

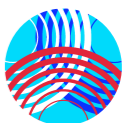
SensorScope: Experiences with a Wireless Building Monitoring Sensor Network

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Outline

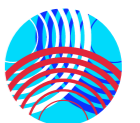
- The Vision
- Overview SensorScope
- Ingredients
 - Server Side
 - Mote Side
- Performance
- Channel Utilization
- Mote Lifetime and Maintenance
- Future of SensorScope
- Conclusion



Sensor Networks: The Vision

- *“So many nodes you can’t count or keep track of them.”*
- *“Nodes are so cheap you don’t need to keep track of them.”*
- *“Randomly sprinkle 10’000 nodes and the rest happens by magic”*

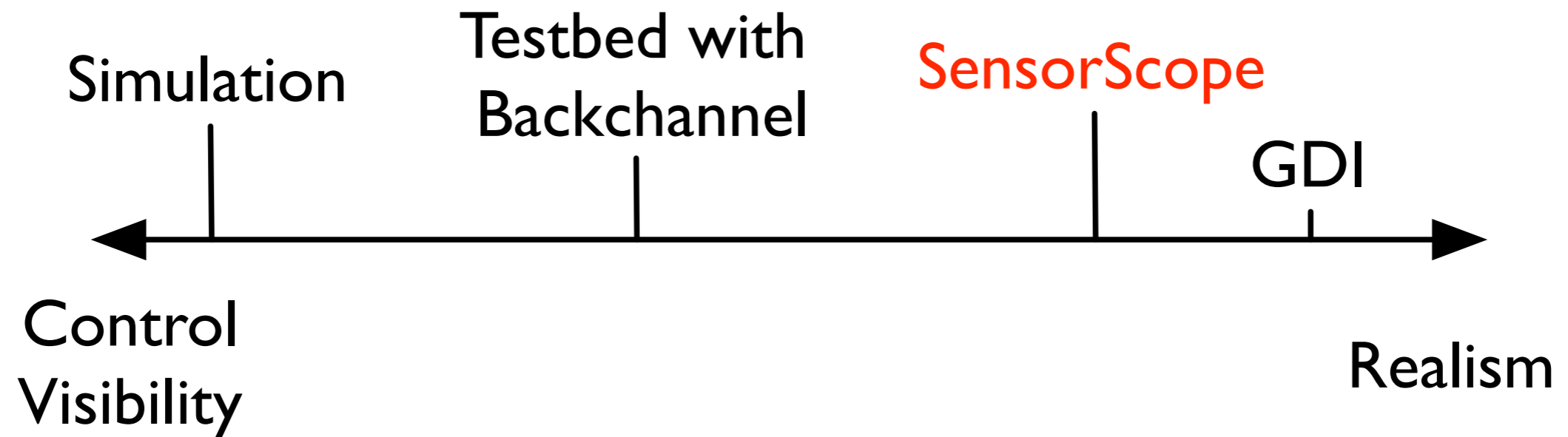
But: We are not quite there yet...



SensorScope

- Gain operational experience with a test deployment that is long-running and realistic
- Consider a complete system from sensors to web-accessible interface
- Intended as standard data-gathering application
- Focused on using existing, standard TinyOS components
- Setup in 3 months over Summer 2004
- Currently 20 nodes, placed in offices / public spaces on 4 floors in the new I&C building at EPFL
- Operational since October 2004

