
Global Communications Newsletter

January 2004

Wireless, Mobile, and Always Best Connected

On the Proceeding of the First ANWIRE International Workshop, Glasgow 2003

<http://www.ece.ul.ie/anwire-workshop-glasgow/proceedings/index.html>

By Máirtín S. O'Droma

Always Best Connected" (ABC), a fixed and mobile wireless access vision, is an integral and challenging dimension in the evolving paradigm of fourth-generation (4G) networks. It goes beyond the "always-on" slogan and seeks a firm foundation in already existing, expected, proposed, and yet to be conceived networks. The vision is perceived as a strategic goal to inform and define the significant advances happening and forecast in technologies, networks, user terminals, services, and service delivery, and in the future business models encompassing these, which will help crystallize and realize the 4G paradigm. It presents great research challenges, with road maps already beginning to take shape and evolve. Taking the ABC concept as an underlying theme, the aim of this workshop is to identify key issues, present 4G type scenarios, concepts, and solutions, and speculate and foster debate on the evolution of the 4G paradigm for future fixed and mobile wireless networks.

Next generation, Beyond 3G, and 4G are just some of the terms being applied to this further evolution of mobile and wireless communications beyond the 3G world. Whether the 3G world conceived as the logical step from 2G and then 2.5G will ever come to be is a separate question. Basically, through the provision of more bandwidth, its promise is to be the first purpose-built wireless network integration of voice, data (Internet), and video services. 4G paradigms and visions being debated [1, 2] do not follow this logic (more bandwidth, more integrated services) and in fact do not depend on 3G being a success or even coming into existence. Rather, as portrayed by Dr. Jorge Pereira of the EU Commission in his presentation "Optimising Spectrum Efficiency in a Heterogeneous Network Environment," 4G is conceived as encompassing all existing, planned, and future mobile and fixed wireless networks, both terrestrial and satellite. The goal is to sell comprehensive integrated services in a more open, accessible, competitive environment to a great common market of consumers in overlapping local, regional, and global domains. Terms that characterize this 4G debate include ABC, application/service adaptability and dynamic quality of service (QoS) provisioning, and network and terminal dynamic reconfigurability. Proximate challenges this 4G paradigm raises are convergence, integration, and/or open interworking of existing and emerging terrestrial (wired and wireless) and satellite networks.

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As may be gleaned from papers presented at this workshop, in "all-IP" networking the ABC vision should include the capability of flexible management of the all important QoS requirements, which are largely realized in the lower protocol layers, but the management and request generation of which range over all protocol layers. In environments containing multiple wireless (and fixed) networks, ABC includes open access to all of these networks under certain conditions, and the ability to create and update a mix and match of desired services based on acceptable price/performance ratios — all responding to requirements set down by users in their user profiles. Whether in a mobile or fixed context, it also includes a capacity to advertise, discover, and learn about new networks (and nodes/users in ad hoc networks), new network and service options and price/performance offerings, and dynamically change access, without losing service connection, in accordance with user preferences, or network provider or service provider obligations to meet per-service or per-connection service level agreements, or service-dependent application service provider (ASP)-desired QoS performance. The list could go on. Largely the above is coming at an ABC definition from a user's viewpoint. There are other viewpoints such as those of the ASP, Internet service providers (ISPs), and network providers. Clearly the implications for the reconfigurability of networks and terminals, network interworking, application adaptability, business models, and so forth will raise major new and exciting challenges. An example of the early stages of the trend may be seen in present commercial activity to create wireless network interworking involving 2.5G cellular systems, 802.11 wireless LANs (WLANs), and 802.15 Zigbee to deliver services over a type of always-on or always-connectable wireless network access connection service at attractive location-dependent price/performance ratios [3, 4].

In this first international workshop organized by ANWIRE [5], three of the invited speakers, Prof. Dipankar Raychaudhuri, Director of WINLAB, Rutgers University, United States, Prof. Barry Evans, Director of the Centre for Communication Systems Research, University of Surrey, United Kingdom, and Prof. Bernhard Walke, Director, Communication Networks Laboratory, University of Aachen, Germany, propose and discuss futuristic though realistic networks and interworking scenarios.

