Deutsches Forschungszentrum für Künstliche Intelligenz
German Research Center for Artificial Intelligence

Robotic Teleoperation: A Real-World Test Environment for 6G Communications

28. Fachtagung Mobilkommunikation
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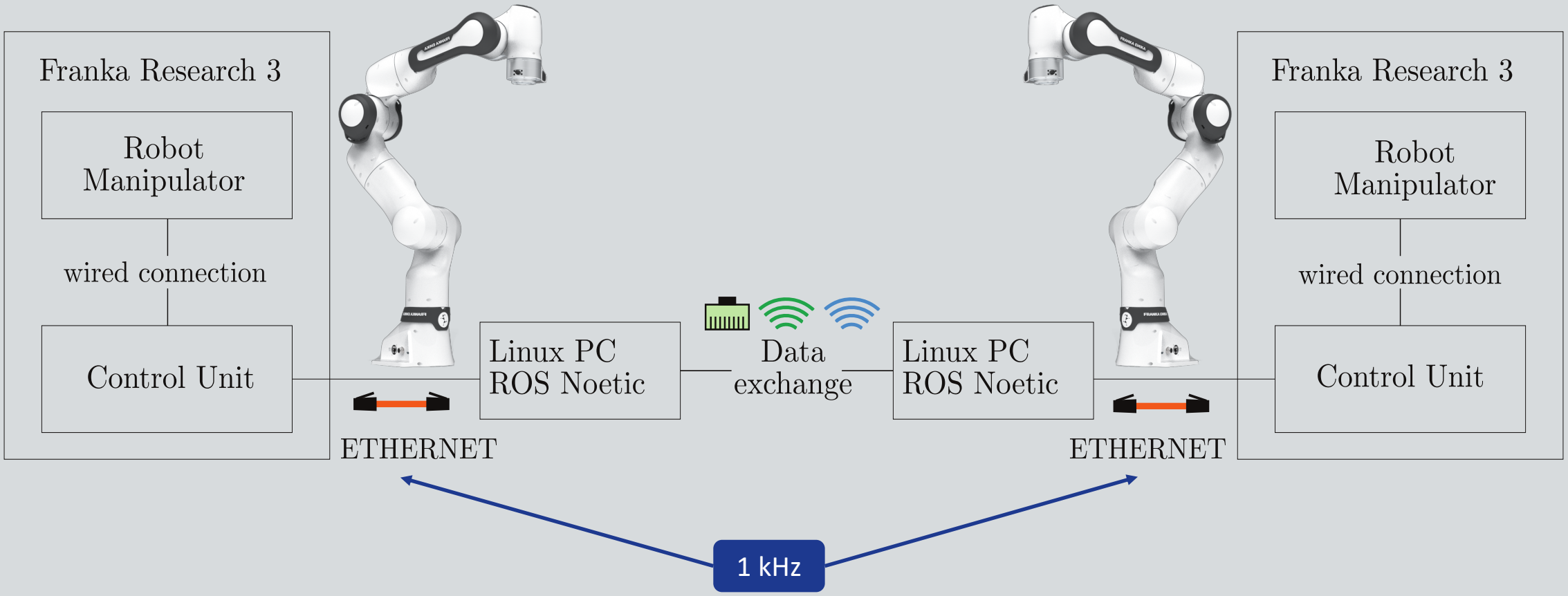
Motivation

- Latency is a crucial factor in wireless communication
- Real-time applications are sensitive to latency
  - Industry
  - Health sector
- Real-world test environments provide invaluable insights
- Test environments often complex
  - Custom engineered middleware

Environment Setup: Overview



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Environment Setup: Controller

- Based on open-source controller by Franka Robotics
- Impedance Control
- Theoretical data rates
  - Leader → Follower: 2.8 Mbps
  - Follower → Leader: 4.9 Mbps

Model

$$\boldsymbol{\tau} = \boldsymbol{M}(q)\ddot{q} + \boldsymbol{c}(q,\dot{q}) + \boldsymbol{g}(q) + \boldsymbol{h}(q,\dot{q}) + \boldsymbol{\tau}_{ext}$$

