from 9/11 to routine first aide level emergency events.

3.3.2 SAGM Real-Time Tactical Video Mobile Networking Technical Pattern

The SAGM Real-Time Tactical Video Mobile Networking Technical Pattern is devoted to the transmission of video over Private Mobile Radios for ambulances, fire fighters and police forces.

3.3.3 Contribution and participation to standardisation bodies

Contribution to the SAGM Real-Time Tactical Video Mobile Networking Technical Pattern was the main TCS target on NCOIC. Indeed, activities on video adaptation realised in WP4 can be effectively applied to video transmission over Private Mobile Radios, which is one of the main TCS exploitation plan.
TCS is already involved in this pattern development. A second edition, including more interoperability details, as well as new formats in particular for metadata handling, is foreseen and TCS plans to actively contribute.
However, the activities on this pattern development have been suspended due to scarcity of clients funding the work and at the moment a date in which the activities will start again is not available. Hence, no contribution was possible, nevertheless TCS will keep monitoring NCOIC activities also after the end of the CONCERTO project to provide, when the occasion will appear, contributions based on CONCERTO results.

3.4 IEEE P3333.1

Kingston University is actively participating in the “Quality Assessment of Three Dimensional (3D) Contents based on Psychophysical Studies Working Group” (IEEE P3333.1).
Within this working group the IEEE Draft Standard for the Quality of Experience (QoE) and Visual Comfort Assessments of Three Dimensional (3D) Contents Based on Psychophysical Studies (P3333.1.1) has been delivered and the focus at the time of writing this deliverable was on the P3333.1.2 Standard for the Perceptual Quality Assessment of Three Dimensional (3D) Contents based on Physiological Mechanisms. The purpose of the latter standard is to define quality metrics for 3D image and video quality assessment, and establish guidelines for reducing risks to users accessing 3D contents over 3D displays and 3D devices. The major parameters dealt within this standard include viewers' characteristics, visual contents, visual environment, display and devices described in the scope. This standard will define how each human factor impacts the visual quality over the 3D domain. This standard provides objective 3D image and video quality metrics that are in agreement with subjective human judgments and previous researched in the

academy and the industry. This standard also establishes methods of quality assessment of 3D contents based on physiological mechanisms such as perceptual quality and visual attention.
Kingston University contributed in particular with the 3D quality database developed within CONCERTO and with a quality metric also developed within CONCERTO (presented in Deliverable D3.3).

The meetings attended within this working group (often online) are listed below. Kingston University hosted one of the meetings in October 2014 (first meeting outside Korea). 17 participants attended the meeting in Kingston University, in addition to the participants connected online.

Date	**Location**	**CONCERTO (Kingston) proposal**
11/6/2013	Korea	-
1/10/2013	Korea	-
17/12/2013	Korea	-
16/4/2014	Korea	-
26/9/2014	Korea	Presentation on 3D quality
31/10/2014	UK (Kingston University)	Presentation of 3D quality metric (D3.3)
26/1/2015	Korea	Presentation of the 3D quality database (packet losses)

Figure 1 – Prof Sanghoon Lee giving a presentation during the IEEE P3333.1 standardization meeting in KU

Figure 2 – Some of the participants in the IEEE P3333.1 standardization meeting in KU

3.5 IEEE 1907.1

Kingston University has been involved in the IEEE 1907.1 standardization group for **"**Network-Adaptive Quality of Experience (QoE) Management Scheme for Real-Time Mobile Video Communications**"** and participated in the relevant meeting in June 2013 (co-located with IEEE ICC).

4 CONCERTO events

To meet broader knowledge of the achieved results and addressed challenges by CONCERTO, as well as to foster collaboration activities, several events have been organized all along the project lifetime, In particular, each year one or more events have been organized with different targets according to the maturity of the project results.

During the first year of the project, the main objective was to share the direction selected for CONCERTO studies and to obtain further validation and possible refinement of CONCERTO use cases and requirements, in order to assure the relevance of the CONCERTO work for healthcare professionals, as well as to put light on the most interesting ehealth applications for the medical staff and technical communities. The initial idea was to organize a workshop on ICT for e-health titled "ICT solutions for rehabilitation" in the frame of the periodical cluster meeting organized among European projects. Unfortunately, due to the reorganization of the clusters' structure, this workshop was not held. The consortium decided then to reorganize a workshop during a special session at the MobiHealth 2012 conference.

During the second year, even if not initially planned, following the success of the first year workshop, the consortium decided to organize a workshop to share the most significant scientific results obtained in CONCERTO and to compare them with the researches of other institutions in the telemedicine domain. A workshop on "Service Science for e-Health" (SSH 2013) was then co-organized by CONCERTO in the frame of IEEE Healthcom 2013.

Finally, during the third year, the objective was to disseminate the CONCERTO results both to the scientific and to the medical community in order to advertise CONCERTO solutions and to promote the adoption of new models in the medical interventions that can be enabled by the CONCERTO proposed technologies. On the scientific dissemination side, a workshop was organised in conjunction with MoWNet'2014 and, following the success of SSH 2013, CONCERTO project was also involved in the organization of SSH 2014, during IEEE Healthcom 2014. Finally, the CONCERTO project organized a more medical-oriented event in Perugia, during which the project results and expected improvements in hospital effectiveness as well as a real-time demonstration of CONCERTO solution have been presented to a public mainly composed by medical doctors.

In the next sections more details on the aforementioned events are provided.

4.1 CONCERTO at Mobihealth 2012

4.1.1 Event and participants

The 3rd International Conference on Wireless Mobile Communication and Helathcare (MobiHealth 2012[1]) was organised by the European Alliance for Innovation the 22nd and 23rd of November 2012 in Paris, France. Since the topics of the conference were in line with CONCERTO interests, the consortium contacted the organizers and discussed the possibility to organize the first CONCERTO workshop during MobiHealth 2012. The organizers – strongly interested in CONCERTO project – agreed with the CONCERTO consortium to have a special session dedicated to the first CONCERTO workshop.

A panel of five participants form the project animated the session (Figure 3):

- Dr. Maria Martini (Kingston University, UK): chair of the session,
- Lorenzo Iacobelli (Thales Communications and Security, France);
- Benoit Lecroart (Nec Technologies, UK);
- Simone Moretti (Consorzio Nationale Interuniversitario per le Telecomunicazioni, Italy);
- András Takács (Budapest University of Technology and Economic, Hungary).

