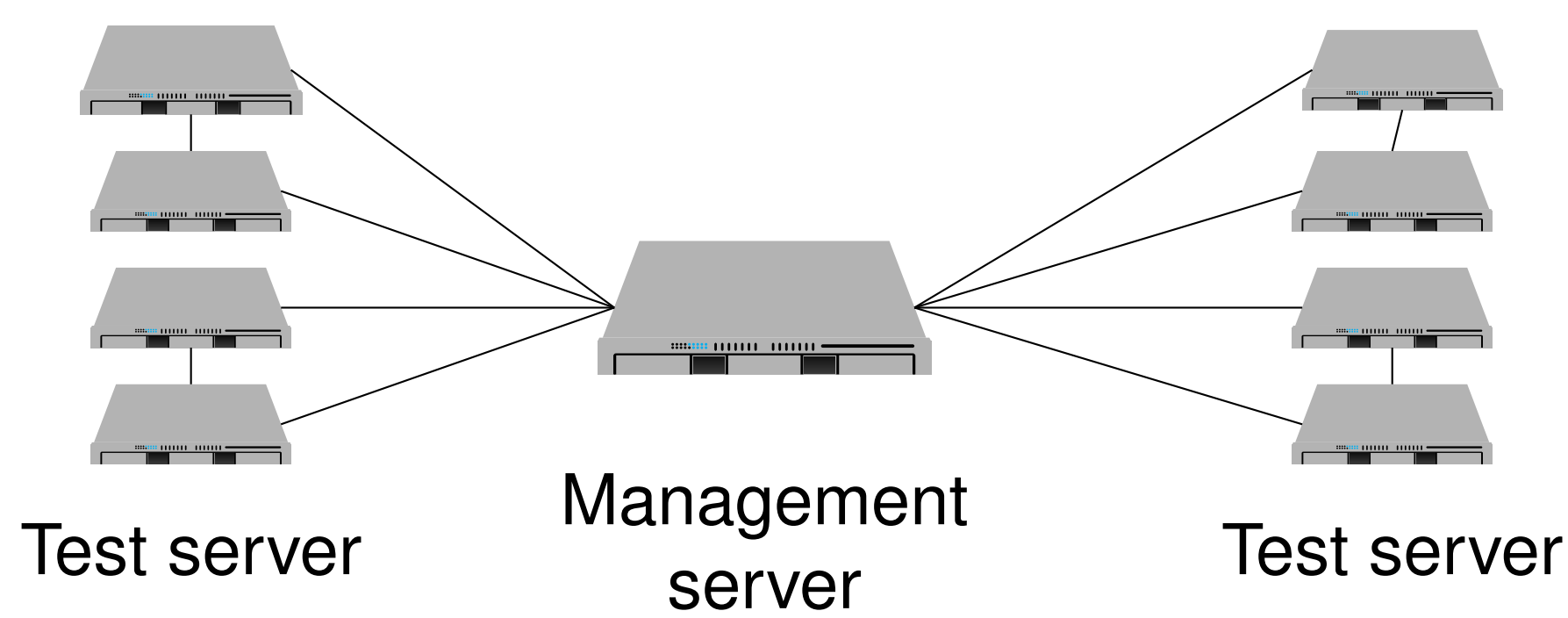


MOONSHINE

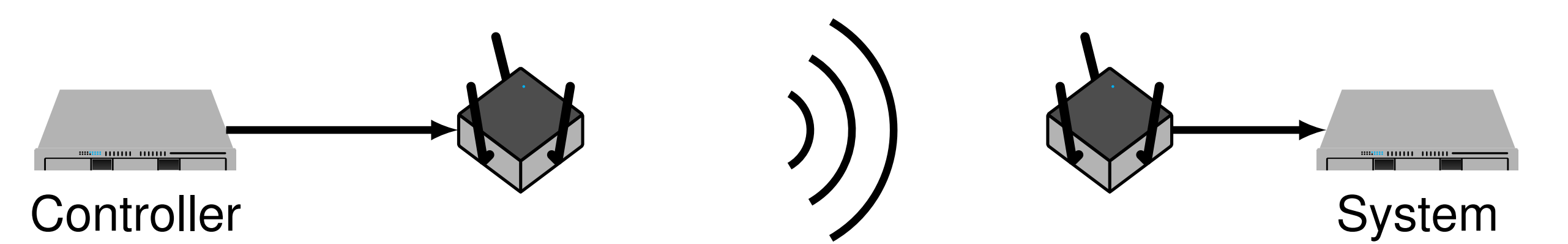
Measurements for Composable Performance Models of Cyber-Physical Network Components

