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On Channel Restructuring for Complete FIFO Recovery

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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**

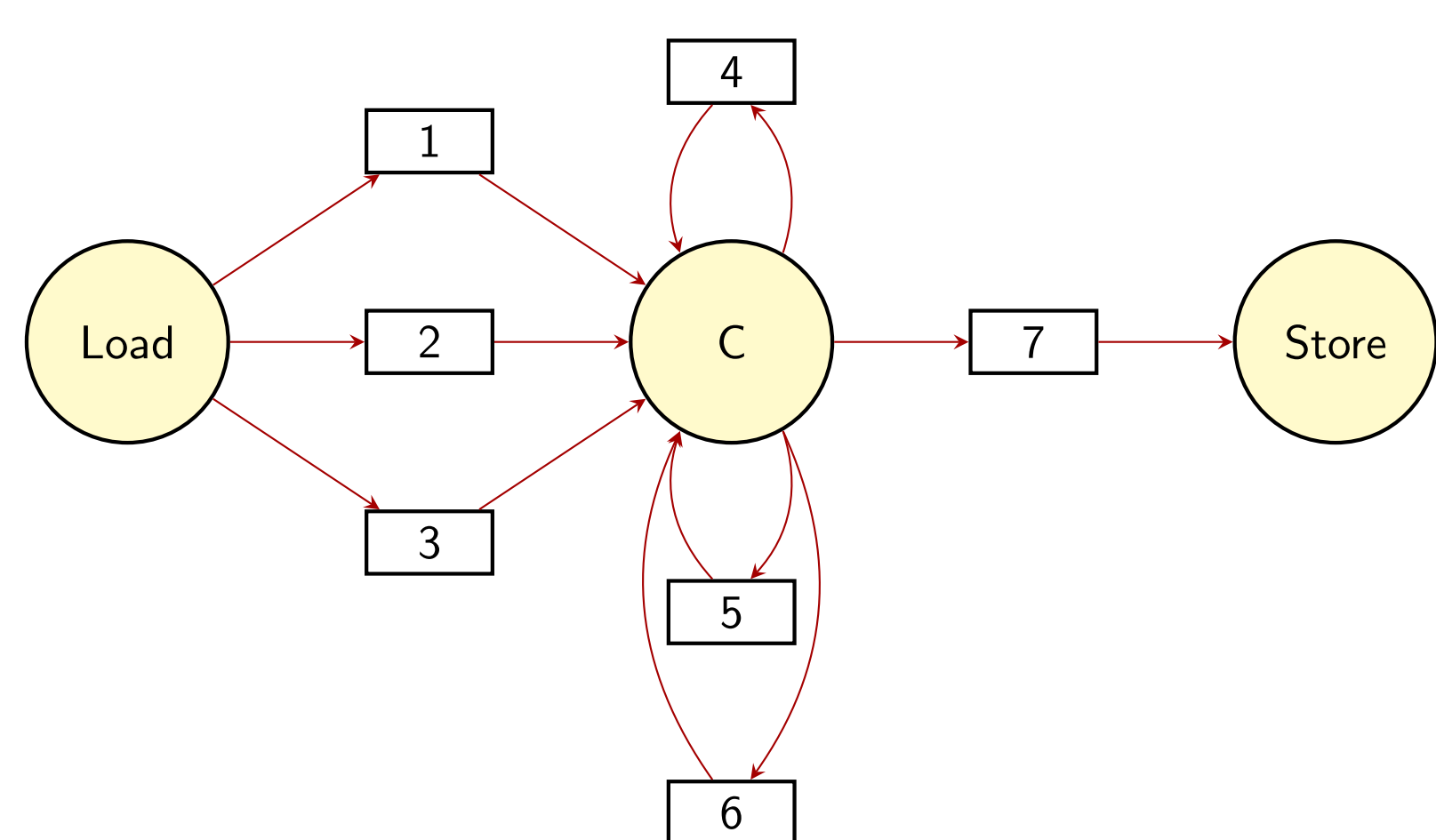
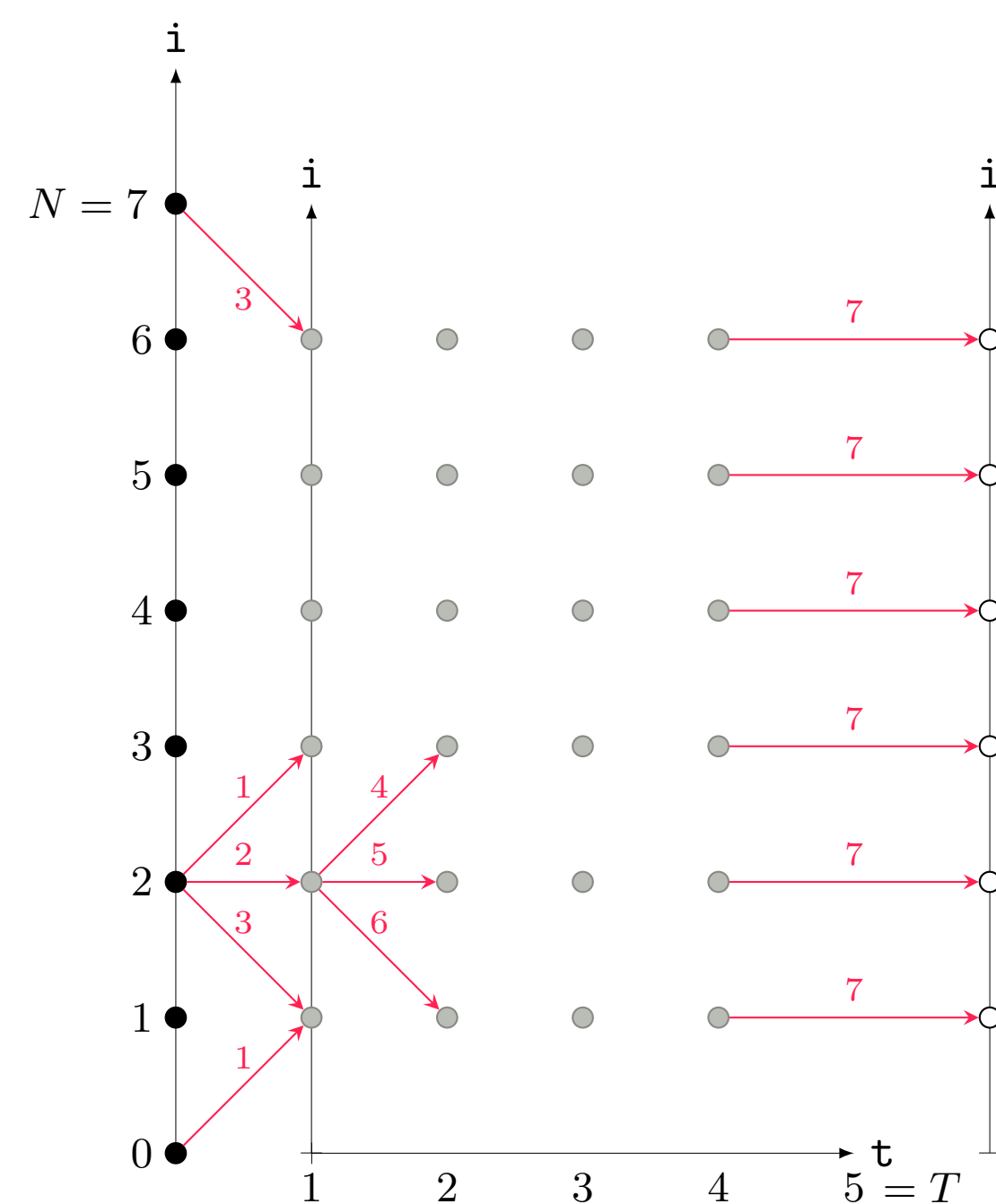
