Digital Twin for High-Performance Real-Time Distributed Control systems in IIoT

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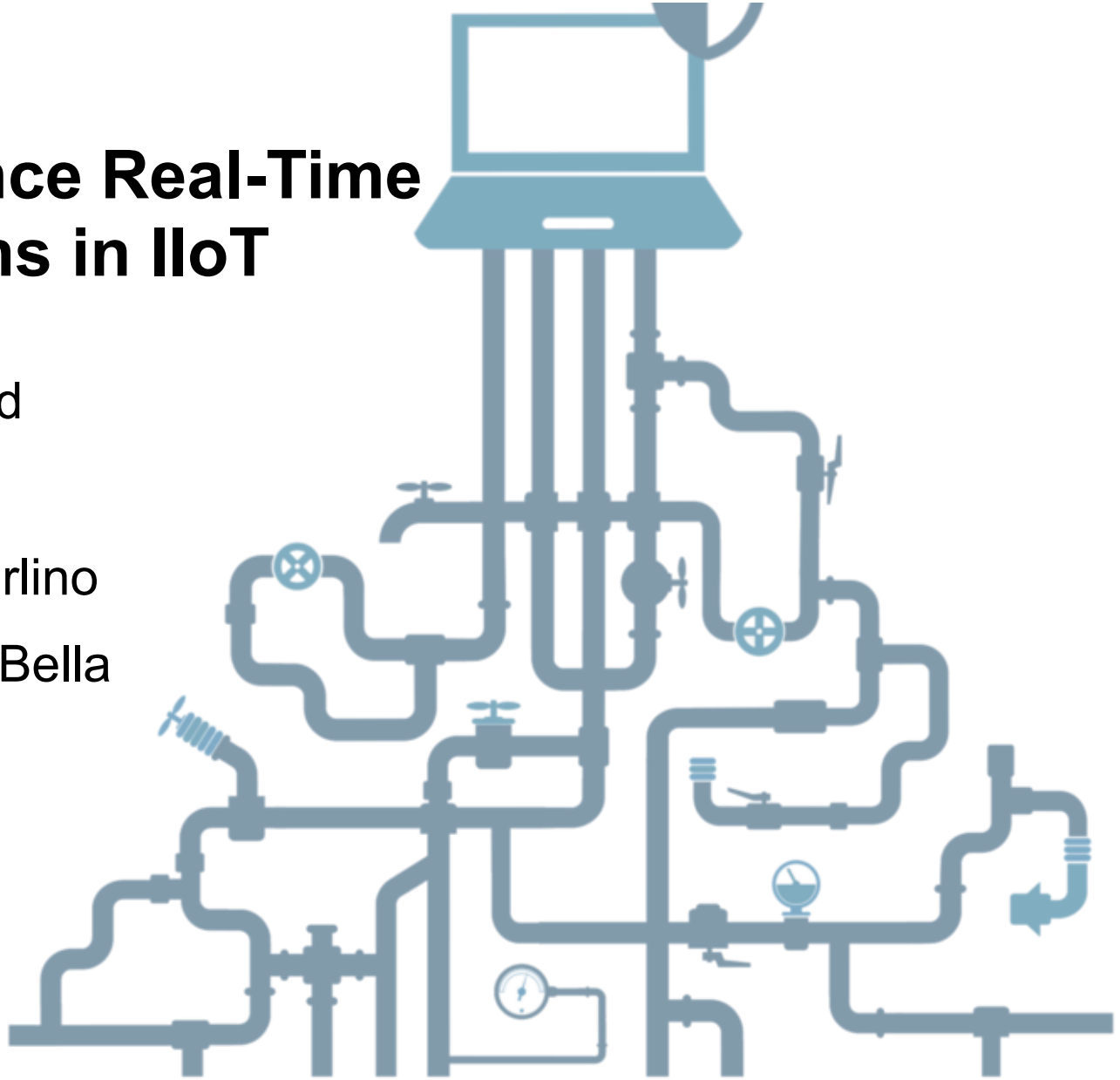
IoT lab



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Why do modern industrial systems fail after deployment?

