Fresh from the boat: Great Duck Island habitat monitoring

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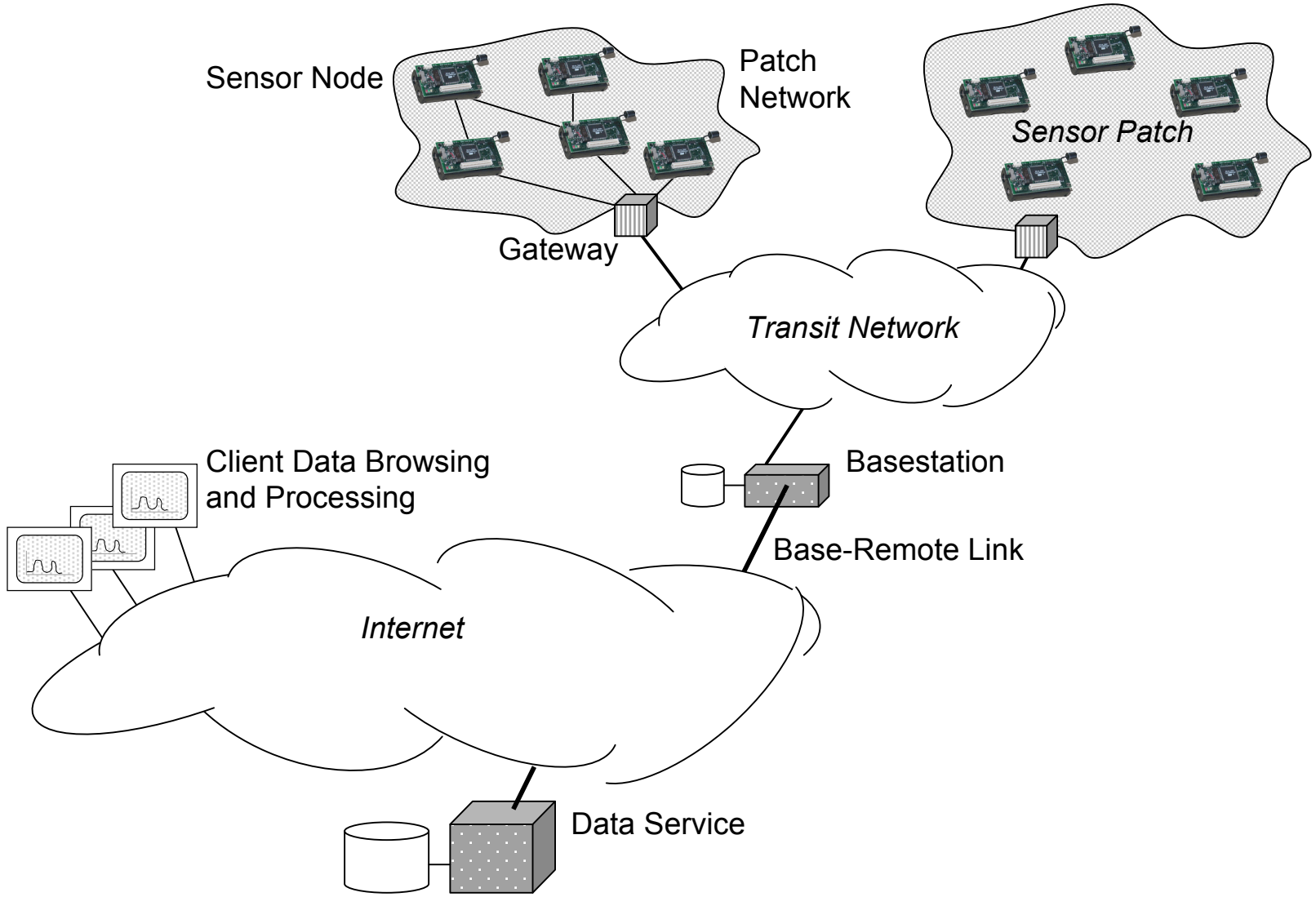
Outline

- Application overview
- System & node evolution
- Status & preliminary evaluations
- Conclusions

