Simulation Blocks for TOSSIM- T2

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Outline

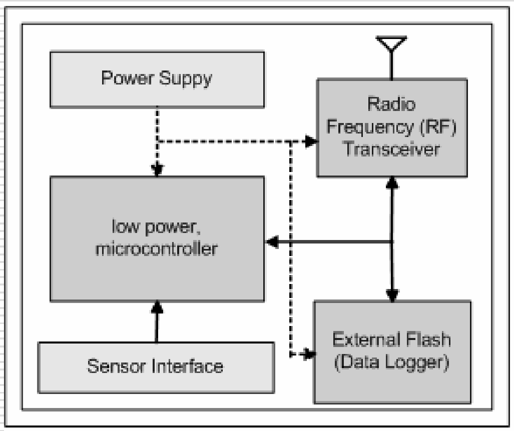
- Motivation
- Simulation Models
  - Radio, Noise
- Energy estimation Blocks
  - Radio, MCU, Flash and LED
- Case Study
- Summary and Conclusions

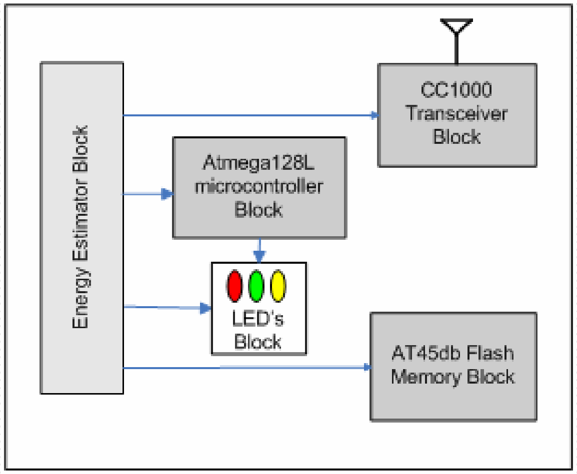
Motivation

- Provide support for MICA2 under TinyOS-2 (T2) released in Nov 2006
- Energy estimation for MICA2 in T2
  - How long does the battery last?
  - Is algorithm ‘a’ energy efficient compared to algorithm ‘b’?
- Improving wireless simulation
  - Realistic packet delivery model
- Verify simulation-analysis results experimentally

Simulation Blocks

- H/W and S/W simulation elements
  - - MCU, Radio, Flash, LED, & Environment noise model, Packet delivery model
- Introduced an energy estimator block





Radio Modeling - I

- Byte level radio model for CC1000
- Several internal hardware registers were created for storing configuration
  - Transmission power, Radio data rate, Frequency of operation, receiver sensitivity
- SPI Communication between MCU and Radio was established
  - SPI interrupts upon reception and transmission were handled
- SPI event loop is handled – virtual channel access node is introduced

Radio Modeling - II

- Byte Level SPI Simulation to solve packet corruption due to SPI event sync mismatch
  - Simulating capture and release of the SPI events for Packet transmission and reception
- Medium state (free/busy) polling to solve ack wait problem
  - The ack packet issued by a receiver collides with the preamble of another source

