Rate Monotonic vs. EDF: Judgment Day

von Buttazzo, G. C.

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Technische Hochschule Ingolstadt

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Gliederung

Meta-Informationen

- Author:
  - Giorgio C. Buttazzo
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- Whitepaper
  - Rate Monotonic vs. EDF: Judgment Day
  - Real-Time Systems, 29, 5–26, 2005

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Abstract

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[1] Rate Monotonics vs. EDF: Judgment Day, Girorgio C. Buttazzo, 2005

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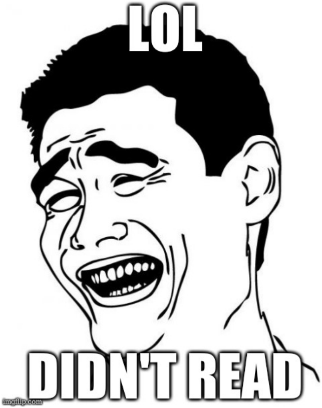

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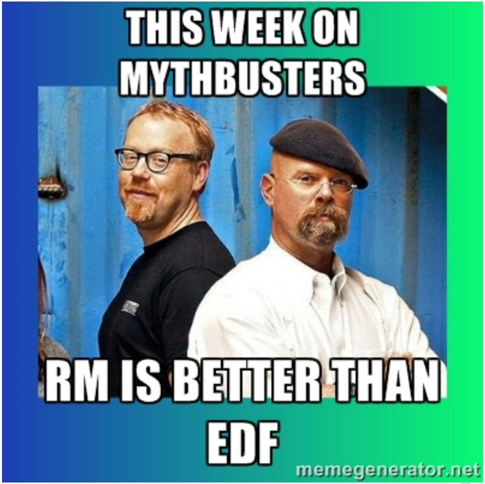
THIS WEEK ON
MYTHBUSTERS
RM IS BETTER THAN
EDF
memegenerator.net

Gliederung

Flashback - Scheduling

Wir definieren:

$$\tau_{i,k} \text{ als Job mit einer absoluten Deadline } d_{i,k} \tag{1}$$

$$\tau_i \text{ als infinite Folge von Jobs } \tau_{i,k} \text{ mit} \tag{2}$$

$$\begin{array}{ll} \text{Wort-Case-Execution-Time} & C_i \\ \text{Task-Period} & T_i \end{array} \tag{3}$$

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Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
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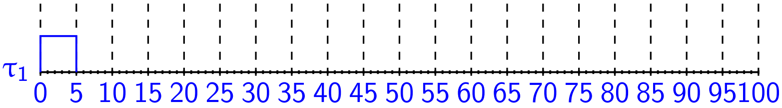

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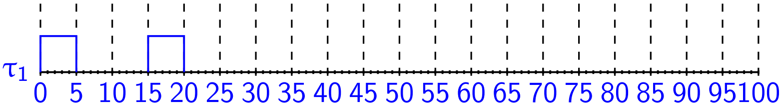

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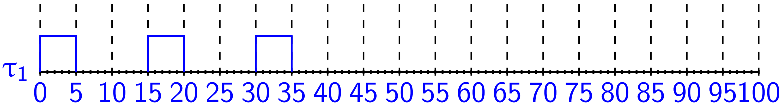

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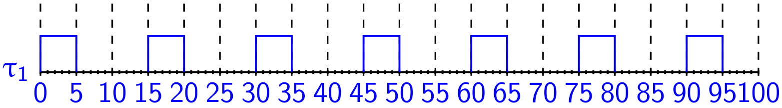
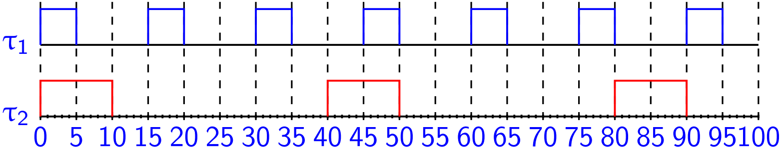


Flashback - Scheduling

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	5	15
τ_2	10	40



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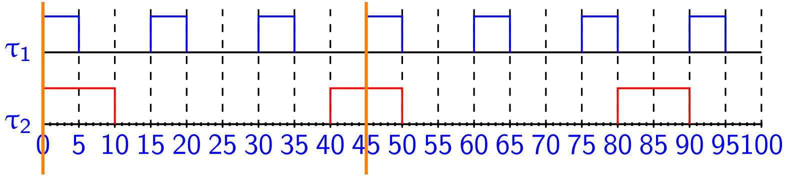

Gliederung

Grundlagen

Rate Monotonics:

- Task T_i mit kürzester Periode wird bevorzugt
- Task T_i wird anfangs eine Priorität zugewiesen

Erliest Deadline First:

- Job $T_{i,k}$ mit der nächsten Deadline wird bevorzugt
- In diesem Paper ist die Deadline gleich mit der Periode
- Die Priorität von Task T_i entscheidet sich während der Laufzeit

Gliederung

Beispiel Rate Monotonics

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	4	10
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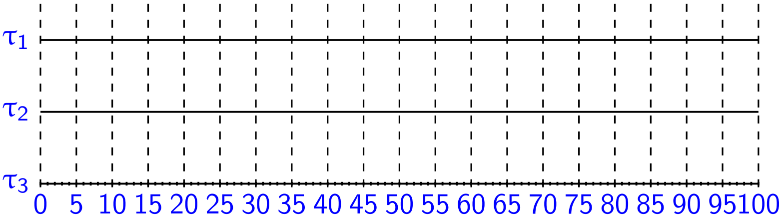