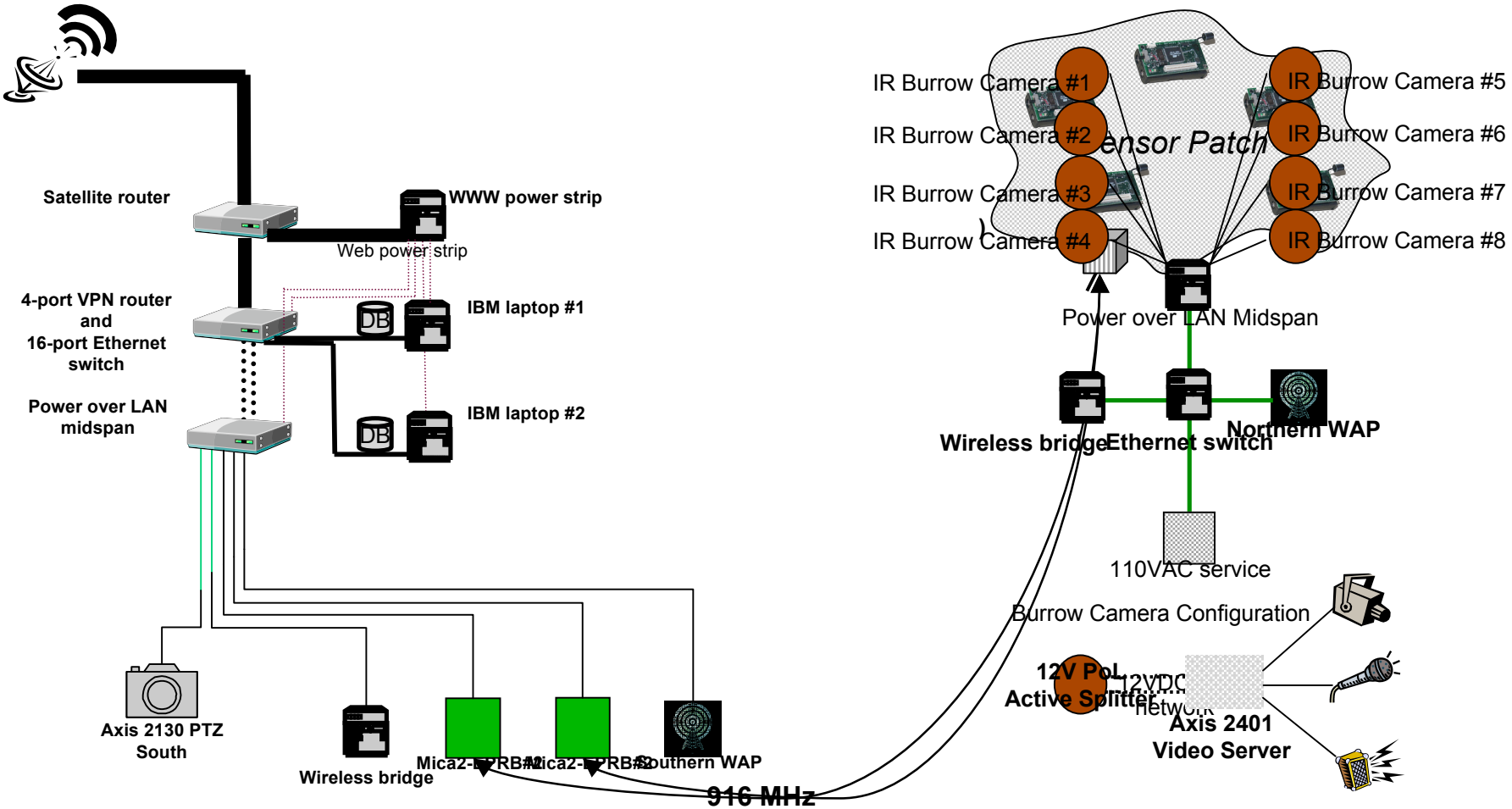
Great Duck Island Petrel monitoring

- **Goal: build ecological models for breeding preferences of Leach's Storm Petrel**
  - **Burrow (nest) occupancy during incubation**
  - **Differences in the micro-climates of active vs. inactive burrows**
  - **Environmental conditions during 7 month breeding season**
- **Inconspicuous Operation**
  - **Reduce the "observer effect"**
- **Sensor Network**
  - **Lifetime, size, quantity requirements**
  - **Environmental conditions**
- **Data**
  - **As much as possible in the power budget**
- **Predictable operation**
  - **Confidence in collected readings**
- **Unattended, off-the-grid operation**

System structure



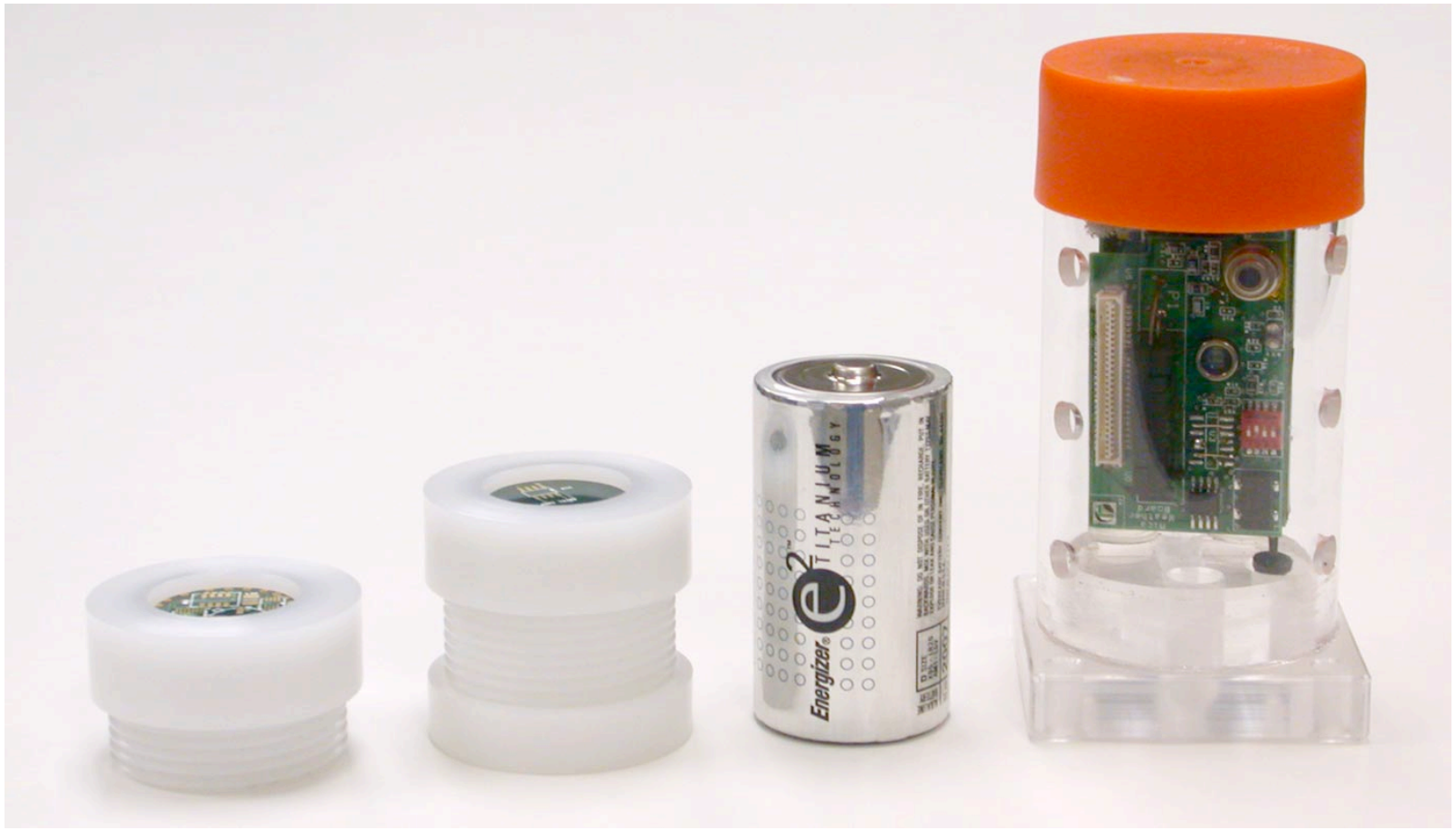
System implementation



Node architecture advances

- **Problems observed in previous deployment**
  - **Size – motes were too large to fit in many burrows**
  - **Packaging – did not provide adequate protection for electronics or proper conditions for sensors**
  - **Reliability – last retreat talk; high rate of node loss, lack of scientifically meaningful environmental data**
  - **Power consumption – boost converter a minimal return at a high price**
- **New generation of motes to address most of these concerns**
  - **Platform based on mica2dot**
  - **Primarily calibrated, digital sensors**
  - **Multiple application-specific packaging, power, and sensing options**

Mote evolution



Miniature weather station

- **Sensor suite**
  - Sensirion humidity + temperature sensor
  - Intersema pressure + temperature sensor
  - TAOS total solar radiation sensor
  - Hamamatsu PAR sensor
  - Radiation sensors measure both direct and diffuse radiation
- **Power supply**
  - SAFT LiS02 battery, ~1 Ah @ 2.8V
- **Packaging**
  - HDPE tube with coated sensor boards on both ends of the tube
  - Additional PVC skirt to provide extra shade and protection against the rain

Burrow occupancy detector

- **Sensor suite**
  - Sensirion humidity + temperature sensor
  - Melexis passive IR sensor + conditioning circuitry
- **Power supply**
  - GreatBatch lithium thionyl chloride 1 Ah battery
  - Maxim 5V boost converter for Melexis circuitry
- **Packaging**
  - Sealed HDPE tube, emphasis on small size

