Technische Universiteit Eindhoven University of Technology

Throughput-Buffering Trade-Off Analysis for Scenario-Aware Dataflow Models

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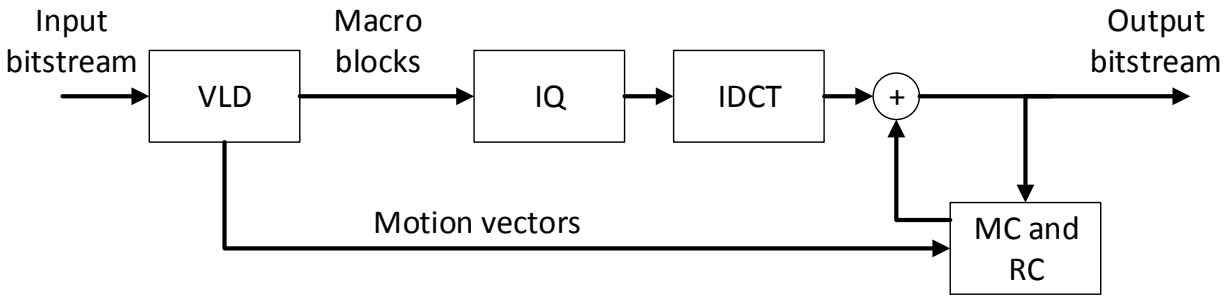
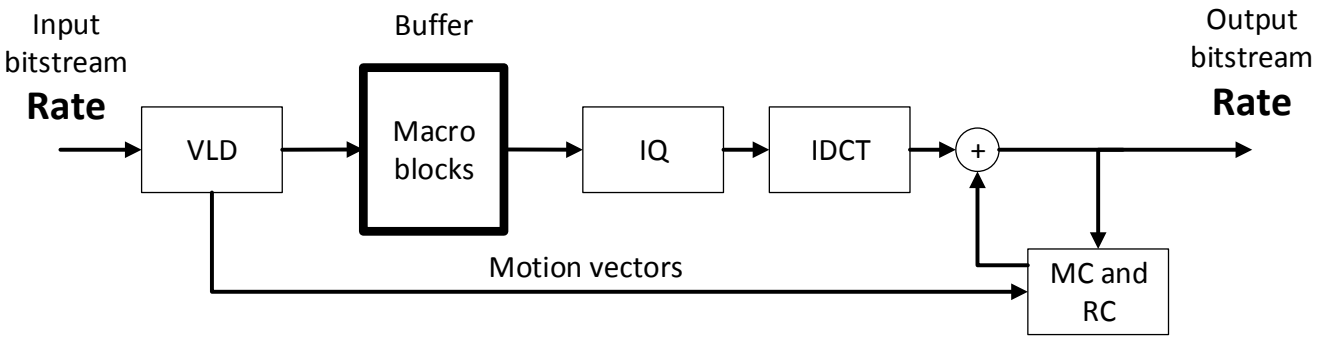
Where innovation starts

Real-Time Streaming Applications



H.263 decoder

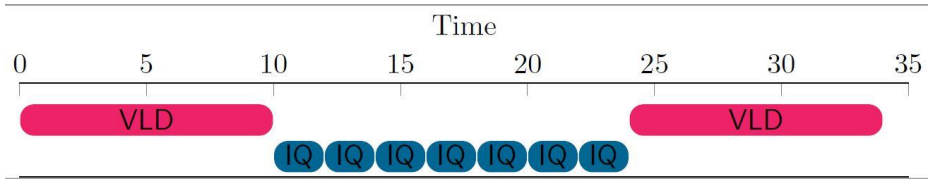
Throughput and Buffers



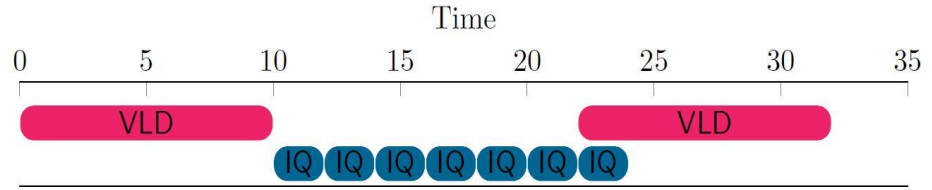
H.263 decoder

Throughput is the maximum data rate the application can handle.

