

Tracing and Stimulating Timing Sensitive Behavior of Wireless Embedded Systems

Roman Lim, Benjamin Dissler, Christoph Walser, Jan Beutel

Computer Engineering and Networks Lab, Swiss Federal Institute of Technology (ETH) Zurich

X-Sense2 Scenario

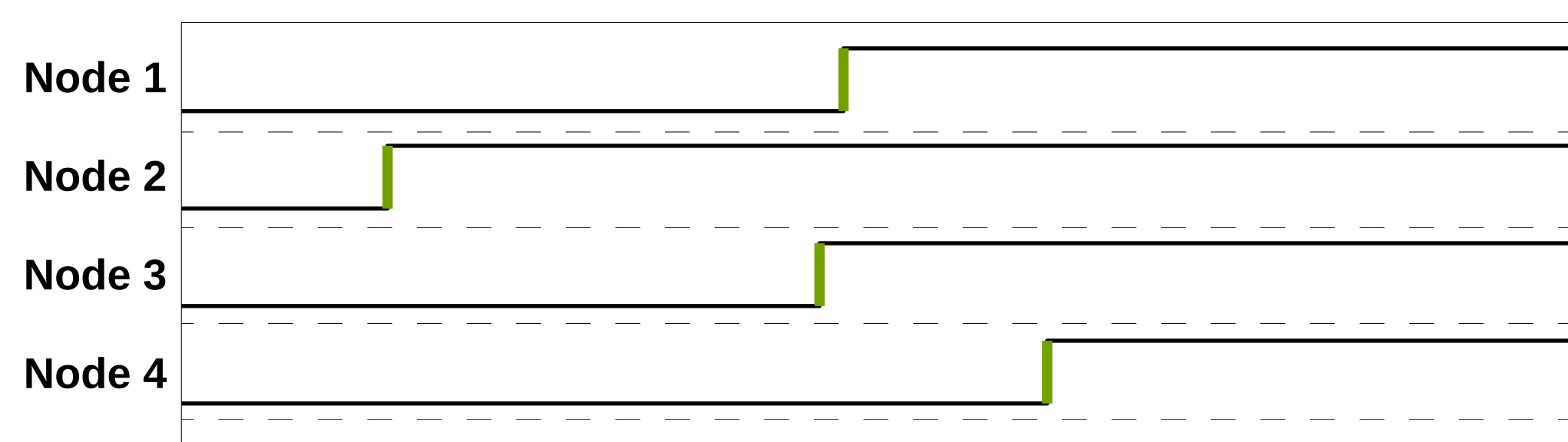
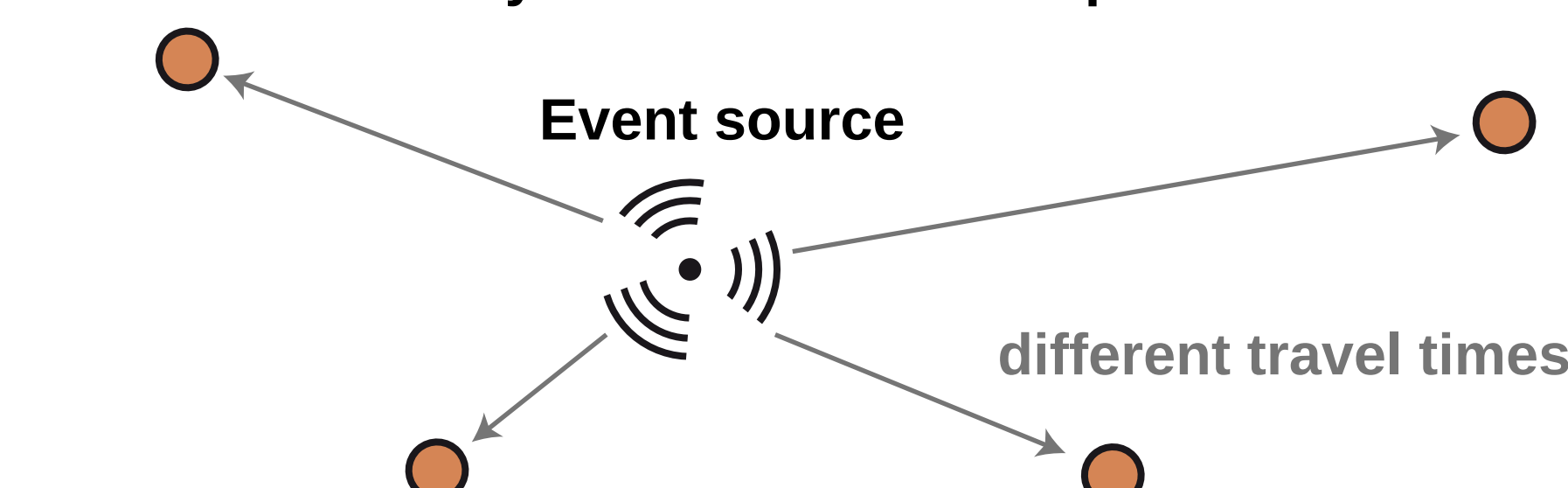
Application on target nodes:

- Localization of acoustic events in rock
- Propagation speed of acoustic wave ~3000 m/s
- Low latency control of other sensor systems



Test environment:

- Acoustic events are reproduced in testbed
- Timing accuracy must be sufficiently high
- Allows to study effects on network protocol

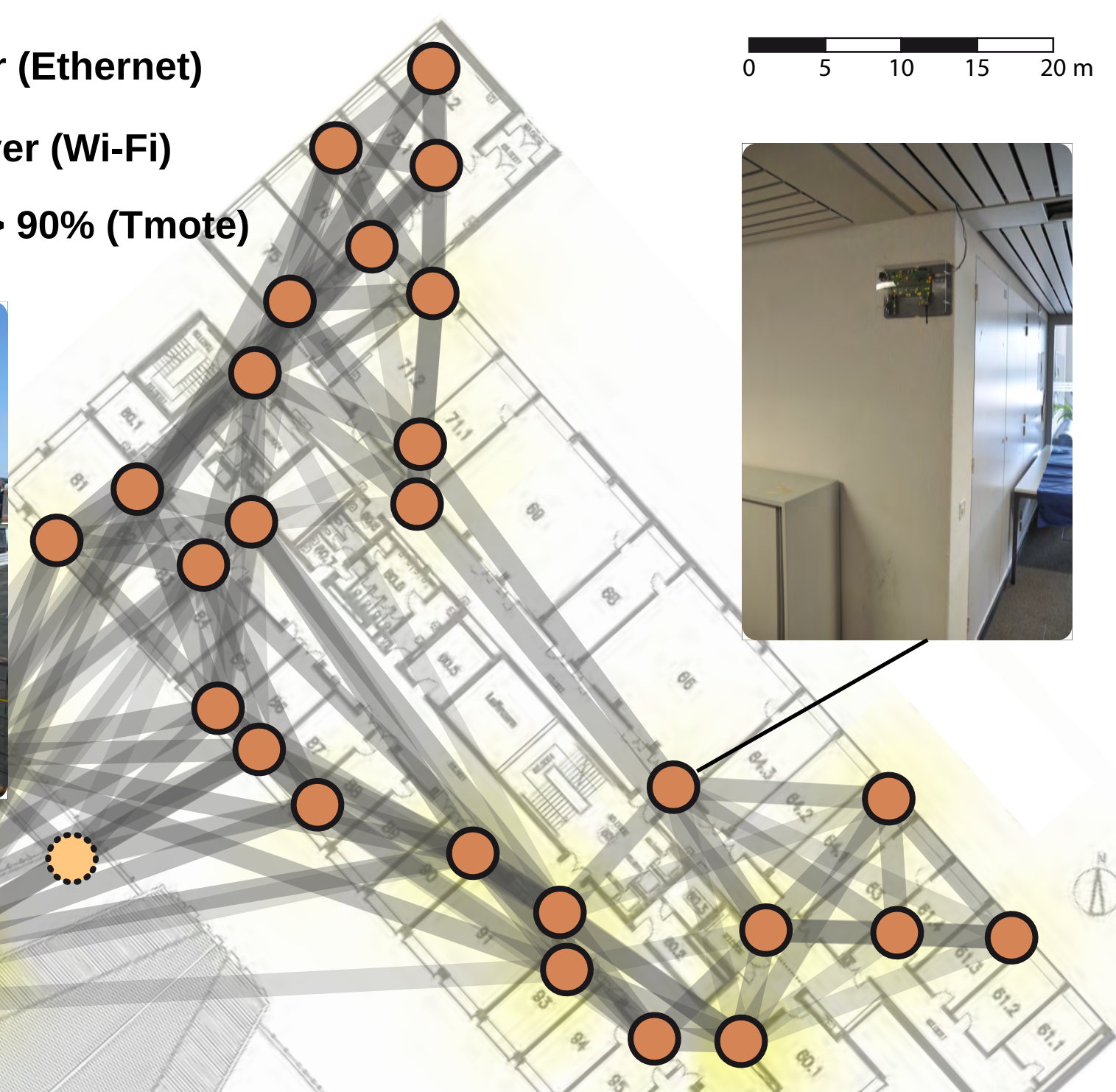


Potential testing pattern based on a wave propagation model.

Distributed test pattern generation requires highly accurate time synchronization (~1 μ s).

Deployment

- Indoor observer (Ethernet)
- Outdoor observer (Wi-Fi)
- Link with PRR > 90% (Tmote)



