An Overview of WBANs

Presented By
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Outline

- Introduction
  - Definition
  - Difference between WSNs and WBANs
- WBAN Routing
  - Routing Related Characteristics
  - Routing Related Problems
  - Routing Strategies
- WBAN Security

Introduction

- Definition
  - Wireless Body Area Network (WBAN) is a collection of low-power, miniaturized, invasive/non-invasive lightweight wireless sensor nodes that monitor the human body functions and the surrounding environment.
- Differences between WSNs and WBANs

Differences between WSNs and WBANs

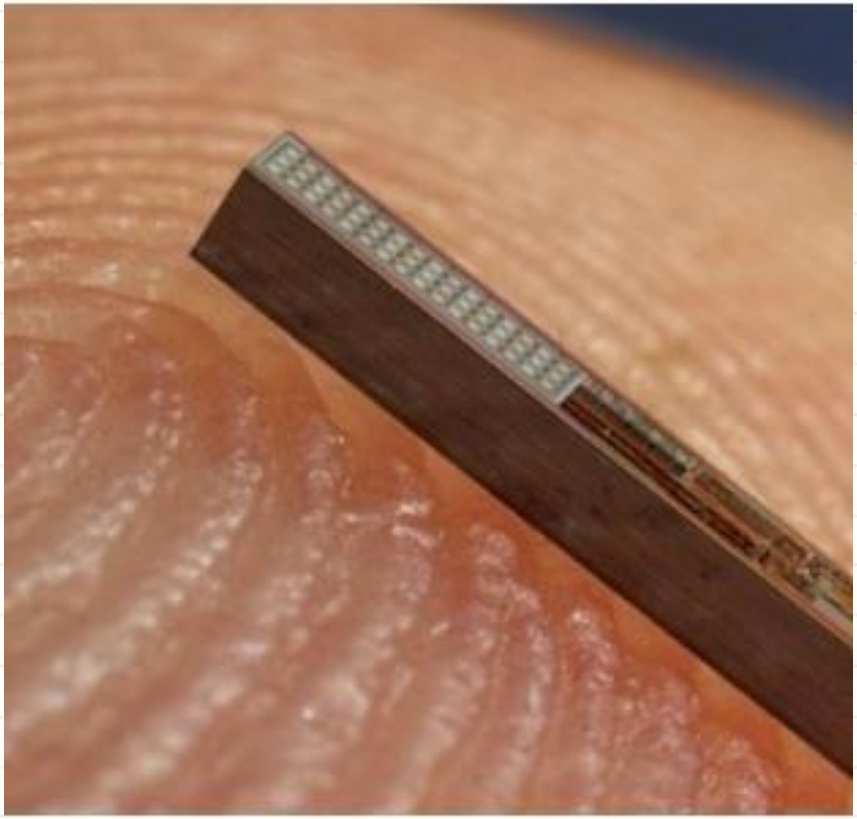
- Node Density
- Use Frequency
- Latency

Introduction

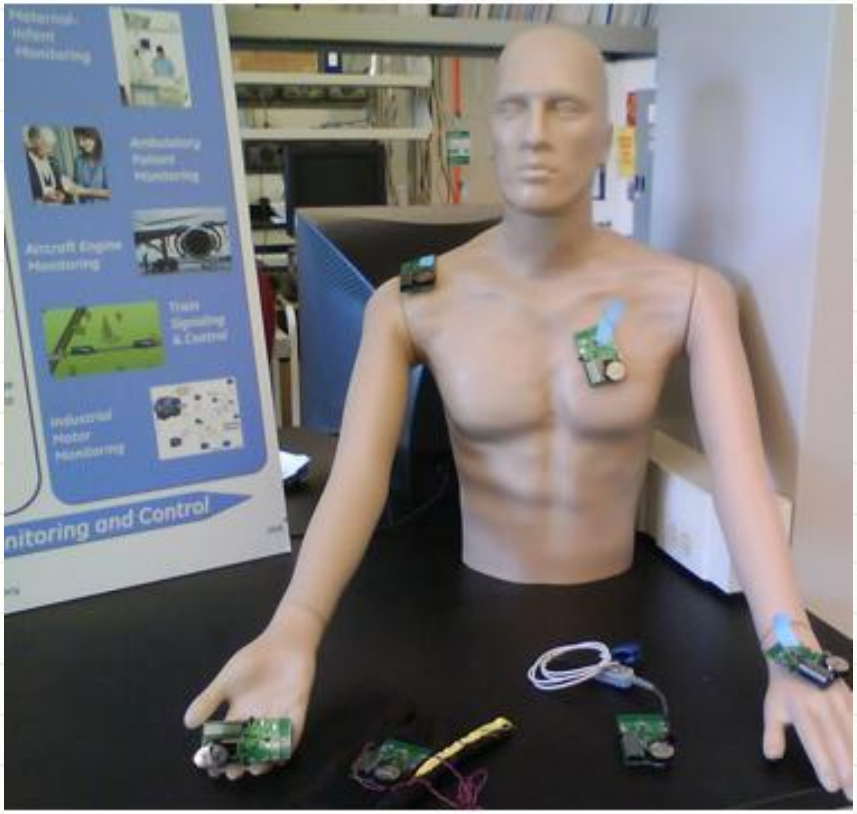
- WBAN
  - Wireless Body Area Network
  - Sensor Network
  - Health Monitoring
  - Fast and accurate