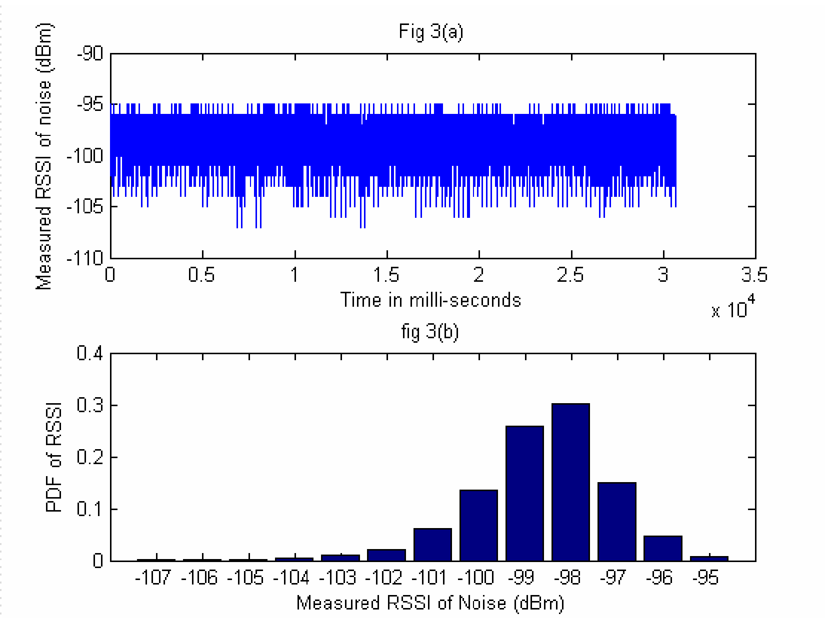
Noise modeling - Goal

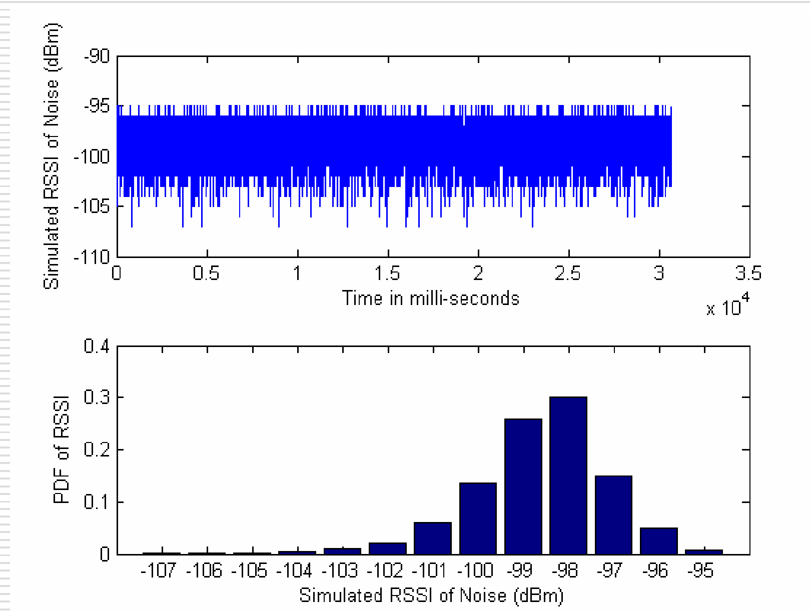
- Connectivity is more complex than simple RF propagation models
  - Low power wireless networks have complex, rare and difficult behavior
- Accurately simulate wireless packet delivery between 2 nodes
- Early studies used unit disc model. Nodes within ‘r’ successfully receive packets (TOSSIM 1.x uses this!)

Noise modeling

- Environment noise model is developed
  - Interfering sources not considered
  - Characterized being brief, strong, and short-lived
- Used Naïve sampling and Closest-fit pattern matching techniques
- Measure the RF energy at 1 KHz by reading ADC0 pin of MCU
- Noise ranges from -95dBm to -105 dBm

