The Neurorobotics Platform in HBP
Current state and upcoming changes

HBP CodeJam #12
November 25th, 2021

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State of the NRP

The NRP as it is available today:

- Latest full release: v3.2
- Both v3.2 and v3.0.5 available online.
- Docker images also available for both.
- 3.0.5 last NRP release based on Python 2.7

Release 3.0.5	Release 3.2
Python 2.7	Python 3.8
Ubuntu 18.04	Ubuntu 20.04
ROS Melodic	ROS Noetic
Gazebo 9	Gazebo 11.3
NEST 2.12	NEST 2.18
PyNN 0.9.4	PyNN 0.9.5

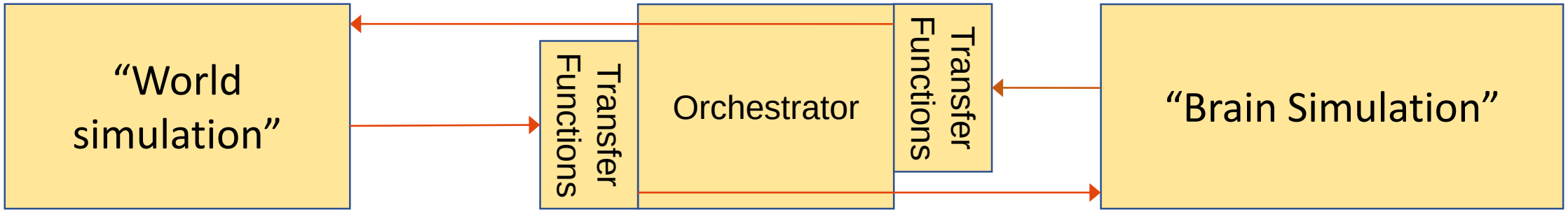
The future of the NRP as it is being prepared now:

- Release 4.0 (est. March 2022)
- NRP-core for orchestration of simulation modules (also as standalone)
- New frontend based on REACT (incl. refactored proxy for new infrastructure)

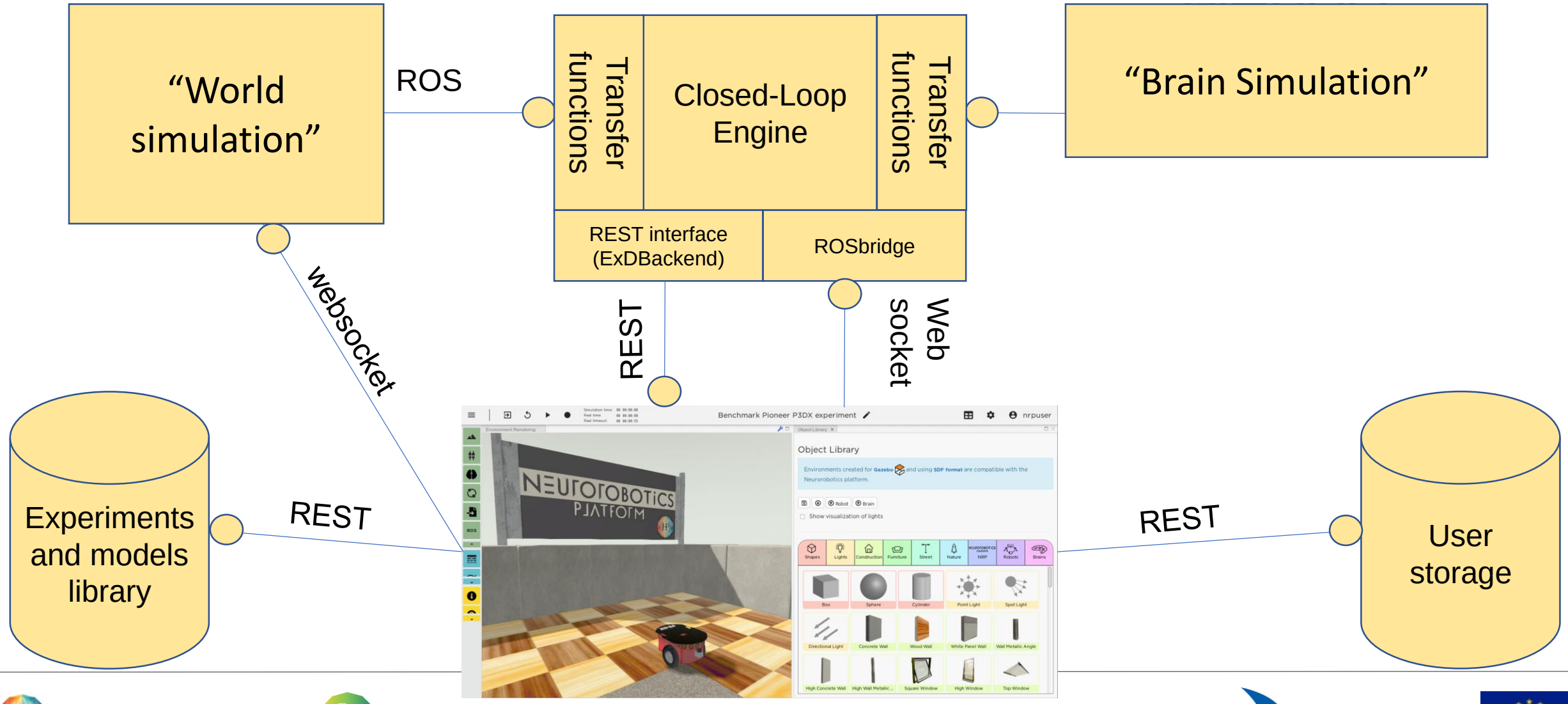
Simulations in NRP v3.x

NRP simulations are based on fixed time increments and comprise:

- A “World Simulation” component
  (embodied agent interacting with a physically relevant environment)
- A “Brain” component
- A set of Python functions (transfer functions) to define the brain-body connection
- An orchestration mechanism to synchronize execution of the above components



