01_Introduction

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1. Real-Time system Introduction

1.1. What is Real-Time system

A **computing system**, the operation of which depends on (both of them)

- its input

- the time in which the results are produced

1.2. Requirements

- perform computations **within given timing constraints**
- provide **bounded response times** to tasks with bounded execution, in **all possible scenarios** (personal understanding: each task should finally be finished in finite time)
- The response times and performance should be **predictable** for **all possible combination of events.**

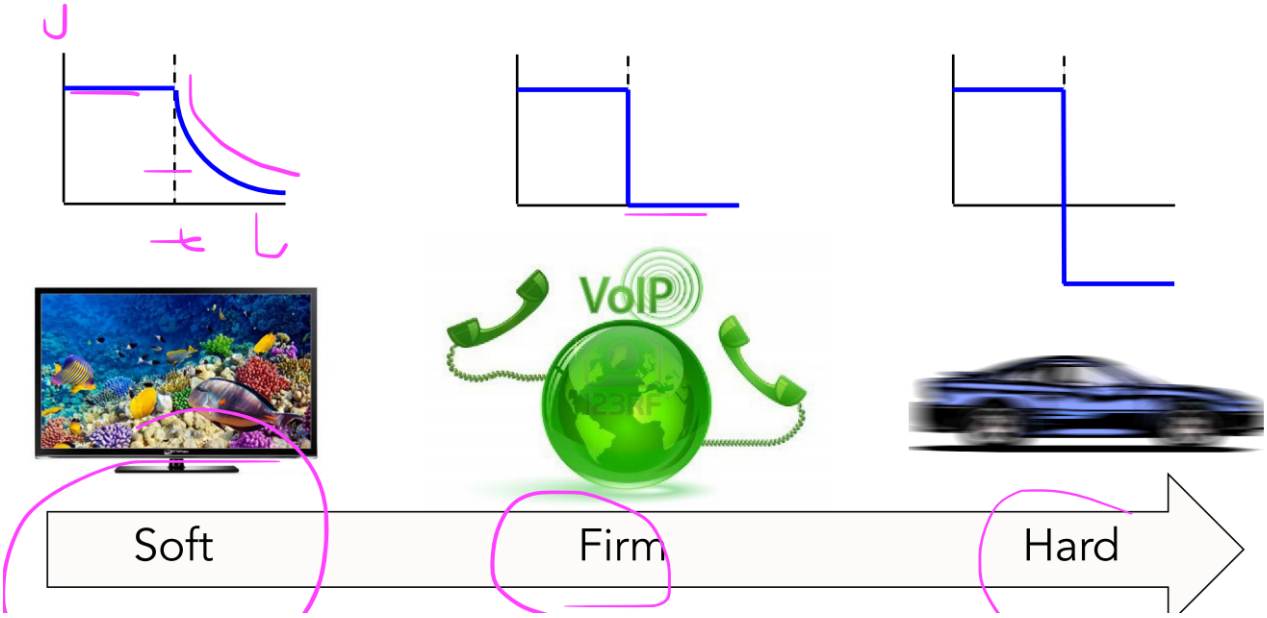
1.3. Misunderstanding of design RT Systems

- It is not a software testing problem.
    - Using low-level programming might sound like a good solution, but it is not a principled approach
    - Testing cannot (usually) offer guarantees
- It is not a resource availability problem.
    - Brute force & overprovisioning does not always solve the problem;
- Fast computing & Fast systems are not enough

1.4. How to design RT Systems

- time and deadlines
- predictability
- we focus on worst-case analysis

1.5. Classes of RT-Tasks and Systems



Hard Real-time

imperative to respond before the deadline

Soft Real-time

deadlines are “nice-to-have”;

