CogniMem, a High Speed Non-linear Classifier

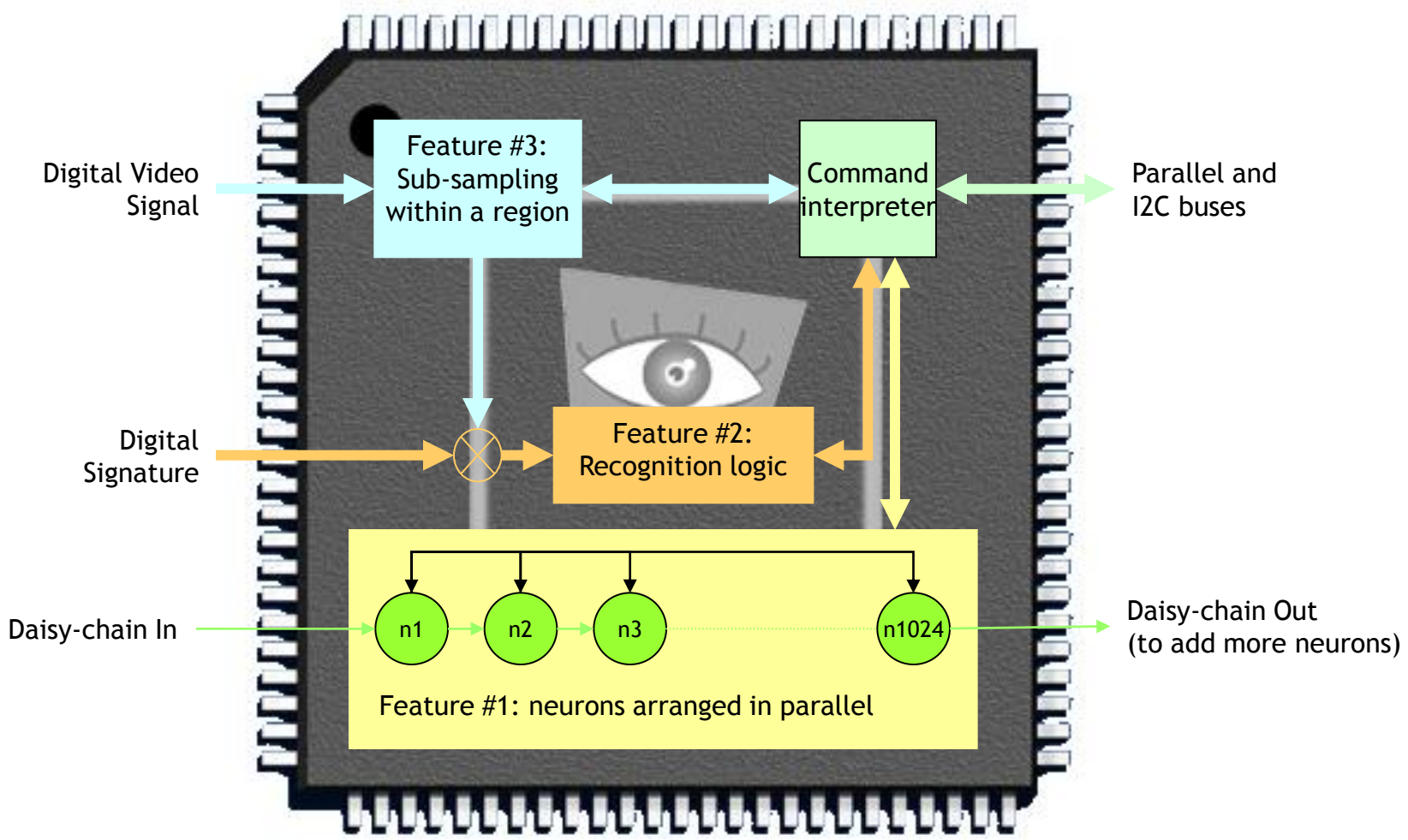
The practical merger and implementation of two proven concepts

A non-linear classifier
(Restricted Coulomb Energy, 1982)
Invented by Nobel prize Winner Leon Cooper, et al
derived from Bruce Batchelor's work)

A hardwired parallel architecture
Designed for the CERN's UA1 experiment (1984)
Lead by Nobel prize winner Carlo Rubia