NRP: base architecture of v3.x



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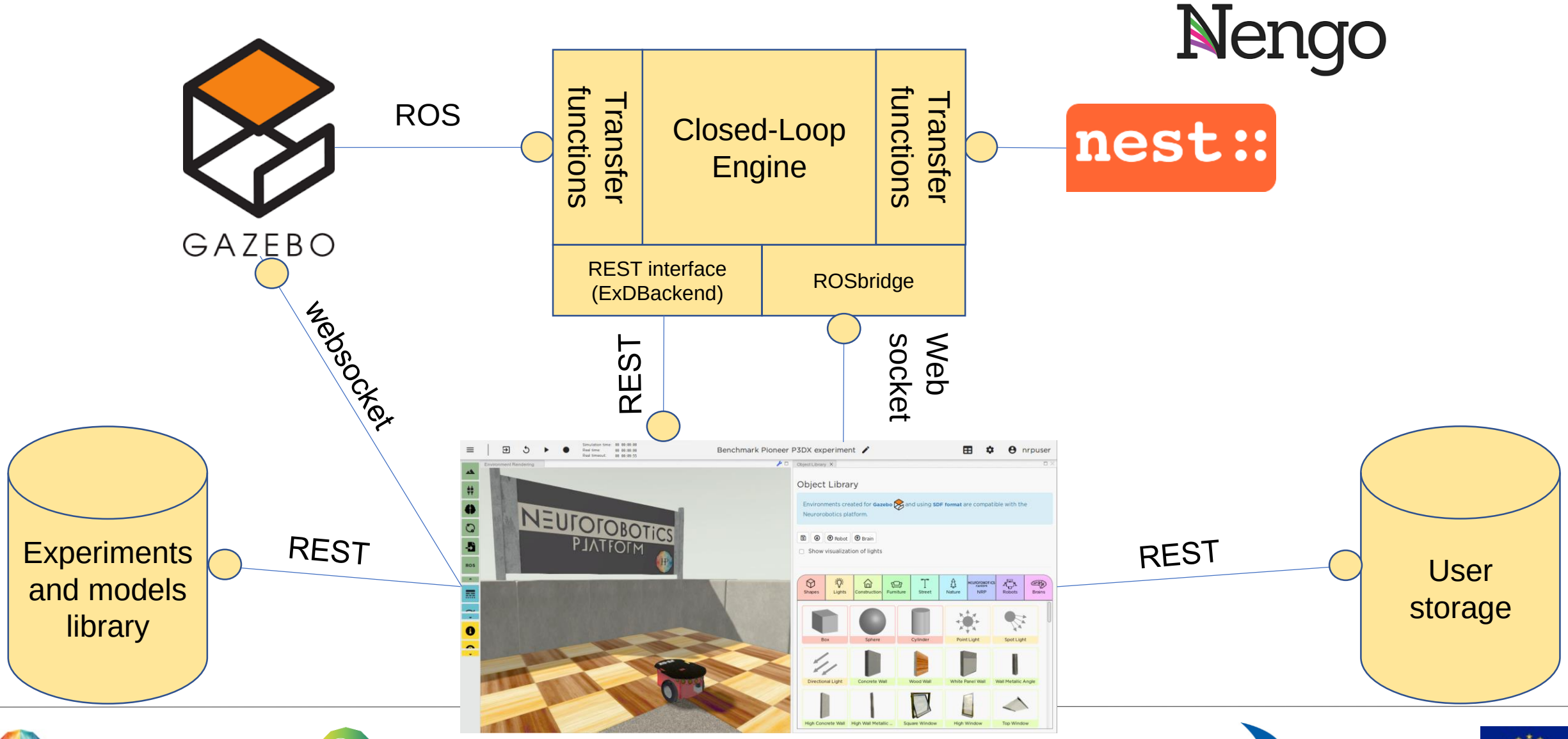
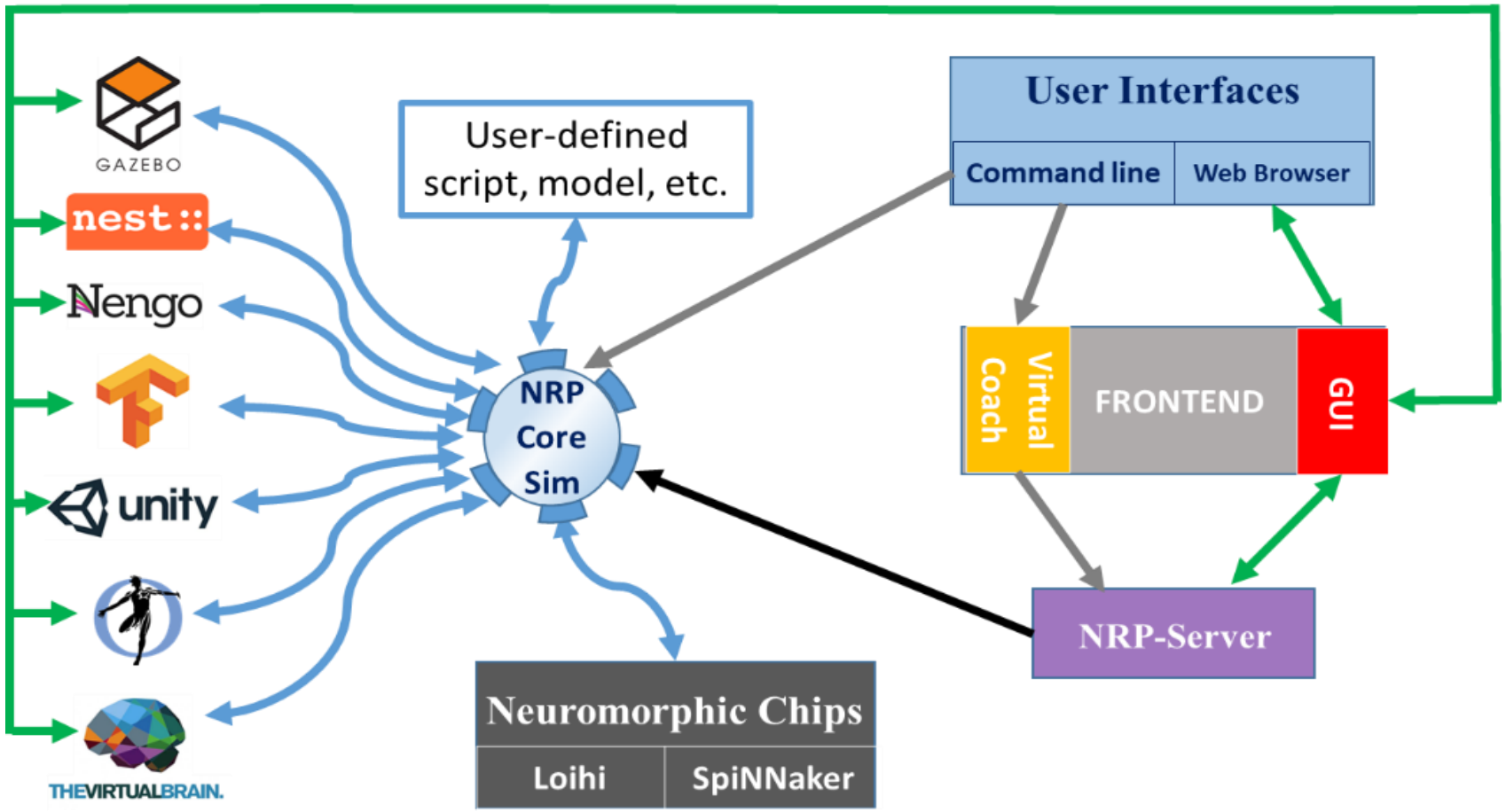
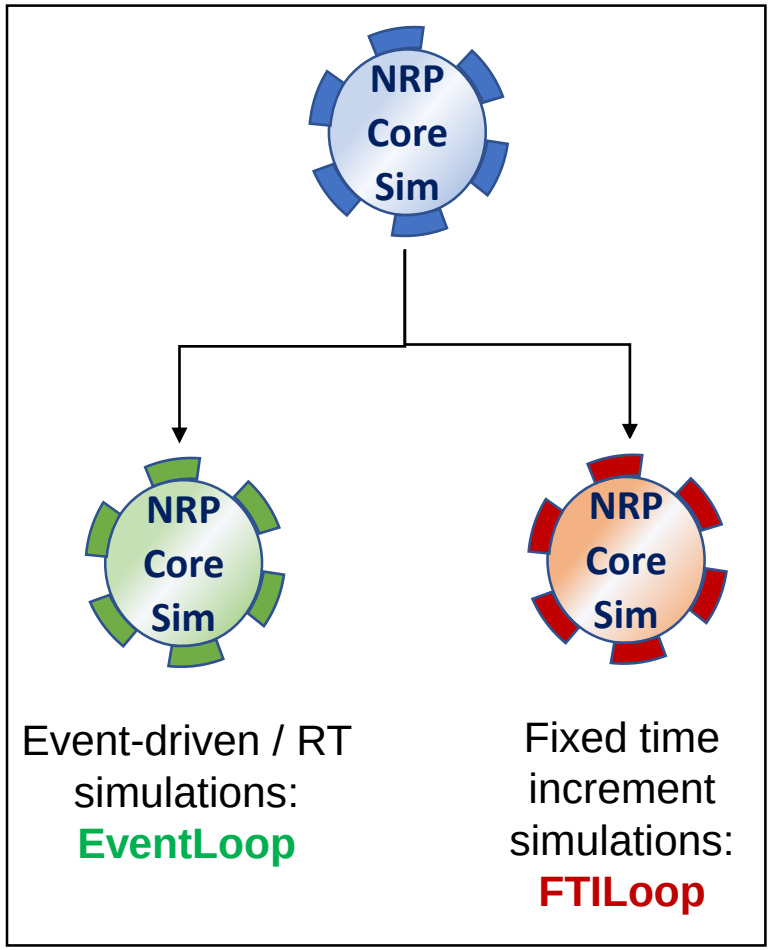


