Power Adaptive Communication Protocol for WBANs

Abbas Arghavani, Haibo Zhang, Zhiyi Huang

Department of Computer Science
University of Otago

Wireless Body Area Network

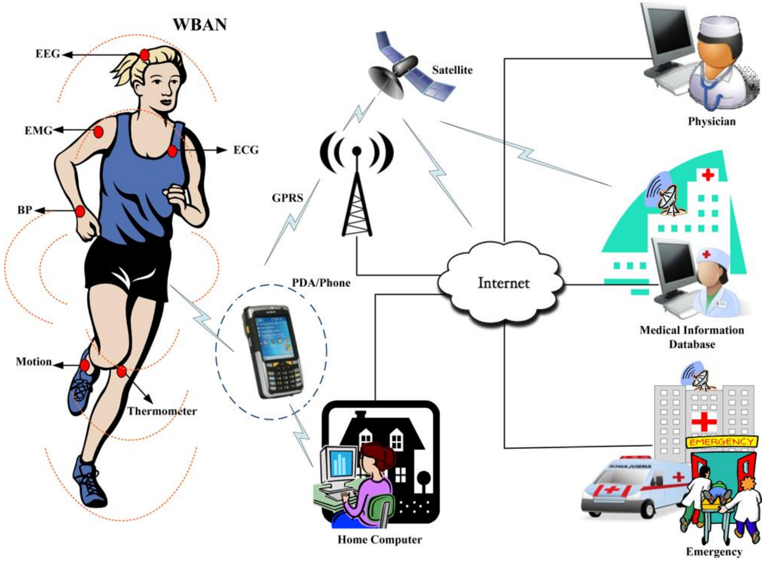
A **WBAN** is composed of a few or tens of miniaturized sensors attached to or implanted in body parts.

Applications:

- Ambulatory Health Service
- Sport
- Military
- …

Challenges:

- Resource Limitation (e.g. Battery)
- Interference
- Reliable Communication



Wireless Body Area Network

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Research Question:

- How to adjust the power of transmission signal to reduce energy consumption and interference range, while guarantee communication reliability?

Challenges:

- Topology Instability

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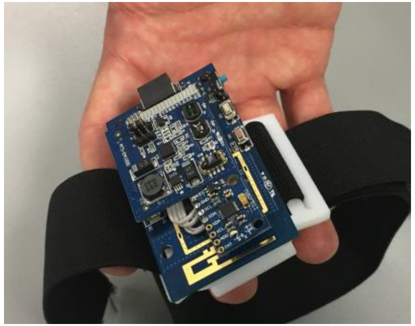
System Model and Definitions

TelosB platform with CC2420 Radio Chip (IEEE 802.15.4 compatible)



Research Question:

Assuming the sender has a packet to send to the gateway, which power level (1, 2, 3 or 4) is the best level to provide energy efficiency, limited interference, and communication reliability?

Body Posture:

- Static Postures (Sitting, standing, lying down)
- Dynamic Postures (Walking, Bicycling, running)

Energy Model and Cost Function

Performance Metrics

Energy, Interference, Reliability

Energy Consumption for Transmitting a Single Packet of L bits

$$E_{tx_i}(L) = \frac{L}{B} \times V \times e_{tx_i}$$

Energy Consumption for Receiving a Single Packet of L bits

$$E_{rx}(L) = \frac{L}{B} \times V \times e_{rx}$$

Total Amount of Energy Consumption for a Single Transmission

$$E_i^{total} = E_{rx_i}(L) + E_{rx}(ACK)$$

Transmission Cost for a Single Transmission

$$c_i = \omega \times \left(\frac{E_i^{total}}{\max\limits_{1 \le j \le n} E_j^{total}} \right) + (1 - \omega) \times \left(\frac{I_i}{\max\limits_{1 \le j \le n} I_j} \right)$$

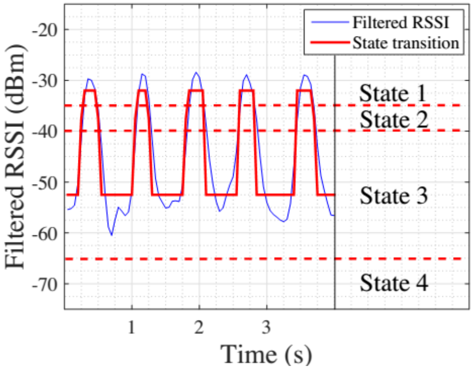
Expected Transmission Cost

$$C_i = \frac{c_i}{r_i}$$

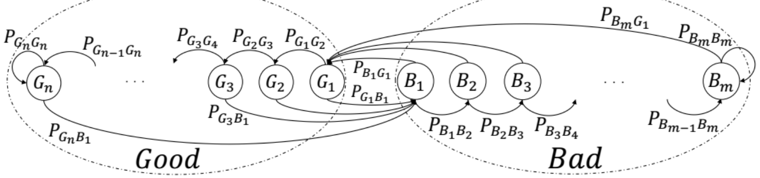
Markov-based Channel Model

Channel quality variation in static and dynamic postures shows a spatio-temporal locality