- Timing violations
- Network delays and jitter
- Lack of coordination between control and communication
- Centralized solutions don’t scale

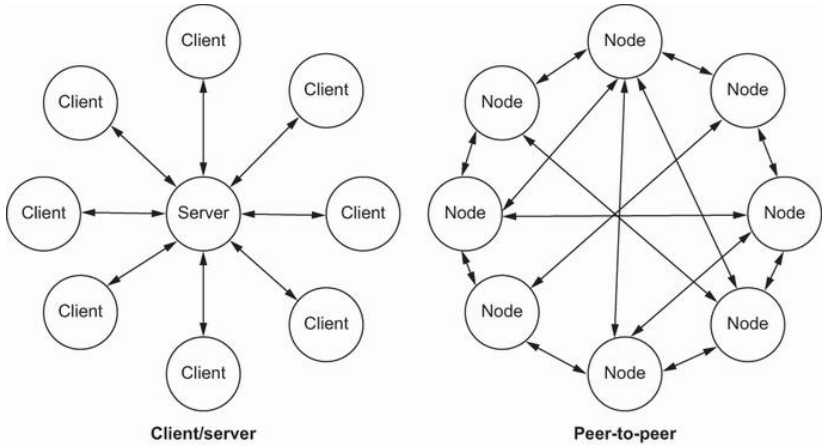


Fig3. Centralized VS. Distributed systems

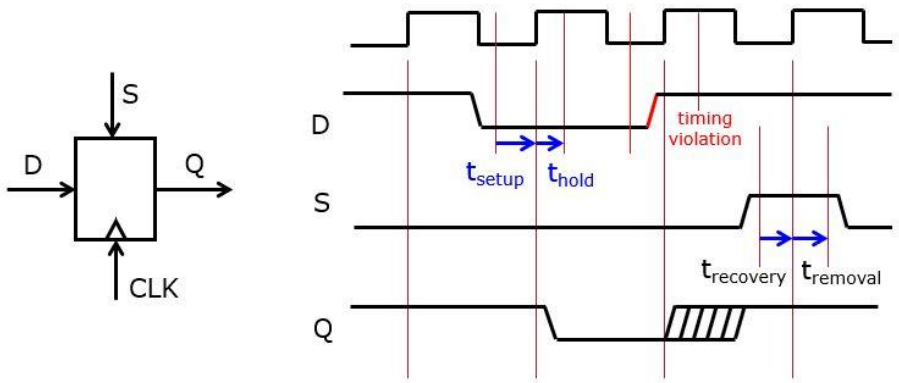


Fig1. Timing violations

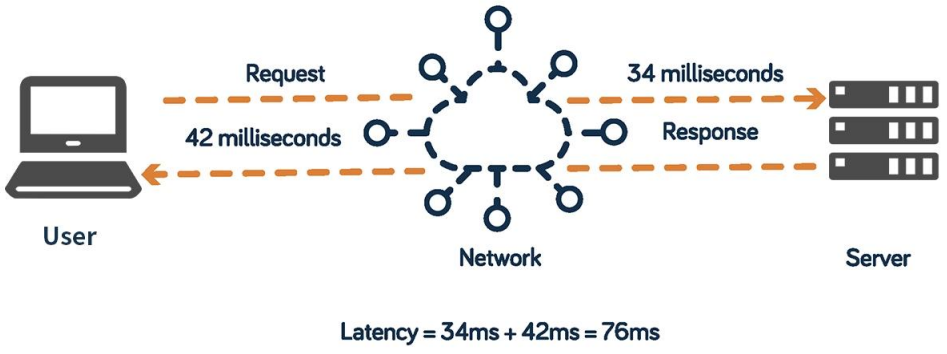


Fig2. Latency example in the network

System Examples:

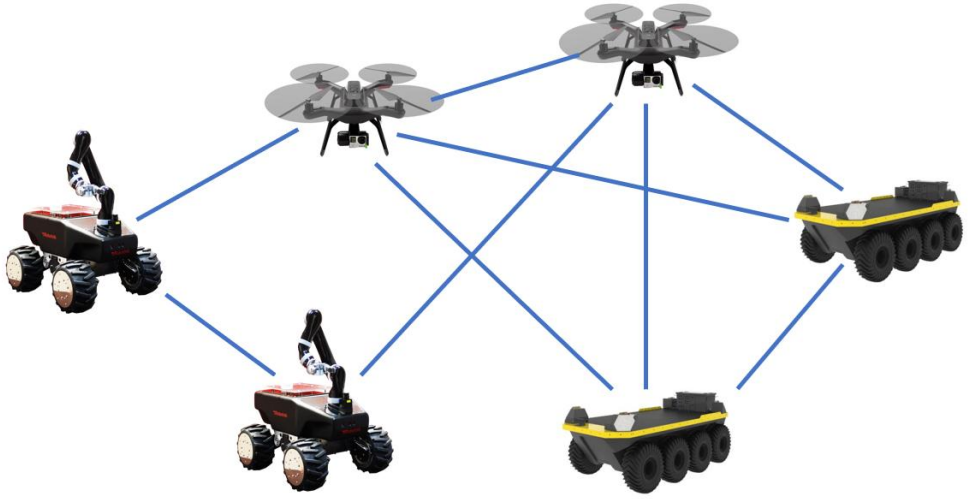


Fig4. IoT in Networked robots

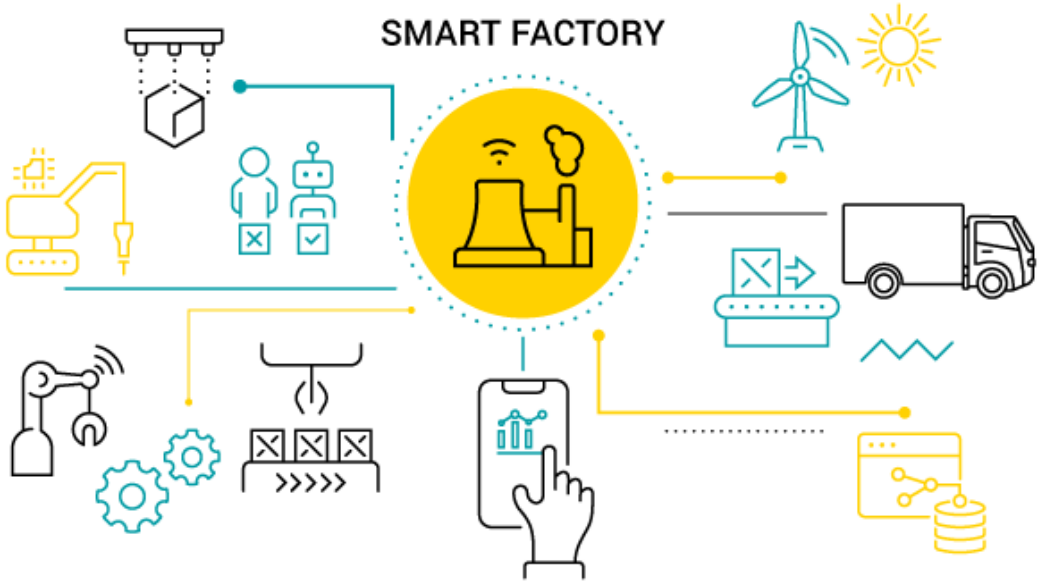


Fig5. IoT in Smart Factories, IIoT

Digital Twin: a safe and realistic experimentation space

- Runs with real timing constraints
- Includes control logic
- Models communication and network effects
- Can run before or in parallel with the real system

“But what kind of control are we talking about?”