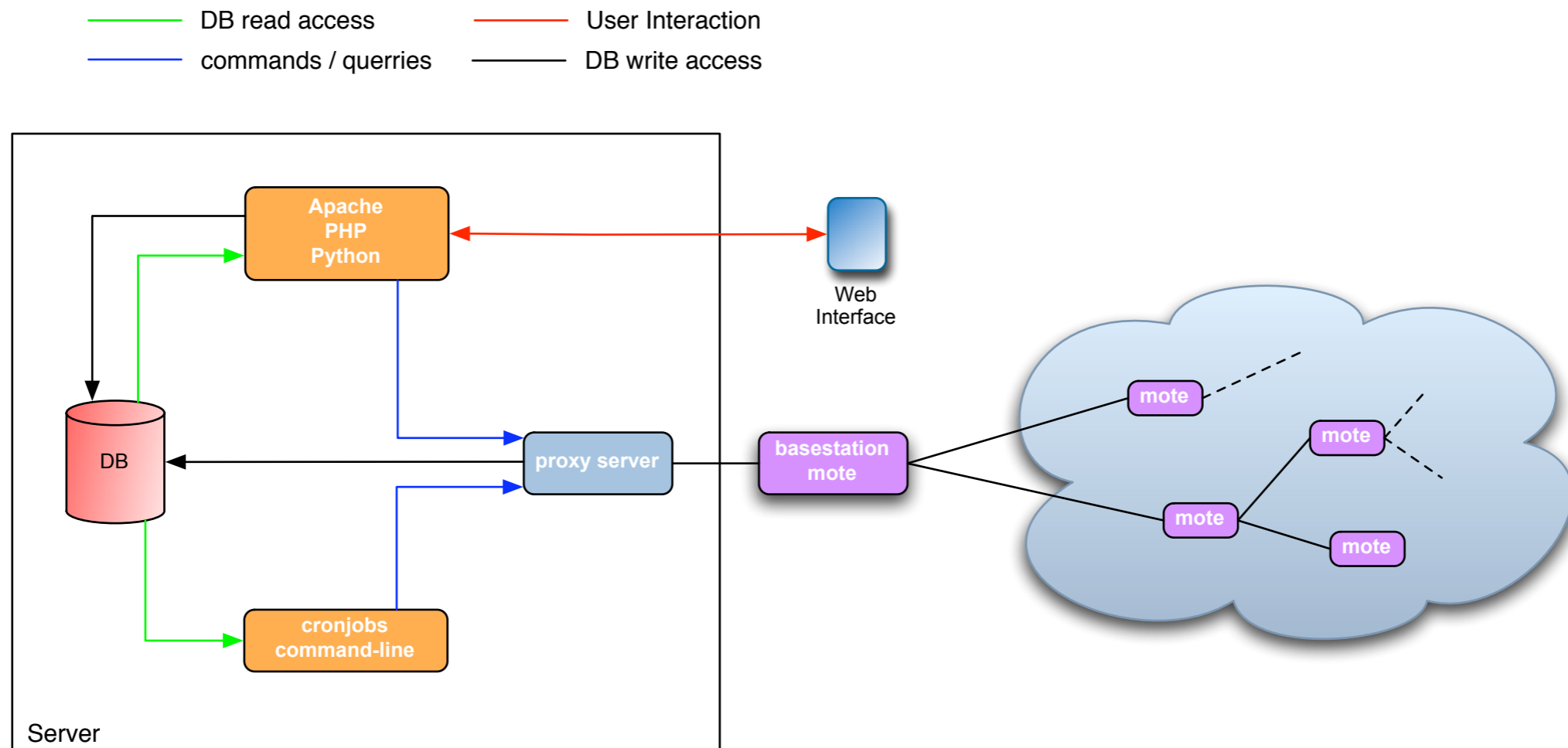
Tradeoff



- **But** adding new features to a running system is risky and slow

Server Side

- Apache / PHP / Python for Web Interface
- Database to store sensor data and maintenance information
- Middle-ware in Java makes the link between Database / Sensor Network and user interfaces



SensorScope

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Home

SensorScope is a **wireless sensor network** deployed in the new [I&C](#) building on the EPFL campus.

The network currently consists of around 20 mica2 and mica2dot motes, equipped with a variety of sensors (such as light, temperature or acoustic).

SensorScope's purpose is to serve as a **realistic** prototype deployment (motes run on batteries, no wired backchannel) for research activities within the [MICS](#) center.

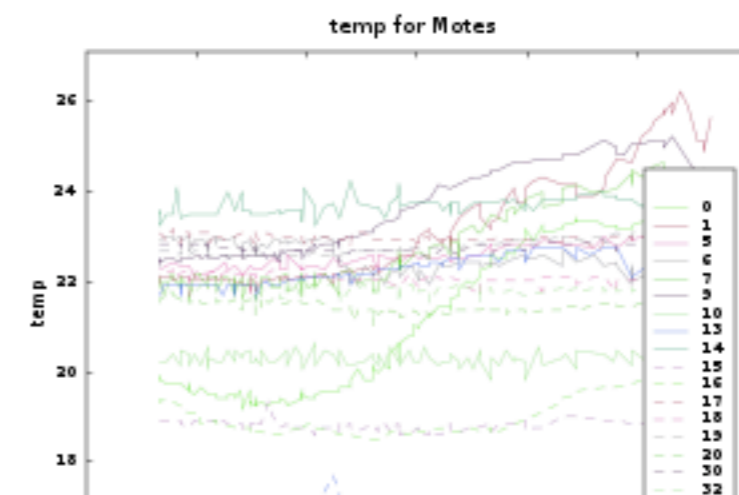
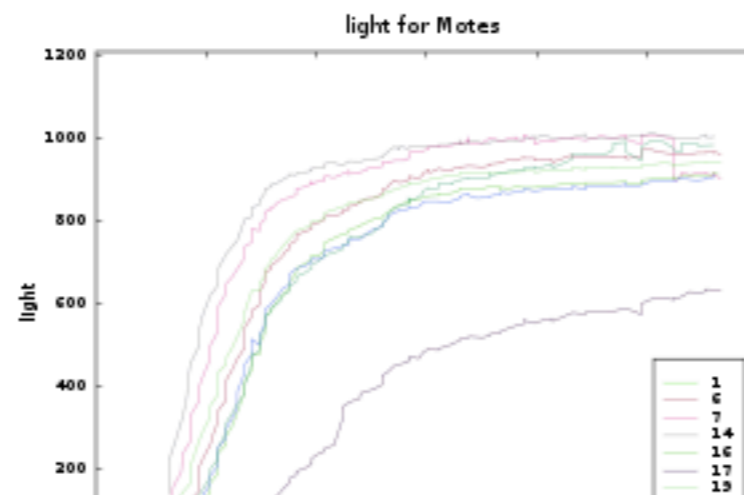


Live Data

Active in the last hour: 18 motes

Nothing heard in the last hour: 0 mote (*pesky batteries!!*)

The graphs below represent actual sensor readings taken from the motes in the I&C building. To see a larger image, click the graph you want to study. The link points to the according sensor on the [continuous graph](#) site.