The agreed objective of the workshop was to present CONCERTO project and to discuss with participants and have feedbacks mainly on the requirements and use cases identified. The program of the workshop included the following six presentations:

- "Introduction of the panel and presentation of CONCERTO project", Dr. Maria Martini, Kingston University, UK
- "Use cases: challenges and business opportunities", Lorenzo Iacobelli, Thales Communications and Security, France
- "Secure QoE-aware image/video coding", Dr. Maria Martini, Kingston University
- "Content-awareness: wireless network support for media transmission", Benoit Lecroart, Nec Technologies, UK

[1] http://mobihealth.name/2012/show/home

- "Context-awareness: media adaptation, fusion and protection", Simone Moretti, Consorzio Nationale Interuniversitario per le Telecomunicazioni, Italy
- "Standardization", Benoit Lecroart, Nec Technologies, UK

The idea was to have short presentations (with the exception of the one on use cases) in order to have enough time to discuss with the attendance.
The first presentation was just a short introduction of the project. The second one was the central presentation of the workshop (around 20 minutes) and intended to introduce CONCERTO use cases and to stimulate the discussion.
The last presentations were short presentations (5-10 minutes) on the main subjects and preliminary results of technical workpackages (WP3, WP4 and WP5) and on current activities in standardization (WP7). The technical subjects presented were strictly related to the use cases in order, once again, to facilitate the exchanges on scenarios.
A feedback form (included in Annex) was also distributed to the participants in order to foster the exchanges and to collect the impressions of the participants.

Figure 3 - Picture from CONCERTO first year workshop.

Moreover, András Takács, the lead programmer of CONCERTO's Distributed and Dynamic Mobility Management framework, presented[2] the necessity of a DMM architecture for mHealth services, and proposed a nomadic system for it based on content- and context awareness, and strongly relying on cross-layer interoperation during the Advances in Personalized Healthcare Services, Wearable Mobile Monitoring, and Social Media Pervasive Technologies (APHS 2012) workshop that was held on the last day of MobiHealth 2012.

4.1.2 Results and exploitation

Around 30 people, mainly researchers involved in telemedicine-related activities, attended the CONCERTO session at MobiHealth 2012 conference.
At the end of the session six feedback forms completed were collected. Despite the low number of written feedbacks, the discussion during the workshop was really reach and fruitful with several questions and comments from the audience that helped to better identify the key challenges for each use case and to clarify some of them. As example, a discussion about required information at medical side helped to better clarify the problems related to the transmission of medical images and videos. In fact, for these data, the received quality cannot be evaluated only with classical metrics, but also specific medical needs should be taken into account. Another interesting point discussed was the security issues related to the use of caching for data that can become critical when dealing with medical data.
Moreover, the discussions during the workshop and the comments received through the feedback forms helped the consortium to improve our evaluation of business opportunities for each use case and to better identify the more interesting ones from a business perspective. In particular the "ubiquitous tele-consultation" use case emerged as the more interesting from a short term, economic perspective, while the emergency area use cases appeared to be more long

[2] http://ict-concerto.eu/twiki/pub/Concerto/Publications/TakacsBokorMobiHealth2012.pdf

term use cases, but also more interesting considering their potential medical impact. These feedbacks helped in the choice of the use cases to focus on for the simulator.

In addition to the useful feedbacks received, attendants demonstrated to be really interested in the project and discussions started with people form three different research centres to evaluate possible future collaborations.

4.2 CONCERTO at IEEE Healthcom 2013

4.2.1 Event and participants

A workshop on "Service Science for e-Health" (SSH 2013) was organised in conjunction with IEEE Healthcom 2013. The workshop was organized by Katarzyna Wac, Pawel Swiatek and Maria Martini, and it included representatives of the different CONCERTO partners as members of the programme committee.

The main aim of the workshop was to bring together representatives of academia, industry and healthcare business to present recent advances in the field of e-Health. High-quality interdisciplinary papers presenting utilization of service science to develop new or enhance existing healthcare systems and services were specially requested. The prospective authors were invited to submit their original contributions covering completed or ongoing work related to the area of service science for healthcare.

The topics of interest of the workshop were the following:

- e-Health services design and implementation
- Business models for e-Health services' delivery
- Cloud computing for e-Health
- Middleware for e-Health services
- Models and methods for decision making support in the healthcare domain
- Network architectures for e-Health
- Service-based e-Health systems
- Virtual and augmented reality for e-Health
- Wireless access to e-Health services
- Mobile Health solutions

4.2.2 Results and exploitation

The workshop attracting a good number of submissions; in total, 64 submissions were received. 18 papers have been accepted and presented in the workshop. The works were grouped in four sessions, namely Image / video processing and transmission, Wireless, mobile, and streaming services, Planning, adaptation and assessment of e-health services, and Case studies and disease prevention. The participants, from a large number of countries and different backgrounds, were actively involved in the discussion and useful feedback and considerations were received, in particular from participants in the medical domain. For instance, an interesting discussion took place about image quality assessment and the impact of the experience of the evaluator, the content, and the scenario / context.

Session 1: Image / video processing and transmission

- Paper 1: Joint Source and Turbo Trellis Coded Hierarchical Modulation for Context-aware Medical Image Transmission
- Paper 2: Medical Image and Video quality assessment in e-health Applications and Services
- Paper 3: An Intelligent System for Renal Segmentation

Session 2: Wireless, mobile, and streaming services

- Paper 4: Detecting Obstructive Sleep Apnea events in a real-time mobile monitoring system through automatically extracted sets of rules
- Paper 5: mHealth for Cardiac Patients Telemonitoring and Integrated Care
- Paper 6: Platform for building eHealth streaming services
- Paper 7: Construction of Healthcare Network based on Proposed ECG and Physical-activity Sensor adopting Energy-harvesting Technologies
- Paper 8: A Mobile Health Application for Falls Detection and Biofeedback Monitoring

Session 3: Planning, adaptation and assessment of e-health services

- Paper 9: Planning for Composition of eHealth Services

- Paper 10: A methodology for multi-actor evaluation of the impact of eCare services
- Paper 11: IoT as a Service System for eHealth
- Paper 12: Runtime Data-driven Adaptation of Composite e-Health Services
- Paper 13: Using Low-cost computer-based simulations in the Spanish National Transplant Procedures

Session 4: Case studies and disease prevention

- Paper 14: Ensemble SVM for imbalanced data and missing values in postoperative risk management
- Paper 15: Integrating Bayesian Networks into Fuzzy Hypothesis Testing Problem - Case Based Presentation
- Paper 16: Comparative and adaptation of step detection and step length estimators to a lateral belt worn accelerometer
- Paper 17: A multi-device framework to increase self-awareness for health and disease prevention
- Paper 18: DELPHI: Data E-Platform for Personalized Population Health

The authors of the papers were mostly from outside the CONCERTO consortium. This allowed interesting discussion on different aspects of eHealth and mHealth, especially also on practical aspects from day-to-day hospital work and integrated care targeting specific sets of patients (e.g., those with cardiac conditions).

