Real Time Systems Design

Lecture (3): Signals, Systems, and Specifications (cont.)

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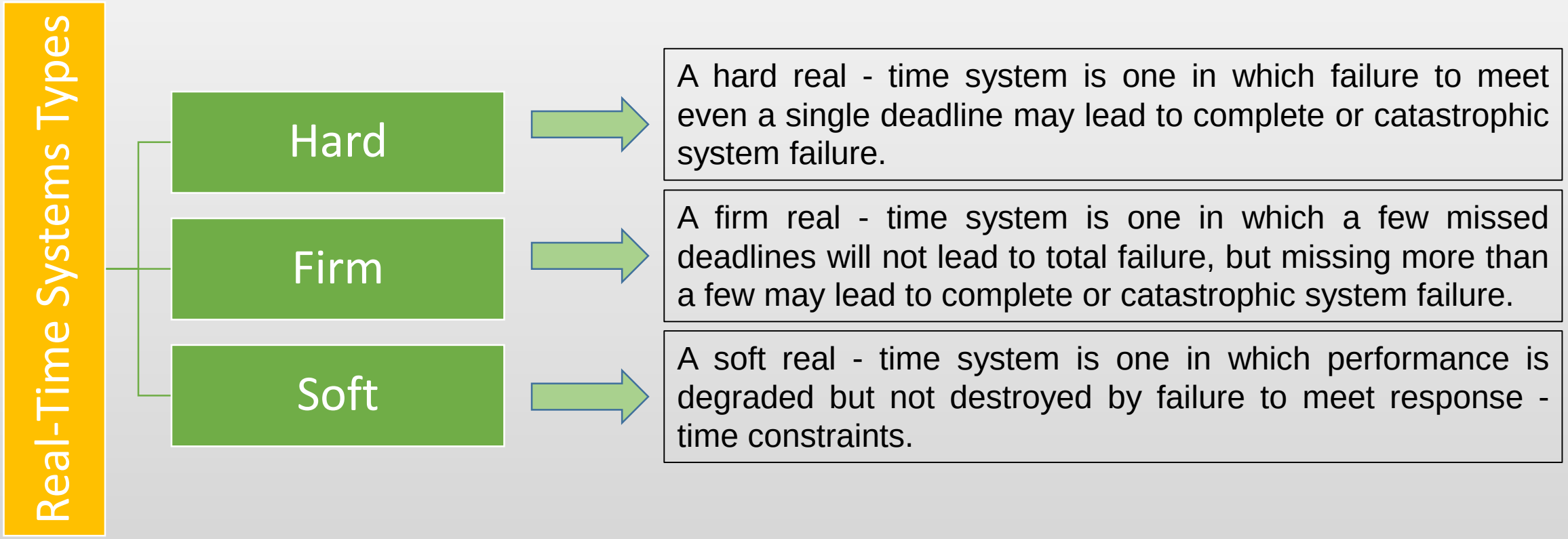
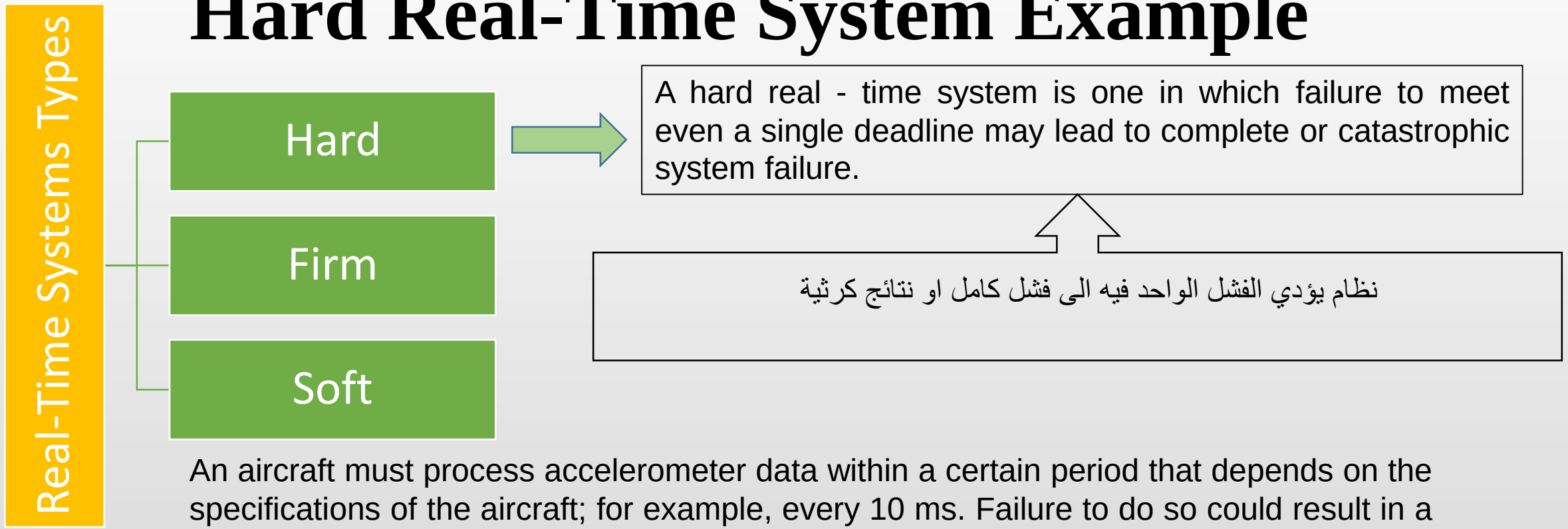
Real-Time Systems Types