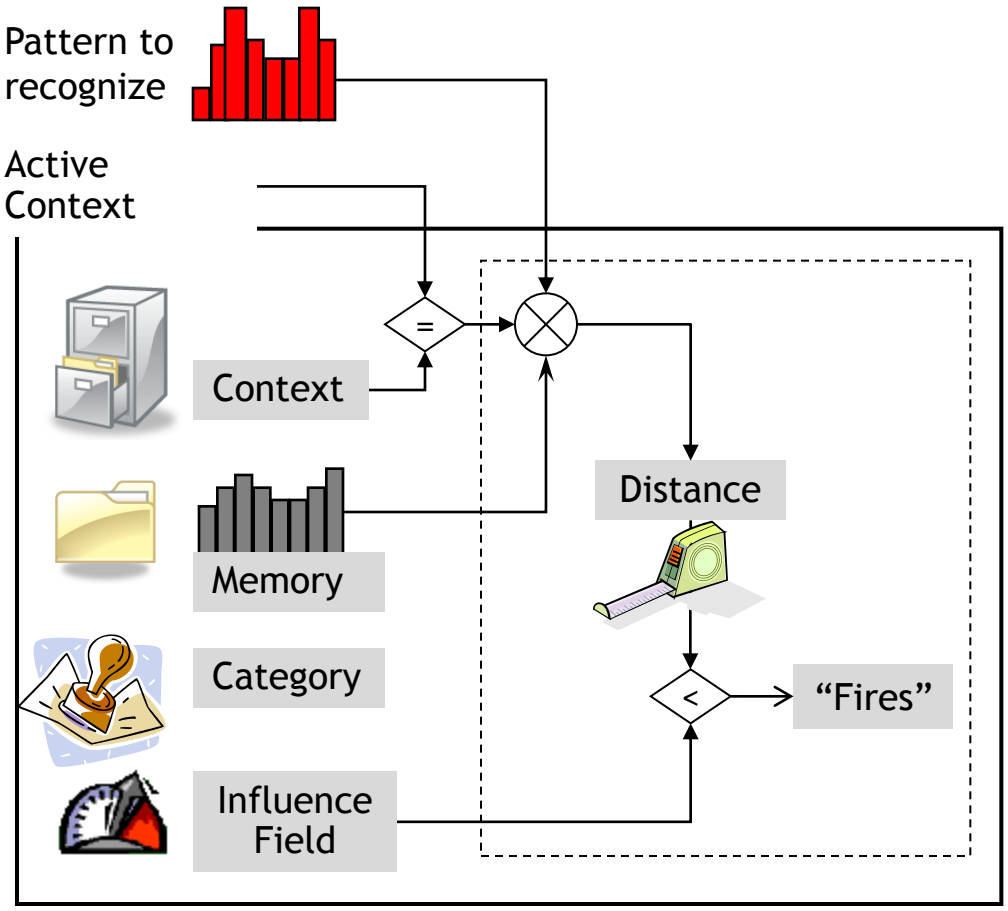
CM1K Benefits
High-speed pattern recognition,
Expandable neural network
Trainability (supervised or unsupervised)
Low power consumption,
Compact (TQFP100), Low cost,
1st production batch released Jan 2008

CM1K, a Network of Neurons in Parallel



What is a Neuron?

A neuron is a reactive memory which can autonomously evaluate the distance between an incoming vector and a reference vector stored in its memory. If this distance falls within its current influence field, it returns a positive classification.

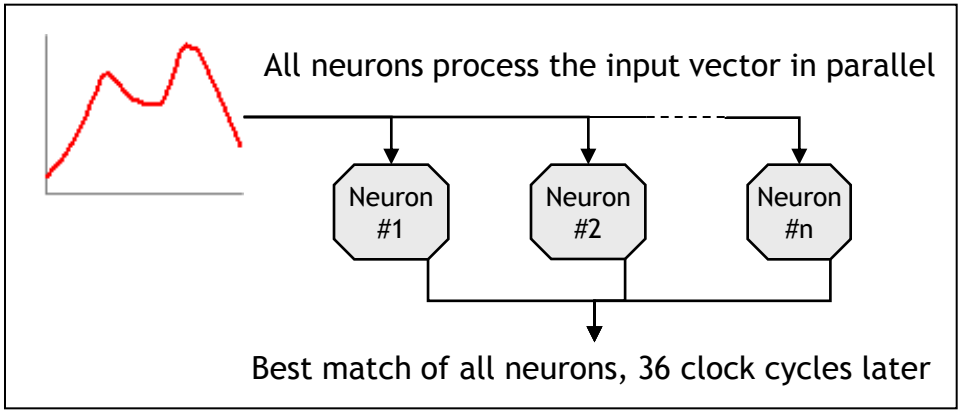


What is a Neural Network?