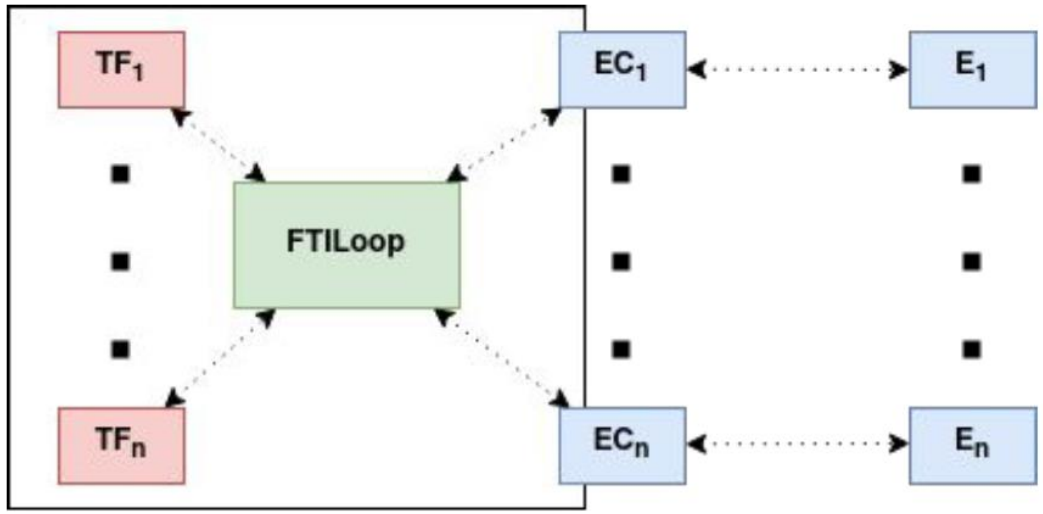
NRP v4.0: a true integrative simulation framework

