

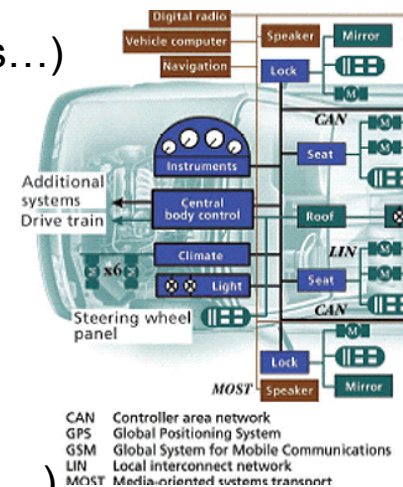
# Managing end-to-end resource reservation

Luis Almeida, Moris Behnam, Paulo Pedreiras



# Application trends

- **Largely distributed real-time interaction**
  - Remote interactions, interactive multimedia, time-sensitive cloud services
- **Complex structure**
  - **High heterogeneity** (functionality, requirements, resources...)
  - **Variable composition** (versions, modes, connections...)
- **Need to be robust with respect to**
  - **Topology changes** (node crashes, reconfigurations...)
  - **Changes in available resources** (energy, bandwidth...)
  - **Denial-of-service** (malfunctioning nodes, malicious actions...)
  - **Intrusion** (unauthorized accesses or actions...)



## How to design these systems ??

# Real-time capable platforms needed

- Amenable to **modeling of timing behavior**

- **Bounded and computable delays**

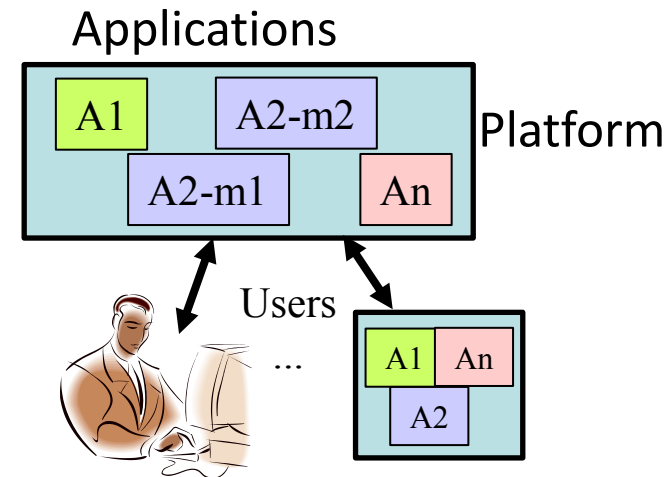
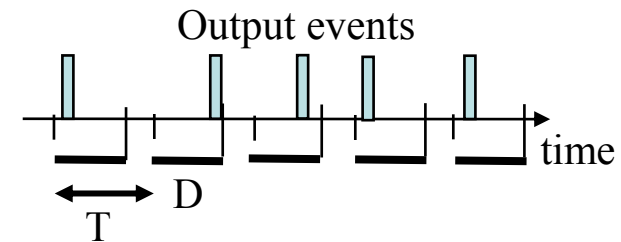
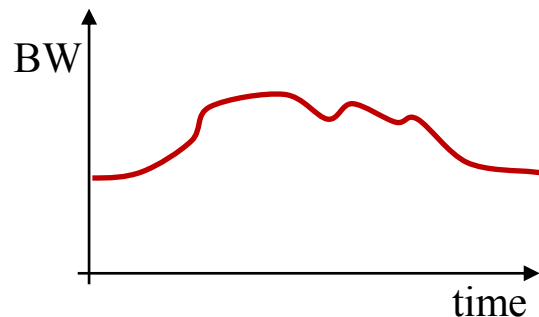
→ real-time guarantees

- While supporting **multiple and varying**

- applications, users, operating conditions, ...

- And being **resource efficient**

- bandwidth, energy



# Focusing on the network...

- **Real-Time communication technologies**

- well developed for **(static) DES**
- focused on **latency** and **isolation**

**CAN EtherCAT**  
**TTEthernet**  
**PROFINET-IRT**  
...

- **General purpose communication technologies**

- well developed for **large networks** (Cloud/Internet)
- essentially **best-effort** (particularly in access networks)
- focused on **openness, scalability** and **throughput**

