Joint Expert Group and Vision Group Workshop—EuCnC Paris 29th June 2015

Room Molière, Palais des Congrès of Issy les Moulineau

Organizers: Arturo Azcorra, Jean-Sebastian Bedo

Rapporteur report : Rui L. Aguiar, Barry Evans

Summary

The **Expert Group together with the Vision Group of the NetWorld 2020 European Technology Platform for communication networks** and services held a joint workshop collocated with the European Conference on Networks and Communications (EuCNC 2015), held in Paris last June. A total of eight workshops were celebrated on the first day of this renowned international conference. In spite of this competitive offer, the Joint Expert Group and Vision Group Workshop was a great success, attracting a mixed audience of 110 participants amidst researchers and specialised professionals interested on technologies "beyond-5G".

The workshop brought together 16 technical presentations on diverse topics on the field of 5G communications and what lies ahead. The high number of attendees, considering that several other workshops were also scheduled in parallel, clearly shows the interest of the international ICT community on the future of 5G technologies, and how the Expert and the Vision Group are succeeding on gathering the points of view of their different tenants.

As a result of the technical presentations, the workshop originated a very vivid discussion on which technologies and paradigms should be considered for beyond-5G scenarios, discussion that extended until the end of the workshop.

As a tangible outcome of this event, several topics have been identified as of potential interest in beyond-5G systems and a white paper will be written materialising the initial discussion described above.

Agenda

10:00 Welcome and Introduction

Welcome by Expert Group Chair and Vision Group Chair, Arturo Azcorra, IMDEA Networks and Univ. Carlos III, Expert Group Chair, and Jean-Sebastièn Bedo, Orange, Vision Group Chair

10:30 Session One, Chair: Paul Müller

Software Defined Testbed, Paul Müller, University of Kaiserslautern
Applying RINA as a Clean-Slate Approach to Software Networks, Diego R.Lopez, Telefonica
Towards Software Networks beyond 5G, C.J. Bernardos,
H2020 5GEx Project: "Gluing technologies" as drivers of future communication systems, Elisa Rojas, Telcaria Ideas

11:30 Session Two, Chair: Ralf Steinmetz

Location Aware Information -Opening new Frontiers for Technology beyond 5G, Ralf Steinmetz, Technische Universität Darmstadt

Information-Centric Networking: Cisco vision on 5G and beyond, Giovanna Carofiglio, CISCO

5G Converged Networks: System Design and Evolution Path, Rui Aguiar, Instituto de Telecomunicações/DETI, Universidade de Aveiro

Measuring QoS/QoE in 5G/Beyond-5G environments, Rui A. Costa, Ubiwhere

14:00 Session Three, Chair: David Larrabeiti

Elastic optical networks in a converged backhaul-metro beyond-5G scenario, David Larrabeiti, H2020 Xhaul Project

Energy Efficient Backhaul for Highly Dense Urban Areas, David Grace and Alister Burr, University of York

Non coherent massive MIMO for 5G and beyond, Ana García Armada, University Carlos III of Madrid

The 2019 spectrum shared jungle, Julián Seseña, A-CING

15:45 Session Four, Chair: Holger Karl

Predictive/Anticipatory Systems, Holger Karl, Universität Paderborn

Zero-Delay Communication, Paul Müller, University of Kaiserslautern

Network and Device Management in NG Mobile Environments, Andreas Mauthe, Lancaster University

Machine-to-Machine Communications: Beyond 5G, Sinem Coleri Ergen, Koc University

17:00 Discussion and Wrap-up, Chair: Arturo Azcorra/Jean-Sebastièn Bedo

Organization of future Workshops and Workshop Wrap-up
Expert Group Workplan and related actions
Workshop closure

Workshop Objective

The workshop is the first European community event associated with the future of research on the mobile communications after the 5G network becomes a reality. The idea is to start discussing ideas on technologies that are currently out of-radar and clean-slate approaches for new, advanced communication systems that may become relevant after 2020.

Workshop Operation

The workshop is organized by the 5GPPP, jointly by the vision and expert groups, aiming to be the first European community event associated with the future of research on the mobile communications after the 5G network becomes a reality. The idea is to start a discussion on what should be interesting areas for "beyond-5G" (B5G) networks.