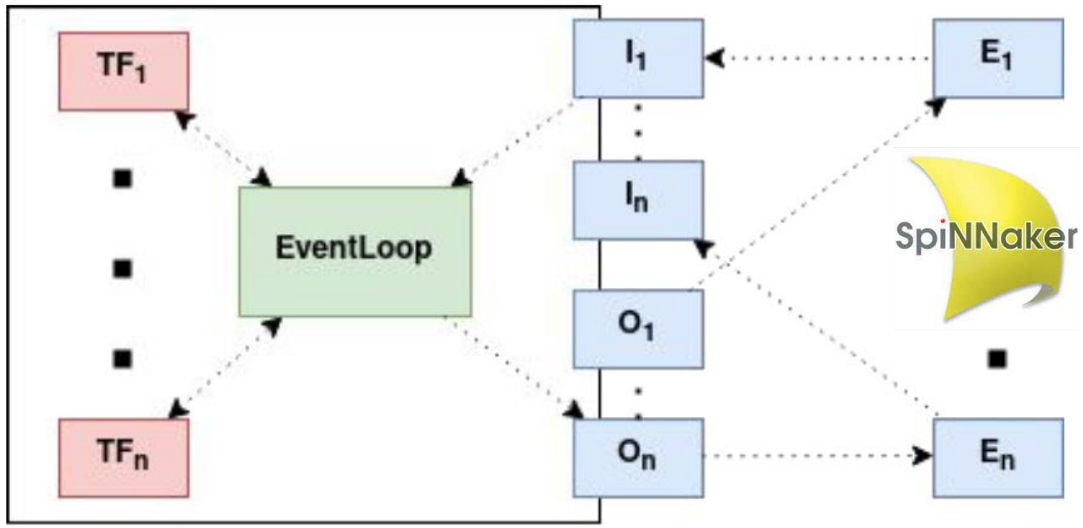




https://bitbucket.org/hbpneurorobotics/nrp-core/src/master

FTILoop vs EventLoop





- En: Nth engine
- En: Nth engine client
- TFn: Nth transceiver Function

- TFn: Nth transceiver function
- In: Nth input node
- On: Nth output node

Contact: Eloy Retamino @ UGR

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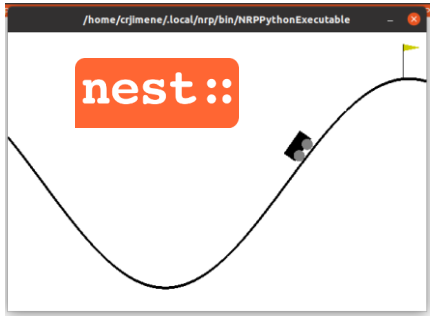
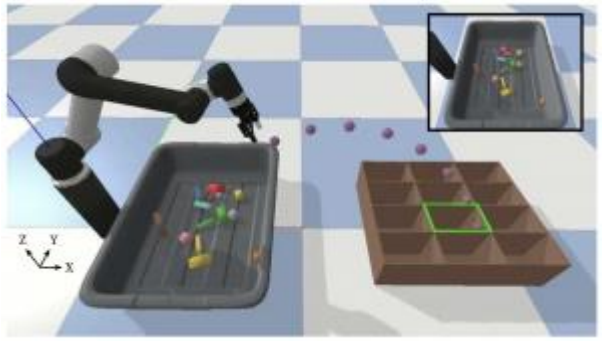
Using NRP 4.0

New models + environments + AI frameworks with NRP v4



OpenAI gym

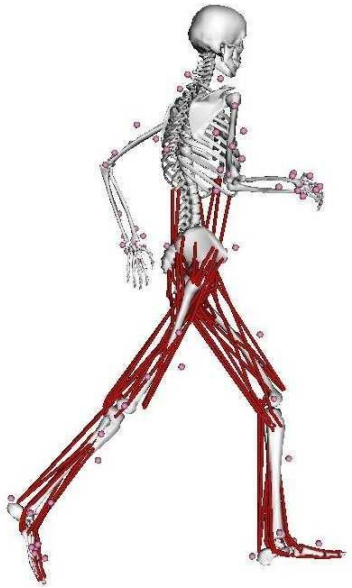


PyBullet

BULLET PHYSICS LIBRARY

THEVIRTUALBRAIN.

OpenSim



unity

L2L

IMPALA

SEED RL

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https://www.youtube.com/watch?v=fPrDSwJhh1M

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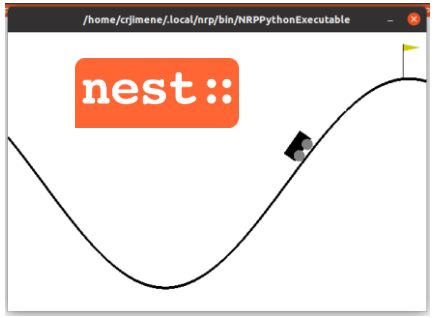
New models + environments + AI frameworks with NRP v4

