An electronic system for simulation of neural networks with a micro-second real time constraint

Arsenia Chorti, Bertrand Granado, Bruce Denby et Patrick Garda

Laboratoire des Instruments et Systèmes

Université Pierre et Marie Curie

Paris France

माहाराज्य

Overview

- Introduction
- Context of the study
- Our System
- Description of the System
- Time Analysis of the System
- Comparizon with Micro-Processors
- Conclusion

Introduction

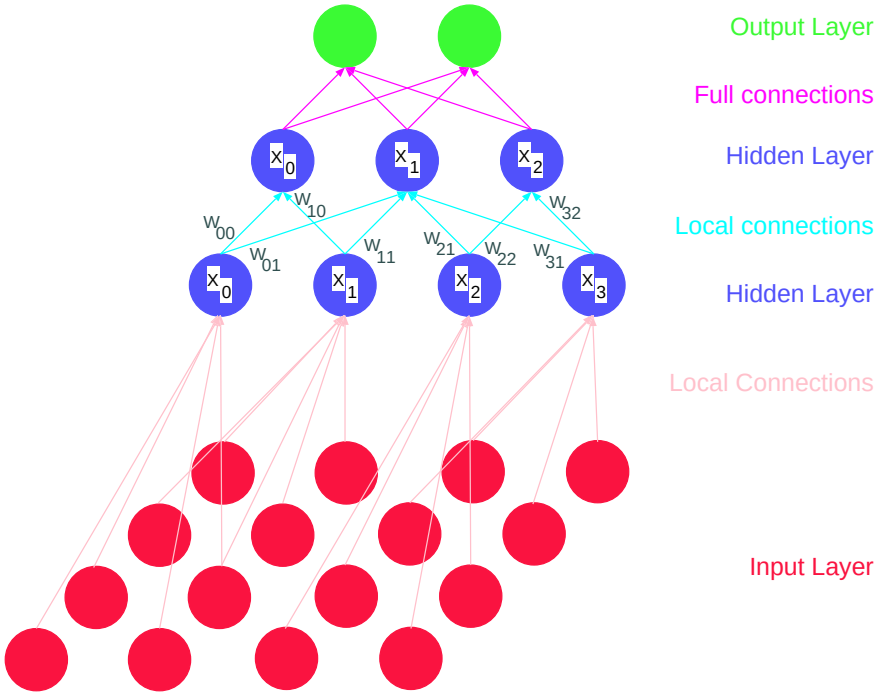
- We have an electronic system that satisfy :
  - low power consumption constraints
  - high input-output bandwidth constraints
  - μs time constraints

Context of the study

- Simulate an HEP Multi-Layer Perceptron (H. Abramowicz, G. Dror and al. - Israel)
- The network has :
  - A four neurons input layer they are dx/dz, x(z=0), dy/dz, and y(z=0),
  - two eight neurons hidden layer
  - a four neurons output layer given pt, tan(phi), sin(theta), and q, the charge
- The simulation time constraint is 10μs.

Mutli-Layer Perceptron

☞ Network organization



☞ Elementary computation

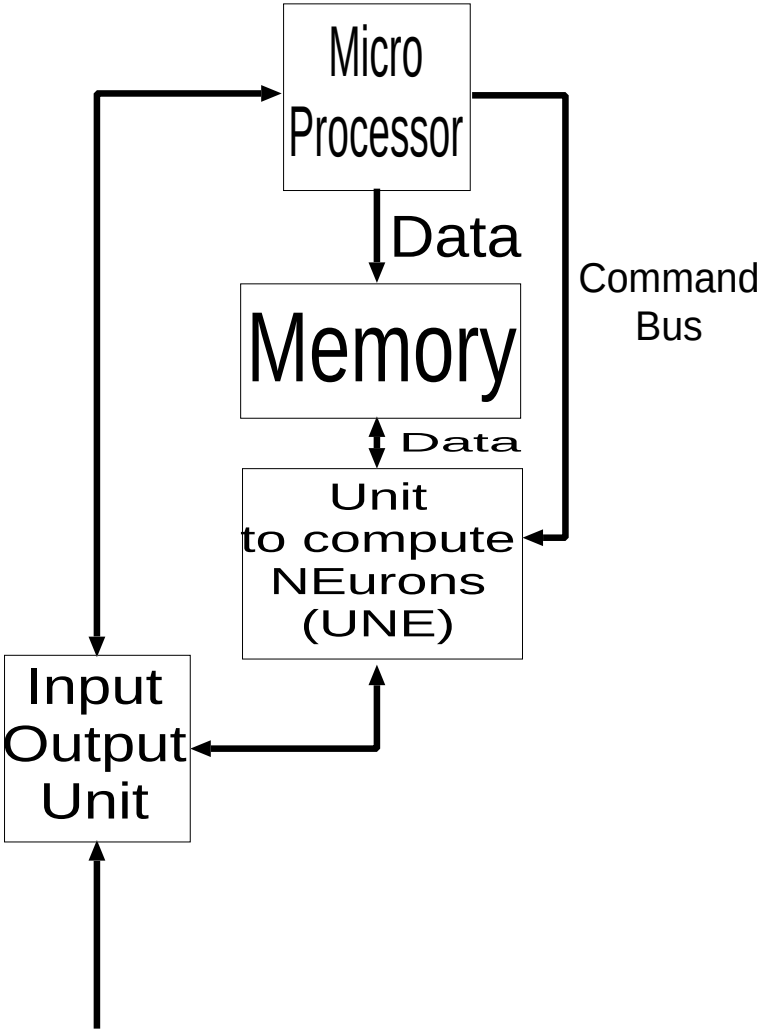
- ☛ Post-Synaptic Potential

$$V_i = g\left(X_{j(\,j\in E_i)}\right) = \Sigma_{j\in E_i} X_j * W_{ij}$$

- ☛ Neuron state

$$X_i = f\,(V_i) = m\frac{1-e^{-\lambda V_i}}{1+e^{-\lambda V_i}}$$

माहाराज्य



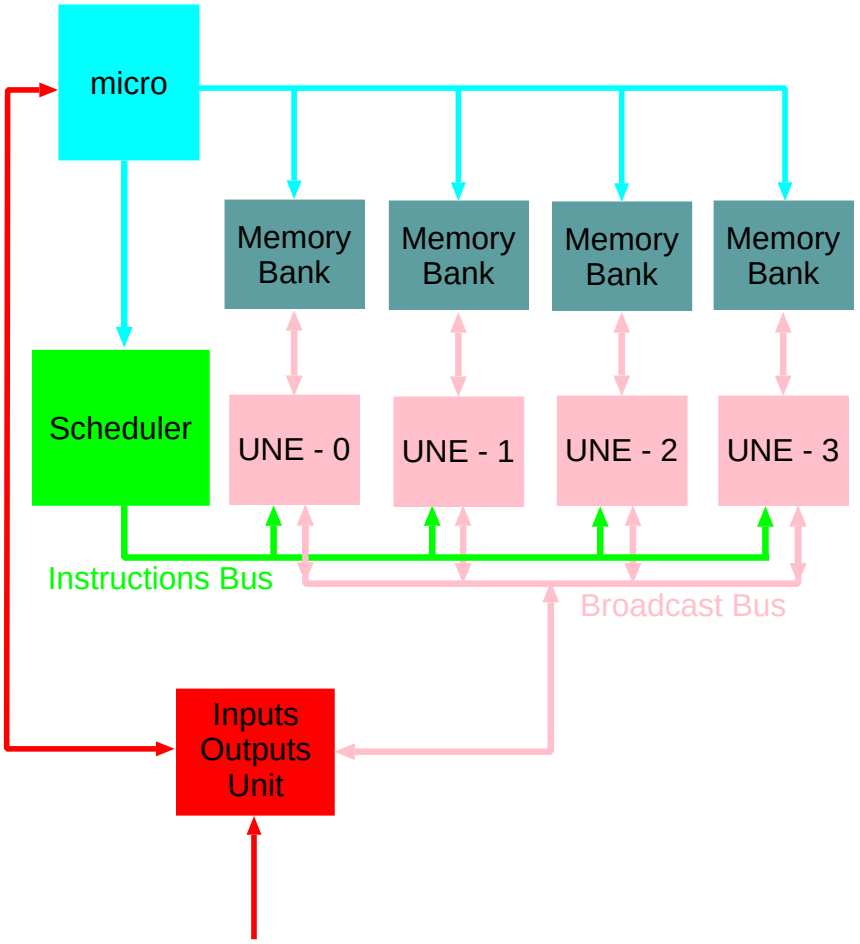
MicroController Execution of the sequential part of the algorithm