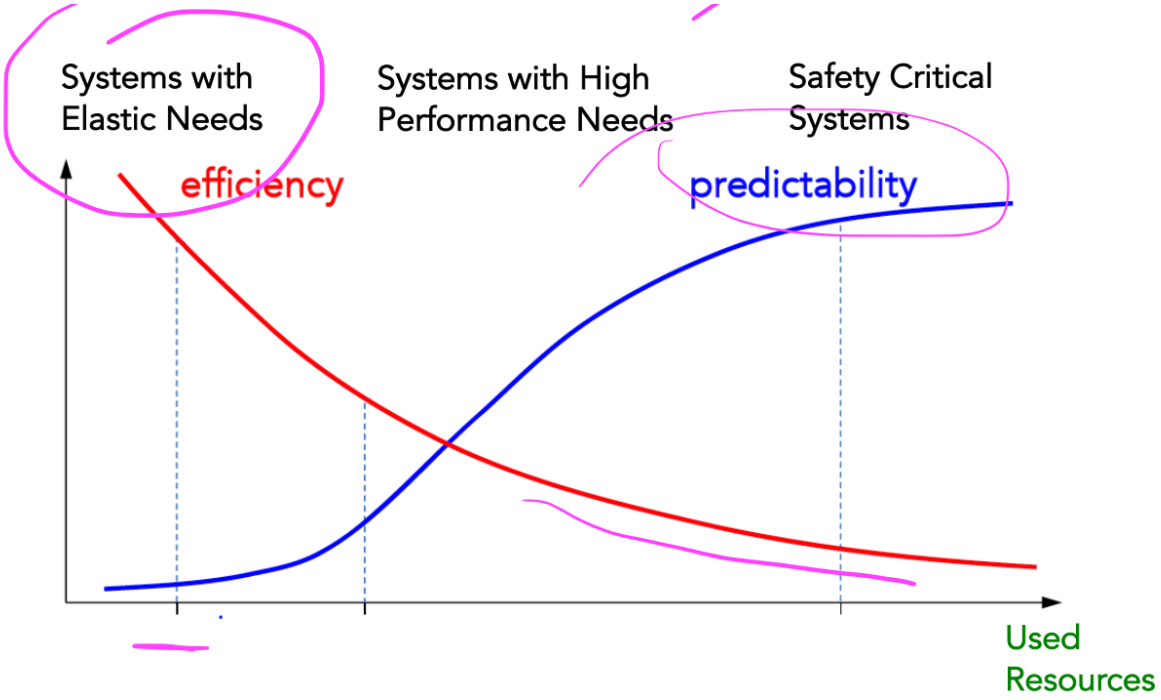
Firm Real-time

tasks which are “soft” but there is no utility (benefit) when deadlines are missed

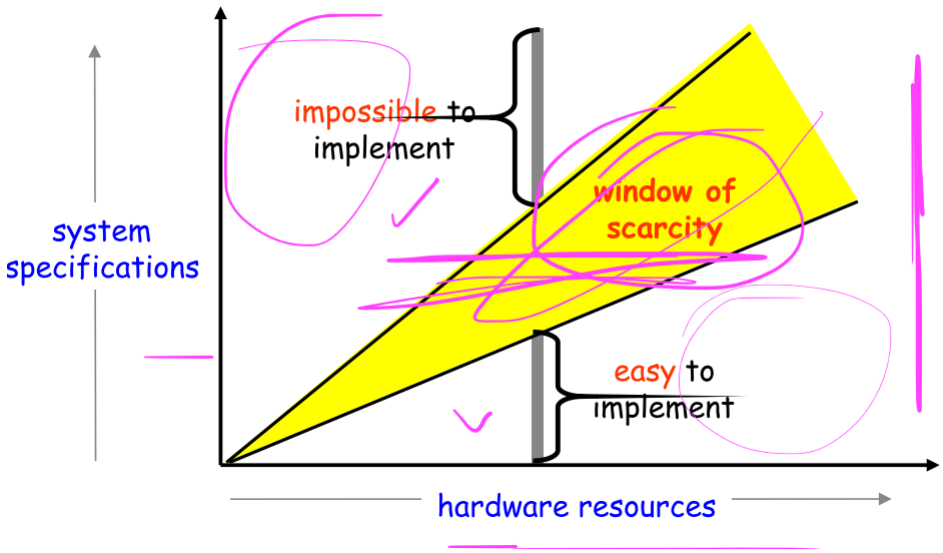
1.6. Properties of RTS

- System **resources** are most often **scarce**
    - should have high efficiency in resource management
- Operation involves **concurrency & resource sharing**
    - **Temporal isolation** to limit cross-task interference
- Interaction with the environment.
    - **High predictability** in outcome and response timing.
- **High variability** of task arrivals (workload).
    - Adaptive/Robust behavior in order to handle overloads