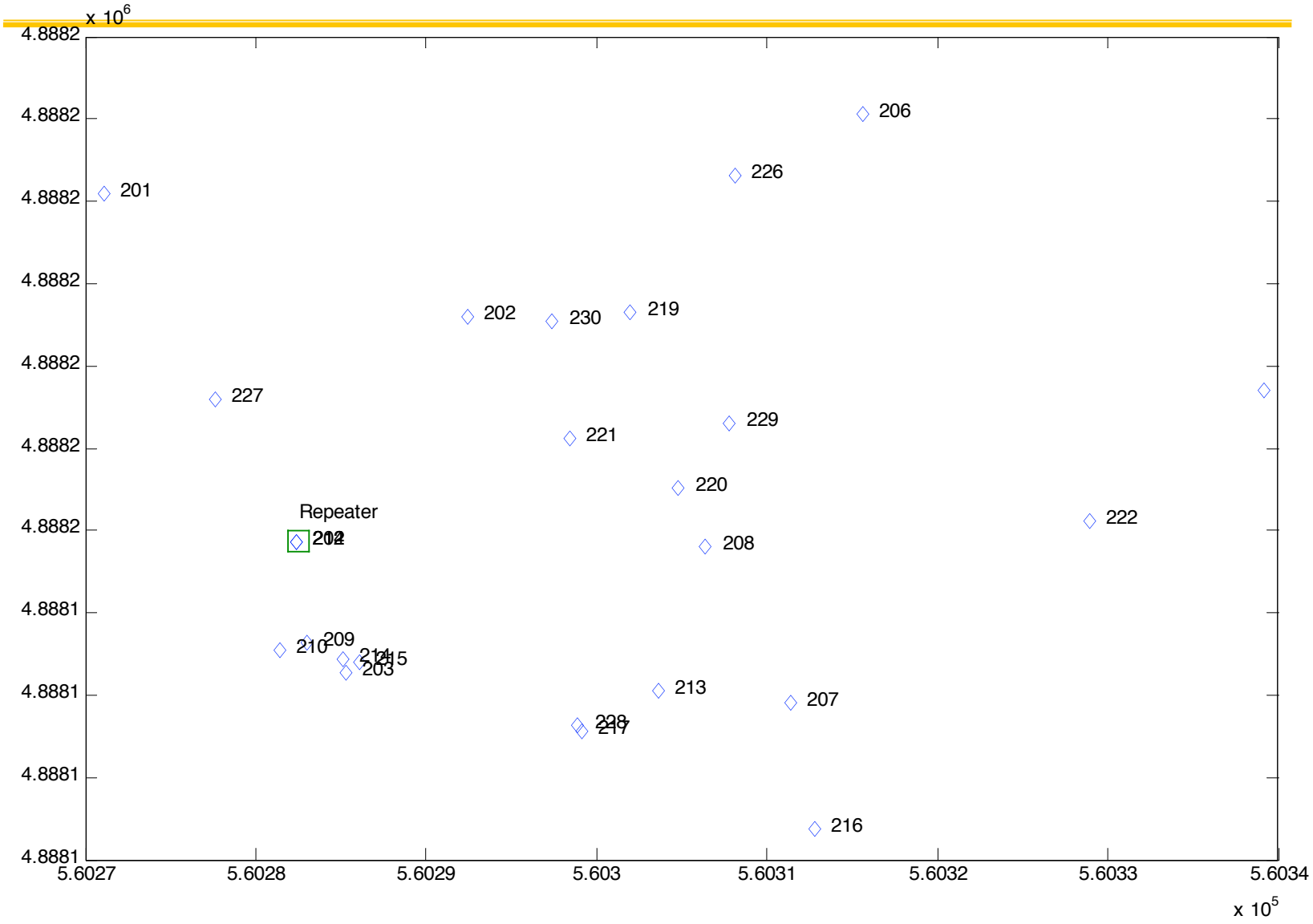
Software architecture advances

- Bi-directional communication with low-power listenting
  - .1% duty cycle
- Parameter adjustment and query
  - Sample rate changes, sensor status queries
- Improved power management scheme
  - Fine granularity through StdControl interface
  - 20 uA sleep mode
- Multihop deployment planned for July
- What it isn't: GSK
  - Emphasis on simplicity and reliability, rather than generality
  - Compatible with most GSK server-side interfaces