UNE Speedup of the neural computation

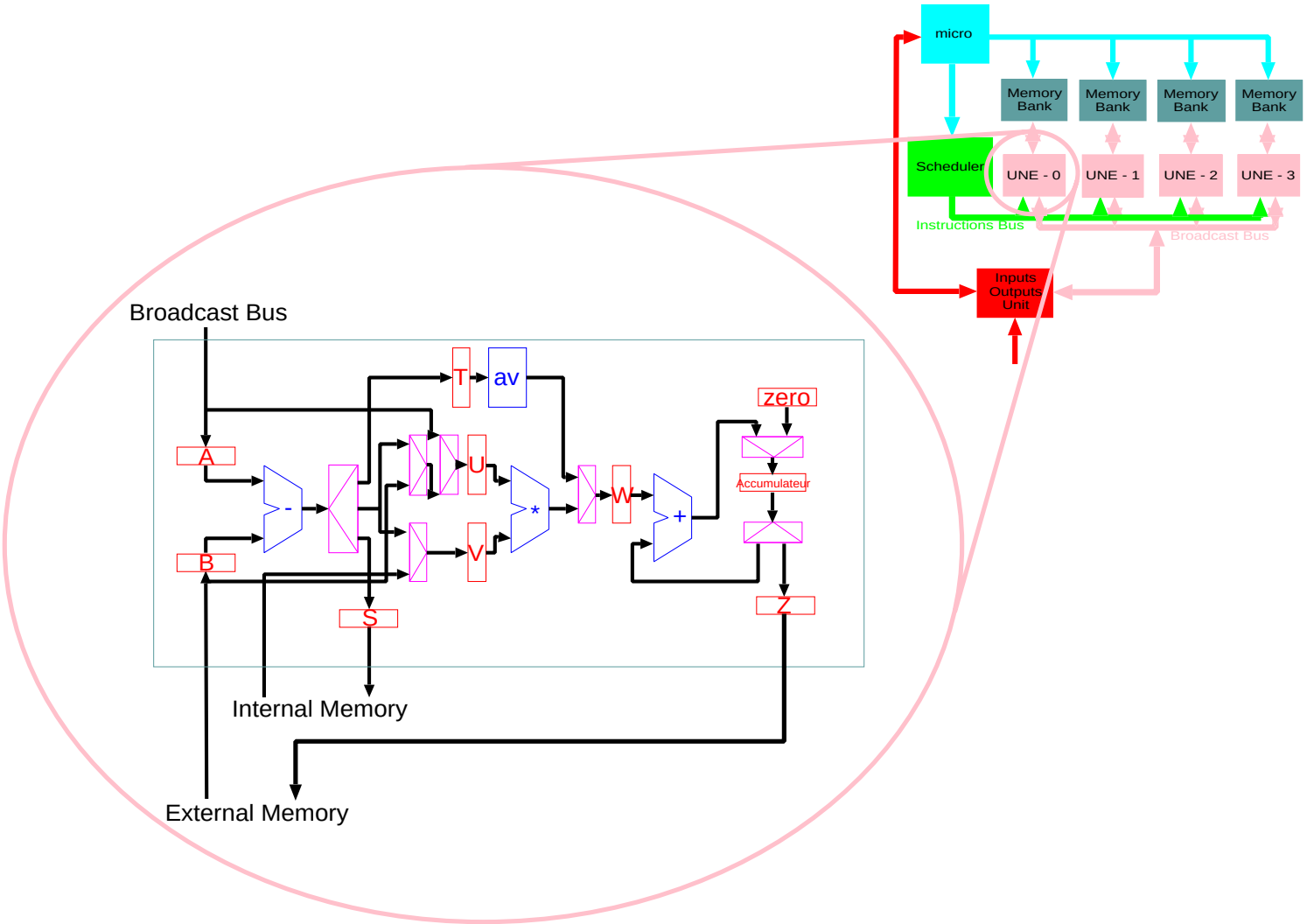
Memory Store the parameters of the network