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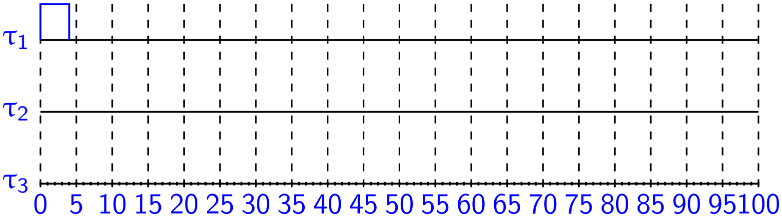

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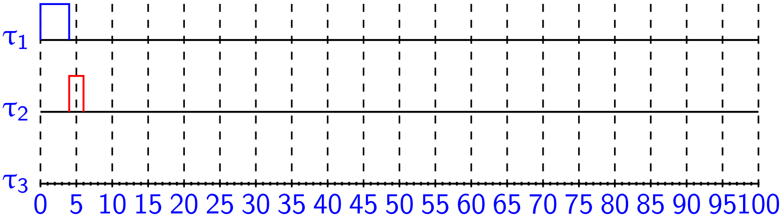

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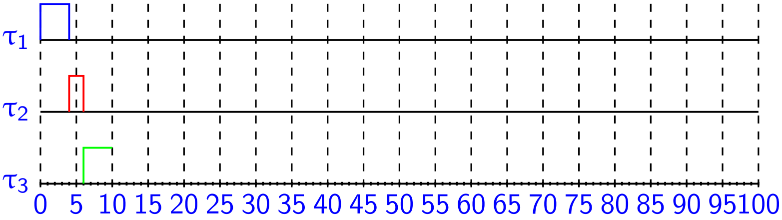

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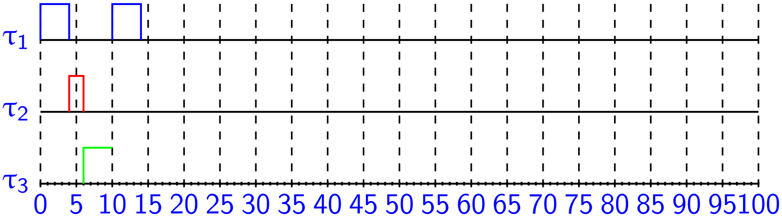

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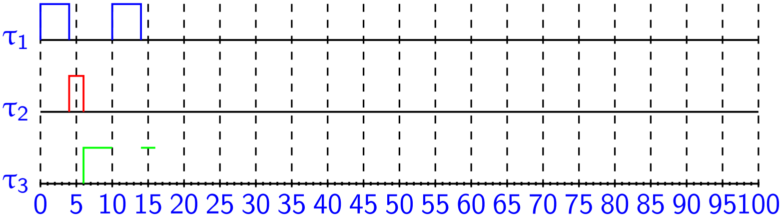

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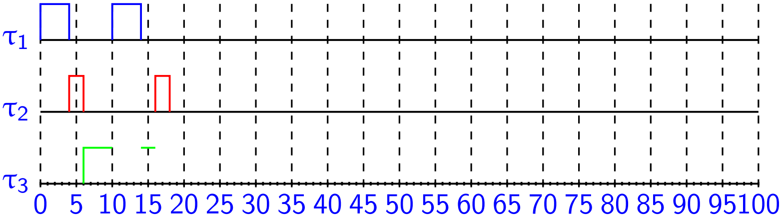

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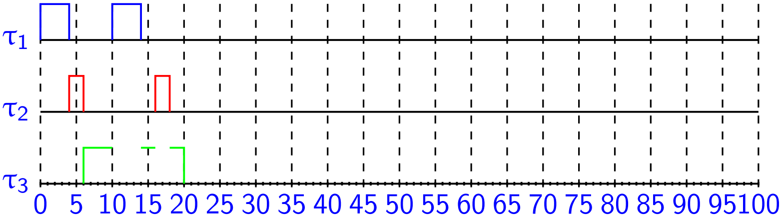

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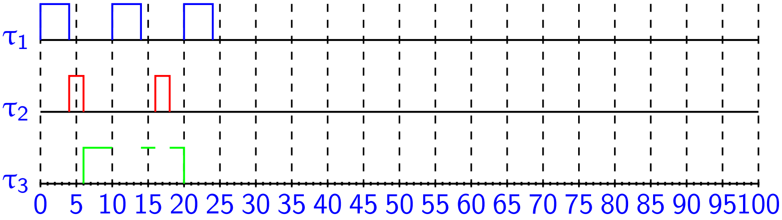

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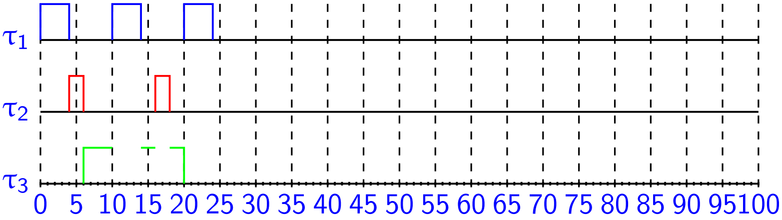