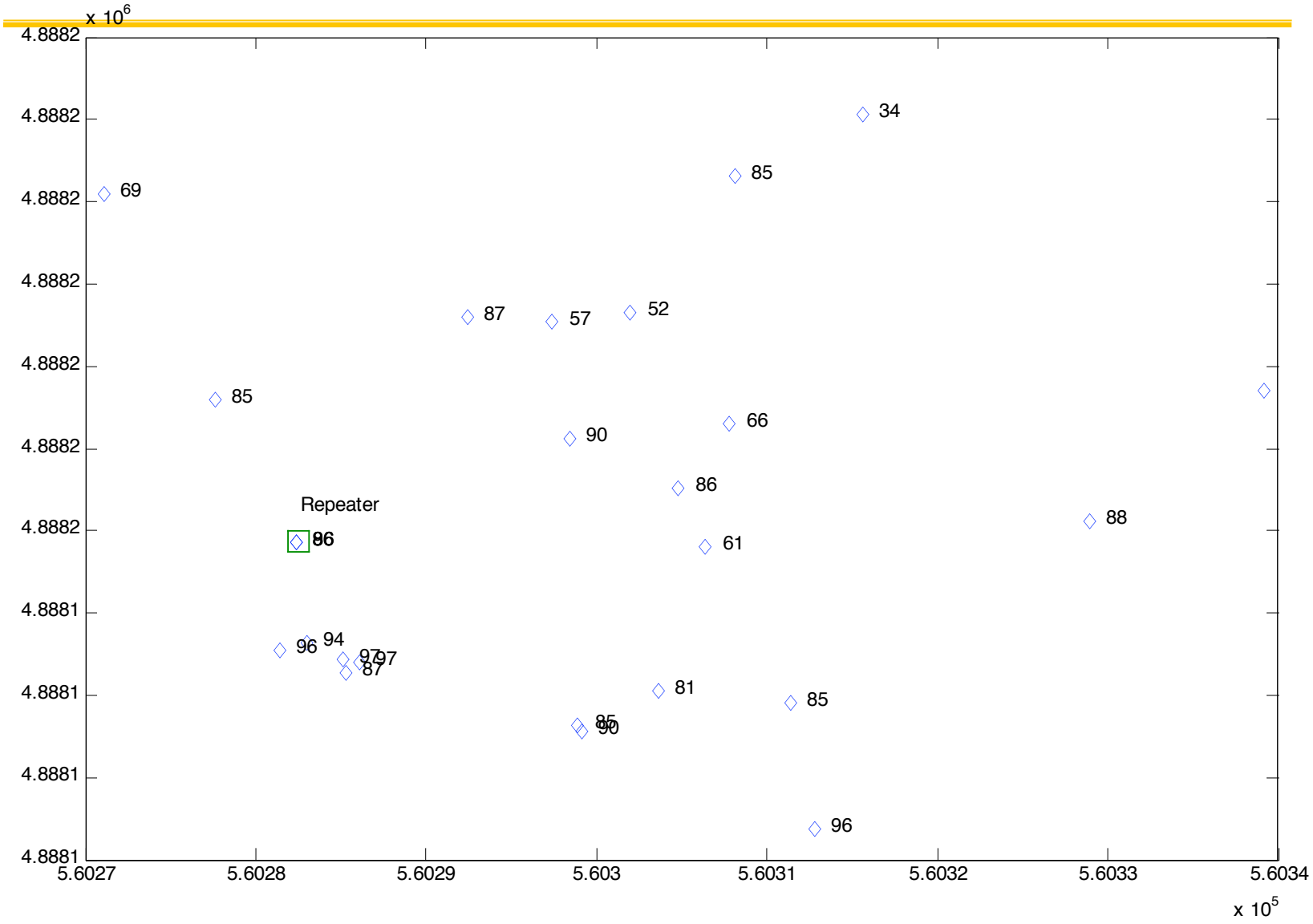
Application status

- **Sensor network**
  - **26 burrow motes deployed**
  - **12 weather station motes deployed (+2 for monitoring the insides of the base station case)**
    - » **Another 14 are awaiting deployment within days**
- **Redundant database setup online**
  - **2 base stations logging packets to 2 database servers**
  - **Replication to Berkeley**
- **Verification infrastructure**
  - **Overview cameras in place**
  - **Burrow cameras temporarily offline, wireless bridge problem**
  - **Video logging still needs to be synchronized with the mote data service**

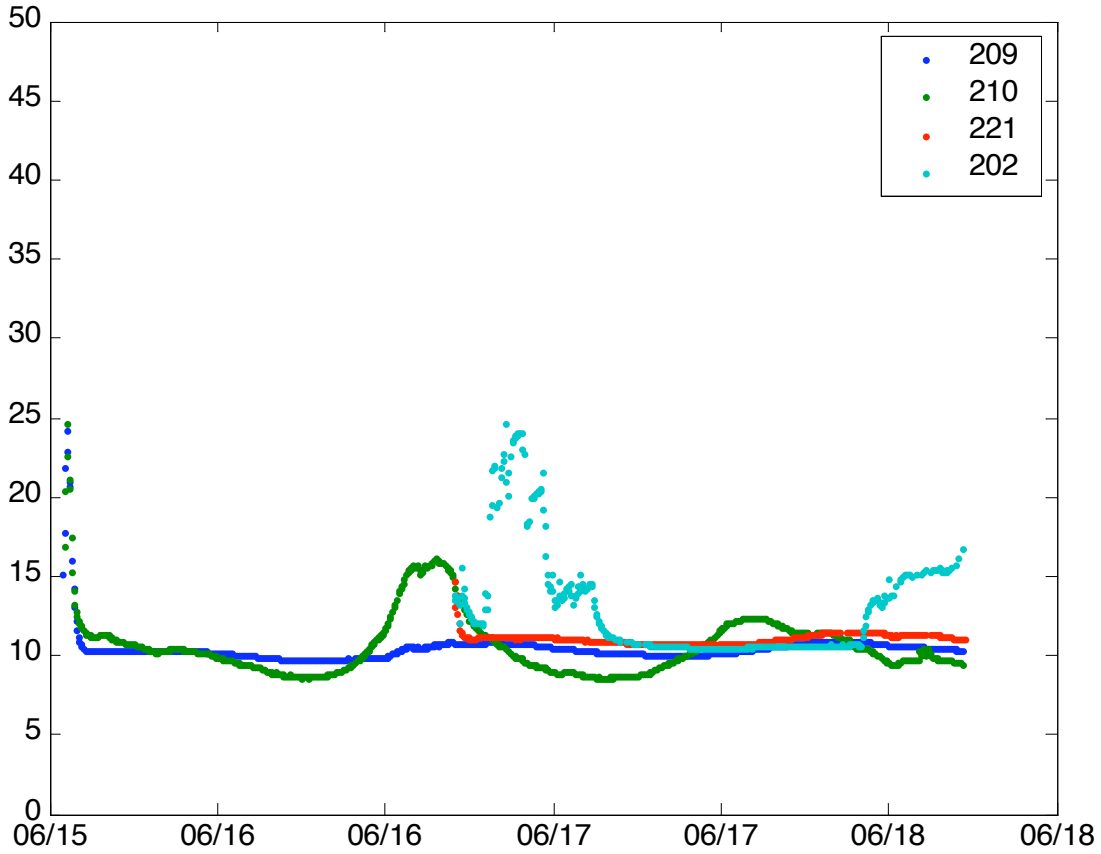
Burrow motes: deployment



Burrow motes: link performance



Burrow motes: sample data



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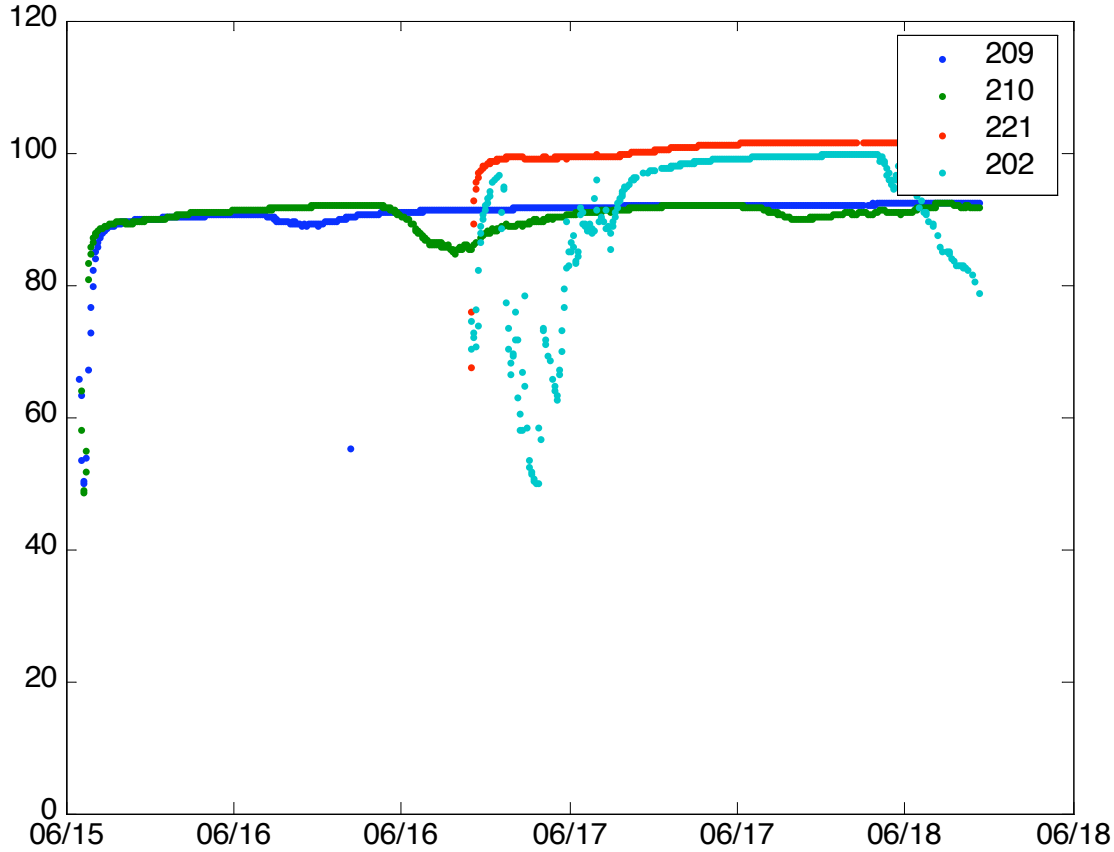

