rtable Devices

Paper:

Low Power Medium Access Control Protocols for Wireless Sensor Networks

Jerome Rousselot, Amre El-Hoiydi, Jean-Dominique Decotiginie
Centre Suisse d'Electronique et Microtechnique SA
14th European Wireless Conference, June 2008, pages 1-5, IEEE

Presented by:

Nafiseh Mazloum

Outline

- Introduction
- Analytical power consumption
  - ✓ Radio model
  - ✓ Traffic scenario
  - ✓ Mathematical modeling of power consumption
- Summary

Introduction

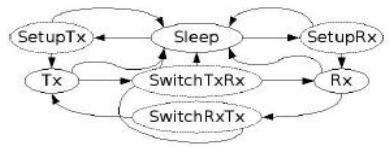
- MAC protocols must meet
  - Low power requirements
  - Be robust to node failures
  - Deal with low data rate traffic
  - Accomodate to sporadic bursts
- MAC protocols influenced by radio => analytical model
  - Bit rate
  - Power consumption
    - ✓ Steady state
    - ✓ Transition state
  - Byte-level or packet level
- MAC protocol Implementation

Analytical power consumption(I)

- Radio model
  - Steady states
    - ✓ Sleep
    - ✓ Transmission
    - ✓ Reception
  - Transient states
    - ✓ Setup Rx
    - ✓ Setup Tx
    - ✓ Switch RxTx
    - ✓ Switch TxRx

CC2420 TRANSCEIVER CHARACTERISTICS

Parameter	Value
P_{Rx}, $P_{SetupRx}$	56.4 mW
P_{Tx}, $P_{SetupTx}$	25.5 mW
P_{Sleep}	0.06 mW
P_{SwTxRx}, P_{SwRxTx}	54.3 mW
T_{SwTxRx}	160 µs
$T_{SetupRx}$	192 µs
$T_{SetupTx}$	12 µs
T_{CCA}	128 µs
T_{Sync}	160 µs
Θ	$30 * 10^{-6}$
Bit rate	250 kbps



n(II)

Å Traffic scenario

- ï Network of N devices, fully connected
- ï Traffic generation according to exponential distribution (λ=1/L)
- ï L is mean interval between two packets
- ï Packets of duration T_M

Å Mathematical modeling of power consumption

- ï Ideal protocol
- ï SCP-MAC
- ï CrankShaft
- ï WiseMAC and optimal LPL

PROTOCOLS PARAMETERS.

Parameter	Value
T_W, T_W^{WM}, T_F^{CS}	500 ms
T_M (50 bytes)	6.9 ms
T_{Ack}, T_{Beacon}^{WM} (4 bytes)	1.02 ms
T_{CW}^{CS}	0.0615 ms

Analytical power consumption(III)

Å Ideal protocol

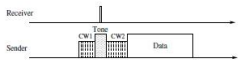
- ï Channel info acquired instantanously
- ï Receiver and transmitter meet without wasting energy

$$\overline{P_\lambda^{Opt}} = \frac{1}{L}\left[T_M\left(P_{Tx}+P_{Rx}\right) + E_{SetupTx} + E_{SetupRx} + \left(L - 2T_M - T_{SetupRx} - T_{SetupTx}\right)P_Z\right]$$

Analytical power consumption(IV)

Å SCP-MAC

- ï Optimal polling time (T_{poll}=L/N)
- ï Neglecting cost of *synchronization* and *failed* channel access



$$\overline{P_\lambda^{SCP}} = \frac{1}{T_{Poll}}\left[\overline{E_{Poll}^{SCP}} + \overline{E_{Recv}^{SCP}} + \overline{E_{Trans}^{SCP}} + \overline{E_Z^{SCP}}\right]$$

$$\overline{E_{Poll}^{SCP}} = \frac{N-1}{N}\left(E_{SetupRx}+T_{CCA6}P_{Rx}\right)+\frac{1}{N}\left(E_{SetupTx}+\frac{T_{CW}^{SCP}}{2}P_{Tx}\right)$$

$$\overline{E_{Recv}^{SCP}} = \frac{1}{N}T_M P_{Rx} + \frac{N-1}{N}\overline{T_O^{SCP}}P_{Rx}$$

$$\overline{E_{Trans}^{SCP}} = \frac{1}{N}T_M P_{Tx}$$

$$\overline{E_Z^{SCP}} = P_Z\left\{T_{Poll}^{SCP} - \left[\frac{N-1}{N}\left(T_{SetupRx}+T_{CCA6}+\overline{T_O^{SCP}}\right) + \frac{1}{N}\left(T_{SetupTx}+\frac{T_{CW}^{SCP}}{2}+2T_M\right)\right]\right\}$$