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Speculative Networks

Prof. Raychaudhuri in "Topics in 4G Wireless Networks: Ad Hoc Nets, Adaptive Services and QoS" addressed novel concepts and scenarios. He argued the case for promoting opportunistic and adaptive formation of wireless network infrastructures as a way of overcoming critical technical and business model limitations of today's cellular and WLAN networks. He proposed novel ideas for creating a wireless "network of networks" together with techniques for support of heterogeneous radios, protocols for self-organization and ad hoc routing, and services that adapt to dynamic and opportunistic exploitation of available or expected resources to meet application needs. Within this context he also discussed software architectures suitable for adaptive service creation and QoS management. Supporting his ideas, Prof. Raychaudhuri presented some initial results from prototyping of candidate 4G wireless network technologies, such as infostations, ad hoc 802.11 networks, and sensor nets.

Satellites have a unique role and great importance in wireless communications. Despite their daunting upfront capital investment demands, seeing their amazing capacity to be successfully and flexibly involved in virtually all communication services markets, it was considered important that they be included in a workshop on the evolution of ABC 4G wireless and mobile networks. This is in contrast to most cellular mobile conference traditions! As Prof. Barry Evans pointed out, "The mention of satellites in any gathering of mobile communications specialists tends to engender either disinterest or outright hostility. This in itself is an interesting reaction and symptomatic of the classical and still pervasive division between the terrestrial and satellite camps which has been rife in the standards bodies since time immemorial." Almost by way of response to this unattractive division, in his paper "Satellite Networks in 3G and Beyond Systems" Prof. Evans provided an incisive and useful review of fixed, broadcast, and mobile satellite services: their contributions to date in effectively and distinctively serving commercial communication needs, and proposed ways their unique attributes will contribute and complement the evolution of 4G network infrastructures and service delivery. Among the examples on which he expounded, he highlighted the advantages satellites have in delivering broadcast and multicast services to the mass market relative to the cost and complexity of their delivery through 3G networks. Much of this theme was echoed and reaffirmed from a quite different perspective by Prof. Bernhard Walke in his wireless media system (WMS) proposals for 4G infrastructural environments, including the idea that with sufficiently large storage capacity in user terminals, unidirectional point-to-multipoint (p-t-m) services are able to provide on-demand and interactive applications because push and store mechanisms make the p-t-m relationship transparent to users.

In illustrating the development of these ideas with pilot and prototype field trials, Prof. Evans spoke about the EU project SATIN where a geostationary Earth orbit (GEO) satellite was being complemented by terrestrial repeaters called intermediate module repeaters to provide mobile network operators with cost-effective solutions of increased p-t-m transfer capacity over their whole MNW coverage. The system uses 3G Partnership Project (3GPP) technology to prevent any cost impact on the terminal. Another EU project, MoDiS, provided a demonstrator in 2003 using the 3G network in Monaco. The system will be an example of a truly integrated satellite/cellular system for use by mobile operators and is the way forward for similar collaborations toward 4G.

In a groundbreaking invited paper Prof. Bernhard Walke and his co-authors, Ian Herwono, Ralf Pabst, and Daniel Schultz, at the Communication Networks Laboratories, Aachen University (RWTH), Germany, and Joerg Habetha of Philips Research, have drawn on a wealth of research experience in evolving low-power wireless networking concepts to propose practical integrating and interoperating networking systems. Targeting goals of highest efficiency and lowest possible transmit power, their broadband WMS proposal will use 1 W air interfaces for pico base stations and fixed wireless routers (FWRs). The latter are incorporated to extend radio coverage range of the high capacity available from a pico base station. Connectivity relies essentially on multihop communication across wireless bridges/routers and to some extent also on ad hoc networking. Both base stations and FWRs are small enough in size to allow the system to be spoken of as an "invisible infrastructure." The low RF radiating power, while maintaining high bandwidth and high connectivity, naturally has the attraction of low radio exposure of users.

