

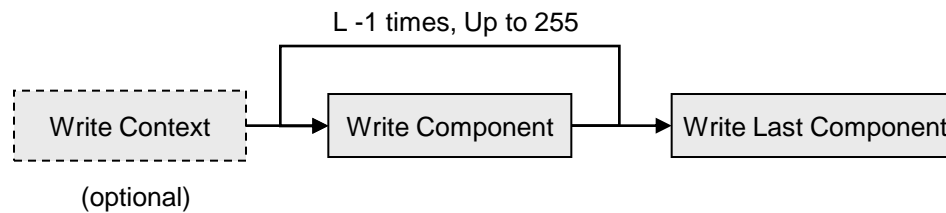
CM1K Speed Performance



- All 1024 neurons operate in parallel
- Learn and recognize a 256-bytes vector < 11 μ S @ 27Mhz
- Save or restore of the 1024 neurons < 10 μ S @ 27Mhz
- Disruptive performance for standard GPU !

Learn & Recognize Ops < 11 μs/Vector

1) Broadcast a vector of L bytes...

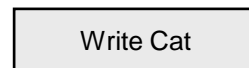


Clock Cycles @ 27Mhz
L=256

$$(1)+L+3$$

9.55 μs

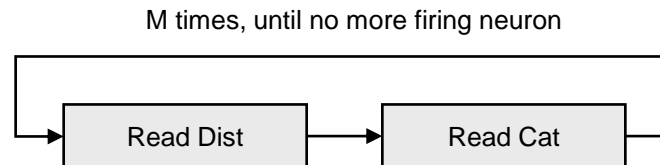
2) ...to learn



19

0.66 μs

3) or to recognize and evaluate response of M first neurons

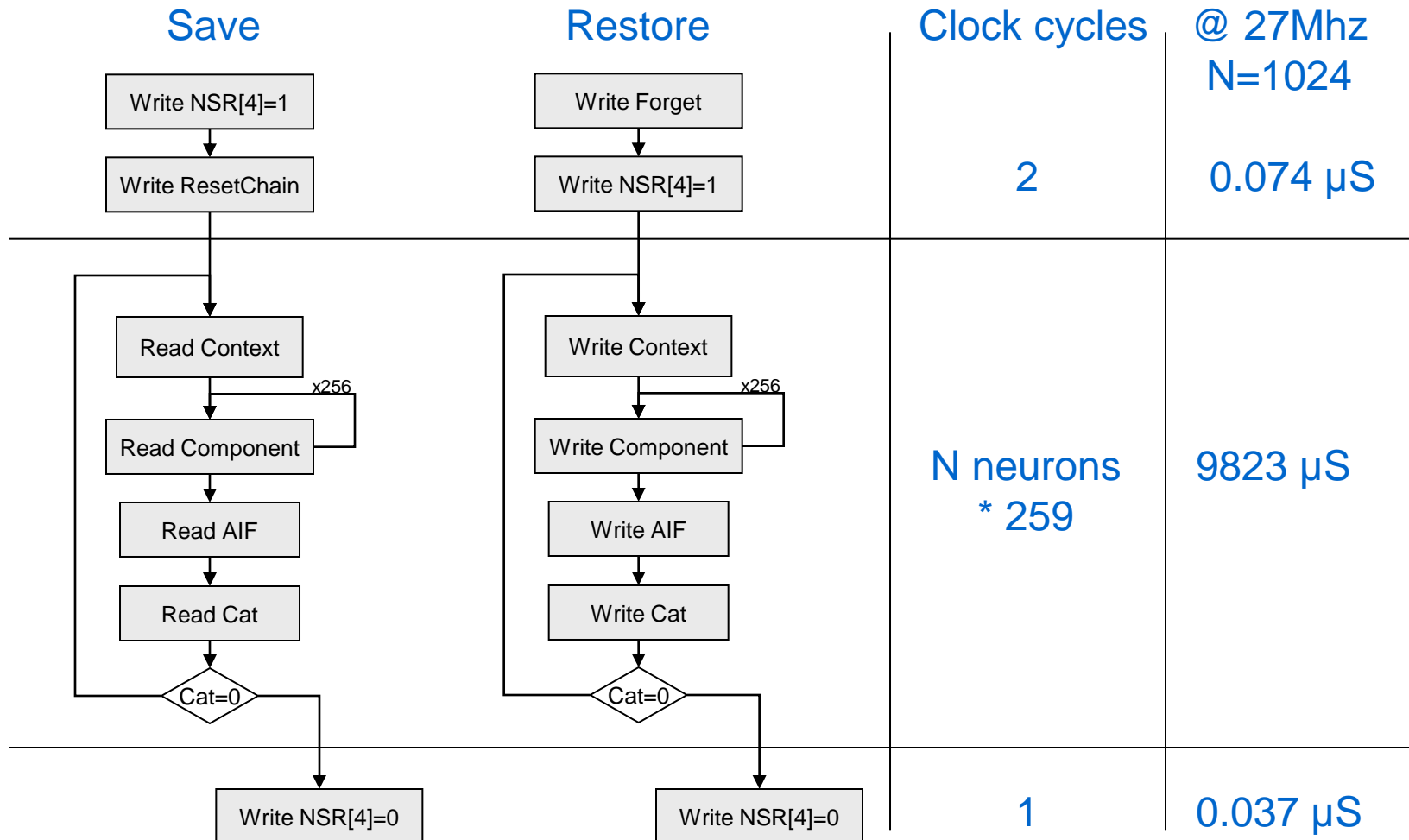


$$M * (18+19)$$

M=1

1.33 μs

Save and Restore Ops (9.8 μ S/chip @27Mhz)