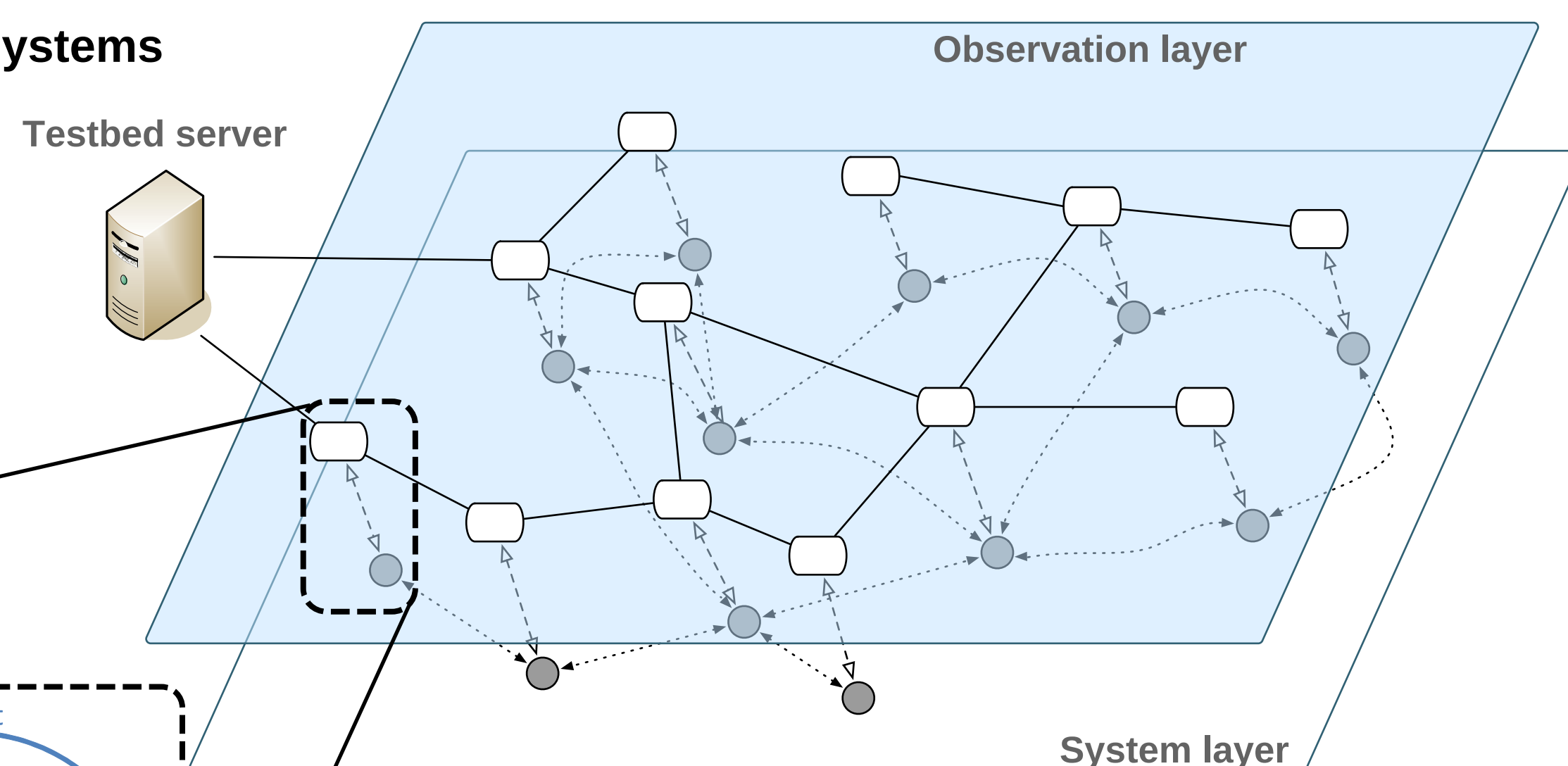