Prof. Walke also described ways this broadband WMS concept combines broadcast, multicast, and single-cast services to minimize the number of transmissions required, thereby again reducing radio exposure of humans, to provide the contents requested by user terminals. The attraction and potential of integrating telecommunications satellite and HAPs into the WMS is also addressed here.

For any of these speculative networks to realistically set the roadmaps or trends toward 4G, appropriate standards, as always, are needed. In his paper "Internet Protocols for Wireless Internet," Prof. Kimmo Raatikainen of the University of Helsinki, Finland, reviews the protocols developed in the Internet Engineering Task Force (IETF) that may provide the foundation for a ubiquitous ABC wireless Internet. He also discusses recent developments in the Open Mobile Alliance that address some middleware issues in the wireless Internet.

QoS-Related Issues

The first of several papers to address QoS issues was that by Dr. Yevgeni Koucheryavy, Tampere University of Technology, Finland, entitled "On Quality of Service and Performance Evaluation in 4G All-IP Networks." The theme taken up in his paper is that reconfigurable mobile networks (including ad hoc networks) are envisioned as being highly dynamic self-organizing and self-configuring networks, which will not necessarily require fixed infrastructure and may take on the characteristics of an autonomous system in the Internet. Within this view, and in a context of all-IP networking, meeting QoS requirements and creating traffic engineering enablers will be defining challenges.

In "Physical Layer Strategies and Issues for ABC Vision," Dr. Carlos Bader and Dr. Carolina Pinart of Telecommunications Technological Center, Catalonia, Spain, discussed the interesting topic of support for reconfigurability through cross-layer protocols at the physical and link layers. They proposed a classification of information exchange in the cross-layer consisting of channel state information, physical layer resources, and QoS parameters, and suggested the use of fuzzy logic to assist in the reconfigurability decision process.

Seeing 4G as a movement toward a new "anytime, anywhere, with anybody" type of communication, through and over all-IP multi-access networks together with multimode terminals and intelligent access selection that will allow the user to be in some sense always best connected, is the motivation behind the paper by Dr. Ivan Armuelles and Prof. Tomas Robles, Technical University of Madrid, Spain. In

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such a scenario, a mobile terminal is the subject of interactions that presuppose new functionality requirements, including novel QoS support mechanisms. To assist the meeting of these requirements, they describe a proposed new "Enhanced Socket Interface for Next Generation Systems," which is an advanced interface defined as a component of an open and modular terminal architecture developed in MIND, an EU IST project.

QoS provision for wireless mobile nodes operating freely and reconfigurably in a multitude of heterogeneous access networks was further addressed by Dr. Nikos Passas and Prof. Lazaros Merakos of the University of Athens in their paper "Unified QoS Provision in Wireless Access Networks." Transferring to wireless systems the QoS advantages DiffServ and IntServ bring to the core and edge of wired IP networks cannot be done smoothly. They describe some of the new problems and potential remedies characteristic of wireless and mobile access that these IETF IP QoS fixed network solutions must face, and for which they suggest potential remedies.

Managing ABC

ABC decisions naturally will be made on the basis of criteria, many of which will be set down in multidimensional user, terminal, network, and service profiles. Such profiles will grow in complexity with time, in parallel with the growth in the range of terminal, network, and service access options, and consist of complex sets or arrays of competing parameters. How this may be managed in a dynamic adaptable way is no small challenge. Deriving a structured implementable policy-based management framework as a way to begin addressing this need is the subject of a paper by Hakima Chaouchi and Prof. Guy Pujolle, Paris 6 University, France, "Policy-Based Management Framework for Always Best Connected Users." Their framework allows for awareness of specific application QoS requirements, terminal capabilities, and the characteristics of the available access networks. They include an outline specification for a suitable network and ABC terminal architecture. In addition, they propose policy-based handover management. This is a handover triggered not only on the basis of a fading signal, but taking into account other constraints such as cost, resource availability, and load balancing. They discuss how such a policy-based handover will be useful in a heterogeneous 4G wireless network environment.