Analytical power consumption(V)

Å CrankShaft

- ï Neglecting cost of broadcast traffic

$$\overline{P_\lambda^{CS}} = \frac{1}{T_F^{CS}}\left[E_{Poll}^{CS} + \frac{T_F}{L}\left(\overline{E_{Rx}^{CS}} + \overline{E_{Tx}^{CS}}\right) + E_{BCast}^{CS} + \overline{E_Z^{CS}}\right]$$

$$E_{Poll}^{CS} = E_{SetupRx} + T_{CCA6}P_{Rx}$$

$$\overline{E_{Rx}^{CS}} = T_M P_{Rx} + E_{SwRxTx} + T_{Ack}P_{Tx}$$

$$\overline{E_{Tx}^{CS}} = E_{SetupTx} + \overline{T_{CW}^{CS}}P_{Tx} + T_M P_{Tx} + E_{SwTxRx} + T_{Ack}P_{Rx}$$

$$\overline{E_Z^{CS}} = P_Z\left[T_F^{CS} - \left(T_{SetupRx}+T_{CCA}+\frac{T_F}{L}\left(2T_M+T_{SwRxTx}+2T_{Ack}+T_{SetupTx}+\overline{T_{CW}^{CS}}+T_{SwTxRx}\right)\right)\right]$$

n(V)

Å WiseMAC and optimal preamble sampling

- ï WiseMAC, SyncWUF, CSMA-MPS, X-MAC
- ï Zero-length wake-up preamble

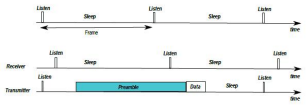
$$\overline{P_{\lambda}^{OptPS}} = \left(E_{CCA}^{PS} + \overline{E_{Recept}^{PS}} + \overline{E_{Trans}^{PS}} + \overline{E_{Z}^{PS}}\right)$$

$$E_{CCA}^{PS} = T_{CS} P_{Rx} + E_{SetupRx}$$

$$\overline{E_{Recept}^{PS}} = \frac{T_W}{L}\left[\left(\overline{T_{LP}^{PS}} + T_M\right) P_{Rx} + E_{SetupTx} + T_{Ack} P_{Tx}\right] + (N-2)\frac{T_W}{L}\overline{T_{O}^{PS}} P_{Rx}$$

$$\overline{E_{Trans}^{PS}} = \frac{T_W}{L}\left[E_{SetupTx} + \left(\overline{T_{MR}^{PS}} + \overline{T_{CDC}^{PS}} + T_M\right) P_{Tx} + E_{SwTxRx} + T_{Ack} P_{Rx}\right]$$

$$\overline{E_{Z}^{PS}} = P_Z\left[T_W - T_{SetupRx} - T_{CS} - \frac{T_W}{L}\left(\overline{T_{LP}^{PS}} + T_M + T_{SetupTx} + \overline{T_{Ack}} + (N-2)\overline{T_{O}^{PS}} - \frac{T_W}{L}\left(T_{SetupTx} + \overline{T_{MR}^{PS}} + \overline{T_{CDC}^{PS}} + T_M + T_{SwTxRx} + T_{Ack}\right)\right]$$

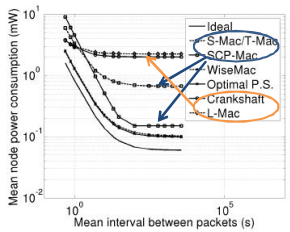


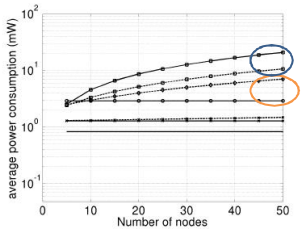
Results

Å Matlab implementation

Å Two scenarios

- ï Traffic adaptation
  - ✓ To evaluate influence of data rate on power consumption
- ï Network density





Summary

- ï A mathematical modeling of power consumption of MAC protocols has been proposed.
- ï Preamble sampling is best choice for low power MAC protocols.
- ï Performance comparison with ideal protocol shows there is a little room for future improvment.
- ï Future development on better scalibility with high data rate or better latency.