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A Brief Survey on Design of Intrabody Communication System for Human Area Network Applications

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Abstract: Intrabody communication (IBC) is a new data transmission concept that uses human body as a communication channel to transmit data. One of the main objectives of research into intrabody communication is the characterization of the human body as a transmission medium for electrical signals. And these characterization is strongly influenced by the conditions under which the experiments are performed. This survey examines the on-going research in this area and highlights IBC core fundamentals, IBC transceiver designs, and the remaining research challenges to be addressed.

Index Terms- *Intrabody communication (IBC), Human Area Network (HAN).*

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I. INTRODUCTION

IBC is a new Human Area Networking technology that uses the surface of the human body as a safe, high speed network transmission path. IBC uses the minute electric field emitted on the surface of the human body. Technically, it is completely distinct from wireless and infrared .A transmission path is formed at the moment a part of the human body comes in contact with a IBC transceiver.. While in the case of different RF standards such as Bluetooth and Zigbee electromagnetic energy get radiated in the environment causes more power consumption. IBC application area is very wide. It can be used for communication between mobile terminals as well as for communication between two mobile terminals, between a mobile terminal and a terminal embedded in the environments and between the other terminals embedded in the environments.

The typical advantages of intrabody communication are as follows: first, cables are eliminated. Second, communication can easily be started or terminated at will as communication channels are formed only when a person touches terminals. Third, it is more secure than ordinary wireless communication because data signals are not radiated outward as it is confined to the body.

These advantages have led researchers to improve IBC electronic prototypes [1]–[3] as well as to define new applications [4], [5]. Therefore, IBC is a promising approach capable of covering some of the main technical challenges that are yet to be resolved in BSN [6], such as the requirement of small-size, power-saving, and miniaturized intelligent wearable devices.

A variety of IBC techniques have been proposed, which can be grouped into three main approaches: galvanic coupling [7], [8], capacitive coupling [9], [10], and waveguide methods [11]. The first two rely on the coupling of low frequency, low-level currents and voltages into the human body, respectively, whereas in the last technique, an electromagnetic wave propagates through the body, which is commonly associated with the use of higher frequencies, thus involving a non negligible radiation component into the air.

Recently a technology was developed by Japanese Company Nippon Telegraph and Telephone Corporation. The NTT labs has announced that it is currently testing a revolutionary technology called “ Red Tacton ”,which uses the electric fields generated by the human body as medium for transmitting the data . The chips which will be embedded in various devices contain a transmitter and receiver built to send and accept data in digital format. The chips can take any type of file such as mp3 music file or mail and convert it in to the format that takes the form of digitals pulse that can be passed and read through a human being electric field .the chip in receiver devices reads these tiny changes and convert the file back into its original for.

II. RELATED WORKS

The concept of IBC was originally proposed by Zimmerman [12]. He demonstrated how mobile devices near the human body can exchange digital information by capacitive coupling in Pico ampere currents through the human body. Zimmerman said that, the near-field communication can operate at very low frequencies and low transmission power. The prototype of the PAN transmitter operates at 330 kHz, 30V, with a transmission power consumption of 1.5mW for charging the electrode capacitance. Direct coupling by Masaaki Fukumoto [13] et al is a modified version of the basic capacitive method. The system operates by analog frequency modulation at frequencies within 50 kHz to 90 kHz for transmitting a simple protocol of ID numbers. Sasaki [14] et al tried to illuminate the principles of intrabody communication, where the Electro Optic [EO] sensor is used to receive data signal. Maria Amparo Callej´on [15] et al implemented galvanic [16], [17] and capacitive coupling [18], [19] setups and carried out comprehensive set of measurements by analyzing fundamental IBC parameters such as optimum frequency range, maximum channel length and type of electrodes.

III. Model of Intrabody Communication

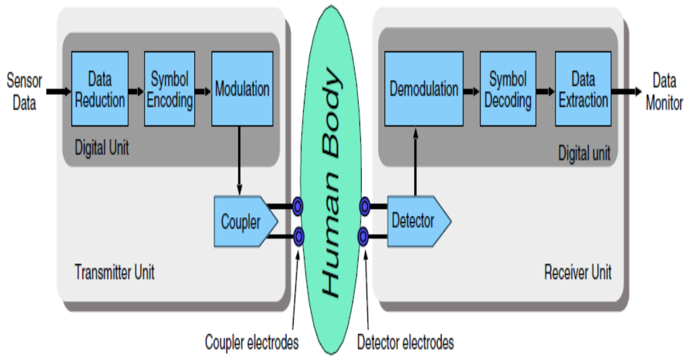

Figure 3.1 Intra-body communication for data transmission between sensors enabled by transmitter and receiver units: The human body acts as the transmission medium.