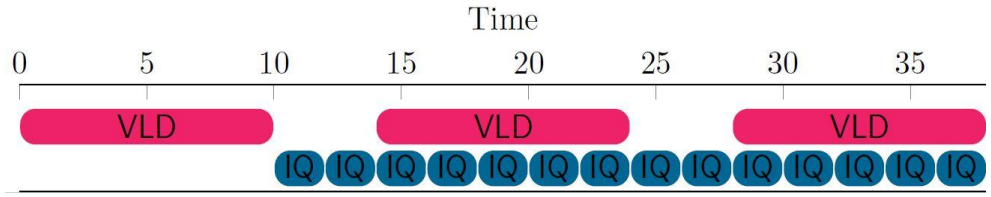
Throughput-Buffering Trade-Offs



Buffer size = 7
Throughput = 1/24

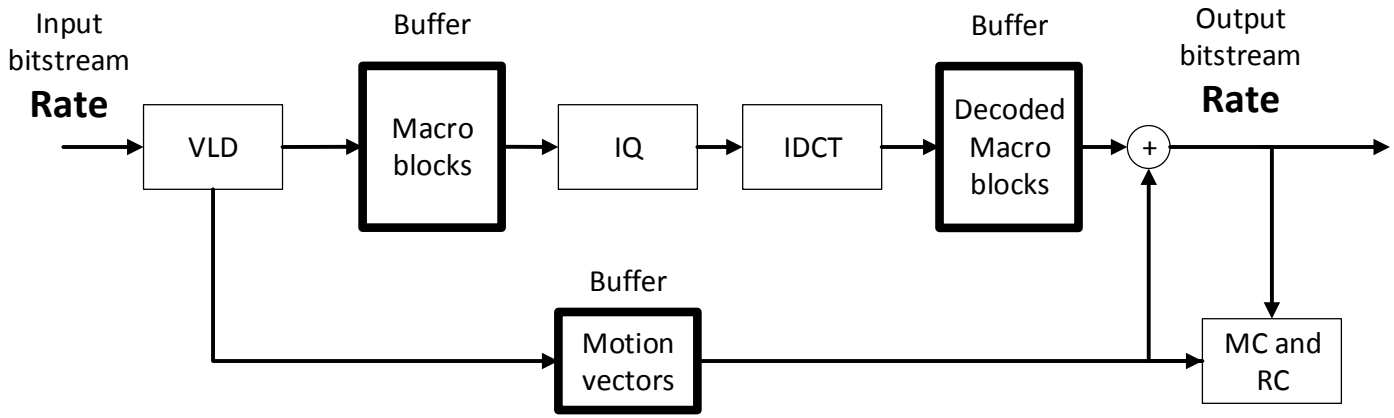


Buffer size = 8
Throughput = 1/22



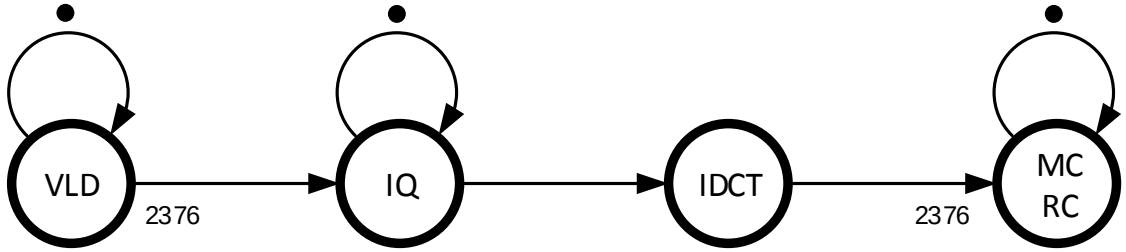
Buffer size = 12
Throughput = 1/14

Throughput-Buffering Problem



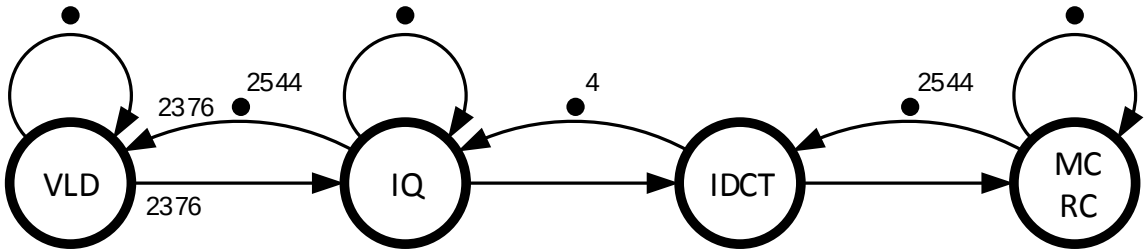
Finding the minimum total buffer size for a given throughput requirement

Synchronous Dataflow (SDF)



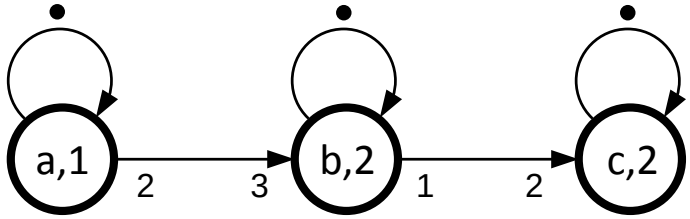
SDF model of the H.263 decoder