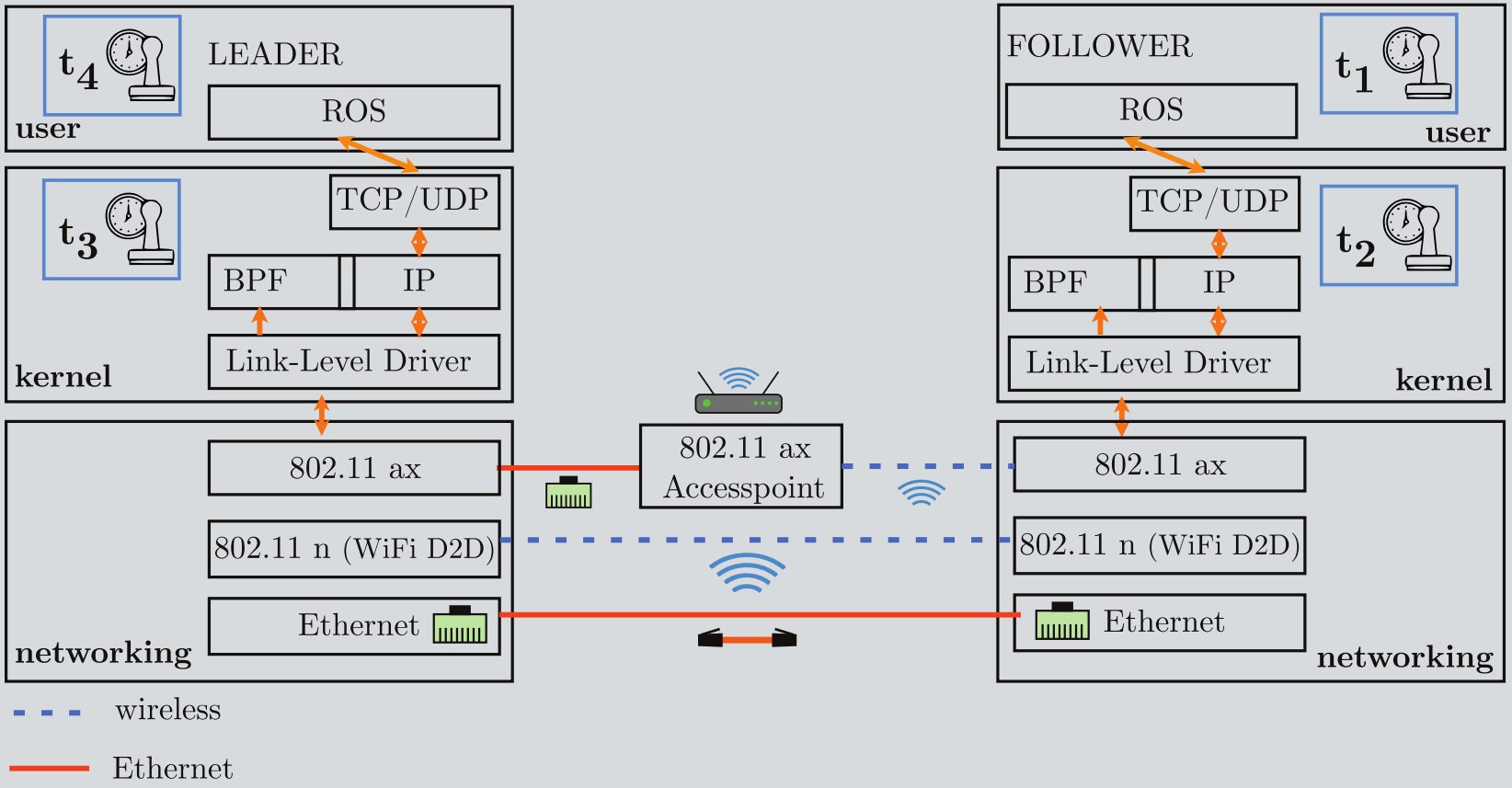
PD Controller

$$\boldsymbol{\tau} = \boldsymbol{K}(q_d - q) + \boldsymbol{D}(\dot{q}_d - \dot{q})$$

Force Feedback

$$\boldsymbol{\tau}_L = \boldsymbol{D}(\dot{q}) - k_c \cdot \boldsymbol{\tau}_{ext,F}$$

