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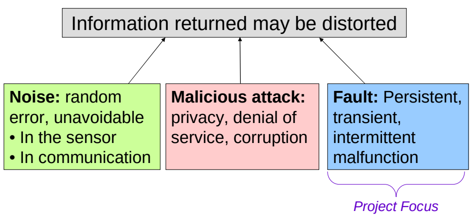
An Investigation of Sensor Data Integrity

Laura Balzano, Nithya Ramanathan, Eric Graham, Mark Hansen and Mani Srivastava

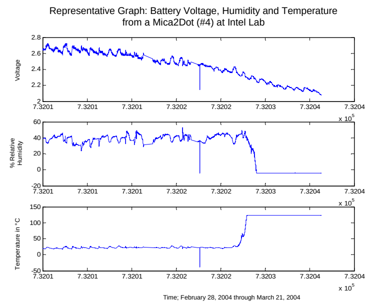
Introduction: Data Integrity a confluence of factors



How to sustain high information integrity for long durations in the presence of external and internal uncertainties?

We speculate that the accuracy of sensor and mote systems is a function of voltage, temperature, and other factors depending on the type of sensor and the environment.

Faulty data measurements are a large source of error in data collected from sensor networks today; a human views the data, identifies the faults, and then usually disregards data from that mote all together.



Problem Setup: Formulate fault models based on Experimental Data

- For now, look at accuracy as a function of time
- Say the measured value y is a linear function of the true measurement value x
- $\beta_0(t)$ is offset
- $\beta_1(t)$ is gain
- $\varepsilon(t)$ is normal sensor measurement noise

$$y(t) = \beta_0(t) + \beta_1(t)x(t) + \varepsilon(t)$$

- **Calibration –** when you can get some information about x(t) from y(t)
  - Map the observed values y to the true values x
- **Fault –** when you are unable to extract information about x(t) from the measurement y(t)
  - Eg: a stuck-at value
    - $y(t) = \beta_0(t)$
  - Eg: When $y(t) = \beta_0(t)$, $\beta_1(t)$, or $\varepsilon(t)$ are too large so as to obliterate x(t)
    - "Too Large" means that they cause us to exceed an error tolerance threshold

Experiment: Accelerated Life Test

10 Setups like the ones at James Reserve.

- Mica2 Mote + MDA300 Sensor Board + BCcomponents Thermistor and Humirel Humidity sensor.

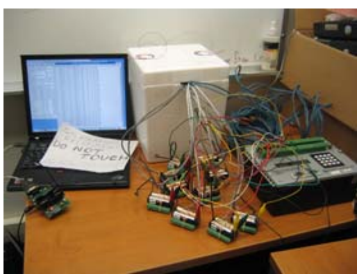
Sensors bundled in a styrofoam box.

- homogenize phenomena and dampen out changes.

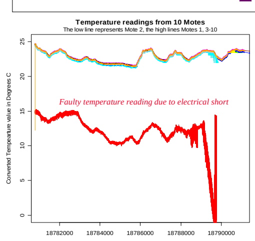
Motes wirelessly transmitting measurements to a sink mote.

- sink attached to wall power and logging to laptop.

The LEDs were on to drain the battery.



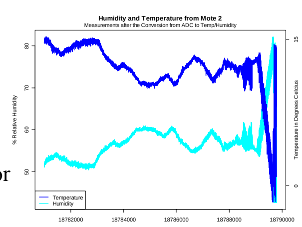
The Problem of Mote 2

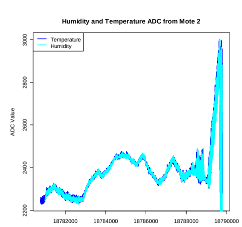


One of our sensor mote systems had temperature readings entirely unrelated to the phenomenon.

When we plotted both temperature and humidity from mote 2, we could visually see that there was a mirrored correlation. This would be very difficult to identify automatically.

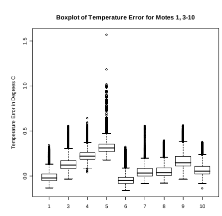
Once we viewed the ADC values before conversion, it became clear that the fault was due to a short, and this is a practical method for automatic detection.

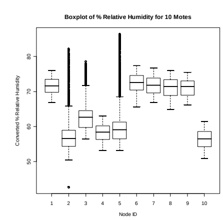


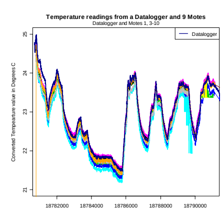


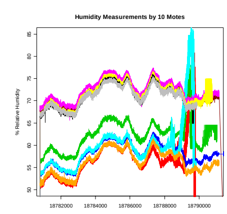
→ Mote 2 has motivated us to incorporate ADC from other modalities on the same sensor board into our β_0, β_1 coefficients.

Variability









All sensors are tracking very similar curves.

The biggest problem is the offsets → we should adjust the β_0 coefficient in our calibration.

The temperature error remained stable as the battery drained, but not once it failed. The error increased temporarily while the temperature was quickly increasing → β_0, β_1 should incorporate hysteresis