Monotonicity and Run-Time Scheduling

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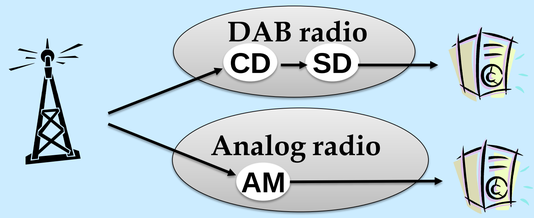
1. Context

Stream processing applications

- Multi-processor system
- End-to-end performance requirements

Multiple streams processed concurrently

- User starts and stops streams
- Not all streams completely characterised → Budget schedulers



2. Problem

Task graphs

- Can be cyclic
- Use blocking writes (wait on sufficient space)

Dataflow is natural model

- Suff. conditions for functional determinism
- Known how to model static-order schedules
- *Unknown* how to model run-time scheduling

3. Contribution

Dataflow model of an individual application scheduled by run-time schedulers

- Functionally deterministic task graph
- Budget schedulers

Conservative simulation of individual application

- Prerequisite for conservative analysis and synthesis

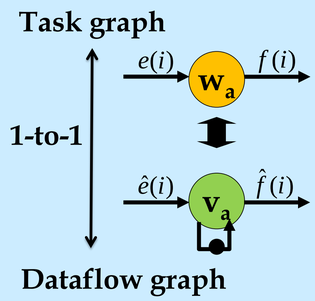
4. Approach

Task graph

- One-to-one relation with functionally deterministic dataflow graph

Functionally deterministic dataflow

- Temporally monotonic, smaller firing duration cannot lead to later token arrivals



Conservative, given required 1-to-1 relation, if:

$$e(i) \le \hat{e}(i) \Rightarrow f(i) \le \hat{f}(i)$$

5. Including Effects of Budget Schedulers

← *Worst-case enabling time*

Response time: $\hat{f}(i) = \hat{e}(i) + x(i) + (P - B)\left\lceil \frac{x(i)}{B} \right\rceil$

Contribution: $\hat{f}(i) = \max(\hat{e}(i) + P - B, \hat{f}(i-1)) + P\frac{x(i)}{B}$

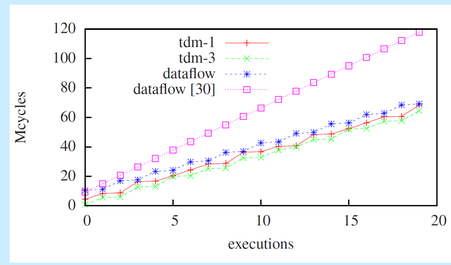
Improved model

- Latency and rate parameters instead of response time
- Captures multiple executions in a single budget
- Valid for sequences of execution times

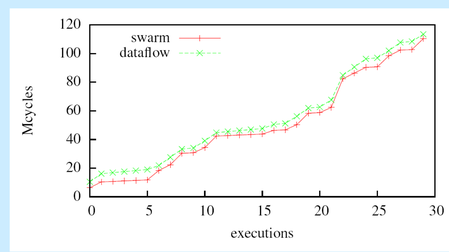
6. Accuracy and expressivity

Comparing cycle-true and timed dataflow simulation

Sequence of execution times



Data-dependent production quanta



7. Conclusion

Accurate conservative dataflow model is proposed

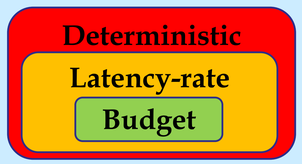
- Includes effects of run-time scheduling
- Has monotonic temporal behavior
- No scheduling anomalies in *model*

Model requires

- Functionally deterministic task graph
- Application of budget schedulers

Monotonicity (and its generalization: linearity) is basis for my other work that computes budget and buffer sizes satisfying latency and throughput constraints with variable-rate phased dataflow graphs

Scheduler classes:



Application classes: