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On Channel Restructuring for Complete FIFO Recovery

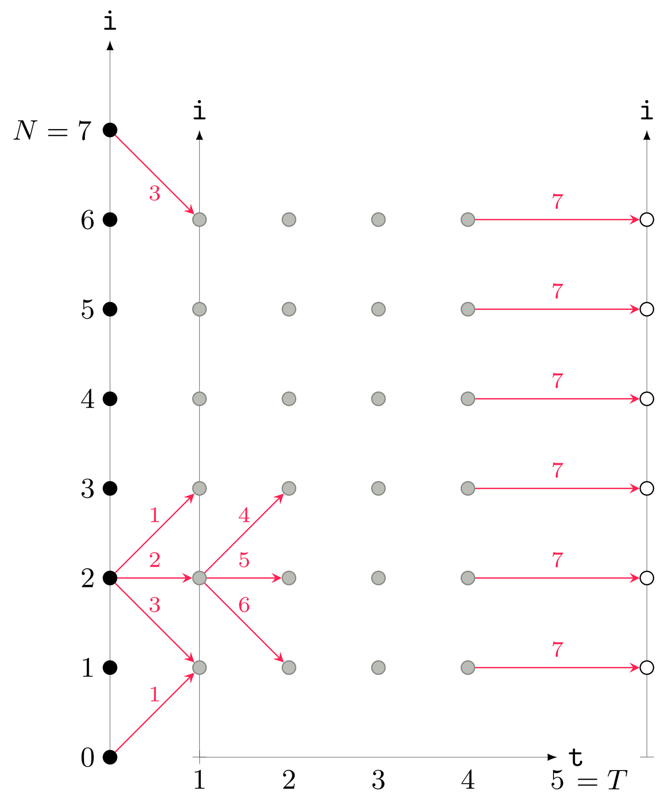
Focus: **Dataflow models** as an intermediate representation for **High-Level Synthesis**

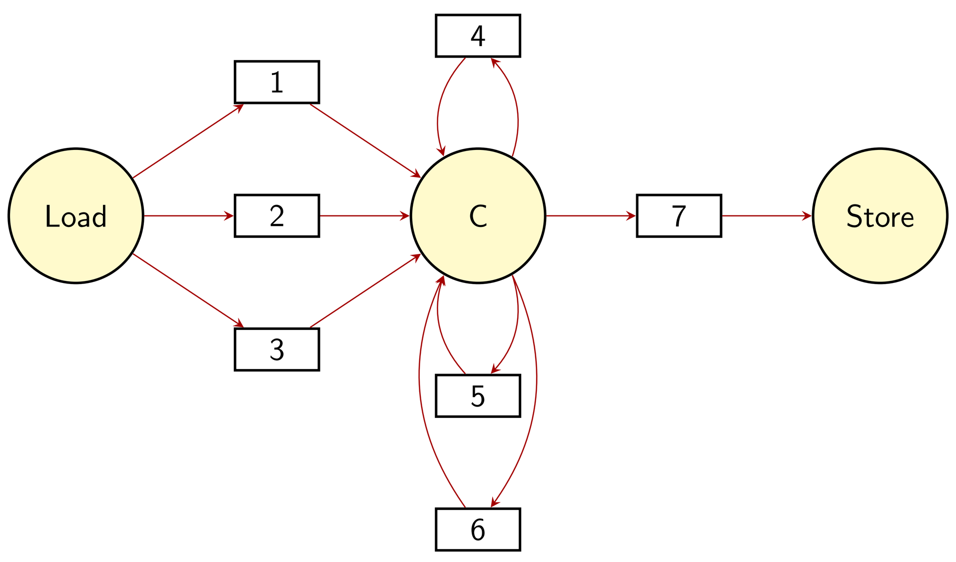
Challenge: Recover FIFO channels **after code restructuring**

Contributions: **HLS algorithm** for channel restructuring + **Dataflow model** to ensure completeness