Modelling Limited Capacity Buffers



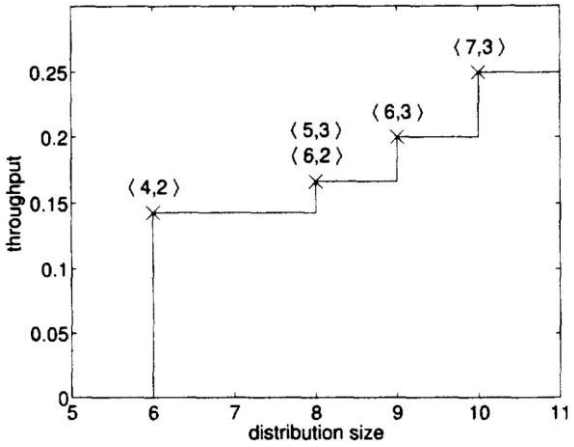
SDF model of the H.263 decoder

Design Space Exploration



Key concepts:

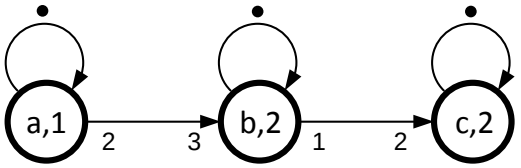
- **Monotonicity**
- **Critical buffers**



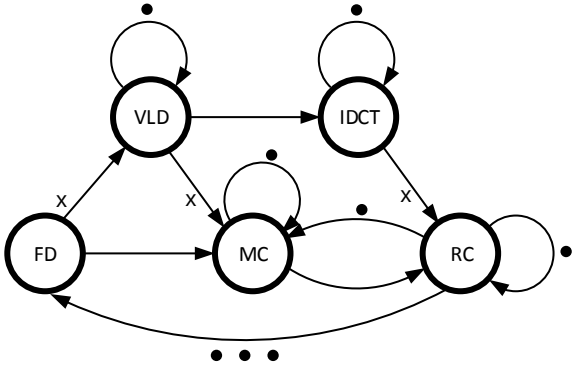
Pareto points

Synchronous dataflow is a pessimistic abstraction for dynamic applications.

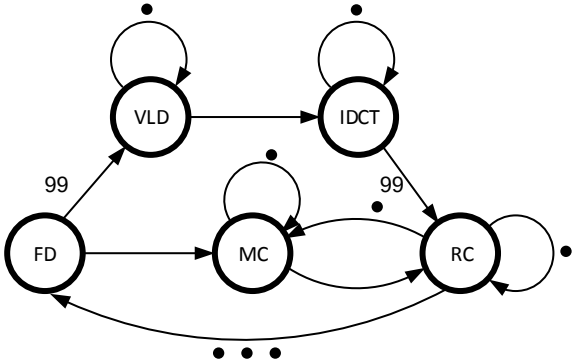
Constant actor rates
Constant execution times



Scenario-Aware Dataflow (SADF)