4.3 CONCERTO at MoWNet'2014

4.3.1 Event and participants

Following the past positive feedbacks, CONCERTO organized a new workshop more focused on wireless in conjunction with MoWNet conference the 8th of September in Rome.
The workshop was titled "First workshop on Wireless Solutions for Healthcare Applications"; in order to cover a larger spectrum of applications, CONCERTO involved in the workshop the Marie-Curie project WSN4QoL which deals with patient monitoring through sensor networks.

Figure 4 - Participants to the MoWNet 2014.

The workshop was chaired by Lorenzo Iacobelli (TCS) while Maria Martini (KU) and Peter Amon (Siemens) chaired two of the three planned sessions. The third session was chaired by Stefano Tennina, from the WSN4QoL project.
The workshop was organized in three different sessions with a total of ten presentations, which followed the agenda below:

First workshop on Wireless Solutions for Healthcare Applications

Chair: Lorenzo Iacobelli, Thales Communications & Security, France

11:30- 11:40 **Opening**
Lorenzo Iacobelli, Thales Communications & Security, France

11:40- 12:30 **Session 1: Wireless Body Area Networks**
Chair: Dr. Stefano Tennina, WEST Aquila srl, University of L'Aquila, Italy
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Paper 1: “Efficient simulation of optical wireless channel Application to WBANs with MISO link”
Paper 2: “A Cooperative Beamforming Technique for Body Area Networks”
Paper 3: “Evaluation of MAC Protocols with Wake-up Radio for Implantable Body Sensor Networks”

14:00- 15:00 **Session 2: Patient monitoring via sensors and ultrasonography**
Chair: Dr. Maria Martini, Kingston University, UK

Paper 4: “Investigation of Stability and Reliability of the Patient's Wireless Temperature Monitoring Device”
Paper 5: “Context-aware IPv6 Flow Mobility for Multi-Sensor based Mobile Patient Monitoring and Tele-consultation”
Paper 6: “Rate-Distortion and Rate-Quality Performance Analysis of HEVC compression of Medical Ultrasound Videos”

15:30- 16:30 **Session 3: Content and context awareness and cross-layer design**
Chair: Peter Amon, Siemens Corporate Technology, Germany

Paper 7: “Cross-layer scheduling with feedback for QoS support”
Paper 8: “Content/Context-Aware Multiple Camera Selection and Video Adaptation for the Support of m-Health Services”
Paper 9: “Network Coded MIMO aided Cooperative Communications in the Ambulance-and-Emergency Area”
Paper 10: “Road Based Mobility with Network Information Services“

All the presented papers have been published by Elsevier.

4.3.2 Results and exploitation

The workshop allowed to share some significant technical results achieved within the project with the wireless research community and to have some presentations of other researchers in the domain.

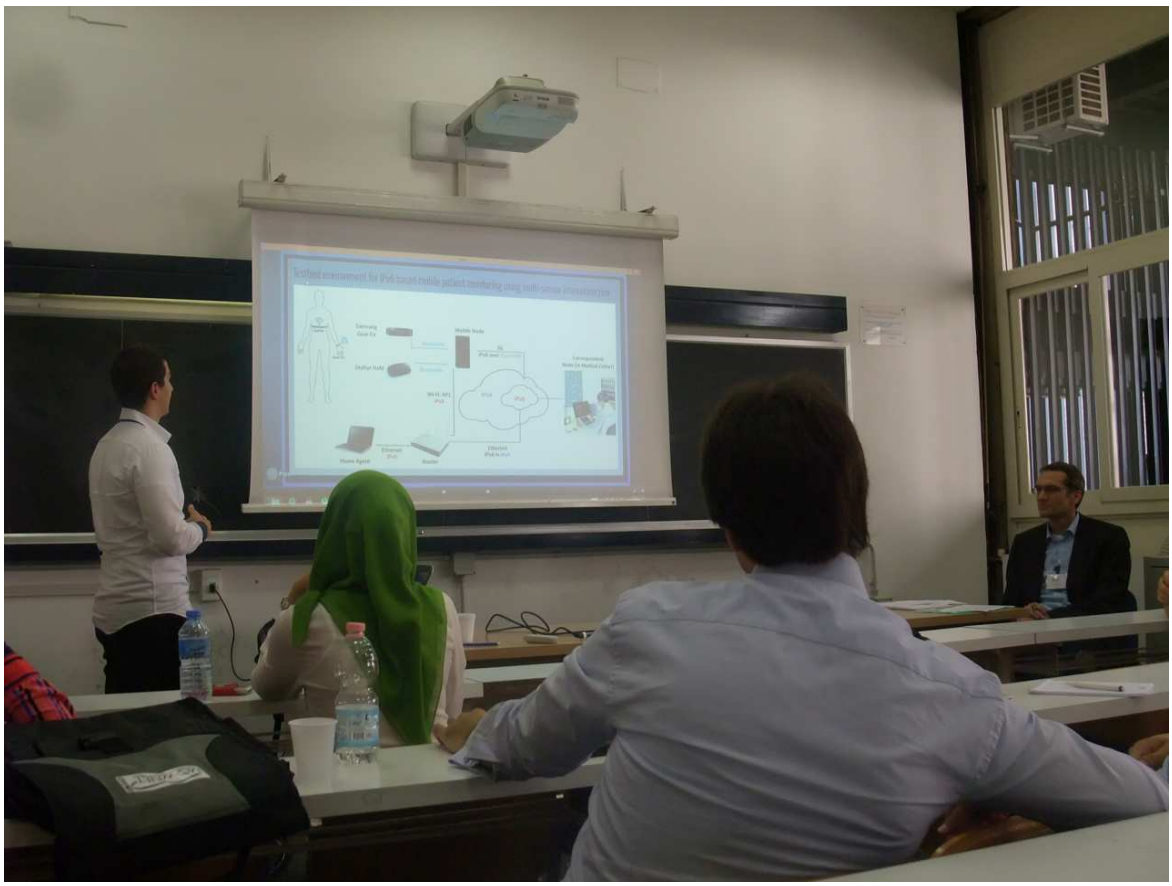

Figure 5 - A presentation during the workshop.