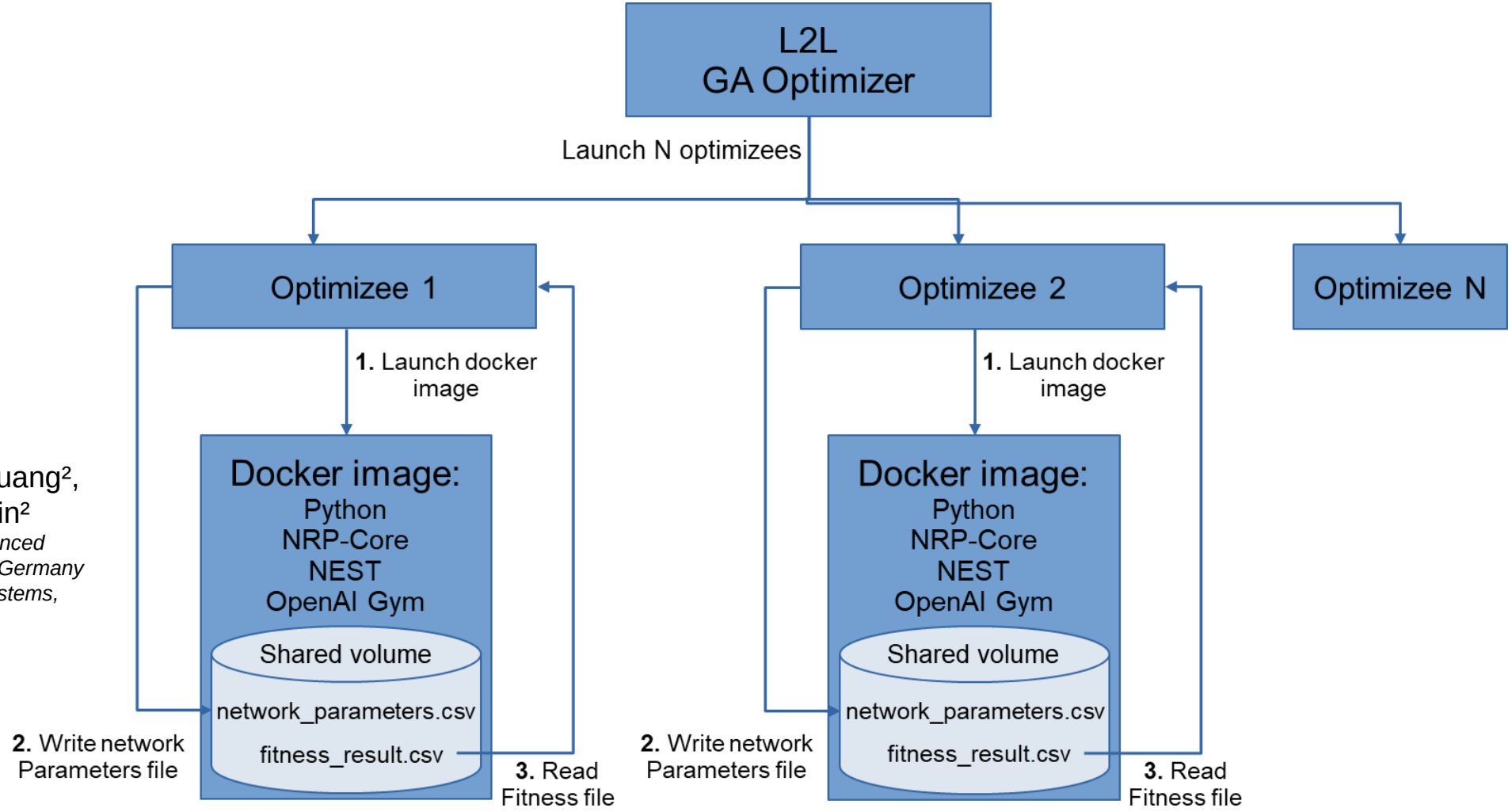


OpenAI gym

Cristian Jimenez Romero[1], Yuhong Huang[2], Alper Yegenoglu[1], Fabrice O. Morin[2]

[1] Simulation Lab Neuroscience, Institute for Advanced Simulation, JARA,Forschungszentrum Jülich, Jülich, Germany

[2] Robotics, Artificial Intelligence and Real-Time Systems, Technical University of Munich, Germany



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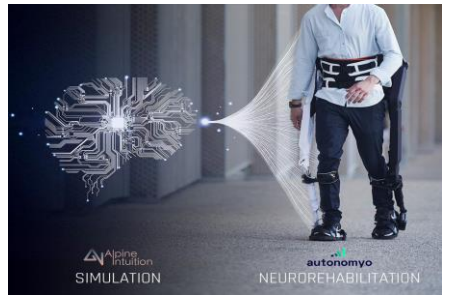
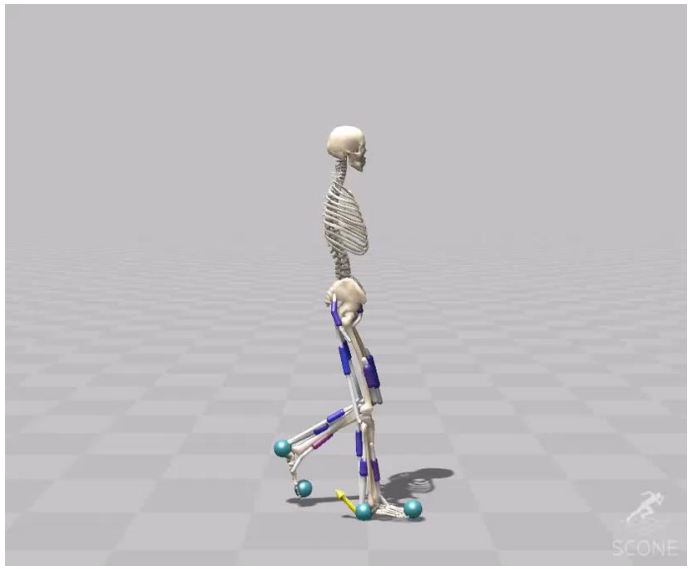
Closed-loop exoskeleton simulation for personalized assistive rehabilitation