1.7. Trade-off in RT Systems



1.8. Windows of Scarcity



2. Taxonomy of RT Systems

2.1. Static and Dynamic RT Systems

Static

Task arrival times can be **predicted**.

- Static (compile-time) analysis is **possible**:
    - Worst Case Execution Time (WCET) can be found
- Allows good resource usage

Dynamic

Arrival times are **unpredictable**.

- Processor utilization decreases dramatically
- Must **avoid over-simplifying assumptions**

2.2. Soft & Firm & Hard Systems

Soft Systems

Allow **more slack** in the implementation

- Scheduling can be very complicated: Too many options yield **a large feasible solution space**
- Common ways of handling non-trivial soft real-time system requirements
    - **Set somewhat loose hard timing constraints**
    - Informal design and extensive testing

Hard Systems

Creates difficult problems

- Some timing constraints are inflexible

But, it simplifies the problem formulation!

2.3. Periodic and Aperiodic Systems

Periodic Systems

Each (group of) tasks is recurrent with a certain period.

- single rate periodic
- multi rate periodic

Aperiodic Systems (Sporadic)

Creates a dynamic situation

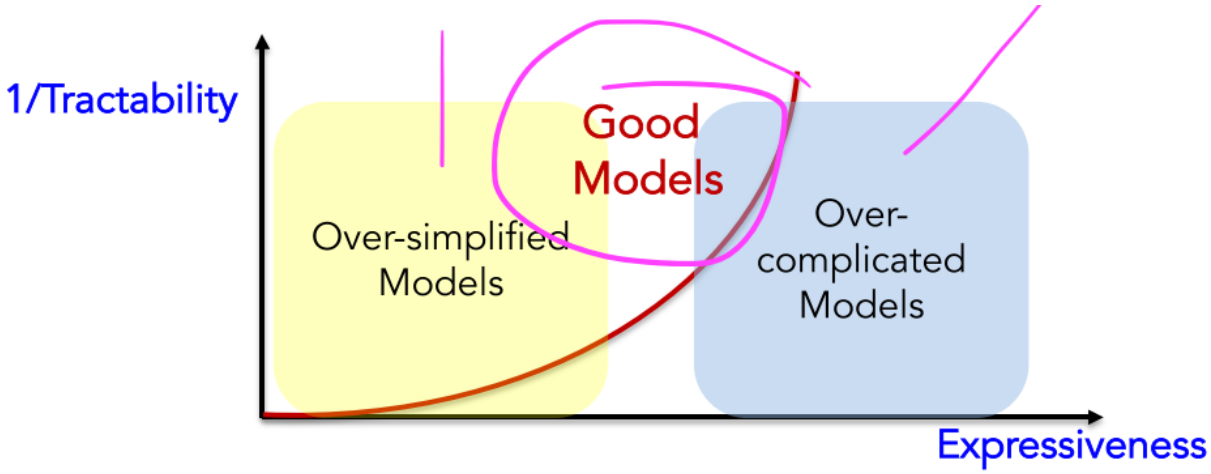
- **Bounded arrival time intervals** are easier to handle.
    - Can be “reduced” to **worst-case periodic tasks.** (set the period to the shortest possible arrival period, so it will be the worst-case)
- Unbounded inter-arrival times are challenging to handle with resource-constrained systems

3. Modeling of RT Systems

A model is a representation of a real "thing"

A delicate exercise between:

- **Expressiveness** (capture all details) vs.
- **Tractability**, (amenable to math analysis)



3.1. The Optimization Perspective