SensorScope

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Navigate this page

- > Active Network
- > Full Connectivity Graph

Statistics

- > Networkgraph
- > Mote Information
- > Message Rate

Network Plans and Sections

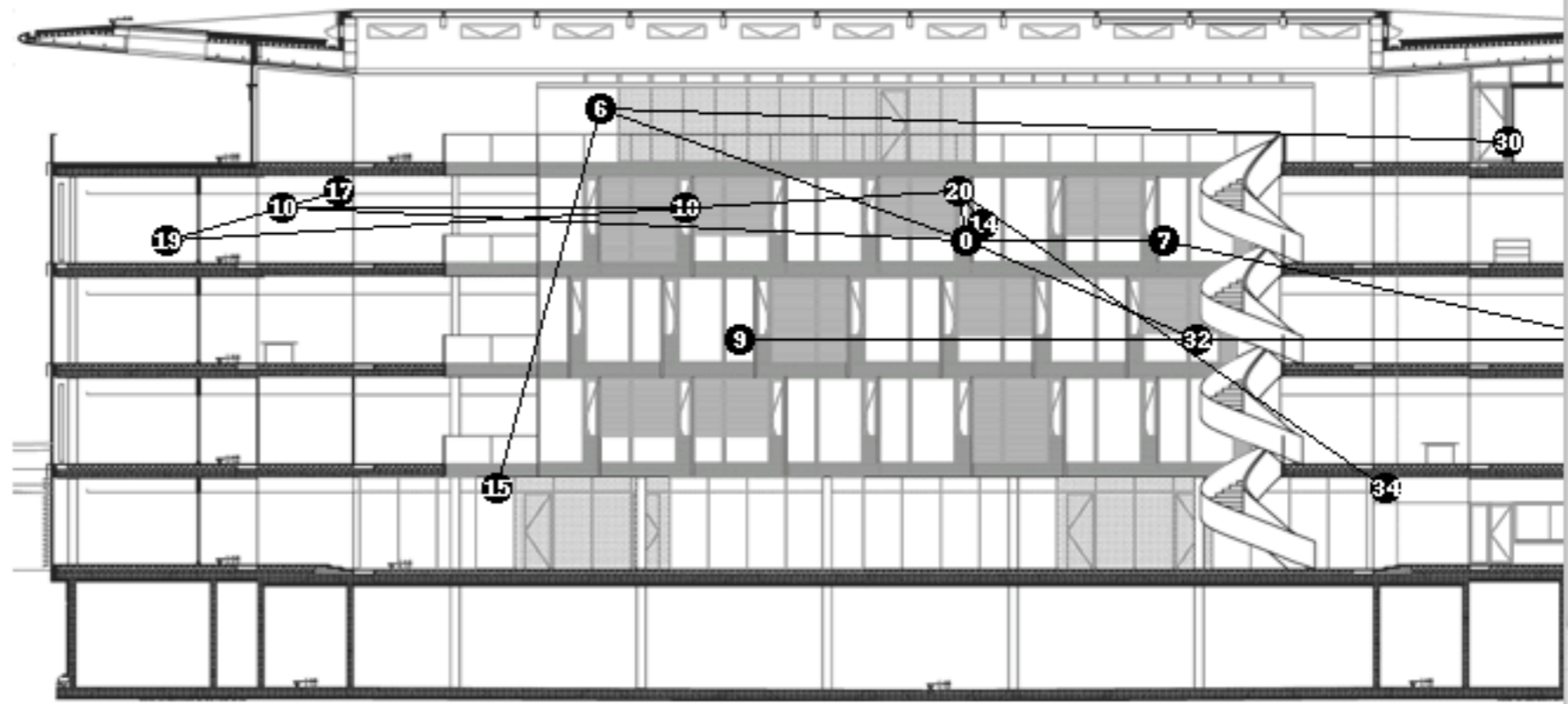
We send two 'get_routing_all' commands to the motes with 1 second pause in between. The result is written into the database. Then, we query the database for the last reported parent for each mote and draw a graph. The network graph is updated periodically at 5 minute intervals.

Detailed information will be showed in a tooltip if you move the mouse over a mote.

BC 3rd Floor, small
Section North-South, small
Section North-South
Section Est-West

Update

Last update 08.06.2005, 10:50



Sensor Data

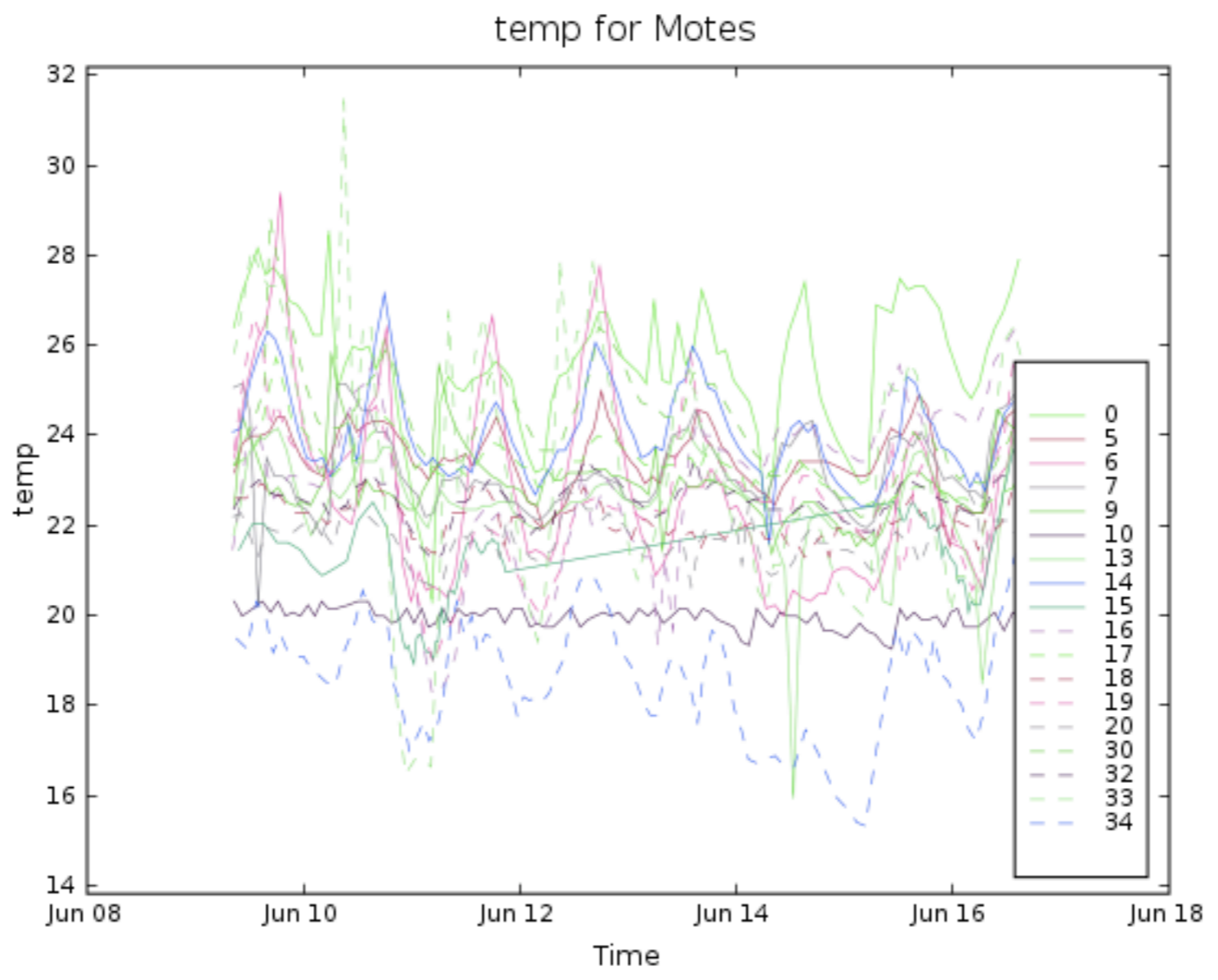
- > Continuous Graph
- > Sensor Graphs
- > Contour Maps