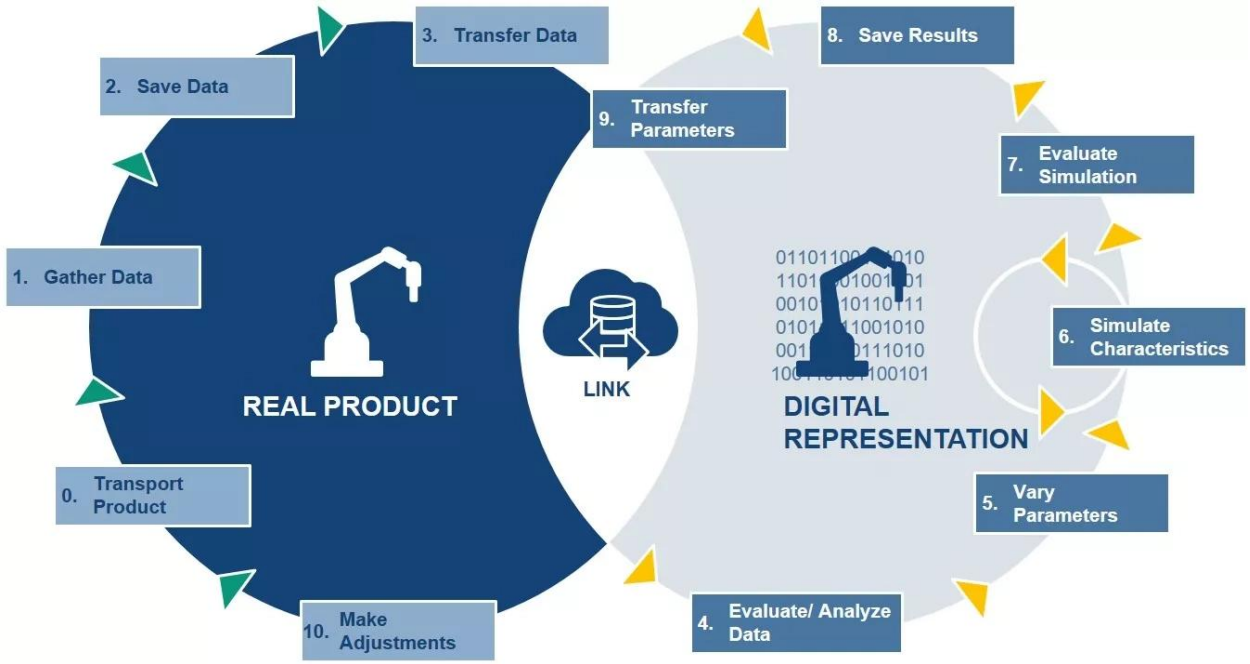


Fig6. Digital Twin workflow

When control is distributed and time matters?

- Multiple controllers
- Each controls a local subsystem
- They communicate over a network

“These controllers must not only make correct decisions, but make them on time.”

- Distributed MPC
- Coordination mechanisms
- Local autonomy + global objectives

“A correct decision made too late is still a failure”

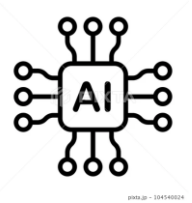
From models to realistic validation

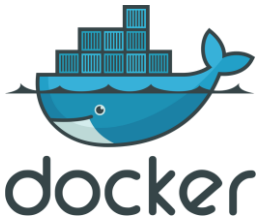
Theoretical side

- Control models
- Performance and stability analysis
- Real-time constraints

Experimental side

- Digital twin implementation
- Middleware-level experimentation
- Network and timing emulation


Why this research matters

- ✓**Safer system design**
- ✓**Faster development and validation**
- ✓**Better scalability of distributed control**
- ✓**Reduced deployment risks in IIoT systems**

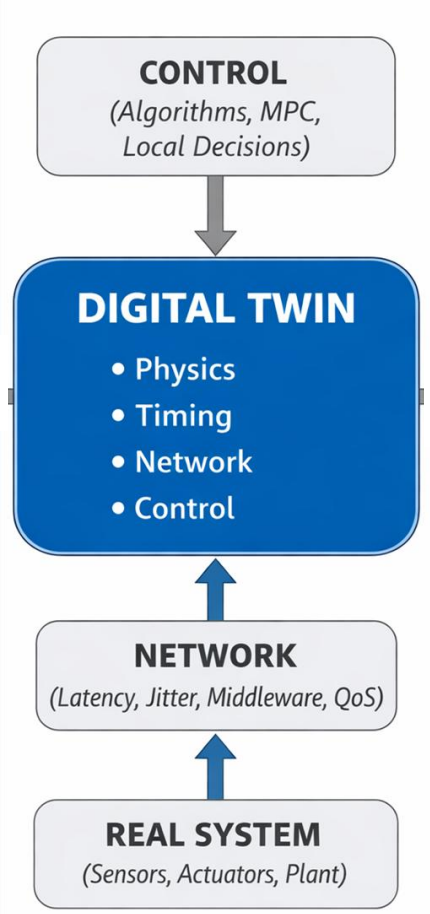


Fig7. High-performance IIoT architecture

Thank you for your attention!