Baltikum testbed



- ▶ Started with DFG LUPUS '09 and constantly updated since (1/10/40 GbE, OpenFlow Switch, MikroTik router)
- ▶ **18 publications** and **34 student theses** conducted on the testbed
- ▶ Testbed with extensive capabilities:
 - Management server configures network experiments
 - Network experiment execution is **automated, documented**, and becomes **reproducible**
 - Energy consumption measured automatically

Work area A - measurements of CPNs

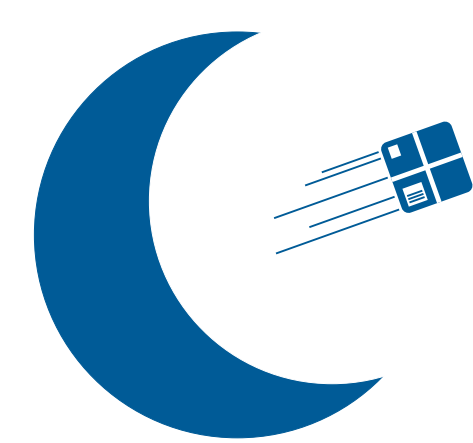


- L4 DTLS, SCTP
- L3 IPsec, IPv4, IPv6
- L2 802.11a/b/g/n(ac/ad), 15.4e TSCH
- Pr CPU (x86, ARM), Cores, Cache