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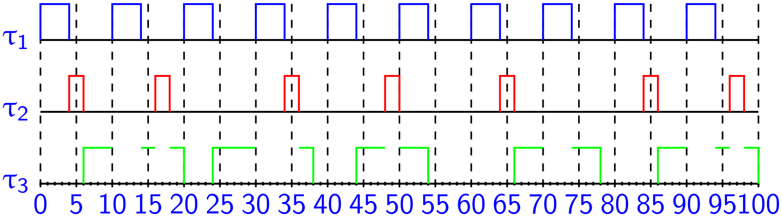

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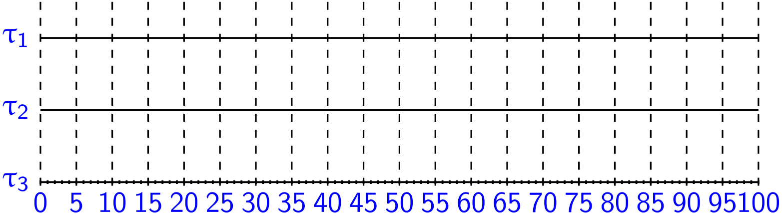

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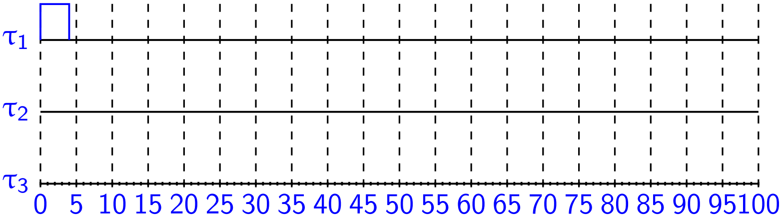

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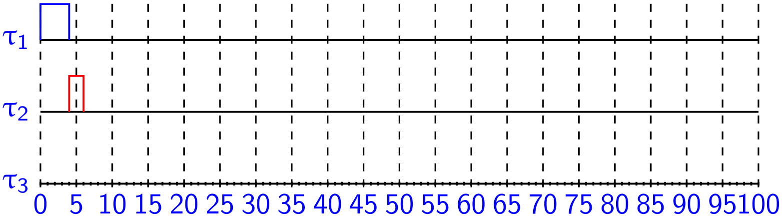

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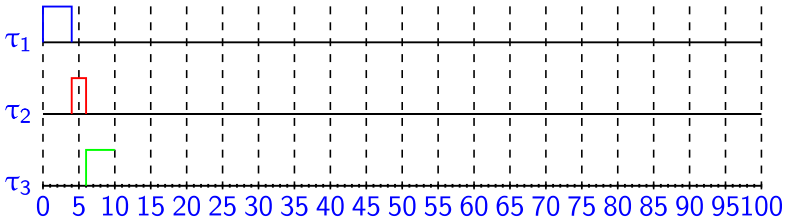

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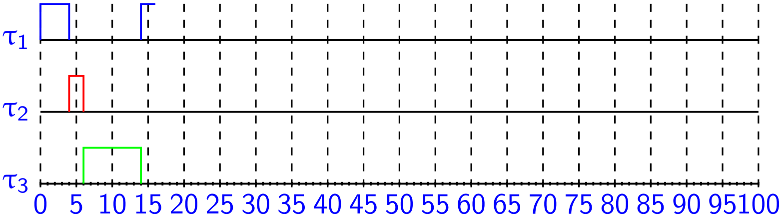

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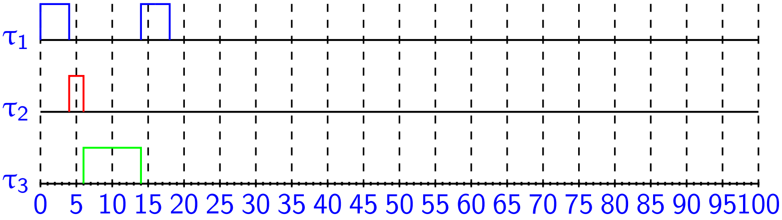

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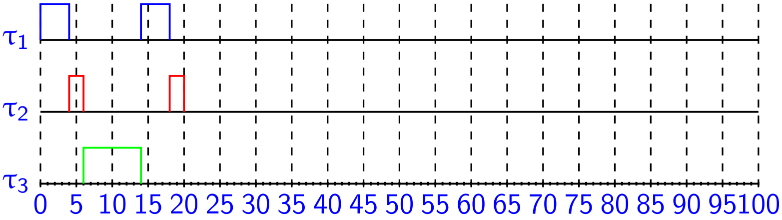

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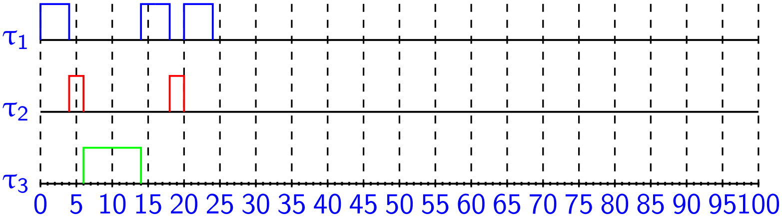

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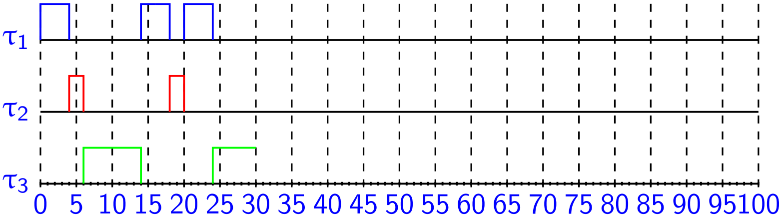