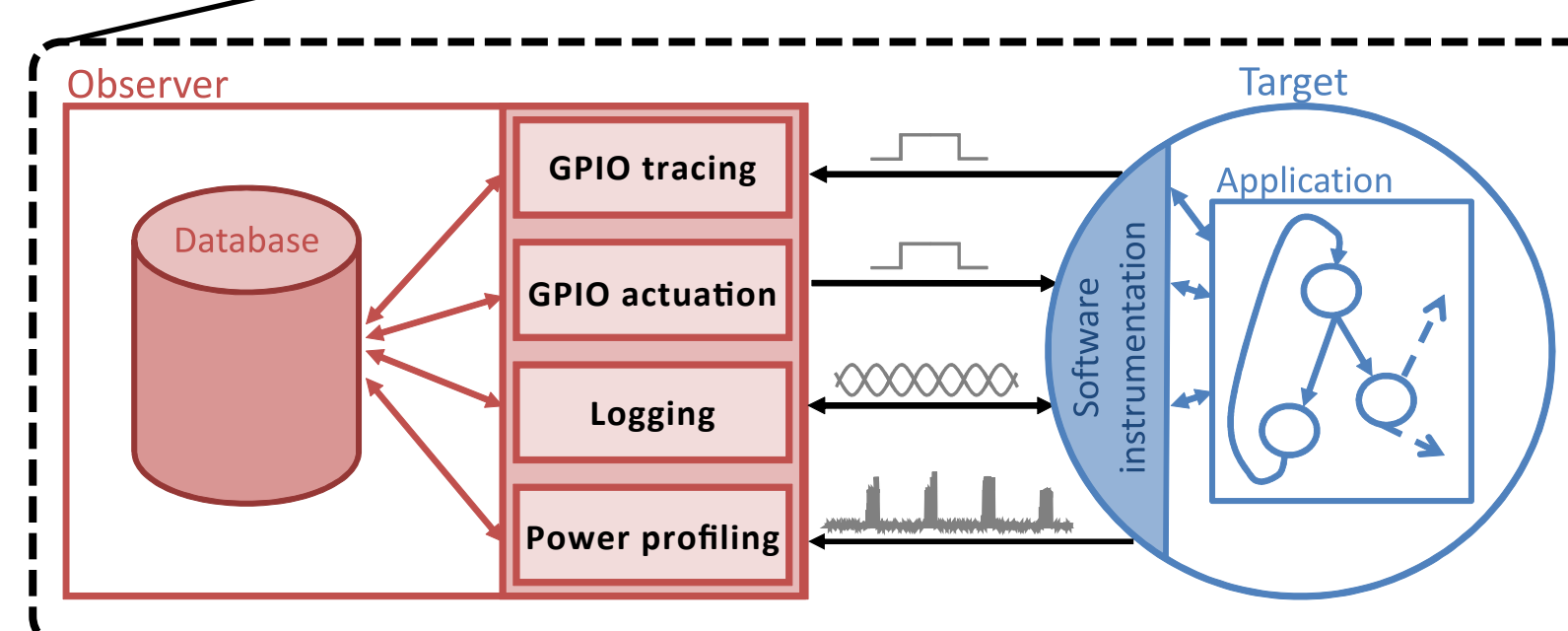
Testbed Architecture