4.4 CONCERTO Convention at Perugia

One of the key enablers to deploy CONCERTO solutions in hospitals is the evolution of methods and procedures currently in use. Indeed the new technologies proposed by the project imply some modifications in the standard procedures in order to fully exploit their benefits. For this reason the CONCERTO consortium considered essential to spread as much as possible the awareness of the project innovations and potential applications in the medical world and to convince medical doctors and healthcare managers of the positive impact on the healthcare system of the CONCERTO solutions.

For this reason, CONCERTO organized a convention at the hospital of Perugia inviting doctors, medicine students and managers of the Italian healthcare system.

Figure 6 - CONCERTO convention.

4.4.1 Event and participants

The event, titled "*Telemedicine: new tools for diagnosis and care of the patient*" was organized the 5th of February 2015 at the hospital of Perugia and was composed by a convention and a live demonstration. During the convention CONCERTO results, necessary evolutions in hospital procedures and future perspectives were discussed. At the end of the discussion a live demonstration of the CONCERTO emergency scenario was presented.
The agenda of the convention was the following:

11:00 – Greetings from the Rector
Prof. Franco Moriconi – Head University of Perugia
11:10 – Opening
Prof. Giuseppe Ambrosio – Head of the Cardiology and Cardiovascular Pathophysiology Department, University of Perugia
11:20 – When ICT Technology meets Healthcare – the CONCERTO project
Ing. Lorenzo Iacobelli – Coordinator of CONCERTO project
11:40 – New Tools and New Organizational Models in Healthcare
Prof. Pier Giorgio Fabietti – Professor of Bioengineering and Medical Informatics, University of Perugia
12:00 – Present and Future of Telemedicine in the Hospital of Perugia
Dott. Walter Orlandi – Director of the Hospital of Perugia
12:15 – The Telematic Regional Plan (2014-2016)
Dott. Emilio Duca – Regional Director of Healthcare
12:30 – Closing and Guided tour of the CONCERTO demonstrator

The convention targeted a non-technical healthcare audience. More than one hundred people attended the event, mainly doctors, nurses and medicine students.

Figure 7 - Attendance at the CONCERTO convention.

4.4.2 Results and exploitation

The event was a big success, at the end we received very positive feedbacks and several exchanges with doctors allowed identifying a real request for advanced technical solutions in the medical world. One of the most significant outcomes was the availabilities of several doctors to test the proposed technological solutions and the agreement on the need to make the current procedures evolve.

The event had a large impact also on the media. Several journalists from newspaper and television attended the convention. Articles on CONCERTO convention have been published on paper and/or web version of Italian national and regional newspapers like "La nazione" [171], "Il giornale dell'Umbria" [170], "Agi" [174], "Umbria24" [172], "Umbria Journal" [173]...

Two regional televisions and the national public television RAI were also present at the convention and talked about it in their news.

Figure 8 - CONCERTO convention.

A member of the consortium was invited in a TV studio to be interviewed in live during the RAI regional news [175]. Some interviews were also released to local televisions and blogs.
The advertising of the project convention generated interest in the project results and the consortium was contacted by doctors and students in medicine that wanted to have more information and know more about the possibilities to apply the proposed innovations in different medical contexts.

In addition, the event boosted the discussions between the Umbria region and the hospital of Perugia on the need to launch a pilot project for remote patient assistance. The negotiations are ongoing and an agreement is expected in the next months.

5 Demonstrations

5.1 CONCERTO at FIA 2014

A part of the CONCERTO demonstrator was presented at the Future Internet Assembly (FIA) in March 2014, in Athens (Greece). In FIA 2014 exhibition, the two main areas of the full CONCERTO demonstration have been represented, namely the emergency area and the hospital.

At the emergency area side, CONCERTO showed the capability to combine in real time video acquisitions of multiple cameras in a single video stream adaptively coded according to cross layer information on available bandwidth or on user preferences.

At the hospital side, it was shown how the medical and environmental videos stocked at a coordination centre are transmitted on a tablet of a mobile user (i.e., a doctor walking inside the hospital) in real time and adaptively according to the interactive preferences of the user.

Figure 9 - CONCERTO booth at FIA 2014

5.2 CONCERTO at EuCNC 2014

A more advanced version of the CONCERTO demonstrator was shown at the European Conference on Networks and Communications (EuCNC) in June 2014, in Bologna (Italy).

Both the source and the hospital areas were presented. In addition to the functionalities already shown at FIA 2014, at the source side it was realized the transmission of not only videos acquired in real time by multiple cameras but also of pre-recorded medical videos generated by an ultrasound machine. The ciphering of the transmitted videos was also demonstrated. The transmission was realized through a 3G commercial network and the videos were received at the hospital side where they were stored and re-transmitted on a tablet of a mobile user in real time through RTP streaming.

A highly customized Android smartphone deployed at the emergency side together with a cross-layer optimized and fine-grained (i.e., flow level) mobility management solution capable to take advantage of different overlapping access networks (e.g., Wi-Fi and 3G) to enhance medical multimedia stream transmission to the hospital have also been demonstrated.

Finally a demonstration of the CONCERTO real-time quality meter realized to allow subjective evaluation of medical videos was also demonstrated.

Figure 10 - CONCERTO booth at EuCNC 2014

5.3 CONCERTO convention at the Hospital of Perugia 2015

At the CONCERTO convention organized at the hospital of Perugia the 5th of February 2015 (details are provided in Section 4.4) the CONCERTO demonstrator was shown. In this occasion the full demonstrator was deployed realizing two main demonstration scenarios, namely the emergency and the ubiquitous tele-consultation scenarios, and also showing some other functionalities (like 3D storage and encoding).

