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Abstract: [Channel Characterization for BAN Communications]

Purpose: [To provide an introduction to the channel modeling of BAN]

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Channel Characterization for BAN Communications

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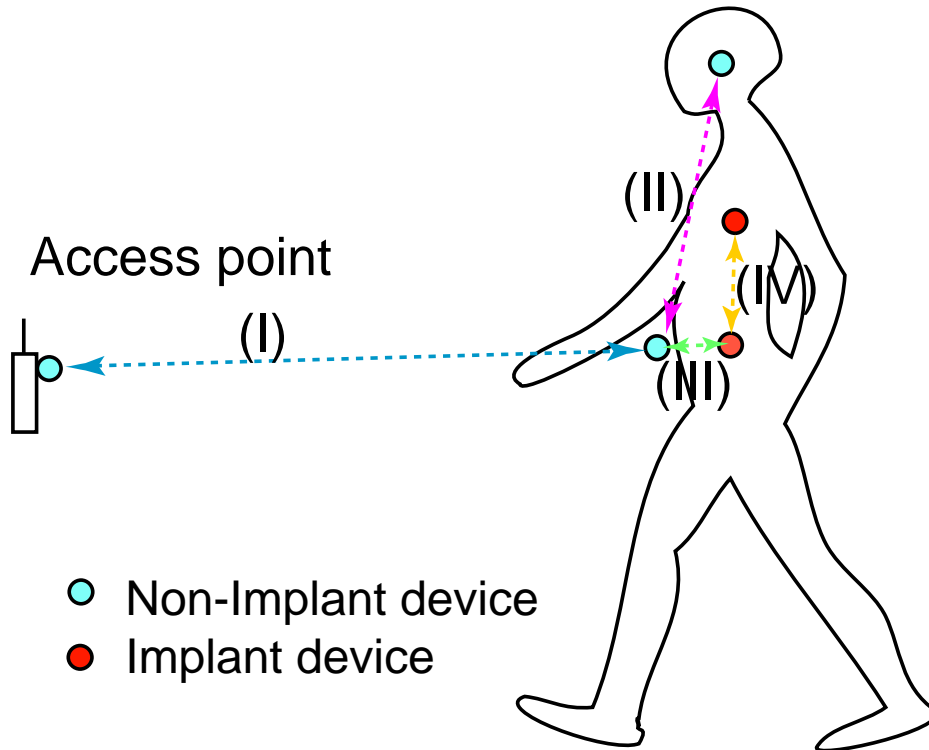
Outline

- Introduction
- Categorization of BAN Channel
- Why a New Channel Modeling for BAN?
- Radiation pattern of Wearable antenna
- Transceiver Locations on the Body
- On-Body Propagation Link
- Antenna Design Consideration
- Antenna Positions and Wave Propagations
- Conclusions
- References

Introduction

- There are several wireless standard for body-worn device, which provides high level of flexibility and comfort, such as:
 - Bluetooth
 - BodyLAN
 - Zigbee
- Variation in the channel for conventional and UWB mobile communications is due to interference between multiple rays scattered from walls or furniture in the indoor case and buildings in the outdoor case.
- Mostly using vertically polarized omni-directional antennas
- There are a few criteria for BAN channel:
 - Must be small and lightweight (needs high frequency)
 - Consumes minimum power, with high efficient link
 - Must support high data rate for future
 - Effect of human body must be consider

Categorization of BAN channel



BAN Channel

- (I) Access point to surface of body
- (II) Surface of body to surface of body
- (III) Surface of body to inside body
- (IV) Inside body to inside body

Assumption; channel models are based on a single hop while multiple hops are available for indirect or relayed transmission in case (II).

Case (I) is almost PAN, however, channel model is different from PAN case. Antenna has directivity, and is effected by absorption of body.

Why a New Channel Modeling for BAN?

- Significant variation in the channel for communications between terminals mounted on the body:
 - Local scattering
 - Changes in the geometry of body
 - Standing or sitting
 - Normal activity
 - Extreme activity (sport)

Why a New Channel Modeling for BAN?