P-frame scenario

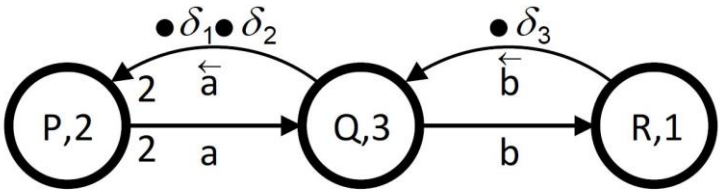


I-frame scenario

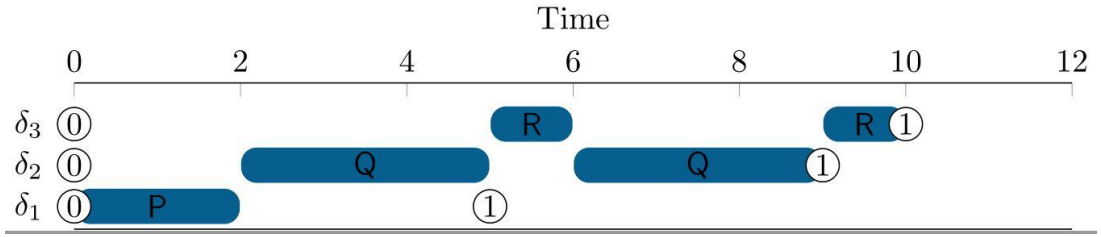
SADF model of an MPEG-4 decoder

We provide a throughput buffering trade-off analysis for scenario-aware dataflow models using a guided design space exploration

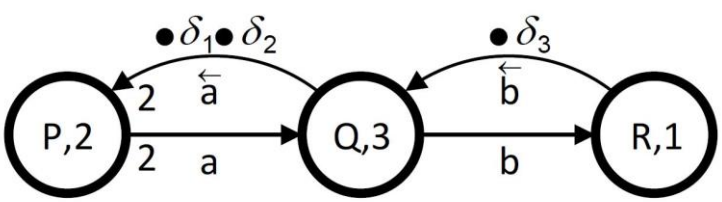
Scenario-Aware Dataflow



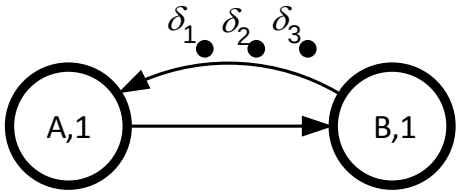
s_1



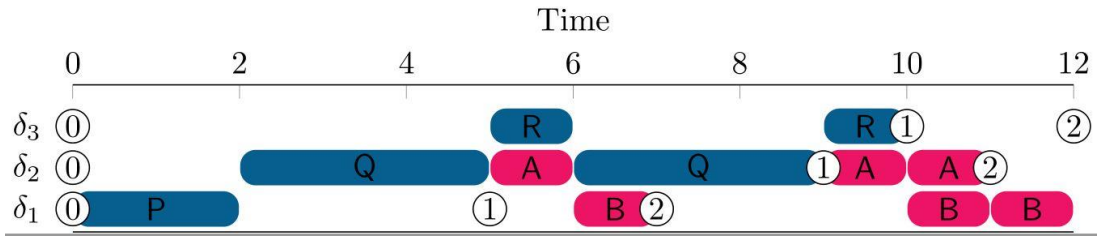
Scenario-Aware Dataflow



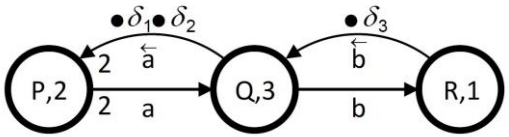
s_1

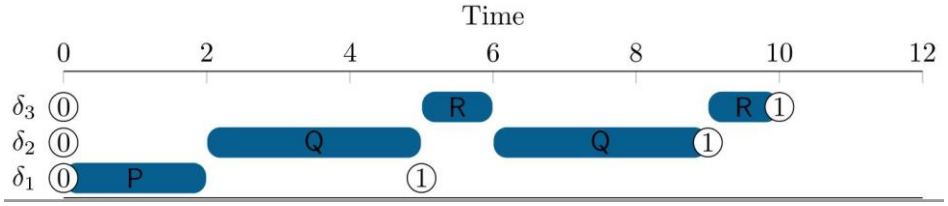


s_2



(max,+) Representation





$$\begin{bmatrix} t'_{\delta_1} \\ t'_{\delta_2} \\ t'_{\delta_3} \end{bmatrix} = \begin{bmatrix} 5 & 5 & 3 \\ 9 & 9 & 7 \\ 10 & 10 & 8 \end{bmatrix} \otimes \begin{bmatrix} t_{\delta_1} \\ t_{\delta_2} \\ t_{\delta_3} \end{bmatrix}$$