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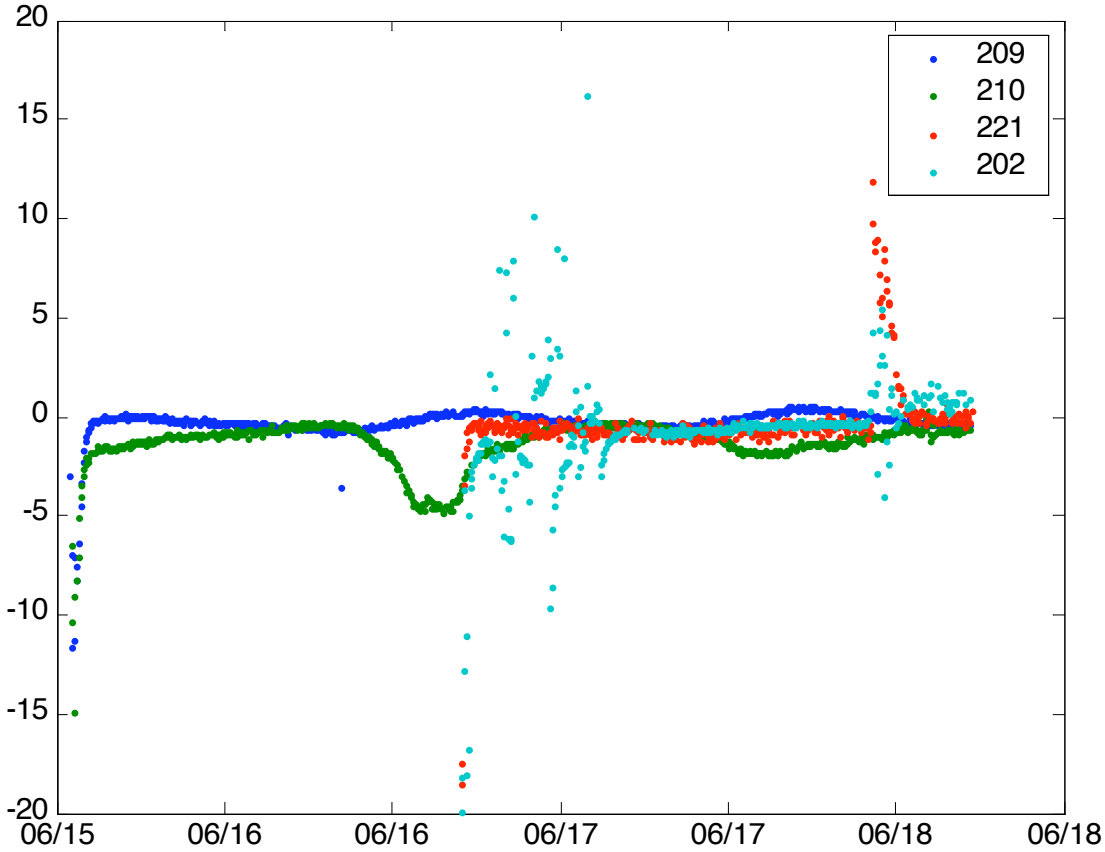
