

N2S3 Is Ready To Run Simulations !



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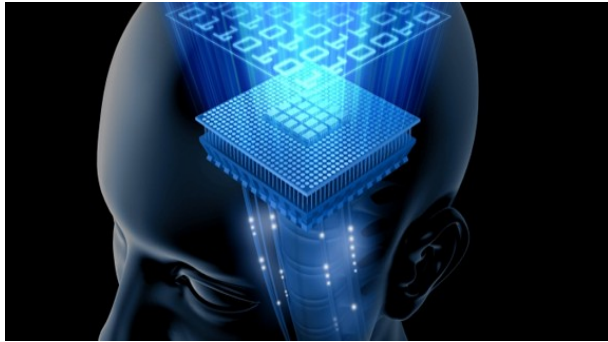
Émeraude team



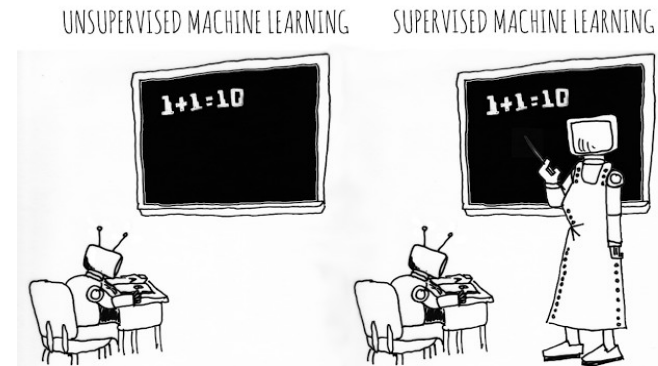
N2S3: **N**eural **N**etwork **S**calable
Spike **S**imulator
[Nessy]



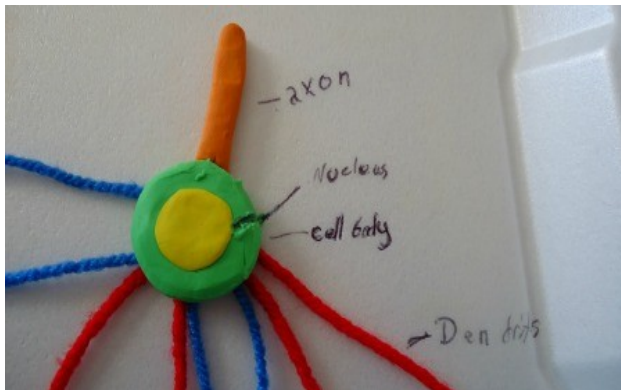
Why a simulator for neuromorphic accelerators?



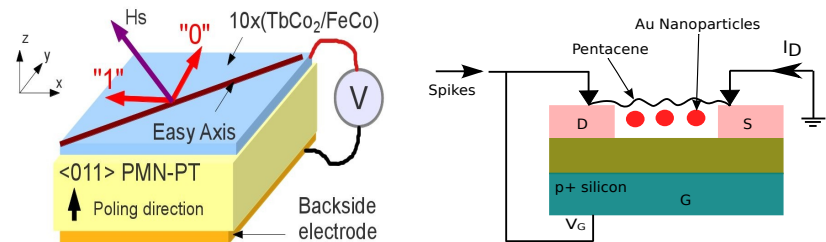
Architecture explorations



Learning algorithms



Models of Neuron



Models of Synapse

Other Simulators

Simulator	Language/year	Characteristics
NEURON	C-Python extension / 1983	GP, Clock-driven, Powerful GUI, biologic Numerical Model (NM)
Nest	C++, Python extension/2002	GP, Event-driven/Clock-driven, ANN, GUI, NM
CSIM	C++, Matlab extension/2001	GP, Event-driven/Clock-driven, No GUI, biologic, NM
Brian	Python/2008	GP, Clock-driven, NO GUI, biologic, NM
Xnet	C++/2011	SP, Event-driven, No GUI, ANN, NM
NEGO	Python-Java/2001	SP, Clock-driven, GUI, ANN, NM
GeNN 2	C++-C/2011	SP, Clock-driven, GUI, ANN, NM
N2S3	Scala/2014	SP, Event-driven, GUI not yet, ANN, Analytical Model

Another Simulator!