WBAN Sensors

In-Body Sensors



On-Body Sensors



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Routing Related Characteristics

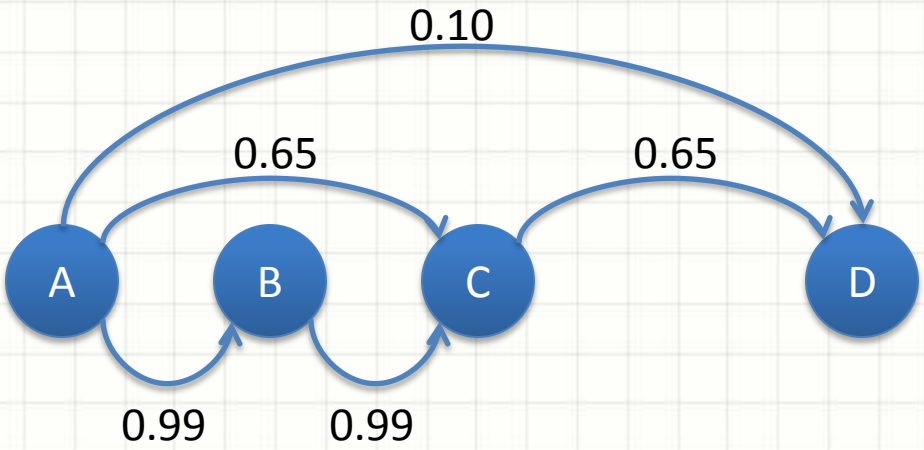
- **Bandwidth**
  - The available bandwidth is limited, shared and can vary due to fading, noise and interference. As a result, the overhead generated by the protocol should be limited.
- **Energy Sensitive**
  - The nodes that form the network can be very heterogeneous in terms of available energy or computing power.
- **Health Concerns**
  - An extremely low transmit power per node is needed to minimize interference to cope with health concerns and to avoid tissue heating.
- **Relative Mobility**
  - The devices are located on the human body that can be in motion. WBANs should therefore be robust against frequent changes in the network topology.

Routing Related Problems

- **Network Topology**
  - Very little research about the most optimal network architectures in WBANs
  - Most researchers assume that a single-hop topology
- **Energy Efficiency**
  - energy consumption of
    - entire network
    - individual nodes
  - single-hop or multi-hop (body)

Routing Related Problems (cont.)