Table: icmon_sensor_data

Sensors	NodeIds	Date From	To
temp	20	2005-06-09 08:48:18.115195	2005-06-16 17:55:36.503777
voltage	30		
mic	32		
accelx	33		
accely	34		

Update Graphs

Sensor: temp ^ TOP



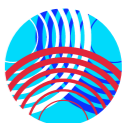
Mote Hardware

- Mica2 and Mica2dot motes
- Sensorboards with light, temperature, acoustics and acceleration sensors
- 10 bit ADC
- 433 MHz Radio
- 38 kbit/s raw data
- -20 to +5 dBm RF Power



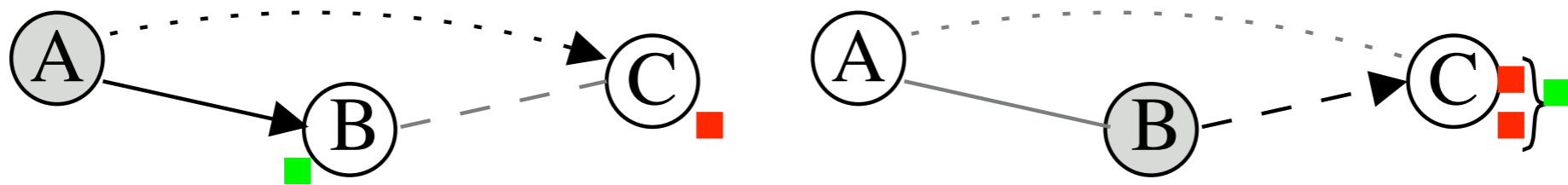
Mote Software

- TinyOS
- Two basic duties:
 - sample sensors
 - route readings back to the base-station
- Uses `tos/lib/Route`, later `tos/lib/MintRoute`
- Integrated Deluge for wireless reprogramming
- Processes query requests and configuration commands
- Multi-hop hybrid ARQ layer between network and link layers