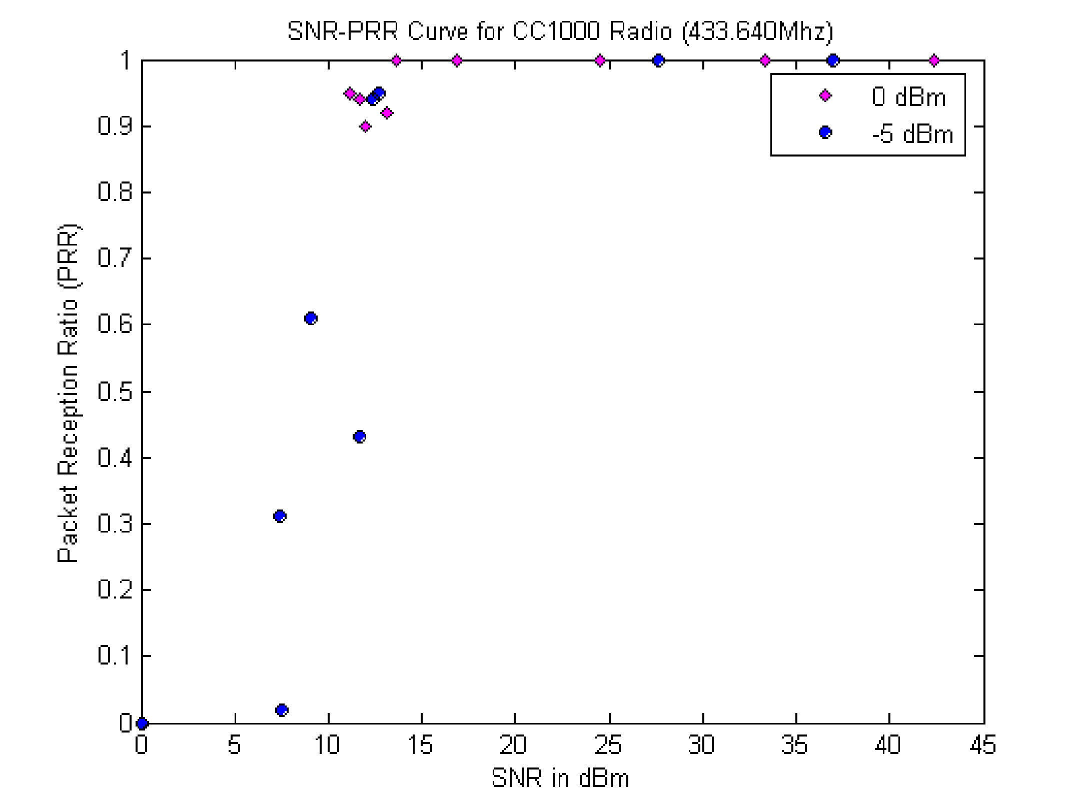
Noise model for CC1000 Radio





SNR – PRR curve

- link connectivity between node pairs



MCU Component

- Limited to energy consumption in several states of the MCU
  - Poll 3 bits of the MCUCR hardware register
  - Log data to energy estimator block
- Data sheet provides information about power states
  - Idle 3.3mA
  - ADC Noise Reduction 1.0mA
  - Power Down 0.116mA
  - Power Save 0.124mA
  - Power Standby 0.237mA
  - Extended Standby 0.243mA

Radio component

- Current consumption depends on transmit power level.
  - 0dBm – 10.4mA, 5dBm – 14.8mA, ..
- Receive current is fixed – 7.4mA
- Track and estimate the energy in several radio states
  - Power Down, Receive, Transmit
- Estimate energy by radio electronics
  - Oscillator, Bias, Syntesizer

Flash and LED

- Energy consumed in several states:
  - Standby, Active Read, Program and Erase
- Log energy information for read/write
- Pin state monitor is implemented for LED
  - Keep track of low – high and high – low transitions