The true significance of a neuron is its arrangement into a parallel network

-To learn and recognize a vector in a constant amount of time independent from the number of neurons

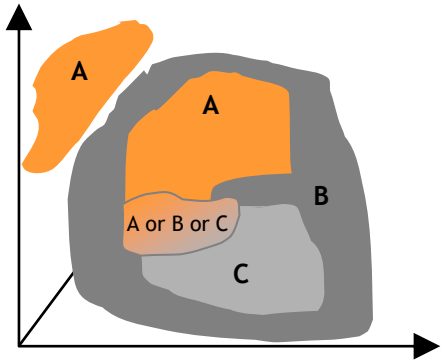
-To add neurons at will to the network



CM1K, an Adaptive Model Generator

- Learn by examples (supervised or unsupervised)
- Map decision spaces by aggregate instead of hyper planes
- Cope with non-linear, convex, disjoints and embedded categories
- Possible modulation between conservative or moderate engine
- Save and restore the contents of the neurons
- Can append more training at any time

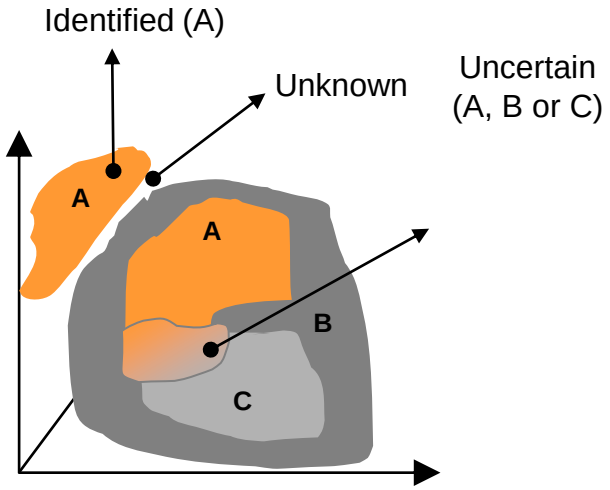
Learning =
Building a **"decision space"**
by teaching examples