Performance impact:
 latency,
 reliability,
 application-level
 quality metrics

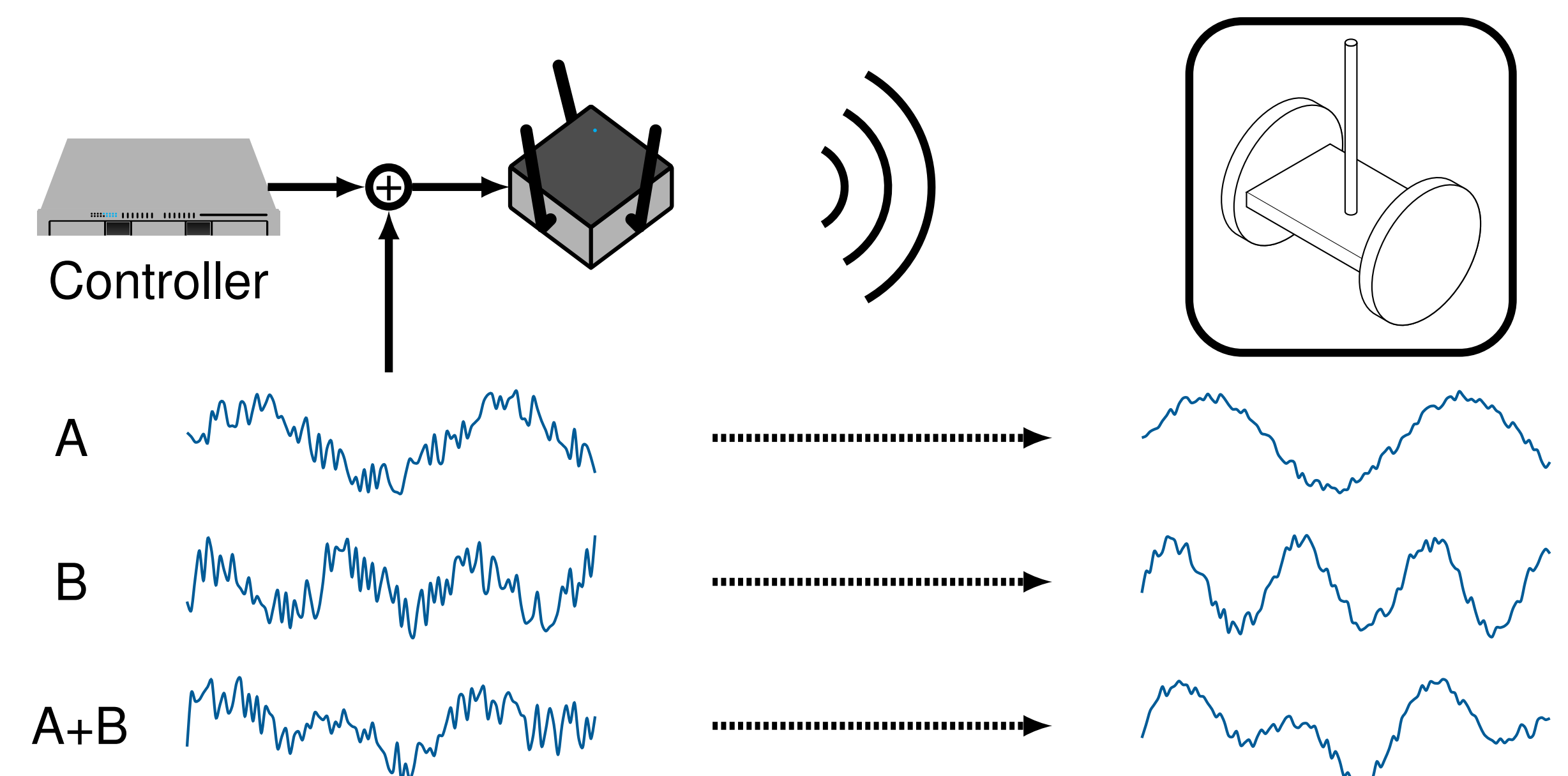
- ▶ **WP 1:** CPN testbed as part of the software prototype
- ▶ **WP 2:** Control loop software emulation software prototype
- ▶ **WP 3:** Software-defined radio wireless channel emulation

Scientific background



- ▶ **MoonGen** [4] a packet generator developed at the Chair of Network Architectures and Services:
 - Latency measurements in the range of nanoseconds
 - 10 Gbit/s packet generation on a single core
 - High-precision generation of arbitrary traffic patterns
 - Easy extendability using the Lua scripting language
- ▶ Experiments with wireless technologies: **GNU Radio** toolkit, **USRP B210**, **SmartMeshIP**, and **OpenMote**
- ▶ High-performance **network coding** software library [1]
- ▶ Application of **network calculus** to on-board avionic networks

Work area B - deriving models



- ▶ **WP 4:** Service curve parameter estimation
- ▶ **WP 5:** Identification of configuration for meeting latency, robustness, and energy consumption goals
- ▶ **WP 6:** Improved modeling methods

