Rate Monotonic Analysis

Introduction

Periodic tasks

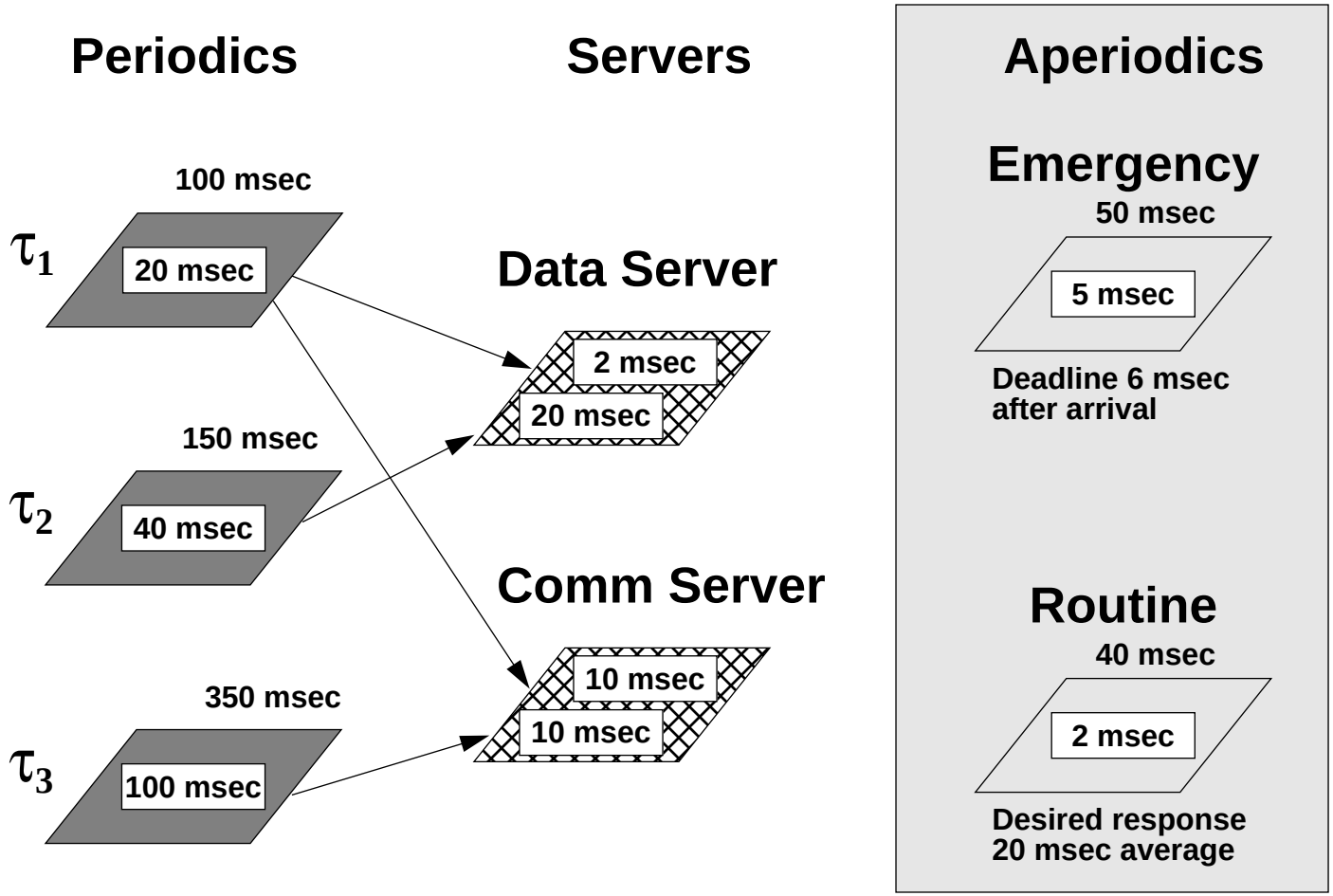
Extending basic theory

Synchronization and priority inversion

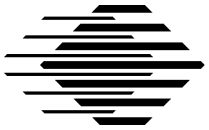
Aperiodic servers

Case study: BSY-1 Trainer

Sample Problem: Aperiodics



τ_2's deadline is 20 msec before the end of each period.



