AvroraZ: Extending Avrora with an IEEE 802.15.4 compliant radio chip model

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Problem Statement:

"Wireless Sensor Networks protocols designers must consider hardware constraints in the simulation phase"

Challenges

- Development efforts for protocol design in wireless sensor networks normally involves researches using sensor models for either network simulators or sensor OS i.e. OMNET++, TOSSIM.
- The advantage of using simulators is that developers can establish a variety of scenarios to test their protocols.
- The disadvantage of using simulators as a primary development tool is that when testing the protocol in physical test-beds the developer experiences numerous hardware (h/w) platform constraints.
- This results in a lot of wasted development effort as the protocol need to be reprogrammed and frequently redesigned.

Solution

- To overcome the limitations of not appropriately representing h/w constraints in a simulation model we propose to use Avrora.
- In Avrora, the code is then cross-compiled for the sensor node architecture and it is executed on an emulated processor providing the greatest measure of software modeling fidelity.
- This allows researchers to develop the protocols in a simulation environment without any modifications in the code and with the ease of mind that the protocol will operate in a physical test-bed.
- Extending Avrora to AvroraZ allows the emulation of an Atmel AVR microcontroller based sensor node platforms with IEEE 802.15.4 compliant radio chip, e.g. cc2420, MicaZ.

Project Implementation and Evaluation

Major elements added to create AvroraZ:

- Full implementation of registers and command strobes
- Address recognition and acknowledgement of frames
- Radio model considering motes placed inside buildings
- Real-time LQI and CCA support

The evaluation was carried out building test applications in TinyOS-2.x and installing them on AvroraZ and real hardware in order to achieve same performance results.

1)Address Recognition and acks:

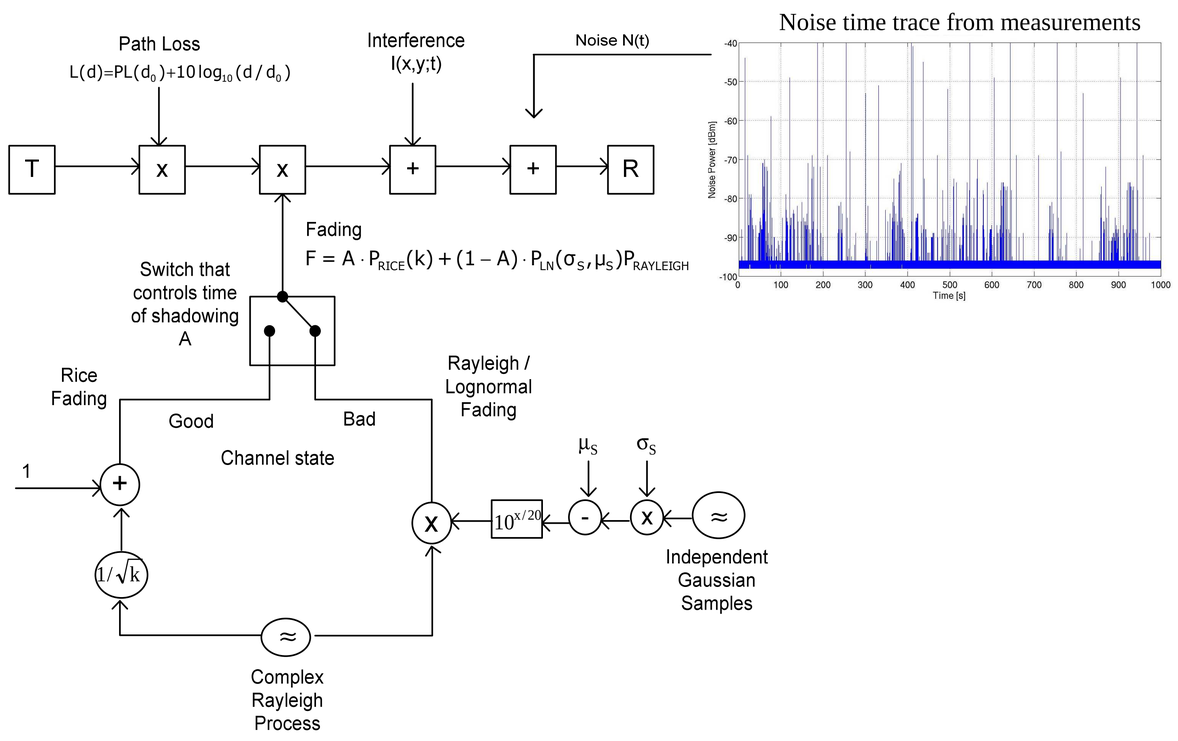
- CC2420 has support for address recognition to filter incoming frames in the physical (PHY) layer.
- This filtering based on 802.15.4 standard requirements has been fully implemented in AvroraZ.

Node	Event	
0	→	00.00.00.0F.A7.0C.61.88.00.22.00.01.00.00.00.00.5B.16
1	←	00.00.00.0F.A7.0C.61.88.00.22.00.01.00.00.00.00.5B.16
1	→	00.00.00.0F.A7.05.02.00.00.60.6E
0	←	00.00.00.0F.A7.05.02.00.00.60.6E
1	→	00.00.00.0F.A7.0C.61.88.00.22.00.00.00.01.00.00.3A.8B
0	←	00.00.00.0F.A7.0C.61.88.00.22.00.00.00.01.00.00.3A.8B
0	→	00.00.00.0F.A7.05.02.00.00.60.6E
1	←	00.00.00.0F.A7.05.02.00.00.60.6E

Tinyos2-x TestAcks application results for AvroraZ and real hardware

2) Indoor radio model:

- The chosen radio model (adopted from WiFi networks) considers that rapid and frequent transitions between line of sight (LOS) and non line of sight (NLOS).
- This is caused by the movement of obstacles in the radio path such as people that occur in typical node locations inside buildings.