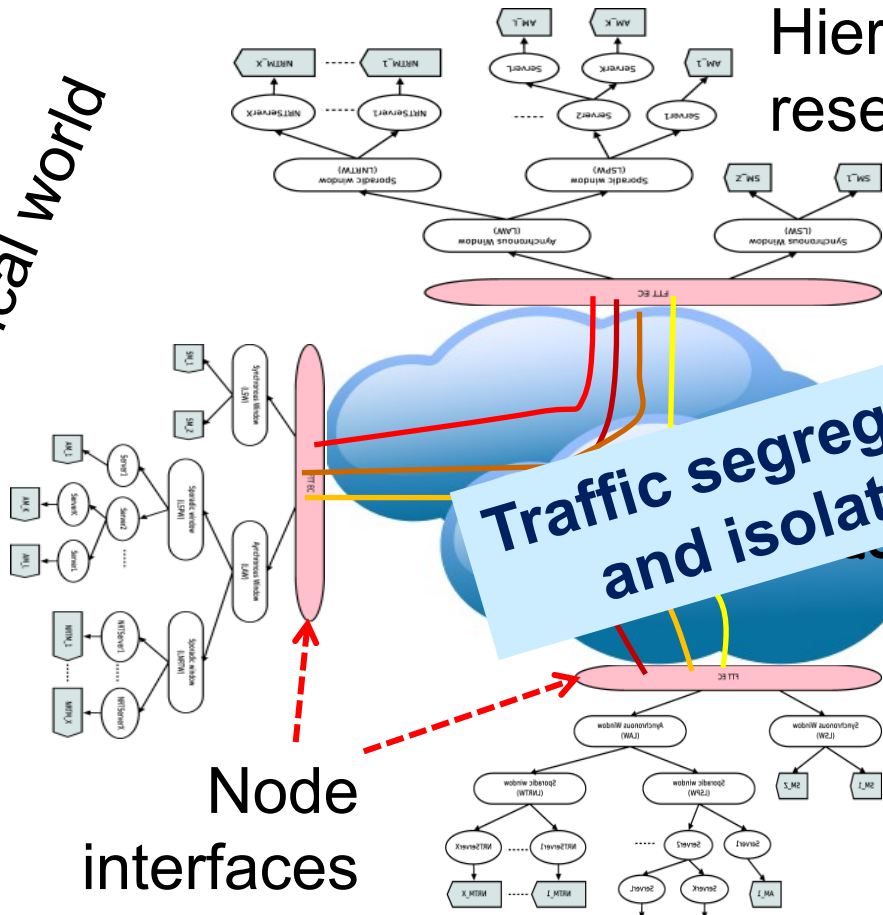
**Ethernet**  
**WiFi**  
**TCP/UDP**  
**RSVP-TE**  
**LTE**  
...

**Unifying effort** needed, towards  
**scalable, open and efficient**  
**real-time communication**

# The real-time enabled cloud

Physical world

Hierarchy of reservations  
(virtual channels)



Node interfaces

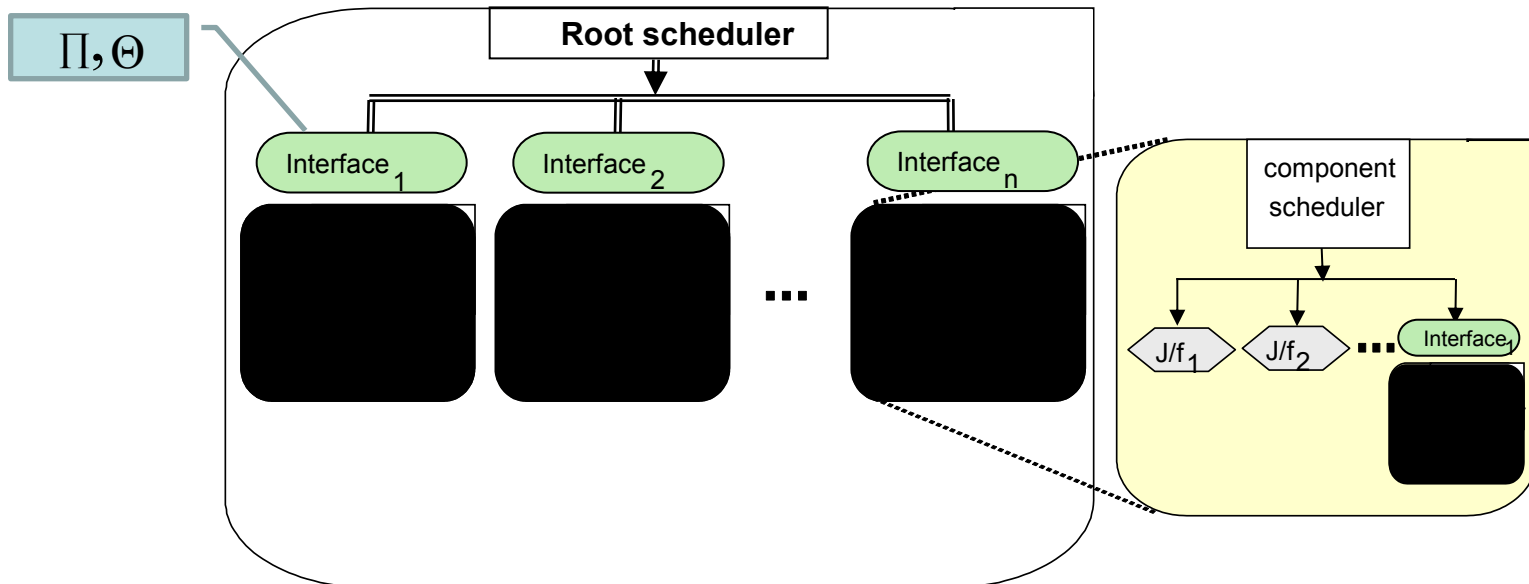
Physical world



# Related frameworks

- **Hierarchical Scheduling Framework**

- Generation of efficient interfaces
- Enforcement protocols in realistic settings



# Related frameworks

- **Global resource management frameworks**
  - FRESOR: Framework for Real-time Embedded Systems
  - (H-)QRAM: (Hierarchical) QoS-based Resource Allocation Model
- **End-to-end resource reservations in networks**
  - RSVP: Resource Reservation Protocol (RSVP)
  - SRP: Stream Reservation Protocol (IEEE 802.1Q-2011)
  - TTEthernet, Profinet-IRT, Ethernet POWERLINK
  - AFDX, Ethernet IP, ...

**Generalized limited scalability and  
absence of slack sharing**

# Open problems

- **Formulating resource requirements**
  - Defining adequate **interfaces**
- **Expressing adaptivity**
  - In requirements and interfaces
- **Scalable adaptive reservations**
  - Adapting entangled reservations
- **Requirements feasibility**
  - Per resource and in whole
- **Global admission control**
  - And reservations enforcement
- **Track and distribute slack**