Simulation of a subject

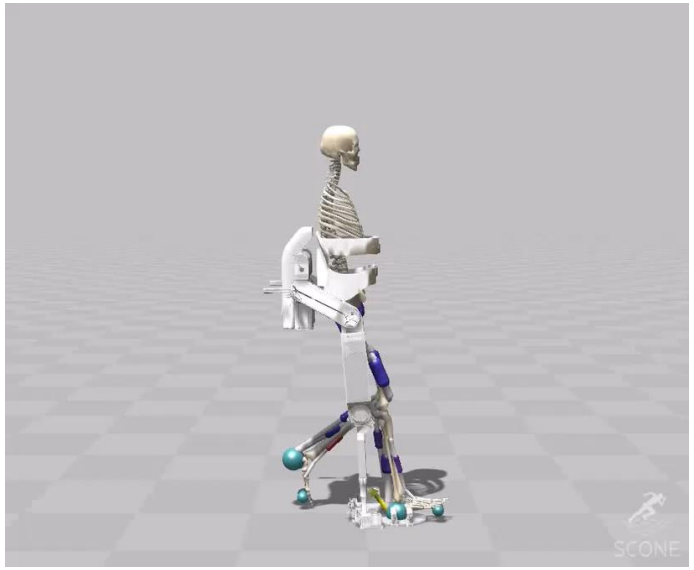
A mapping strategy to transfer human data into simulation



We are gathering data from stroke patients as an initial objective

Exoskeleton OFF

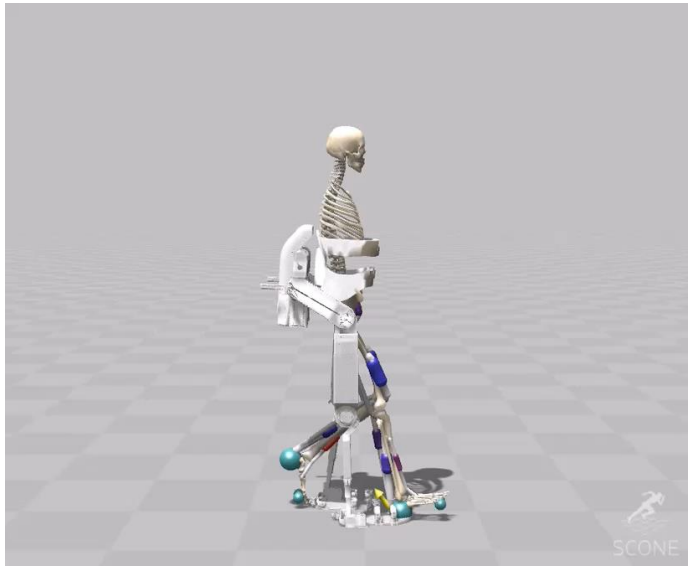
Subject performs worst due to additional weight of the exoskeleton



Integration of the pipeline to NRP is underway

Exoskeleton ON

The gait is improved once the exoskeleton is active to compensate muscle deficiency



We have been working on several control strategies: Impedance control, Model Predictive Control and Reinforcement Learning

Contact: Dr. Berat Denizdurduran, CSO - Alpine Intuition, berat.denizdurduran@alpineintuition.ch

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Large-scale NEST simulations with NRP 3.2 on Piz Daint