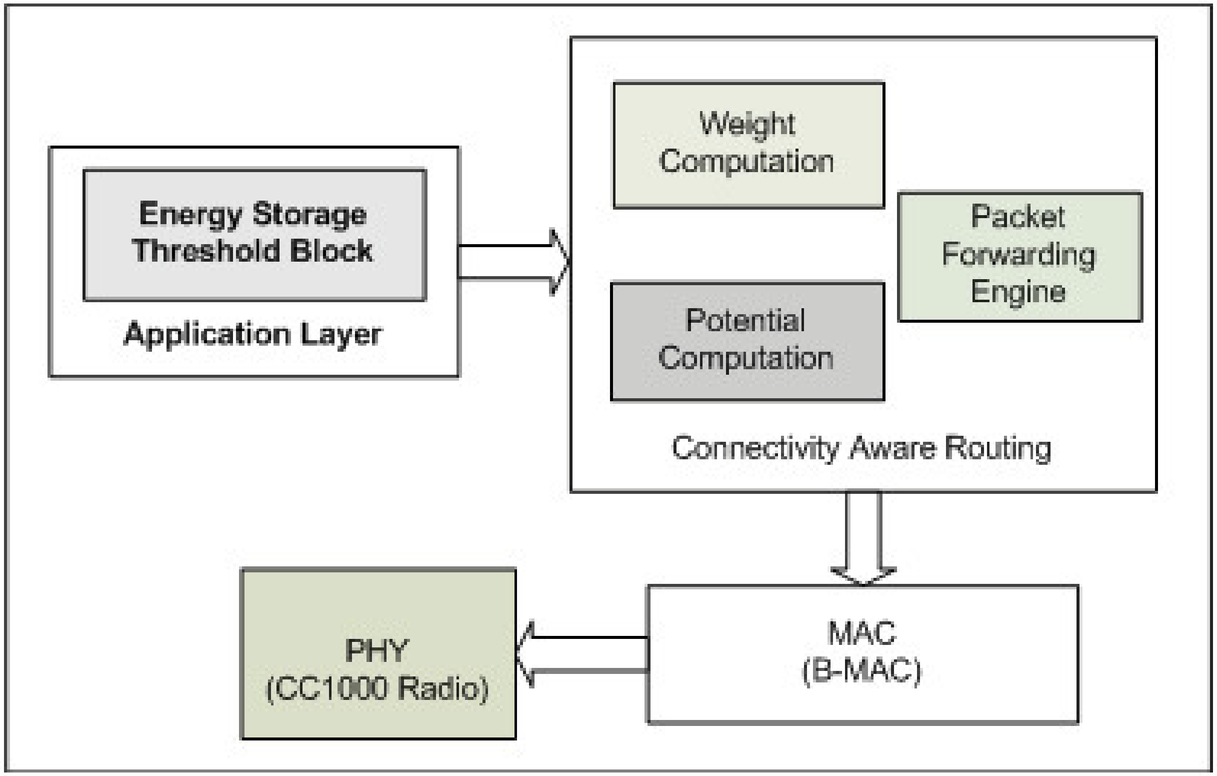
Case Study - Efficacy test!

- Implemented a routing algorithm
- Compare theoretical and simulation lifetime
- MICA2 mote implementation using 10 motes
- Two scenarios are implemented to support the paper’s analysis

Connectivity aware routing

- Choose a routing strategy such that network partitioning gets extended
  - One-by-One, Common-last approach
    - Utilizes common relays between networks at the end
  - Analytical results show network partitioning time is greater than common-first approach