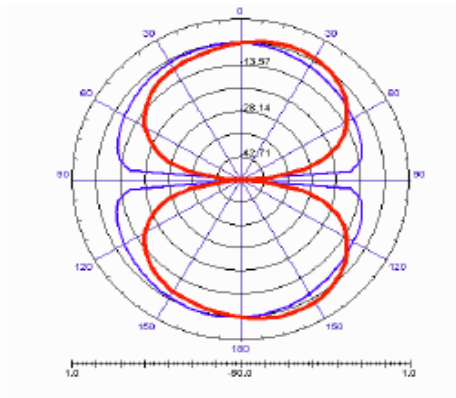
- Effect of changes in the body geometry:
 - Effect on operation of antenna
 - Radiation Pattern
 - Matching
 - Communications paths on the body

Why a New Channel Modeling for BAN?

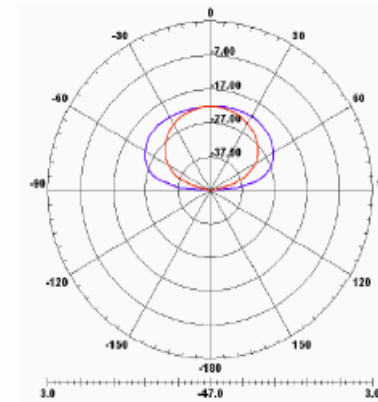
The effect of the proximity of the human body on the BAN unit:

- On the far side of the body (transmitter), there will be a deep null caused by absorption of power by the body
- Loss of BAN communication due to the antenna pattern null

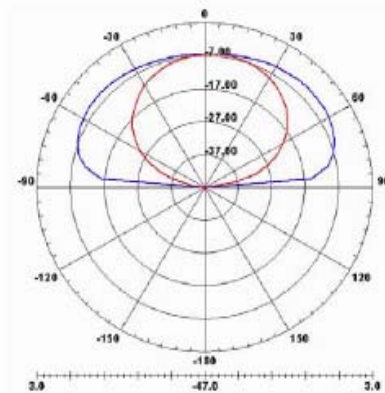
Radiation pattern of Wearable antenna (Simulation) at 4.1 GHz for x-z Plane