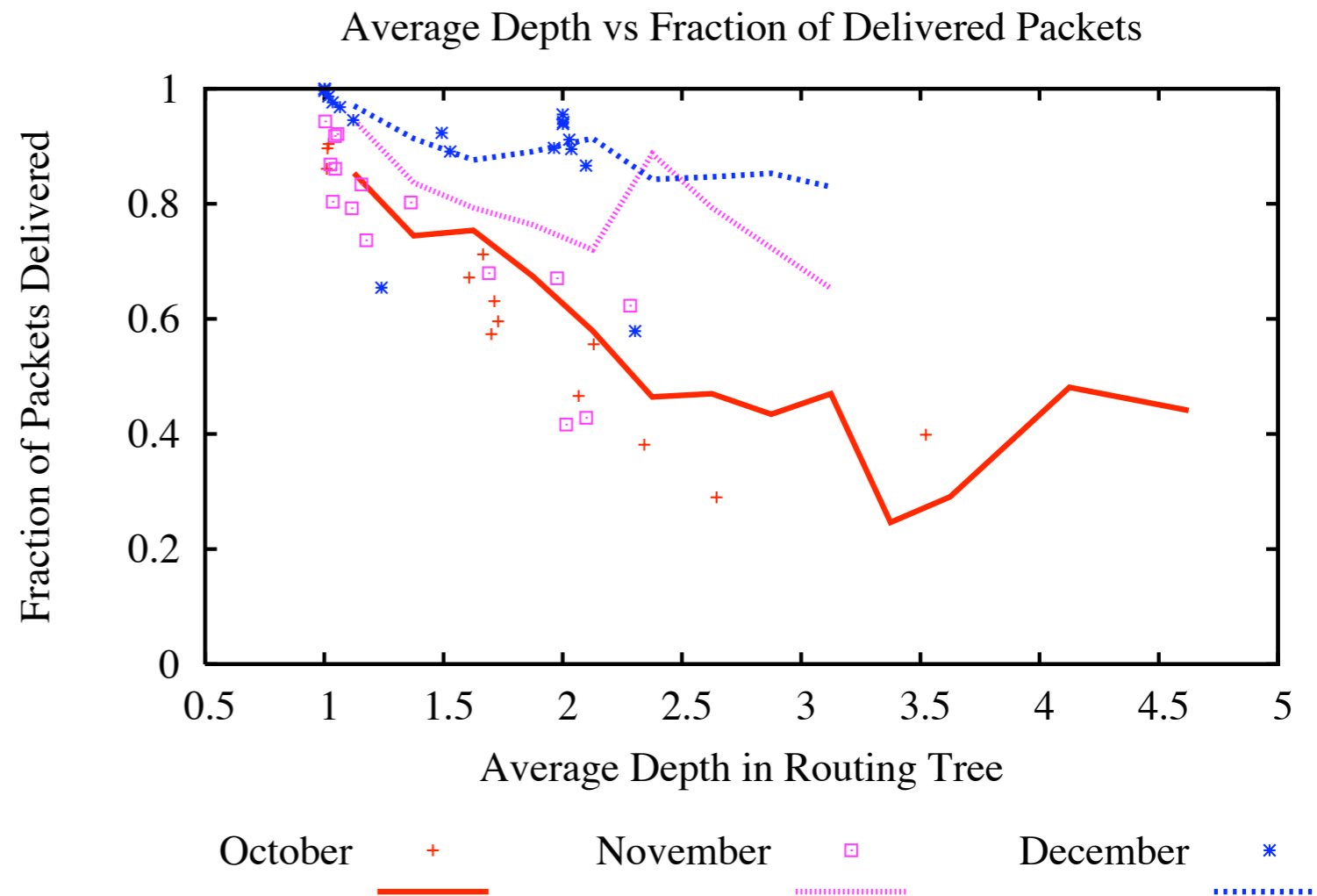
Multi-hop Hybrid ARQ

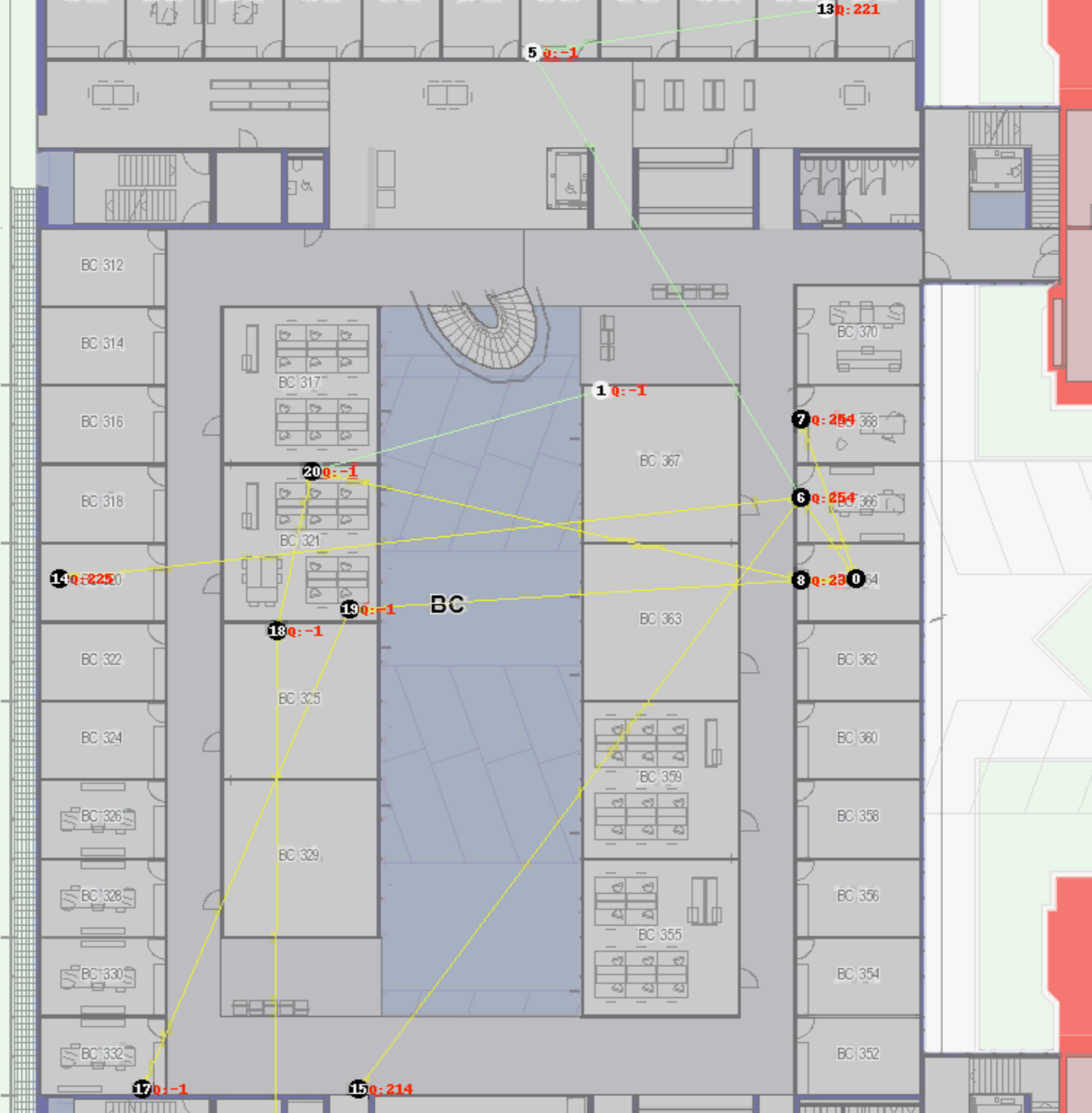
- Tries to combine two corrupt versions of a packet
- Does not transmit redundant overhead on good links
- Exploits spatial diversity arising from the broadcast, multi-point nature of a sensor network