For the first scenario, it was realized a real-time acquisition and transmission of environmental and medical videos from an ambulance to the coordination centre through a 4G commercial network. At the hospital side the videos were stored and retransmitted both using RTP and HTTP streaming to tablets through Wi-Fi. A medical doctor was present at the hospital side to evaluate the quality of the received streams through the CONCERTO quality meter.

For the second scenario a Body Area Network was realized with sensors in charge to monitor the patient conditions and to transmit the information to a local collector, a fully customized Android smartphone that was then in charge to send the information to the hospital. The transmission was done exploiting heterogeneous wireless networks (i. e., Wi-Fi and commercial 3G and 4G) thanks to the CONCERTO mobility management solution.

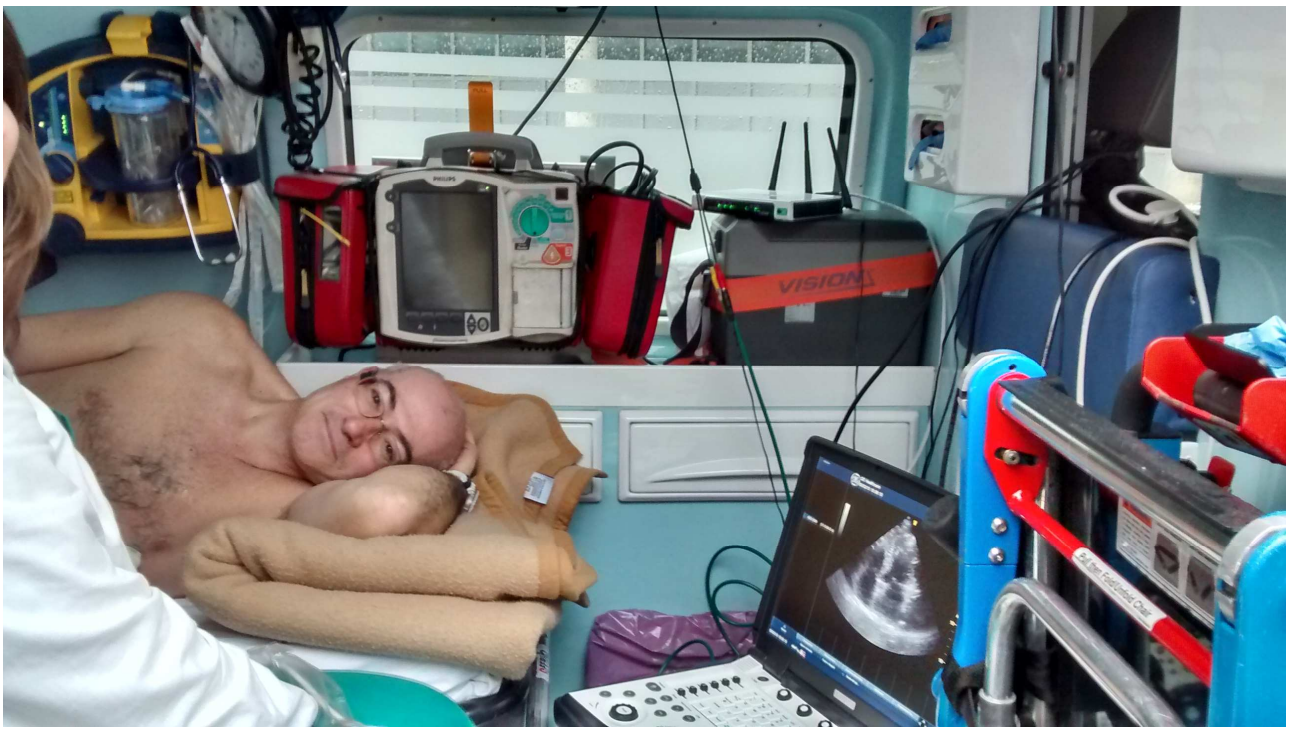

Figure 11 - CONCERTO demonstrator deployed in Perugia in February 2015

6 Project liaisons

6.1 Project collaborations and interactions

6.1.1 FP7 project for intelligent transportation systems (ITSSv6)

The ITSSv6 project[3] has been started to deploy a stable, standardised, reliable and secure IPv6 framework to the Field Operation Test (FOT) projects for Intelligent Transport Systems (ITS) across Europe. It is led by INRIA, and Bluetechnix, Institut Telecom, IPTE, Lesswire, Mines Paris tech, MTA SZTAKI and UMU are involved as partners. The current issues and limitations of the Mobile IPv6 architecture are the same for ITS and mHealth services as well, which ensures the common interests. András Takács is involved in both projects, which has been generated the possibility of the cooperation. The leaders of the Hungarian partner organizations in ITSSv6 and CONCERTO projects have been organised an informal workshop to harmonise their vision about possible cooperation (please see Appendix A2 for the meeting minutes). Unfortunately, strong partnership could not be initiated, mostly because some crucial differences in the roadmaps of the two projects. The mip6d-ng development[4], hosted by CONCERTO could produce its first results before the end of the development tasks in ITSSv6. Even so, both of the projects are looking forward to further, more loose cooperation and relationship, e.g. in forms of consultation, organizing joint workshops, and continuously follow the efforts and results of each other.

6.1.2 FP7 Enriched Network---aware Video Services over Internet Overlay Networks (ENVISION)

A workshop between CONCERTO and the FP7 ICT project ENVISION was organised in June 2012. During this workshop D. Griffin (coordinator of ENVISION) gave a presentation of the ENVISION project and of its main results, while R. Fracchia presented the CONCERTO project, its objectives, its planned work and the use cases defined.
Three main topics of common interest have been identified:

- The discovery of the best caching/transcoding server: some work, done by ENVISION and presented in D3.1, could be a starting point for CONCERTO,
- Novel video quality metrics are defined by CONCERTO and could be used by ENVISION for the final validation phase,
- SVC video adaptation is done in both projects and a discussion between the involved partners could be beneficial.

Since then, some information exchanges between partners of the two projects went on.
For instance in November M. Martini (KU) was invited in UCL to give a seminar on the topics identified above (in particular on novel video quality metrics and their usage for video adaptation). A detailed discussion followed.