Input-Output Unit High Input-Output band-width

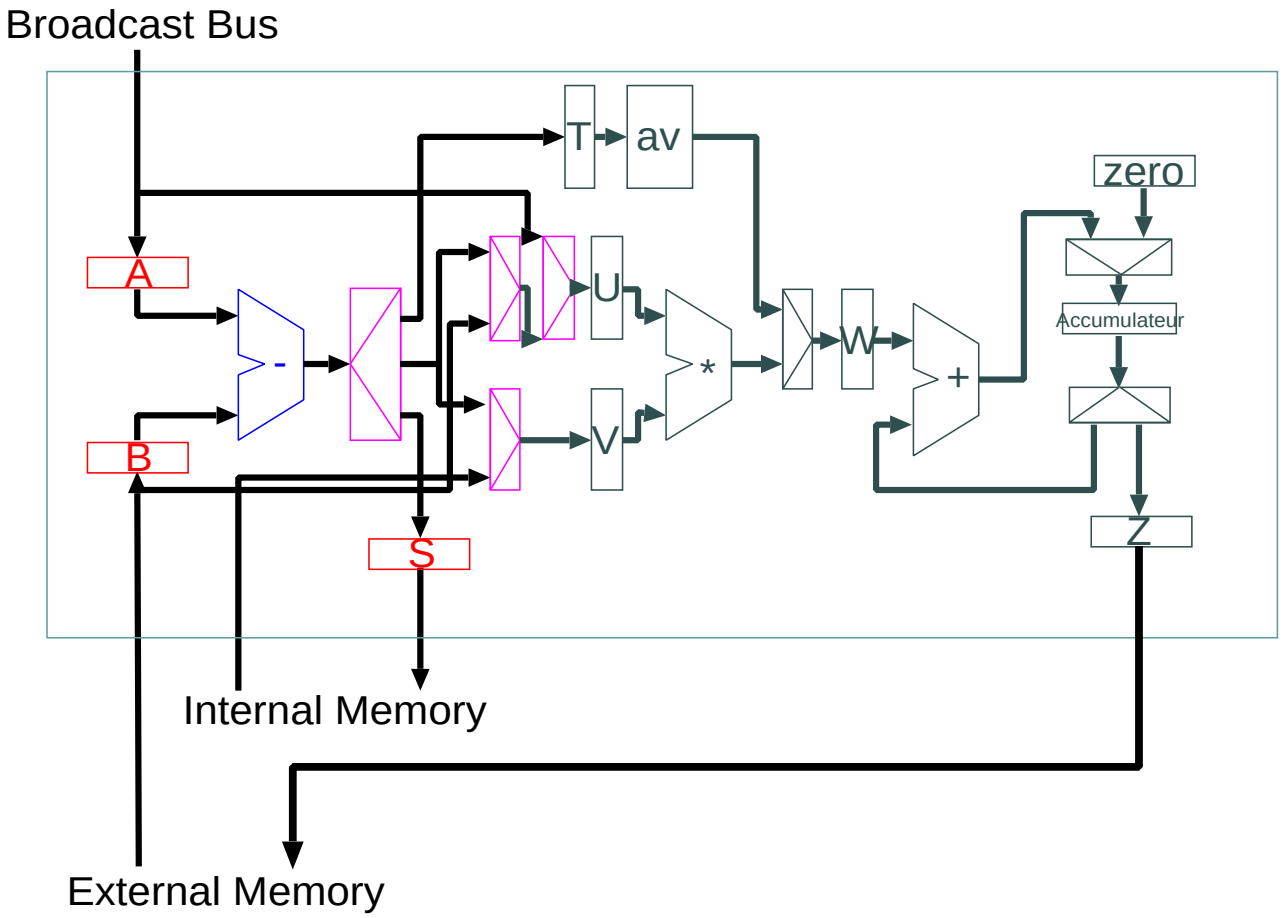
MAHARADJA **Architecture**



UNE of MAHARADJA : Internal

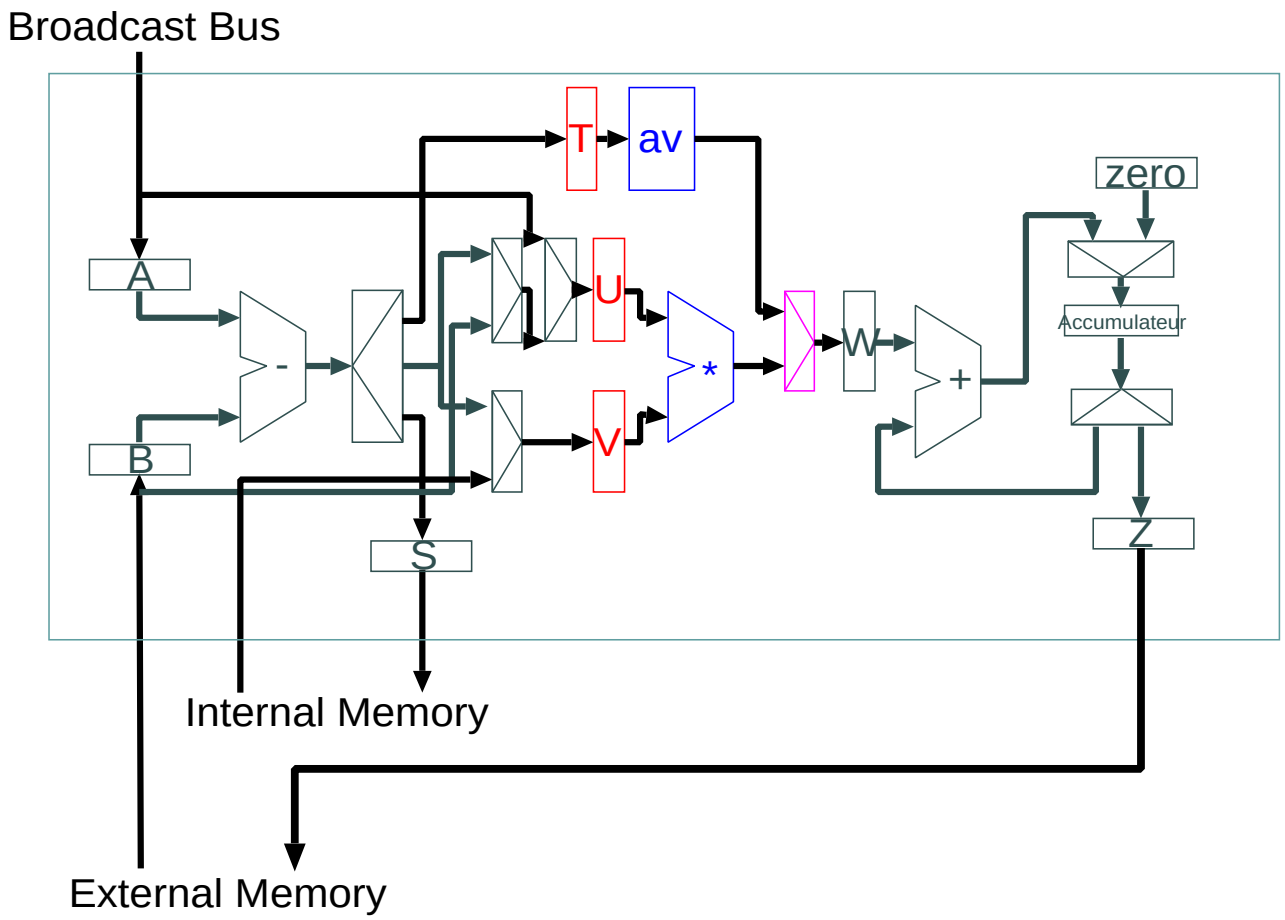


UNE **of** MAHARADJA **: Internal**

