Body area networks : a new wireless network paradigm

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I. Abstract

Body area networks (BANs) refer to embedded wireless systems in, on, and around bodies. A BAN is made of several nodes, typically few sensors and a sink, but also potentially may include actuators. BANs are expected to take an important role for health, leisure, sports, and all the facets of our daily life. They are indeed essential in the chain of a connected human in the digital world and may extend in a fascinating manner, the current applications offered by cellular wireless networks. From a technical point of view, a rapid analysis would let a BAN be considered as just yet another wireless sensor network. But a deeper study eventually highlights strong particularities of BANs. These particularities further concern all aspects of the network and new protocols are highly desirable. Let start with the surrounding environment of BANs. Recent studies show how the radio channel differs from usual contexts: the path-loss appears distance independent and its time variations present cyclic properties due to the human motion. A BAN may then be represented as a fully connected but highly random graph. Albeit the size of the network is not large, delay constrained transmissions may take advantage of intelligent and opportunistic cooperative transmissions or relaying techniques. BAN protocol optimization relies on dealing with PHY and MAC layers simultaneously, seeing the BAN as a whole dynamic cooperative system. Minimizing the radiated power as well as the energy consumption are of primary importance. However, the dynamicity of the BAN is not only due to the body motion. The surrounding environment may change. More significantly, several BANs may be located in the same vicinity for a certain period. How could we control interference ? Could we manage the resource allocation in a distributed manner ? This refers to BAN co-existence management. Last but not least, large scale applications may be of interest when the BAN is extended to as a set of moving nodes equipping different bodies. A typical example is a team sport game where each player holds one or several sensors. In this case, it may be relevant to exploit the graph structure of the whole network to transmit some data over the network. The dynamicity of this network may be advantageously exploited to enforce large scale communications and interactions. Then, the BAN context offers three levels of complexity : intra-BAN structure, BANs co-existence and cooperative multiple BANs. From a theoretical point of view, BAN represents a new framework where theoretical tools such as network information theory, game theory, control theory or consensus algorithms may find new reference schemes. In this tutorial, we first give an overview of typical BAN scenarios and applications covering a broad variety of applications including health, sport or leisure. We give a proof of evidence that BANs possesses specific features needing to be specifically addressed. We illustrate the very original properties of the BAN channel aforementioned. We present some recent results not yet published giving a complete multi-point to multi-point description of the body channel. Then we focus on PHY/MAC aspects. After a rapid overview of existing standards such as IEEE802.15.6 or Bluetooth LE, we discuss some recent research results focusing on cooperative transmissions. Last we open the discussion to the more theoretical challenges related to BAN scenarios.

II. Bio of the speaker

Jean-Marie Gorce is full professor of Wireless Communications at the National Institute of Applied Sciences (INSA), Lyon, France, and he is currently visiting scholar at Princeton University in the team of Prof. H. Vincent Poor. He joined INSA as an associate professor in 1999, becoming full Professor in 2008 and received the Dipl. Ing. (M.Sc.) degree in electrical engineering (1993) and PhD degree (1998) working on parametric feature extraction from radio-frequency ultrasound signals in echocardiography. He has been a junior visitor scientist at the Medical imaging center in KU Leuven (Belgium) in 1998, a senior researcher at Bracco Research, Geneva (Switzerland) in 1999 and a visiting senior researcher as a Marie Curie fellow, at Ranplan Ltd, Sheffield (UK) in 2012.

His main research fields concern wireless communications focusing on modeling, wireless system optimization and performance assessment considering both infrastructure-based and ad hoc networks.

In September, 2009, he has been apointed as the director of CITI (Centre for Innovation in Telecommunications and Integration of Services), a research group associated with INRIA focusing on ambient networking, distributed systems and wireless networks, including about 80 professors, associates, researchers and PhD students.

Since 2001 he has been an associate member of Inria and he is a member of the Greentouch consortium. He has been involved as a leading scientist in several French and European projects. He has published over 80 refereed journal and conference papers (e.g., IEEE Ant & Propag, IEEE TWC, IEEE Wireless Com, IEEE Com. Lett., etc). He served as an evaluator for several for various French and international programs.He has been a TPC member of various conferences and serves as an Associate Editor of Telecommunication Systems (Springer) and Eurasip journal of wireless communications and networking (JWCN, SpringerOpen).

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