Real-time Edge Analytics for Cyber Physical Systems using Compression Rates

Sokratis Kartakis & Julie A. McCann

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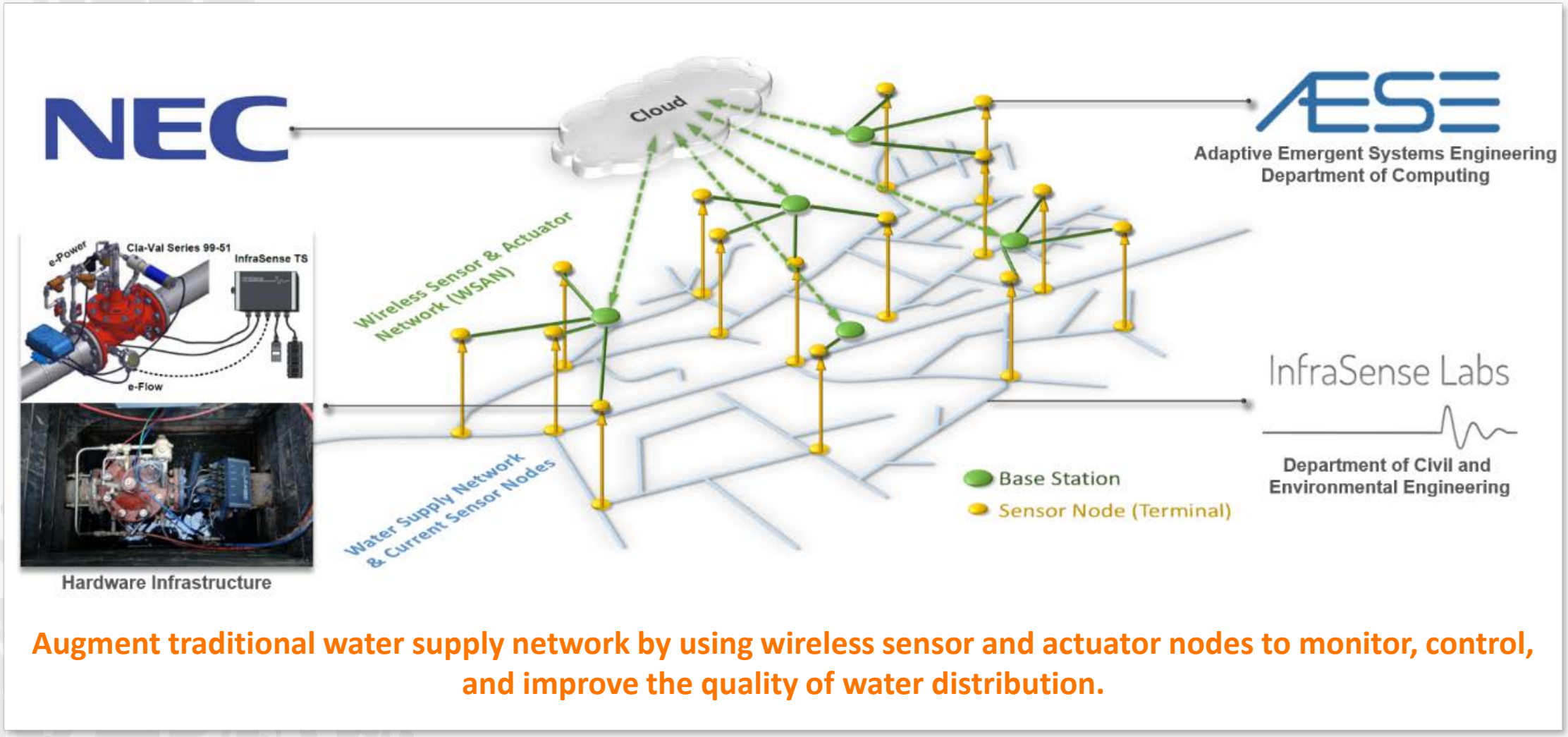
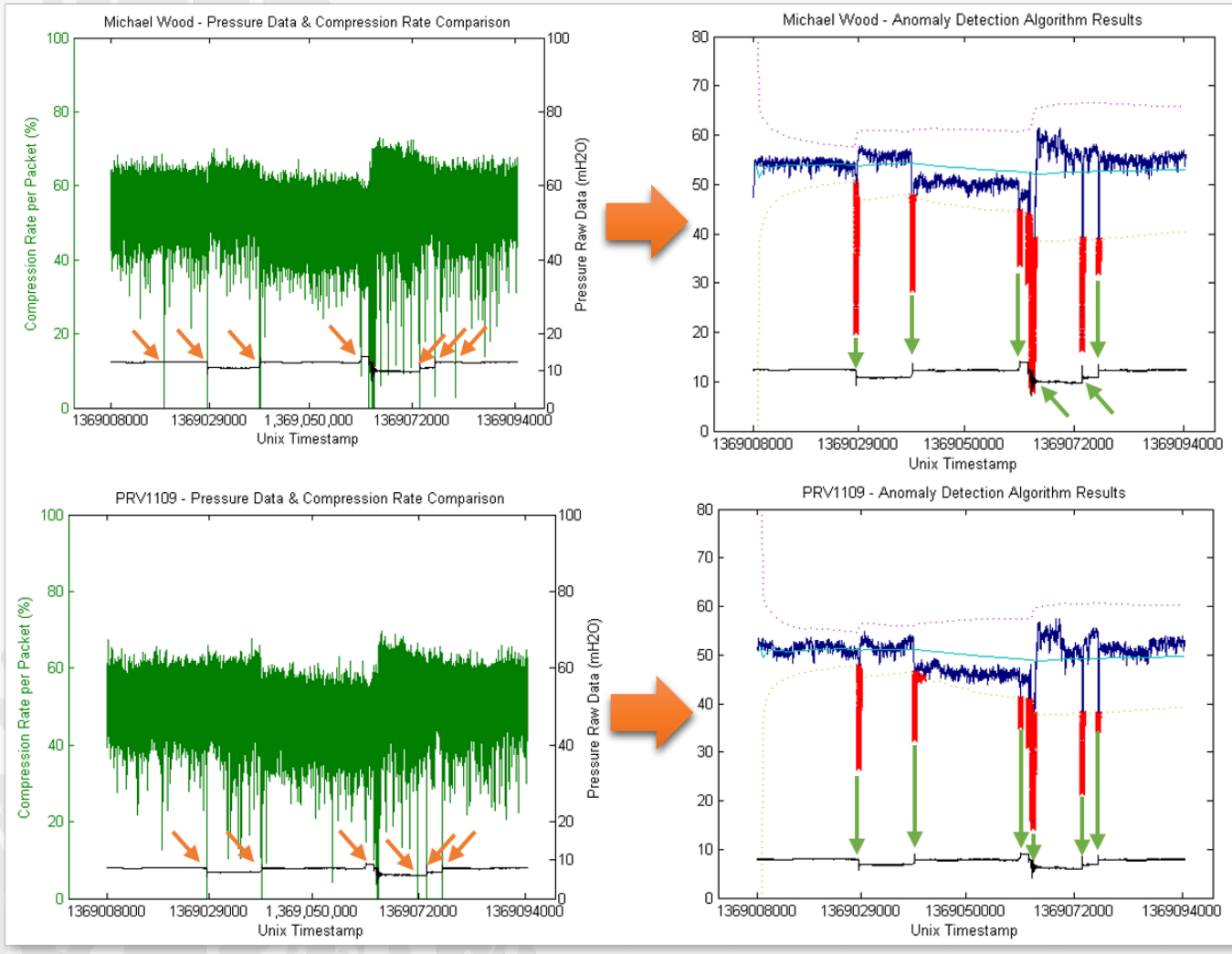
System Overview – Smart Water Project