- Event-based
- Analytical Model
- Scalable
- Extensible

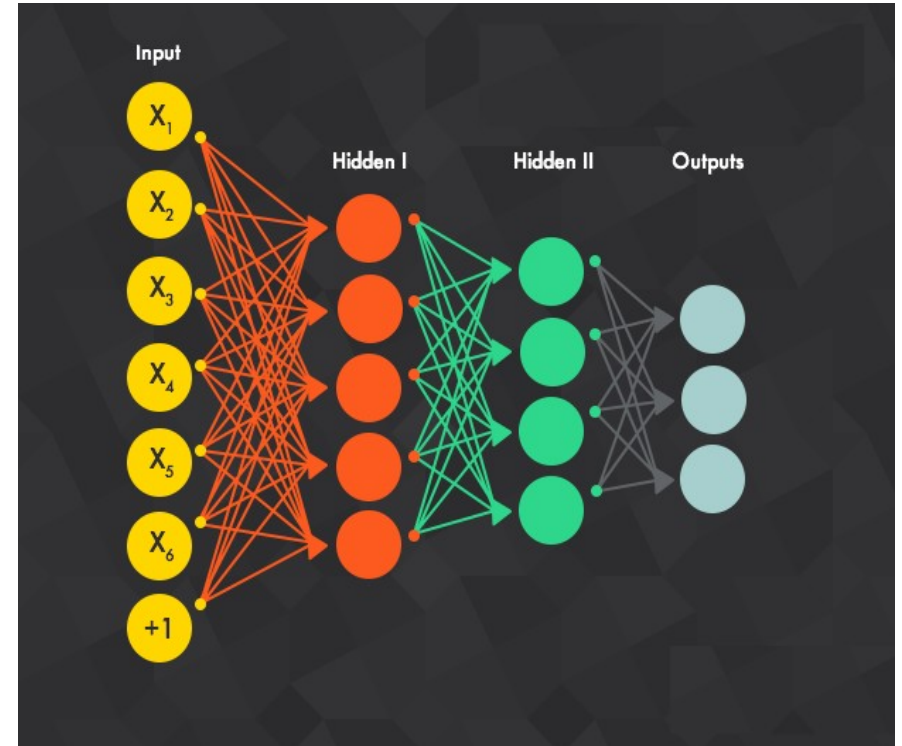


Outline

- What did we achieve?
- Architecture of N2S3
- Summary & Roadmap

Network Topology

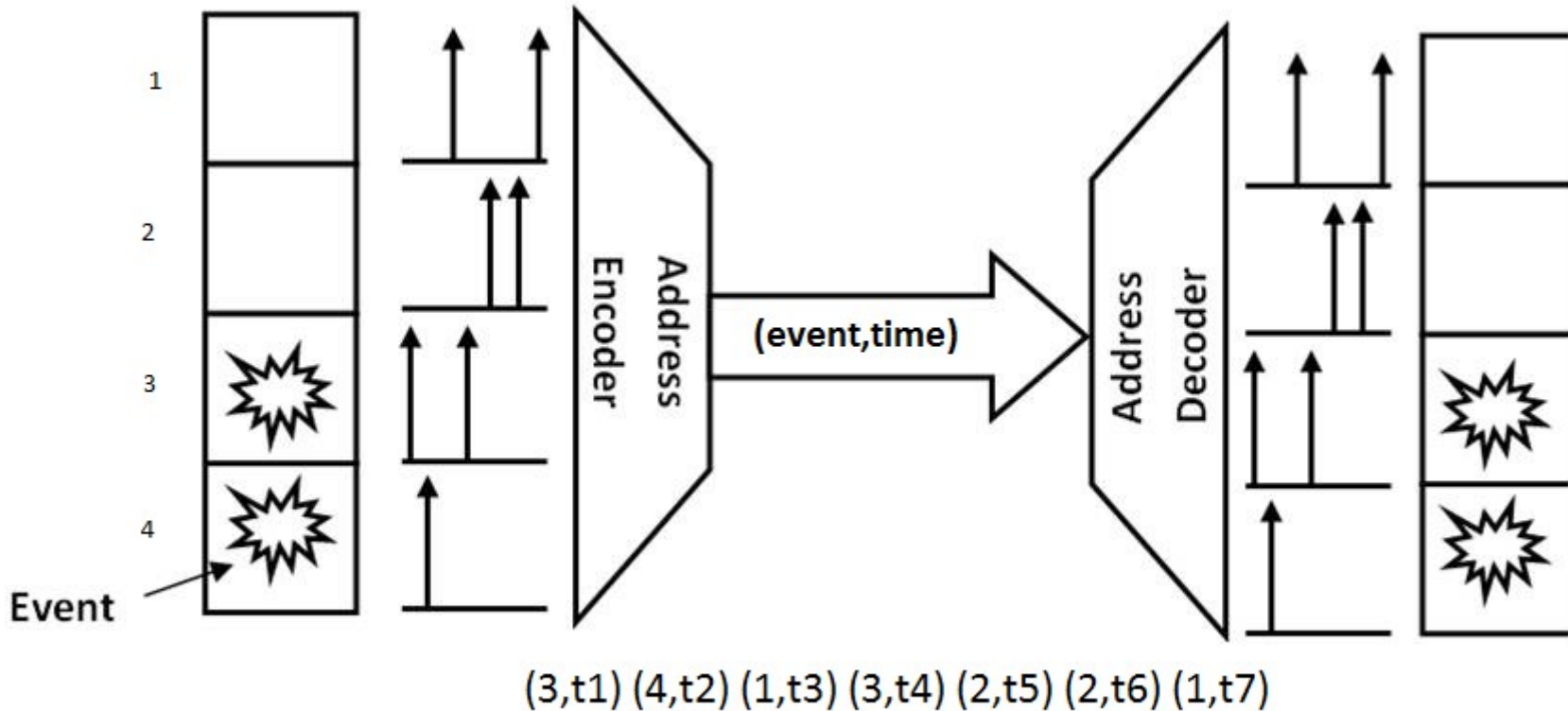
Restricted Boltzmann Machine
(Fully interconnected layers)