6.1.3 Celtic-Plus project COgnitive network ManageMent under UNcErtainty (COMMUNE)

VTT organized an internal collaboration and cooperation event between CONCERTO and Celtic-Plus COMMUNE (http://projects.celtic-initiative.org/commune/) projects in Oulu, Finland, 14th of December 2012. The focus was to find possible topics for collaboration between the projects. The COMMUNE project aims to build an innovative solution for cognitive network management under uncertainty. COMMUNE will seek to mitigate the practical effects of uncertainty by exploring the latest advances in knowledge based reasoning and other relevant cognitive methods. This approach is chosen due to the intuitive applicability of these models and their computational efficiency. The developed COMMUNE Management System shall be thoroughly tested through a combination of network trials (a proper mix of current wireless and wireline Internet technologies) and simulation campaigns. Special attention will be paid to access networks, focusing on two relevant scenarios: LTE and FTTH.

The event had more than 15 participants from both projects and also from outside the projects. Some topics which are in the interest of both projects are adaptive video streaming, QoS/QoE metrics to help decision making, information signalling and novel network architectures. The main shared topic was the adaptation decision making and network management which is developed in both projects. The results of COMMUNE project have been utilised especially when studying multipath delivery of video in order to improve the robustness of transmission for critical data such as medical video. One of the main results of COMMUNE project was a cognitive network management testbed for mobile video streaming optimization and some parts of this testbed could be used in studies of multipath media delivery in CONCERTO WP5. On the other hand, studies on adaptive HTTP-based streaming could be used in COMMUNE project when defining the protocols and techniques for video streaming.

[3] https://project.inria.fr/itssv6
[4] http://www.mip6d-ng.net/

6.1.4 EIT ICT Labs activity Adaptive Streaming Framework (EIT ASF)

VTT and Siemens have participated on EIT ICT Labs partially funded activity called Adaptive Streaming Framework during 2013-2014 which focused on the development of novel networked streaming application and service prototypes for healthcare and entertainment business utilizing the open-source GPAC platform. While CONCERTO project has focused on higher level architectural design of next-generation m-health services and especially on multimedia delivery optimisation, this activity has focused on more short-term service and application prototype development for healthcare and entertainment business. The experience and know-how related to implementation of adaptive HTTP streaming and hybrid delivery gained during this activity has helped also implementation work done in CONCERTO WP6 related to media delivery and different studies related to adaptive HTTP-based streaming, medical imaging and multipath delivery have helped the implementation work done in this activity.

6.1.5 FP7 MultiMEDia transport for mobIlE Video AppLications (MEDIEVAL)

After some exchanges during FuNeMS 2013 between CONCERTO and MEDIEVAL project, a workshop was organized in December 2014 between the two projects to share results and viewpoints in particular on cross-layer signalling solutions. The coordinator of MEDIEVAL project presented its project to the CONCERTO consortium and gave its insights on the selected solutions. After a presentation of CONCERTO approach and results from the coordinator of CONCERTO project, the participants exchanged on several common technical topics and in particular on cross-layer signalling solutions and on field-trials results.

6.1.6 FP7 CROSSFIRE (Uncoordinated network strategies for enhanced interference, mobility, radio resource and energy saving management in LTE advanced networks)

CROSSFIRE is a Multi-Partner Initial Training Network (MITN) Marie Curie project that is focused on providing forward-looking solutions for LTE-A network coexistence, including aspects ranging from the physical layer, such as co-channel interference and cognition, to the user's perception of the service, i.e. Quality of Experience.
The project organised an event on "Real-life experimental tools for QoE over mobile Network". KU participated, also presenting the CONCERTO project and the relevant results.
(http://gain.di.uoa.gr/crossfire/files/Training/Crossfire-Seminar-program-Vod.pdf)

6.2 Dissemination in European and international fora and organised events

6.2.1 Future Internet for eHealth (Dagstuhl)

http://www.dagstuhl.de/en/program/calendar/semhp/?semnr=12231

The design of emerging eHealth applications can only be tackled in a multi-disciplinary way. The goal of this seminar was to cluster together experts from healthcare, elderly care, insurance, together with experts from domains such as human-computer interaction, interactive application design, telecommunications, networking and economy to understand and support each other in designing and deploying future-proof eHealth services and applications based on Future Internet technology.

At large, the seminar addressed the following questions:

1. Which will be the key eHealth applications and services in the Future Internet?
2. Which are current and future quality requirements of eHealth applications and services?
3. Which business models are viable for future eHealth applications?
4. Which methodological support is required to design economically sustainable network-supported eHealth services?

Question 1 teamed up the participants around relevant use cases and facilitated discussions on the technical question 2 and the economical question 3, respectively. Question 4 addressed research needs from different domains and fertilized corresponding activities for advancing the topic of Future Internet for eHealth.

The event was held at Schloss Dagstuhl - Leibniz Center for Informatics. Dagstuhl Seminars and the Dagstuhl Perspectives Workshops bring together internationally renowned leading scientists for the purpose of exploring a

cutting-edge informatics topic. The friendly and open climate at the conference centre promotes a culture of communication and exchange among the seminar participants.

Dr. Maria Martini (Kingston University) presented her research and the CONCERTO project and approach in the event (Figure 12).

Figure 12 - Picture from Future Internet for eHealth.

6.2.2 SPHERA workshop (Innsbruck, Austria)

Siemens presented CONCERTO project results at the SPHERA local workshop 'Cross-Border-Care and E-Health in Alpine Space' on 1th July 2014 in Innsbruck, Tyrol. The scope of the workshop was to discuss with international experts, local players, and decision makers challenges, potentials, strategies, best practise as well as financing models, gaps, limitations and future needs in the domain of Cross-Border-Care and eHealth/Telemedicine in its neighboring countries.

The agenda of the workshop is given below.