An early call for contributions was made to the EC community, through the 5GPP expert group lists, which led to the creation of the workprogramme. The end of the workshop was dedicated to conclusions and assessment of this first exercise.

Workshop Lessons

The programme considered four key technical sessions, orgnaized along four main ideas: "the software network", "architecture issues", "optical and radio", and "ultra-fast networks". The following sections discuss the key ideas of each session. Although with a variable number of participants, all sessions had more than 100 persons on the room.

Session 1 – The software network.

The first presentation, by Paul Muller, made a strong case for on-demand test-beds, sofware based and reconfigurable. The G-Lab ToMaTo was suggested as a potential guiding line for developments. These must be sustainable and interconectable, and specific research incentives should be planned for funding. Software defined testbeds can overcome the problems of sustainability and offers the domain researchers a flexible tool for experimentation, which can be fitted to the demands of the experiment and the demands for experiments beyond 5G.

Diego Lopez then presented RINA, as a formal approach for a new network architecture. Going beyond 5G will demand an underlying networking infrastructure able to support the dynamic allocation of resources, flexible function composition, elastic component placement and migration, and implicit security. While current approaches consider the adaptation of present mechanisms, such as overlays, clean-slate proposals can provide a rather better substrate. RINA may have the potential to support fast network creation times, through the exploration of design patterns. Research is however needed on the question if this model fits the 5G small cells architectures.

The following presentation was on software defined networks beyond 5G, by Carlos Bernardos. It is to be expected that software-oriented-networks will still be on a roll-out stage after 5G, and it is clear that several questions will exist on what should be softwarized. True and secure self-configuration & self-organization will be essential. There are still issues about composing services with both physical and soft implementation which should be driven by the service requirements.

The final presentation, from Elisa Rojas, discussed the ideas of ultra-flexible and composable networks, and the pressure to instantiate services on the fly in heterogeneous environments. The key idea is the reduction of complexity by slicing into blocks and then gluing them together (in what can be seen an evolution of SDN and NFV concepts). Current results are much more dependent on technology than on the gluing issues, but there is a need for a single point of entry for SDN that controls the complete cycle.

Session 2 – Architectural Issues.

Ralf Steinmetz made the case for building location awareness on packet information. Context-aware mobile multimedia applications experienced a tremendously increased popularity, that enable users (i) to interact with their vicinity in the context of location-based services and (ii) to interact with other users in the context of social applications. Location awareness would open many new services, and would increase the richness of

information extractable from the packet transversal of the network. Questions on how to include this, and how to trade the concepts of circuit and packet switching (or other communication techniques) are still open.

ICN was again argued by Giovanna Carofiglio, as a potential network architecture, in particular as it can provide mobility and security through context awareness. The question of it is reasonable and worthwhile to run the Internet over ICN is however still unknown, and the evolutions of ICN routers will have an impact on it.

Rui Aguiar made the case for a continuum of evolution(s). Not all the features being discussed will be in 5G early standards, and Beyond 5G research will need to be based on the network at the time. Regulation aspects, including radio spectrum, will become a nightmare, as regulators and business will change much less than technology may allow. Designing for energy will be a key issue, and questions on how to design an intelligent control plane requiring low energy, and how to design an efficient data plane, will still be pending (and increasingly important).

Finally, Rui Costa raised issues on data gathering and on QoE evaluation and measuring, on a per application basis, raising the need of a network of probes. Learning from the 5G evolution will influence the upcoming applications and the future of B5G. For instance, it is not clear what to measure for M2M communications, and what will be the import QoE aspects for many applications.

Session 3 – Radio and Optical

The third session started with David Larrabeiti bringing the discussion on elastic optical networks for converged backhaul-metro scenarios. Optical research will need to move to hybrid IP/OTM approaches, with a unified data data plane, in order to support more than 100Gpbs with simple modulations, targeting ~375GHz channels.