AvroraZ radio model

Noise time trace from measurements

3) Real-time LQI and CCA support:

CCA support is implemented following IEEE 802.15.4 standard

- CCA = 1 when $RSSI\_VAL \leq CCA\_THR - CCA\_HYST$
- CCA = 0 when $RSSI\_VAL \geq CCA\_THR - CCA$ or receiving

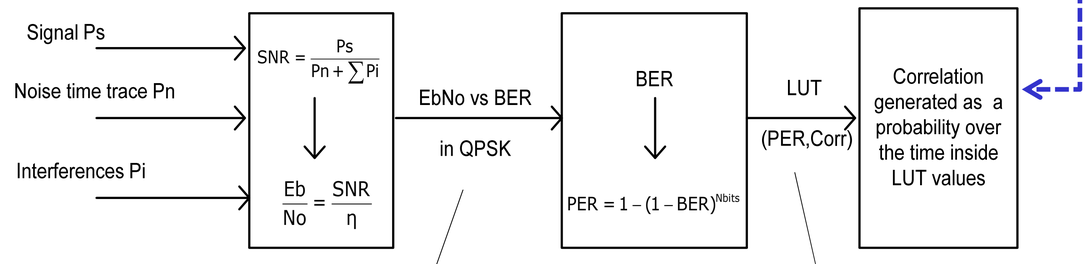
LQI defined in IEEE802.15.4 standard may be implemented using RSSI, a SNR estimation, or a combination of these methods.

- RSSI value is computed from received power as

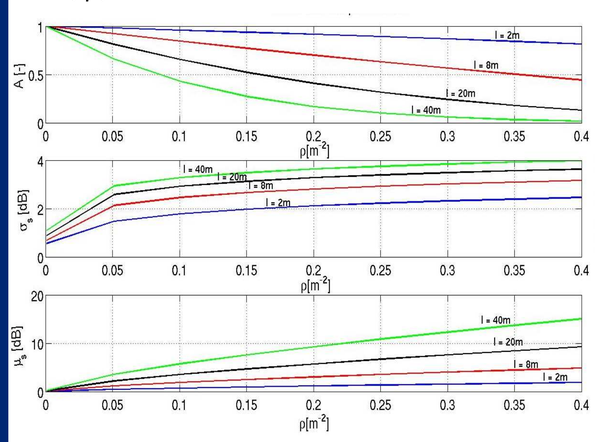
$$RSSI\_VAL = Pr - RSSI\_OFFSET$$

- SNR estimation is modeled considering the correlation chip value given in cc2420 as a Chip Error Rate (CER).

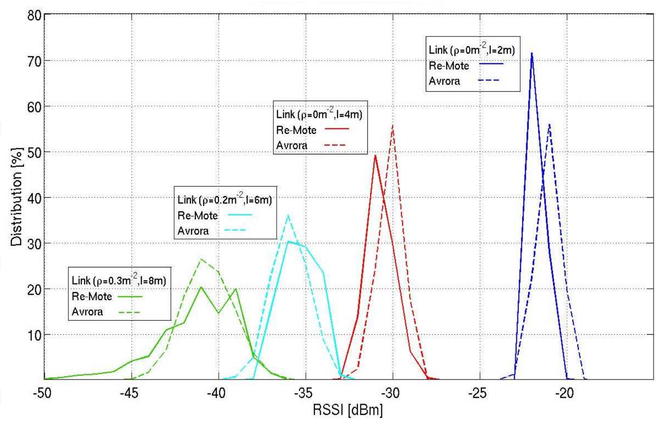
Process to compute correlation value in AvroraZ



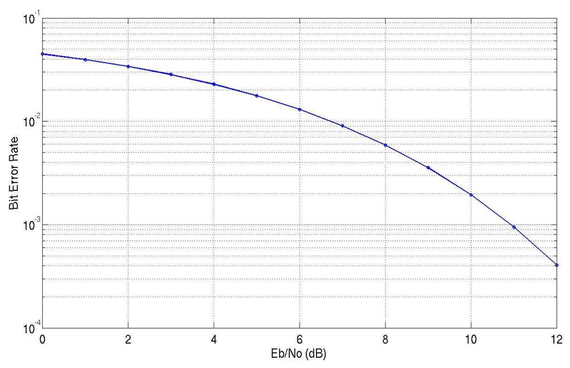
A, μ, σ for several distances and obstacle densities



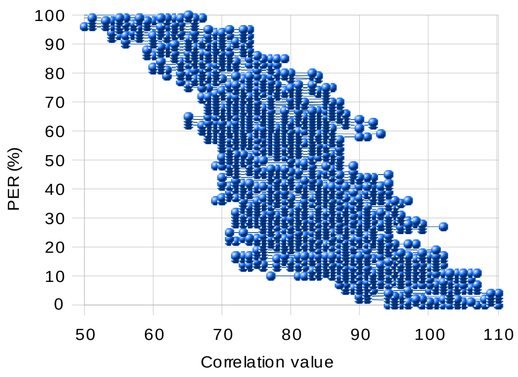
RSSI PDF comparison between test-bed and AvroraZ



EbNo vs BER for AWGN channel in QPSK



PER vs correlation value measurements



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