

# Improved multiprocessor global schedulability analysis of sporadic DAG tasks



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# Improved multiprocessor global schedulability analysis of sporadic DAG tasks

Presented at ECRTS 2013:

1. Li, Agrawal, Lu, and Gill. Analysis of global EDF for parallel tasks
2. Bonifaci, Marchetti-Spaccamela, Stiller, and Wiese. Feasibility analysis in the sporadic DAG task model

The speedup factor of GEDF for sporadic DAG task systems is  $\left(2 - \frac{1}{m}\right)$

A **speedup-optimal** sufficient schedulability test

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Phillips, Stein, Torng, and Wein. **Optimal time-critical scheduling via resource augmentation**. STOC – the ACM Symposium on the Theory Of Computing (1997)

- The speedup factor of GEDF for collections of **independent jobs** is  $\left(2 - \frac{1}{m}\right)$

Bonifaci, Marchetti-Spaccamela, and Stiller. **A constant-approximate feasibility test for multiprocessor real-time scheduling**. ESA – the European Symposium on Algorithms (2008)

- The speedup factor of GEDF for collections of **(C<sub>i</sub>, D<sub>i</sub>, T<sub>i</sub>) sporadic tasks** is  $\left(2 - \frac{1}{m}\right)$

The speedup factor of GEDF for sporadic DAG task systems is  $\left(2 - \frac{1}{m}\right)$

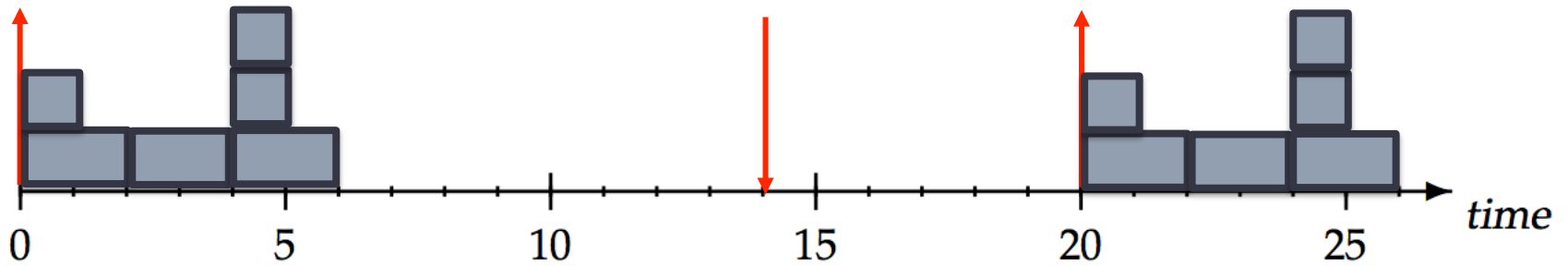
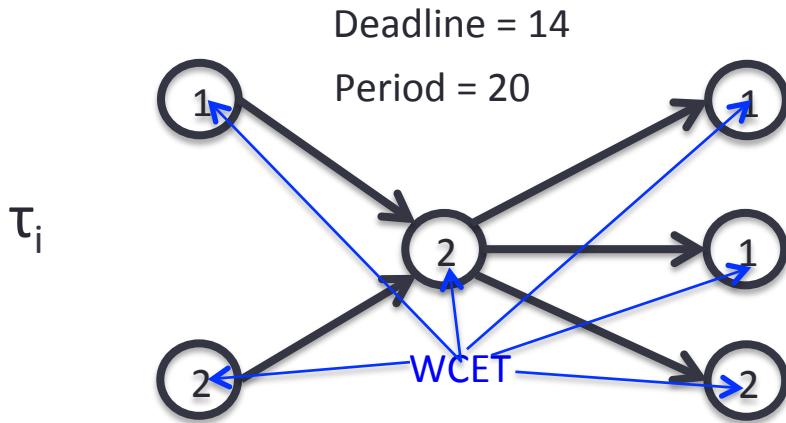
A **speedup-optimal** sufficient schedulability test