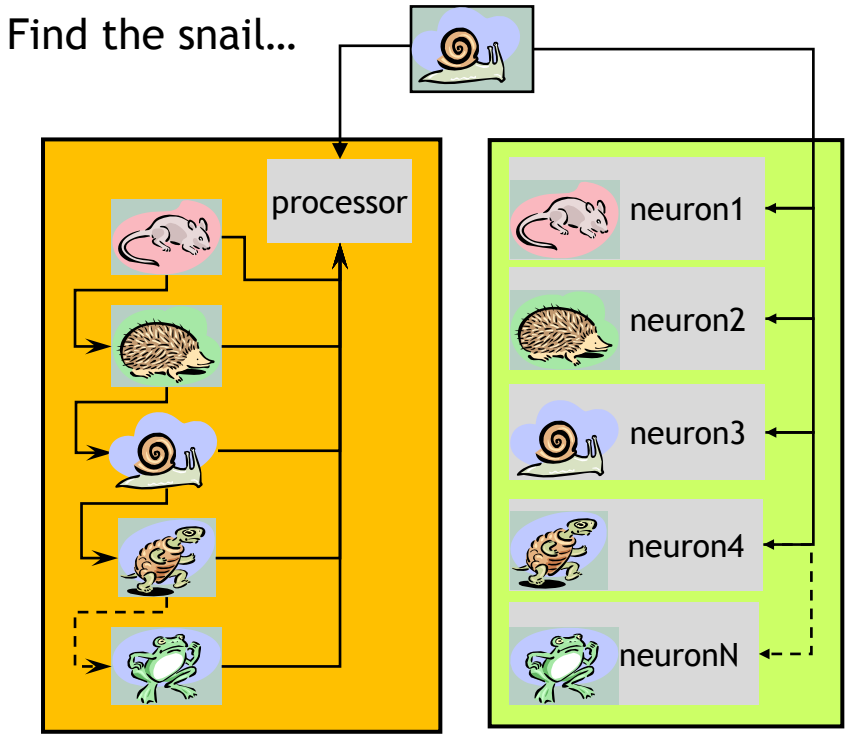
CM1K, a High Performance Classifier

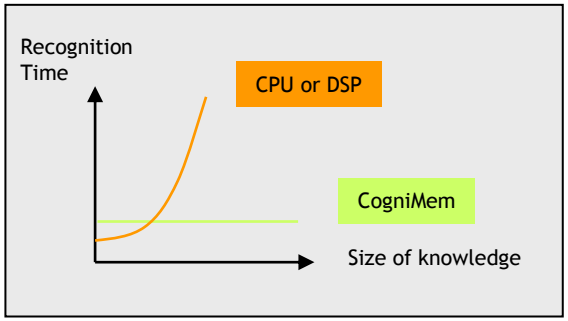
- Global response readout:
  - Positively identified
  - Identified with uncertainty
  - Unknown
- Detailed response of all the firing neurons
  - Category and confidence level (or distance)
  - Retrieved per decreasing confidence

Recognition =
Where does the sample
fall in the decision space?



CM1K, High Speed Performance

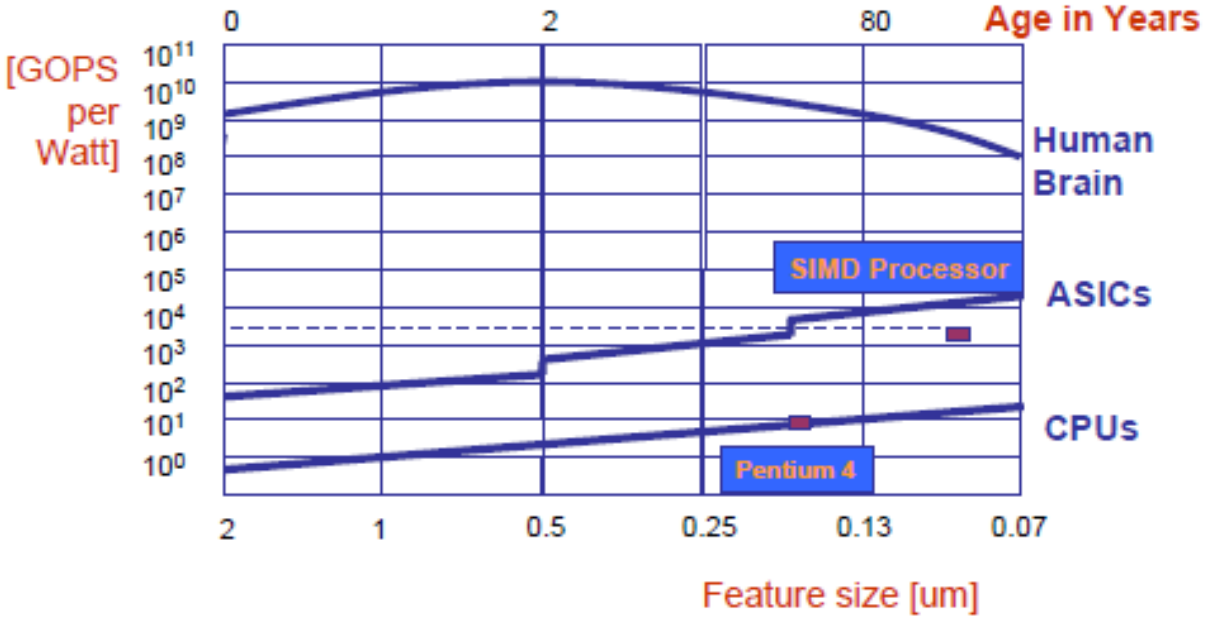




-CogniMem ➔ Constant recognition time independent from the number of neurons in use

- 9.47 µsec to broadcast a pattern of 256 bytes to all neurons (@ 27 MHz)
- 1.3 µsec to find the best match among N (whatever the value of N!)

