Can the RUN scheduling algorithm go beyond periodic task models?

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A little of context

- RUN (Regnier et al, 2011) is capable of
  - optimally scheduling a set of preemptive independent implicit-deadline periodic tasks on a multiprocessor platform
  - presenting low overheads in terms of preemption and migration
- Extensions exist
  - shared resources (Bonato et al, 2014)
  - mixed-criticality (Chishiro et al, 2015)
  - energy-consumption optimisation (Gratia et al, 2015)
  - ....(all these for periodic tasks)
- Sporadic tasks have been addressed sacrificing optimality (Baldovin, 2014)
- Why is it so? Afterall, periodic arrivals describe the worst-case sporadic load

Stated open problem

Can RUN be modified to optimally schedule implicit-deadline independent sporadic tasks on identical multiprocessors?

To what extent?

- does the necessary modification impose overheads?
- can the elegancy of the algorithm be preserved?

A quick background on RUN

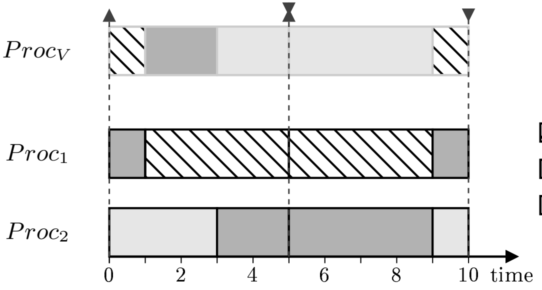
RUN is based on two key principles:

- Duality: knowing when a task should execute is the same as finding out when it does not
  - Schedule the slacks may be easier than dealing with the tasks
  - A task τ_i:(C_i, T_i) has its dual τ_i^*:$(T_i - C_i, T_i)$
- Aggregation: instead of dealing with a large number of small entities, pack them into a few big entities.
  - A big entity (server) can be set to deal with the packed entities (tasks or server)
  - Configure the servers to properly schedule their clients.

Duality

Observation: If duals of periodic tasks can be scheduled on a single processor, multiprocessor and uniprocessor scheduling problems can be made equivalent

Consider $\Gamma = \{\tau_1\colon(4,5), \tau_2\colon(8,10), \tau_3\colon(4,10)\}$
Its dual set is $\Gamma^* = \{\tau_1^*\colon(1,5), \tau_2^*\colon(2,10), \tau_3^*\colon(6,10)\}$



But duality is not enough

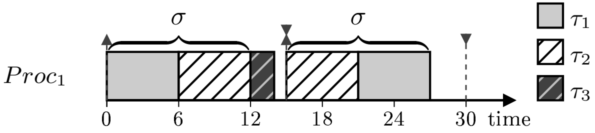
- Low utilisation tasks: $U(\tau) < 1/2 \rightarrow U(\tau^*) > 1/2!$
  - A dual set may reque more processors than its primal
  - Aggregation plays a central role here

- Under-utilised system: $U(\Gamma) \neq \lceil U(\Gamma) \rceil \rightarrow \exists$ slack $\neq$ dual
  - Dummy entities are required to fill up the gaps

Aggregation

- Aggregation mechanism (servers) must provide scheduling capabilities
- Optimality should be preserved

$\Gamma = \{\tau_1\colon(6,15), \tau_2\colon(12,30)\}$ be client set of a server σ, which is concurrently executed with $\tau_3\colon(2,30)$ with $U(\sigma) = U(\Gamma) = 0.8$



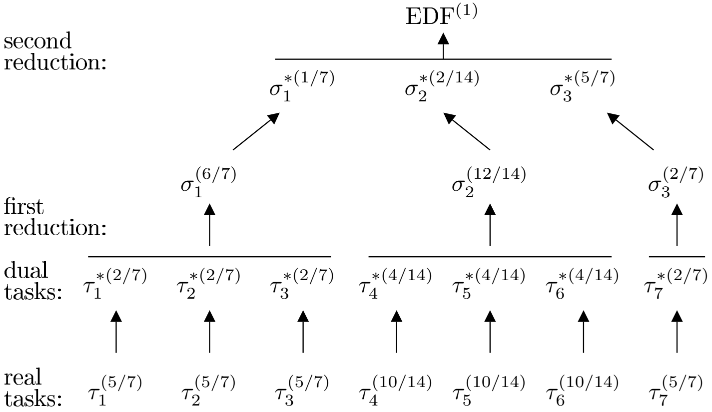
The RUN algorithm

- Off-line phase. Apply aggregation and create duals until reaching systems schedulable on a single processor.

- On-line phase. Schedule one-processor systems via EDF and deduce the scheduling decisions via duality: when an entity σ^* is executing, its dual σ must not execute.

RUN – An illustration

7 tasks with utilisation 5/7 each on 5 processors



RUN – An illustration

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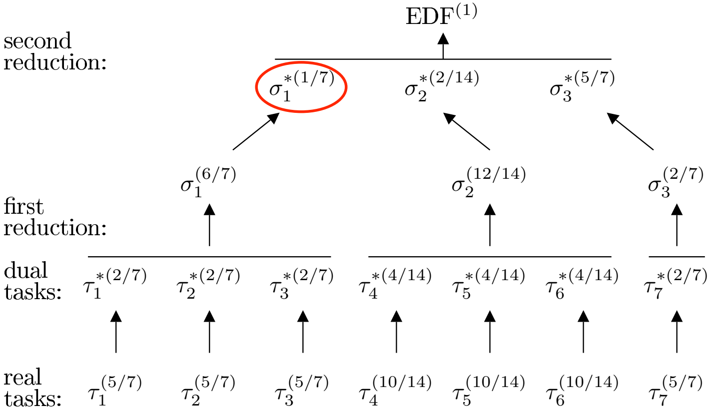

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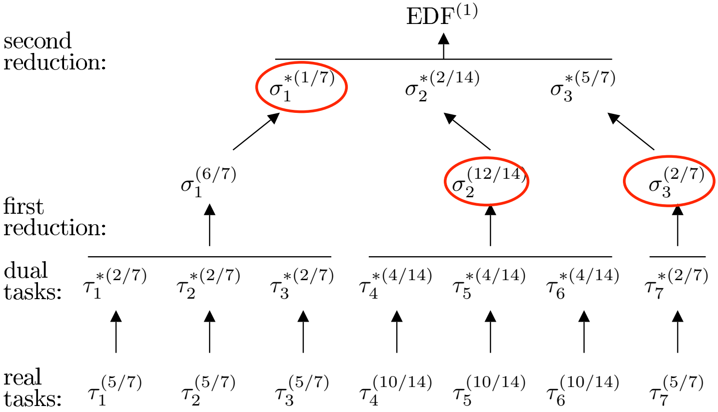

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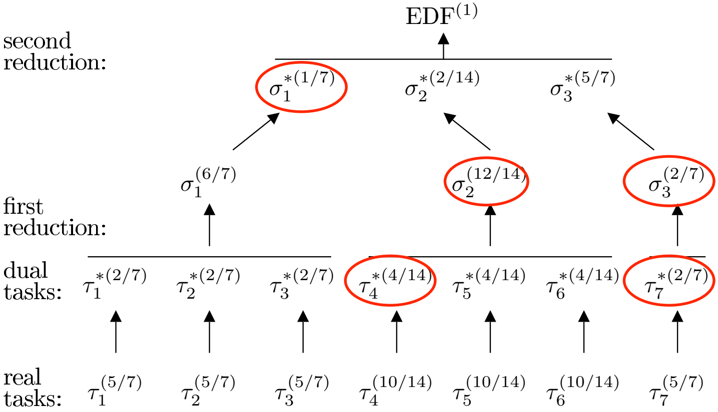

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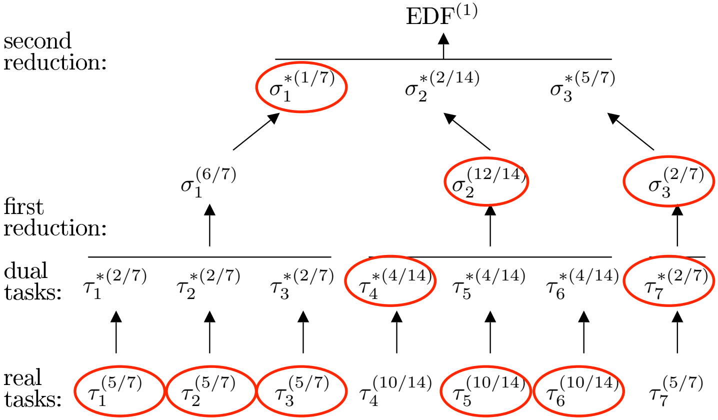
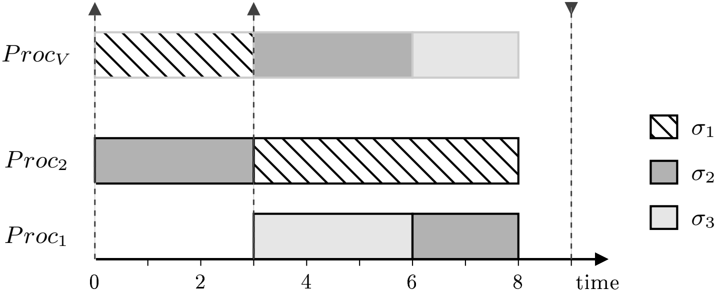


But duality doesn't go well with sporadic loads

- $U(\sigma_1) = U(\sigma_2) = U(\sigma_3) = 2/3$
- All jobs with deadlines at 9
- σ_3 arrives at instant 3, the others at time 0

Preserving duality causes deadline misses



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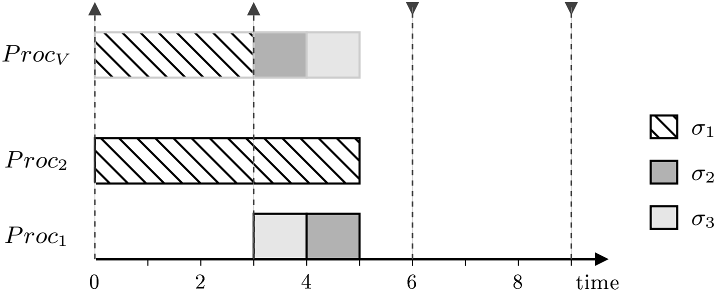
Relaxing duality breaks down the primal-dual complementarity



Final comments

- RUN is characterised by its elegancy, simplicity and low-overhead
- Duality plays a central role
  - But it also makes it difficult for sporadic task models
- Broadening RUN application spectrum is welcome
  - But only if its good characteristics are not compromised

Thanks!

Questions are welcome

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