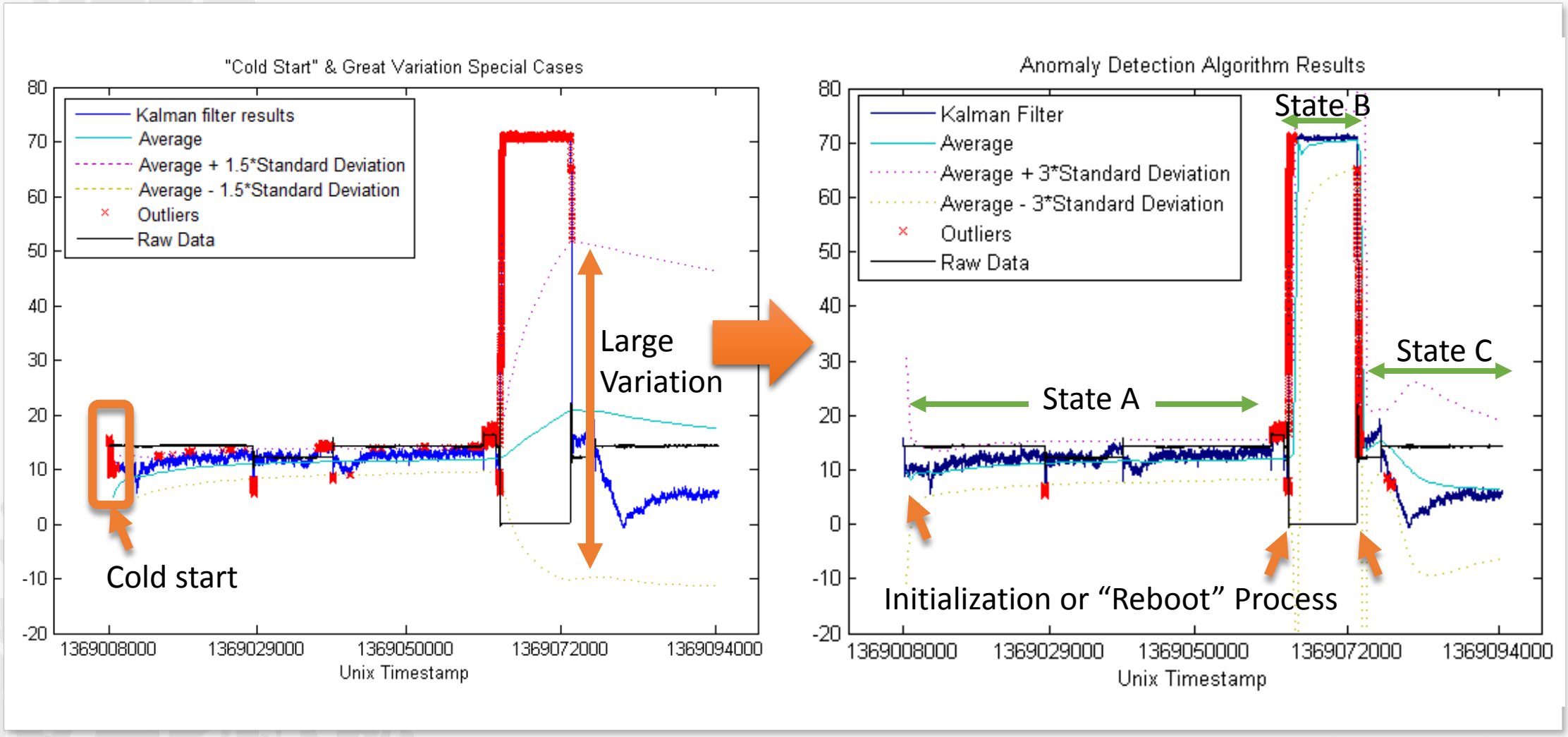
Augment traditional water supply network by using wireless sensor and actuator nodes to monitor, control, and improve the quality of water distribution.