The main components of an intra-body communication link are shown in Fig. 3.1. A transmitter unit allows sensor data to be compressed and encoded and transmits the data by a current-controlled coupler unit. The human body serves as the transmission channel. Electrical signals are coupled into the human tissue and distributed over multiple body regions. The receiver unit consists of an analog detector unit that amplifies the induced signal and digital entities for data demodulation, decoding, and data extraction.

IV. VARIOUS PROPOSED IBC TECHNIQUES

A variety of IBC techniques have been proposed, which can be grouped into three main approaches: galvanic coupling, capacitive coupling and waveguide methods. The first two rely on the coupling of low frequency, low-level currents and voltages into the human body, respectively, whereas in the last technique, an electromagnetic wave propagates through the body, which is commonly associated with the use of higher frequencies, thus involving a non negligible radiation component into the air.

In general, IBC can be classified into two basic coupling types (i.e. how the electrical signals are transmitted): capacitive coupling (Electric field) and the galvanic coupling (Waveguide). For both coupling types the transceiver needs two pair of electrodes. In capacitive coupling only one of the electrodes (signal electrode) of the transmitter side and receiver side is attached to the body while the other electrode (ground electrode) is floating. In the galvanic coupling method both electrodes of transmitter and receiver side are attached to the human body.

The theory of capacitive coupled IBC shown in fig.4.1, is established based on the capacitive coupling of the human body to its surrounding environment. The signal is generated between the body channel transceiver by making a current loop through the external ground. The signal electrode of the transmitter induces the electric field in to the human body. The induced electrical signal is controlled by an electrical potential and the body acts as a conductor with the ground as the return path.

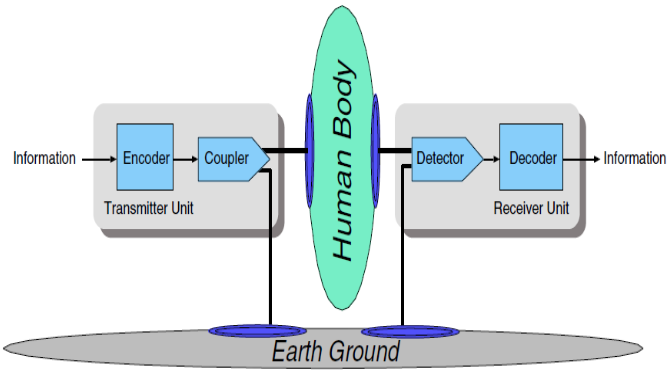

Fig.4.1 Capacitive coupling for data transmission between transmitter and receiver units: One signal path is established through the human body while the return path has to be connected by earth ground.

On the other hand, galvanic coupling shown in fig. 4.2, is achieved by coupling alternating current into the human body. It is controlled by an AC current flow and the body is considered as a transmission line (waveguide). In the galvanic coupled IBC an electrical signal is applied differentially between the two electrodes of the transmitter. Major propagation of the signal occurs between the two transmitter electrodes and a largely attenuated signal is received by the two receiver electrodes.

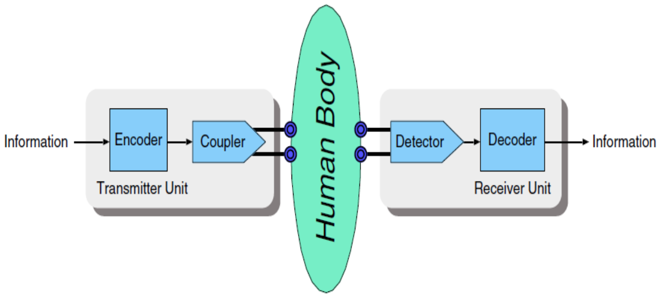

Fig.4.2. Data transmission by galvanic coupling between transmitter and receiver units: Differential current is coupled into the human body by the pair of coupler electrodes and sensed by the pair of detector electrodes.