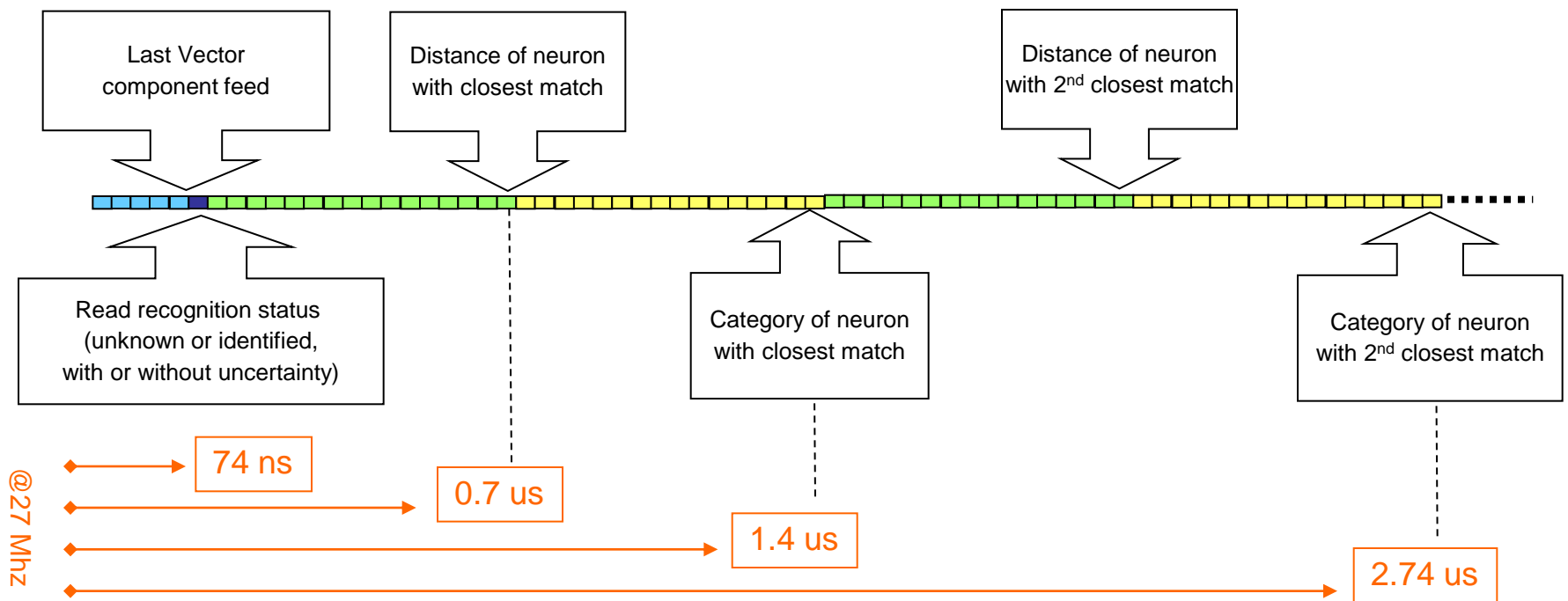


CM1K Register Access Time

Addr	Name	Description	Default	LR mode		SR mode	
0x00	NCR	[6:0]=Neuron Context [7]= Norm [15:8]=Neuron identifier[23:16]	0x0001			W (1)	R (1)
0x01	COMP	Component	0x00	W (1)		W (1)	R (1)
0x02	LCOMP	Last Component	0x00	W (1 if no neuron is committed, 3 otherwise)			
0x03	IINDEX	Component Index	0x00	W (1)		W (1)	
0x03	DIST	Distance	0xFFFF		R (18)		R (1)
0x04	CAT	Category[14:0] Degenerated flag[15]	0xFFFF	W (1 if ID, 19 otherwise)	R (3 if ID, 19 otherwise)	W (1)	R (1)
0x05	AIF	Active Influence Field	0x4000			W (1)	R (1)
0x06	MINIF	Minimum Influence Field	0x0002	W (1)	R (1)		R (1)
0x07	MAXIF	Maximum Influence Field	0x4000	W (1)	R (1)		
0x0A	NID	Neuron Identifier[16:0]	0x0000		R (1)		R (1)
0x0B	GCR	[7]= Norm [6:0]= Global Context	0x0001	W (1)	R (1)		
0x0C	RESET CHAIN	Point to the 1 st neuron in the chain				W (1)	
0x0D	NSR	Network Status Register	0x00	W (1)	R (1)	W(1)	
0x0F	FORGET	Forget (clear the knowledge and some global registers)*		W (1)			
0x0F	NCOUNT	LR mode: committed neurons SR mode: neuron index			R (1)		R(1)

3 Levels of Recognition

- From the feed of the last vector component...
 - Level 1: Recognition Status = +1 cc (ex: anomaly detection)
 - Level 2: Closest distance = +18 cc (ex: tracking)
 - Level 3: Best match category = +19 cc (ex: identification)
- Readout of subsequent distance and category = + 37 cc