Environment Setup: Software Stack



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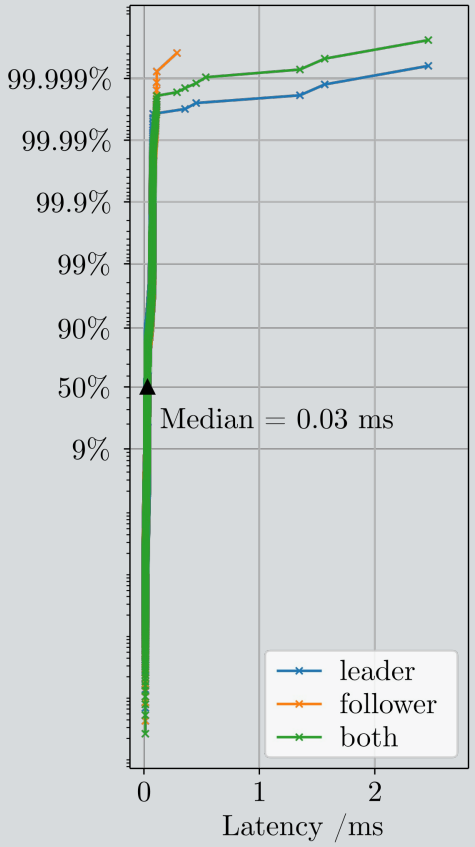
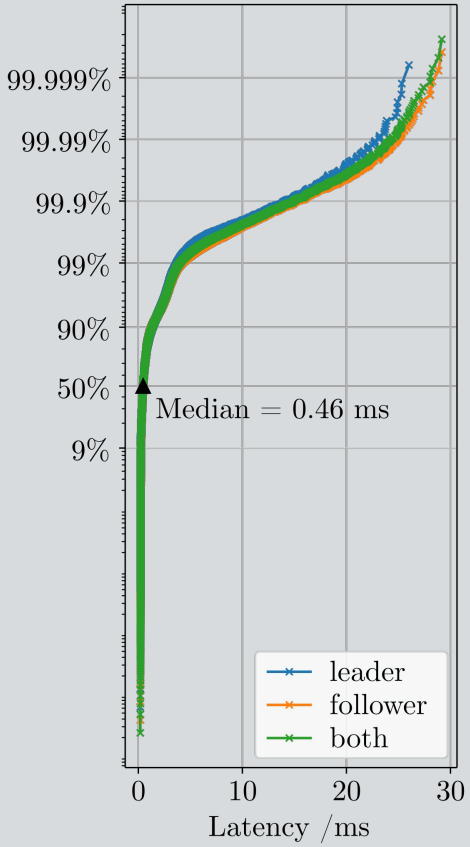
Performance Analysis: Overview

- Ethernet connection as baseline
- Prelaminary tests
  - WiFi Device-to-Device (D2D)
  - WiFi Infrastructure
- Reliability metrics according to 3GPP standard for 5G systems