V. IBC Transceiver Design

In communication systems design several challenges need to be addressed. Channel characteristics are the main challenge for an ideal communication system design. Typically, transmitter, communication channel, and receiver comprise three fundamental stages of any communication system. The transmitter is composed of several sub systems: an analog-to-digital converter (ADC) an encoder, and a modulator. Likewise, the receiver may include a demodulator, a decoder, and a digital-to-analog converter (DAC). A communication channel refers to a physical transmission path which allows the propagation of the signal. It determines the technique to be used in a real communication.

A communication channel functions relatively like a filter that attenuates the signal and causes transmission signal loss. The channel distance affects the signal attenuation, where larger distances result in more attenuation. Furthermore, frequency dependent gain characteristics and multipath effects cause transmission wave shape distortion. These phenomena necessitate deeper understanding of the transmission medium to design more effective IBC transceivers.

A distinctive feature of IBC is to design efficient hardware transceivers, the hardware complexity of units including size, power, and cost must be minimized . However, there is no definite principle to obtain the best electronic design of an IBC system. Power consumption, data rate, carrier frequency, and modulation method are the main concerns. Therefore, the IBC transceiver should be simple, have full integration ability, consume low power, and have the ability to transmit at low power. Since power hungry transceiver nodes need large batteries, power sources like solar cells appear to be suitable for IBC. At the same time, low voltage operation is required for IBC due to health and safety reasons e.g. direct contact with the body.

Several IBC transceiver designs have been proposed based on capacitive and galvanic coupling approaches. However, no acceptable standard has been established to implement an optimal design of a full intra-body transceiver system in terms of carrier frequency, modulation scheme, data rate, and power consumption.

VI. CHARACTERISTICS OF IBC TECHNIQUES

The IBC technique have the following desirable characteristics.

- ***Security:*** The IBC system is a protected and private communication network which provides natural security and interference-free communication. The required operating frequency of IBC is much lower compared to RF systems. This means signals are confined to the person's proximity since reading data requires body contact. There is no signal leakage through the skin in IBC method and environmental noise has less effect on communication. At higher frequencies (300 MHz to several gigahertz), the signal wavelength becomes comparable to the human body channel length and body radiates energy acting as an antenna (dipole antenna). Since transmitter and receiver contain small size electrodes (for example Neuroline electrodes active area is 54 mm2) instead of antennas, the larger wavelength of the carrier signal compared to the electrode size results in interferencefree IBC below 300 MHz.
- ***Energy consumption*:** The key issue with RF propagation in portable devices is that it consumes battery life quickly. For example Zigbee has maximum data rate of 250 kb/s at 26.5mW resulting in 106 nJ per received . The energy consumption of UWB is 2.5 nJ/b when data rate was 16.7 Mb/s. Bae *et al.* recently demonstrated that IBC consumes an order of magnitude less energy (0.24nJ/b) at data rates up to 10 Mb/s which makes it an attractive communications method for WAN applications.
- ***Frequency reuse:*** IBC forms a short range communication network inside and around human body and therefore allows the same frequency band to be reused by WBANs on other users with minimal interference. This property potentially allows future designs to focus on improving data rates, reducing power consumption, and integrating smaller form factors.

VII. CATEGORIZATION OF IBC

Considering realistic application scenes, intrabody communication can be categorized into three types, as follows:

1) communication between a mobile terminal and a terminal embedded in the environments;
2) communication between two mobile terminals;
3) communication between two terminals embedded in the environments.

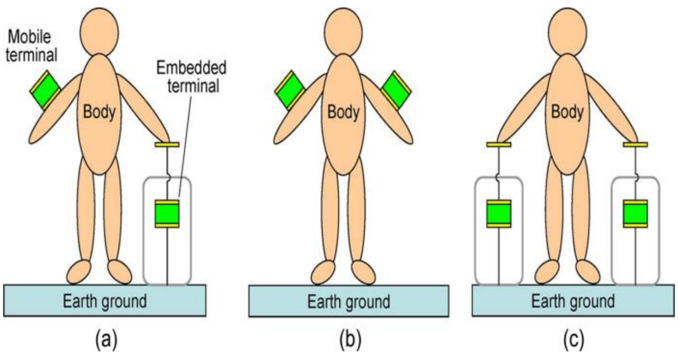

Fig. 7.1 Typical three situations of intrabody communication. (a) Mobile embedded. (b) Mobile to mobile. (c) Embedded to embedded.