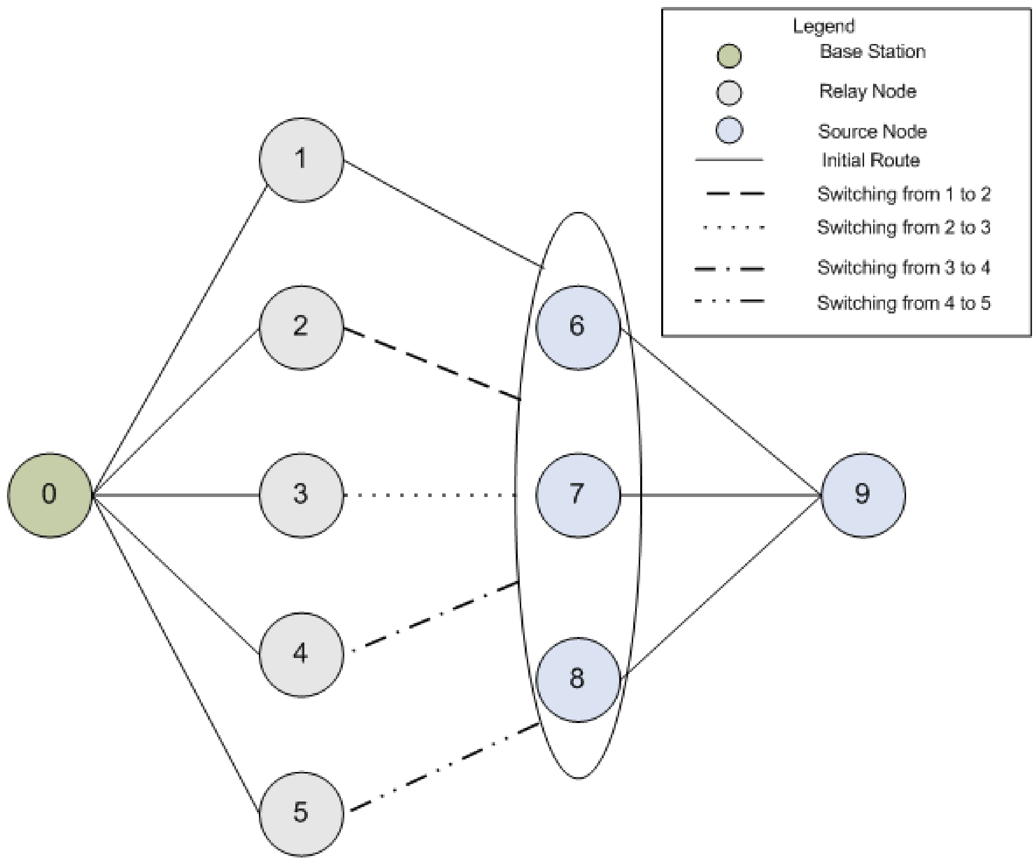
Connectivity aware routing



Routing Implementation

- Weight and Potential computation and communication
- Routing beacons carry route topology information
  - Contain the weight, potential, number of neighbors, distance, and number of non relay neighbors.
  - Another type of route packet contains the number of sink nodes