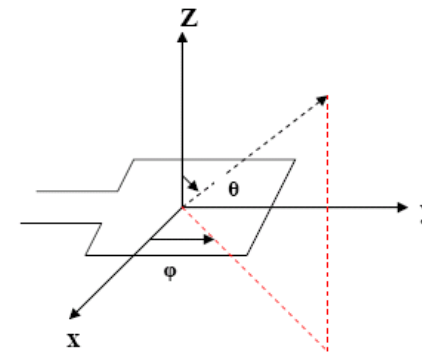
Free Space



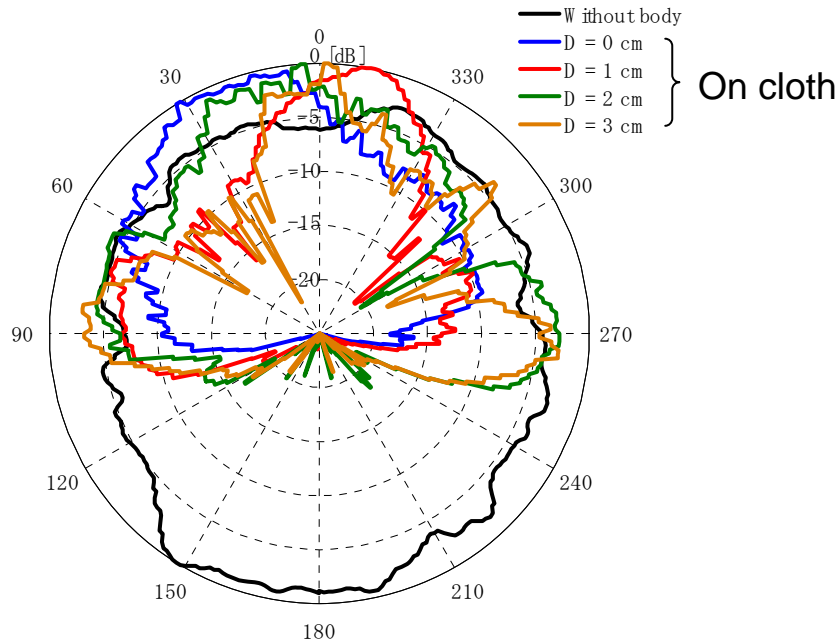
Direct Contact



1.4 cm far from body



Radiation pattern of Wearable antenna



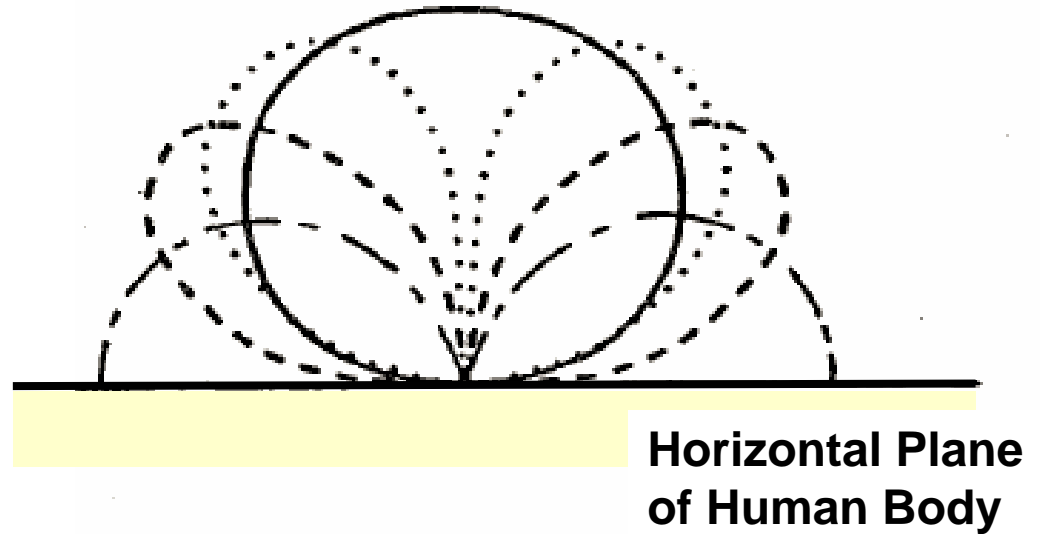
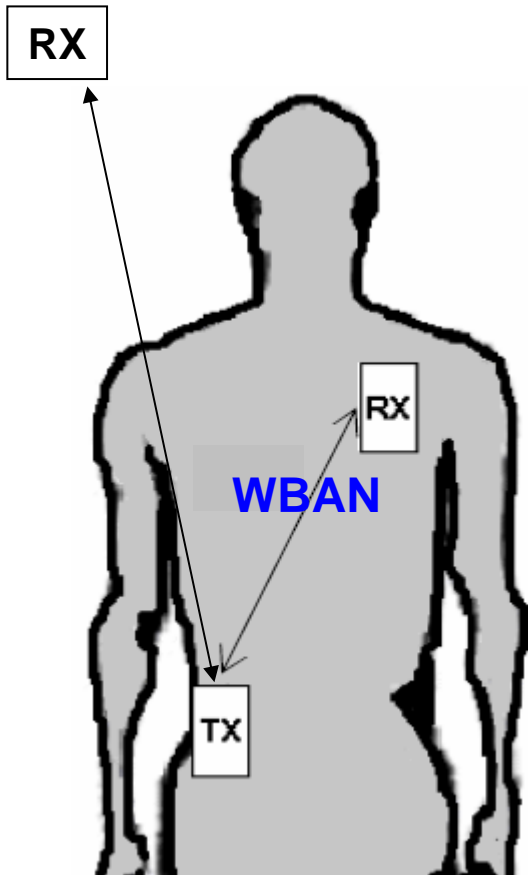
Antenna pattern in H-Plane



Skycross antenna on body
 $f = 6.85$ GHz

- Radiation pattern is changed due to distance between antenna and human body
- Backlobe is absorbed by human body
- Side lobe is appeared toward side of body