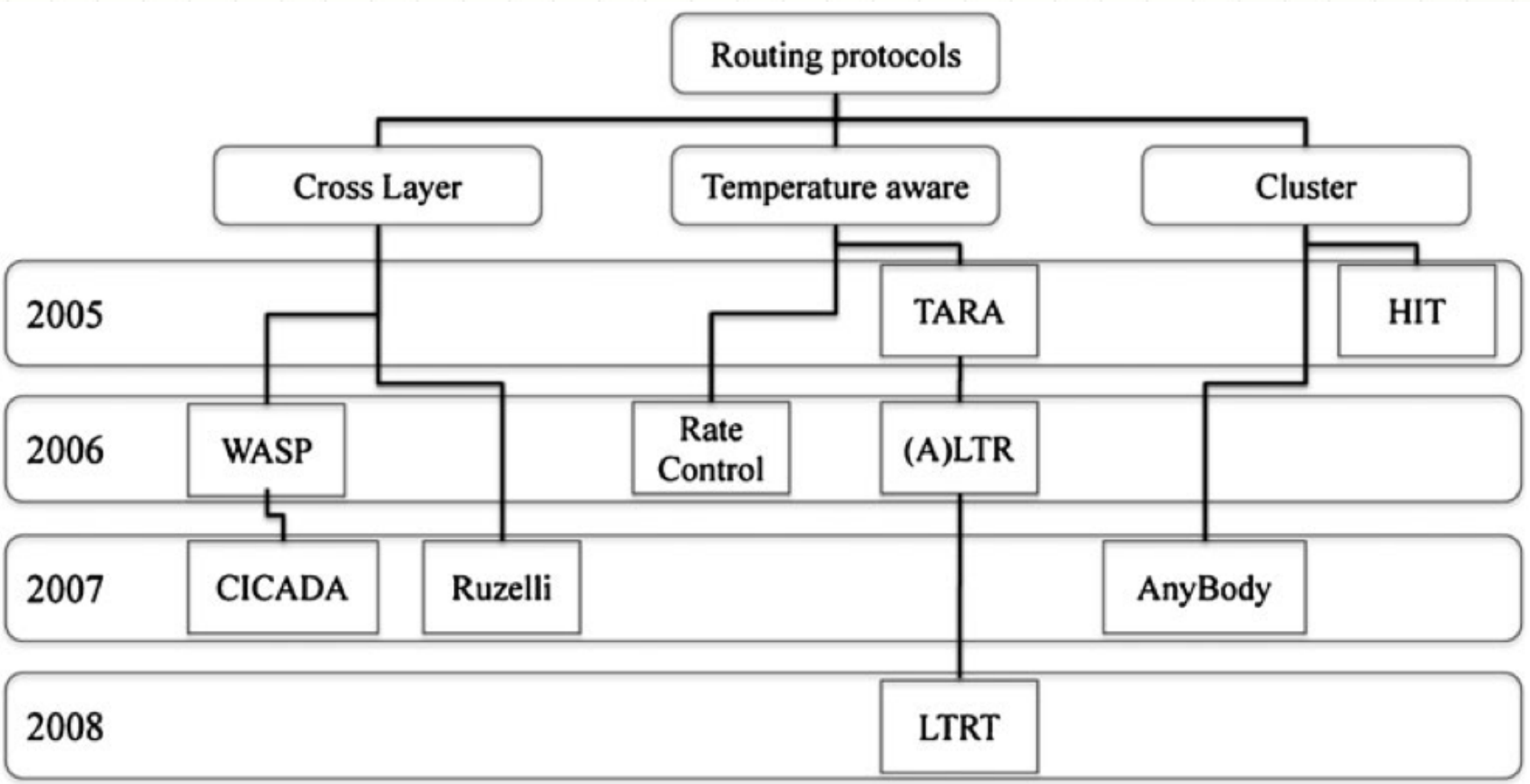
- **Reliability**
  - Earlier, reliability was not considered
  - Some researchers experimentally investigated it by measuring the **packet delivery ratio**
  - Multi-hop strategy turns out to be the most reliable



Routing Strategies in WBANs

- **Temperature Based Routing**
  - radiation absorption and heating effects on the human body
- **Cluster Based Routing**
  - spread the energy dissipation
- **Cross Layer Based Routing**
  - to improve the efficiency of and interaction between the protocols

Routing Protocols in WBANs



"A Comprehensive Survey of Wireless Body Area Networks", Sana Ullah, Henry Higgins, Bart Braem, Benoit Latre, Chris Blondia, Ingrid Moerman, Shahnaz Saleem, Ziaur Rahman, and Kyung Sup Kwak

Temperature Routing

- To avoid heat generation
  - the radio's transmission power should be limited
  - traffic control algorithms should be used
- Bioeffects
  - incident power density
  - network traffic
  - tissue characteristics

