Introduction to the Distributed Real-Time System

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When is a Computer System Real-Time?

- The correctness of the system behavior depends on...
  - The logical results of the computations,
  - Physical instant at which these results are produced.
The Property of Real-Time System

- A real-time computer system must react to stimuli from the controlled object (or the operator) within time intervals dictated by its environment.
- Deadline: the instant at which a result must be produced.
- Classification or RT-system
  - Soft real-time computer system.
  - Hard real-time computer system.

Real-Time Entity

- A controlled object, e.g., a car or an industrial plant, changes its state as a function of time.
- Real-Time Entity (RT-Entity)
  - A set of state variable that we are normally interested in.
  - Car: the speed of the car, the position of switches on the dashboard, the position of a piston in a cylinder.
Real-Time Image

- The first functional requirement of a real-time computer system is the **observation** of the RT entities.
- **Real-Time Image (RT-Image)**: An observation of RT-Entity
- **The property of RT-Image**
  - A given RT-image is only *temporally accurate* for a limited time interval. (Since the state of the controlled object is a function of real time.)
  - The length of this time interval depends on the dynamics of the controlled object.
  - If the state of the controlled object changes very quickly, the corresponding RT image has a very short accuracy interval.

The Meaning of “Temporally Accurate”

- An upper bound for the accuracy interval is given by the duration of the yellow phase of the traffic light

How long is the observation:
“The traffic light is green” temporally accurate?

*Temporal accuracy of the traffic light information*
The Distributed Real-Time System

- If the real-time computer system is distributed, it consists of a set of (computer) nodes interconnected by a real-time communication network.

![Diagram of Distributed Real-Time Communication System]

**Issue 1: Composability**

- An architecture is said to be *composable* with respect to a specified property if the system integration will not invalidate this property once the property has been established at the subsystem level.

![Diagram of Subsystems]
Issue 2 : Scalability

- In a scalable architecture, the complexity of reasoning about the proper operation of any system function is independent of the system size.

![Transparent expansion of a node into a new cluster](image)

Issue 3 : Dependability

- **Error-containment regions.**
  - A fault-tolerant system must be structured into partitions in such a way that the consequences of faults that occur in one of these partitions can be detected and corrected or masked before these consequences corrupt the rest of the system.

- **Replication**
  - Given that the failure hypothesis holds, node failures can be masked by providing actively replicated nodes.
  - The replicas must show deterministic behavior.
Reference