Hard Real-Time System Example



An aircraft must process accelerometer data within a certain period that depends on the specifications of the aircraft; for example, every 10 ms. Failure to do so could result in a false position or velocity indication and cause the aircraft to go off - course at best or crash at worst.

For a nuclear reactor thermal problem, failure to respond swiftly could result in a meltdown.

Firm Real-Time Systems Types

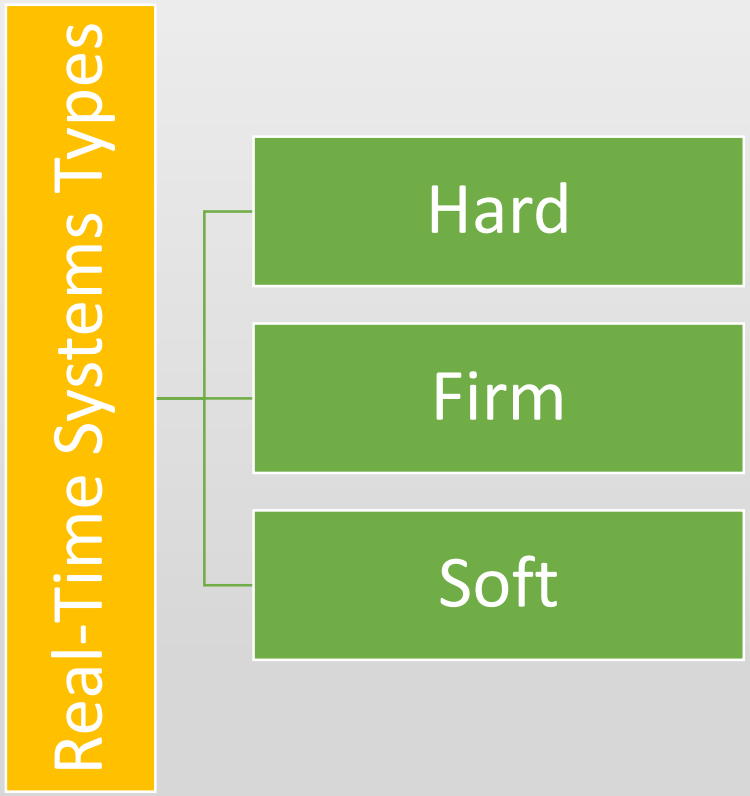
- Hard
- Firm
- Soft

نظام يتدهور فيه الأداء لعدد محدد من الإخفاقات لكن زيادة الإخفاقات عن العدد المحدد يؤدي الى دمار النظام

A firm real - time system is one in which a few missed deadlines will not lead to total failure, but missing more than a few may lead to complete or catastrophic system failure.

For example, in the automated teller machine, missing too many deadlines will lead to significant customer dissatisfaction and potentially even enough loss of business to threaten the existence of the bank.

Soft Real-Time Systems Types



نظام يتدهور فيه الأداء لكن لا يدمره الفشل في تحقيق الاستجابة خلال الوقت المحدد

A soft real - time system is one in which performance is degraded but not destroyed by failure to meet response - time constraints.

Hard Real-Time Systems Examples

Examples:

- Air France Flight 447 crashed into the ocean after a sensor malfunction caused a series of system errors. The pilots stalled the aircraft while responding to outdated instrument readings. All 12 crew and 216 passengers were killed.
- Mars Pathfinder spacecraft was nearly lost when a priority inversion caused system restarts. A higher priority task was not completed on time due to being blocked by a lower priority task. The problem was corrected and the spacecraft landed successfully.
- An Inkjet printer has a print head with control software for depositing the correct amount of ink onto a specific part of the paper. If a deadline is missed then the print job is ruined.

Firm Real-Time Systems Examples

Examples:

- Manufacturing systems with robot assembly lines where missing a deadline results in improperly assembling a part. As long as ruined parts are infrequent enough to be caught by quality control and not too costly, then production continues.
- A digital cable set-top box decodes time stamps for when frames must appear on the screen. Since the frames are time order sensitive a missed deadline causes jitter, diminishing quality of service. If the missed frame later becomes available it will only cause more jitter to display it, so it's useless. The viewer can still enjoy the program if jitter doesn't occur too often.

