

Power-Aware Scheduling with Dynamic Priorities

Raj Rajkumar
Lecture #11

Outline

- Static voltage scaling with EDF
- Cycle-conserving Dynamic Voltage Scaling
- Look-Ahead Dynamic Voltage Scaling

Static Voltage Scaling w/ EDF: Motivation

τ

Pre-run schedule with holes

C_i = worst case computation time @ F_{\max}

Next arrival
of τ_I



Holes in the pre-run schedule imply:

EDF Test:

$$\sum (C_i/T_i) < 1 \text{ at frequency} = F_{\max}$$

In other words, whenever $\sum (C_i/T_i) < 1$ there are holes in the EDF schedule

Static Voltage Scaling w/ EDF: Exploiting “Holes”

“Holes” in the schedule correspond to idle times on the processor.

Pre-run schedule with holes

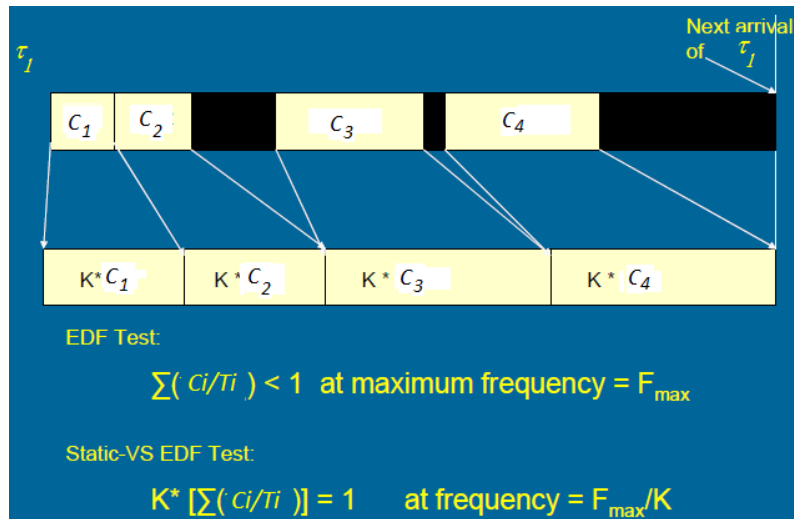
C_i = worst case computation time @ F_{\max}

Next arrival
of τ_I



Processor typically idles
during holes.
Instead, the holes can be
exploited to slowdown the
processor to save energy

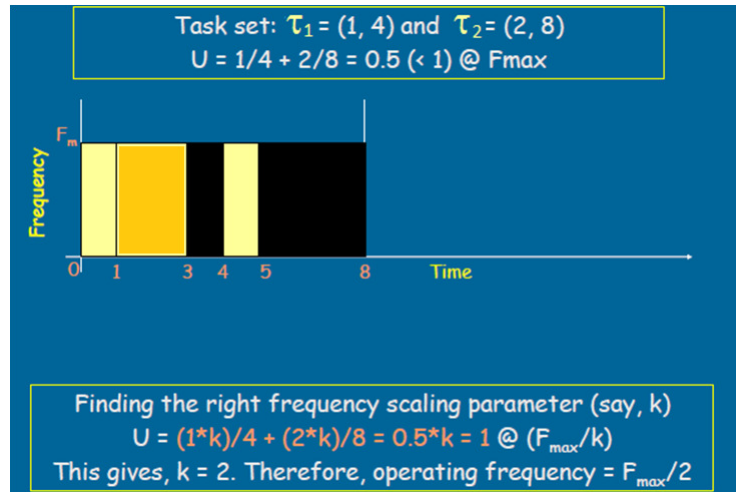
Static Voltage Scaling w/ EDF



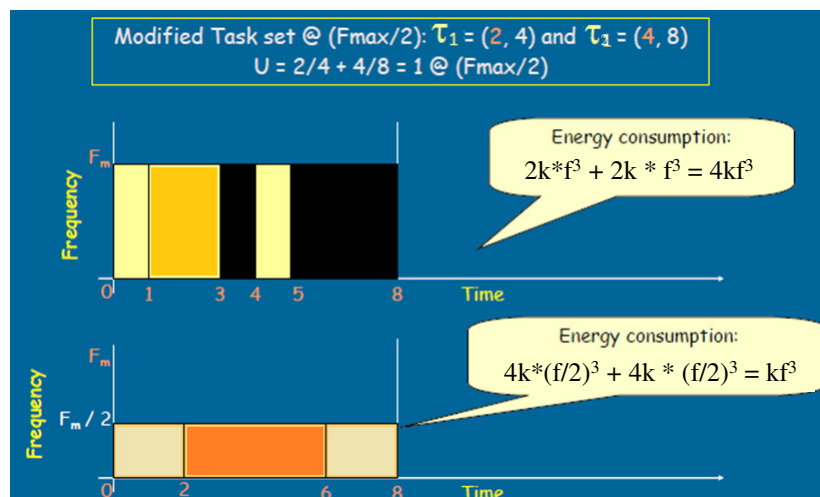
Static Voltage Scaling: Example Taskset

- Taskset: $\tau_1 = (1, 4)$ and $\tau_2 = (2, 8)$
- $U = 1/4 + 2/8 = 0.5$ @ F_{\max}
- What is the value of scaling factor k at which the taskset is still schedulable @ (F_{\max} / k) ?
 - $U = (1k)/4 + (2k)/8 = k(1/4 + 2/8) = 1$
 - Solving for k ,
 - $k = 2$
 - Therefore, we should operate at $f = F_{\max} / 2$ in order to meet all task deadlines.