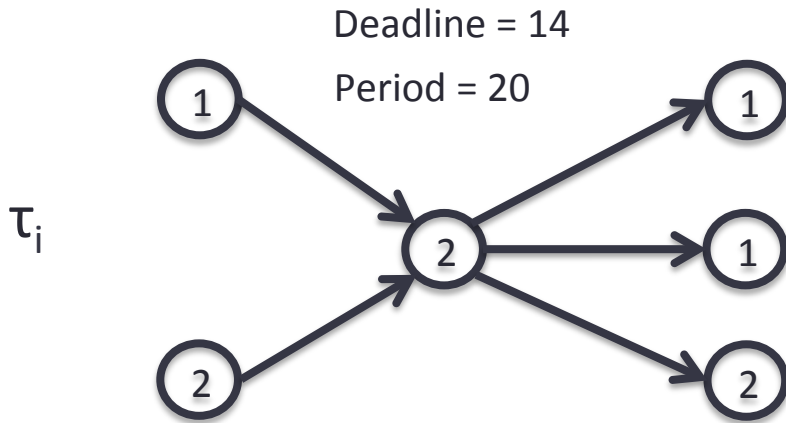
# Improved multiprocessor global schedulability analysis of sporadic DAG tasks

An **improved** sufficient schedulability test

- **dominates** the one in [Bonifaci et al.]
- **Speedup-optimal**
- Entirely based on the insights in [Bonifaci et al.]

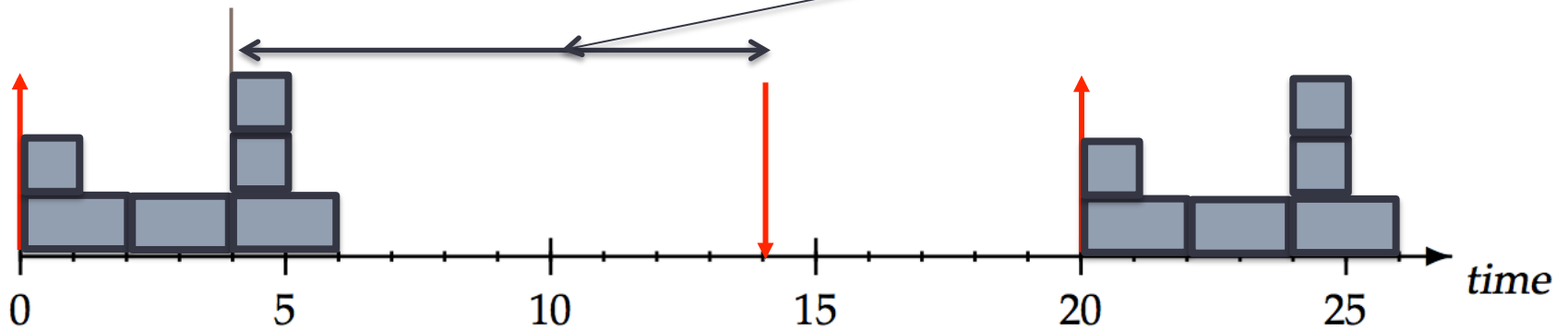
# The sporadic DAG task model



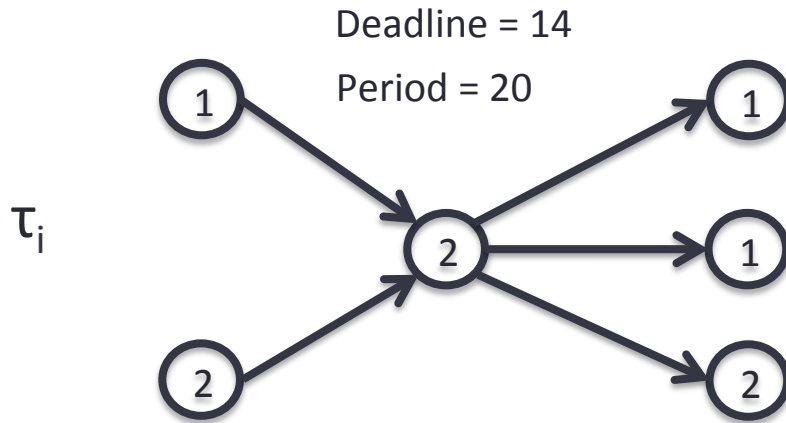


- Work executes **as soon as possible**
- Intervals **ending at deadlines** have the **minimum possible amount** of execution

Any correct schedule must complete at least 4 units of execution over these 10 time units

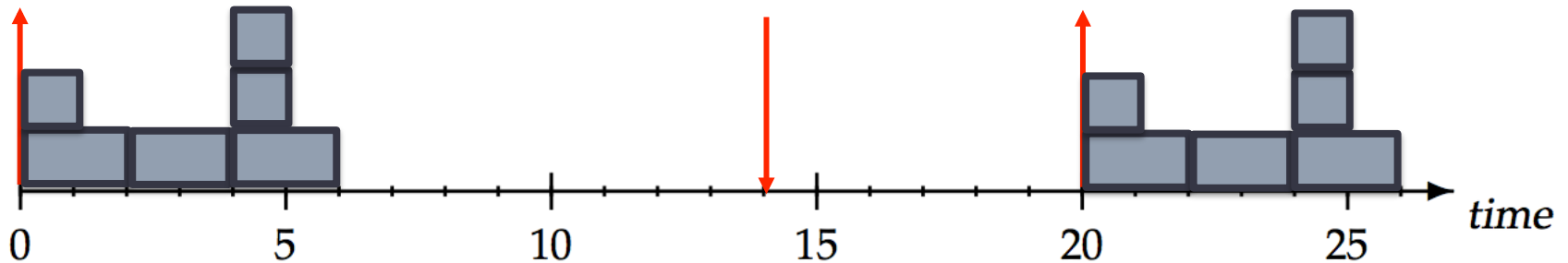


# The **work** function

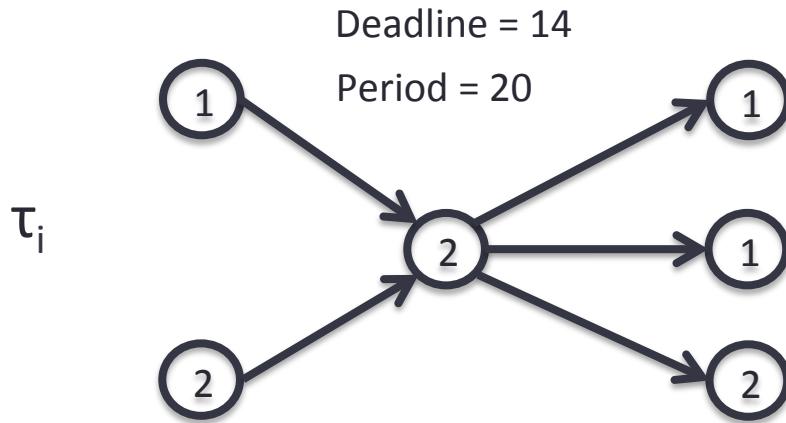


$\text{work}(\tau_i, t)$ : Minimum amount of execution that must be done by any correct scheduler over some interval of duration  $t$

A generalization, to sporadic DAG tasks, of the concept of **demand bound function (dbf)** (and **forced-forward dbf**)



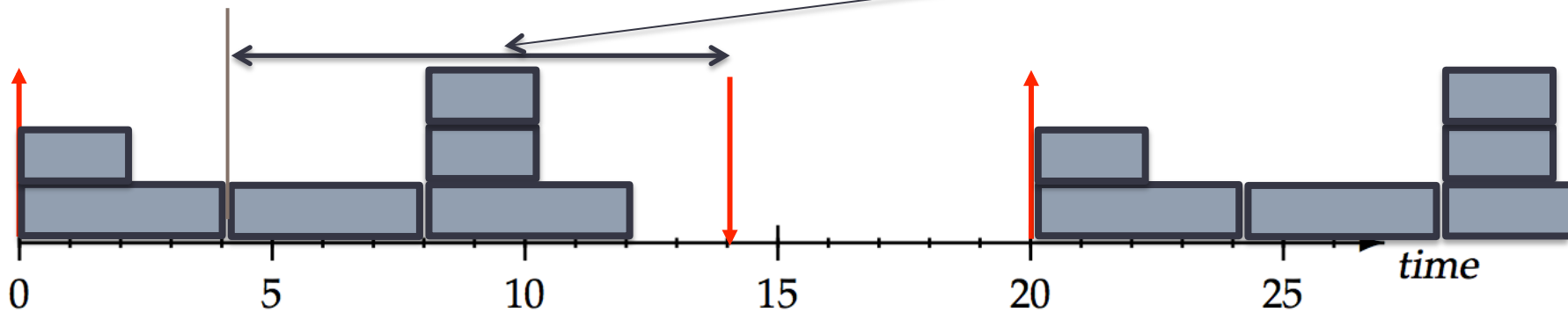
# The **work** function



$\text{work}(\tau_i, t, s)$ : Minimum amount of execution that must be done by any correct scheduler over some interval of duration  $t$  upon speed- $s$  processors

Upon speed- $s$  processors ( $s < 1$ ) [Here,  $s = \frac{1}{2}$ ]

Any correct schedule must complete at least 6 units of execution over these 10 time units





# The Big Result in [Bonifaci et al.]

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A system of sporadic DAG tasks is GEDF-schedulable on  $m$  speed-1 processors if **there is an  $s$** ,  $0 < s < 1$ , such that for all  $t \geq 0$ ,

$$\sum_{\text{all } \tau_i} \text{work}(\tau_i, t, s) \leq (m - (m - 1)s) \times t$$