Soft Real-Time Systems Examples

Examples:

- Weather stations have many sensors for reading temperature, humidity, wind speed, etc. The readings should be taken and transmitted at regular intervals, however the sensors are not synchronized. Even though a sensor reading may be early or late compared with the others it can still be relevant as long as it is close enough.
- A video game console runs software for a game engine. There are many resources that must be shared between its tasks. At the same time tasks need to be completed according to the schedule for the game to play correctly. As long as tasks are being completely relatively on time the game will be enjoyable, and if not it may only lag a little.

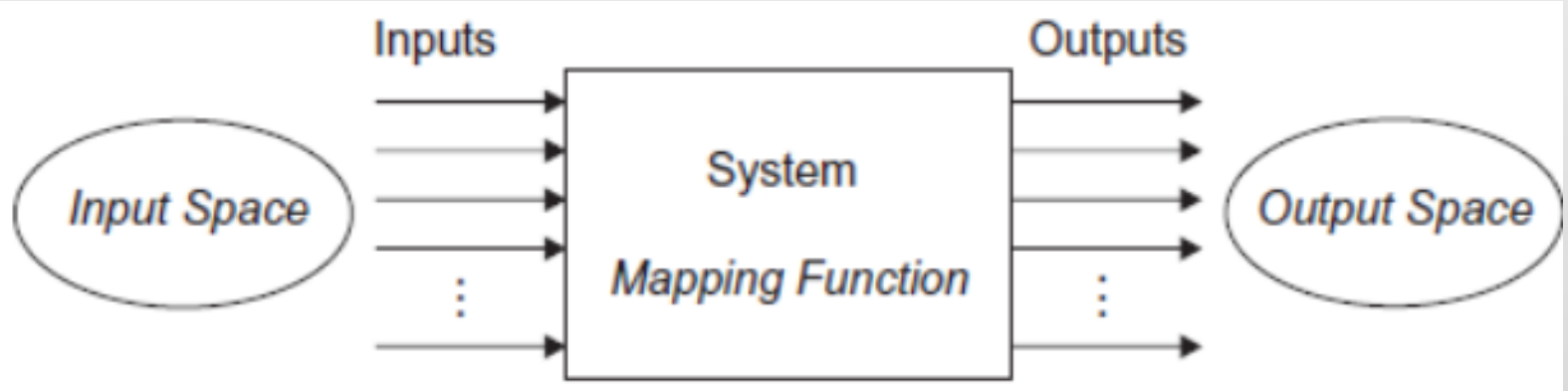
Samples of Hard, Firm, Soft RTSs

TABLE 1.1. A Sampling of Hard, Firm, and Soft Real-Time Systems

System	Real-Time Classification	Explanation
Avionics weapons delivery system in which pressing a button launches an air-to-air missile	Hard	Missing the deadline to launch the missile within a specified time after pressing the button may cause the target to be missed, which will result in catastrophe
Navigation controller for an autonomous weed-killer robot	Firm	Missing a few navigation deadlines causes the robot to veer out from a planned path and damage some crops
Console hockey game	Soft	Missing even several deadlines will only degrade performance

Definition of Response Time

Response Time: is the time between the presentation of a set of inputs to a system and the realization of the required behavior, including the availability of all associated outputs.



How fast and punctual the response time needs to be depends on the characteristics and purpose of the specific system

Example
Where a Response Time Comes From

An elevator door is automatically operated, and it may have a capacitive safety edge for sensing possible passengers between the closing door blades. Thus, the door blades can be quickly reopened before they touch the passenger and cause discomfort or even threaten the passenger's safety.

What is the required system response time from when it recognizes that a passenger is between the closing door blades to the instant when it starts to reopen the door?

Example
Where a Response Time Comes From

Sensor Response Time: $t_{S\_min} = 5$ ms, $t_{S\_max} = 15$ ms, $t_{S\_mean} = 9$ ms.

Hardware Response Time: $t_{HW\_min} = 1$ µs, $t_{HW\_max} = 2$ µs, $t_{HW\_mean} = 1.2$ µs.

System Software Response Time: $t_{SS\_min} = 16$ µs, $t_{SS\_max} = 48$ µs, $t_{SS\_mean} = 37$ µs.

Application Software Response Time: $t_{AS\_min} = 0.5$ µs, $t_{AS\_max} = 0.5$ µs, $t_{AS\_mean} = 0.5$ µs.

Door Drive Response Time: $t_{DD\_min} = 300$ ms, $t_{DD\_max} = 500$ ms, $t_{DD\_mean} = 400$ ms.

Now, we can calculate the minimum, maximum, and mean values of the composite response time: $t_{min} \approx 305$ ms, $t_{max} \approx 515$ ms, and $t_{mean} \approx 409$ ms.

Thus, the overall response time is dominated by the door-drive response time containing the required deceleration time of the moving door blades.

Summary

- ✓ Definition of signal
- ✓ Types of signals
- ✓ Definition of systems
- ✓ Five General Properties of any System
- ✓ Signals and systems classification
- ✓ Terms definitions for Real-Time systems