Antenna Beam Patterns for WBAN

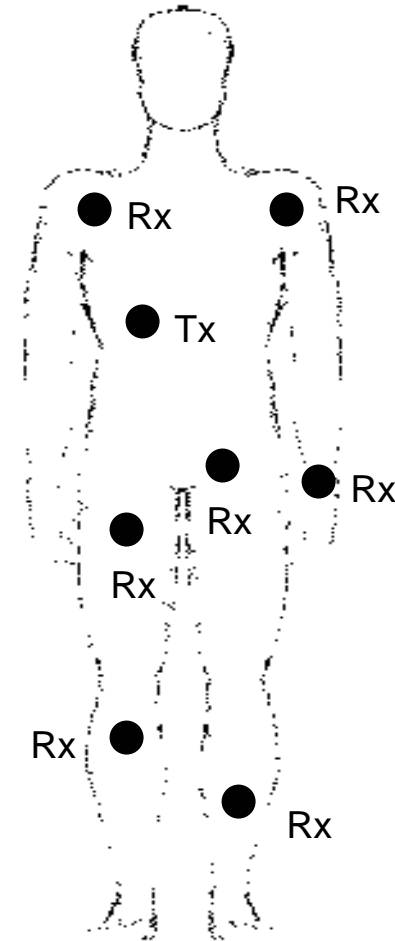


- Pattern 0
- Pattern 1
- - - - Pattern 2
- . - . Pattern 3

- Unidirectional (pattern 0) vs. Conical beam (pattern 1, 2, 3)

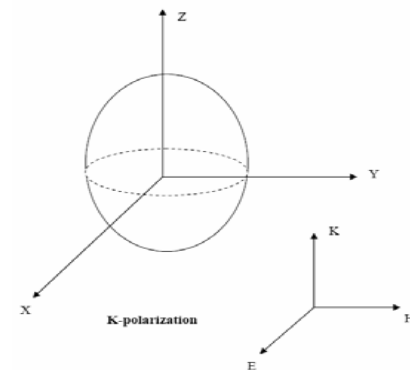
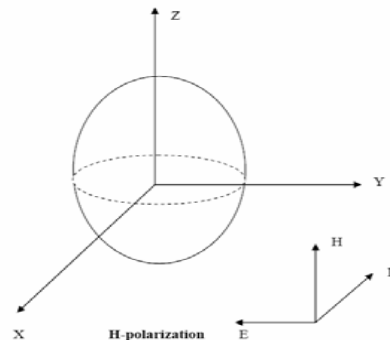
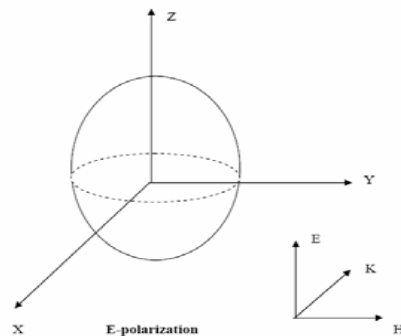
Transceiver Locations on the Body

- **Transmitter/ Receiver Position:**
The freedom to change transmitter/ Receiver position adds dependencies to a wireless BAN channel representation.
- **Transmitter/ Receiver Orientation:**
A transmitter/ receiver may be reoriented in any direction in space, which changes the polarization and gain pattern interaction of the transmitter/ receiver antenna