1) Polyhedral Process Networks

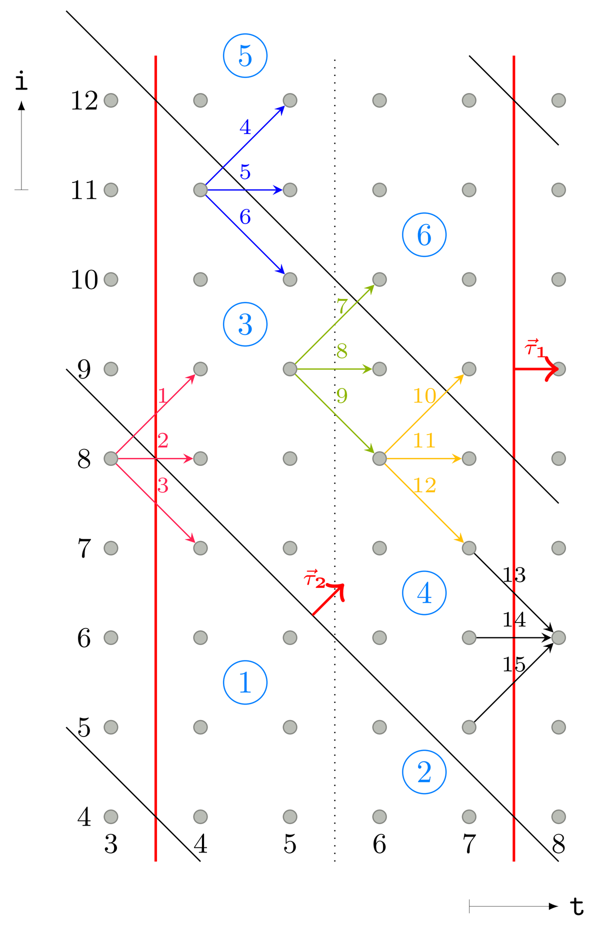
for $i := 0$ **to** $N+1$
• load($a[0,i]$);
for $t := 1$ **to** T
  for $i := 1$ **to** N
  • $a[t,i] :=$
    $a[t-1,i-1] + a[t-1,i] + a[t-1,i+1]$;
for $i := 1$ **to** N
∘ store($a[T,i]$);