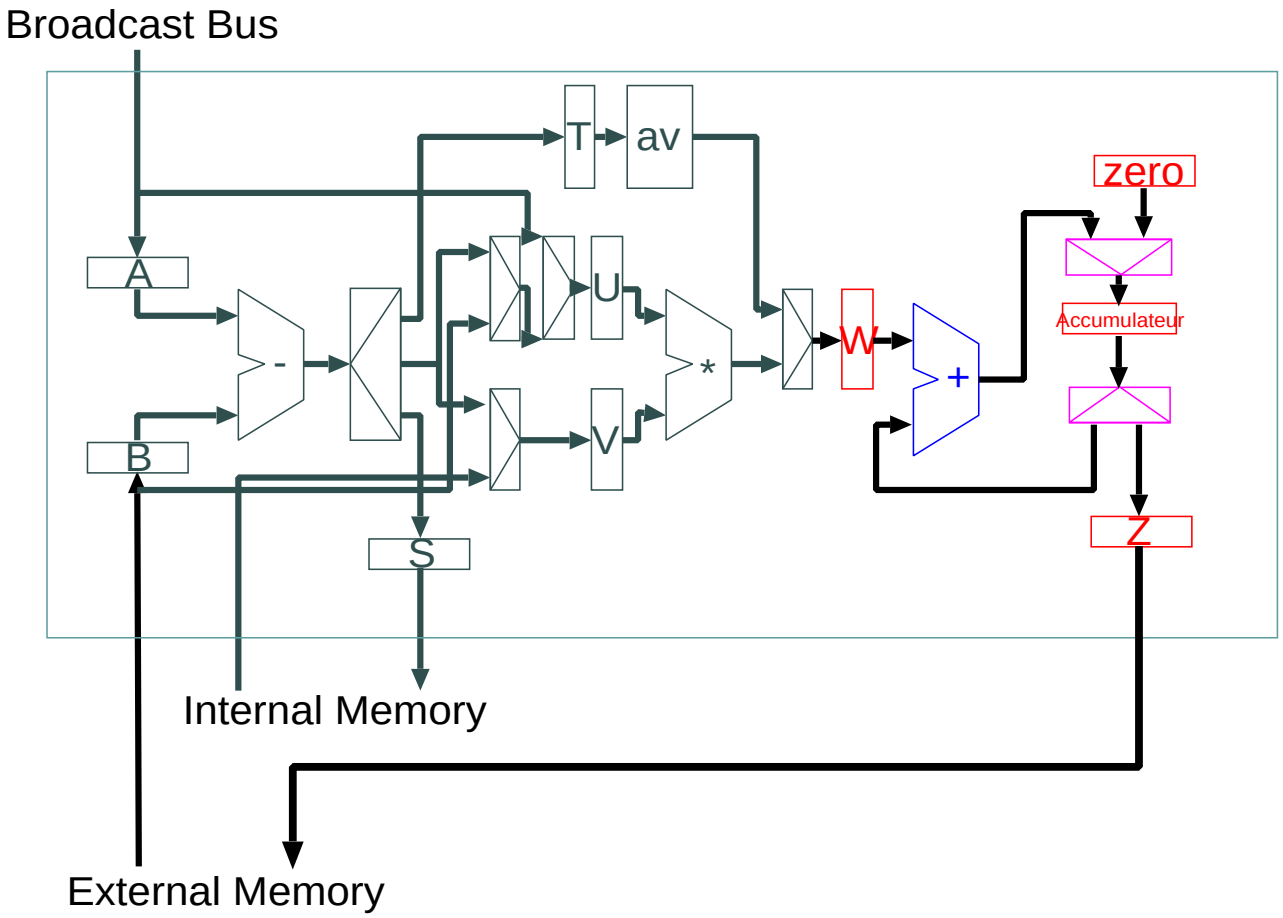


माहाराज्य

UNE of MAHARADJA : Internal

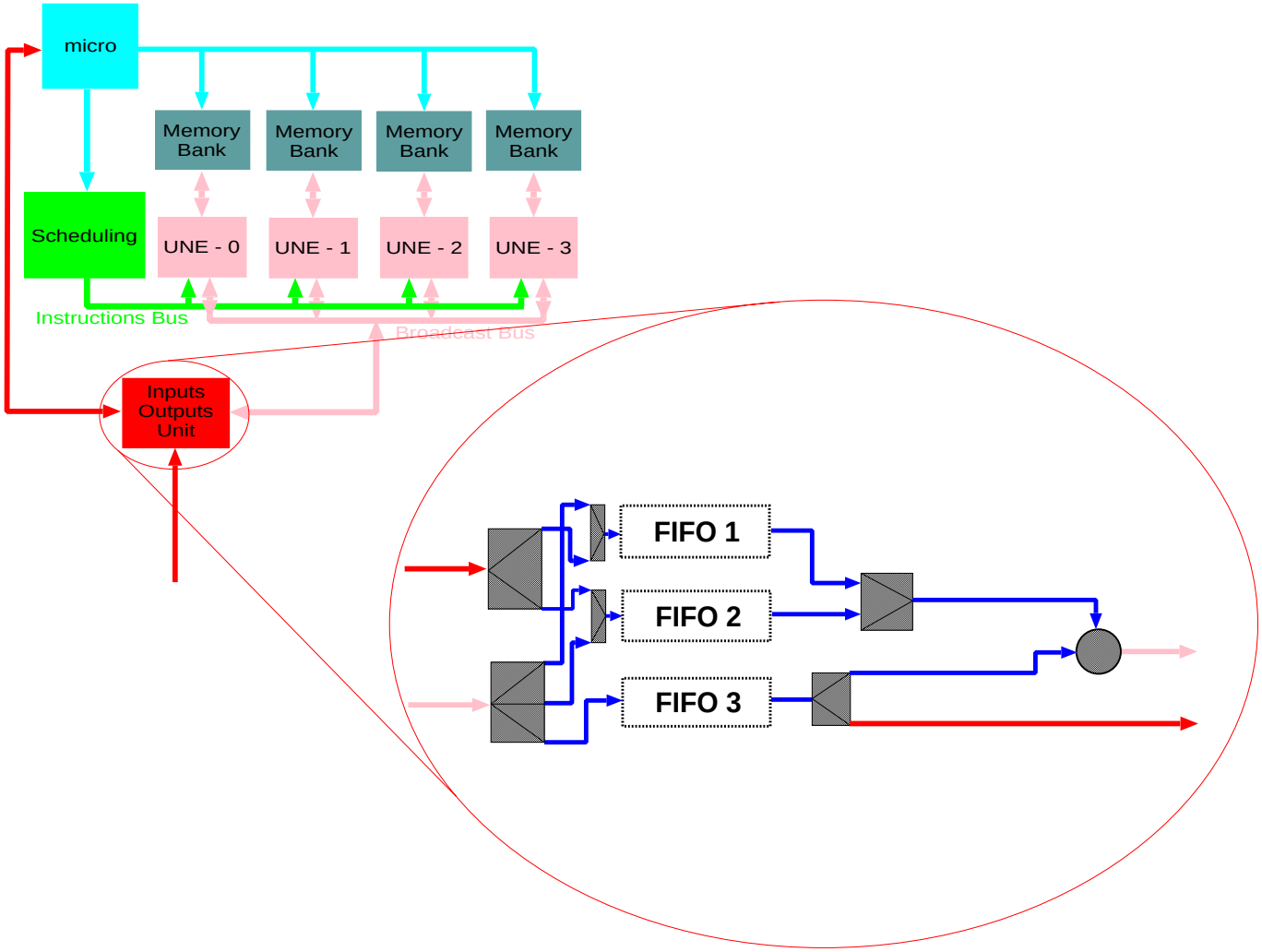


UNE **of** MAHARADJA **: Internal**

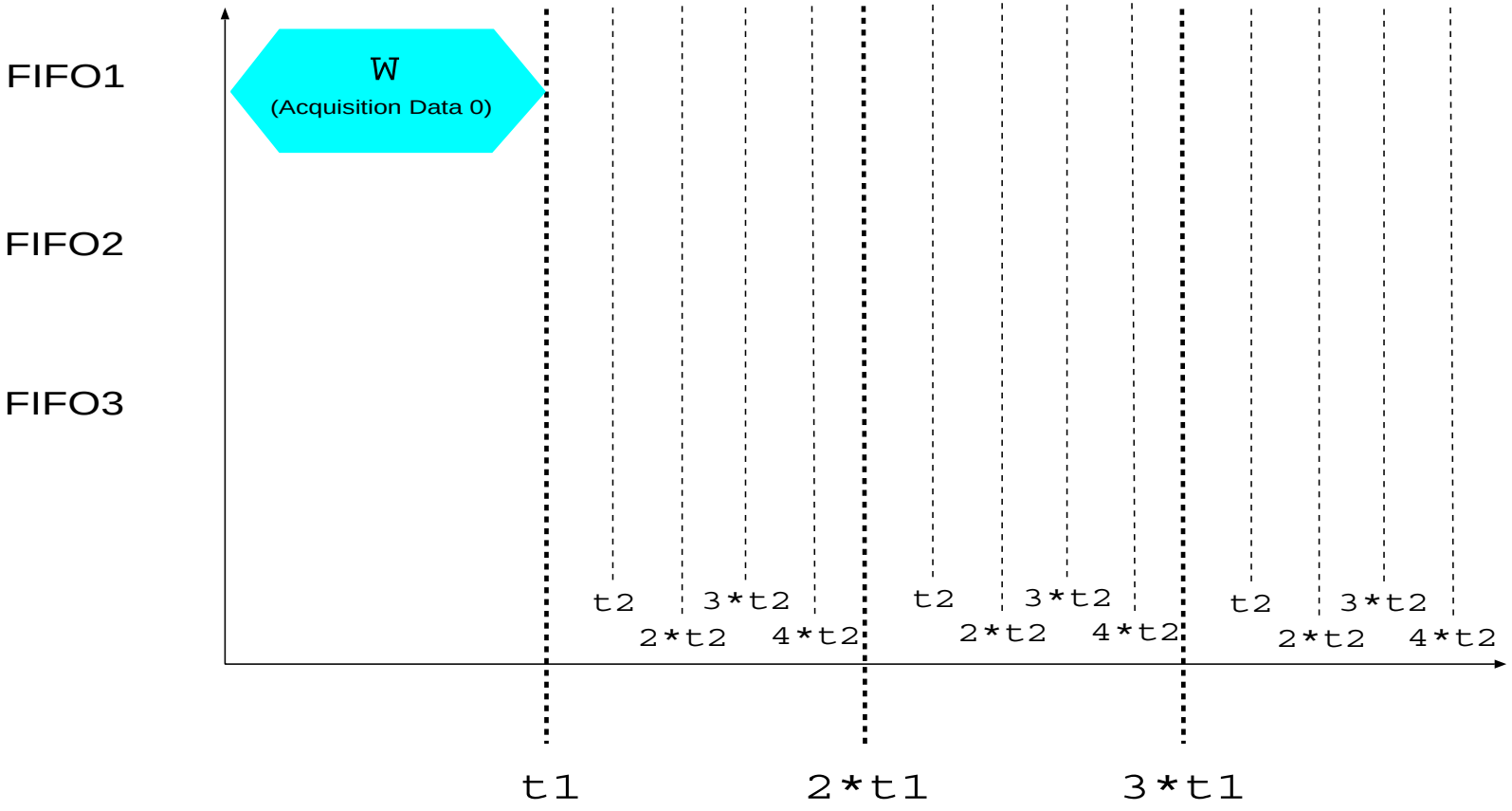


माहाराज्य