Network Topology - I



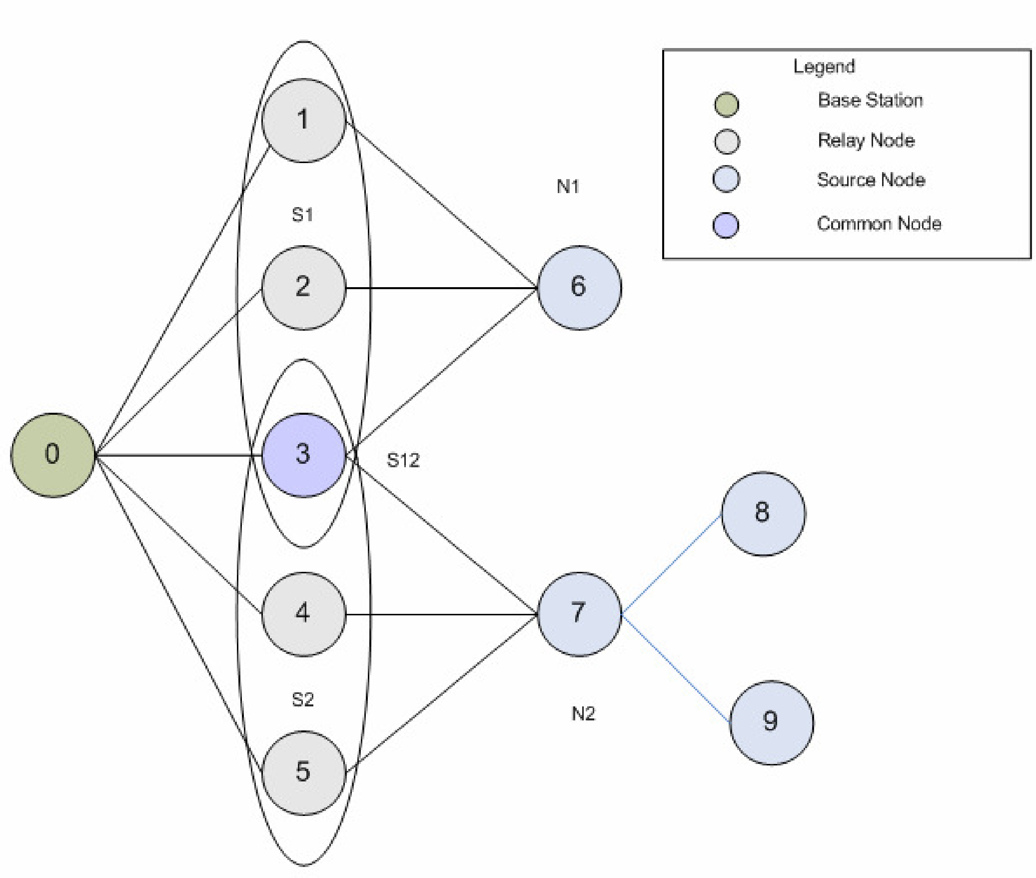
Weight computation

$W^i = (nu\_non\_relay\_nbrs)^{-1}$

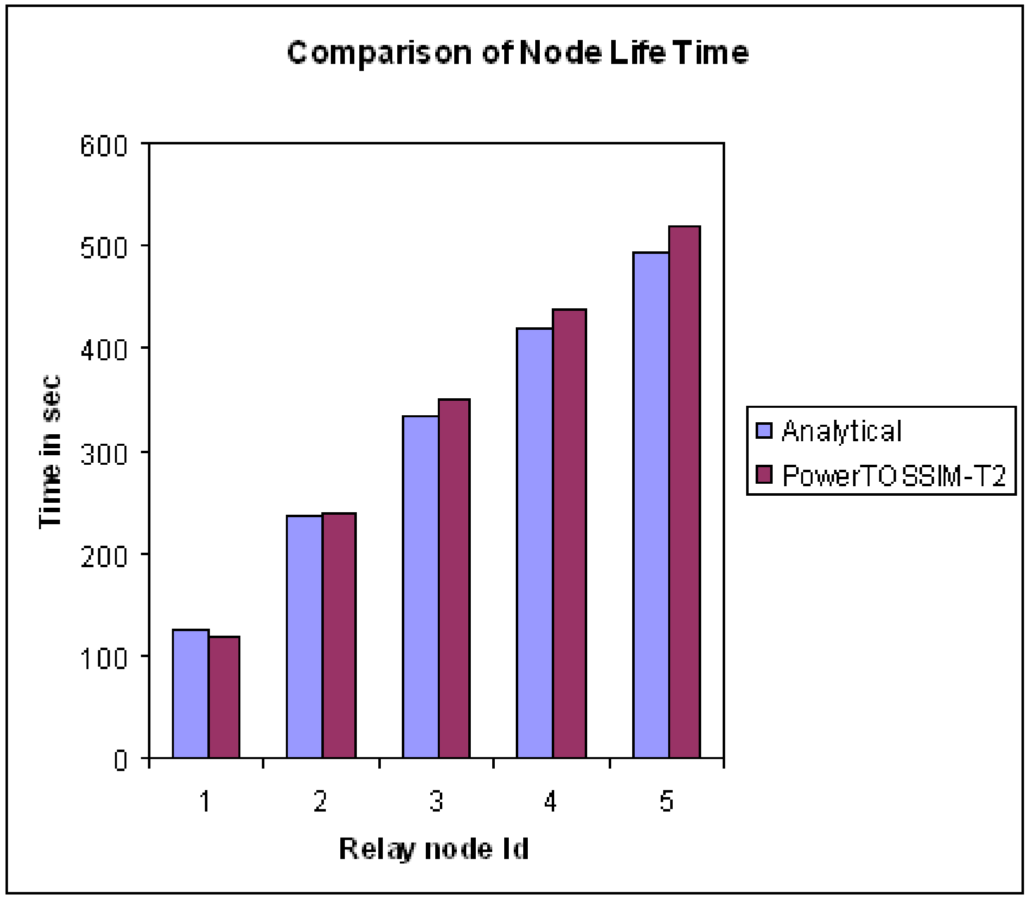
Potential = $\phi_A = \max_{1 \le i \le L} \frac{W^i_{min}}{d_i^k}$