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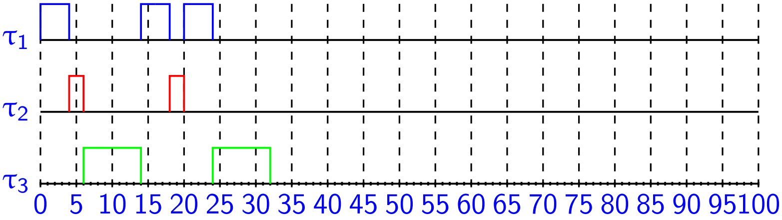

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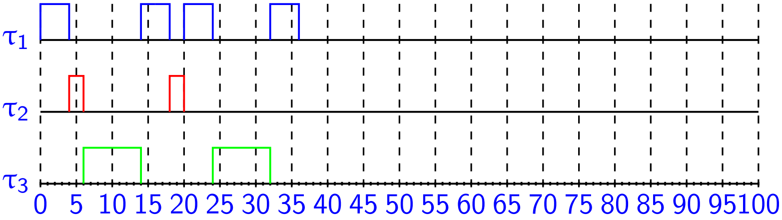

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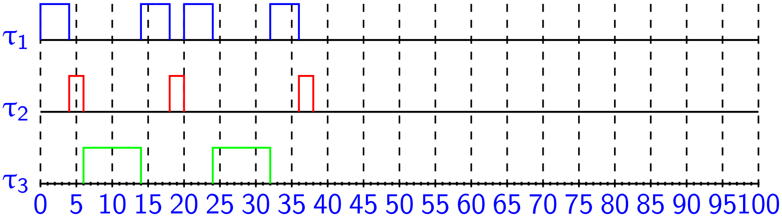

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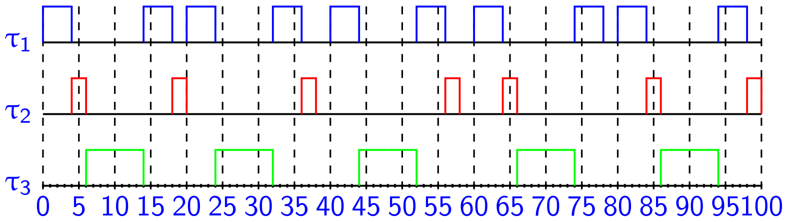

Vergleich

Gliederung

Implementation Complexity

Mythos:

- Rate Monotonics ist einfacher zu implementieren als Erliest Deadline First.

Implementation Complexity

Fakt:

- Auf einem kommerziellen Kernel mit festen Prioritätsleveln ist Rate Monotonics einfacher zu implementieren.

Ist es so einfach?

Faktoren:

- Wird auf einem bestehenden System entwickelt?
- Sind die Prioritäten festgesetzt oder können diese während der Laufzeit verändert werden?
- Wie viele Prioritäts-Level gibt es?

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Implementation Complexity

Annahme

- Das System wird von Grund auf mit einer Ready-Queue implementiert.
- In dieser werden die Tasks für Rate Monotonics
  - absteigend nach nach dem Prioritäten-Level

  und für Erliest Deadline First
  - aufsteigend nach der absoluten Deadline

  gespeichert.

Implementation Complexity

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  und für Erliest Deadline First
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  gespeichert.

Implementation Complexity

Fazit:

- Unter den richtigen Vorbedingungen ist auch EDF leicht zu implementieren.

Implementation Complexity

Gliederung

Runtime Overhead

Mythos:

- Rate Monotonics produziert weniger Runtime-Overhead, da die Prioritäten währen der Laufzeit nicht neu berechnet werden müssen.

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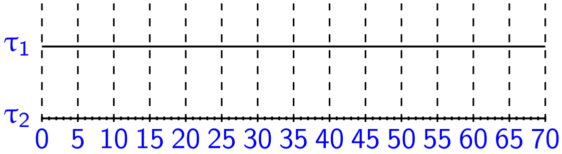

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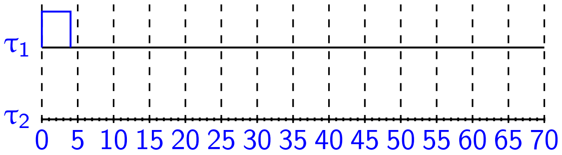

Beispiel Rate Monotonics

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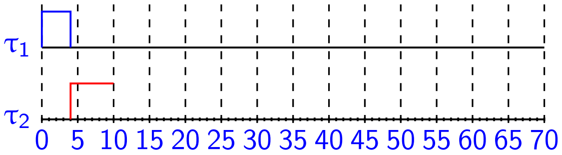

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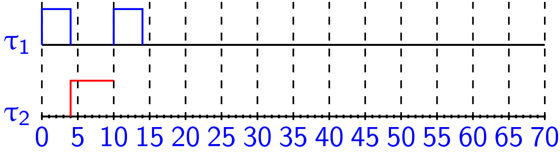

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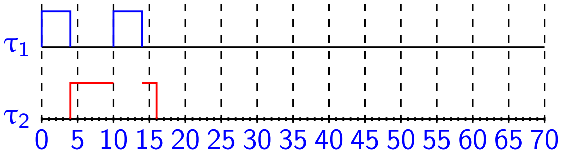