Ad Hoc Networking

Within the vision of 4G as consisting of multiple heterogeneous networks, there is little doubt that one genus of these is being spoken of as a new multiform dynamic networking infrastructure with important potential contributions, particularly in the areas of always-on and ABC. Naturally then, a number of forward-looking papers on ad hoc networking were selected for presentation at the workshop. In the first of these Dr. Takayuki Yamamoto *et al.*, Osaka University, Japan, proposed in "Routing in Ad Hoc Networks for Processing Many Short-Lived TCP Connections" a novel low-latency hybrid routing protocol (LHR) that resolves a number of performance problems of existing routing algorithms designed to support persistent TCP connections. Their technique aims to bypass the large overhead of exchanging routing tables, and the large latency for both an initial route search and new route searches in the case of link disconnections. Their LHR combines on-demand route search and proactive route maintenance. With comparative performance analysis they demonstrate its superior performance.

QoS in IP ad hoc networks is addressed in two papers. In one, presented by Michael Barry, University of Limerick, Ire-

land, "QoS Techniques in Ad Hoc Networks," a multidimensional network model is described where different elements of ad hoc networks and their influences on RRM and QoS can be investigated.

Anelise Munaretto, Guy Pujolle, *et al.*, Paris 6 University, France, proposed an optimized version of the classical link state routing protocol (OLSR) as a basis for designing a QoS-based routing scheme (QOLSR) suited to mobile ad hoc networks (MANETs), where route choice is based less on hop metrics and more on delay metrics.

ANWIRE Panel Session

Dr. Jorge Pereira, EU Commission, chaired the workshop panel session focused on a review of ongoing activities of the ANWIRE task forces (TFs), in the context of the 4G and ABC debate. It included a particularly interesting paper and presentation entitled "Towards an ANWIRE B3G Wireless System Integration Architecture" by M. Siebert (RWTH), H. Chaouchi (LIP6), A. S. Jahan (KCL), I. Demeure (ENST), I. Armuelles (UPM), L. Palma, & L. M. Correia (IST-TUL), J. Liu (CTTC), M. O'Droma (UL), V. Friderikos (KCL), W. Xing (UCY), and N. Alonistioti (UoA). With the aim of generating creative proposals for an integrated system service architecture, this paper summarised a detailed structured review of current system integration R&D efforts happening within Europe and elsewhere in the world. The ANWIRE TF is clearly making a good start toward evolving an initial set of requirements for a targeted architecture by extracting, crystallizing, and integrating ideas from many excellent but perhaps independent and autonomous projects.

Another interesting paper was presented by Vasilis Friderikos of KCL, UK, on behalf of his 12 co-authors from six EU research centres — C. F. Bader (CTTC), C. Pinart (CCTC), Z. Boufidis (UoA), N. Passas (UoA), I. Ganchev (UL), M. Dikaiakos (UCY), C. Christophi (UCY), E. Tsiakkouri (UCY), Wei Xing (UCY), T. Robles (UPM), J. Salvacha (UPM) and E. Tsontsis (KCL) — "Analysis of User Requirements for Future Heterogeneous Wireless Networks." In this they indicate that the attempt to define an overall user-centric approach to heterogeneous mobile/wireless network design was one of the main driving forces in establishing 4G user requirements. The ANWIRE TF has organized these requirements structurally within three generic classes: connectivity, service provision, and adaptability and reconfigurability. Also, objective criteria for QoS characterization are being explored.

Other formal contributions were made by Dr. G Morbito, University of Catania, on efficient and always-on connectivity, by Dr. N. Alonistioti and Dr N. Houssos, UoA, Greece, on 4G reconfigurability architectures, and by Dr. I. Demeure, ENST, France, entitled "Towards Adaptable Services."

Dr Periera opened the discussion to the floor and, naturally, participation was lively, especially with lateral thinking contributions from such distinguished academics as Profs. Hamid Agvami, Bernhard Walke, Barry Evans, Kimmo Raatikainen, Guy Pujolle, and others. These may be listened to on the DVD [6].