Node Id	Weight	Potential
1	¼	¼
2	¼	¼
3	¼	¼
4	¼	¼
5	¼	¼
6	¼	0.125
7	¼	0.125
8	¼	0.125
9	¼	0.0833

Network Topology - II



Result for Topology - I

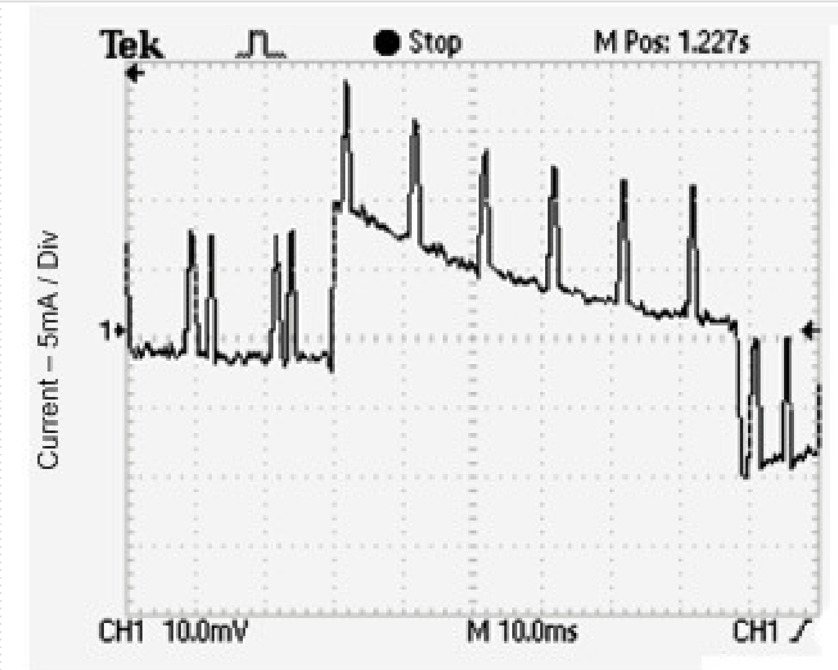


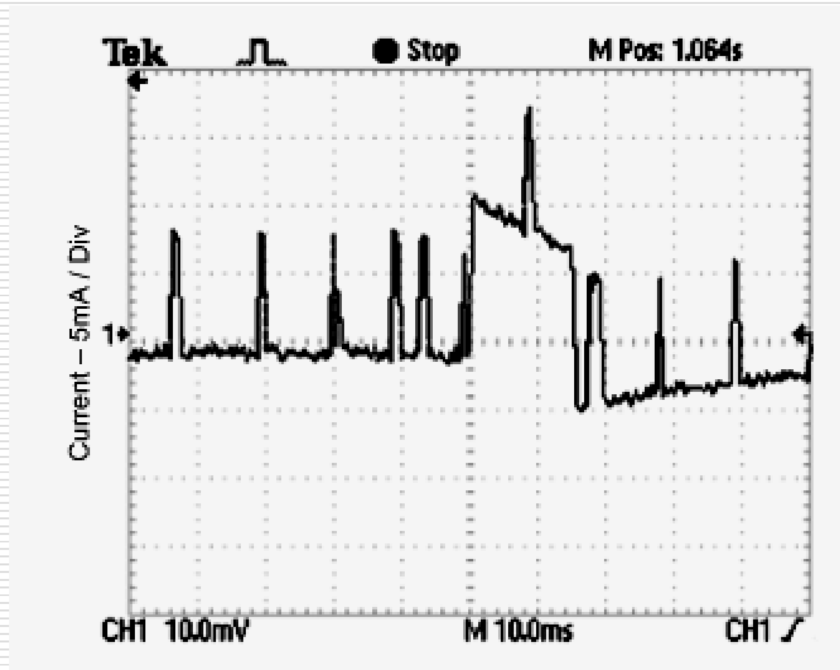
Results – Topology -II

Scenario	Network Life time
Common- First	600 secs
Common-last	660 secs

Measurements

- Snapshot of data and routing packet transmission

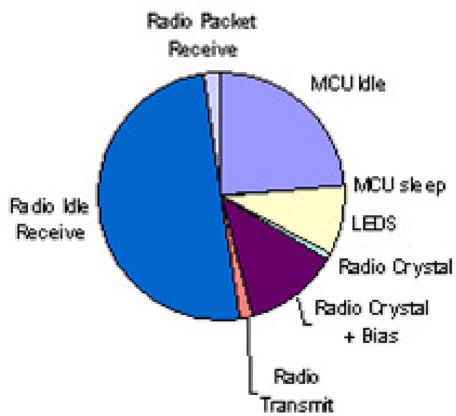




Energy Results for node 1 (Joules)

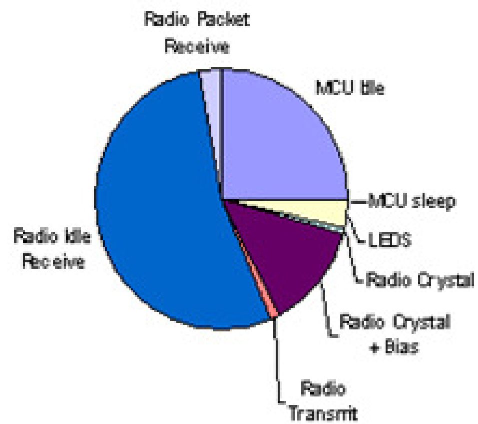
	TOSSIM-T2	Analysis	Measurements
MCU Total	0.89	-	-
Radio Total	2.56	-	2.14
