Modelling Power Consumption and Transmission Reliability of Motes

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Objectives

To analyze transmission reliability and predict battery life of mesh with Waspmotes by Libelium under a variety of configurations, e.g.

- Standard Water Sensors
- GPS Module
- ZigBee Module
- SD Card

pCharts

Visual formalism for analyzing quantitative properties of embedded systems:

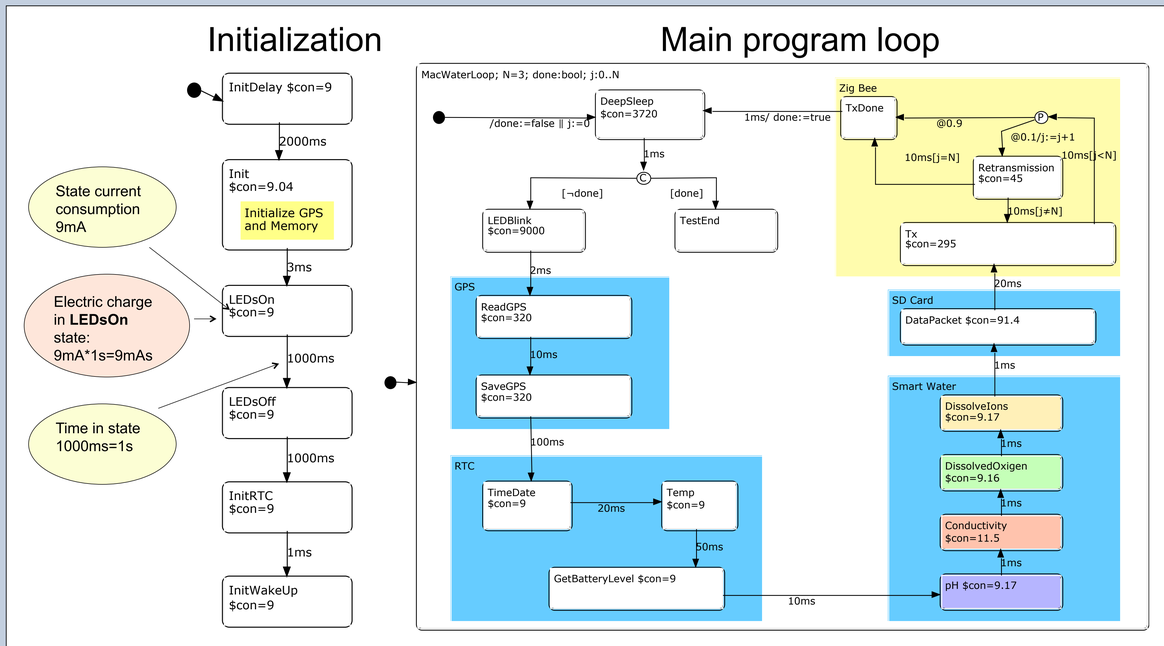
- Resource consumption (e.g. power)
- Reliability (e.g. lost messages, life expectancy)
- Performance (e.g. throughput)

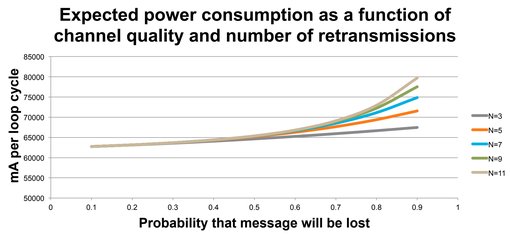
Borrows hierarchical states, concurrent states, and broadcasting from statecharts, adds

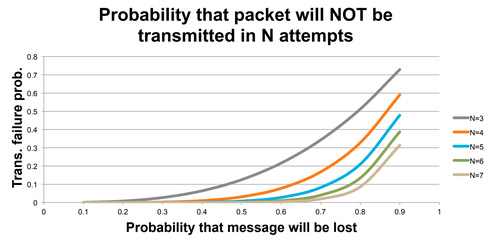
- State invariants – safety conditions that can be attached to a state
- Probabilistic transitions – to quantify the uncertainty of the environments
- Stochastic timing – timed transitions with certain distribution
- Costs – real values associated with states or transitions (elapsed time, power consumption, number of messages successfully delivered)

pState is a tool for the automated analysis of pCharts and code generation from pCharts

Quantitative Verification with *pState*





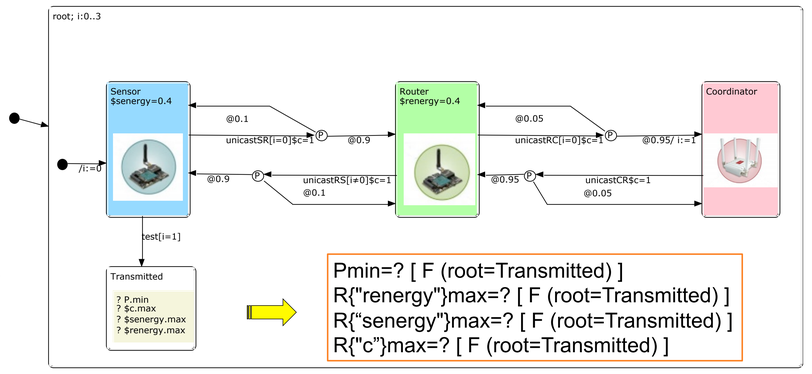


Sensor-Router-Coordinator Communication

Modelling assumptions per transmission with acknowledgement

- Current: 1mA
- Voltage: 4V
- Time in Router: 100ms
- Time in Sender: 100ms

- Sensor consumption: 0.4mWs
- Router consumption: 0.4mWs



- Minimal probability that message is eventually transmitted: 1
- Maximum expected consumption on a router: 0.86549 mWs
- Maximum expected consumption on a sensor: 0.84444 mWs
- Maximum expected number of transitions: 4.32748

Results

- Average current consumption: **0.99159** mA
- Average current consumption (no GPS, no SD): **0.40561** mA
- **95.2%** of time the sensor is in a deep sleep mode
- By increasing number of retransmissions, probability of messages successfully being transmitted is increased exponentially, but consumed power consumption is increased at the same rate

Conclusion

For battery capacity of 6600mAh and data transition of every 60s

- Battery life time = (6600*3600mAs)/(0.99159mA) ≈ **277** days
- Battery life time (no GPS, no SD) ≈ **675** days

References

http://pstate.mcmaster.ca/

http://www.libelium.com

pState: A Probabilistic Statecharts Translator [Nok. & Sek. 13]

Verification and Code Generation for Timed Transitions in pCharts [Nok. & Sek. 14]

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