CM1K, Low Power Consumption



Targeted power for an embedded system < 1W

→Pentium IV - 2,4 GHz = 6 GOPs, peak consumption= 59W

→ 1 CM1K = 0.3 W → N CM1K in parallel = N*0.3 W

CM1K, Enabler for New Architectures

PC Pentium	DSP Shark	DSP Tiger	CM1K
2 GHz	100 MHz	300 MHz	27 MHz
T = 1714µS	T = 7925µS	T = 949µS	T = 10µS

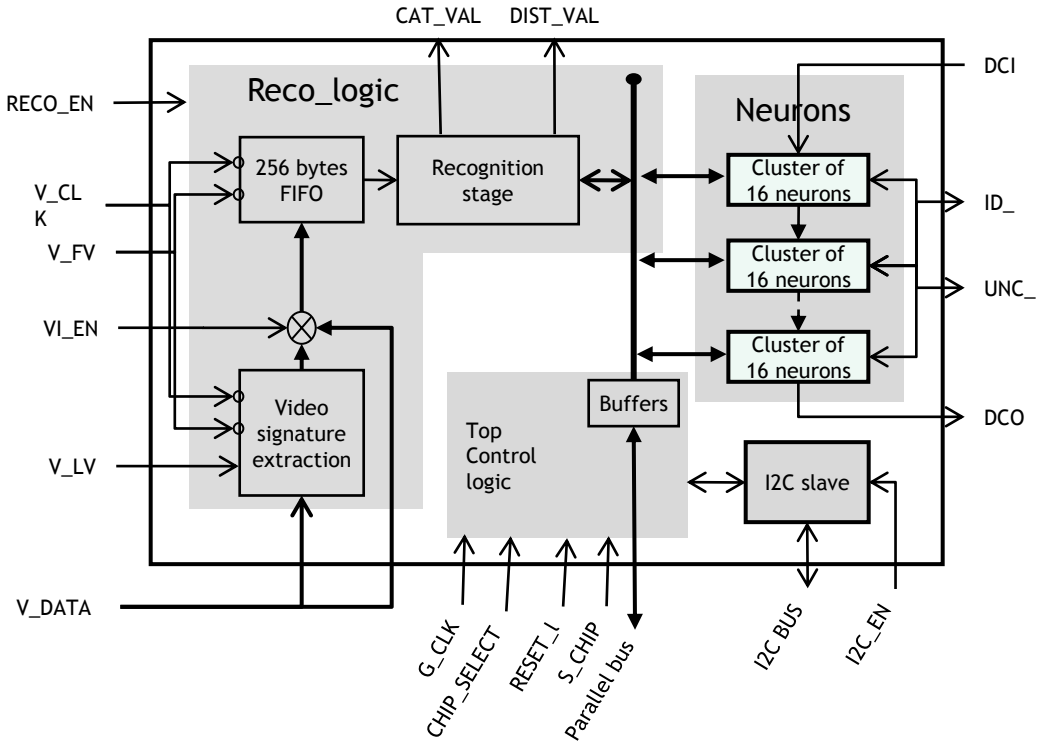
- **170 times faster than a computer running at 2.4 Ghz**
- **Capable of comparing 100,000 256-byte vectors/sec**
- **120 times less power than a Pentium (0.5W vs. 60W)**

Built-in Recognition Engine (optional use)

- Receive vector data directly on the digital input bus (8-bit data, ext clk, 2 sync lines)
- Bypass to the neurons in real-time
- Upon receipt of the last vector data
    - Recognition status in 4 clock cycles (74 ns @ 27 MHz)
    - Category of the neuron with the closest match in 37 clock cycles (1.3 µsec)

- In the case of video input, the CogniMem signature extraction can be selected
    - Sub-sampling of the pixels inside a region of interest to fit in a 256-byte vector
    - **Total recognition time = 10.80 µsec after each video frame @ 27MHz**