Input-Output Unit **of** MAHARADJA **Architecture**



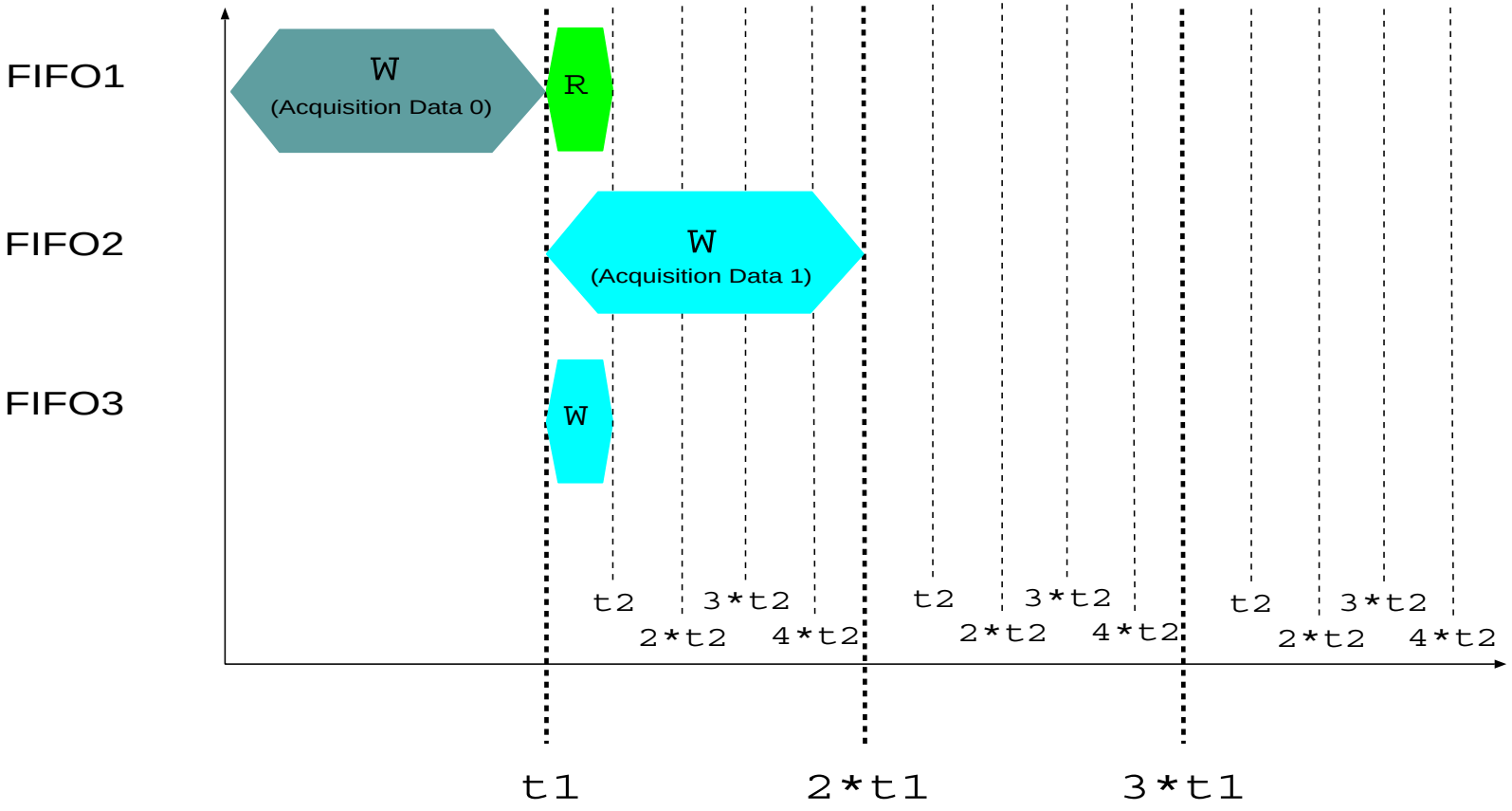
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

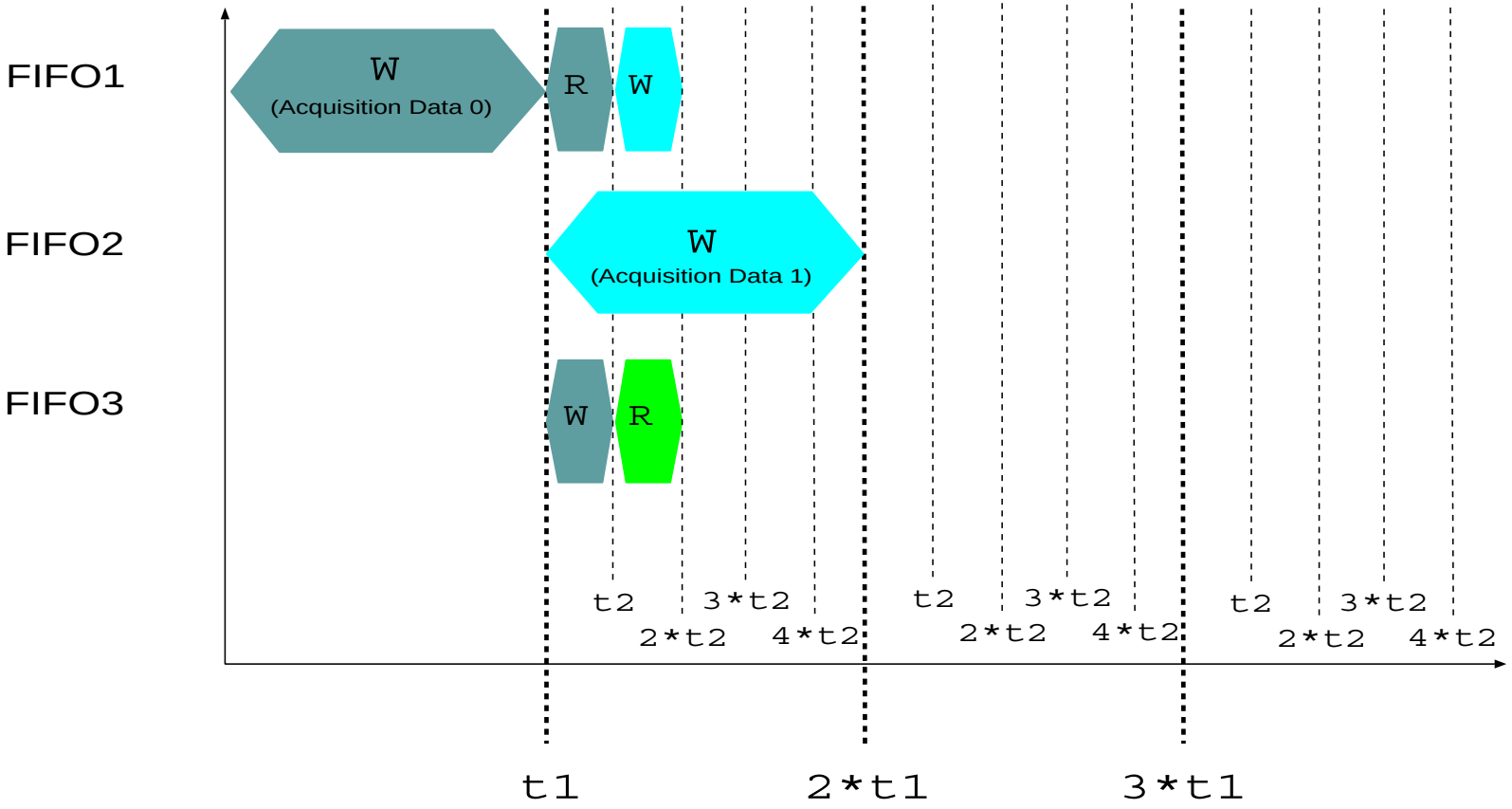
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