Contributions: **HLS algorithm** for channel restructuring + **Dataflow model** to ensure completeness

1) Polyhedral Process Networks

```

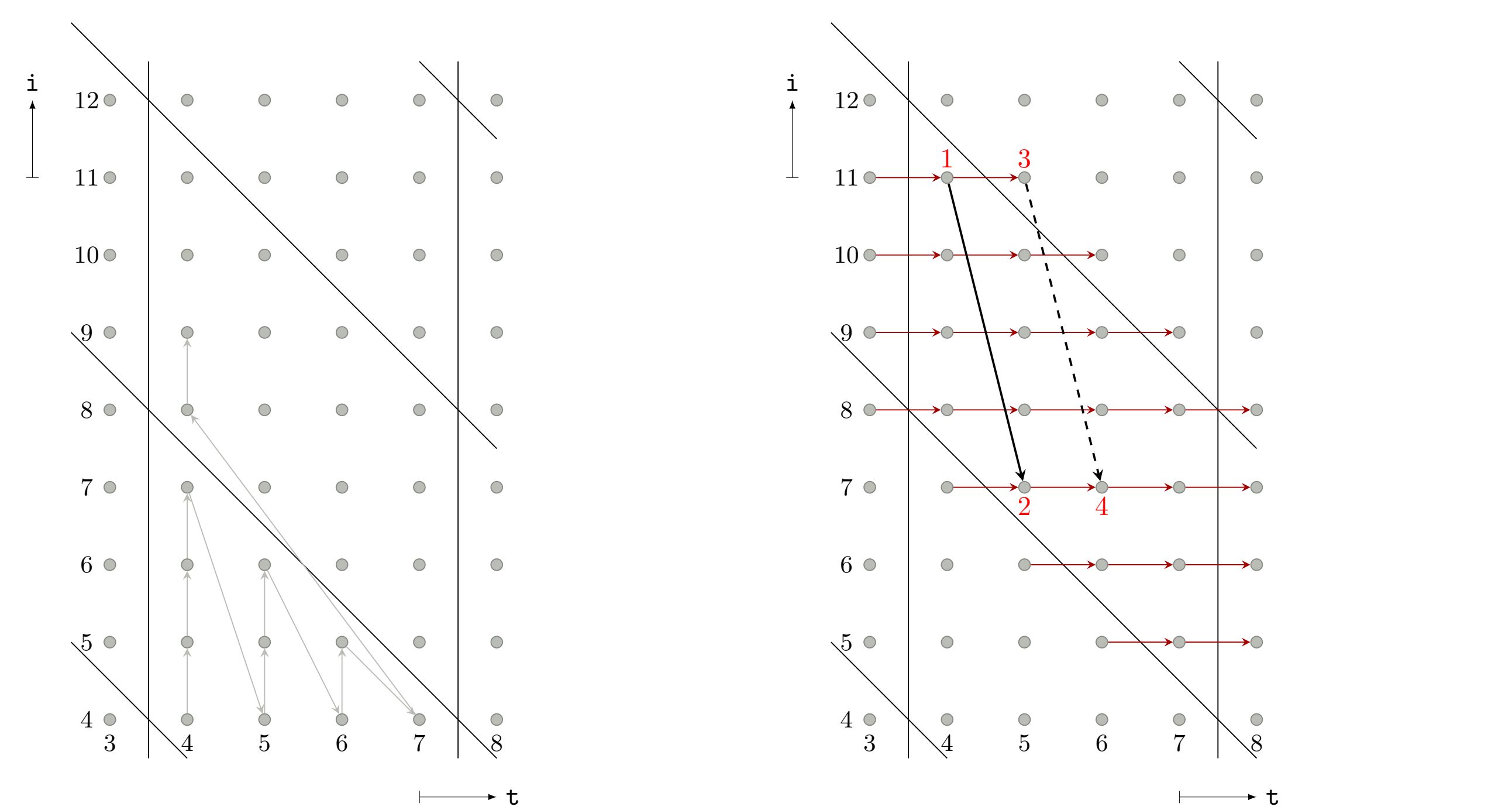
for i := 0 to N + 1
• load(a[0, i]);
for t := 1 to T
  for i := 1 to N
    a[t, i] :=
      a[t - 1, i - 1] + a[t - 1, i] + a[t - 1, i + 1];