Performance

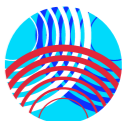
- Three data-sets
- October: first version
- November: higher RF Power
- December: Retransmission, Deluge, MHARQ





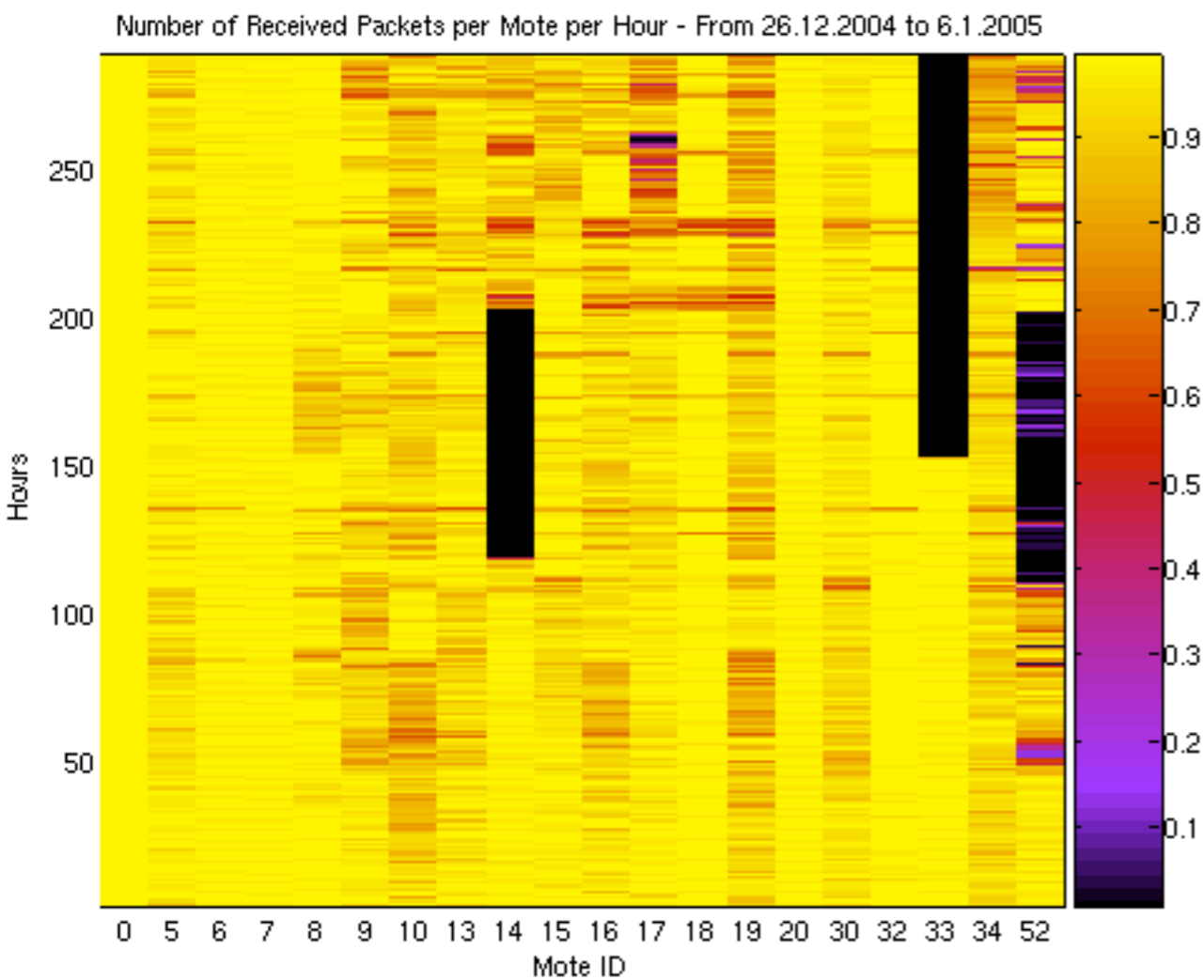
Channel Utilization

- Increased monitoring traffic could lead to congestion
- Nodes report number of transmitted bytes
- Analyzing those numbers shows that network is not congested
- How does the network perform if it is congested?