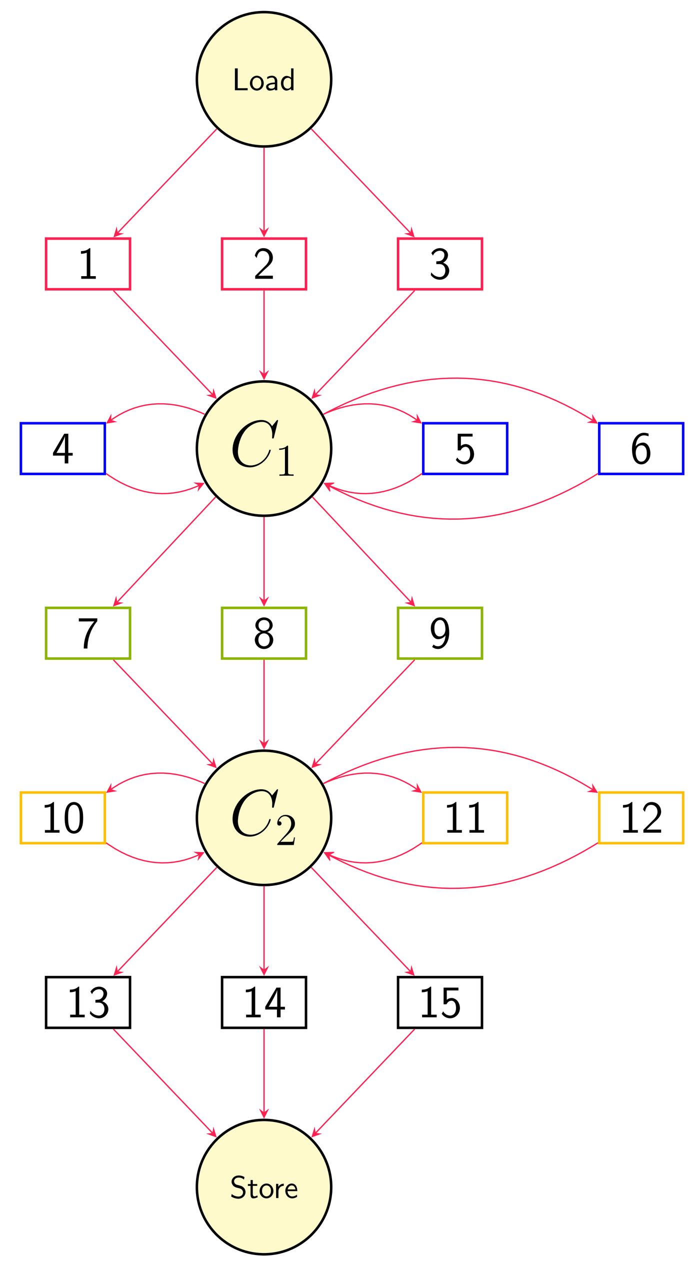




Challenge addressed: Channel synthesis

2) Data-aware Process Networks

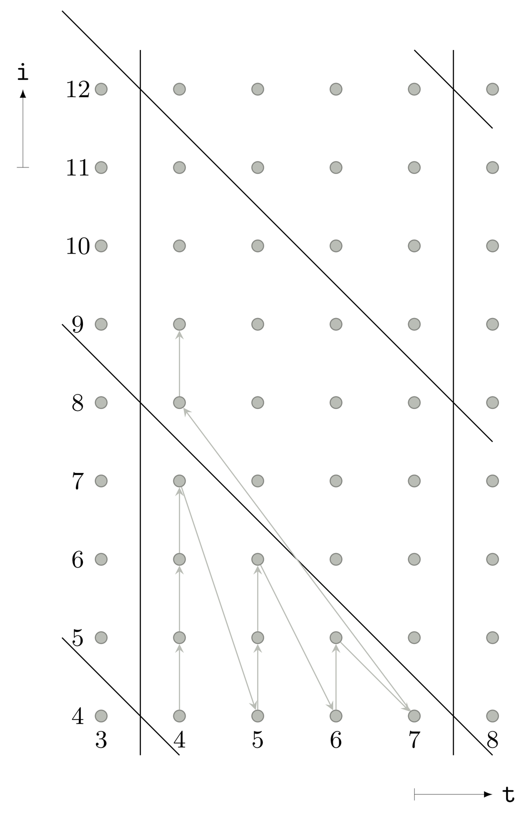


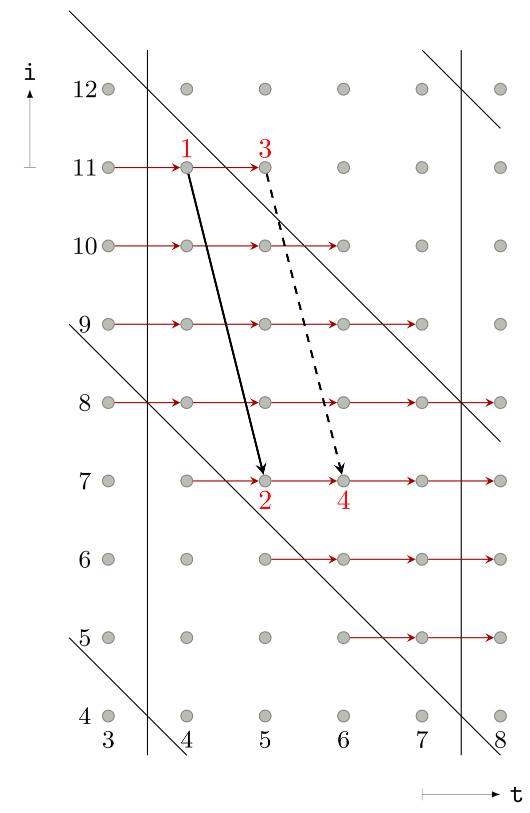


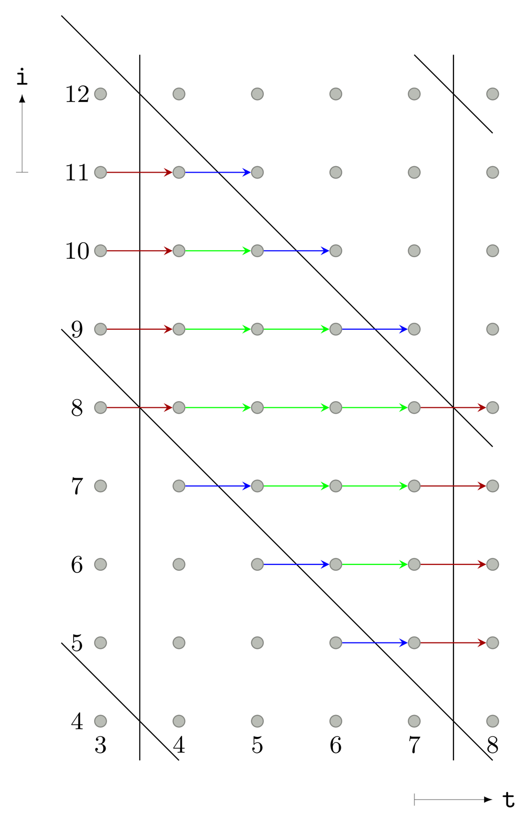
Features:

- PPN partitioning based on **loop tiling**
- Incoming dependences (1,2,3) are **loaded**
- Outgoing dependences (13,14,15) are **stored**
- Internal dependences (4 to 12) are solved through **local channels**

3) Our FIFO Recovery Algorithm







SPLIT($\rightarrow_c$,θ_P,θ_C)
  for $k := 1$ **to** n
    ADD($\rightarrow_c \cap \{(x,y),\ \theta_P(x) \ll^k \theta_C(y)\}$);
  ADD($\rightarrow_c \cap \{(x,y),\ \theta_P(x) \approx^n \theta_C(y)\}$);

FIFOIZE($(\mathcal{P},\mathcal{C})$)
  for each channel c
    $\{\rightarrow_c^1, \ldots, \rightarrow_c^{n+1}\}$:= SPLIT($\rightarrow_c$,θ_{P_c},θ_{C_c});
    if fifo($\rightarrow_c^k, \prec_{\theta_{P_c}}, \prec_{\theta_{C_c}}$) $\forall k$
      REMOVE($\rightarrow_c$);
      INSERT($\rightarrow_c^k$) $\forall k$;