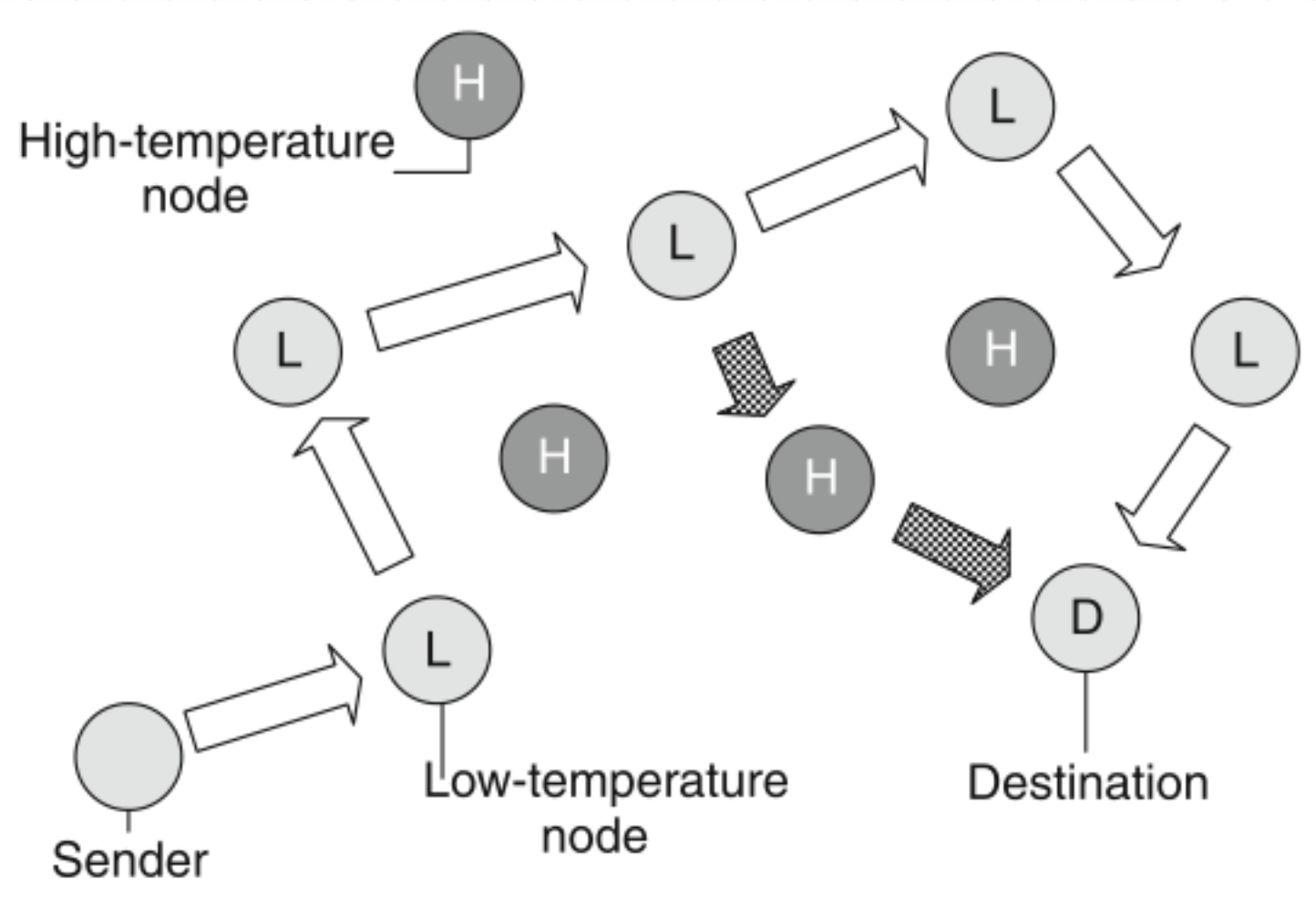
Temperature Routing (cont.)

- Rate Control
  - normalized bioeffect metric or Coefficient of Absorption and Bioeffects (CAB)
  - price-based rate allocation algorithm
- Thermal Aware Routing Algorithm (TARA), Least Temperature Routing (LTR) and Adaptive LTR (ALTR)
  - balance the communication over the sensor nodes

Temperature Routing (cont.)

- TARA
  - routes data away from high temperature areas
  - Each node derive the current temperature of the neighbors by
    - Monitoring neighbors packet counts
    - Calculating the communication radiation and power consumption
  - the temperature of a neighboring node > threshold
    - the packets will no longer be forwarded to the node but will be withdrawn and rerouted through alternate paths

Temperature Routing (cont.)

