COMPARISON OF APPROACHES TO INTRA-BODY COMMUNICATION

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***Abstract* - Intra-body communication (IBC) is a new, "wireless" communication technique that enables electronic devices on or sometimes near the body to exchange the information. It uses the dielectric properties of human tissues so that human body can be used as the communication channel for data exchange. Transmitting data directly through the skin is can be much more efficient than current wireless transmission technologies (Bluetooth, Wi-Fi), since it requires much less energy. In this paper the concept of Personal Area Networks (PANs) is presented to demonstrate how electronic devices on and near the human body can exchange digital information through the body. Various methods available for Intra-body communication are studied and presented. The advantages of this method over current wireless communication techniques are discussed along with possible limitation. The technology can have a wide range of applications, hence future scope of the system is presented.**

***Keywords* – Intra-body communication, Waveguide, Galvanic coupling.**

I. INTRODUCTION

Intra-body Communication (IBC) is a new way for electronic devices to communicate with each other. Rather than connecting them by wire or transmitting a radio signal, IBC uses the human body to conduct an imperceptible electrical signal. Devices send and receive the signal using dry electrodes: conductive surfaces of several square centimeters in close contact with the skin. Because signals pass through the human body, electromagnetic noise and interference have little influence on transmissions; while the signals are largely contained by the skin.IBC can also be used to communicate between wearables and devices in the environment. A person’s identity, access privileges, or other customization information can be transmitted. Intra-body communication is a new method to connect mobile devices on and inside the human body. This technique of using the human body as a signal transmission medium has many advantages over the conventional RF approaches. Since its operation is based on near-field coupling, most of the signal from the transmitter is confined to the body area without interference with external RF devices. Since the communication frequency can be lowered without enlarging antenna size, the power consumption of the transceiver is also much reduced compared to Bluetooth and Zigbee radios.

IBC has the characteristics of high transmission quality, high data rate, high security, easy network access and no communication bandwidth problem, etc.Methods for intra-body transmission can be divided into three types: the simple circuit, electrostatic coupling, and waveguide which are further discussed in the report.

The concept of intra-body communication was first proposed by IBM in 1996. This communication mechanism was later evaluated and reported by several research groups around the world. All those reported technologies had two limitations: the operating range through the body was limited to a few tens of centimeters and the top communication speed was only 40 bit/s. These limitations were overcome by NTT (Nippon Telegraph and Telephone Corporation) located in Tokyo, Japan by using photonic electric field sensors and finally came up with a human area networking technology called ‘REDTACTON’. It considered the electrostatic coupling type of transmission.

II. RELATED WORK

User-centered wireless communication can be divided into wide, local, and personal area network. Wide area network is represented by satellite network and cellular network. Local area network consists of WLAN (Wireless LAN). Personal area network is about connecting person and devices and can be very close. This leads to BAN (Body Area Network). Recently, in a society that is becoming ubiquitous, BAN is attracting more attention in research. BAN can be realized using physical contact or touch as a natural action to communicate. One of the proposed communication technologies to achieve these goals is intra-body communication (IBC).

The development of WBAN technology started around 1995 by considering wireless personal area network (WPAN) technologies for communications on, near and around the human body. Later around 2001, this application of WPAN has been named as body area network (BAN) to represent the communications on, in and near the body only. A WBAN system can use WPAN wireless technologies as gateways to reach longer ranges**.**

WBAN is studied for data transfer as well as in medical field .The sensors of a WBAN measure for example the heartbeat, the body temperature or record a prolonged electrocardiogram. A survey on wireless body area network has been conducted by Benoit Latre, Bart Braem.

Several approaches for communicating with implanted devices using the body as the communication channel has been proposed and tested. Each of these methods offers some insight in how such communication system can be realized. Intra-body communication offers several advantages over wires and RF wireless technologies for communicating with implanted devices.

