The Wireless Body Environment in 5G Mobile Networks from EU COST IC1004 perspective

Narcis Cardona

iTEAM Research Institute, Universidad Politécnica de Valencia. Camino de Vera S/N 46022 Valencia, Spain ncardona@iteam.upv.es

ABSTRACT

This talk presents the view of the European COST Action on the future of Body Area Networks and the open research challenges in this topic. Body communications are evolving from centric approach to networking topologies, meaning that all the current devices used in Wireless Body Area Communications will be nodes of Body Environment Networks, extending their role of centrally coordinated sensors or user terminal peripherals to new functions of an equivalent Moving Network. European COST Action IC1004 has become a network of knowledge in the European Research Framework which deals with the new scenarios in Radio Communications technologies, being the Wireless Body Communications one of its main topics of interest.

INTRODUCTION

Fifth generation networks are called to overcome the limitations of the current cellular networks approaches, searching for new paradigms on Spectrum management, Core and RAN architectures, and transmission systems [1]. This huge reformulation of the way the mobile terminals are getting access to information and services is based on all the forecasting analysis made by the market players [2], from which it is obvious to determine that the data traffic to be supported by the future networks will be times more restrictive in terms of bandwidth, capacity, density and heterogeneity of the traffic patterns.

In the last decade the Mobile economy has grown extremely fast, driven by several forces, and the new user interfaces and devices have boosted the broadband data traffic in wireless and mobile access networks. The trend in mobile handsets has been the integration in the same device of sensors, multimedia, local wireless links, near field readers, etc., driving the mobile terminal to be a powerful "pocket computer". The software community has also accompanied this quick evolution of the "mobile phone" concept, providing thousands of applications for download.

So far, the potential applications of such "pocket computer" have been centred on the terminal itself, but the trend these days starts being to make the terminal sense its local environment, and to connect and control peripherals and other devices around it. Watches, glasses, earphones and bracelets are the most popular, but there are dozens of other wearable and implantable devices which a person could carry in the future. In some sense, grouping those devices into a small network coordinated by the central personal device, which today is the "phone", may change it to become the "router" of such Body Area Network (BAN).

After the 4G technologies deployment, and in the 5G networks scope, the role of wearable and implanted devices in people lives will be to revolutionize health monitoring, wellness and assisted living [1]. Many promising applications have already been identified from the concept of Wireless BAN. The initial approach in BANs is to consider the implanted or wearable devices report data to the terminal, where centralised coordination of such monitoring is performed, and the connectivity to wide area networks is allocated. This paves the way to health remote monitoring. Recent studies foresee that in 2017 Mobile Healthcare can help cutting costs in the range of 400billion dollars in OECD countries [3].

2. WIRELESS BODY ENVIRONMENT NETWORKS

Beyond the concept of centralised one-way sensing network, the wearable and implanted devices can play an active role in two directions: sensing the environment, and relaying each other to create Wireless Body Environment Networks (WBENs). Sensing signals around the human body will permit the interaction between elements in the proximity of the body and the network of body implanted or wearable devices, enabling the exchange of health and other data in real-time. At the end, the implanted or wearable device will move from being a peripheral of the user terminal to become a node of a local area wireless network, and this will require the implementation of communication protocols and network (self-)management, like in any common wireless local area network.

While the WBEN concept is fully defined for a single person [4] or for Human to machine interfacing [5], the possibilities of connecting two or more WBENs each other are still to be explored. Future Body Communications may include the relaying between two WBENs, i.e., between persons, to work in cooperative manner for different purposes, like coordination of moving groups, peer location, exchange of real time data, sharing sensors information, etc.

But Human Body is a very particular communications environment, which puts new and challenging constrains to the design of the above mentioned WBENs. First, devices have to be limited in power, to avoid overcoming the exposure limits, so the link budget for radio communication links is quite below those for over-the-air systems. Second, devices, mainly those implanted, have to be long life autonomous, meaning that have to reduce to the minimum the possible the energy consumption, with consequences on the communications protocols design, transmission schemes, coding, electronics, etc. Third, propagation inside the body, over the body or in-to-outside the human body, follow different radio channel behaviours, which are far away from those modelled for the over-the air systems. And finally, implanted and also wearable devices sizes are many times limited to dimensions quite below the wavelength, which adds restrictions to the transceiver design, being the antenna the most evident.

3. OPEN CHALLENGES FOR FUTURE RESEARCH

All those limitations in WBEN implementation, which cannot be solved with the classical approaches to Wireless Communications Systems, have opened many challenges in the Research Framework, and quite a few of it remain open [1]:

- Increase the knowledge of around-the-body and in-body propagation channels. The propagation scenario of a WBEN consists on relaying a set of in-body and on-body devices, located in a wide range of potential positions, and accounting with the body postures and movements. This means that time-varying radio channel models are required for a complete characterisation of performance and system design.
- Explore the best frequency bands for the WBEN scenario, especially for implanted devices, in which power saving and antenna design are critical. Interference between WBENs and from other radio systems will be an important issue, so protection margins have to be determined.
- Design antennas based on flexible and biocompatible materials. Designs will be respect to their allocation in or on the body, to increase efficiency, improve link budget, extend the range and reduce the power requirements.
- Define new optimisation concepts for the WBENs. To exploit the new possibilities that a network of devices in or around the body opens, and depending on every application to be implemented,

optimisation will apply to fulfil requirements in terms bit rate, latency, error rate, reliability, security and privacy.

- Enhance the performance of WBENs by multiple links approaches. Virtual MIMO techniques can be a first approach to tackle this challenge, on the basis of the well-known technologies of MIMO in other radio communication scenarios. The WBEN applications can also take advantage of the presence of distributed elements inside or on the body surface for new purposes, like diagnostic, location, self-coordination of the WBEN, relaying to reduce transmission power, among others.

4. REFERENCES

[1] N. Cardona (editor), "COST IC1004 White Paper on Mobile Communications Challenges towards 5G". December 2013. *Available on-line at www.ic1004.org*

[2] GSMA, "The Mobile Economy 2014". February 2014. *Available on-line at www.gsma.com*

[3] GSMA, "The Mobile Economy Report 2013". February 2013. *Available on-line at www.gsma.com*

[4] WiserBAN - Smart Miniature Low-power Wireless Microsystem for Body Area. EU FP7 Project. www.wiserban.eu

[5] Wear-a-BAN - Unobtrusive Wearable Human to Machine Wireless Interface. EU FP7 Project. www.wearaban.com