Adjusting the weights of synapses by using STDP learning method.
STDP: Spike Timing-Dependent Plasticity

Standard Inputs

- Address Event Representation (AER)

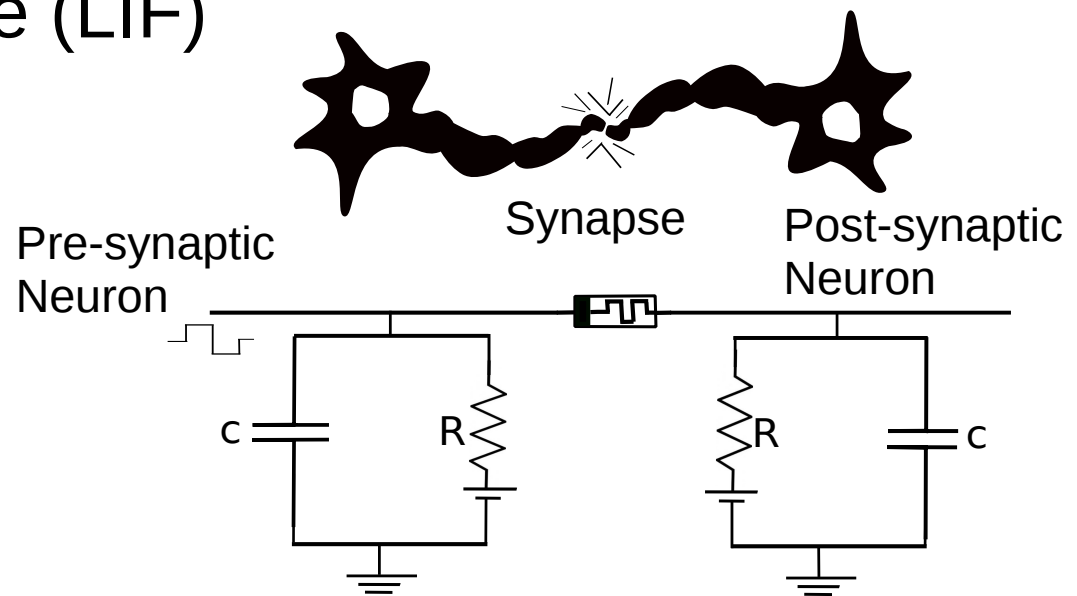


- XML network topology (node, edge, weight)

Model of Neuron & Synapse

- Neuron Model:

Leaky Integrate & Fire (LIF)



- Synapse Model:

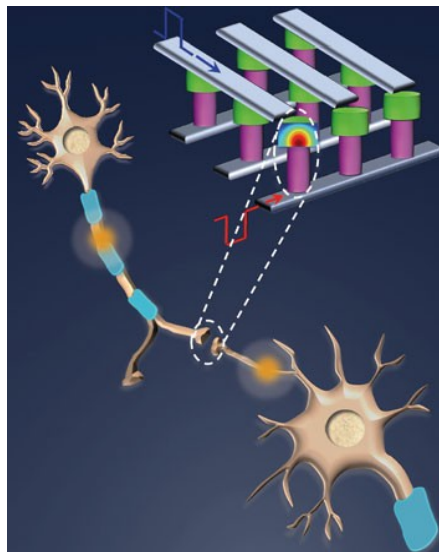
Memristor model presented by O.Bichler

Which outputs?

- There are three types of outputs in the system:



Neuron activity (Time of events, Action Potential)



Synapse activity (Time of events, Synapse Conductance)



Synchronizer report

Architecture of the N2S3

- Technical platform
 - Scala
 - Akka Actors
- Main Package
 - Core
 - Feature
 - Model
 - Experiment

Why Scala!

- Programming language for JVM
- Functional and Object-Oriented
- Strongly typed
- Concise
- Extensible
- Concurrent and distributed computing