@27Mhz

Recognition/Seconds

RBF

Vector length (bytes)	Vector reco* (clk cycles)	Time** (μ S)	Reco/sec
256	293	10.84	92,250
128	165	6.10	163,934
64	101	3.73	268,096

*Reco = read nearest distance and associated category

KNN

Vector length (bytes)	Vector 5NN* (clk cycles)	Time** (usec)	Reco/sec
256	347	12.83	77,942
128	219	8.01	124,843
64	154	5.69	175,746

*KNN (K=5) = read 5 nearest distances

**Thanks to CM1K parallelism
there is no need to know how many neurons are committed to fill this table!**

Comparison with DSP for Manhattan Distance Calculation

Pattern length	256
Number of neurons, N	1,024

L1 distance calculation per neuron	CM1K
Write components (less last one)	255
Write last component + flag if distance < AIF	3
Read Distance	18
Memory access V[i]	
Absolute Subtraction + Branch	
Init + Accumulation	
Branch and Write if Dist[i] < AIF[i]	
Branch and Write if MinDist > Dist[i]	
Total cycles for 1 neuron	276

In the CM1K, ALL the neurons calculate their distance in parallel in the 276 clock cycles time lapse

Smallest L1 distance between 1 vector and N neurons

	CogniMem	DSP SHARK 21160	DSP Tiger-SKARK TS101
clock frequency (Mhz)	27	100	300
Clock cycle (ns)	37.04	10.00	3.33
Number if instructions	276	N*774+7	N*278+34
Total cycles	276	792,583	284,706
Total time (usec)	10.22	7925.83	949.02
Ratio		775	93

CM1K is 93 times faster!