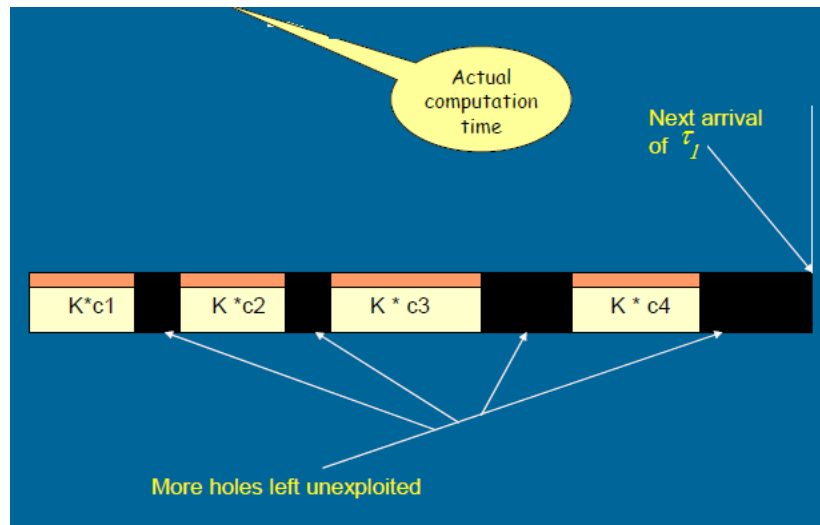
Static Voltage Scaling: Example (1 of 2)



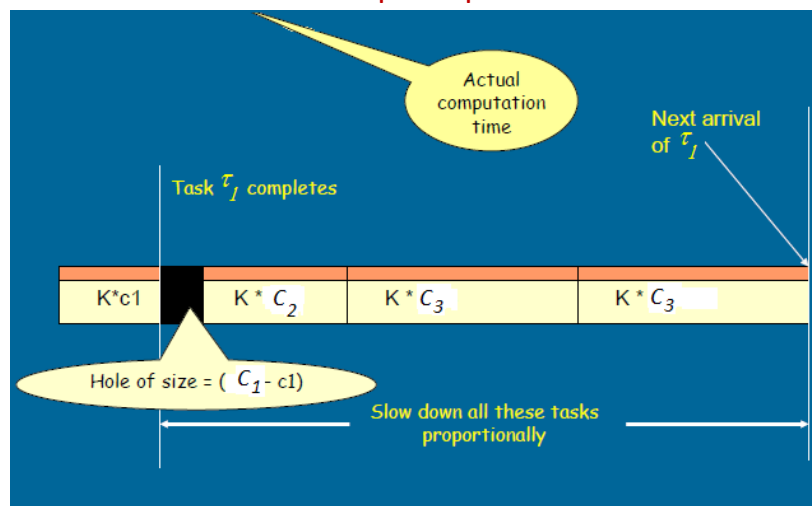
Static Voltage Scaling: Example (2 of 2)



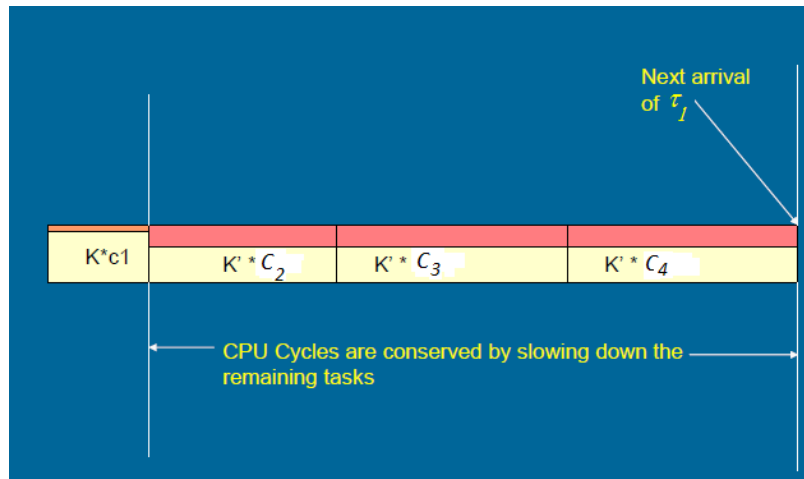
What if ($c_i < C_i$)? (1 of 3)



What if ($c_i < C_i$)? (2 of 3)