David Grace and Alister Burr took a completely different approach to a similar problem, but relying on dense urban areas. For backhaul, and easy ability to a dense connected car networks, street lamps can be used, with a mm-wave front and back-haul. Using line-of-sight MIMO, low-energy mesh networks can support very large bit-rate networks through the exploration of intelligent digital signal processing.

Massive MIMO, with non-coherent systems, was tackled by Ana-Garcia Armanda, which claimed for simpler systems. To obtain all the advantages of MIMO, the knowledge of channel state information (CSI) at the transmitter and receiver is required: the problem of pilot contamination, that is, uplink pilot sequences from different cells interfering with each other, make obtaining even imperfect CSI very challenging for massive MIMO where the number of channels that need to be estimated is very large. As scale increases, complexity and the number of antennas become an issue, and this should be tackled at design stage as soon as possible: removing (e.g.) CSI estimation may provide on the long run much more reliable and realizable systems. Non-coherent communications and their application to massive MIMO may be the key to really implementing these systems with their

advantageous energy efficiency (required power decrease in proportion to the number of antennas).
.

Julian Sesena brought the regulation into play, and the need for a paradigm shift in the flexible allocation of spectrum. Spectrum is needed across bands and needs to be used flexibly, and statistical spectrum allocation approaches need to be considered for the future. Technology can certainly contribute enormously to enhance the efficiency of the use of the spectrum. Future allocations of spectrum, or identification of spectrum for certain applications, will not need to follow the traditional schemes known today. Technological trends for the Beyond 5G era should target new spectrum access schemes, towards more efficiency, more flexibility, less costs, faster access, etc., exploiting advances like the cognition of the network and the terminals, miniaturization of electronics, high processing capabilities, new software solutions, etc.

Session 4 - Ultra-fast networks

The final technical session started with Holgar Karl discussing the concept of networks anticipating and predicting what applications need, making systems aware of what is happening. Architectural questions like proper APIs for participating applications, the need and right to know which types of anticipatory data, or the suitability of different application classes have yet to be answered.

Paul Muller continued with these concerns, and the need for zero delay communications. His point was bringing the operating system into discussion: to achieve low latencies we need an holistic approach E2E, and this implies all delays both at the network and the operating system, need to be consider. How to map application requirements (timewise) into the network and on current protocols is an issue to be considered.

The device was also an issue on Andreas Mauthe presentation. In heterogeneous networking the devices will need to select and connect do diverse networks, as they move through them, so they will need to be integrated in the network monitoring process. What Ultimately this vision argues for the integration of independent mobile network technologies and communication channels by using edge devices as part of the network management infrastructure in an extensible and future proof manner, without the need for global or central coordination instances. Coordination between all system and network aspects will be ensured through aneasily extensible policy infrastructure.

The final presentation, by Sinem Coleri-Ergen addressed M2M communications. It highlighted that 67% of current M2M communication still uses 2G, and for low-power wide area, the sensing cost in 4G is too high (energy wise). For Low-cost wide-area and low-latency ultra-reliable M2M communications, we will need to explore novel waveforms with low delay and low . Furthermore, controlling the elements in our environment based on the data provided from machines in this class of M2M applications requires a paradigm shift for

control and communication systems with novel strategies for their joint design in beyond 5G networks.

Discussion and conclusions

The final session led to a discussion across all participants of what has been presented.

It was clear that several of the topics presented are evolutions of research areas that will be present in 5G networks. In that sense, it is not easy to foresee at this stage in what degree these concepts will be already realized in 5G networks. Clearly, B5G will also be an evolution of 5G concepts, but larger experience on 4G networks, and final standards for 5G will be required to design research questions for that time.

Another two global concerns were related with the lack of discussions on visions from standard and/or industry for a (lack NGNM or 3GPP), which could suggest a reference view against which to consider further research challenges; and about the rarity of discussions from an application and intelligent terminal point of view, as the "app-world" is now starting to dominate our interface with the information society.

A global conclusion was that we will need vision documents to consolidate what challenges will expect us after 2020, and to start laying the ground work for this. Given the current difficulty in separating long-term 5G research from B5G research, this vision paper should provide a structure that relies on very clear and structured technical lines, resilient to the variable technological pace of 5G networks.