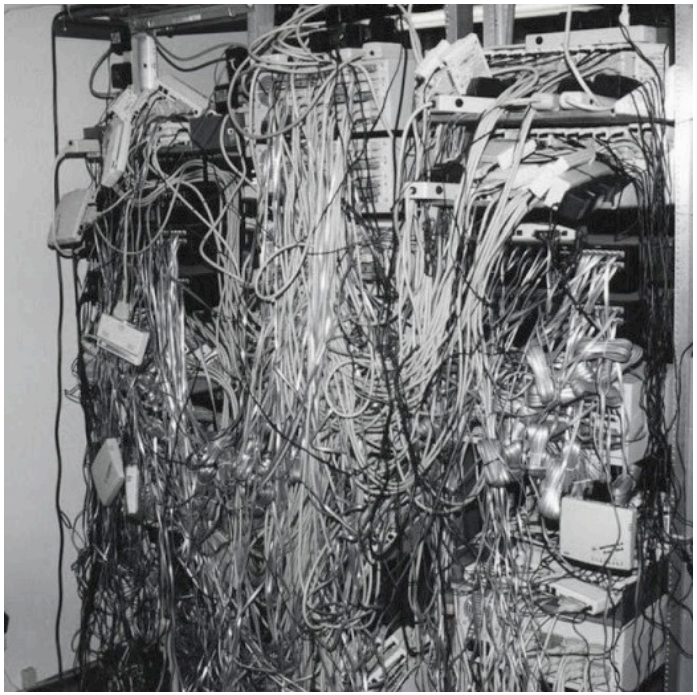

Distributed Real Time Systems

Introduction

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Overview

The Real-Time Environment

- Definition of a real-time system.
- Simple model with operator, computer system, and controlled object.
- Introduction of distributed real-time systems.
- Hard real-time systems and soft real-time systems.
- Functional, temporal, and dependability requirements.
- Sphere of control
- Event-triggered versus time-triggered systems.

Distributed Real-Time Systems

- Distributed system architecture overview, clusters, nodes, communication network
- Structure of node with host computer, communication network interface, communication controller
- Event and state messages, gateways.
- Concept of composability.
- Event- and time-triggered communication systems.
- Scalability, dependability, issues of physical installation.

Global Time

- Notions of causal order, temporal order, and delivery order
- External observers, reference clocks, and global time base
- Sparse time base to view event order in a distributed real-time system
- Internal clock synchronization to compensate for drift offset. Influence of the communication system jitter on the precision of the global time base.
- External time synchronization, time gateways, and the Internet network time protocol (NTP)

Modeling Real-Time Systems

- Introduction of a conceptual model for real-time systems
- Tasks, nodes, fault-tolerant units, clusters
- Simple and complex tasks
- Interface placement and interface layout
- Temporal control and logical control
- The history state

Real-Time Entities and Images

- Real-time entities
- Observations, state and event observations
- Real-time images as current picture of real-time entity, and real-time objects
- Temporal accuracy and state estimation to improve real-time image accuracy
- Permanence in case of race conditions and idempotency with replicated messages
- Replica determinism to implement fault-tolerance by active redundancy

Fault Tolerance

- Failures, Errors, and Faults
- Error Detection
- A Node as a Unit of Failure
- Fault Tolerant Units
- Reintegration of a Repaired Node
- Design Diversity

Real-Time Communication

- Real-Time Communication Requirements
- Flow Control
- OSI Protocols for Real-Time
- Fundamental Conflicts in Protocol Design
- Media-Access Protocols
- Performance Comparison: ET versus TT
- The Physical Layer

Time-Triggered Protocols

- Introduction to Time-Triggered Protocols
- Overview of the TTP/C Protocol Layers
- The Basic CNI
- Internal Operation of TTP/C
- TTP/A for Field Bus Applications

Input and Output

- The dual role of time
- Agreement protocol
- Sampling and polling
- Interrupts
- Sensors and actuators
- Physical installation

Real-Time Operating Systems: OSEK and AUTOSAR

- Task management
- Interprocess communication
- Time management
- Error detection
- OSEK and AUTOSAR

Real-Time Scheduling

- The scheduling problem
- The adversary problem
- Dynamic scheduling, dynamic priority servers
- Static scheduling, fixed priority servers

Validation

- Building a Convincing Safety Case
- Formal Methods
- Testing
- Fault Injection
- Dependability Analysis