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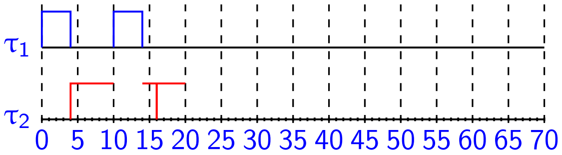

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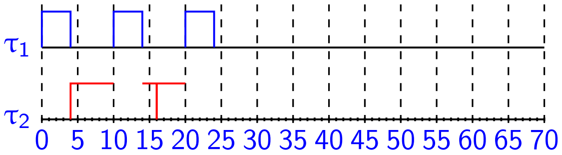

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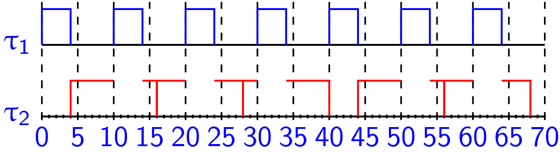

Beispiel Erliest Deadline First

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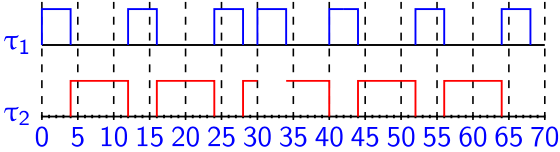
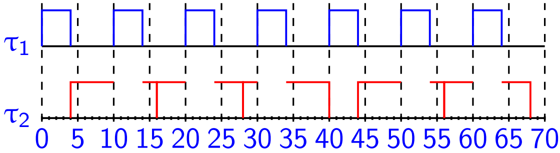
τ_2	8	14



Runtime Overhead

Rate Monotonics:



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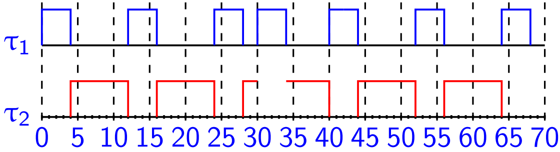


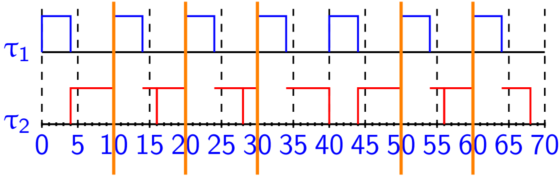
Runtime Overhead

Context-Switching/Preemptions:

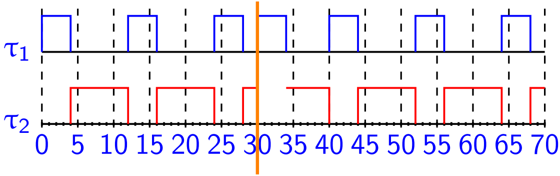
- Umschalten zwischen verschiedenen Tasks.
- Zieht Aufwände mit sich.

Runtime Overhead

Rate Monotonics:



Erliest Deadline First:



Runtime Overhead

Fazit:

- Beachtet man den Aufwand der Context-Switches, erzeugt Rate Monotonics mehr Overhead als Erliest Deadline First

Runtime Overhead

Gliederung

Schedulability Analysis

Schedulability meint, dass eine Menge von periodischen Task mithilfe eines Algorithmus planbar ist.

Mythos:

- Die Einteilung ist Rate Monotonics leichter berechenbar als bei Erliest Deadline First.

Schedulability Analysis

Schedulability meint, dass eine Menge von periodischen Task mithilfe eines Algorithmus planbar ist.

Mythos:

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Schedulability Analysis

Allgemein:

$$U_i = C_i / T_i \tag{4}$$

Desweiteren gilt, dass ein Task-Set P unter RM nur sicher planbar seien kann, wenn

$$\prod_{i=0}^{n} (U_i + 1) \leq 2 \tag{5}$$

und unter EDF nur (und auch wirklich nur) planbar sein, wenn

$$\sum_{i=1}^{n} U_i \leq 1 \tag{6}$$

Schedulability Analysis

Beispiel:

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	1	4
τ_2	3	8
τ_3	2	16

RM: $U = (\frac{1}{4}+1)(\frac{3}{8}+1)(\frac{2}{16}+1) \approx 1.93 \leq 2$

EDF: $U = \frac{1}{4}+\frac{3}{8}+\frac{2}{16} = \frac{3}{4} = 0.75 \leq 1$

Schedulability Analysis

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Schedulability Analysis

Response Time Analysis (RTA) Algorithmus für Rate Monotonics:

$$D_i \geq \begin{cases} R_i^{(0)} = C_i \\ R_i^{(k)} = C_i + \sum_{j:D_j<D_i} \lceil \frac{R_i^{k-1}}{T_j} \rceil C_j \end{cases} \tag{7}$$

Processor Demand Criterion (PDC) Algorithmus für Erliest Deadline First:

$$\forall L > 0, \sum_{i=1}^{n} \lfloor \frac{L + T_i - D_i}{T_i} \rfloor C_i \leq L \tag{8}$$


I HAVE NO
IDEA WHAT
I'M DOING

Schedulability Analysis

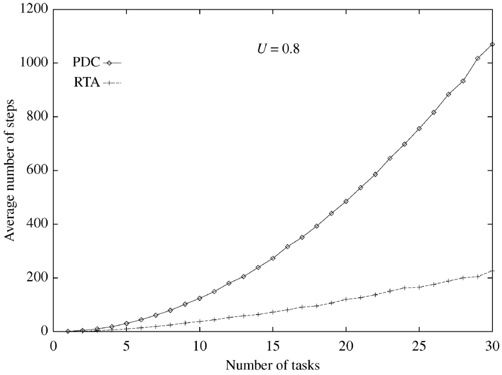

Figure: Vergleich RTA vs. PDC [7]