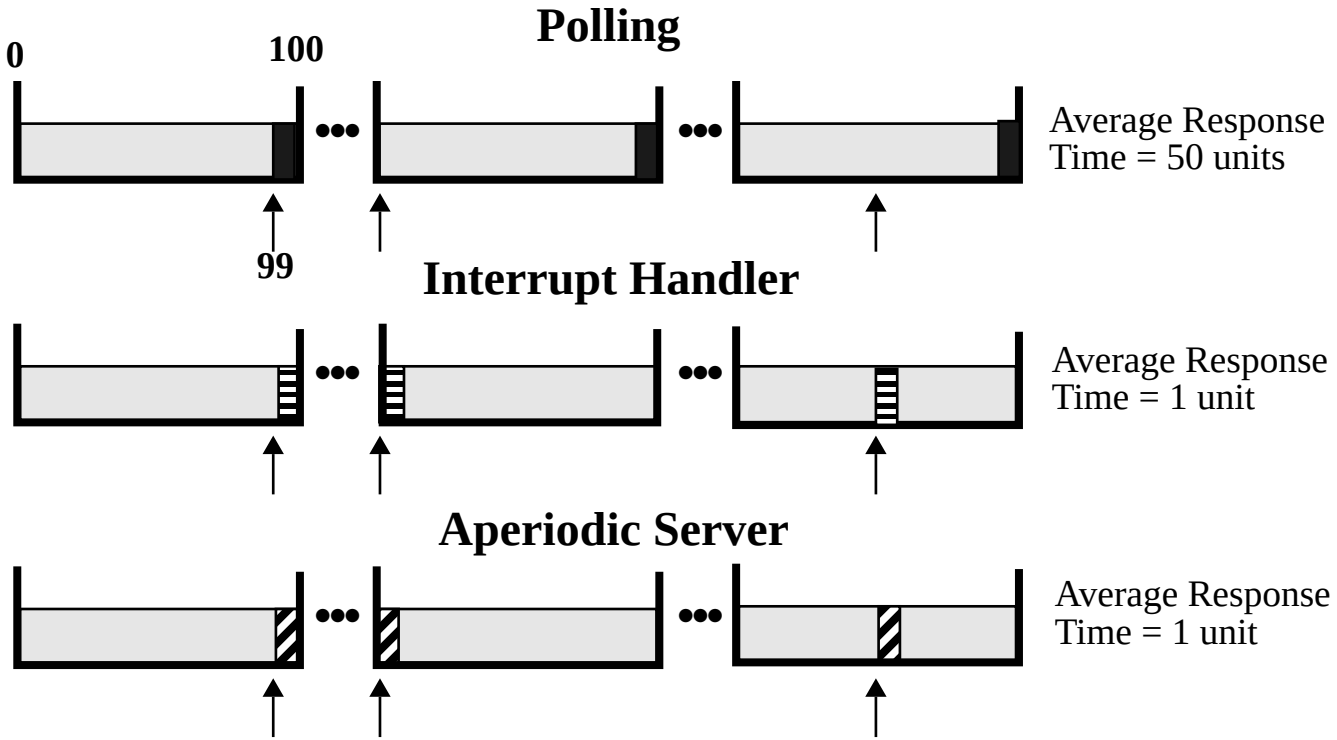
Concepts and Definitions

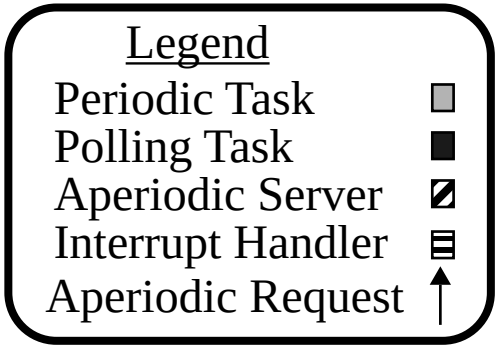
Aperiodic task: runs at unpredictable intervals

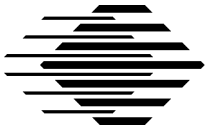
Aperiodic deadline:

- **hard, minimum interarrival time**
- **soft, best average response time**

Scheduling Aperiodic Tasks







Aperiodic Servers

Can be compared to periodic tasks:

- **fixed execution budget**
- **replenishment interval (period)**

Priority adjusted to meet requirements

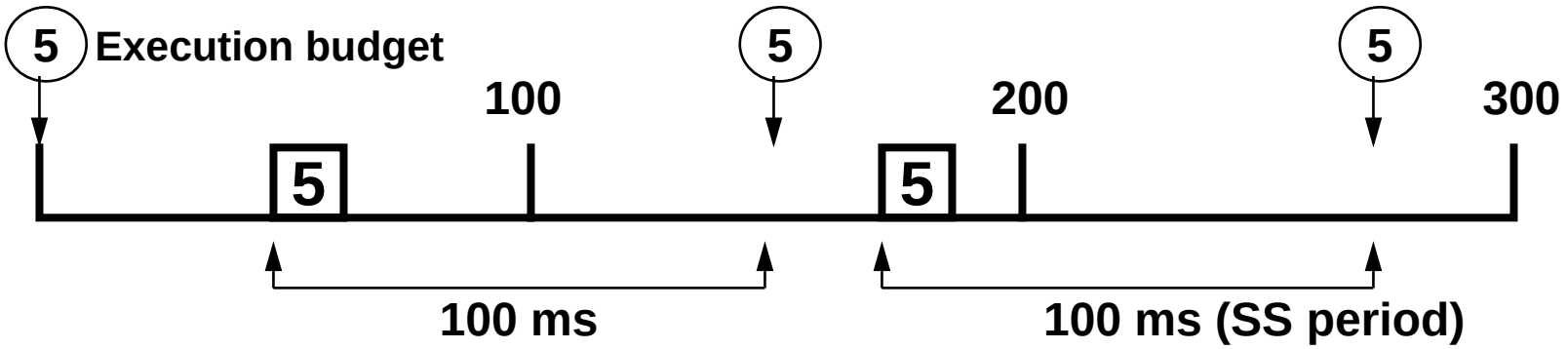
Sporadic Server (SS)

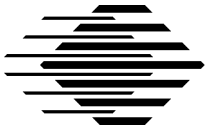
Modeled as periodic tasks:

- **fixed execution budget *(C)***
- **replenishment interval *(T)***

Priority adjusted to meet requirements

Replenishment occurs one “period” after start of use.



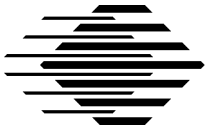


Sample Problem: Aperiodics

The sample problem has the following requirements:

- **emergency event:**
  - **5 msec of work**
  - **arrives every 50 msec, worst-case**
  - **hard deadline 6 msec after arrival**

- **routine event:**
  - **2 msec of work on average**
  - **arrives every 40 msec on average**
  - **desired average response of 20 msec after arrival**



Sample Problem: Sporadic Servers

Emergency server (ES); for minimum response:

- **set execution budget to processing time: *C* = 5**
- **set replenishment interval to minimum interarrival time: *T* = 50**

Routine server (RS); for average response:

- **set execution budget to processing time: *C* = 2**
- **use queueing theory to determine required replenishment interval, *T***

Then assign priorities based on periods, T_i, of tasks.

Routine Server Period

Using M/D/1 queueing approximation:

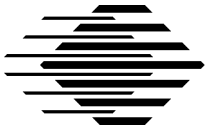
$$W = \frac{\frac{(T_R)^2}{I}}{2\left(1 - \frac{T_R}{I}\right)} + C_R$$

I = average interarrival time between events

W = average response time

C_R = capacity of sporadic server = processing time

T_R = required sporadic server replenishment period



Routine Server Budget

Computing server replenishment interval:

$$T_R = (C_R - W) + \sqrt{(W - C_R)\ (W - C_R + 2I)}$$

$$T_R = (2 - 20) + \sqrt{(20 - 2)\ (20 - 2 + 80)}$$

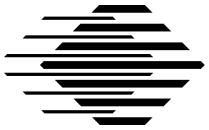
$$T_R = 24$$

Note: For more details, see RMA handbook.

Sample Problem: Schedulability Analysis (BIP)

The task set is now:

Task	Period	Execution Time	Priority	Blocking Delays	Deadline
τ_E	50	5	Very High	0	6
τ_R	24	2	High	0	24
τ_1	100	20	Medium	20	100
τ_2	150	40	Low	10	150
τ_3	350	100	Very Low	0	350



Sample Problem: Schedulability Analysis

Using the RT test, worst-case response times are

- τ_E: **5 ms**
- τ_R: **7 ms**
- τ_1: **56 ms**
- τ_2: **88 ms**
- τ_3: **296 ms**

All requirements for sample problem are satisfied.