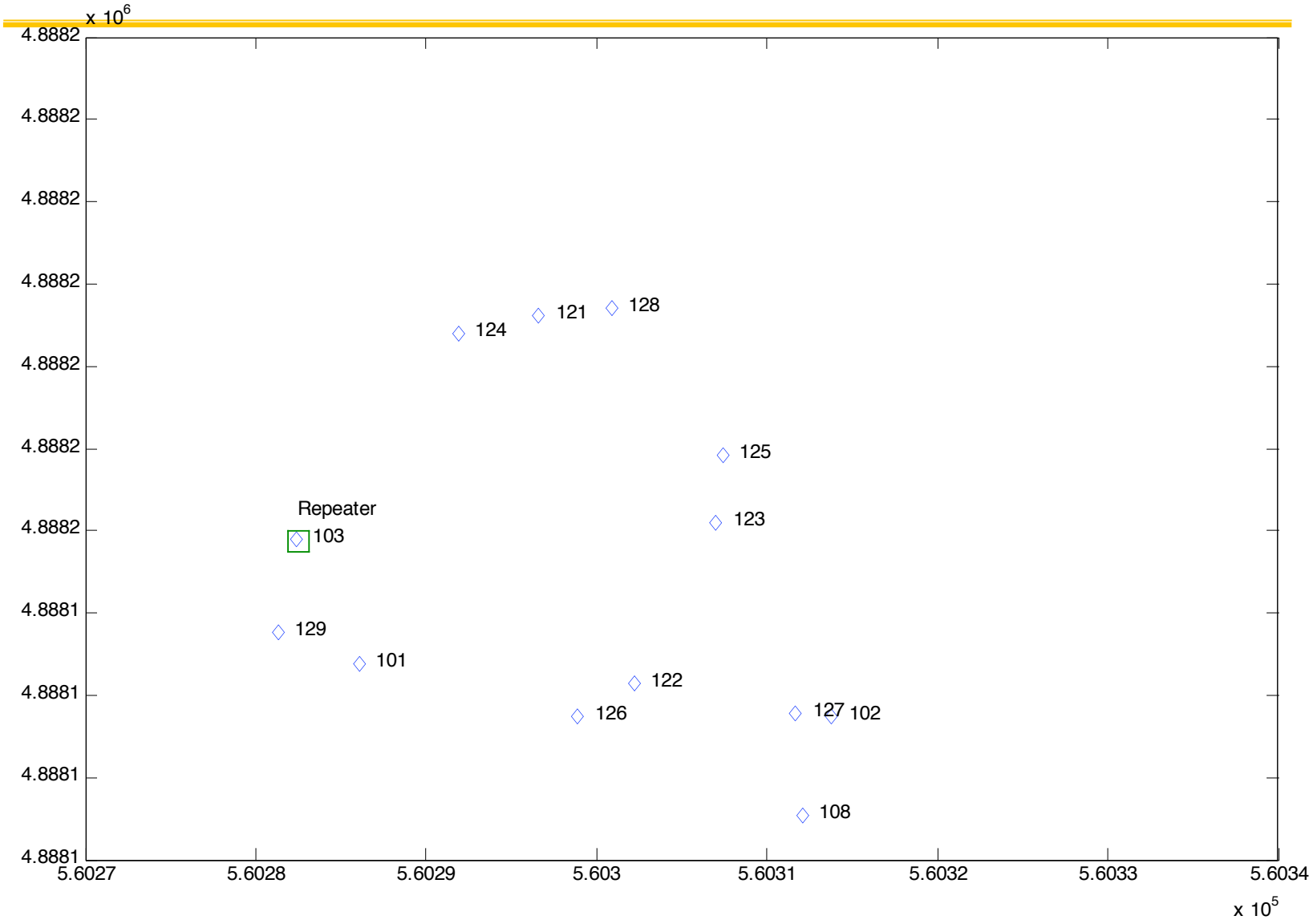
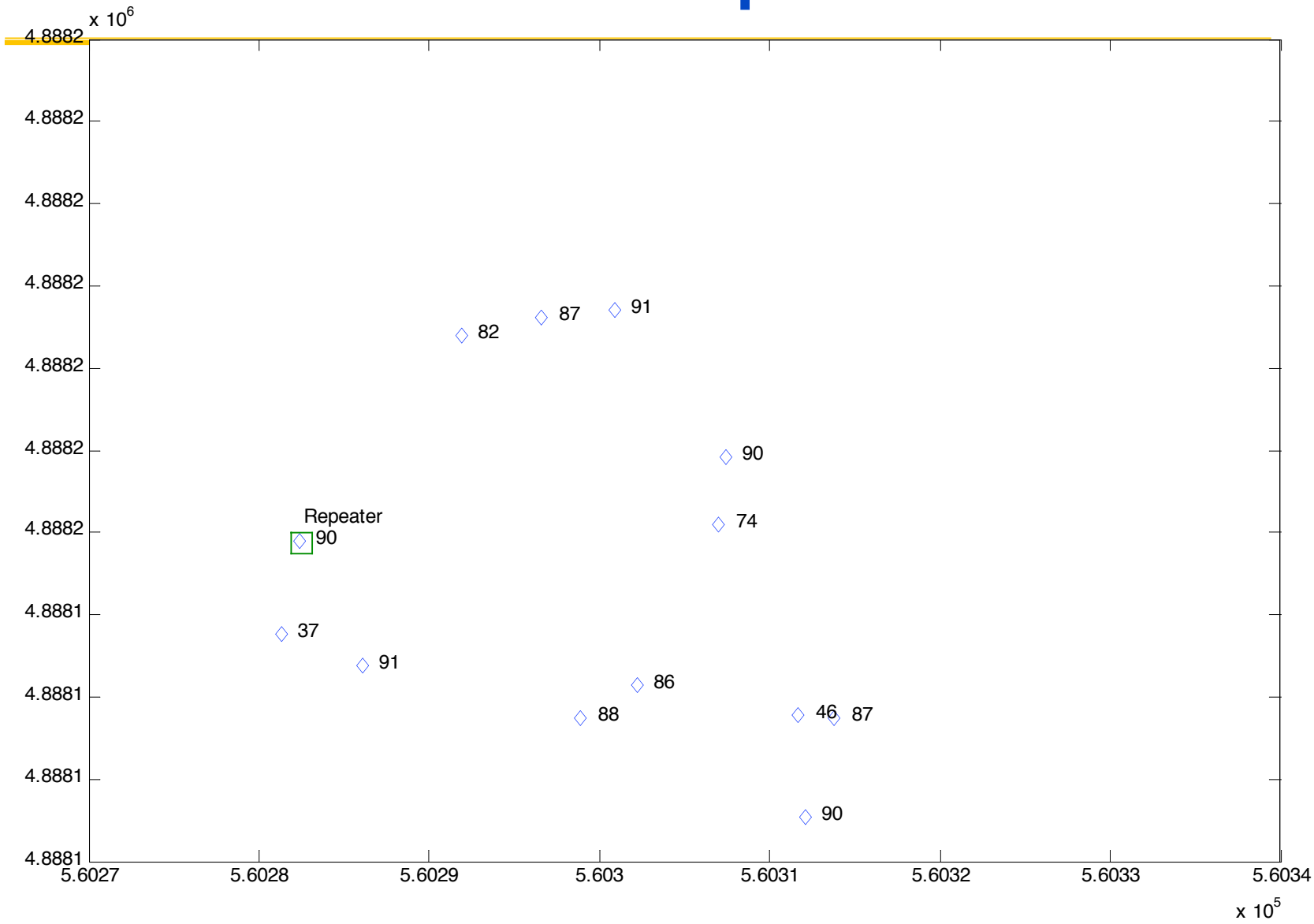