- 

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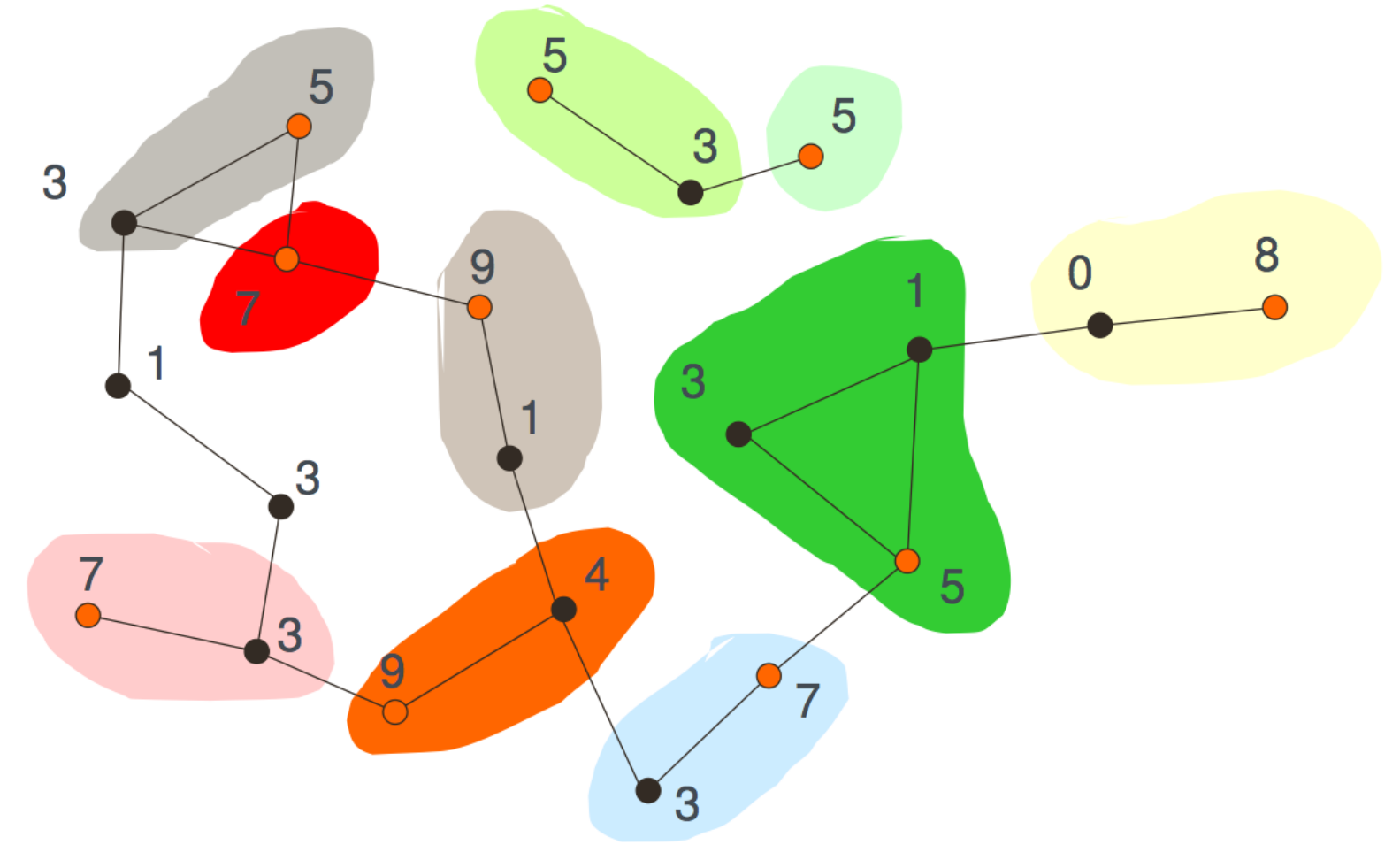
Cluster Based Routing



"AnyBody: a Self-organization Protocol for Body Area Networks", Thomas Watteyne, Isabelle Augé-Blum, Mischa Dohler, Dominique Barthel

Cluster Based Routing (cont.)

- Improvement of LEACH is Hybrid Indirect Transmissions (HIT)
  - combines clustering with forming chains

