Configurable Scheduling Problems
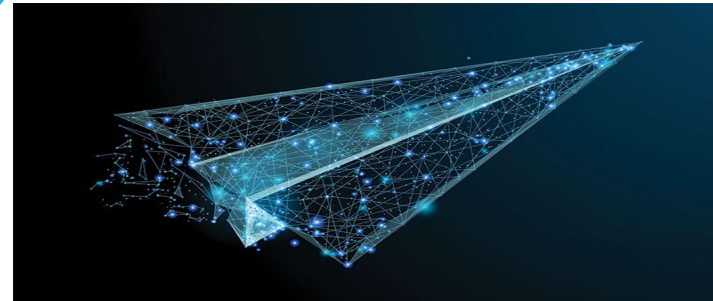
Malte Lochau

Schedulers of Embedded Software Systems

Automotive E/E
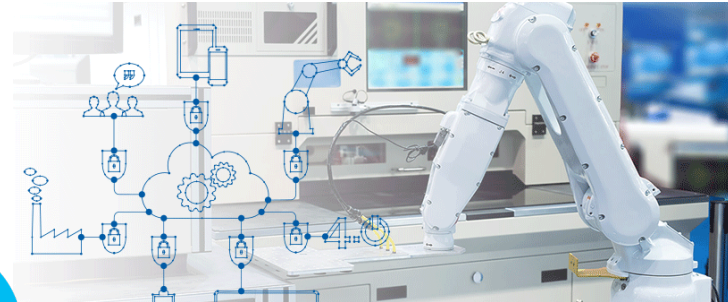
Industrial Automation / Robotics

Medical Devices

Avionics

- Scheduler is central/critical component of modern embedded software systems.
- Scheduler assigns restricted resources to computational tasks.
- Scheduler influences functional feasibility and non-functional properties.
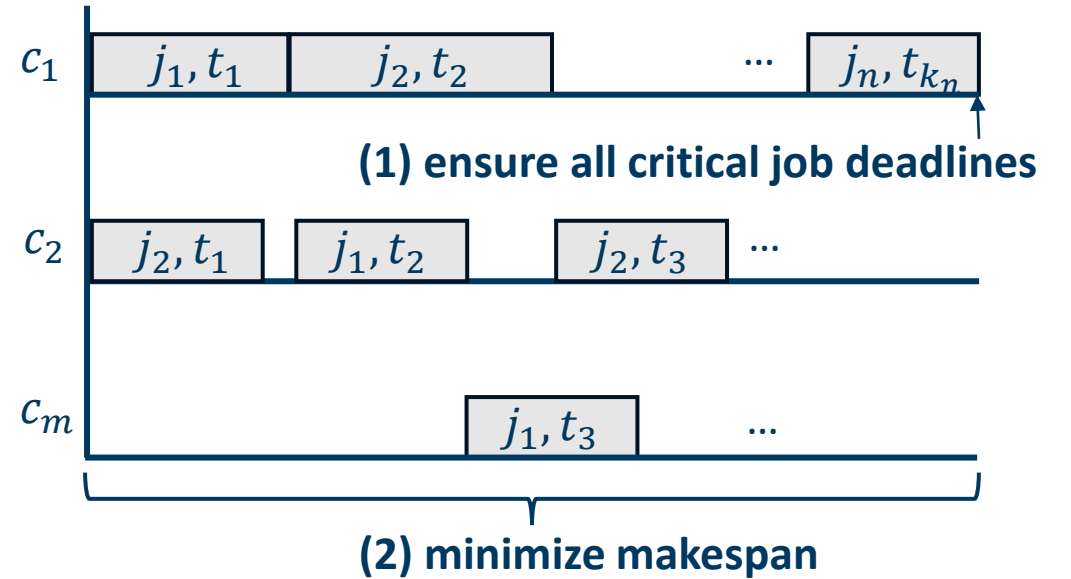
Job Shop Scheduling Problem (JSP)

Problem Instance:

Solution (Schedule):

Cores:

Jobs:

Constraints / Goals:

c_1

j_1

$(\langle \chi_1, t_1 \rangle, \langle \chi_2, t_2 \rangle, \ldots, \langle \chi_{k_1}, t_{k_1} \rangle)$ $\quad t_{D_1}$

the first task of job j_1 requires core χ_1 for t_1 time units.

deadline job j_1

c_2

j_2

$(\langle \chi_1, t_1 \rangle, \langle \chi_2, t_2 \rangle, \ldots, \langle \chi_{k_2}, t_{k_2} \rangle)$ $\quad t_{D_2}$

...

...