[7] Rate Monotonics vs. EDF: Judgment Day, Girorgio C. Buttazzo, 2005

Schedulability Analysis

Fazit:

- Komplexität für Rate Monotonics: pseudo-polynomial
- Komplexität für Erliest Deadline First:
  - pseudo-polynomial
  - in besonderen Fällen $O(n)$
- Bei einer hohen Anzahl von Tasks ist Rate Monotonics besser zu berechnen (mit Ausnahmen)
- Bei Erliest Deadline First ist für höhere Auslastungen ein garantiertes Scheduling möglich

Schedulability Analysis

Schedulability Analysis

Gliederung

Robustness During Overloads

Mythos:

- Rate Monotonics ist in Overload-Situationen besser vorhersehbar.

Szenarien:

- Permanent Overload
- Transient Overload

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- Transient Overload

Permanent Overload: Rate Monotonics

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	4	8
τ_2	6	12
τ_3	5	20

$$U = \left(\frac{4}{8}+1\right)\left(\frac{6}{12}+1\right)\left(\frac{5}{20}+1\right) \approx 2.81 \not\leq 2$$

Permanent Overload: Rate Monotonics

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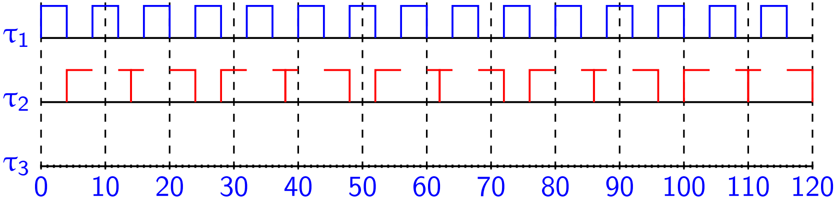

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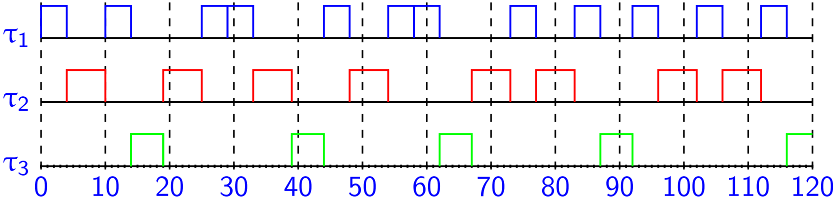

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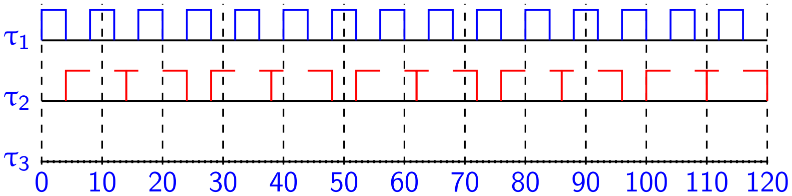

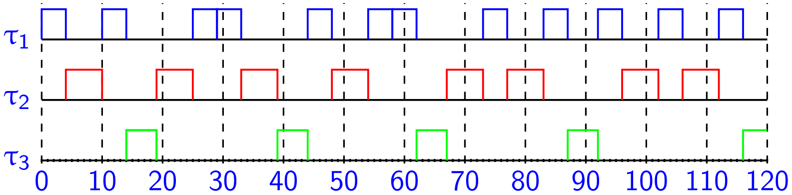

Permanent Overload

Rate Monotonics:

- Tasks mit langer Periode werden vollständig blockiert!
- Gut vorhersagbar.

Erliest Deadline First:

- Sieht chaotischer aus.
- Durchschnittliche Periode $\bar{T}_i$ für einen Task τ_i ist gegeben durch

$$\bar{T}_i = T_i \cdot U \qquad (9)$$

Permanent Overload

Fazit:

- Beide Verfahren bei permanenter Überlastung gut vorhersagbar.
- Einsatzgebiet ist stark Situationsabhängig.

Transient Overload

Annahme für RM:

- Es werden Tasks mit kurzen Perioden bevorzugt.

$\Rightarrow$ Falls ein Task seine Deadline überschreitet, wird der Task mit der längsten Periodenlänge verschoben/unterbrochen .

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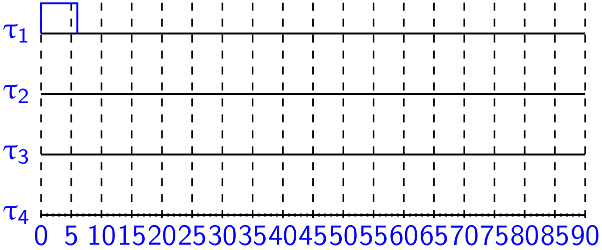
Transient Overload

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	6	15
τ_2	9	27
τ_3	3	60
τ_4	3	90



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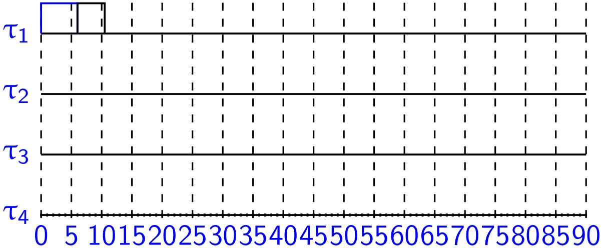