  for i := 1 to N
    store(a[T, i]);

```



Challenge addressed:
Channel synthesis

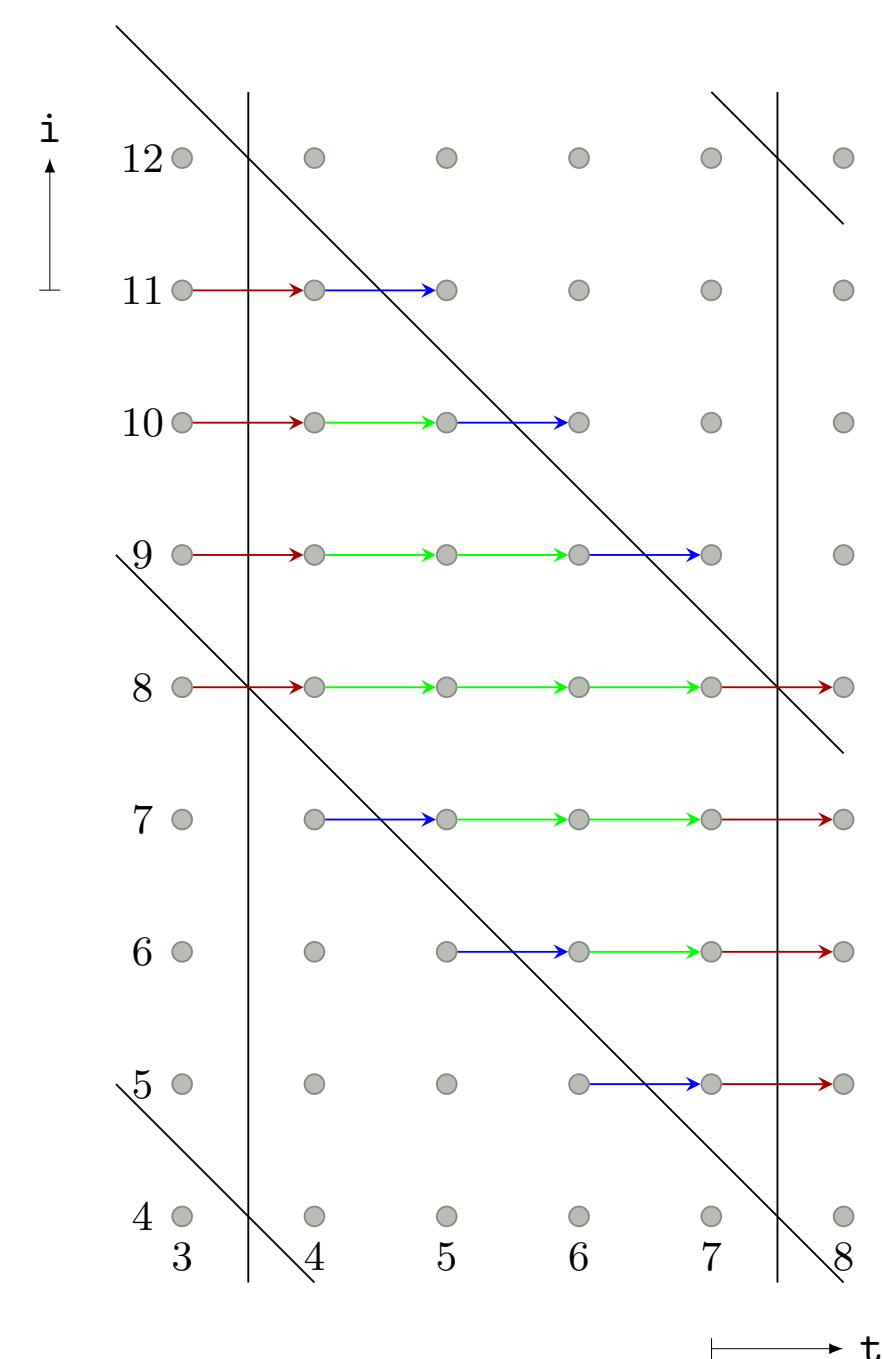
3) Our FIFO Recovery Algorithm



```

1 SPLIT( $\rightarrow_c, \theta_P, \theta_C$ )
2 for k := 1 to n
3   ADD( $\rightarrow_c \cap \{(x, y), \theta_P(x) \ll^k \theta_C(y)\}$ );