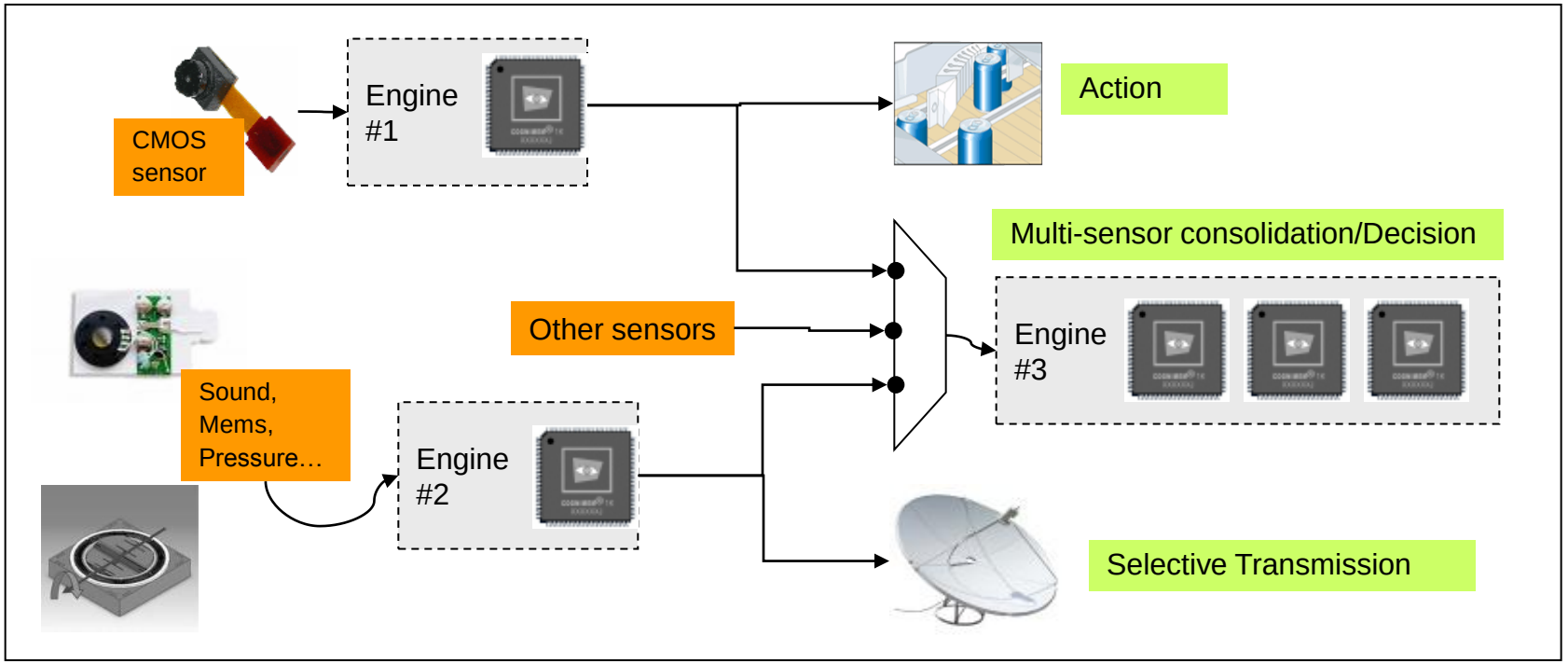
Detailed Block Diagram



CogniMem, Cognitive Memory Chip with Endless Possibilities from Sensors to Servers

Neurons directly connected to a sensor output for real-time recognition at low-cost and low power

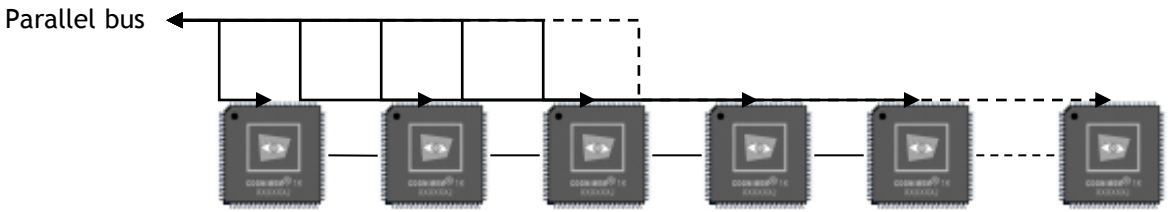
Thousand of neurons assembled in parallel for high-speed data mining



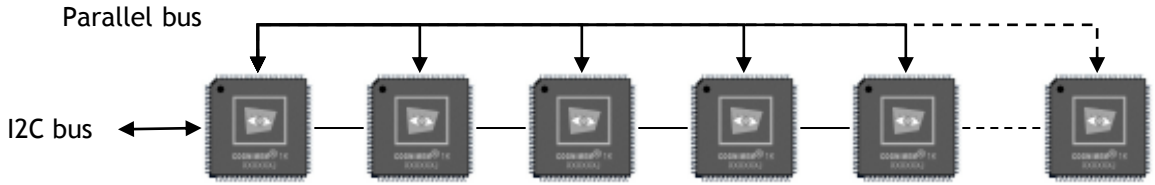
Cascading CogniMems…for Data Mining

Size your neural network in increments of 1024 neurons

Example #1:
High-speed comm. With parallel bus (28 lines)



Example #2
Low connectivity with I2C bus (2 lines)



Example #3
1st CM1K receives the digital input (11 lines) and runs its reco-logic