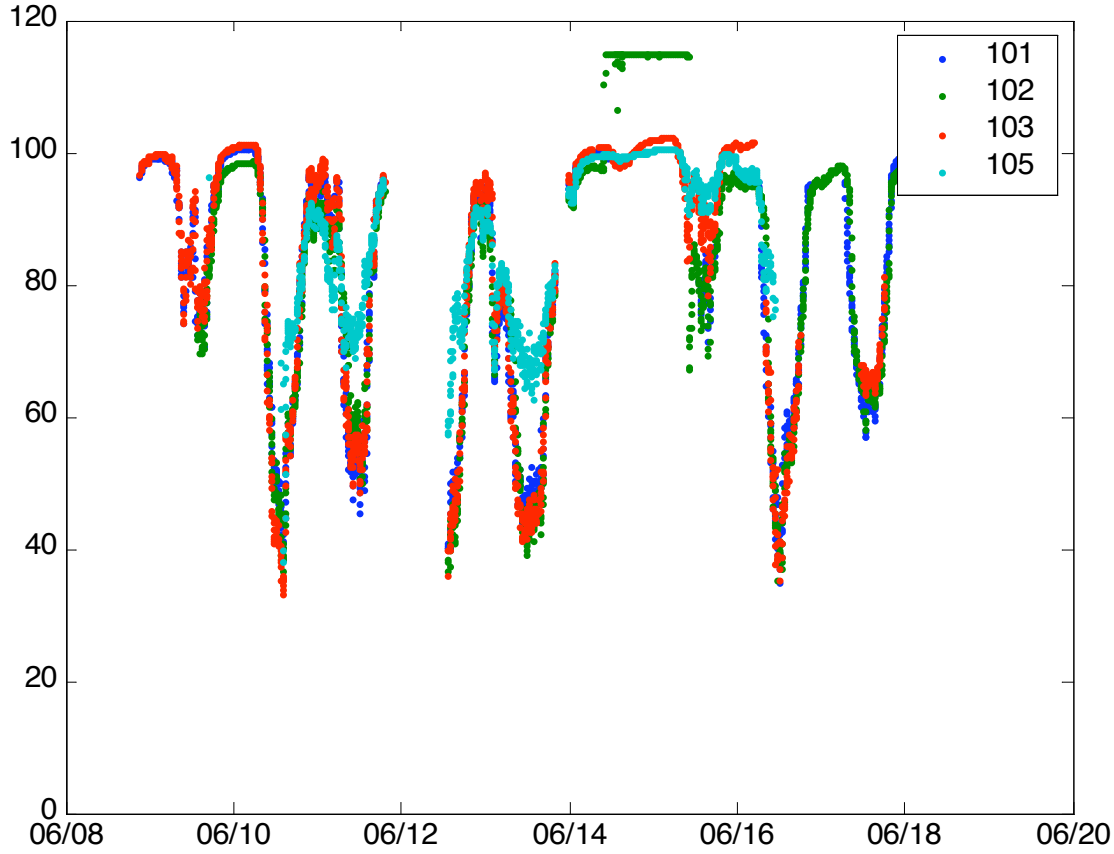
Weather stations: deployment



Weather stations: link performance



Weather stations: sample data



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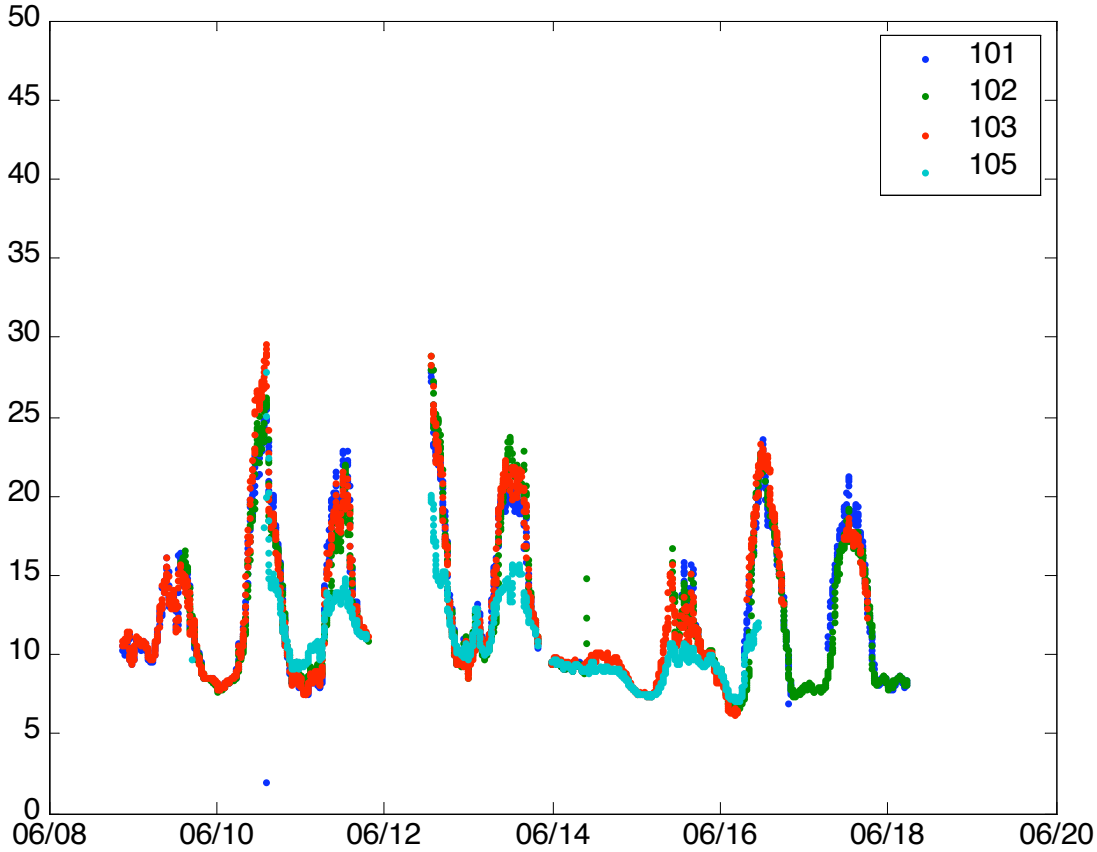

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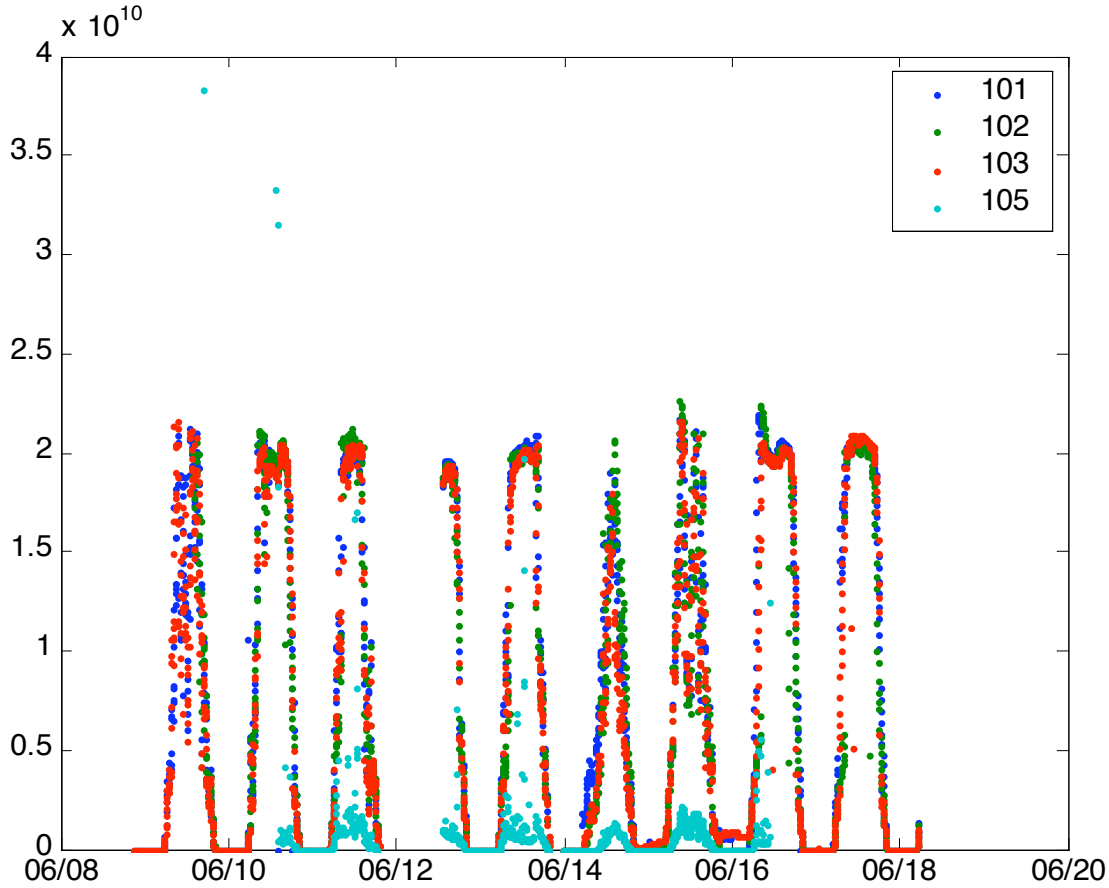