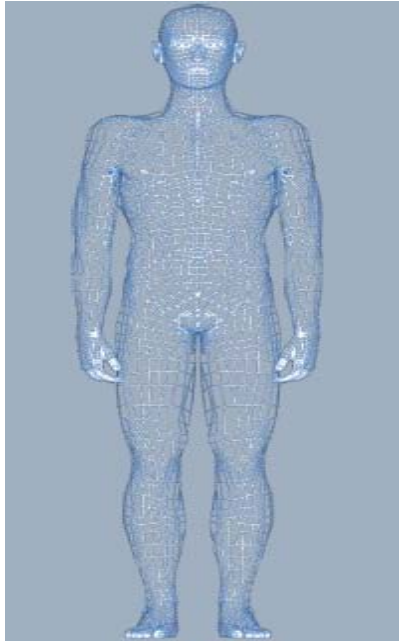


Orientation of Incident Field

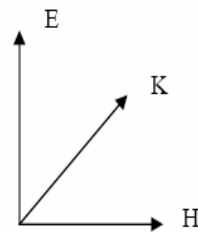
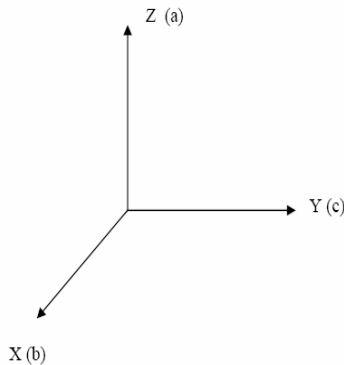
- Orientation of incident Electric field (E) and Magnetic field (H) with respect to the irradiated object has a very strong effect on the strength of fields.
- Polarization for objects of revolution (circular symmetry about the long axis) is defined by the incident field parallel to the long axis of the body (z).



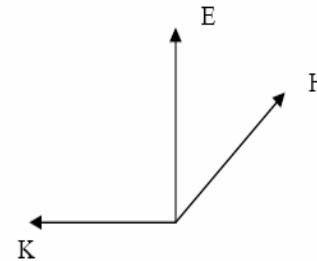
Planes & Polarization for Human Body



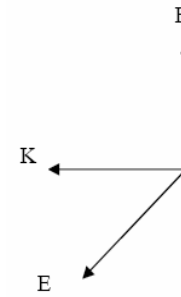
The X-Y plane parallel to the ground
 The X-axis going from left to the right
 The Y-axis passing from front to the back
 The Z-axis going up and down



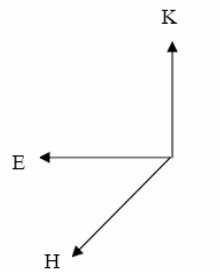
EHK polarization



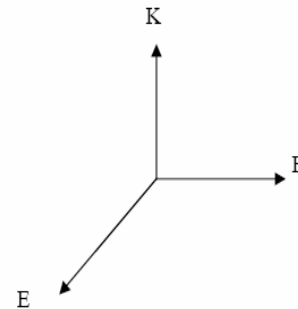
EHK polarization



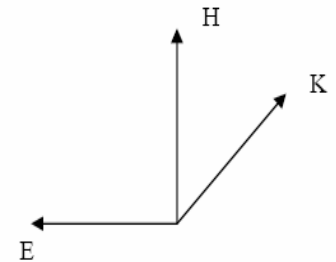
HKE polarization



KEH polarization



KHE polarization



HEK polarization

On-Body Propagation Link

On-body propagation link can be categorized according to the parts of the body at which the transmitter and receiver antennas are placed:

- Trunk to Limb, significant variation due to the movement of the limb
- Trunk to Trunk, more stable

Antenna Positions and Wave Propagations

- The path gain is highly dependent to the antenna type and link geometry. The antenna positions are strong effect on the propagation mode;
 - Chest to Chest, the propagation will be predominantly due to a creeping wave
 - Chest to Arm;
 - 1- free-space path (arm in the front of body)
 - 2- diffraction around the body (arm in the behind of body)

On body communication

Antenna



Antenna

There are many configurations for antenna on body

Antenna Design Consideration

- There are two primary requirements for on-body antenna:
 - 1- Insensitive to the proximity of body
 - 2- Have a radiation pattern shape that minimize the link loss.
- The influence of the body on antenna reactive fields, which will effect the matching of the antenna

Conclusions

- The properties of BAN (wearable and implant) communications are very different from other forms of communications. They are dependent on:
 - the material properties
 - the antenna design
 - the physical properties of body
- Body will effect the antenna properties
- Communications node on the body are often in the near-field region
- On-body radio communication is strongly dependent to the type of antennas
- One of the distinct features of the BAN radio channel is its variability in path loss and delay profile, due to antenna placement and posture changes
- Body orientation and movements will effect the signal strength in the receiver side

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