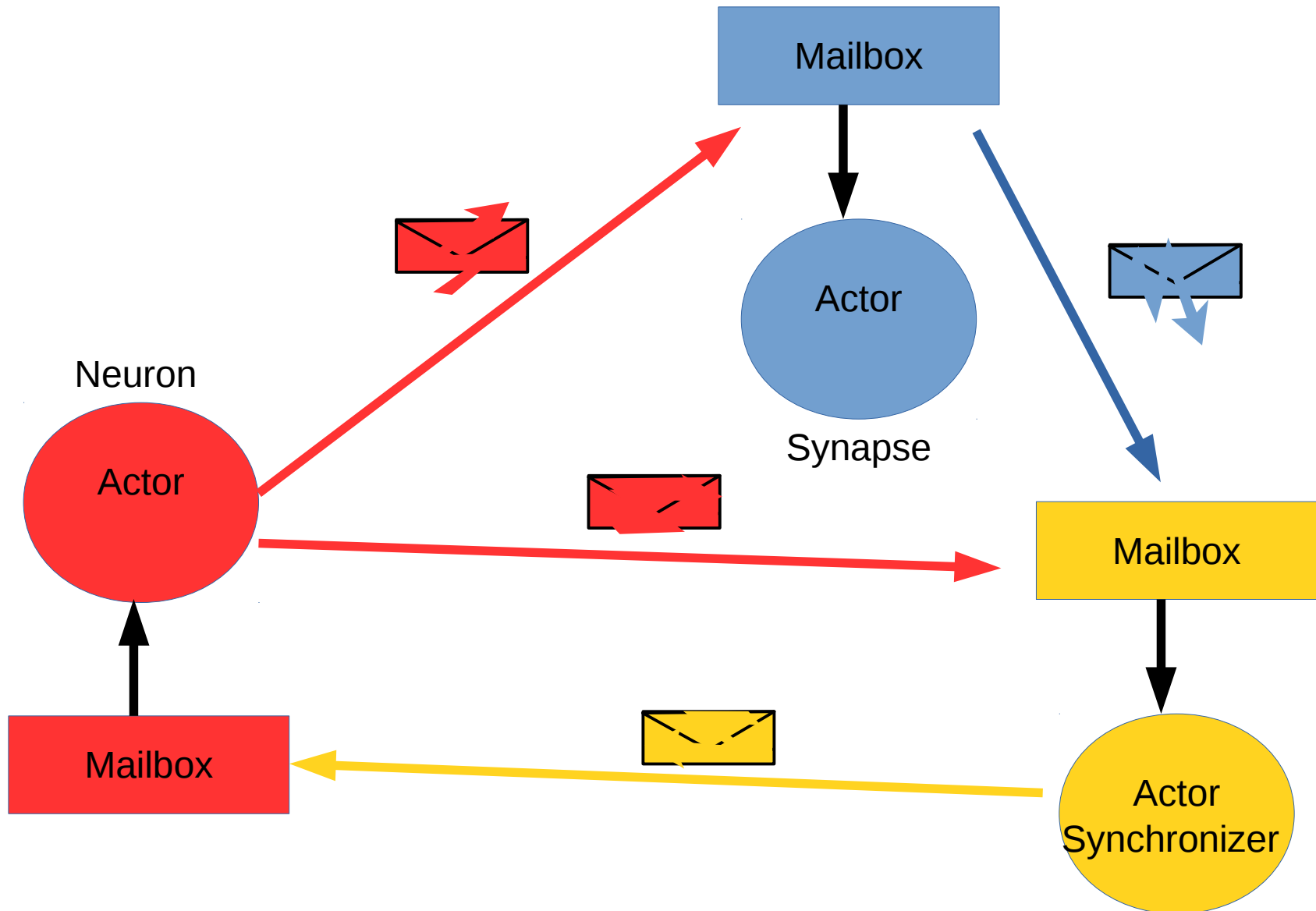
Event-based

Analytical Model

Scalable

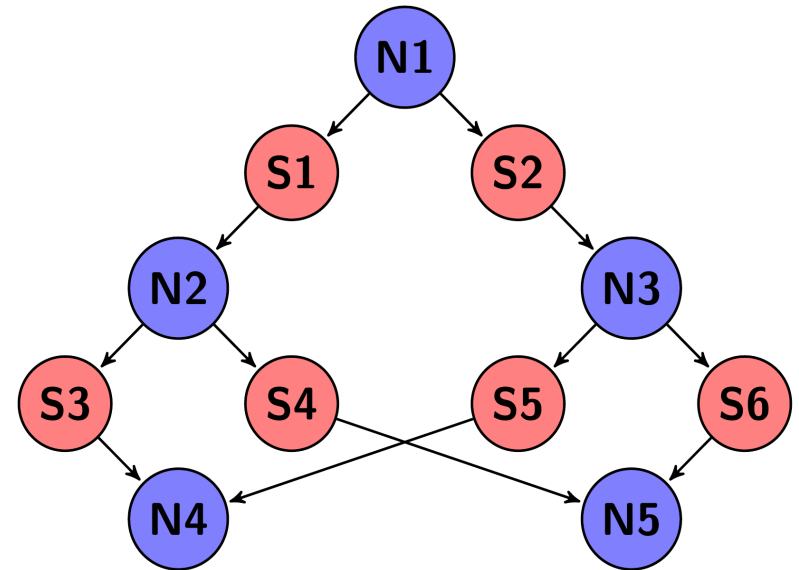
Extensible

Akka Actor



Main Package-Core

- Create Network (connections)
- Create Neuron (computing unit)
- Create Synapse (memory)
- Message (communication)
- Synchronizer(s)



The core is hidden from user,
user can change the models

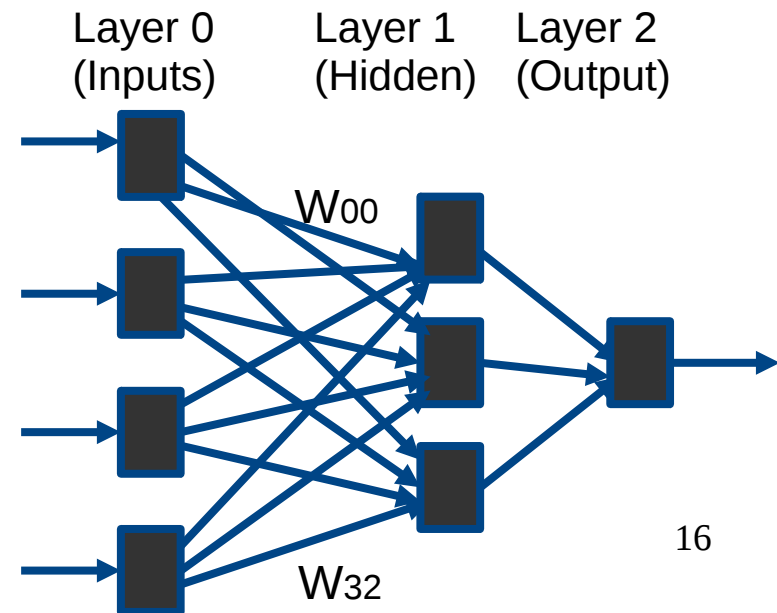
Main package-Feature

- Read an input AER file and generate the events
- Generate Log output files:
 - **Neuron** (membrane potential, timestamp)
 - **Synapse** (weight of the synapse, timestamp)
 - **Global trace : AER file**