Observation and Implementation

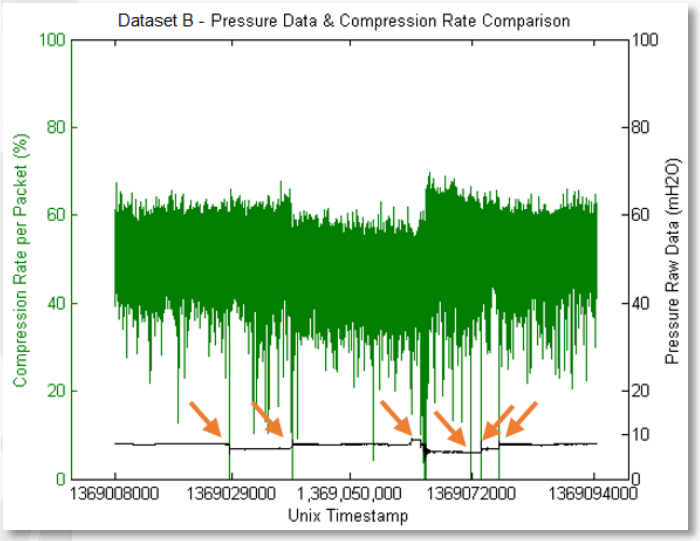


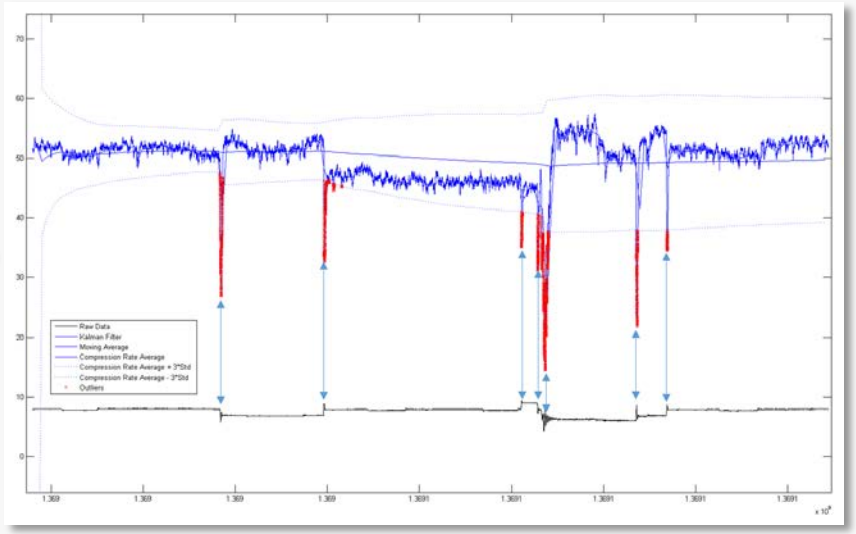
1. Produce compression rates
2. Apply one-dimensional Kalman filter
3. Use moving average to define trends
4. Create bound based on standard deviation
5. Check for outliers