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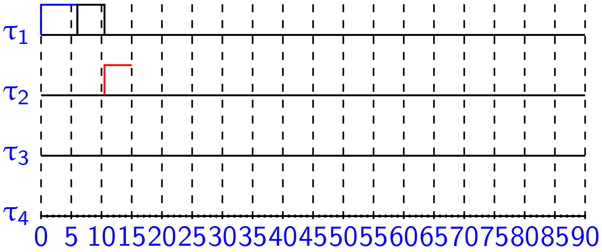

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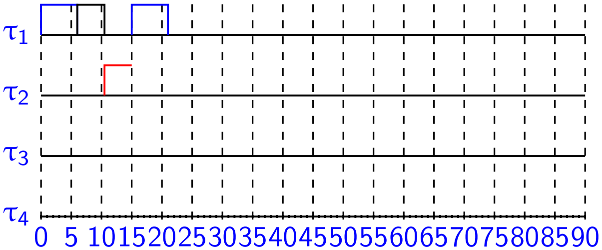

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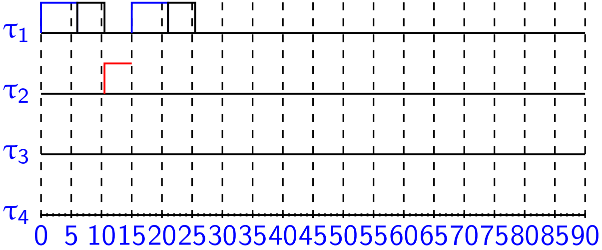

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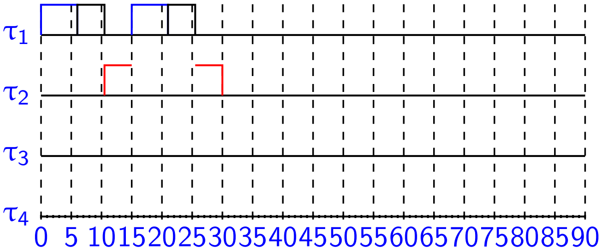

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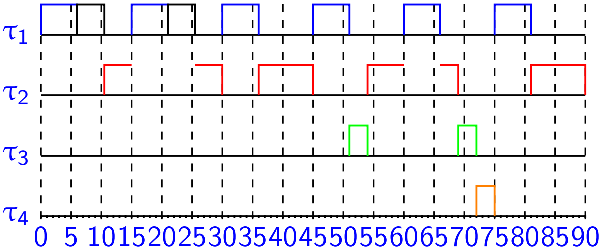


Robustness During Overloads

Fazit:

- Permanent Overload: Gleichwertig.
- Transient Overload:
    - Rate Monotonics verführt zu falschen Annahmen.

Robustness During Overloads

Gliederung

Jitter and Latency

Definition von Jitter:
Absolute Response Time Jitter ARJ_i ist definiert durch

$$ARJ_i = maxR_{i,k} - minR_{i,k} \tag{10}$$

mit $R_{i,K}$ als Response-Time für den k-ten Job von τ_i.

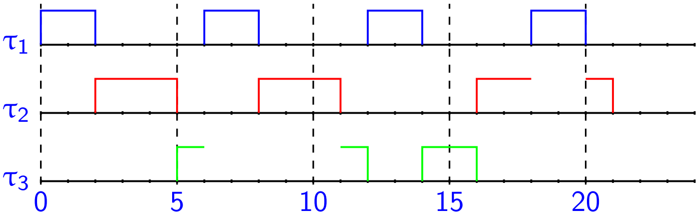
Jitter and Latency

Mythos:

- Durch die festen Prioritäten entsteht währen der Laufzeit bei Rate Monotonics weniger Jitter als bei Erliest Deadline First.

Beispiel Jitter Rate Monotonics

Task (τ_i)	Dauer (C_i)	Task-Periode (T_i)
τ_1	2	6
τ_2	3	8
τ_3	2	12



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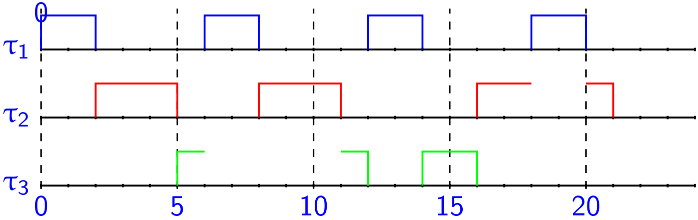

$ARJ_1 =$

Beispiel Jitter Rate Monotonics

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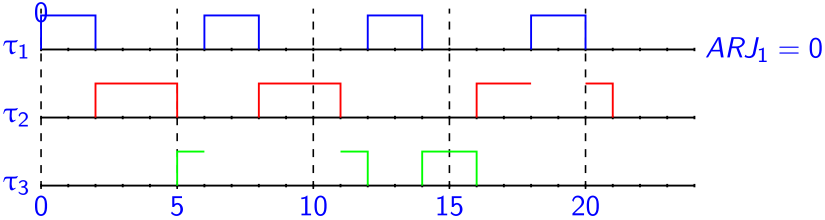