Introduction		
8:30	9:15	Registration and Welcome Coffee
9:15	9.35	Presentation of SPHERA Project Dr. Mario Döller
9.35	9.45	Workshop Agenda / Objectives / Methodology Dr. Mario Döller, Mag. Bettina Kindl
9:45	10:30	**Expters Interviews I – Cross-Border-Health Care: Who will benefit?** **Presentation 15 min each** -Cross-Border-Care –Legal aspects and conditions Alexander Meindl, AOK Bavaria -Cross-Border-Care – Regional best practice model Harald Bachmaier, Red Cross Tyrol -Cross-Border-Care in the Euregio Maas-Reihn Marian Ramakers-van Kuijk, EU Project EMRIC+ (NL, BE, D)
10:30	11:30	**Experts-Discussion (20 specialists and decision makers)** Opportunities, experiences, gaps, future needs, financing, legislation of Cross-Border-Healthcare -Moderation: Dr. Siegfried Walch, MCI Tirol

Lunch		
11:30	12.15	
12:15	13:15	**Experts Interviews II - E-Health and Telemedizin – Challenges and Potentials** **Best Practise Models** - Dr. Gerhard Pölzl, Univ. Clinic Innsbruck, Core-Mobile-Tirol-Project - Bob Mulrenin, M.S., Salzburg Research, EU-Projct EMPOWR - Peter Amon, Siemens Germany, EU-Project CONCERTO
13:15	14:00	**Panel Discussion with Experts** Opportunities and current limitations of eHealth and Telemedicine - Dr. Alexander Hörbst, UMIT - Dr. Gerhard Pölzl, Univ. Clinic Innsbruck - Mag. Birger Rudisch, Patient Delegation Tirol - Dr. Arthur Wechselberger, Ärztekammer Tirol - Mag. Klaus Schindelwig, TILAK - Moderation: Andreas Hauser, Journalist
14:00	14:25	Brainstorming potential projects and relevant topics, gathering results, all participants (about 70 people)
Conclusion		
14:25	14:30	Conclusion of the workshop Dr. Mario Döller, DDr. Petra Stöckl

The presentation of the CONCERTO project gave information about the project objective, the target use cases (especially also the main use case on “Ambulance and Emergency Areas”), the emergency handling workflow, the CONCERTO architecture, and key results and focused on the demonstration scenario with video and medical image transmission from an ambulance to a hospital (including a demonstration video).

One general feedback from the workshop (not specifically for the CONCERTO project) was the recommendation that a technical solution should support the users (e.g., doctors, paramedics) in the workflow. In case a system wants to support too many different workflows, this can lead to the situation where the single work flows are not fully supported, which in turn hinders the adoption of a technical solution.

7 Conclusion

For the work on dissemination and standardization done within CONCERTO, it can be concluded that the project objectives were achieve. Numerous publications (about 170) where made, including several book chapters and journal papers. In addition to the two planned CONCERTO-organized workshops, a third one was initiated and conducted. Also the standardization activities led to tangible results in line with the project use cases. Collaboration was done within several projects, focusing on information exchange and cross-usage of project results. Finally, the CONCERTO solution was showcased at three conventions.

Appendix A1: First year workshop: CONCERTO Special Session - Feedback form

- What is your main domain of expertise?

……

- Please, rate each one of the use cases listed below according to how interesting and how relevant from a business perspective you consider it (from 1 to 5, where 1 is not interesting/relevant at all and 5 very interesting/relevant). What is the main medical/economic/social benefit that you can see for each of them?

CONCERTO use cases	Level of interest (1–5)	Business relevance (1–5)	Potential benefits
1) Ambulance and emergency area 2) Emergency area with multiple casualties 3) Emergency room 4) Ubiquitous tele-consultation 5) Surgical assistance 6) Additional in-hospital scenarios 7) Medical education			

- Which use case do you consider as the most relevant from a business (economic and medical advantages) point of view? Why?

……
……

- Have you in mind a use case or a business opportunity that we did not consider?

……
……

- Any further considerations?

……
……

Appendix A2: FP7-ITSSv6 – FP7-CONCERTO Informal Meeting

Logistics

Date:	July 12. 2012 15:00-16:00
Host:	SZTAKI
Contact:	András Edelmayer
Venue:	MTA SZTAKI, Kende u. 13-17. , Budapest, H-1111
Partners:	SZTAKI, BME
Guests:	n/a
Status Agenda:	V0.1

Participants

BME	László Bokor
SZTAKI	József Kovács, András Takács, László Virág, András Edelmayer

Agenda

Time	Agenda items	Responsible
15:00	*Open discussion*	

Minutes

CONCERTO (Content and cOntext aware delivery for iNteraCtive multimedia healthcaRe applications) is an FP7 STREP project aiming at designing and validating several critical building blocks of telemedicine applications. These include network-aware applications that rely on content-aware codecs and storage formats, carried over an application-aware network. The ultimate aim of CONCERTO is to provide high a Quality of Experience (QoE) for medics, which is a necessary condition for providing flawless medical diagnosing of the highest reliability. (http://ict-CONCERTO.eu/)

- Network protocol used by CONCERTO applications is IPv6. The same Mobile IPv6 architecture is used as starting point of development (http://umip.org)
- Almost identical issues were found during their initial review of the implementation as we found during the first year.
- As part of their work, by the end of this year they are comitted to re-implement mip6d, including Mobile IPv6, NEMO, MCoA, Flow Binding functionalities
- Some of the technical details (XFRM tunneling) match our Class-2 goals, in which we modify the existing mip6d implementation to fix tunneling and IKEv2 compatibility.

Most important concept and features of the re-implementation:

- Implementation of wide spectrum of Mobile IPv6 protocol(s)
- Modular design (mostly based on different protocol segments)
- Separation of communication, data storage (binding cache, binding update list, …), control, and environment management (xfrm, addresses, routes, ...)
- Powerful API for runtime management
- Detailed Doxygen documentation
- Open source (GPLv3)

The following collaboration ideas surfaced during the discussions:

- CONCERTO (WP5) and ITSSv6 (WP3) develop the new version of mip6d together
- CONCERTO develops the software framework, and manages the development of NEMO/MCoA

- ITSSv6 provides new tunneling mechanism, IKEv2 and flow binding.

Notes:

- CONCERTO will likely proceed with the new implementation regardless of our decision. Some of the efforts will be redundant if we stay separated
- CONCERTO was launched in December 2011, the deadline for the above listed implementation tasks is December 2012. Two months before our deadlines.
- Development lead of the task from CONCERTO is Andras Takacs (contractor at BME)
- If the development work is well synchronized, the extra work should not cause any details in ITSSv6

Benefits:

- The new implementation is modular and comes with a generic adaptation module, so new functions and SAPs can be easily implemented with its API
- CONCERTO can keep the implementation alive after ITSSv6 is finished (until December, 2014)
- EC will appreciate the collaboration between two running FP7 projects.
- Aligns with our longterm plan to maintain the mobility implementations independently of the projects.

Drawbacks:

- It might cause delays if the development work is stalled.
- Wors case scenario: ITSSv6 will have to implement the IKEv2 compatible new tunneling mechanism in current mip6d.