Algorithm Adaption on Large Variation



Distributed Joint Edge Compression and Anomaly Detection

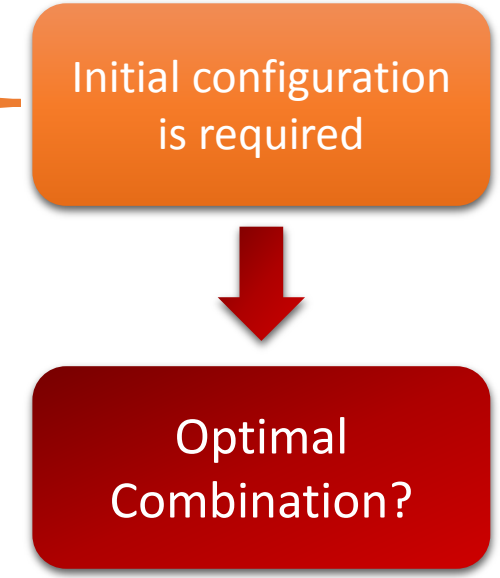




- The C program **requires 10KB** of memory including the **compression algorithm**.
- Achieved **average compression rate around 55%** (maximum was 75% to 80%).
- **55% average power consumption reduction** to send the data (communication reduction).
- Raw data size 5,526,864 values and compression rate 87,715 values => 98.42% data reduction => **98.42% energy savings** because of **computation power consumption**.
- Anomalies/Outliers detection => there is **no need of using past data** => save more memory & real time detection.
- Normalized data ranged between 0 to 100 (or 0 to 1) => data **analysis independent the content**/ type of the input data.

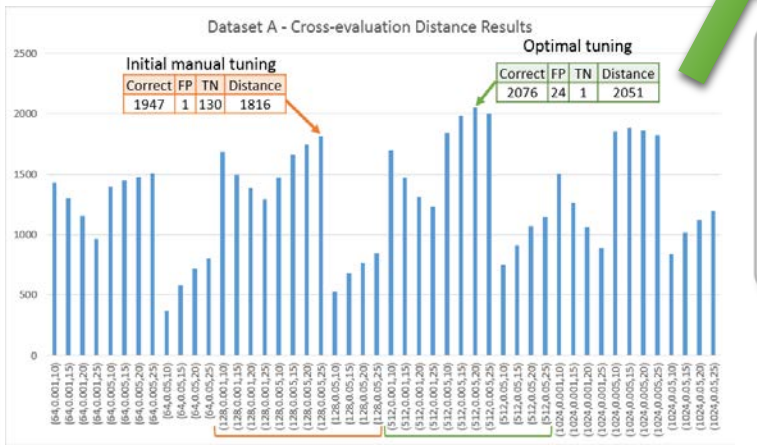
Configurable Algorithm Parameters

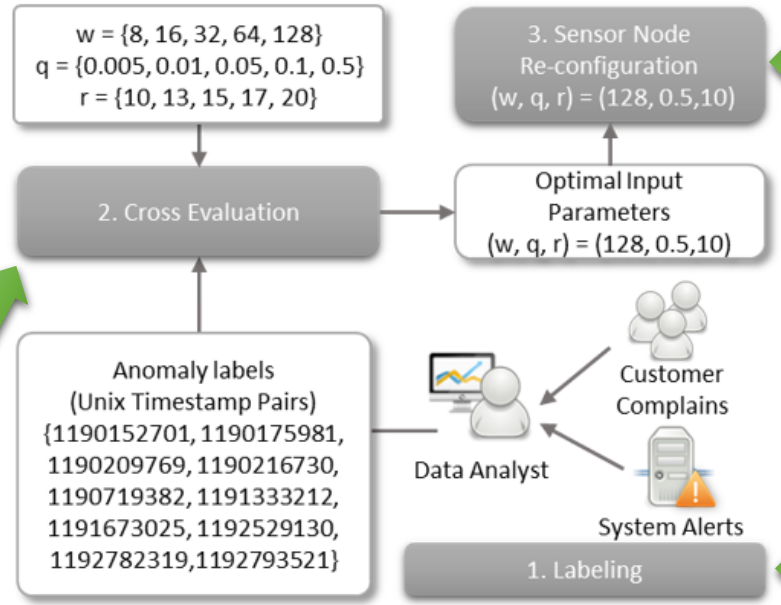
Process	Parameters
Input stream split	Packet size m
Input stream data precision	Measurement bytes
Kalman Filter initialization	Noise q Sensor noise r Initial estimated error p
Moving average computation	Window size w
Boundaries creation	Elasticity l
Large variation threshold	Threshold t