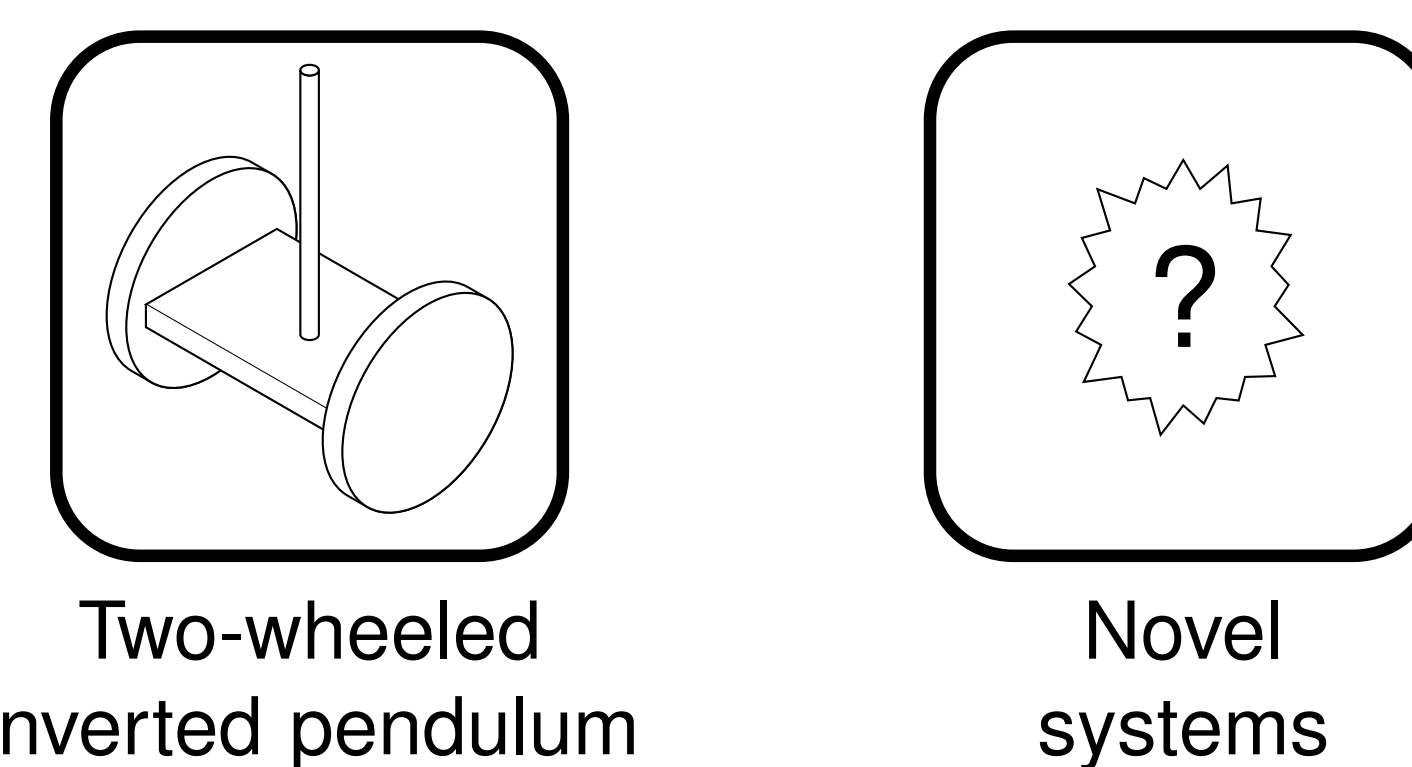
Former projects and cooperations

DFG funded projects (in cooperation with University of Hamburg, Prof. B. Wolfinger):

- ▶ **LUPUS** ('09-'12)
 - Analysis and modeling of network traffic [2]
 - Measuring packet processing on different CPU architectures
- ▶ **MEMPHIS** ('12-'15)
 - Analysis and modeling of software protocol processing [4]

Work area C - interaction with other projects

Benchmark: emulation of a two-wheeled inverted pendulum.
 Reproducible experiments in cooperation with SPP1914 projects.



- ▶ **WP 7:** Cross validation of quantitative results
- ▶ **WP 8:** Cooperation with other projects

[1] S. Günther et al. "Efficient GF Arithmetic for Linear Network Coding using Hardware SIMD Extensions". In: *Proceedings of the International Symposium on Network Coding (NetCod)*. Aalborg, Denmark, June 2014.
 [2] L. Braun et al. "Comparing and improving current packet capturing solutions based on commodity hardware". In: *Internet Measurement Conference 2010 (IMC'10)*. Melbourne, Australia, Nov. 2010.
 [3] P. Emmerich et al. "A Study of Network Stack Latency for Game Servers". In: *Proceedings of the 13th Annual Workshop on Network and Systems Support for Games*. Dec. 2014.
 [4] P. Emmerich et al. "MoonGen: A Scriptable High-Speed Packet Generator". In: *Internet Measurement Conference 2015 (IMC'15)*. Tokyo, Japan, Oct. 2015.