Main Package-Model

- In Model, user can define his own model
- Define network (RBM)
- Define Neuron model (LIF)
- Define Synapse (Memristor model)

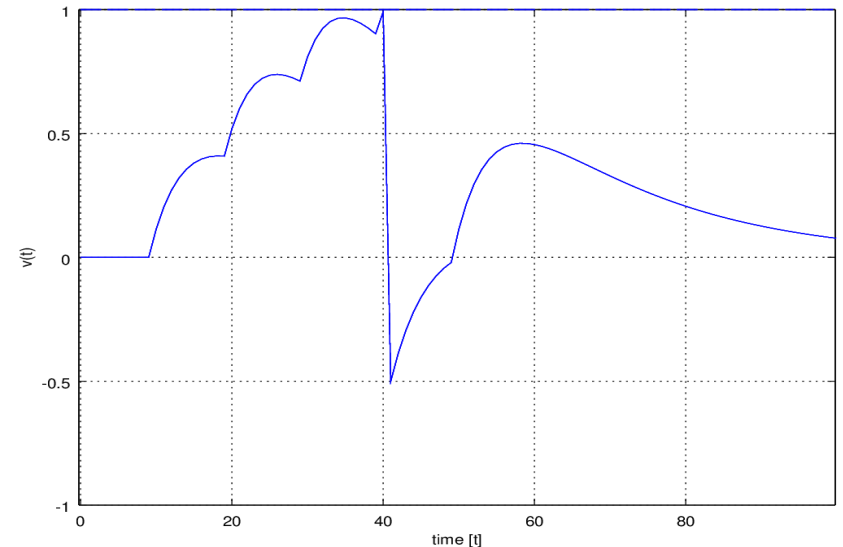
```
val nbNeuronPerLayer = Seq(4, 3, 1)
val net = new Network(nbNeuronPerLayer)
```



Neuron Model

- **L**eaky **I**ntegrate & **F**ire (LIF)

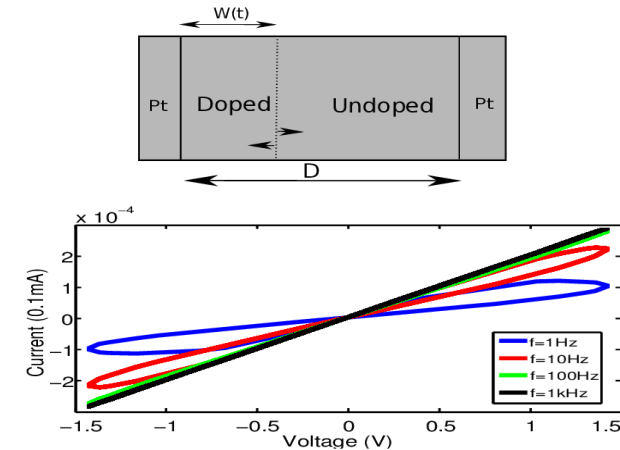
LIF type neuron models are very **fast to simulate**, and are particularly attractive for **large-scale network simulations**.



$$\tau_{neuron} \frac{dv}{dt} + G_{neuron}(t)V = I_{input}$$
$$G_{neuron}(t) = G_{leak} + G_{syn}(t)$$