Transmission	0.11	0.08	0.07
Reception (Rx)	0.09	0.06	0.08
Rx_Idle	1.85	-	1.97
Rx_Total	1.95	-	2.05
Lifetime(secs)	60.8	60	63

Expended Energy Distribution



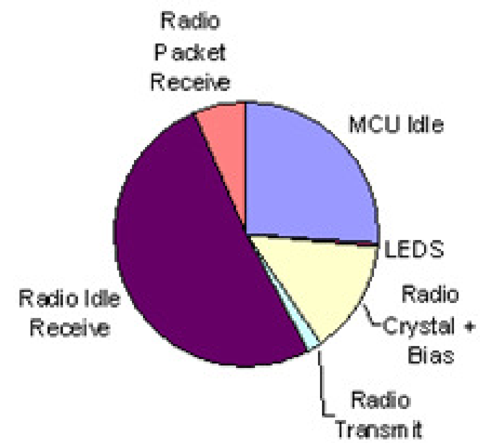
Scenario 1 : Energy Spent by Node 1

(a)



Scenario 2, Case 1: Energy Spent by Node 3

(b)



Scenario 2, Case 2: Energy Spent by Node 3

(c)

Summary and Conclusions

- Several hardware and software blocks are Implemented for MICA2
- Using these blocks energy consumption cab be quite accurate
- Available under GPL.
  - http://tinyos.cvs.sourceforge.net/tinyos/tinyos-2.x-contrib/
    - cedt folder