Theorem: FIFO recovery is complete on our DPN model

4) Experimental Results

Kernel	PPN	PPN with tiling			DPN		
	#fifo	#rem	#rec	%	#rem	#rec	%
trmm	2	1	1	100	1	1	100
gemm	2	1	1	100	1	1	100
syrk	2	1	1	100	1	1	100
symm	6	3	3	100	5	1	100
gemver	4	2	2	100	3	1	100
gesummv	6	6	0	100	6	0	100
syr2k	2	1	1	100	1	1	100
lu	3	0	3	100	0	3	100
trisolv	4	3	1	100	3	1	100
cholesky	6	3	3	100	4	2	100
doitgen	3	2	1	100	2	1	100
bicg	4	2	2	100	2	2	100
mvt	2	0	2	100	0	2	100
3mm	6	2	2	50	3	3	100
2mm	4	2	1	50	2	2	100
covariance	7	4	2	66	4	3	100
correlation	13	9	3	75	9	4	100
fdtd-2d	12	0	6	50	5	7	100
jacobi-2d	10	0	2	20	2	8	100
seidel-2d	9	0	3	33	2	7	100
jacobi-1d	6	1	5	100	2	4	100
heat-3d	20	0	0	0	2	18	100

Experimental setup:

- We have run our algorithm on the kernels of **PolyBench/C v3.2**
- We have checked the completeness of our algorithm on PPN with DPN partitioning (**DPN**)
- We have studied the behavior of our algorithm on general PPN, without DPN partitioning (**PPN with tiling**).

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