Synapse Model

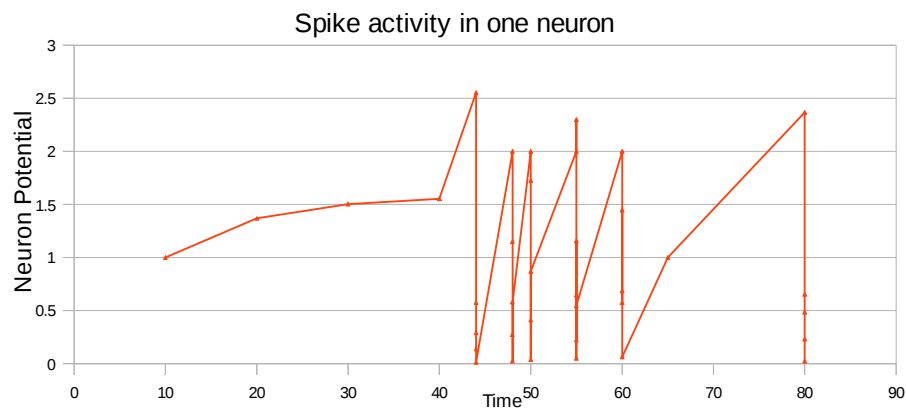
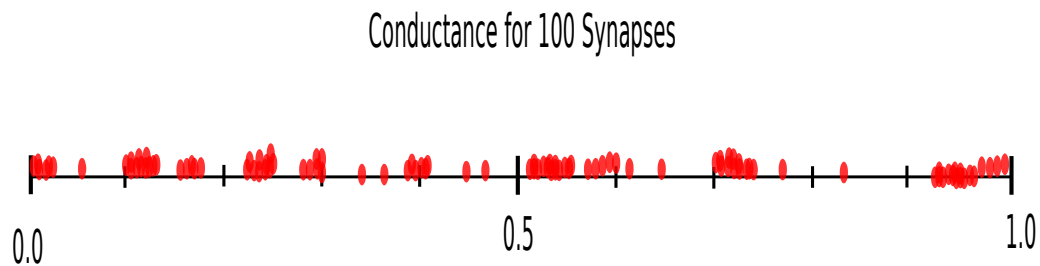
- We started with Bichler's model
 - Phase Change Memory (CPM)
 - Conductive Bridge RAM (CBRAM)
 - NOMFET- Filamentary Switch
 - Magnetoelectric Memory
 - Resistive RAM (RRAM)



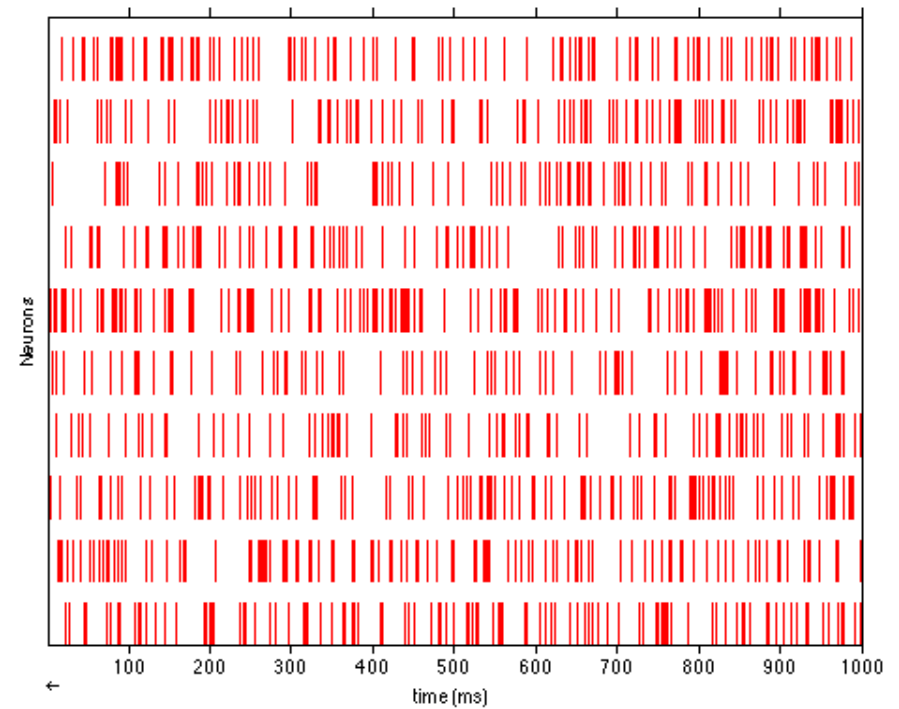
```
def increaseWeight(timestamp: Int) = {  
    var dg=alf_p * exp(-beta * ((g-g_min)/(g_max-g_min)))  
    g=min(g_max,g+dg)  
}  
def decreaseWeight(timestamp: Int) = {  
    var dg = alf_m * exp(-beta * ((g_max-g)/(g_max-g_min)))  
    g=max(g_min,g-dg)  
}
```

Experiments (Freeway AER)

Synapse conductances



Neuron spikes



Summary & Roadmap

- **Increase collaboration with you!**
- Replicate Bichler's experiments
- Relax synchronization
- Optimize the Core in N2S3
- Improve visualization with MINT/Mjolnir

We appreciate master students:

Quentin Bailleul

William Gouzer

Benjamin Danglot

Pierre Falez

Help us to make a better simulator and we can now send our message to you as:

N2S3 Is Ready To Run Simulations!