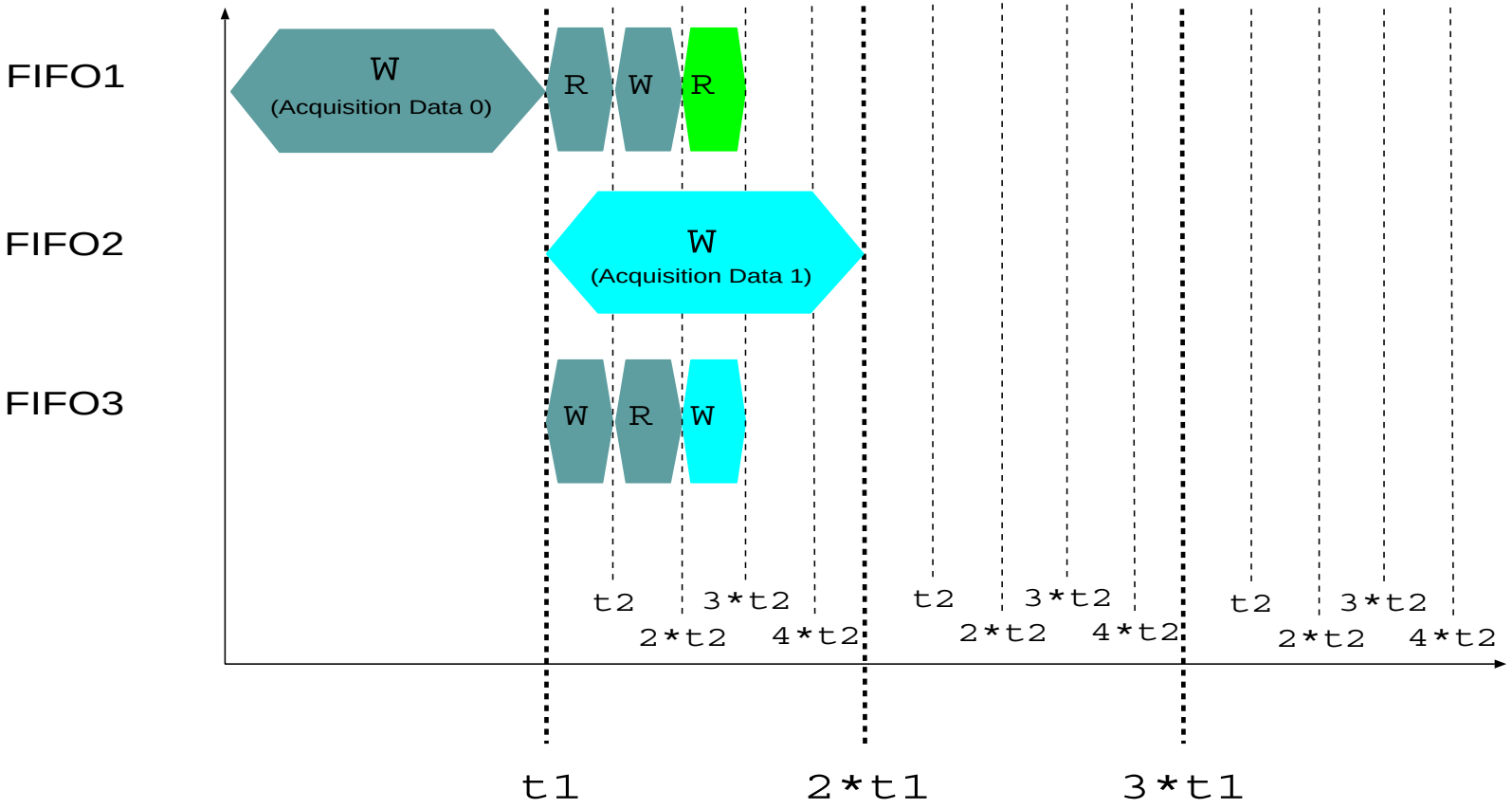
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

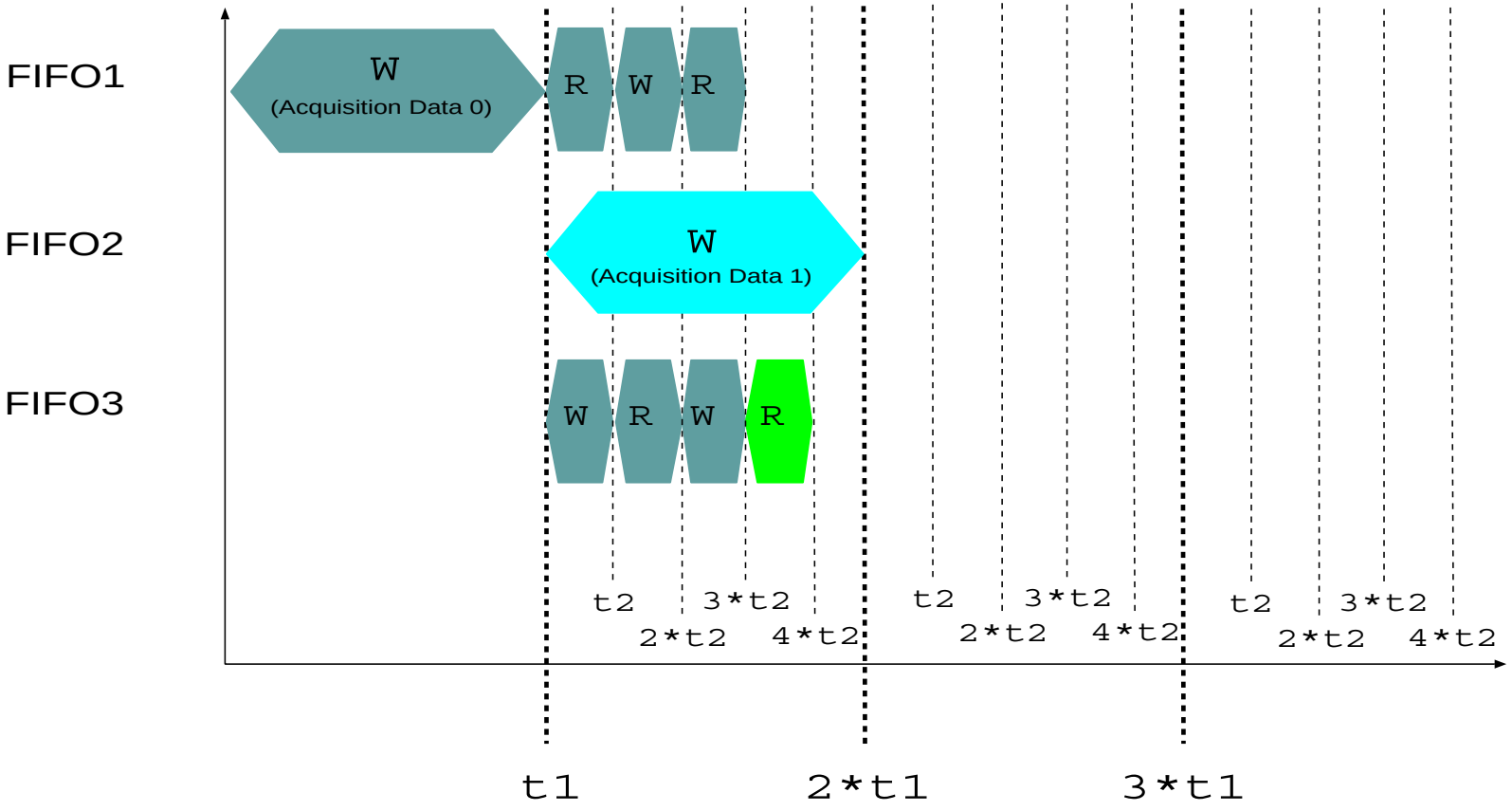
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