Debugging software for wireless embedded systems is difficult

- Non-deterministic environment
- Working close to resource limit makes systems extremely fragile

Testbeds for Wireless Sensor Networks

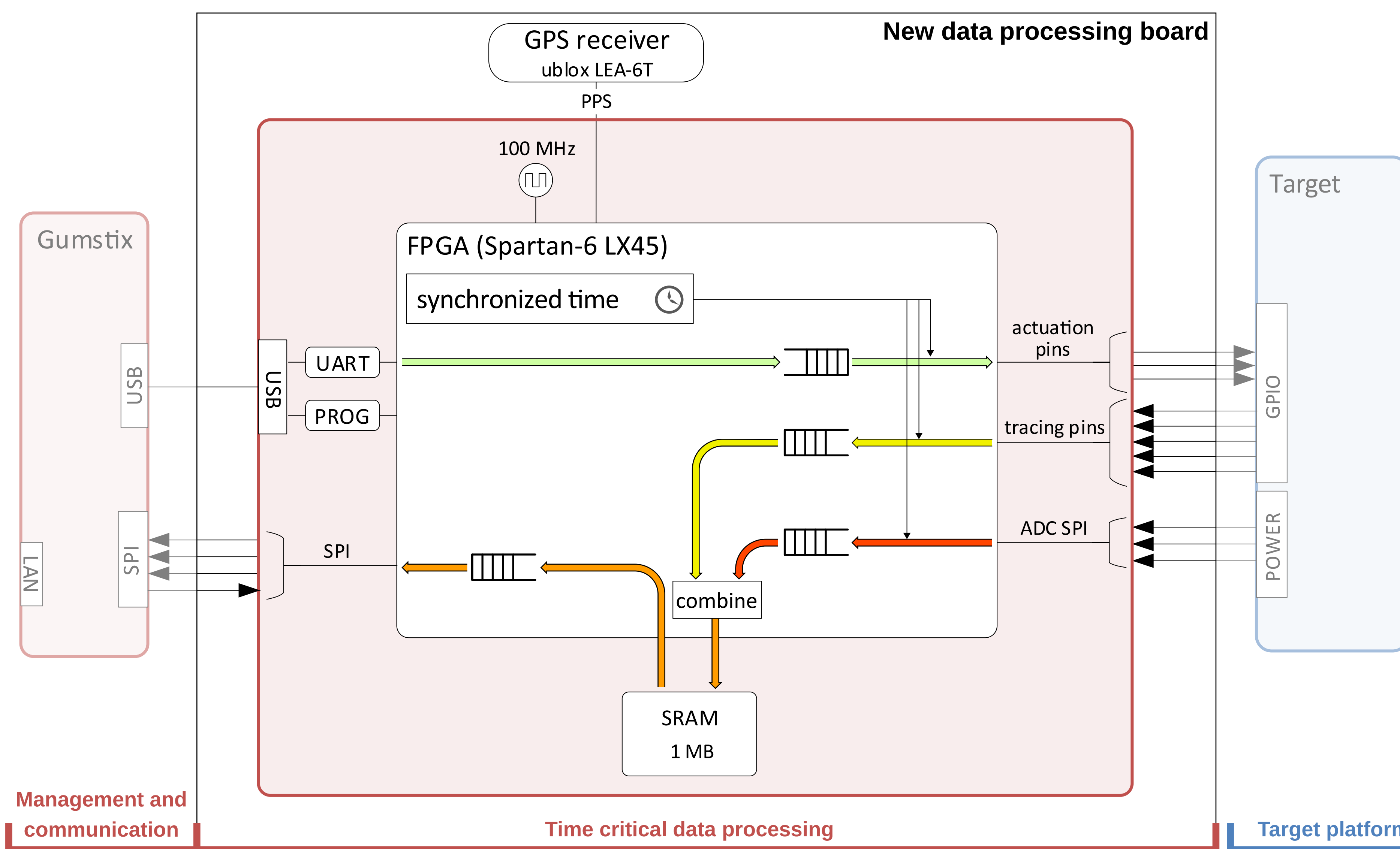
- Increase observability
- Enable testing on real hardware
- Help validate simulation results



