re:mote – Low-cost Software and Hardware Infrastructure for Water Quality Sensing in Indigenous Communities

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Low-cost Sensing Systems for Water Quality

The goal is to develop with project partners low-cost sensing systems for long-term monitoring of water quality parameters. The focus is on the software and hardware infrastructure.

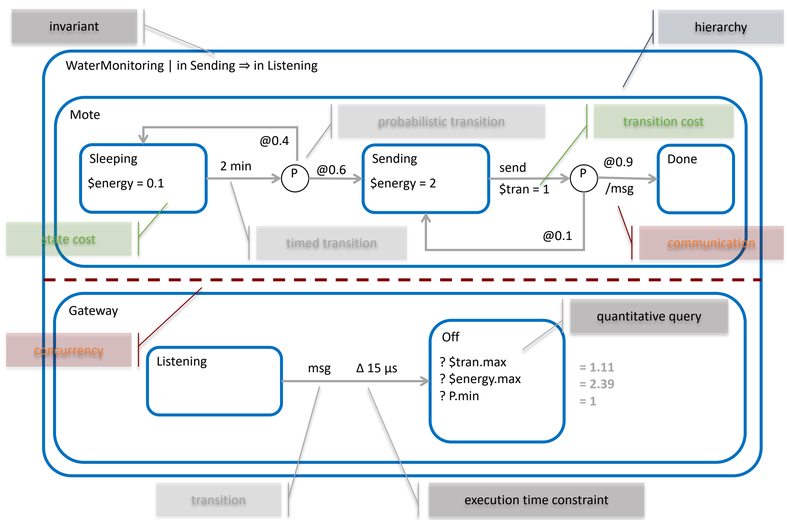
Motes (Sensor Devices, IoT Devices):
- software correctness a must
- unreliable communication, changing network topology, long distances
- limited power supply: low frequency processors, low power modes

Server:
- large amounts of simply-structured data
- erroneous data with “real” anomalies
- visualization and further programmatic analysis

Low-cost hardware and open-source software is preferred. All contributions are open-sourced.

Model-Driven Development of Sensor Systems

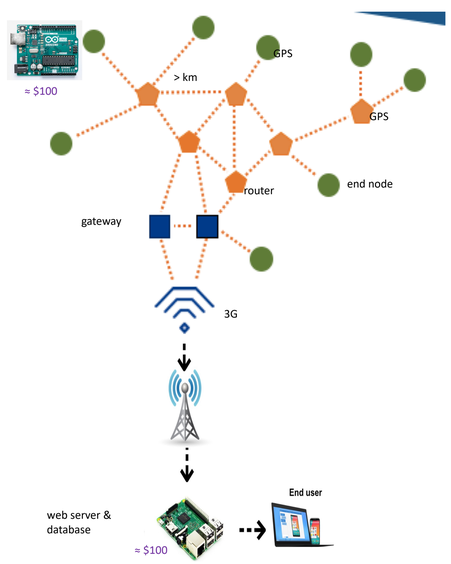
pState: a holistic approach for embedded system development
- correctness, reliability, power consumption, execution time, … deduced from formal model of motes + environment, taking unreliability into account
- code guaranteeing analyzed properties automatically generated
- pState: web-based, “literate” user interface
- backend with probabilistic model checker, SMT (satisfiability modulo theories) solver



1. Park S, Sekerinski E. A Notebook Format for the Holistic Design of Embedded Systems (Tool Paper). In Proceedings 4th Workshop on Formal Integrated Development Environment. Open Publishing Association; 2018. p. 85–94. (Electronic Proceedings in Theoretical Computer Science; vol. 284).
2. Nokovic B, Sekerinski E. A Holistic Approach in Embedded System Development. In Proceedings Second International Workshop on Formal Integrated Development Environment . Open Publishing Association; 2015. p. 72–85. (Electronic Proceedings in Theoretical Computer Science; vol. 187).

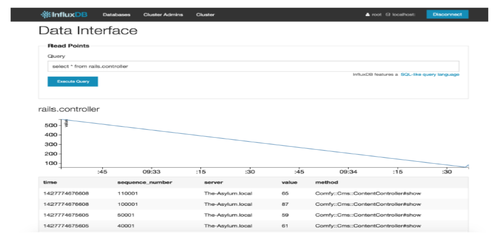
Low-power Long-range Sensor Network

LoRa mesh network for connecting sensors:
- low-bandwidth, low-power, long-range network
- mesh network tolerant to faults, changing network topology, extension, contraction
- initially commercial off-the-shelf sensors for dissolved oxygen, pH, electrical conductivity, temperature, …

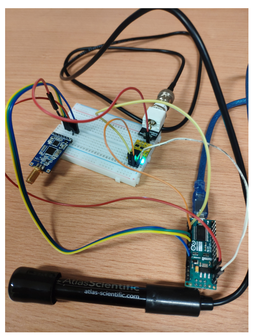


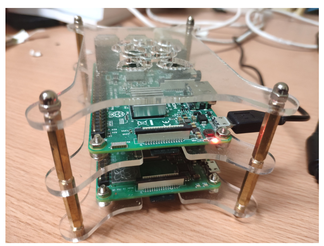
Time Series Databases for Water Quality

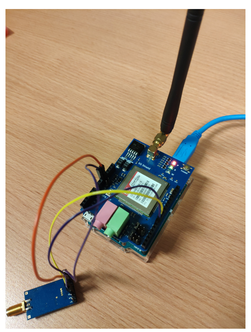
- Relational Databases are ubiquitous:
  - organize data in tables divided into columns and rows
  - offer complex queries connecting data from different tables
  - assume queries are frequent compared to insertions
- Recently Time Series Databases emerged:
  - simpler data model, one column is timestamp
  - assume insertions are frequent compared to queries
  - fast insertion of large amounts of data
  - queries are summarizing in interval, e.g. min, max, average
  - retention policies to eliminate unwanted data
  - smaller footprint
  - used for high-frequency events, e.g. server logs, stock trades



Lab Testing







A Comparison of Time Series Databases for Storing Water Quality Data

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Abstract. Water quality is an ongoing concern and wireless water quality sensing promises societal benefits. Our goal is to contribute to a low-cost water quality sensing system. The particular focus of this work is the selection of a database for storing water quality data. Recently, time series databases have gained popularity. This paper formulates criteria for a comparison, measure selected databases, and makes a recommendation for a specific database. A low-cost low-power server, such as a Raspberry Pi, can handle as many as 450 sensors’ data at the same time by using the InfluxDB time series database.

Fadhel M, Sekerinski E, Yao S. A Comparison of Time Series Databases for Storing Water Quality Data. In: Proceedings of the International Conference on Interactive Mobile Communication, Technologies and Learning, IMCL 2018. Springer; 11 pages.