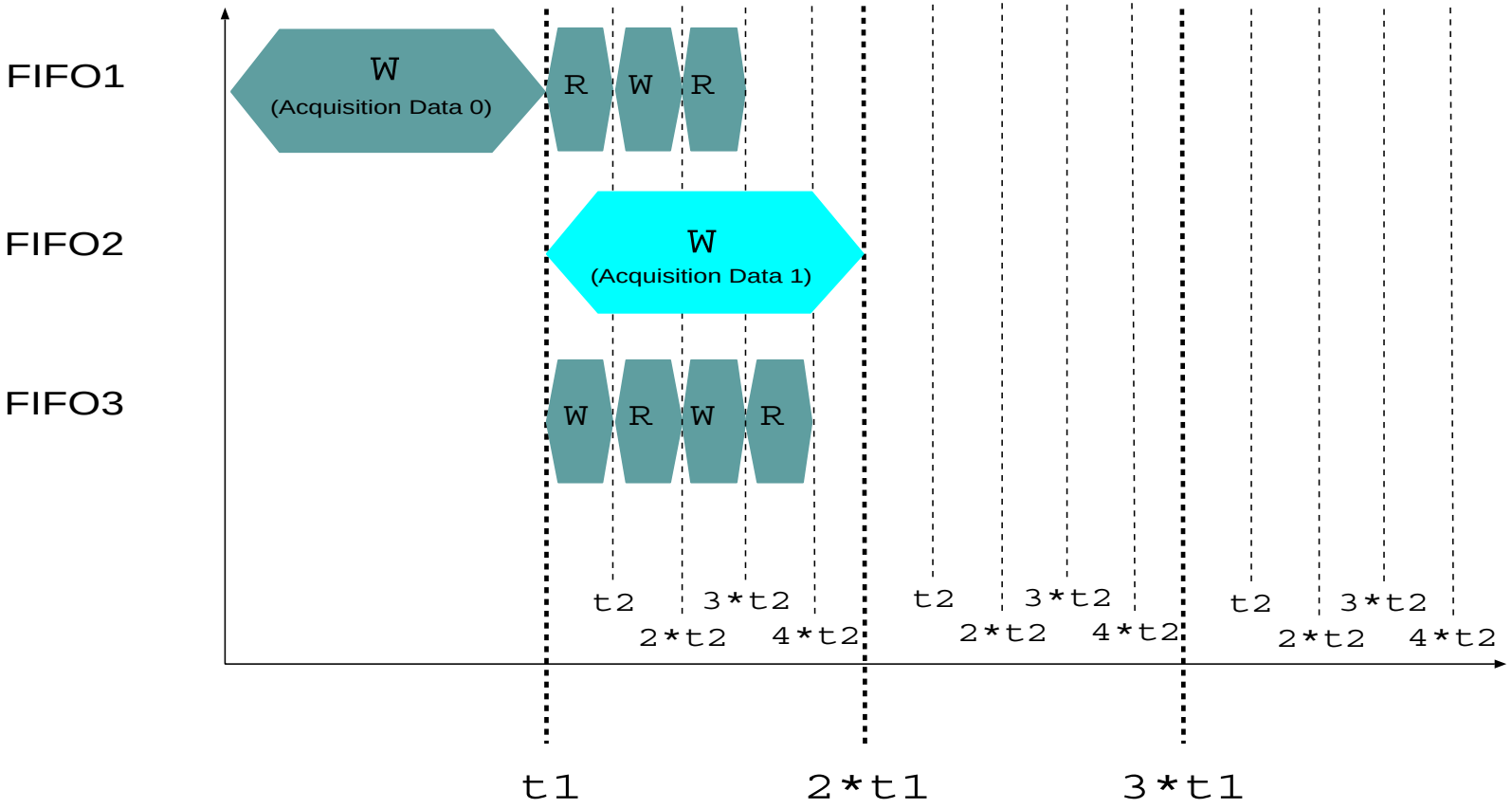
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

- `t1` : Acquisition period of new data
- `t2` : Compute layer period
- `R` : Fifo reading
- `W` : Fifo writing

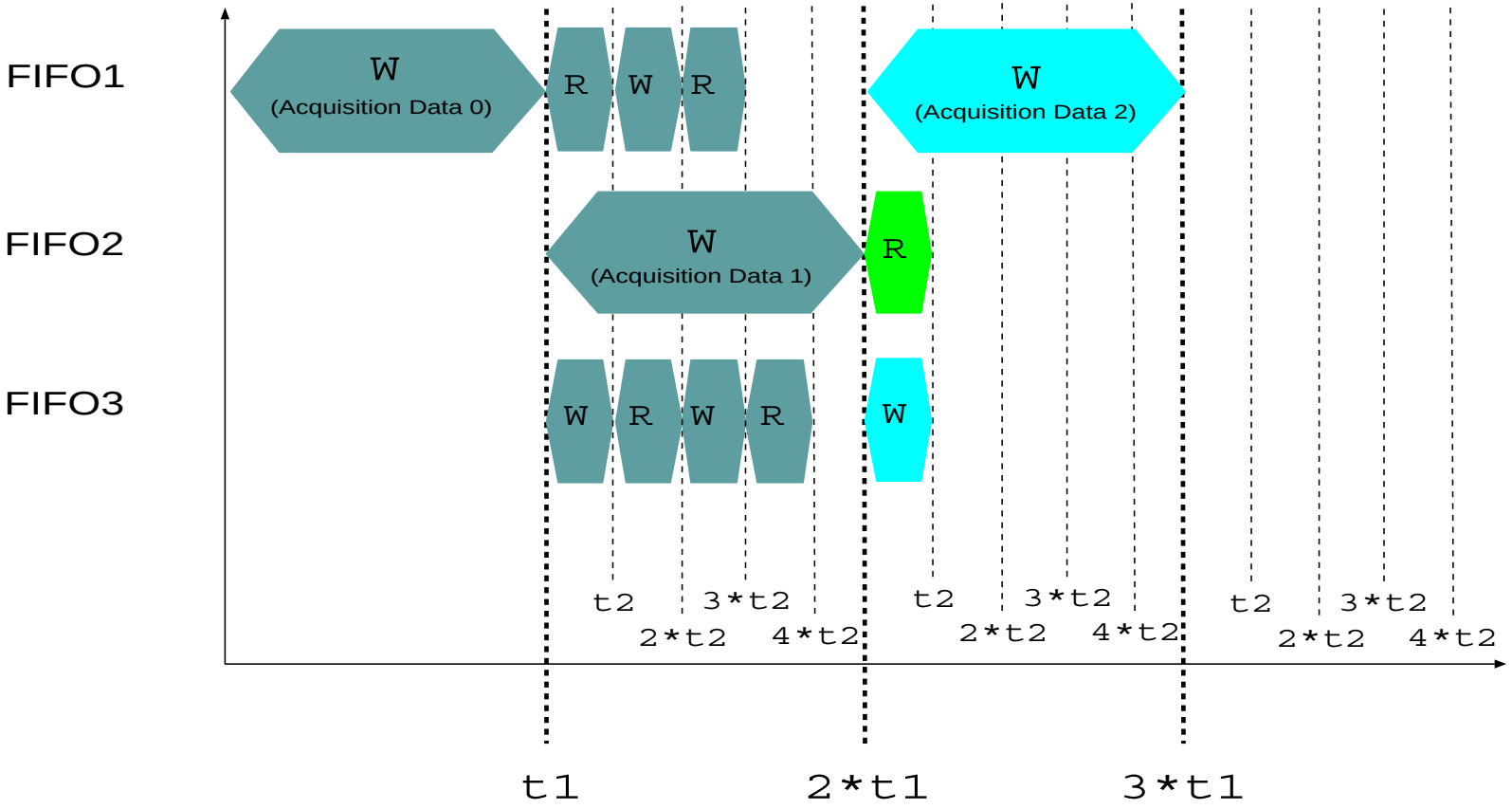
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

