Scenario-Aware Data Flow

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1. Problem Statement

Expressive power ↔ Analyzability

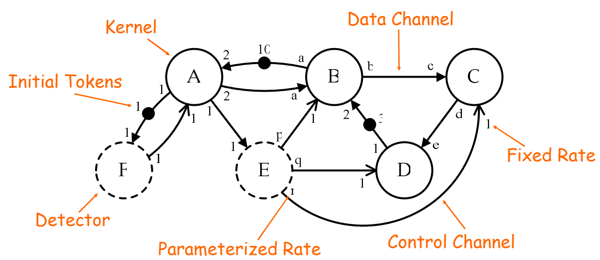
Need for analyzable model of computation that can express dynamism in modern streaming applications

2. Scenario = Mode of Operation

Different scenarios may imply

- Activation/deactivation of tasks/channels
- Different amounts of data to consume/produce
- Different (but correlated) execution times for tasks

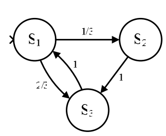
3. Scenario-Aware Data Flow



- Kernels model data processing part of application
- Detectors model control part of application

Task	Scenario	Execution Time	Probability
A	Default	2	1/2
		2.1	1/2
B	Scenario1	3	1/5
		2.8	4/5
	Scenario2	4	1
C	Scenario1	1	1/2
		1.2	1/2
	Scenairo2	3	1
D	Scenario1	4	1
	Scenario2	2.5	1
E	Scenario1	0	1
	Scenario2	0	1
F	Default	0	1

Rate	Scenario1	Scenario2
a	2	1
b	3	2
c	1	1
d	2	1
e	3	1
p	1	2
q	3	4
r	2	4



State	Scenario
S_1	Scenario1
S_2	Scenario2
S_3	Scenario2

Semantics

1. Determine scenario (rates & exec time distribution)
   - Detectors use Markov chain
   - Kernels receive scenario on control channel
2. Wait for availability of tokens on all (data) inputs
3. Execute consuming time according to distribution
4. Consume and produce tokens

4. Performance Analysis

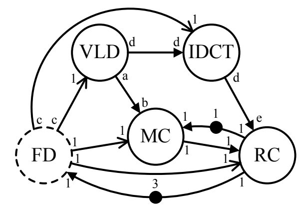
Transform to enable reuse of existing techniques

Transformation to discrete-time Markov chain allows analysis of any average-case and worst case metrics

Transformation to a set of Synchronous Data Flows allows analysis of certain worst-case metrics

6. Pipelined MPEG-4 SP Decoder

- VLD and IDCT fire per macro-block
- MC and RC fire per frame
- FD models control part of VLD detecting frame type
- Image size = 176x144



I-frame

- 99 macro-blocks
- No motion vectors

P0-frame (still video)

- Copy previous frame

Px-frame

- x macro-blocks
- x motion vectors from VLD to MC
- Previous frame from RC to MC

Rate	I	P_0	P_x
a	0	0	1
b	0	0	x
c	99	1	x
d	1	0	1
e	99	0	x

x = {30, 40, 50 ,60, 70, 80, 99}

Prototype tool flow based on POOSL modeling style

Task	Throughput
VLD	0.063 ± 0.036%
IDCT	0.063 ± 0.036%
MC	0.00106 ± 0.190%
RC	0.00106 ± 0.191%

Task	Maximum Latency	Average Latency	Variance in Latency
VLD	710	15.99 ± 0.031%	75.38 ± 0.18%
IDCT	698	15.99 ± 0.031%	56.45 ± 4.99%
MC	3305	940.3 ± 0.017%	$2.4 \cdot 10^5$ ± 3.46%
RC	2216	940.3 ± 0.017%	$1.5 \cdot 10^5$ ± 4.99%

Channel	Maximum Occupancy	Time-Average Occupancy	Time-Variance in Occupancy
VLD and IDCT	9	1.910 ± 0.064%	0.528 ± 1.99%
IDCT and RC	154	60.19 ± 0.178%	671.8 ± 4.55%
VLD and MC	133	34.73 ± 0.517%	698.4 ± 4.39%
MC and RC	1	0.577 ± 0.561%	0.244 ± 3.27%

6. Contributions

Analyzable model of computation that can express several forms of dynamism in streaming applications

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