...

c_m

j_n

$(\langle \chi_1, t_1 \rangle, \langle \chi_2, t_2 \rangle, \ldots, \langle \chi_{k_n}, t_{k_n} \rangle)$ $\quad t_{D_n}$
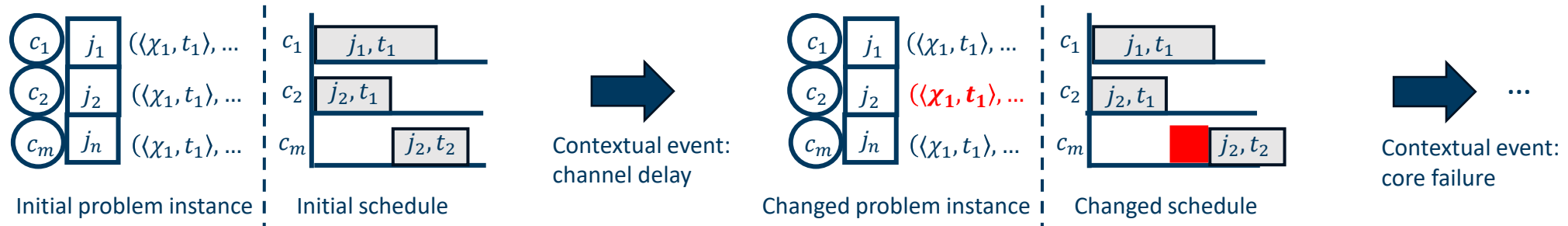
(where $n, m > 100$)

c_1 | j_1, t_1 | j_2, t_2 | ... | j_n, t_{k_n}

(1) ensure all critical job deadlines

c_2 | j_2, t_1 | j_1, t_2 | j_2, t_3 | ...

c_m | j_1, t_3 | ...

(2) minimize makespan

- NP-hard optimization problem (reducible to TSP)
- Canonical exact solution by Mixed Integer Linear Program (MILP) encoding.
- Many problem variations/extensions and heuristic solution approaches.

Static vs. Dynamic Scheduling

Initial problem instance | Initial schedule

Contextual event: channel delay

Changed problem instance | Changed schedule

Contextual event: core failure

Static scheduling strategy: Precomputation of meta-scheduling graph in advance.

+ Unrestricted computational resources available for making optimal scheduling decisions off-line.

- Ineffective scheduling decisions due to lack of knowledge about possible contextual events.

- Complete meta-schedule graph too large for efficient run-time deployment.

Dynamic scheduling strategy: Reactive computation of schedule changes on demand.

+ Precise knowledge about recent run-time context available through run-time monitoring.

- Ineffective scheduling decisions due to limited resources for computing re-scheduling decisions on-line.

- Effective scheduling further requires pro-active re-scheduling by context prediction.

Re-Configurable Scheduling Problems

Extended Context-Feature Model

Configurable Scheduling Problem Instance

Re-Configurable Meta-Scheduler Model
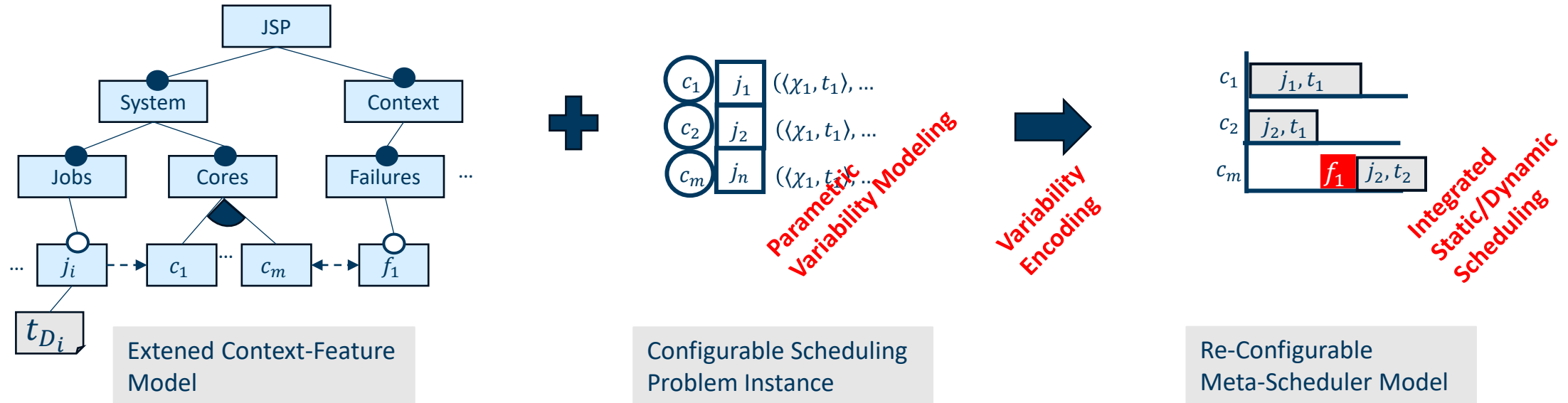
- Apply variability encoding and family-based analysis technique to precompute meta-scheduler model.

- Reduce size of meta-scheduler graph by symbolic representation and superimposition/merging of schedules.

Thank You!

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