Capacity Analysis for On-Body Communications in an Indoor Environment

C. Oliveira and L. M. Correia

Instituto Superior Técnico / INOV-INESC
University of Lisbon, Lisbon, Portugal

Abstract— Body Area Networks (BANs) [1] will be strategic actors of the next generation of wireless systems beyond the fourth generation, supporting the world of everything for connected devices and objects. This work focuses on on-body communications, *i.e.*, both transmitter and receiver antennas are attached to or located very near the body of a BAN user, most of the channel being on its surface. Potential scenarios include monitoring of biological signals in healthcare care units, as well as elderly people monitoring in home environments. The data collected by the wearable sensors can be used either in the network itself or forwarded to any appropriated external one (*e.g.*, emergency service). A novel model is proposed using a smart and cooperative configuration of the wearable nodes, *i.e.*, using clusters of nodes and combining multiple independent paths to behave like multi-antennas systems (*i.e.*, Virtual MIMO). The aim is to enhance the reliability of communications and to overcome the effects of deep fading, which can be critical for some applications (*e.g.*, life support decisions). Different metrics are proposed for the selection of the best wearable nodes, namely, the relative MIMO capacity gain (ratio between the MIMO capacity and the maximum throughput from the SISO branches), and the configuration score (relative capacity of a selected 2×2 configuration in relation to the maximum theoretical capacity of a particular BAN). This approach is supported by a channel model that considers the received signal composed of an on-body component (obtained from full wave simulations [2]) and of several multipath components present in the environment (obtained from a geometrically based statistical channel model adapted to BANs [3]). The model includes realistic body dynamics (taken from motion capture analysis), as described in [4]. Results are presented for the possible usage scenario of a female walking in an indoor complex propagation environment, and wearing a network of nine on-body sensors, organised in a 2×2 configuration (*e.g.*, 2 data sensors transmitting hearing information to a sink composed by 2 nearby nodes). The case studies of the data sensors on the head (front and back), on the ears or on the arms, while the sink is on the front of the body (*e.g.*, belt) are analysed. In case of the head-belt connection the signals are balanced, but, being highly correlated due to the short distances and similar propagation conditions and relative MIMO gains are small (1.57). If the data sensors are moved to the ears, higher relative MIMO gains are achieved (1.81). The trend of the average capacity over time when the sensors are on the arms exhibits higher fluctuations when compared to the placements on the head/ears, corresponding to the arms swinging, leading to an average gain of 1.73. Nevertheless, the performance of the selected virtual MIMO case studies (with relative MIMO capacity gains ranging in [1.57, 1.81]) is always enhanced when compared to the best SISO scenario, even for line-of-sight branches. The selection of the optimum placements should be done according to the specific system under study. The best performance for the analysed case studies corresponds to the sensors on the ears, reaching a configuration score of 0.76.

REFERENCES

1. Hall,P. and Hao,Y., *Antennas and Propagation for Body-Centric Wireless Communications*, Artech House, Norwood, MA, USA, 2006.
2. Mackowiak,M., Oliveira,C. and Correia,L.M., "Radiation Pattern of Wearable Antennas: A Statistical Analysis of the Influence of the Human Body", *International Journal of Wireless Information Networks*, Vol. 19, No. 3, Sep. 2012, pp. 209-218.
3. Oliveira,C., Mackowiak,M. and Correia,L.M., Modelling On- and Off-Body Channels in Body Area Networks, in *Proc. of IMOC 2013 - International Microwave and Optoelectronics Conference*, Rio de Janeiro, Brazil, Aug. 2013.
4. Oliveira,C. and Correia,L.M., "Perspectives for the use of MIMO in Dynamic Body Area Networks", in *Proc. of EuCPAP 2013 - European Conference on Antennas and Propagation*, Gothenburg, Sweden, Apr. 2013.

Capacity Analysis for On-Body Communications in an Indoor Environment

C. Oliveira and L. M. Correia

Instituto Superior Técnico / INOV-INESC
University of Lisbon , Lisbon, Portugal

carla.oliveira@inov.pt, luis.correia@inov.pt

R. Alves Redol, 9, 7D
1000-029 Lisbon, Portugal
tel. +351 213 100 468 / fax +351 213 100 472

*Corresponding author: carla.oliveira@inov.pt

SC4: Antenna-Channel Interactions and Wireless Propagation Channels, organized by Dr. Andres Alayon Glazunov (Chalmers University of Technology, Sweden)