4   ADD( $\rightarrow_c \cap \{(x, y), \theta_P(x) \approx^n \theta_C(y)\}$ );
5 FIFOIZE( $(\mathcal{P}, \mathcal{C})$ )
6 for each channel c
7    $\{\rightarrow_c^1, \dots, \rightarrow_c^{n+1}\} := \text{SPLIT}(\rightarrow_c, \theta_{P_c}, \theta_{C_c})$ ;
8   if  $\text{fifo}(\rightarrow_c^k, \prec_{\theta_{P_c}}, \prec_{\theta_{C_c}}) \forall k$ 
9     REMOVE( $\rightarrow_c$ );
10  INSERT( $\rightarrow_c^k$ )  $\forall k$ ;

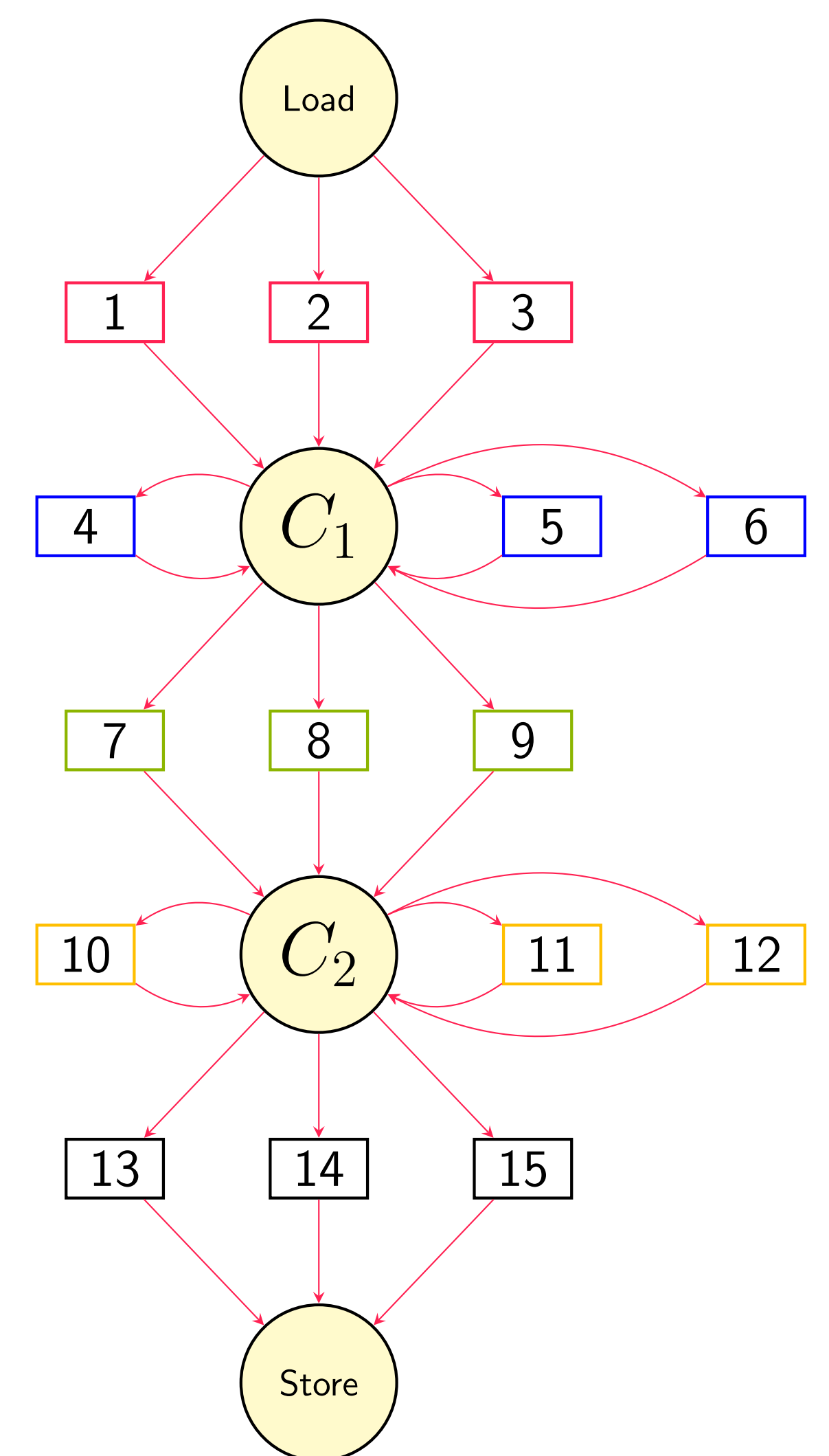
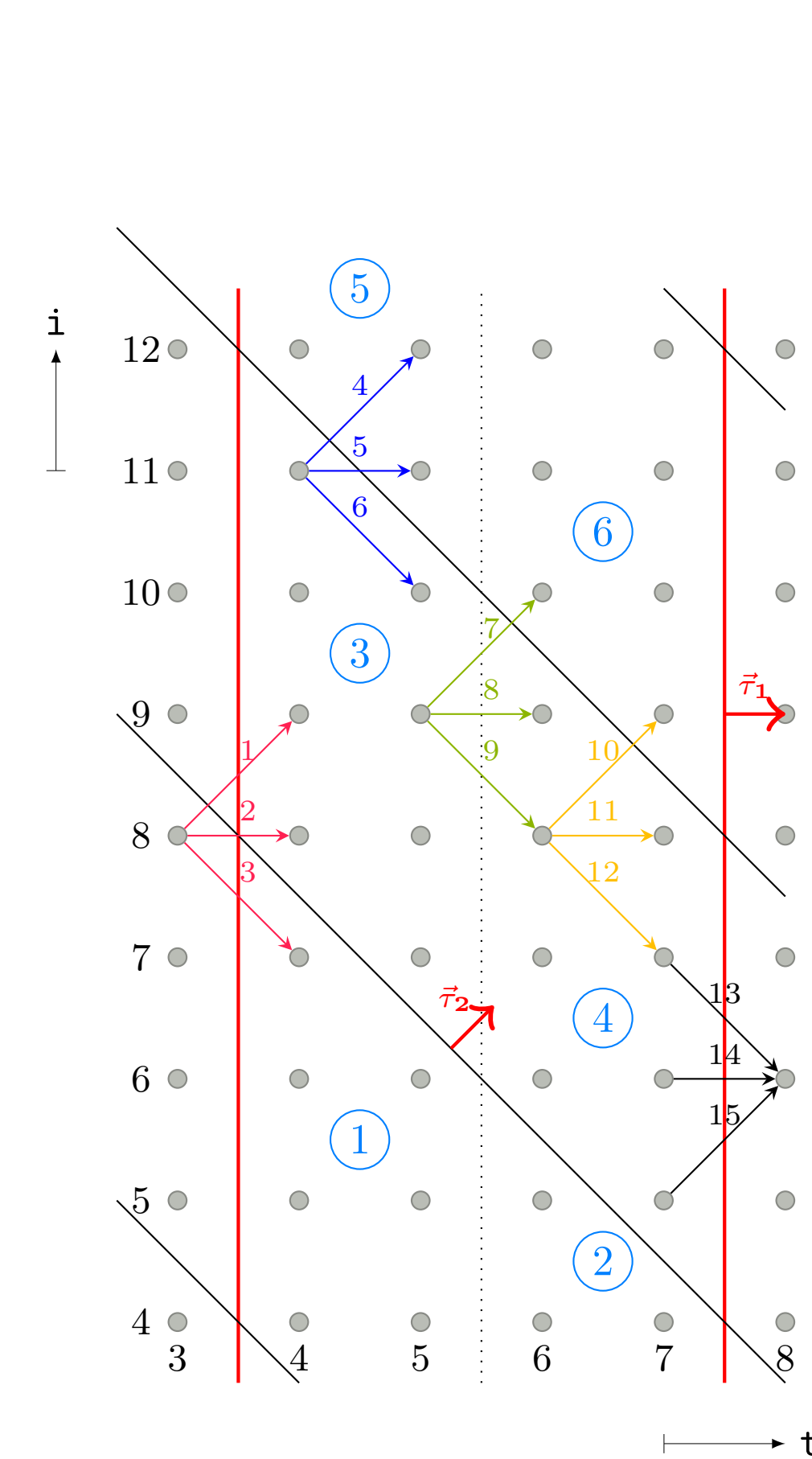
```



Theorem: FIFO recovery is complete on our DPN model

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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**

4) Experimental Results

Kernel	PPN				DPN		
	#fifo	#rem	#rec	%	#rem	#rec	%
trmm	2	1	1	100	1	1	100
gemm	2	1	1	100	1	1	100
syk	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
syk2k	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**).