However literature also shows that it is a new technology and several challenges, especially improving power delivery and thoroughly evaluating safety, need to be addressed before it is implanted in humans and used for routine clinical applications such as physiological monitoring.

III. TYPES OF IBC

There are two methods of Intra Body Communication:

- electrostatic coupling
- waveguide

1. Electrostatic coupling

The basic difference between the two types is that, in electrostatic coupling technique, devices have to be grounded. Zimmerman used this type of transmission in the study of PAN (Personal Area Network). Electrostatic coupling is independent of an external wire, but transmission quality is dependent on the surrounding environment. Electrostatic coupling ensures that the signal or data are transmitted between the transmitter and the receiver - assuming that a suitable capacitance coupling is available to provide earthing between the input and output circuits. The signal is transmitted between the body channel transceivers by making a current loop, which is composed of the transmitter electrode, the body channel, the receiver electrode, and the capacitive return path through the external ground. In this model, the human body is modeled as a perfect conductor, and the electric couplings among the electrodes of the transceiver, body, and environment are modeled as capacitors. Before passing the signals through body, they are encode by the encoder and on receiving they are decoded.

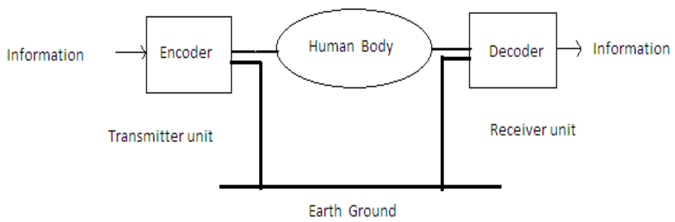

Fig1 . Electrostatic coupling technique

2. Waveguide

In this method, the human body is treated as a waveguide. This technique does not require the connection with the ground. This technique is also known as galvanic coupling. The high-frequency electromagnetic waves are generated at a input terminal which are propagate through the body and are received by another terminal. External wires are not necessary and transmission quality is not affected by an individual's surroundings. In waveguide Intra-body communication, a pair of transmitter electrodes imposes differential signals into the body and the body is used as waveguide to propagate the signal. At the other end, the signal is detected by the receiver electrode pair. Waveguide IBC generally achieves low data rate in the kbps range because the body effectively shorts the transmitter electrodes. Waveguide technique has some subtypes on the basis of the location of the electrodes which are to be places either on the body surface or implanted in the body.

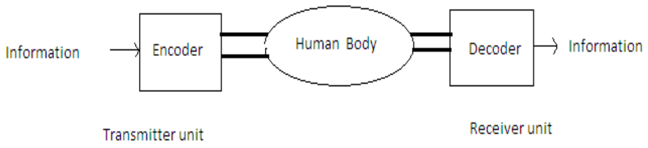

Fig.2 Waveguide technique

Types of Waveguide methods:

1. *Implant to surface communication:*

In implant-to-surface communication, galvanic coupling is used to send signals from a device implanted in the body to electrodes on the skin. In order to improve the quality of signal reception, this method allows for easy placement and repositioning of the skin electrodes. But signals have to travel through the skin, which is less conductive than many of the tissues inside the body, more signal attenuation occurs in implant to implant communication.

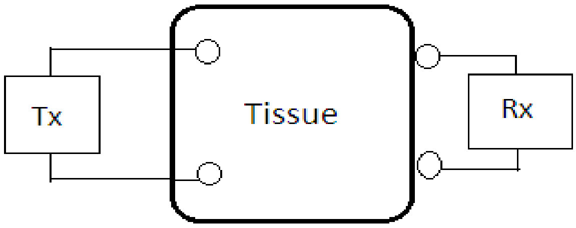

Fig.3.Implant to surface

2. Surface to surface communication:

In Surface to surface communication, devices are mounted on the skin. Surface-to-surface communication allows for quick and easy positioning of electrodes, fewer constraints on the size and power demands of the transmitting devices, and avoids surgical implantation. But, in this type, the sensors are on the skin and not implanted like in case of the implant to implant or implant to surface, hence many times they are far from the sources of the signals that are being measured and can result in weak, distorted or indirect physiological measurements compared with implanted sensors. Nevertheless, surface-to-surface signals can be combined with signals from implanted devices to create a network of sensors across and inside the body which will give further better result.