The *observation layer* provides means to reprogram target nodes, monitor running programs and interact with sensor nodes.

The *system layer* represents the actual sensor network, consisting of individual sensor nodes, wireless links and environment.

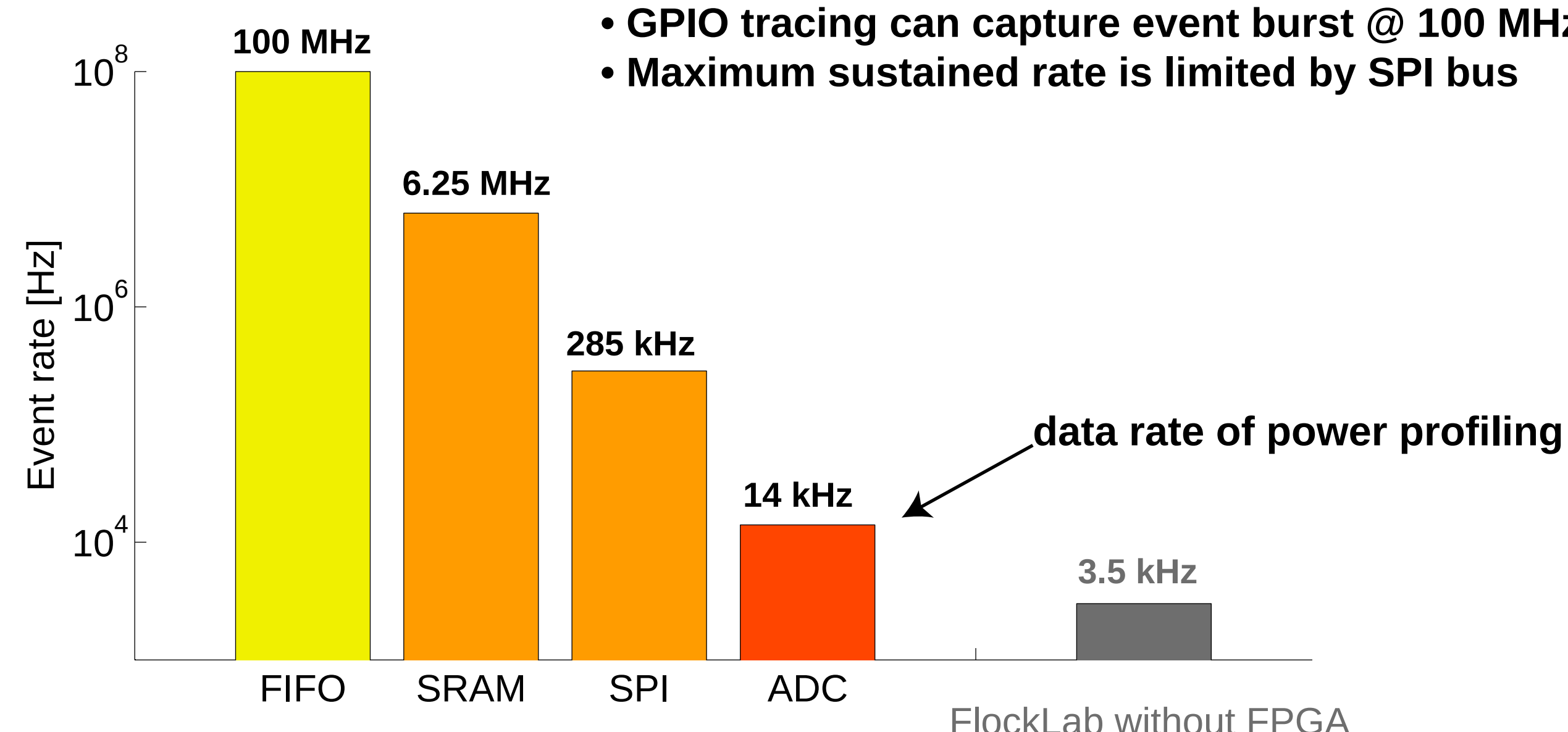
GPIO tracing and actuation provided by the FlockLab observer can be used to trace and stimulate timing sensitive behavior on a target node.
A new FPGA-based data processing board allows for sufficient timing accuracy.