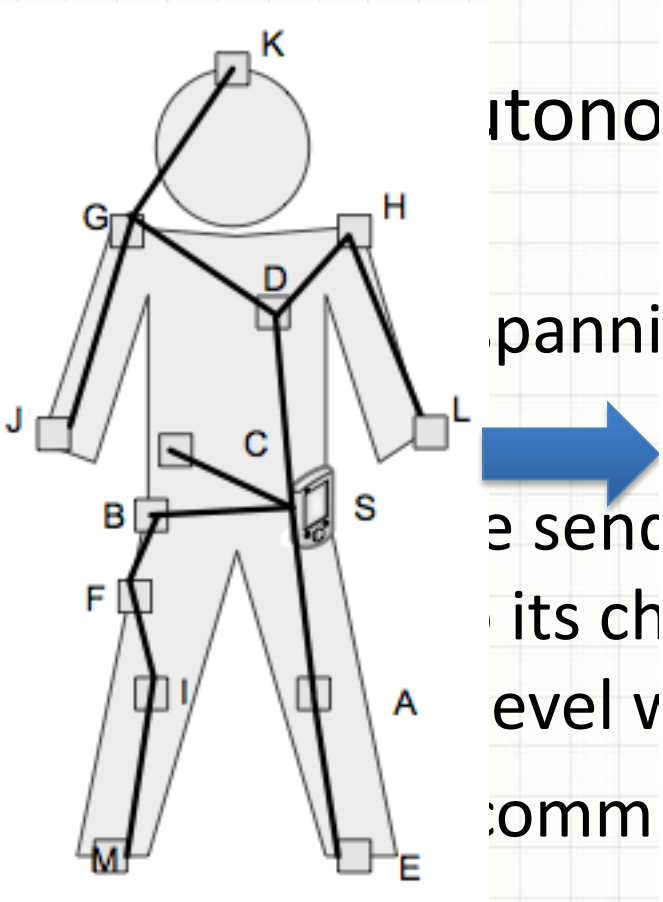
Cross Layer Based Routing

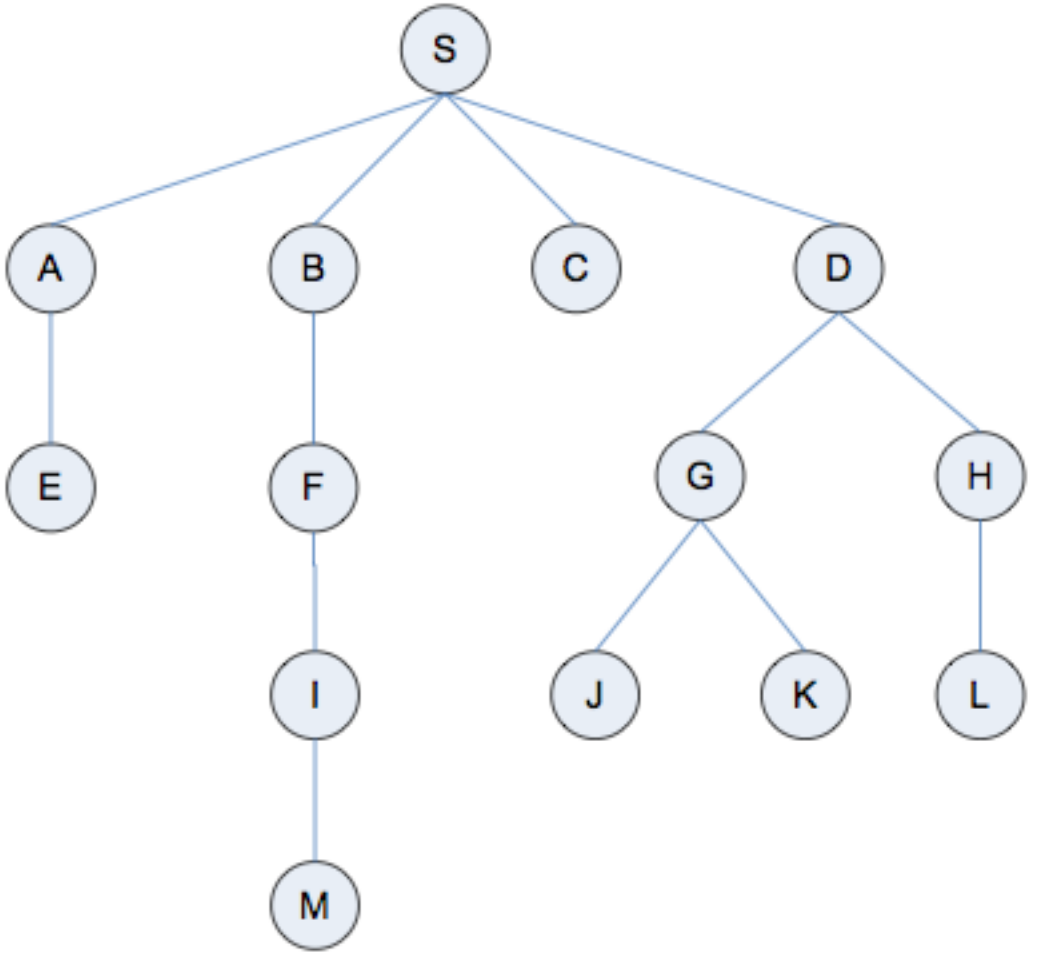
- Cross-layer design is a way to improve the efficiency of and interaction between the protocols in WSNs.
- Little research has been done for WBANs
  - Ruzelli et al. proposed a cross-layer energy efficient multi-hop protocol built on IEEE 802.15.4

Cross Layer Based Routing (cont.)

- Ruzelli
  - multi-hop protocol built on IEEE 802.15.4
  - The network is divided into timezones where each timezone takes turns in the transmission.
  - The nodes in the farthest timezone start the transmission.
  - In the next slot, the farthest one sends its data and so on until the sink is reached.

Cross Layer Based Routing (cont.)





"A Low-delay Protocol for Multi-hop Wireless Body Area Networks", Benoıt Latre, Bart Braem, Ingrid Moerman, Chris Blondia, Elisabeth Reusens, Wout Joseph, and Piet Demeester

Cross Layer Based Routing (cont.)

- Controlling Access with Distributed slot Assignment protocol (CICADA)
  - completely discarding the layered structure and implementing the required functionality in different modules
- Advantages
  - Duplication of functionality can be avoided
  - Heterogeneity is supported as more modules can be added depending on the capabilities of the node
  - Cross layer optimizations are possible
  - Modules can be easily adapted or replaced

Routing Summary

- Temperature Based Routing
  - a specific case of weight based routing
  - reliability and energy efficiency can be hard to guarantee
- Cluster Based Routing
  - based on LEACH
- Cross-layer Based Routing
  - improve the efficiency of and interaction between the protocols