$$\begin{bmatrix} 5 \\ 7 \\ 10 \end{bmatrix} = \begin{bmatrix} 5 & 5 & 3 \\ 9 & 9 & 7 \\ 10 & 10 & 8 \end{bmatrix} \otimes \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

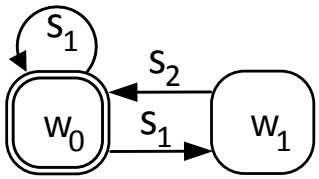
SADF Throughput Analysis

$$\begin{bmatrix} t'_{\delta_1} \\ t'_{\delta_2} \\ t'_{\delta_3} \end{bmatrix} = \begin{bmatrix} 5 & 5 & 3 \\ 9 & 9 & 7 \\ 10 & 10 & 8 \end{bmatrix} \otimes \begin{bmatrix} t_{\delta_1} \\ t_{\delta_2} \\ t_{\delta_3} \end{bmatrix}$$

S_1

$$\begin{bmatrix} t'_{\delta_1} \\ t'_{\delta_2} \\ t'_{\delta_3} \end{bmatrix} = \begin{bmatrix} -\infty & 0 & -\infty \\ -\infty & -\infty & 0 \\ 2 & -\infty & -\infty \end{bmatrix} \otimes \begin{bmatrix} t_{\delta_1} \\ t_{\delta_2} \\ t_{\delta_3} \end{bmatrix}$$

S_2

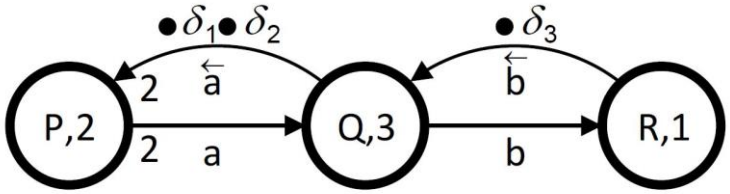


(max,+) automaton

maximum cycle mean analysis

- throughput
- critical cycles

Extended (max,+) Representation



$$\begin{bmatrix} t'_{\delta_1} \\ t'_{\delta_2} \\ t'_{\delta_3} \end{bmatrix} = \begin{bmatrix} 5,\{a\} & 5,\{a\} & 3,\{b\} \\ 9,\{a,b\} & 9,\{a,b\} & 7,\{b\} \\ 10,\{a,b\} & 10,\{a,b\} & 8,\{b\} \end{bmatrix} \otimes \begin{bmatrix} t_{\delta_1} \\ t_{\delta_2} \\ t_{\delta_3} \end{bmatrix}$$

Throughput-Buffering Trade-Off Analysis Results

	WLAN	MP3 Decoder	SUSAN	Figure 3	H.263 Decoder	Modem	Sample Rate	Satellite
nrBuffers	8	46	4	2	3	35	10	48
nrParetoPoints	2	3	7	6	36	3	3	2
nrMinDist	2	3	7	6	146	3	3	2
nrVisitedDist	3	32	12	10	193	7	5	6
maxThr($\times 10^{-4}$)	2.5	0.0017	0.066	830	0.03	620	10	7.5
distSizeMaxThr	10	179	20	21	1224	72	44	1586
minPosThr($\times 10^{-4}$)	2.4	0.0016	0.012	5.80	0.015	320	9.2	9.4
distSizeMinThr	8	172	8	14	1189	70	42	1588
RunTime Alg. 2	3ms	4559ms	11ms	19ms	1296s	74ms	545ms	419s
RunTime [15]	n/a	n/a	n/a	n/a	349ms	1ms	8ms	514ms

Questions?