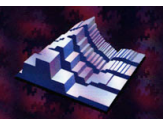
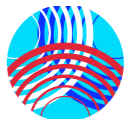
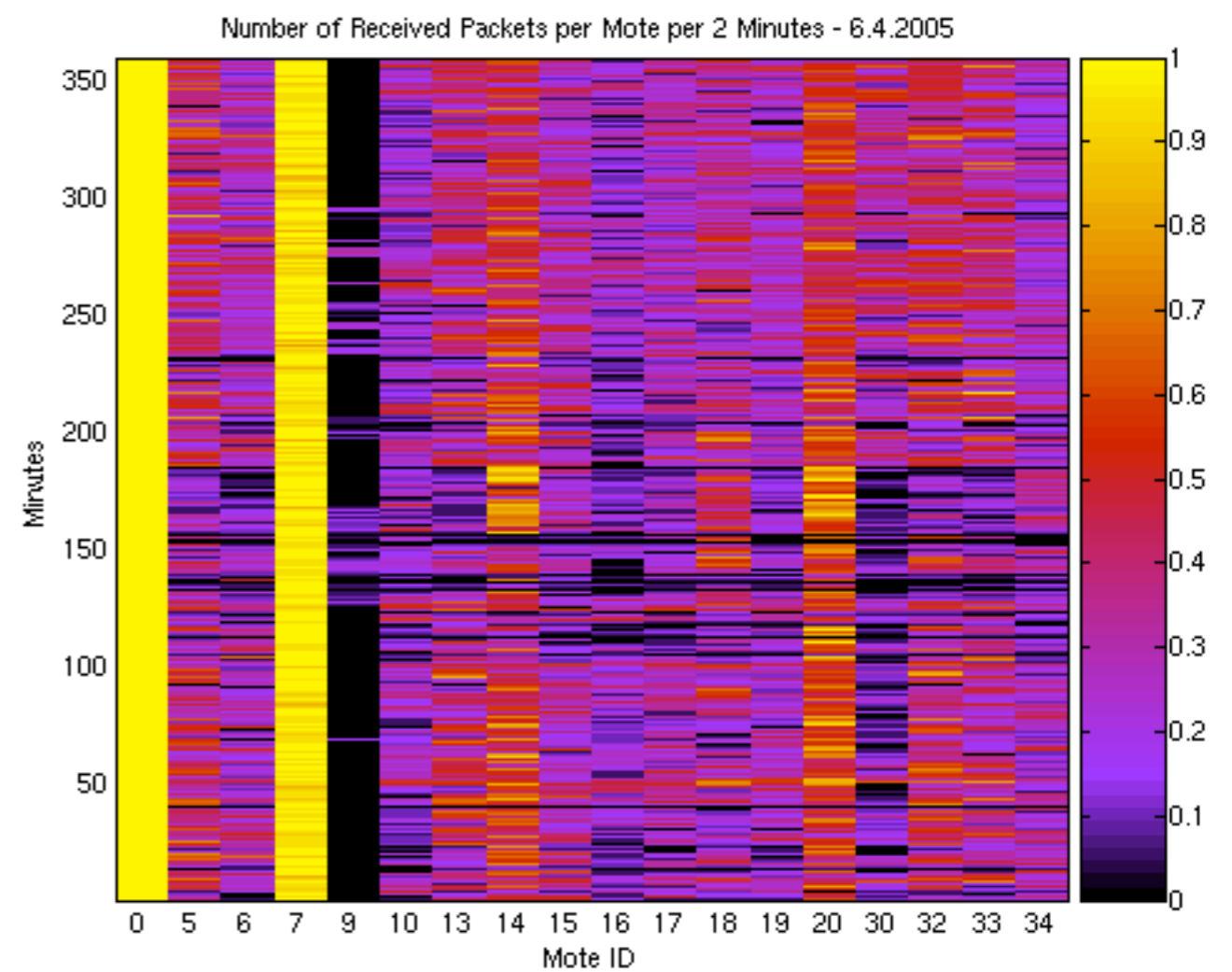


Congestion

Not Congested

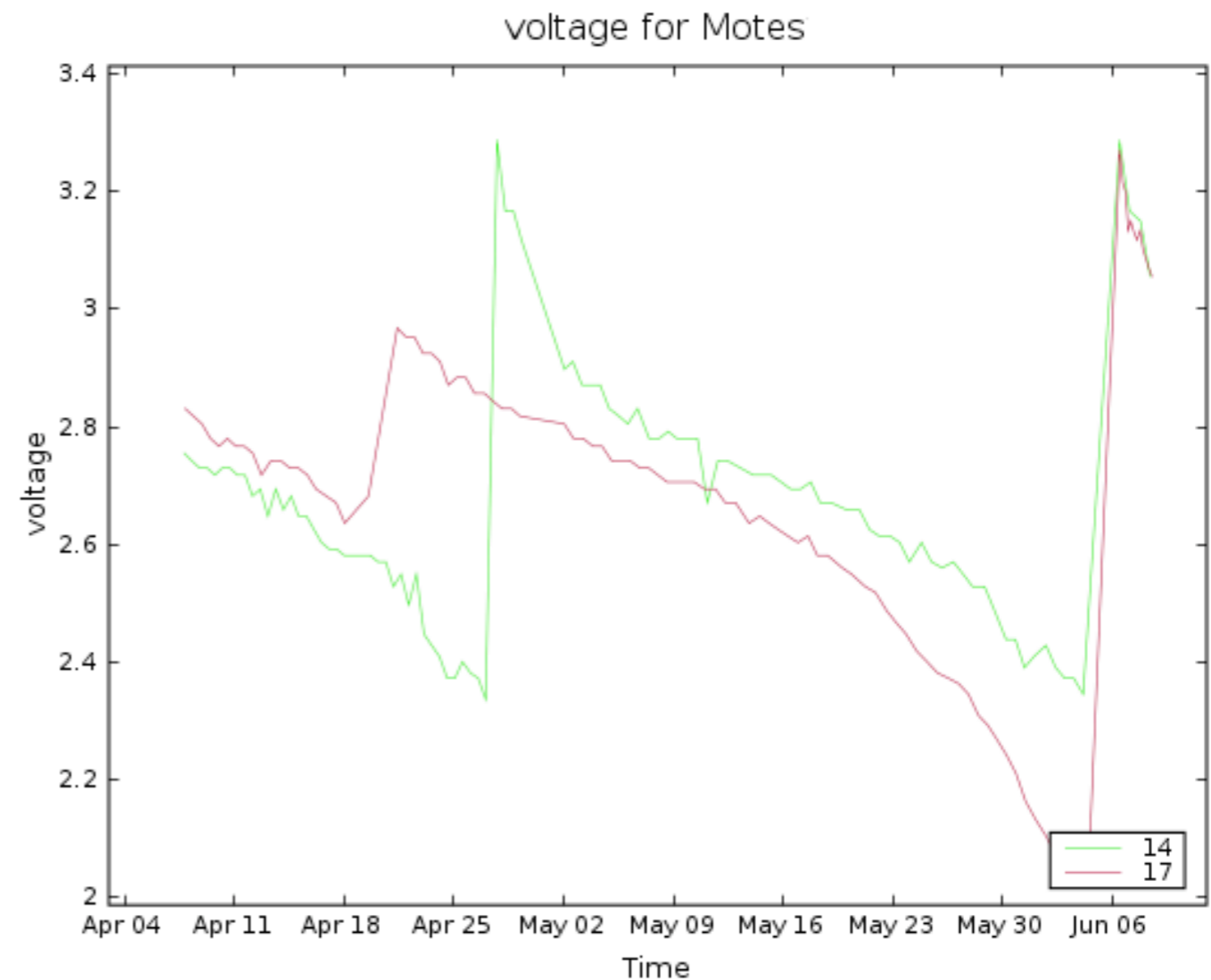


Congested



Mote Lifetime

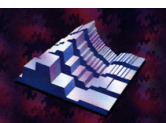
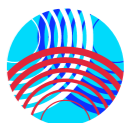
- SMS informs when mote died
- Found significant correlation between numbers of packets delivered and power usage
- On average, 13.1 mV/day



Future of SensorScope

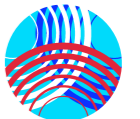
- Improve Web Interface
- Add Nucleus to send configuration parameters
- Include our own routing protocol
- Port to TinyNodes, developed by Shockfish

- Other projects using SensorScope:
 - COMMON-Sense: water supply monitoring for the agriculture in developing countries



Glacier Sensor Network

- Rugged environment
- Two phases
 - Phase I: 60-80 nodes on outdoor test area on EPFL campus
 - Phase II: deployment on Glacier de la Plaine Morte
 - a complex natural environment
 - additional sensors
 - larger scale (over 100 motes)

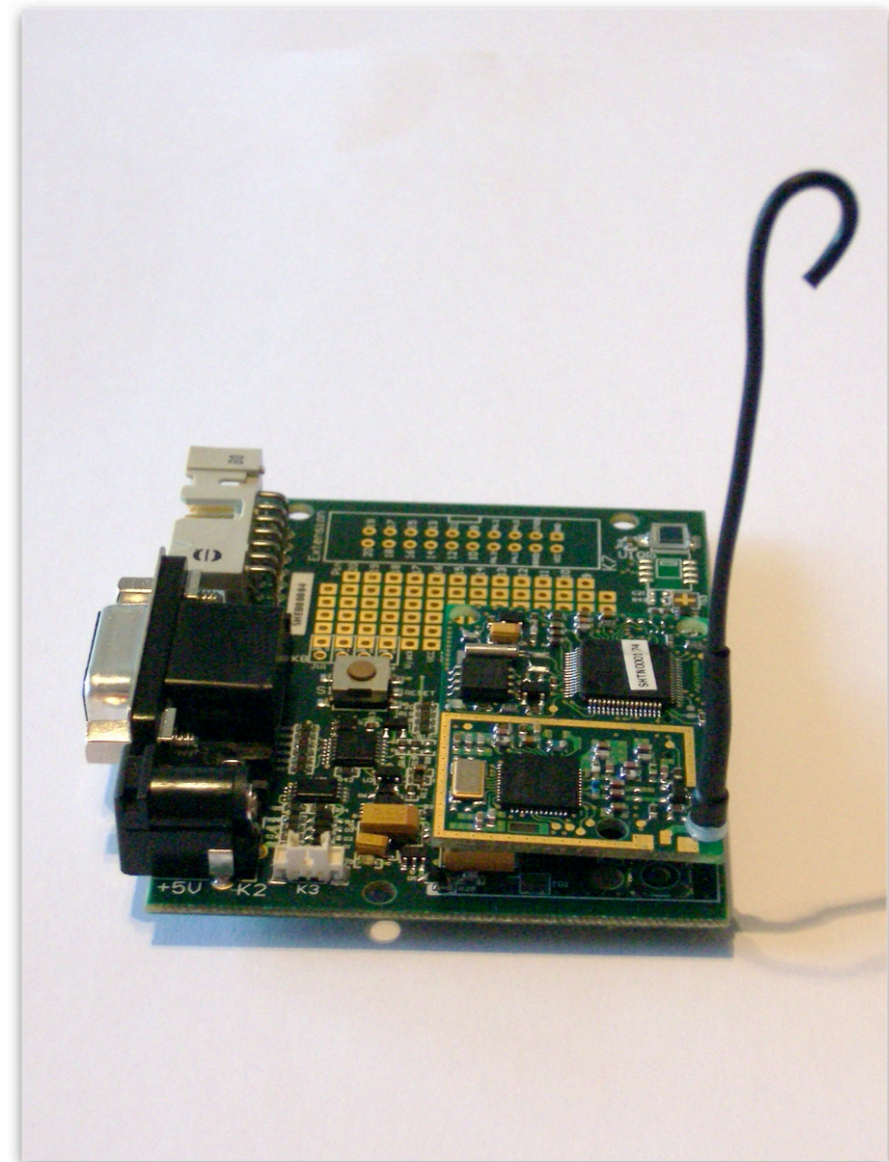






Shockfish: TinyNode

- Texas Instruments MSP430
- 868 MHz Xemics XE1205 wireless transceiver
- 12 bit ADC
- Variety of different sensors available (temperature, humidity, moisture, pressure etc)
- Housing options



Conclusion

- Presented the system architecture of SensorScope
 - Network is running in a non congested regime
 - Through further development, delivery rate improved
 - New projects coming
-
- Source code available under GPL and Intel license

More Information:

<http://sensorscope.epfl.ch>

<http://www.shockfish.com/tinynode>

<http://commonsense.epfl.ch>

Questions?