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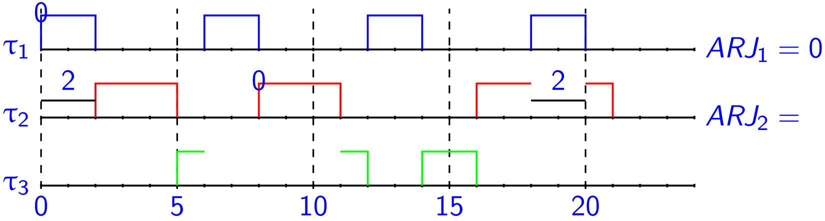

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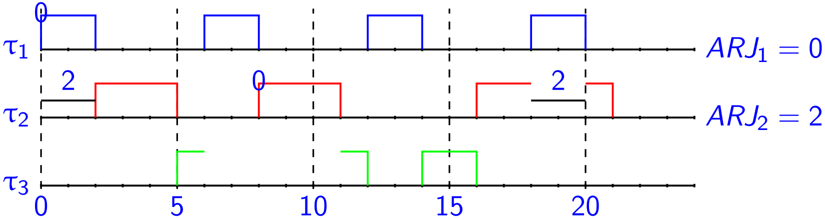

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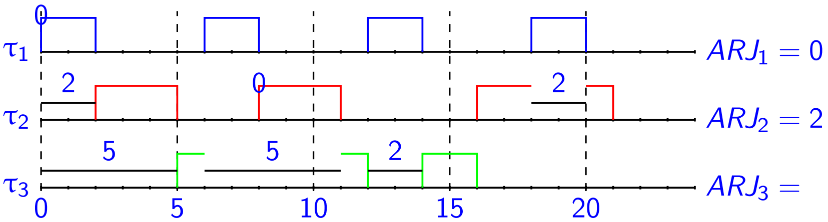

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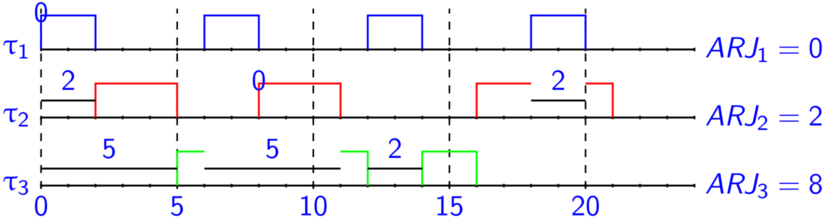

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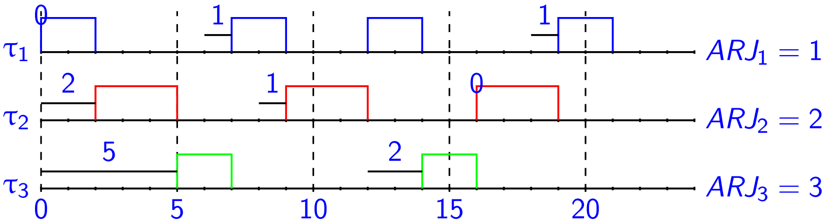

Jitter and Latency

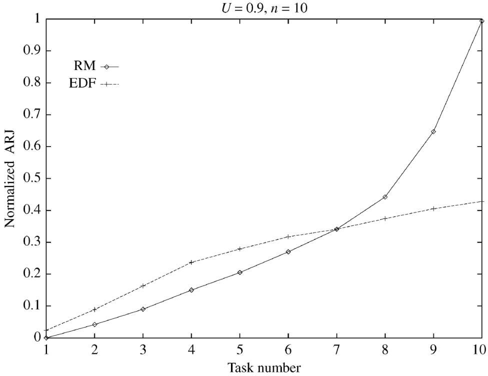

Figure: Vergleich ARJ bei RM vs EDF[8]

[8]Rate Monotonics vs. EDF: Judgment Day, Girorgio C. Buttazzo, 2005

Jitter and Latency

Fazit:

- RM hält Jitter für die hoch priorisierten Tasks sehr niedrig, vernachlässigt jedoch die anderen Tasks.
- Insgesamt erzeugt EDF, gerade bei hoher Auslastung, wesentlich weniger Jitter.

Jitter and Latency

Gliederung

Fazit

Vorteile von Rate Monotonics:

- leichtere Implementierung in kommerziellen Systemen
- RTA benötigt weniger Schritte als PDC

Vorteile Erliest Deadline First:

- Erlaubt vertrauenswürdiges Scheduling solange $U \leq 1$
- Weniger Runtime Overhead

Unentschieden oder Situationsabhängig:

- Overload Situations
- Jitter Control

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- RTA benötigt weniger Schritte als PDC

Vorteile Erliest Deadline First:

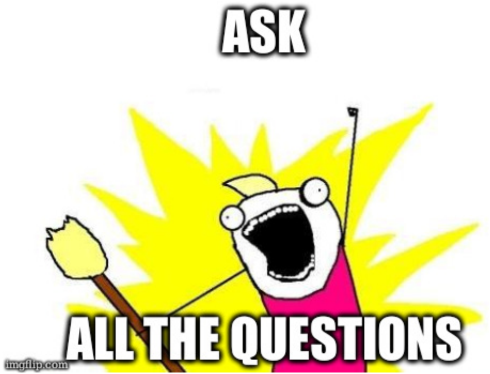
- Erlaubt vertrauenswürdiges Scheduling solange $U \leq 1$
- Weniger Runtime Overhead

Unentschieden oder Situationsabhängig:

- Overload Situations
- Jitter Control

Fazit

Fragen?



Link zum Vortrag:
https://github.com/DominikSchlecht/RMvsEDF