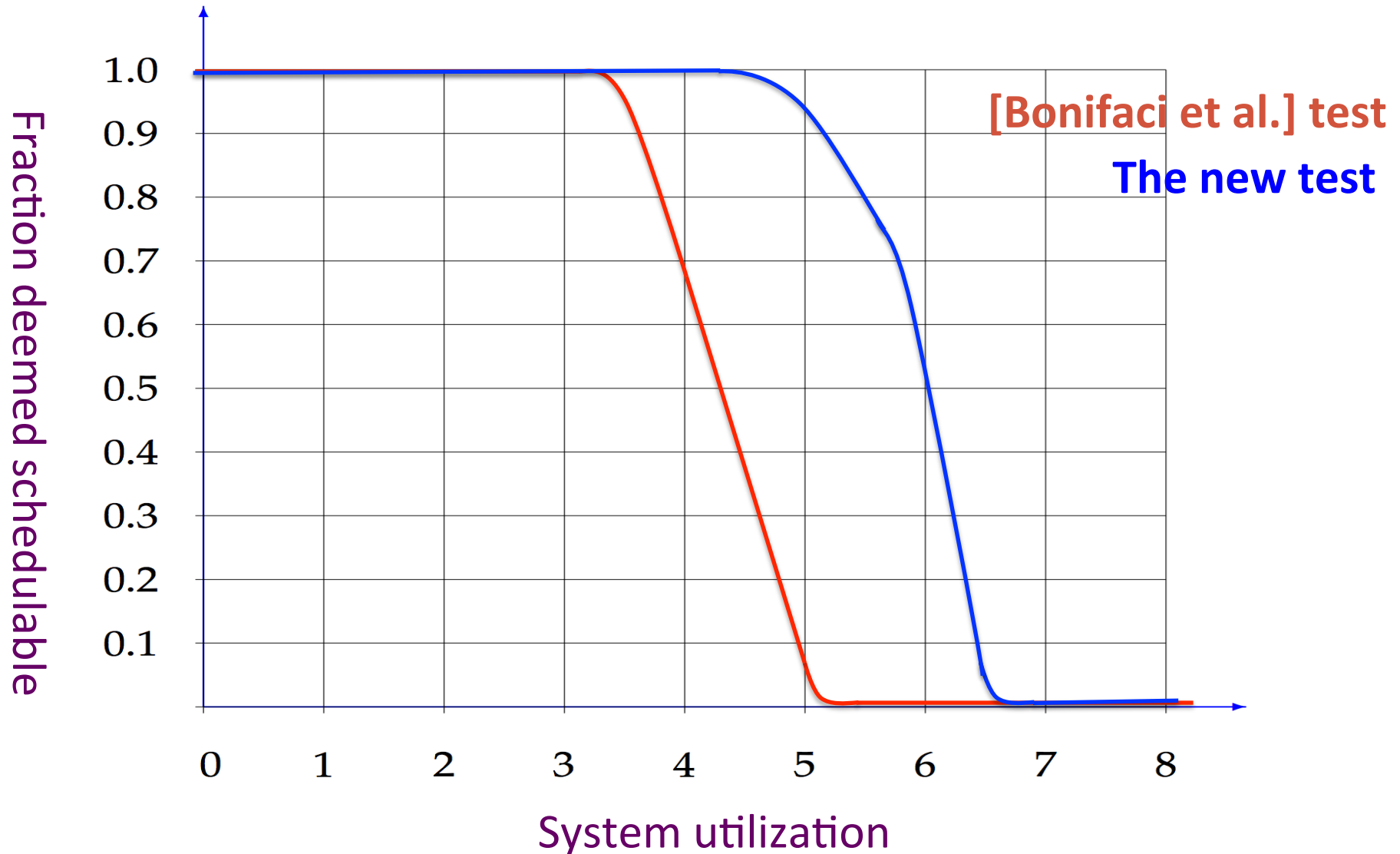
Such an  $s$  is called a **witness** to the GEDF-schedulability of the task system

The schedulability test of [Bonifaci et al.]: Check whether  $s \leftarrow \left( \frac{m}{2m - 1} \right)$  is a witness

My **improved** test: **optimally** determine whether a witness exists

- Is there **any**  $s$ ,  $0 < s < 1$ , that causes this to evaluate to true?

# 8 processors; randomly-generated tasks



# Summary

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EDF is a suitable **global** scheduling algorithm for the multiprocessor scheduling of real-time systems that are **generated by recurrent processes, and exhibit internal parallelism**