Guest Editorial for the Special Issue on Antennas and Propagation on Body-Centric Wireless Communications

BODY-CENTRIC wireless communications refers to human-self and human-to-human networking with the use of wearable and implantable wireless sensors. It is a subject area combining Wireless Body-Area Networks (WBANs), Wireless Sensor Networks (WSNs) and Wireless Personal Area Networks (WPANs). Body-centric wireless communications has abundant applications in personal healthcare, smart home, personal entertainment and identification systems, space exploration and military. The last two mentioned applications of body-centric communications systems have been in existence for some time [1], [2]. Products for personal communications including the mobile phone wireless headset and more recently wristwatch mobile phone controllers and jogging monitors for MP3 players have become available [3], [4]. However many researchers now see the healthcare application as having the biggest potential of the applications listed. Skin surface monitors of vital signs are now integrated with wireless communications and medical implants with links to local base stations are being developed [5], [6]. The human body is an uninviting and often hostile environment for a wireless signal. In all of these systems, antennas and propagation are key study areas.

The topic of body centric communications can be divided into three domains: 1) Communications from the body surface to a nearby base station; 2) both antennas are on the body surface; and 3) at least one antenna may be in a medical implant within the body. These three domains have been called off-body, on-body and in-body, respectively. The classification serves to highlight some of the technical challenges. They may also be encountered by the reader in some of the papers in this Special Issue. However the papers in the Issue have not been arranged in this way but rather in terms of the main topic, namely antennas and propagation.

Within the topic of antennas, four main categories have been identified, namely narrowband, wideband, implants and fabric antennas. Within the first area, the performance of a novel cavity slot antenna close to the human body is described by *Haga et al.* and antennas optimized for over body communications by *Conway* and *Scanlon*. The problem of the varying environment for a mobile phone has been studied by *Pelosi* and the issues raised in that paper are common to many body centric antennas in which variations in the body posture and the position of the antenna relative to the body give rise to changes in matching, efficiency and radiation pattern.

Ultrawideband systems show some promise for on-body communications due to the relatively short ranges and good performance in the face of fading and interference. Papers by *See* and *Chen* and by *Alomainy et al.* address some of the issues and in particular give characterization of the transient behavior of the antenna close to the body. Implant antennas offer some difficult challenges relating to design without the ability to perform *in-situ* measurements and the problem of environmental variation.

Typical geometries of implantable devices, such as implantable cardiac defibrillators and pacemakers, implantable glucose sensors, endoscopic and drug-delivering capsule devices, vary from millimeter to centimeter ranges. Wireless implants are restricted to a compact antenna that needs to be fully characterized and effectively coupled to the transceiver. Also low power consumption is required by implantable devices and these two factors are highly related. *Xia et al.* discuss the design of a miniaturized antenna with an H shape, which is to be located between the shoulder and elbow. Link budgets are given and performance is measured with a scale model in a section of body phantom. *Izdebski et al.* describe a meandered size reduction technique which allows integration of the antenna within an implant for use in the intestine. Computer modelling of the antenna and some implant components in a body phantom with organs is shown. *Yvanoff et al.* propose some feasibility studies of applying implantable LC sensors in the application of monitoring human tissue properties.

Textile antennas are now attracting much interest, as integration with clothing is seen as a desirable feature for some users. *Kennedy et al.* show results of an antenna for use by astronauts that consists of a patch and a complimentary eight wideband element using conductive fibres sewn to the substrate. In another paper *Hertleer et al.* discuss integrated textile antennas for firefighters. Designs of dual-band fabric antennas incorporated with electromagnetic bandgap structures are shown by *Zhu et al.*

The second main topic of radiowave propagation is important for understanding of the behavior of communications links and models to help design systems. The body-centric channels have some distinctive features not found in conventional wireless channels, where for example the performance of the on-body channel can in, some cases, be dominated by the posture and dynamics of the human body. In general the space wave, surface and creeping waves, reflection and diffraction are all present, and computation can be numerically intensive. In the first paper of the propagation part of the Special Issue some propagation mechanisms are discussed by *Sasamori et al.* This is followed by a description of the use of analysis of time series data to characterize on-body channels by *Cotton and Scanlon*.

Diversity and multiantenna systems can be employed to improve the body centric channel, where significant fading is present both due to scattering from the body and its surround-

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ings. Space diversity in the on-body channel, by the use of two small antennas of various types, is characterized by *Khan et al.*, and useful values of diversity gain are obtained. Similar diversity gain levels are also obtained using a switched beam antenna by *Kamarudin et al.* and they also use the antenna to obtain ray cluster angle of arrival data. *Wang et al.* show the characteristics of channels from one body to another and also gives values for improvements by the use of multi-antenna systems. The characterization of channels for wearable antenna systems is demonstrated by *Cotton* and *Scanlon*.

The final two papers on propagation are concerned with other types on-body radio channels. Wang *et al.* studied the UWB on-body channel by applying several homogeneous digital phantoms. They found that the channel characteristics are strongly linked with the human body postures and movement. Some characteristics of the radio channel for an implant antenna in the stomach are given by *Alomainy et al.*, and the computed results are compared to those measured using a physical phantom.

Numerical computation is difficult in body-centric applications due to the problem of multiple scales—fine modelling of the antennas is required while these are located on the body, which depending on the frequency, may be electrically large. A solution is proposed by *Sani et al.* in which the equivalence principle is used to insert a previously obtained detailed solution for an antenna into a finite difference time domain solution of the whole body.

We have found antennas and propagation for body centric communications a fascinating topic with many new challenges. The material that was submitted to this Special Issue, we believe, gives a good and current overview of the topic. We hope you enjoy reading it.

Finally, the Guest Editors would like to thank the Editor in Chief, Dr. Trevor Bird, for inviting us to organize this Special Issue.

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