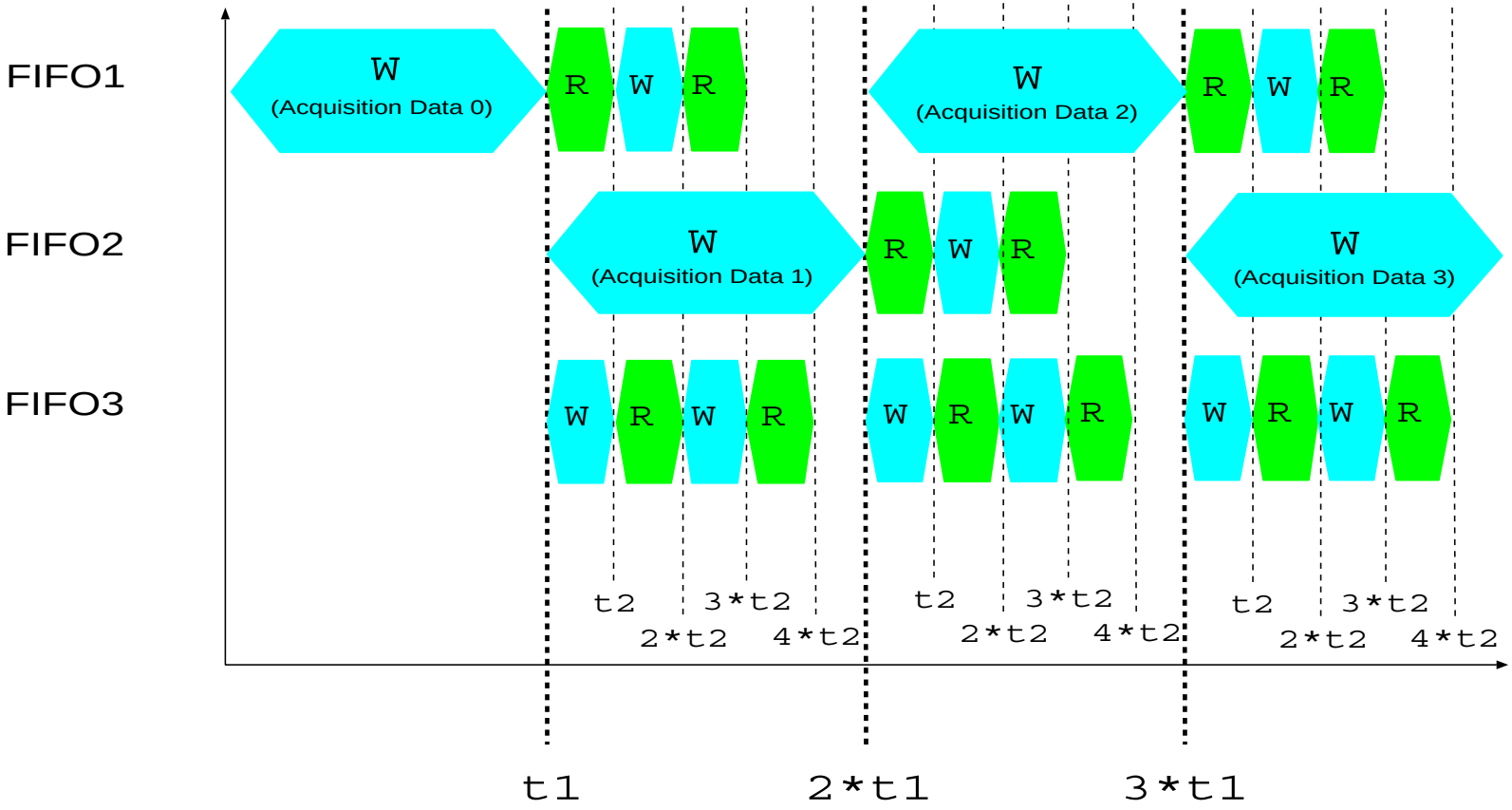
Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

Principle of Input-Output Unit Ping-Pong scheduling



Légende :

t1 : Acquisition period of new data
t2 : Compute layer period
R : Fifo reading
W : Fifo writing

What now?

- Paradigm
- Prototype is now under development
- Altera FPGA Apex20k Solution

Electronic System Methodology Evaluation

- Neural Networks simulation evaluation performances
- Time simulation prediction of a neural network
- Electronic system analysis

Time analysis of MAHARADJA

nbp : Number of post-synaptic potentials (Terminal layer of the connection)

nbe : Number of neurons (Initial layer of the connection)

Multi Layer Perceptrons

$$\sum_{i=1}^{N} \lceil \frac{nbe_i}{4} \rceil * (nbp_i + 2) + nbe_i + 1$$

Manhattan Distance

$$\left\lceil \frac{nbp}{4} \right\rceil * (nbe + 4) + \lceil \frac{nbe_s}{4} \rceil * (nbp_s + 2) + nbe_s + 1$$

Euclidian Distance

$$\left\lceil \frac{nbp}{4} \right\rceil * (nbe + 4) + \lceil \frac{nbe_s}{4} \rceil * (nbp_s + 2) + nbe_s + 1$$

Mahalanobis Distance

$$\left\lceil \frac{nbp}{4} \right\rceil * (nbe^2 + 6 * nbe + 2) + \lceil \frac{nbe_s}{4} \rceil * (nbp_s + 2) + nbe_s + 1$$

Time Comparizon

System	Frequence (MHz)	Time (μs)
MAHARADJA 4 UNE	10	6.5
MAHARADJA 8 UNE	10	3.2
MAHARADJA 8 UNE	20	1.6
PENTIUM	800	5
ULTRA SPARC	333	13

Conclusion

- MAHARADJA simulate the MLP neural networks
- Real time simulation of RBF and MLP
- Satisfy *μs* time constraint.