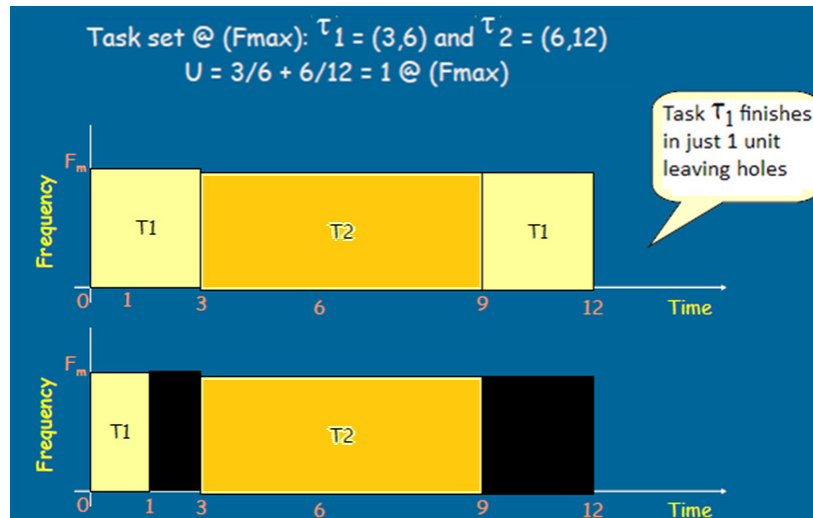
What if ($c_i < C_i$)? (3 of 3)



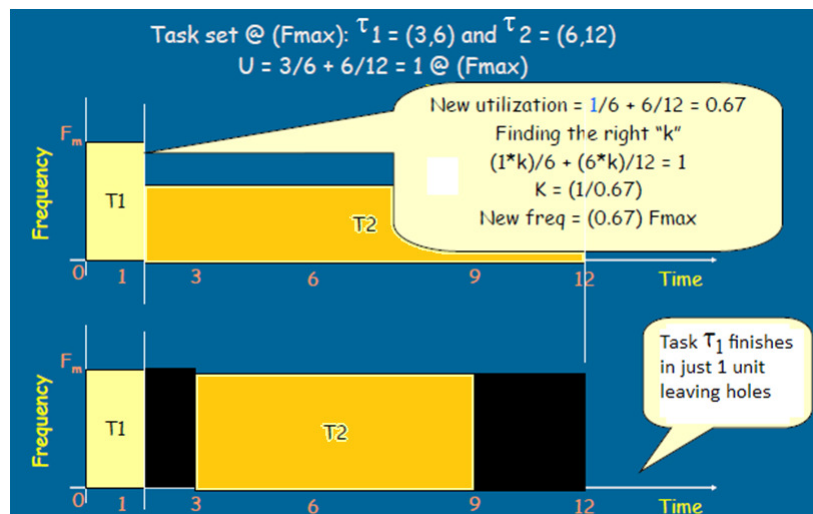
Cycle-Conserving EDF: Taskset

- Taskset:
 - $\tau_1 = (3, 6)$ and $\tau_2 = (6, 12)$
- $U = 3/6 + 6/12 = 1$ @ F_{\max}
- What is the value of scaling factor k at which the taskset is still schedulable @ (F_{\max} / k) ?
 - $U = (3k)/6 + (6k)/12 = 1$
 - Solving for k ,
 - $k = 1$
 - Therefore, we should operate at $f = F_{\max}$ in order to meet all its deadlines.

Cycle-Conserving EDF Example



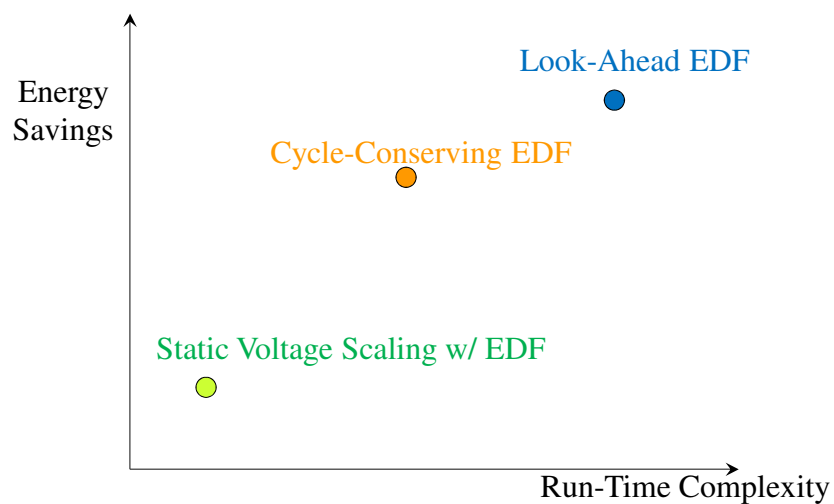
Cycle-Conserving EDF Example (contd.)



Look-Ahead EDF

- Defers as much work as possible.
- Sets the operating frequency to meet the minimum work that must be done now to ensure all future deadlines to be met.

Relative Performance



Conclusions

- RT-DVS schemes are designed to ensure
 - predictability while saving as much energy as possible in real-time systems.