Conclusion

ANWIRE's first international workshop was a success in both technical content and level of the papers presented. As may be seen from the papers presented at this workshop, fundamental research in wireless networking is moving rapidly into a new phase. The papers originate from a wide spectrum of authors covering 12 countries and three continents. Overall

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Sixth Baiona Workshop on Signal Processing in Communications

By Carlos Mosquera and Fernando Pérez-González, Universidad de Vigo, Spain.

At a time when so many conferences compete for getting attendees and good quality papers, we are proud to host a small workshop known as the Baiona Workshop on Signal Processing in Communications. The use of the same location for every edition, the lovely village of Baiona, north-western Spain, just 20 km from Portugal on the Atlantic coast, makes this workshop different from most conferences in the field. The workshop site, a medieval castle transformed into a nice hotel, helps create an atmosphere conducive to technical discussions and social life. On top of that, we cannot forget the nearby Cies Islands, a great natural resort that hosts a regular social session of the workshop.

The first reason for choosing Baiona back in 1991, when the first Baiona Workshop took place, was its proximity to the campus of the University of Vigo. Our university was involved at that time in an European COST action that grouped quite a few European research groups with specific interests in signal processing and its applications. The workshop served as a meeting point for those involved in the COST action, with some additional contributions from outsiders that helped to enhance its scientific quality. With the passing of time, the workshop gained an identity of its own, and has acted as a bridge between American and European scientists, with the incorporation of people from Asia as well. We should remember that Baiona was the first European village to learn that Christopher Columbus and its three vessels had reached the "Indias." The Pinta arrived back in Baiona to announce the discovery of what would be referred to as the "new world." Five centuries later communication technologies have reached amazing frontiers, but many challenges lie ahead awaiting a

new Columbus to solve them.

The invitation of outstanding plenary speakers is a must at every Baiona Workshop. They are expected to give encouraging tutorials on different topics linked to signal processing in communications. These tutorials are designed to help people understand recent advances and challenges in different areas of signal processing in communications. The list of names is quite long, and without trying to be exhaustive we have enjoyed, among others, the dissertations of Thomas Kailath, Sergio Benedetto, David Messerschmitt, Peter Hoeher, Simon Haykin, Andrea Goldsmith, and Giorgios Giannakis. Next we include the names of the invited speakers and the topics of their lectures in this 2003 edition:

- Edward J. Delp: "Multimedia Security: So What's the Big Deal?"
- David Falconer: "Frequency Domain Processing in Broadband Wireless Systems"
- Giorgios B. Giannakis: "Full-Rate Full-Diversity Complex-Field Space-Time Coding"
- Andrea Goldsmith: "Design Challenges in Future Wireless Systems"
- Marco Luise: "A Review of Soft-Information-Based Synchronization for Iterative Data Demodulators"
- Fernando Pereira: "Developments and Trends on Multimedia Content Adaptation"

In addition to the invited lectures, about 60 contributions are selected to be presented in poster sessions, thus providing an exciting environment for discussion. The authors of the best papers are offered the opportunity to write extended versions to be reviewed as possible contributions to the *Signal Processing Journal* of Elsevier.

At this edition, precoding and cross-layer design were presented as some of the most promising schemes to increase communication rates and provide adequate quality of service for end user demands. "Dirty paper coding" and "turbo synchronization" are fancy terms to describe state-of-the-art research in coding with side information and joint synchronization-turbo decoding, respectively. Signal processing also has an important role to play in digital content protection and multimedia content description.

All the documentation regarding this workshop, including the papers in downloadable format, can be found at <http://www.baionaworkshop.org>.

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the workshop and these proceedings represent a fine contribution to the research efforts and debates in this field, and provide the reader with new and stimulating insights.

Copies of the proceedings may be ordered at <http://www.ece.ul.ie/anwire-workshop-glasgow/proceedings/index.html>, or obtained on loan from the British Lending Library.

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