Prototype Performance

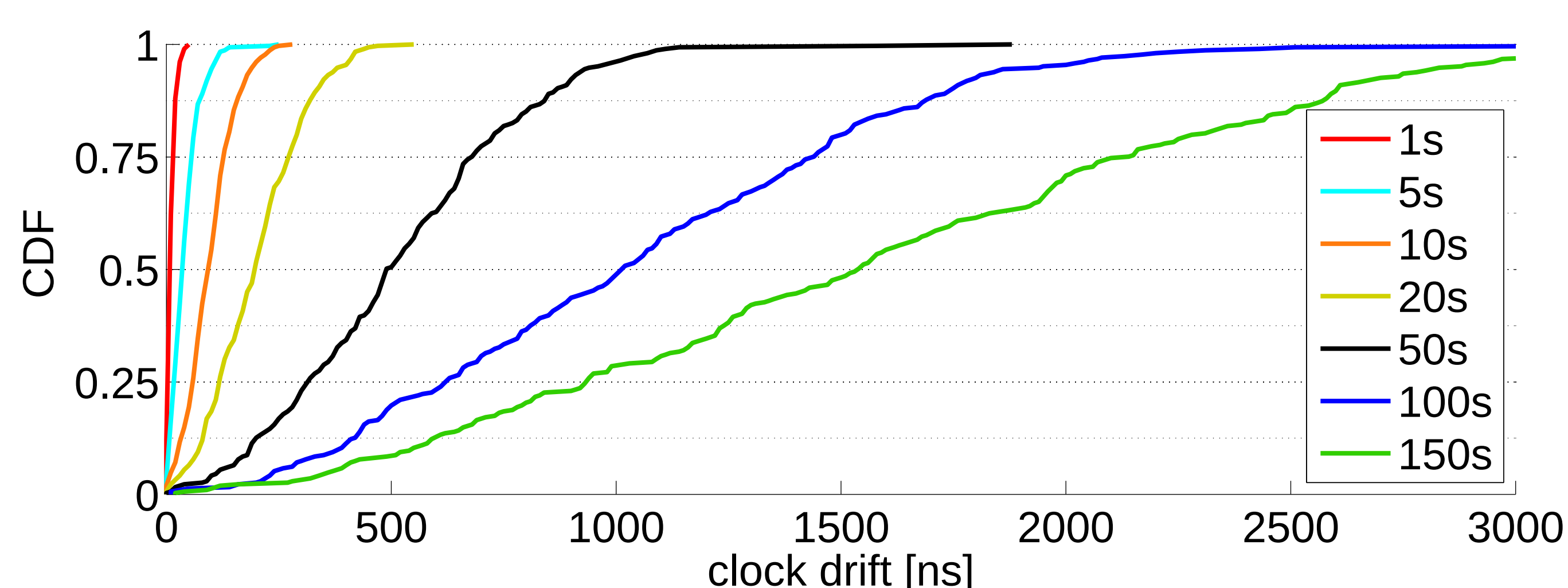
Event detection rate

- GPIO tracing can capture event burst @ 100 MHz
- Maximum sustained rate is limited by SPI bus



Time synchronization stability

- Drift after time pulse (PPS) is lost
- 90% of all the drift measurements (309 in total) are below 0.02 ppm



This prototype implementation of a data processing element for tracing and stimulating timing sensitive behaviour of wireless embedded systems can capture and generate events with a very high timing precision and sustain rapid event bursts.