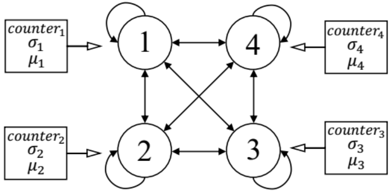
- According to the channel burstiness, we used Markov chain to model the channel behavior
- Then we designed a memory efficient Markov chain
- Using Markov chain, the sensor can predict the channel and adjust its power level accordingly
- We proposed an optimal scheduling policy to buffer the packets when the channel is in bad state and transmit them when the channel becomes good



Channel quality during walking



Extended Gilbert-Elliot model (EGE)



Proposed Model

Markov-based Channel Model

Advantages:

- Very good results in high packet rate scenarios

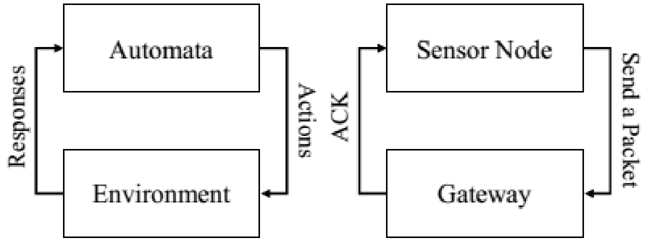
Drawbacks:

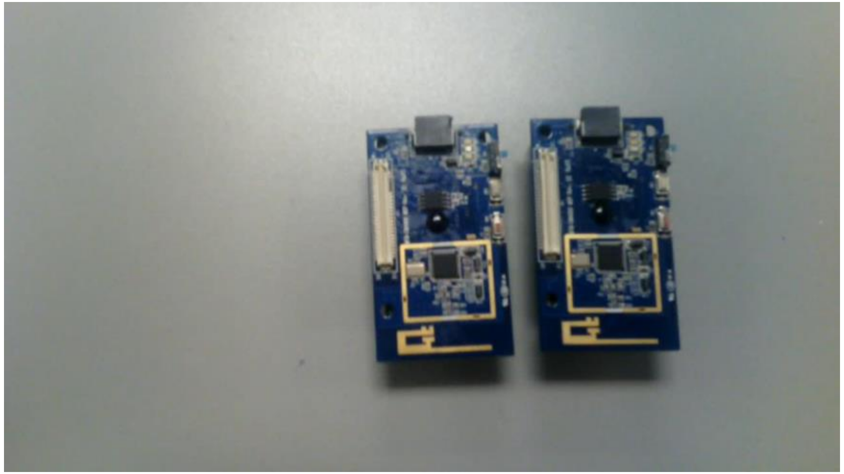
- The idea does not work for low packet rate scenario when the body posture is dynamic
- Does not work for event-driven application

Learning Automata Based Protocol

There is a correlation between channel quality and the location of sensor node

- We designed a new learning automata and proved that the automata can find the best transmission power level per each given location
- Under the absence of location information, we discussed the correlation between channel quality and inertial features like angular velocity.
- We proposed an extended version of LA based idea that benefits the gyroscope information and finds the best power level per each range of velocity (which representing a unique location) in scenarios like walking.





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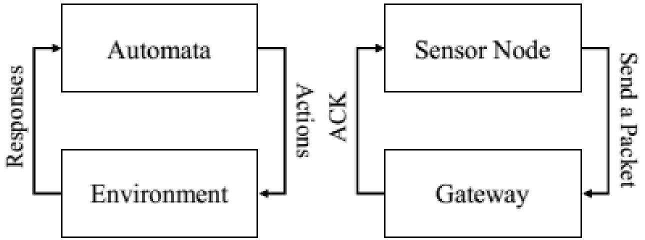

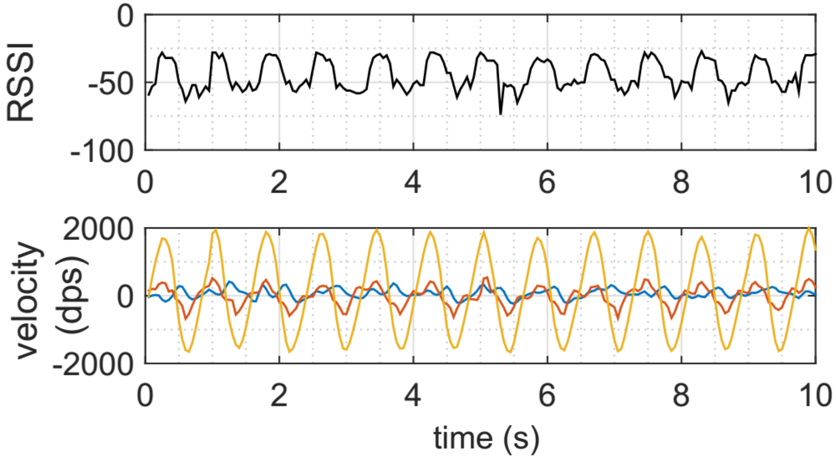

Learning Automata Based Protocol

Advantages:

- Extremely light-weight
- Ɛ-optimal
- Good for event-driven application
- Good for low-packet rate scenarios

Drawbacks:

- When the motion pattern is changed (e.g. from running to walking), the algorithm should re-learn the correlation between channel and angular velocity.

Thanks