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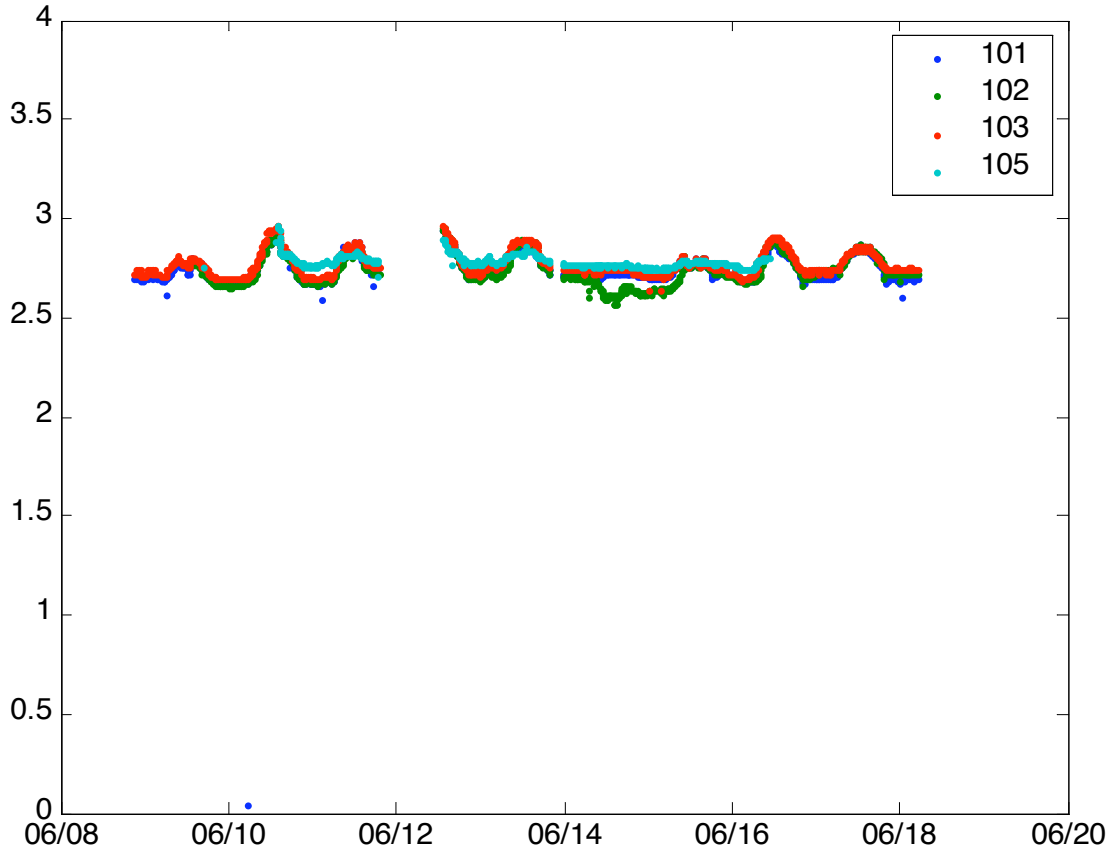
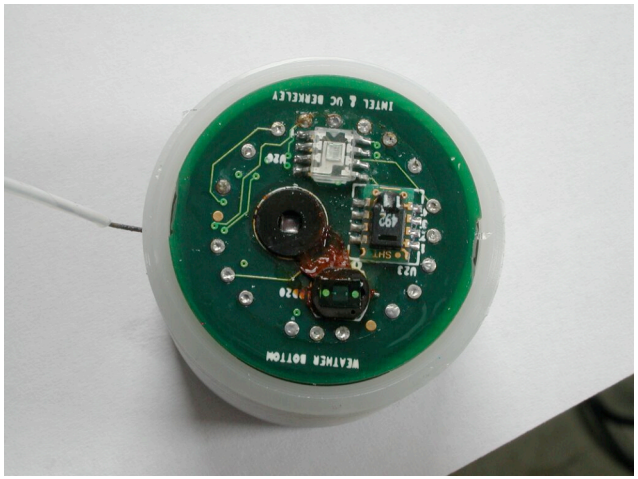
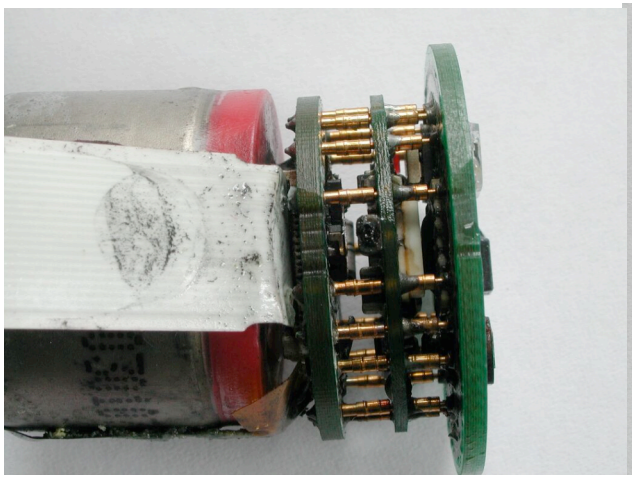
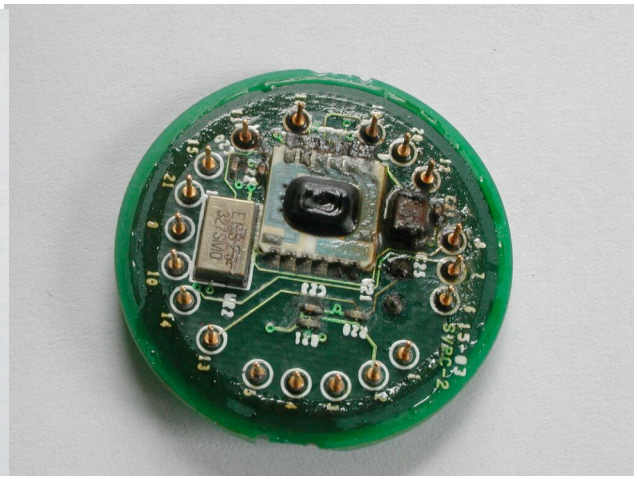


Packaging evaluation

- We observed what happens to motes when packaging fails
  - Battery venting, H2SO3 corroding the entire mote
  - Need to assemble the package correctly – we failed to create proper indication os a good seal
  - Majority of packages survived severe weather!
- Still awaiting evaluation whether the package creates an environment suitable for sensing
  - Convective heating, etc.







Conclusions

- **Next generation of environmental sensor networks**
  - **Smaller, better, more robust**
  - **Application specific sensor suites vs. kitchen sink**
- **Infrastructure matters**
  - **Redundancy at every level**
  - **Remote administration and rebooting**
  - **Data verification is key!**
- **More analysis to come**
  - **Biology studies based on the system**
  - **Compare notes with James Reserve system**