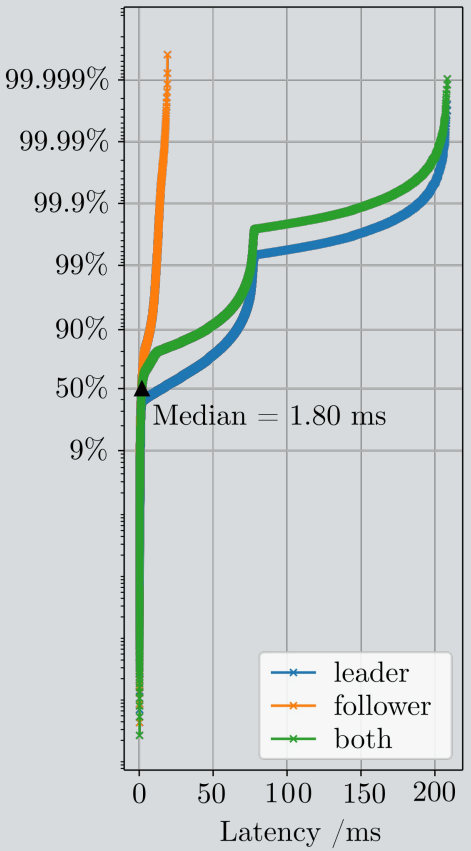
Performance Analysis: Network Tests



Ethernet



WiFi D2D



WiFi Infrastructure

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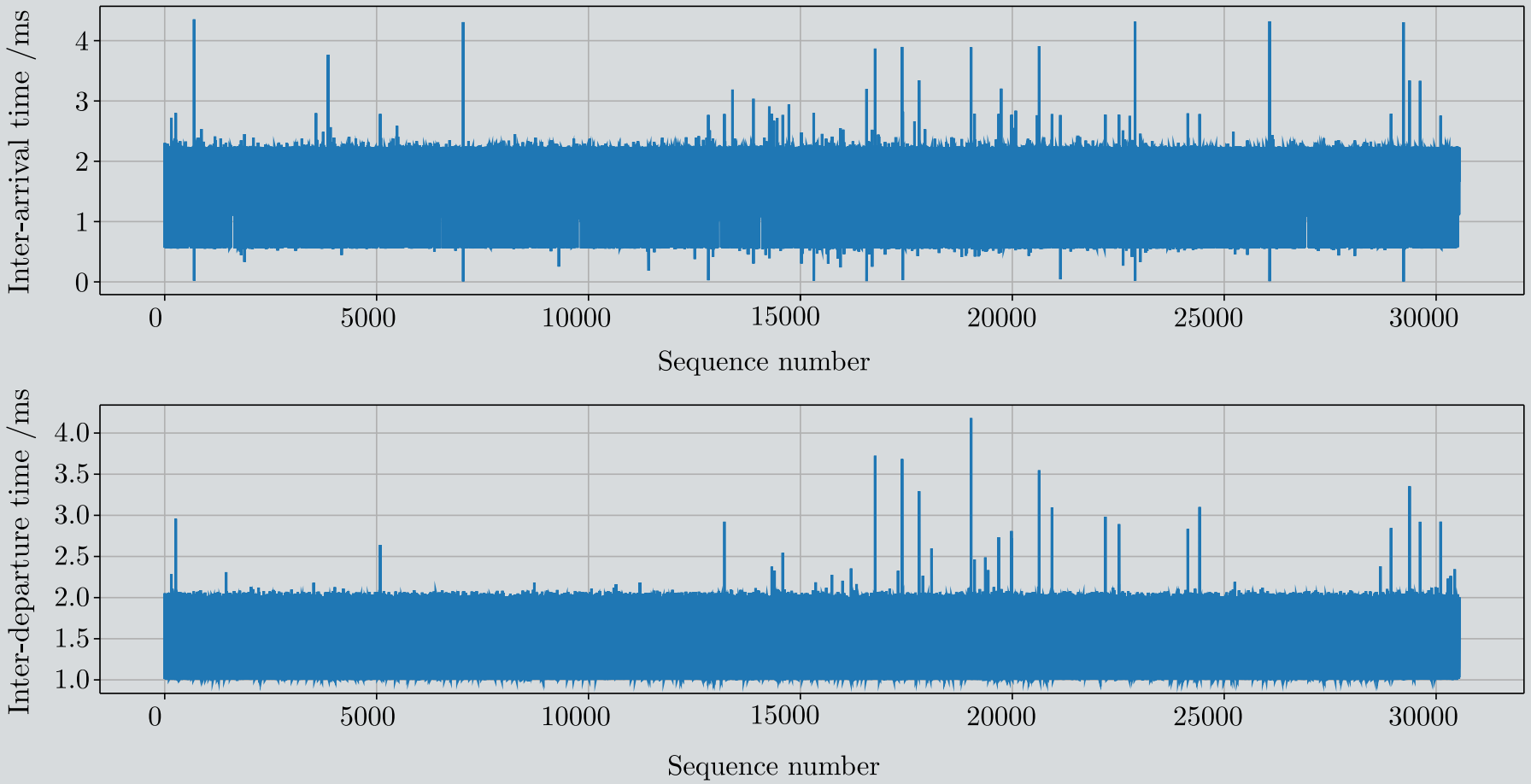
Performance Analysis: ROS

- Designed for flexibility in robotics, not real-time capabilities
- Actual datarates in test environment
  - Leader → Follower: 1.4 Mbps
  - Follower → Leader: 3.1 Mbps
- Local subscriber for evaluation of publishing rate

Performance Analysis: ROS



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Conclusion and Outlook

- Robotic teleoperation test environment
- Baseline: Ethernet
- Prelaminary tests: WiFi
  - Limitations in high-frequency transmission
- Evaluation of ROS
  - Limitations in reliable high-frequency processing
- Transitioning to ROS 2
- Evaluation of further wireless communication systems

Thank you

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