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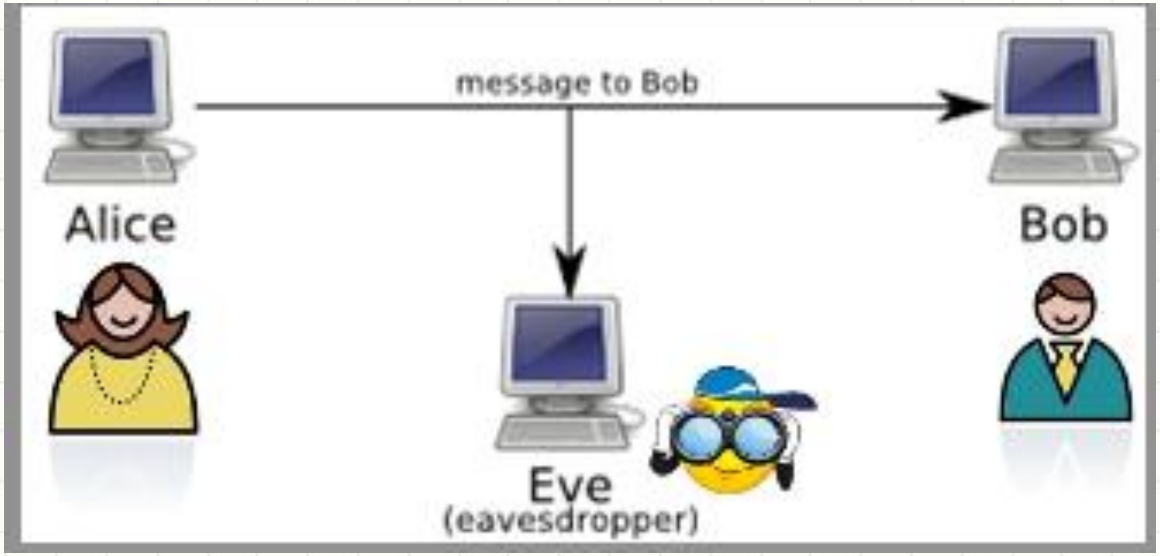
Security in WBAN is CRUCIAL!



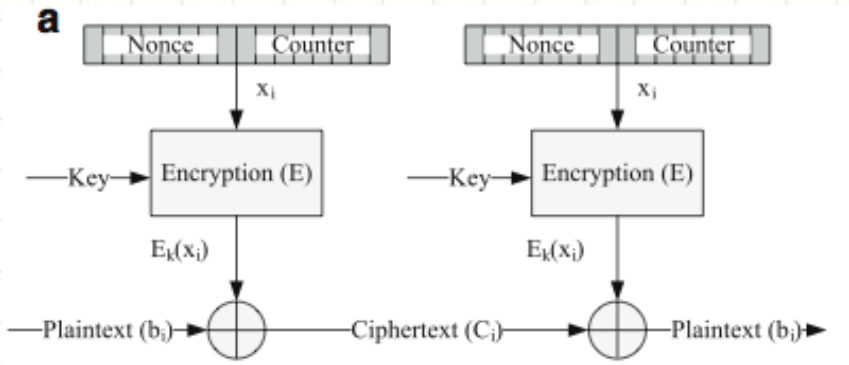
- “Shared” Nature of wireless Network, insecure channel
- Eve could break transmission
- More maliciously, Eve modifies the medical data
- Can lead to severe medical malpractice

A Comprehensive Security System

- Encryption
- Authentication
- Storage Security
- Robustness
- Data Integrity
- Energy Consumption

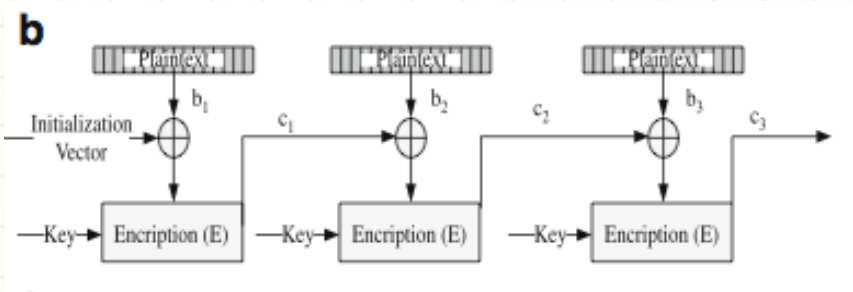
Major security requirements	Description
Data storage security requirements	
Confidentiality	Patient-related data should be kept confidential during storage periods. Especially, its confidentiality should be robust against node compromise and user collusion.
Dynamical integrity assurance	Patient-related data must not be modified illegally during storage periods, which shall be checked and detected by a node dynamically.
Dependability	Patient-related data must be readily retrievable when node failure or data erasure happens.
Data access security requirements	
Access control (privacy)	A fine-grained data access policy shall be enforced to prevent unauthorized access to patient-related data generated by the WBAN.
Accountability	When a user of the WBAN abuses his/her privilege to carry out unauthorized actions on patient-related data, he/she should be identified and held accountable.
Revocability	The privileges of WBAN users or nodes should be deprived in time if they are identified as compromised or behave maliciously.
Non-repudiation	The origin of a piece of patient-related data cannot be denied by the source that generated it.
Other requirements	
Authentication	The sender of the patient-related data must be authenticated, and injection of data from outside the WBAN should be prevented.
Availability	The patient-related data should be accessible even under denial-of-service (DoS) attacks.