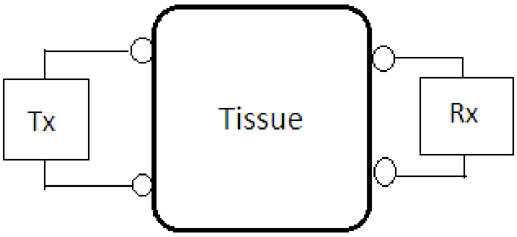

Fig.4.Surface to surface

3. Implant to implant communication:

In implant-to-implant communication, both the transmitter and the receiver are implanted

Inside the body, thus signals are transmitted from the implanted device to receiver electrode. The implanted receiver can then be connected to equipment outside the body using a short wire or with wireless RF telemetry or with implant to surface communication, again forming the network of Intra Body communication. However, the implanted receiver electrodes cannot be as easily repositioned as skin-mounted receiver electrodes. In this way, less power is needed to transmit to the implanted receiver electrodes than to electrodes on the skin.

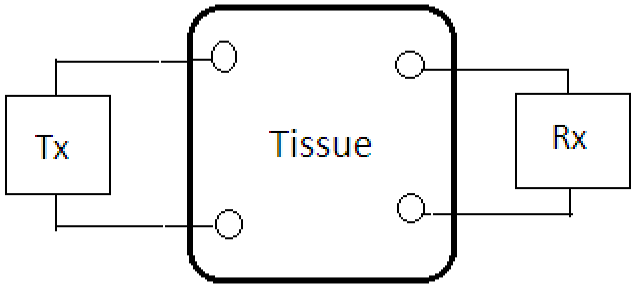

Fig.5.Implant to implant

IV. ADVANTAGES OF IBC

- Since signals pass through human bodies, electromagnetic noise and obstacles have little influence on transmission, and the signals do not leak through the skin.
- In IBC, the signal strength falls off very quickly with distance from the transmitter or person. Radio signal power drops with the square of distance; IBC drops with the cube of distance. This property can be advantageous. The signal is therefore more difficult to intercept, which is desirable for secure transmissions.
- The signal is also more isolated from IBC signals generated by transmitters carried by other people. Also, no ambiguities arise when an environmental device tries to contact the wearable of the user touching the environmental device's UI. Only wearables of the correct user can be contacted; other wearables are out of range.
- Using IBC power is saved and devices can be made smaller.
- It also allows eliminating cumbersome wiring.
- Instant private data exchange.

V. DISADVANTAGES OF IBC

- Low bandwidth: Low bandwidths were characteristic of the first IBC systems. Zimmerman's original system ran at 2400 bps.
- Signal attenuation: A second major problem is signal attenuation. Starting from a transmitter voltage of 20V, the received signal strength might be attenuated to the nanovolt or even picovolt range, making reception very difficult.
- The third major problem IBC faces is a large number of design variables. In addition to coupling location, other factors such as electrode size, transmit voltage, receive gain, most effective frequency, noise sources, and other interfering transmitters affect the overall system performance. The effect of all these parameters is not well understood.
- While short-term electrical damage (e.g. shock) is unlikely in a well-designed system, the long-term effects of electric fields are unknown. Many epidemiological studies have been performed to search for a link between electrical and magnetic fields and cancer, but the results have been inconclusive.

VI. COMPARISON

The two methods of Intra Body Communication namely, the Electrostatic Coupling method and the Waveguide/Galvanic Coupling method have been analysed here.The merits and demerits of these approaches have been compared and appropriate conclusions have been made.