On-line Parameter Adaptation using Active Learning Notion

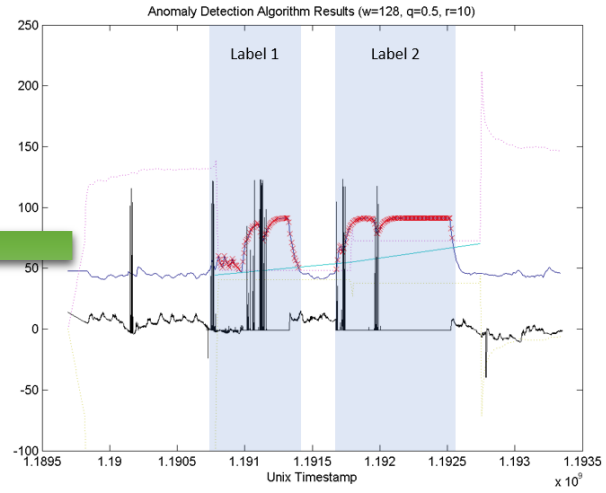
Cross Evaluation of algorithm's input parameters and false-positive calculation





The re-configuration of the algorithm inside the sensor nodes optimize the results of anomaly detection

Define anomalies in test dataset



Questions

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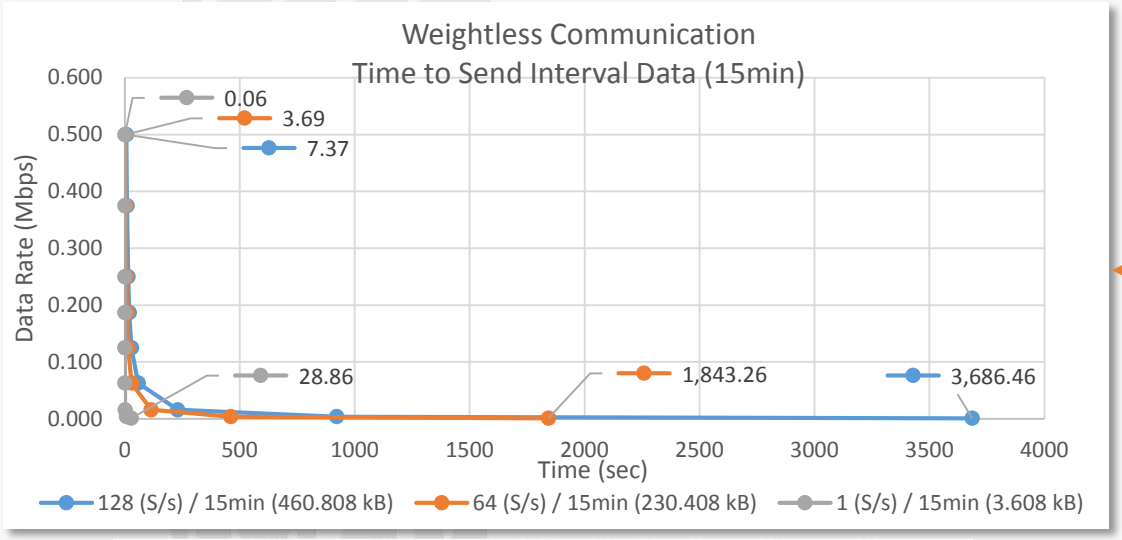
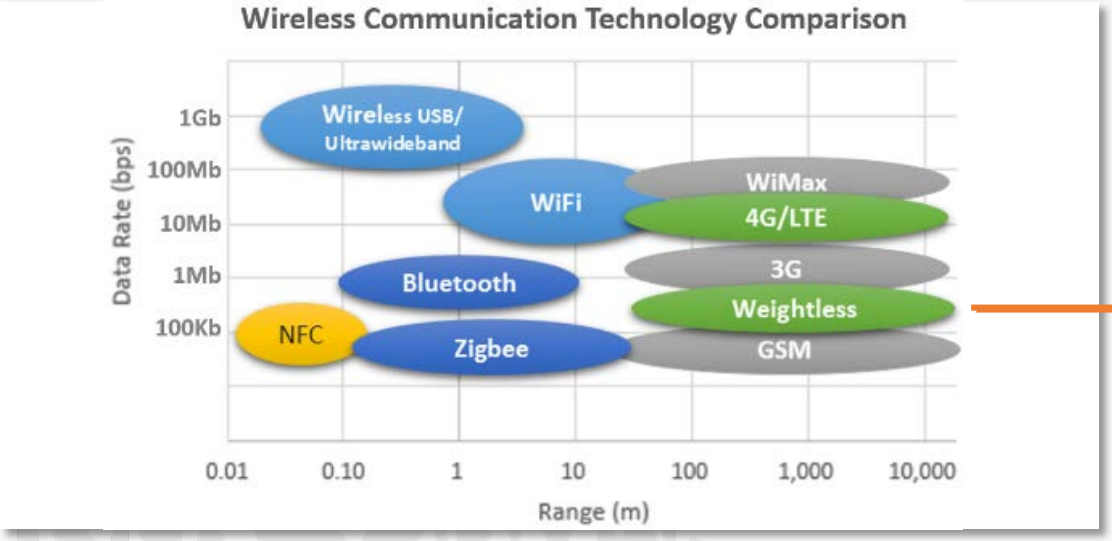
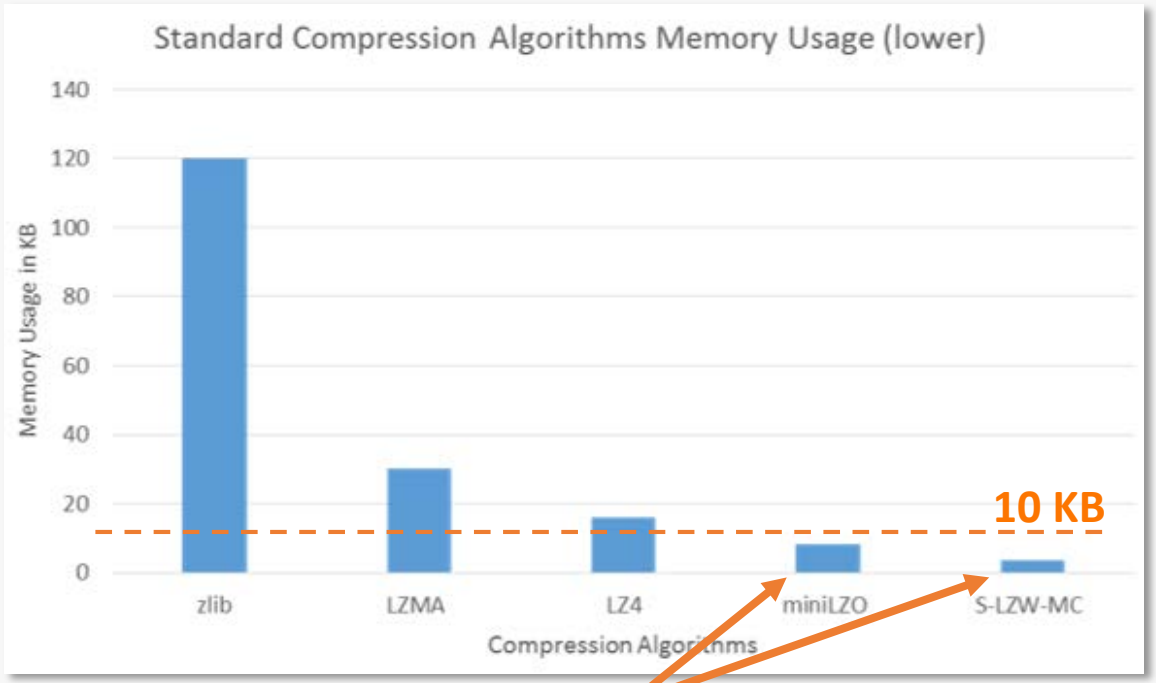
Wireless Communication Needs and Data Reduction Evaluation







MCU Applicable Lossless Compression Algorithms

Low Complexity and Computation

Memory Efficient