AES-CTR



Plaintext is broken into 16-bytes blocks $b_1b_2b_3…b_n$ and computes $c_i = b_i \oplus E_k(x_i)$

AES-CBC-MAC



Cipher-block Chaining Message Authentication Code mode.
The plaintext is XORed with he previous cipher text.
This mode provides authentication and message integrity by allowing WBAN nodes to compute 32 bits, 64 bits, 128 bits MAC.

AES-CCM

- Counter with CBC-MAC mode
- Combines CTR and CBC
- Apply integrity protection using CBC-MAC
- Encrypt Frames using CTR mode

Energy Consumption Overview

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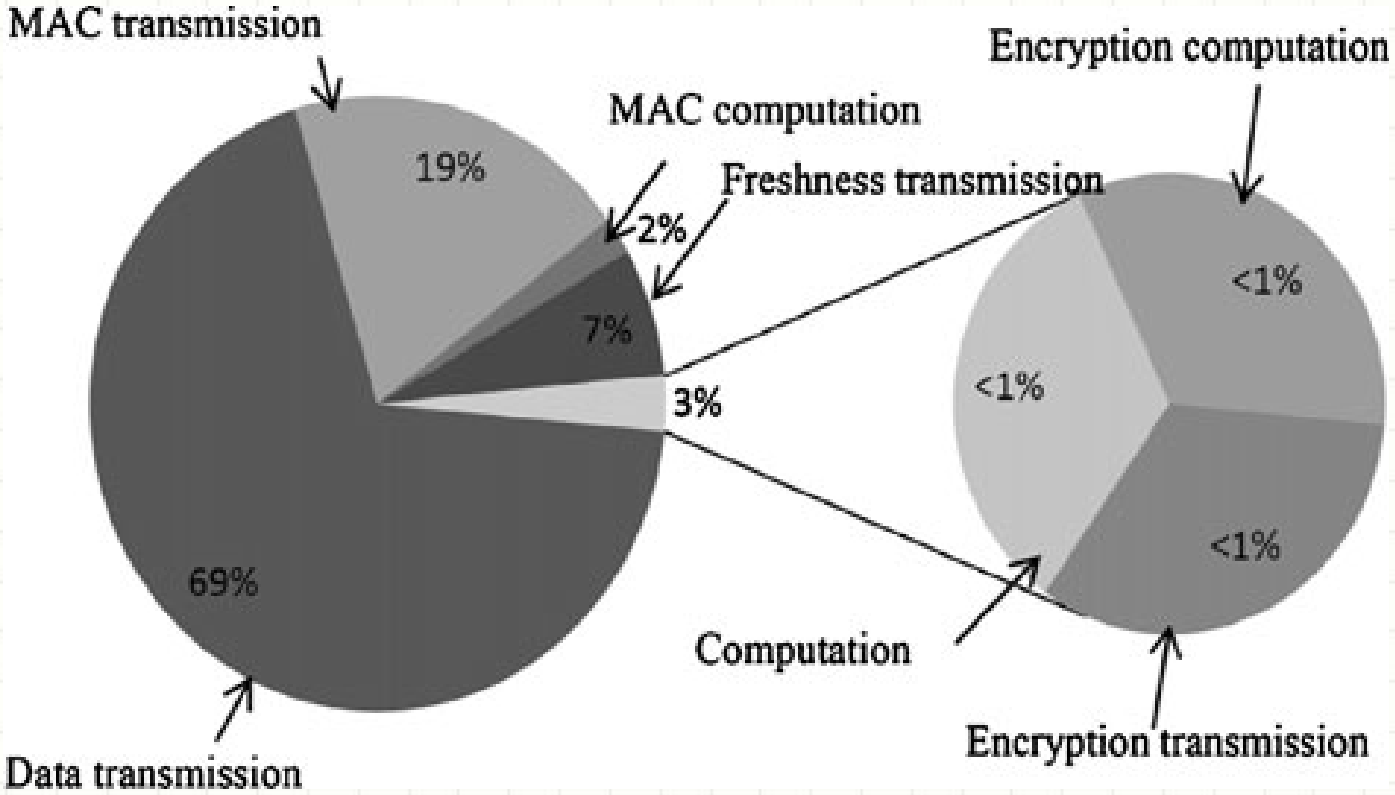

Security Summary

- Variance of Advanced Encryption Scheme(AES)
- AES-CCM most popular
- Consumes only about 3% energy
- Data Integrity and Authentication should be the direction of future research

QUESTIONS?

APPENDIX