The important difference between the two solutions is that the communication behaviour in the electrostatic coupling approach is strongly influenced by the environment around the body. While in the galvanic coupling approach it is more influenced by the body physical parameters.

Electrostatic coupling is not dependent on an external wire, but the transmission quality is dependent on the surrounding environment. Whereas when the human body is treated as a waveguide, the high-frequency electromagnetic waves are generated at a terminal and propagated through the body, and is received by another terminal .In this method, external wires are not necessary and also the transmission quality is not affected by the surroundings. Thus,in waveguide intra-body communication methods, external cables are not required , with signals transmitted by high-frequency carrier waves.

In the galvanic technique does not require the connection with the ground. This technique is also known as galvanic coupling. The high-frequency electromagnetic waves are generated at an input terminal which are propagate through the body and are received by another terminal. External wires are not necessary and transmission quality is not affected by an individual's surroundings.

Waveguide IBC generally achieves low data rate in the kbps range because the body effectively shorts the transmitter electrodes. It makes use of the dielectric characteristics of human tissue, therefore the flow of ions within the human body is the carrier of information. Here, the human body acts as a special kind of transmission line.

While for galvanic coupling, electrodes need to be placed on the skin directly, for capacitive coupling,

there is no need for a direct human skin contact, however, close proximity of the coupler to the body is required. These electrodes can be structured horizontally or vertically where the spacing between them is filled by a dielectric material.

The Galvanic technique requires neither return path nor common reference. Hence, this feature enables the technology attractive for networking biomedical devices on human body and draws much attention from recent studies

VII. APPLICATIONS

- IBC can allow several wearable devices carried by one person to exchange information and share I/O hardware resources such as speakers and microphones.
- IBC can be useful in clinical monitoring wherein on-body and implanted sensors monitor the vital functions and transfer data through the human body to a central monitoring unit.
- Electromyography measurements using an intra-body communication is also possible. Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscles.
- Now DoCoMo is planning to take contactless technology a big step further and enable people to do things like exchange business card info through a simple handshake, or pass through security doors with the mere touch of a finger, all the while leaving their phone—where the data is stored—in their pocket or purse.

VIII. FUTURE SCOPE

- IBC can also be used to communicate between wearables and devices in the environment. A person's identity, access privileges, or other customization information can be transmitted to unlock doors, annotate digital photos, or tailor TV entertainment.
- People can electronically exchange business cards through a handshake.
- Keyboards and displays in the environment can allow more comfortable user interfaces to wearables.
- IBC has significant potential applications for personal health care

International Research and Development

Near-field intrabody communications technology has attracted much interest in the international research community. A number of organizations are developing intrabody technologies in addition to DoCoMo and Kaiser Technology. Nippon Telegraph and Telephone Corp., for example, has developed a similar technology called RedTacton. Another example is the eGo Project which a group of companies and academics working within a Catrene framework. This group aims to design, develop and promote a new technology named eGo which makes our day- to-day life easy and exciting with various possible applications.Research institutions such as the Korea Advanced Institute of Science and Technology, as well as other corporations including Sony Corp., also are putting their fingerprints on the field of intrabody communications.

To build various future applications IBC has to achieve following goals:

Goals to achieve by IBC

- Achieve touch-only communication
- Increase speed
- Build a deployable board
- Evaluate in practical environment

IX. CONCLUSION

Intra-body Communication (IBC) in which human body is used as a signal was studied in this paper. We have studied two techniques of intra-body communication: electrostatic coupling and waveguide. We observed that that intra-body transmission has many advantages as compared with the current short distance wireless technology, including Bluetooth, Zigbee and so. We studied that IBC has the characteristics of high transmission quality, high data rate, high security, easy network access and no communication bandwidth problem. We studied that IBC allows several wearable devices carried by one person to exchange information and share I/O hardware resources. Due to its unique characters, IBC technology is proposed as a novel and promising technology for personal area network (PAN), computer network access, implant biomedical monitoring, human energy transmission etc.

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