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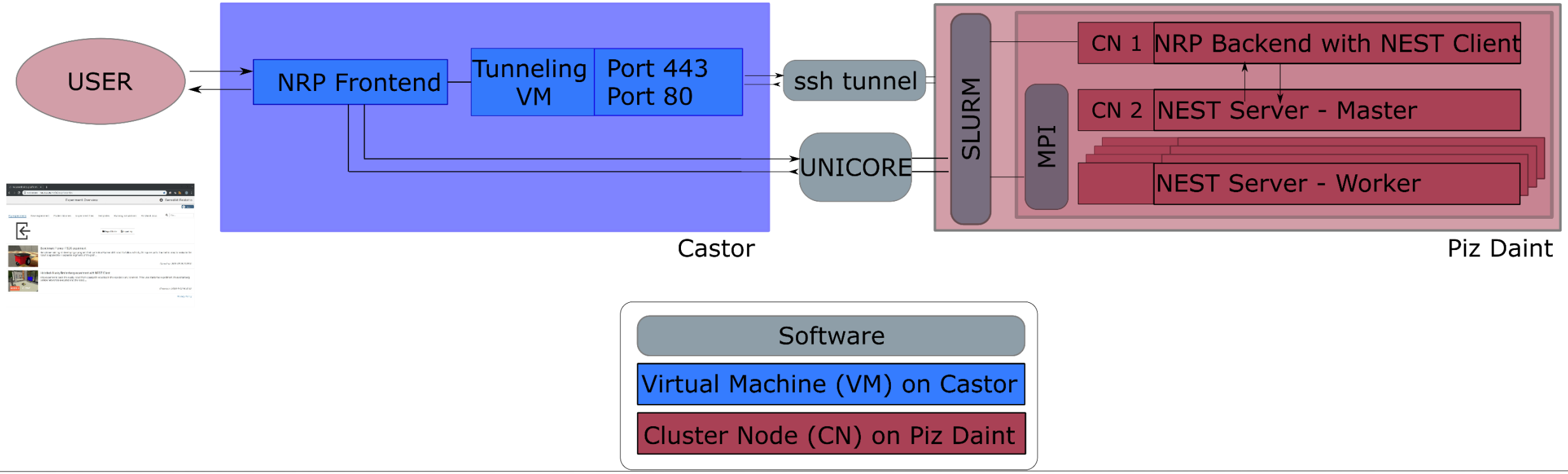
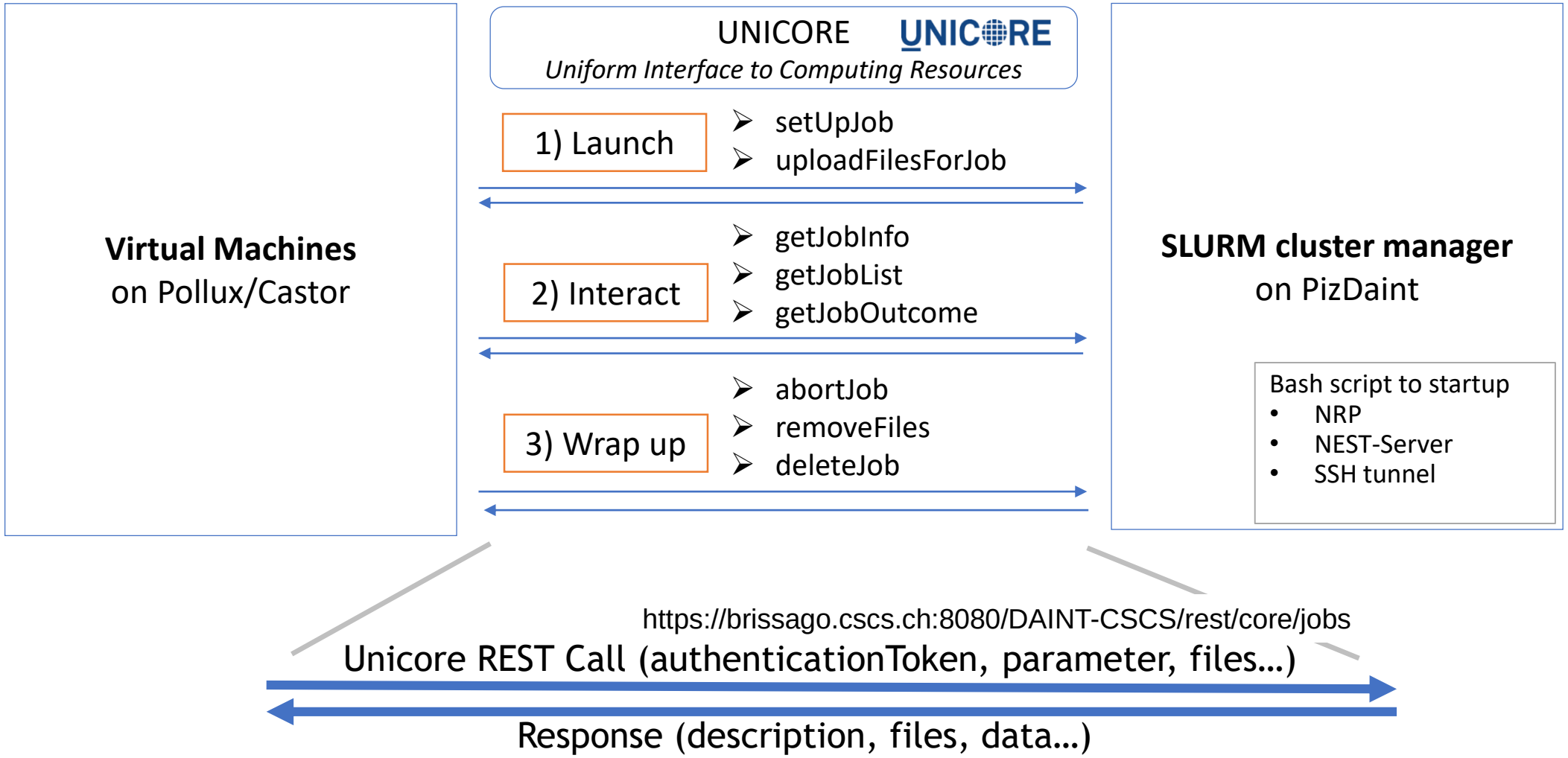
Architecture Diagram

User centric architecture interfacing

persistend and requested compute resources

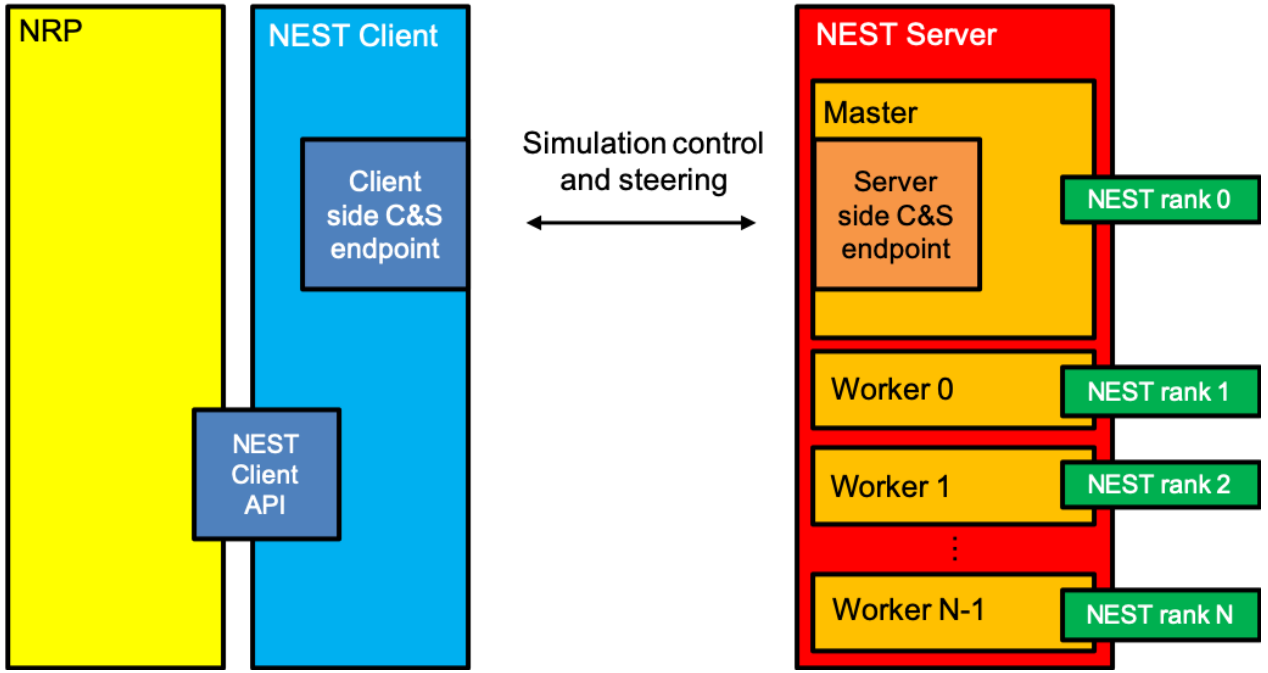


UNICORE REST Interface



Parallelization across multiple Compute Nodes

- **Client-Server** REST interface between NRP and NEST Server
- **MPI Parallelization** of NEST worker processes