Safest approach:

- The tunneling mechanism and flow binding is implemented in a way that it can be used in both new and old implementations.

Appendix A3: Dissemination activities on CEFRIEL's web-site

CEFRIEL published news about the project in Italian and English and implementation of the project sheet since the beginning of the project. In December 2012, a news about the project had already been published (http://www.cefriel.com/concerto-fp7-ict-call-7/) and the original news has been integrated with the achieved results.
The new posts will be continuously published in the portfolio area (http://www.cefriel.com/projects-case-history/) when appropriate.

Appendix A4: Dissemination Activities on social networks

Social Network	Description	Disseminated information	Size of audience
Twitter	Publication of the news about the project in Italian and English and, when possible, retweeted from @ICTconcerto	SSH: IEEE International Workshop on Service Science for eHealth http://buff.ly/1czvNwm	Reach 9.300 users
		FP7 ICT CONCERTO project deliverables http://buff.ly/1czvXUF	Reach 14.600 users
		About... CONCERTO http://buff.ly/RwdByH	Reach 14.600 users
		CONCERTO's FIA 2014 demo on YouTube http://buff.ly/1g8EjJc	Reach 14.600 users
		Events And News: Concerto http://buff.ly/1ieVqKJ	Reach 14.600 users
		Exploring CONCERTO: Content and cOntext aware delivery for iNteraCtive multimedia healthcaRe applications http://buff.ly/1Guaie4 #FP7 #ICT	Reach: 15.200 users
		CONCERTO, una nuova musica “salvavita” http://buff.ly/1sjpMRo	Reach 14.700 users
FaceBook and LinkedIn		FP7 ICT CONCERTO project deliverables http://buff.ly/1czvXUF	Reach 400 users
		Conoscete il progetto CONCERTO? http://buff.ly/RwdByH	Reach 400 users
		FP7 ICT CONCERTO project deliverables http://buff.ly/1czvXUF	Reach NA
		Alla scoperta di CONCERTO: Content and cOntext aware delivery for iNteraCtive multimedia healthcaRe applications - http://ict-concerto.eu/twiki/bin/view/Concerto	Reach 638 impressions
		CONCERTO, una nuova musica “salvavita” http://buff.ly/1sjpMRo	Reach 452 impression
		Alla scoperta di CONCERTO: Content and cOntext aware delivery for iNteraCtive multimedia healthcaRe applications - http://ict-concerto.eu/twiki/bin/view/Concerto	153 people reached
		CONCERTO, una nuova musica “salvavita” http://buff.ly/1sjpMRo	177 people reached
GOOGLE+		FP7 ICT CONCERTO project deliverables http://buff.ly/1czvXUF	Reach NA
		CONCERTO's FIA 2014 demo on YouTube http://buff.ly/1g8EjJc	Reach NA
		About... CONCERTO http://buff.ly/RwdByH	Reach NA
		Events And News: Concerto http://buff.ly/1ieVqKJ	Reach NA
		Alla scoperta di CONCERTO: Content and cOntext aware delivery for iNteraCtive multimedia healthcaRe applications - http://ict-concerto.eu/twiki/bin/view/Concerto	153 people reached
		CONCERTO, una nuova musica “salvavita” http://buff.ly/1sjpMRo	177 people reached
activities on blogs		About.... CONCERTO Blog post about the project and achieved results	
		CONCERTO, una nuova musica “salvavita” Blog post about the project and achieved results	

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Glossary

AF	*Amplify-and-Forward-based*	
ANCC	*Adaptive Network Coded ooperation*	
APPs	*A Posteriori Probabilities*	
AWGN	*Additive White Gaussian Noise*	
BPSK	*Binary Phase Shift Keying*	
CDMA	*Code-Division Multiple-Access*	
CR	*Cognitive Radio*	
CSI	*Channel State Information*	
CT	*Computed Tomography*	
DAF	*Decode-and-Forward*	
D-balanced	*Destination-balanced*	
DF	*Decode-and-Forward-based*	
DMOS	*Differential Mean Opinion Scores*	
EGC	*Equal Gain Combining*	
EMP	*Edge Modeling Prediction*	
EXIT	*Extrinsic Information Transfer*	
FEP	*Frame Error Probability*	
FFR	*Fractional Frequency Reuse*	
FR	*Full-Reference*	
FSK	*Frequency Shift Keying*	
GANC	*Generalized Adaptive Network Coding*	
ILA	*Iterative Local Approximation*	
JNCC	*Joint Network-Channel Coding*	
JSCC	*Joint Source and Channel Coding*	
LDPC	*Low-Density Parity-Check*	
LTE	*Long-Term Evolution*	
MAP	*Maximum A Posteriori*	
MGS	*Medium Grain Scalability*	
MHD	*Multi-Hop Diversity*	
MIMO	*Multiple-Input-Multiple-Output*	
MO-RTT	*Maximum Output-Ratio Threshold Test*	
MQAM	*M-ary Quadrature Amplitude Modulation*	
MS-DIS	*Multiple-Symbol Differential Interference Suppression*	
NGNs	*Next-Generation Networks*	
OFDMA	*Orthogonal Frequency-Division Multiple Access*	
OS	*Opinion Scores*	
PDA	*Probabilistic Data Association*	
PDM	*Proportional Differentiation Model*	
PLR	*Packet Loss Ratio*	
PU	*Primary Users*	
QoS	*Quality of Service*	
R-balanced	*Relay-balanced*	
ReS	*Reed-Solomon*	
RR	*Reduced-Reference*	
SAD	*Sum of Absolute Differences*	
SC	*Selection Combining*	
SC-FDMA	*Single-Carrier Frequency-Division Multiple-Access*	
SFH	*Slow Frequency Hopping*	
SISO-MSDSD	*Soft-Input–Soft-Output Multiple-Symbol Differential Sphere Detection*	
SM	*Spatial Modulation*	
SNR	*Signal-to-Noise Ratio*	
SRAN	*Successive-Relaying-Aided Network*	
SSD	*Subset diversity*	

STBC	*Space-Time Block Code*	
STSK	*Space-Time Shift Keying*	
SU	*Secondary User*	
SVC	*Scalable Video Coding*	
SVD	*Singular Value Decomposition*	
TTCM	*Turbo Trellis-Coded Modulation*	
UXP	*Unequal Erasure Protection*	
VBD	*Verification-Based Decoding*	
WLAN	*Wireless local area network*	