VIII. FEATURES OF IBC SYSTEM

IBC system has three main functional features:

a) Touch:-

- Communication With Just a Touch Or Step
- Touching, gripping, sitting, walking, stepping and other human movements can be the triggers for unlocking or locking, starting or stopping equipment, or obtaining data. Using RedTacton, communication starts when terminals carried by the user or embedded in devices are linked in various combinations through physical contact according to the human's natural movements.

b) Broadband & Interactive:- Duplex, interactive communication is possible at a maximum speed of 10Mbps. Because the transmission path is on the surface of the body, transmission speed does not deteriorate in congested areas where many people are communicating at the same time. Taking advantage of this speed, device drivers can be downloaded instantly and execute programs can be sent.

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IX. APPLICATIONS

IBC system has wide variety of applications, some of the applications are as follows:

a) One to One Services :

-Enable one-to-one services tailored to the user's situation and tastes.

b) Elimination of human error: IBC devices embedded medicine bottles transmit information on the medicines attributes. If the user touches the wrong medicine, an alarm will trigger on the terminal he is carrying. The alarm sounds only if the user actually touches the medicine bottle, reducing false alarms common with passive wireless ID tags, which can trigger simply by proximity. Avoidance of risk at construction sites. (an alarm sounds if special equipment is handled by anyone other than supervisors).

c) Marketing Applications: When a consumer stands in front of an advertising panel, advertising and information matching his or her attributes is automatically displayed. By touching or standing in front of items they are interested in, consumers can get more in-depth information. Inside a shop, shoppers can view related information on their mobile terminals immediately after touching a product.

4) An Alarm: IBC devices embedded medicine bottles transmit information on the medicines attributes. If the user touches the wrong medicine, an alarm will trigger on the terminal he is carrying. The alarm sounds only if the user actually touches the medicine bottle, reducing false alarms common with passive wireless ID tags, which can trigger simply by proximity as shown in fig.

5) Intuitive Operations Natural movements and actions are the trigger (touch). IBC transceivers embedded in two terminals can communicate not only data but also the control or configuration instructions needed to operate devices (broadband & interactive).

6) Instant Private Data Exchange: By shaking hands, personal profile data can be exchanged between mobile terminals on the user.(Electronic exchange of business cards) Communication can be kept private using authentication and encryption technologies. Group photos taken with digital cameras are instantly transferred to individual's mobile terminal. Diagrams written on white boards during meetings are transferred to individual's mobile terminals on the spot.

7) Personalization of Mobile Phones: Your own phone number is allocated and billing commences. Automatic importing of personal address book and call history. The PC is configured to the user's specifications simply by touching the mouse.

8) Conferencing System: An electrically conductive sheet is embedded in the table. A network connection is initiated simply by placing a laptop on the table. Using different sheet patterns enables segmentation of the table into subnets. Walls and partitions can be used as communication media, eliminating construction to install electrical wiring. Ad hoc networking using conductive liquid sprays is possible.

9) Wearable: IBC device can carry music or video between headsets, mobile devices, mobile phones, etc. Users can listen to music from a IBC player simply by putting on a headset or holding a viewer.

10) Security Applications Automatic user authentication and log-in with just a touch. ID and privileges are recorded in a mobile IBC device. Corresponding IBC receivers are installed at security check points. The system can provide authentication and record who touched the device, and when.

X. CONCLUSION AND FUTURE SCOPE

IBC is a new short range non-RF wireless communication technology specified by the IEEE 802.15.6 using human body as a transmission medium. Many authors have presented the issues and challenges of this field in their papers. Still research is going on to address different issues.

Further the rapid increase in healthcare demand has also seen novel developments in health monitoring technologies such as body area network (BAN) paradigm. BAN technology consists of a network of sensors which operates continuously and measure critical physical and physiological parameters like mobility, heart rate and glucose level. The IEEE 802.15.6 standard for WBAN, postulates the maximum data rate of IBC as 1312.5 kb/s in the 21 MHz frequency band. So the Intrabody communication is an alternative option in BAN.

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