Compute Node NR:	1	2	3	4	...	N
Process:	NRP with NEST Client	NEST Server • Master • Worker 0	NEST Server • Worker 1 • Worker 2	NEST Server • Worker 3 • Worker 4	...	NEST Server • Worker (N-1)*2-2 • Worker (N-1)*2-3

Initialized number of Cluster Nodes defined by User

Thanks to the collaborators

Last Mile Developer Team:

- Jochen Martin Eppler (NEST Server/NEST parallelization)
- Cristian Jiminez Romero (NEST benchmarks)
- Christopher Bignamini (CSCS infrastructure)
- Benedikt Feldotto (Simulation as a service/RoboBrain)

CSCS Supercomputing Center

- Christopher Bignamini
- Felipe Cruz
- Colin McMurtrie

NEST Simulation

- Jochen Martin Eppler
- Cristian Jimenez-Romero
- Wouter Klijn
- Abigail Morrison

Neurorobotics Platform

- Benedikt Feldotto
- Viktor Vorobev
- Ugo Albanese
- Eloy Retamino
- Alois Knoll
- Fabrice Morin

RoboBrain Model

- Carlos Enrique Gutierrez
- Sun Zhe
- Morteza Heidarinejad
- Jun Igarashi
- Kenji Doya

And everybody who contributed a bit or byte to this setup and the tools it is build on.

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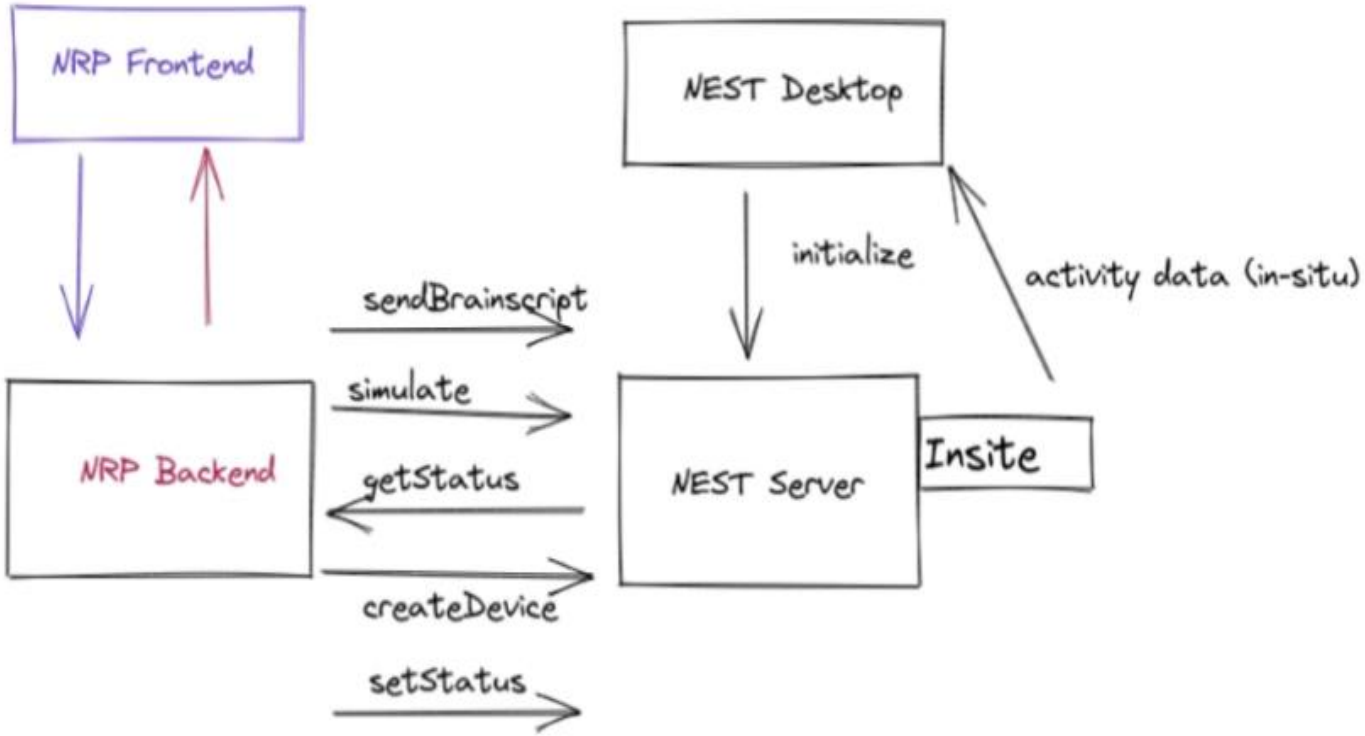
Integration with HBP tools and infrastructure: towards EBRAINS services

Integration with NEST-Desktop + Insite

- **NEST-Desktop** as network design tool
- **Insite** for “real-time” display of neuronal activity (e.g. spike raster plot, membrane voltage, etc.)
- **NRP** as provider of embodiment and tools for brain/body connection



Objective: Graphical tool for teaching computational neuroscience and neurorobotics?

Future EBRAINS services based on the NRP

- **Large-scale embodied simulations** with of spiking NNs with distributed NEST simulations
- **Virtual Public Library:** Access complete experiments online that accompany publications, lectures, etc.: run, modify, observe, share with readership or classmates.
- **Synthetic data generation** and **distributed learning / optimization** (e.g. Reinforcement Learning)

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THANK YOU!

http://neurorobotics.net/

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