GENESIS 3 as a convenient software integration platform: A dedicated example.

Realtime tuning and verification of compartmental cell models using RTXI and GENESIS.

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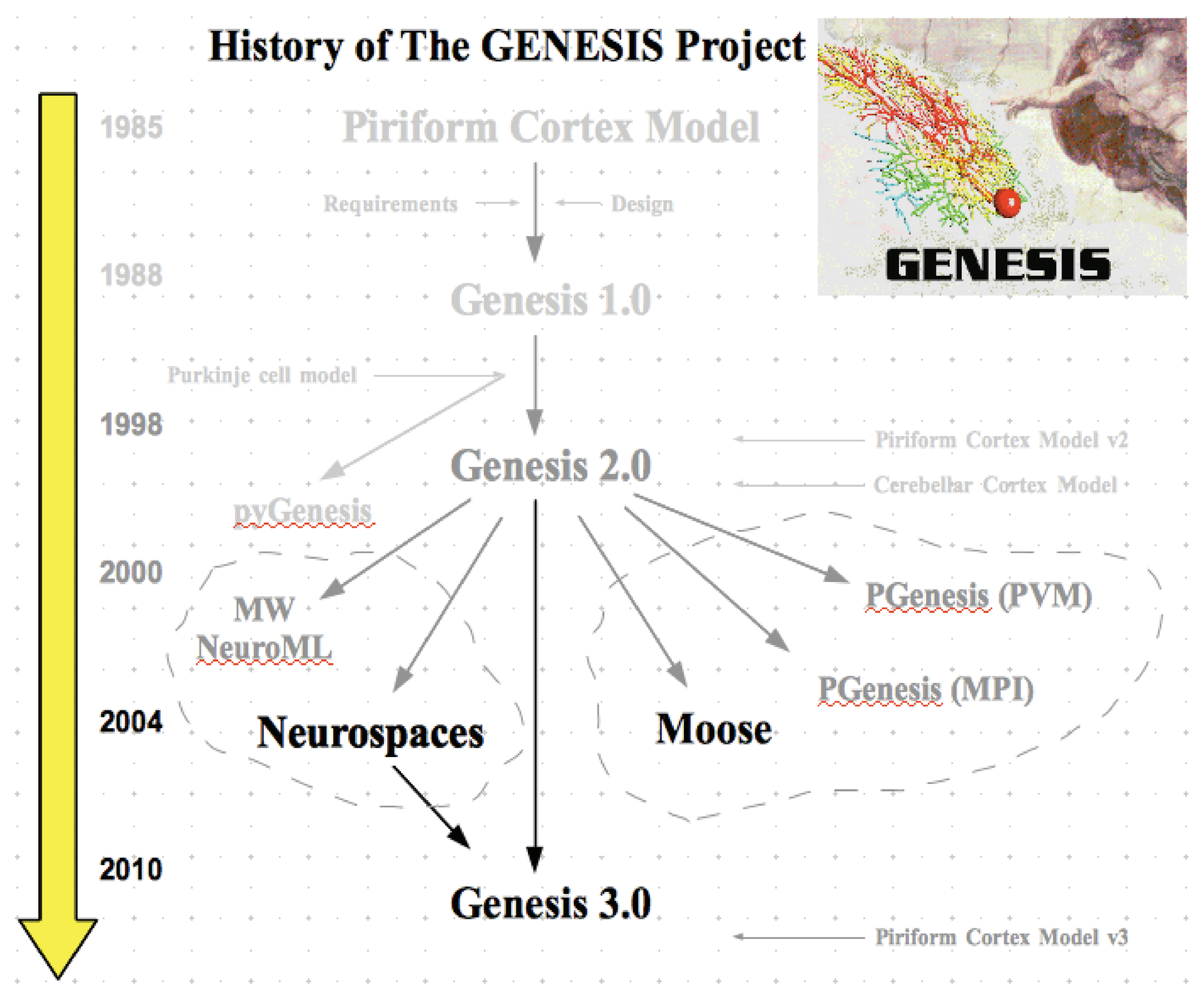
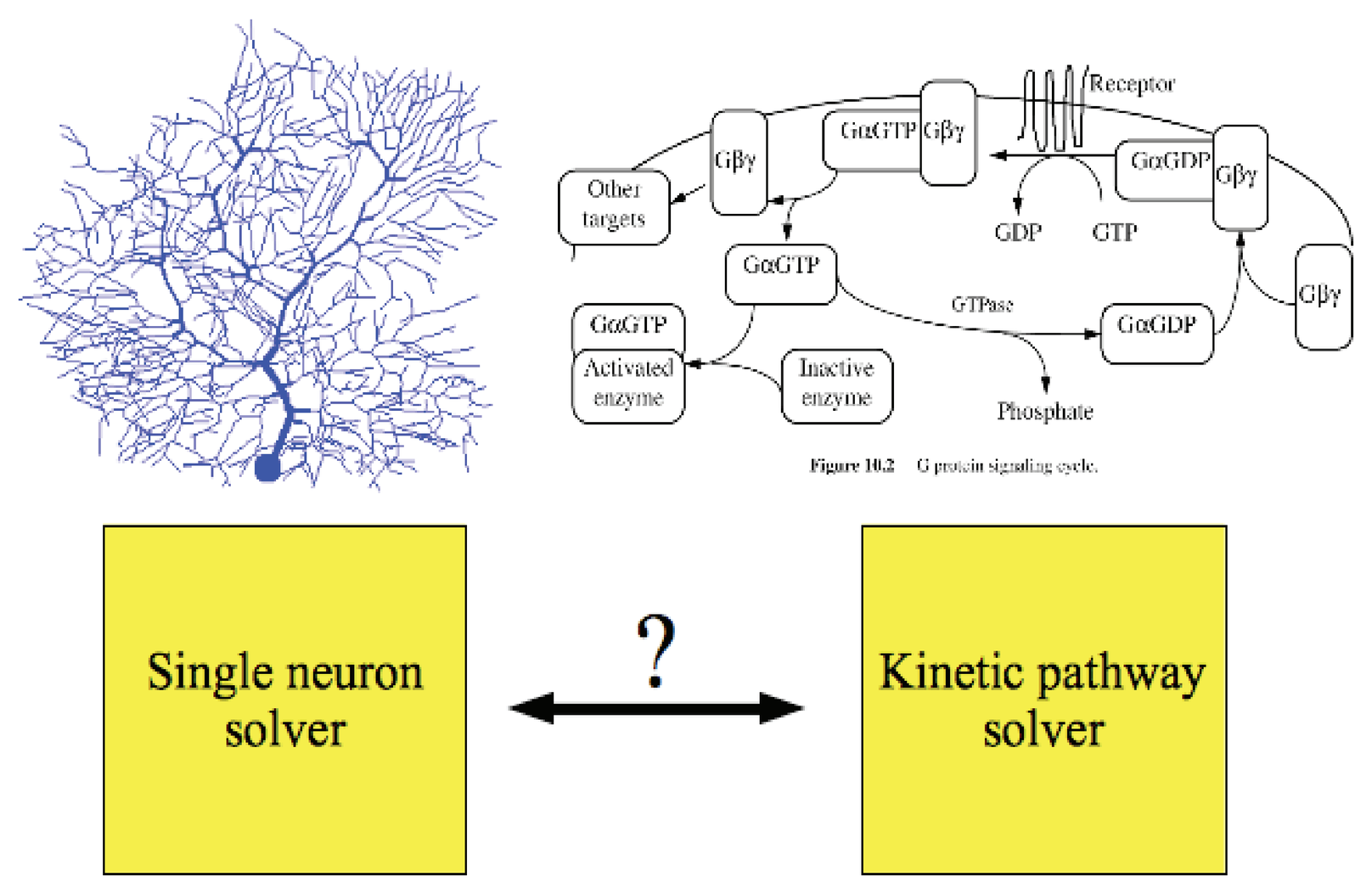
Introduction



Problem Statements and Context



Currently, neural simulation software does not allow for efficient vertical integration of simulations at different scales. For example, the integration of reaction diffusion models into networks of compartmental neurons.

Databases

Different technologies that access different databases in computational neurosience are available to perform specifications for:

Experimental protocols

BrainML.org

Model databases

NeuroMorpho.Org

Declarative modeling technology

NeuroML

NSL

9ML

Figure reproduction

BioModels.Net

SED-ML

In the wider community there are electronic social networking websites that are:

General

myspace. YouTube facebook flickr twitter

Dedicated

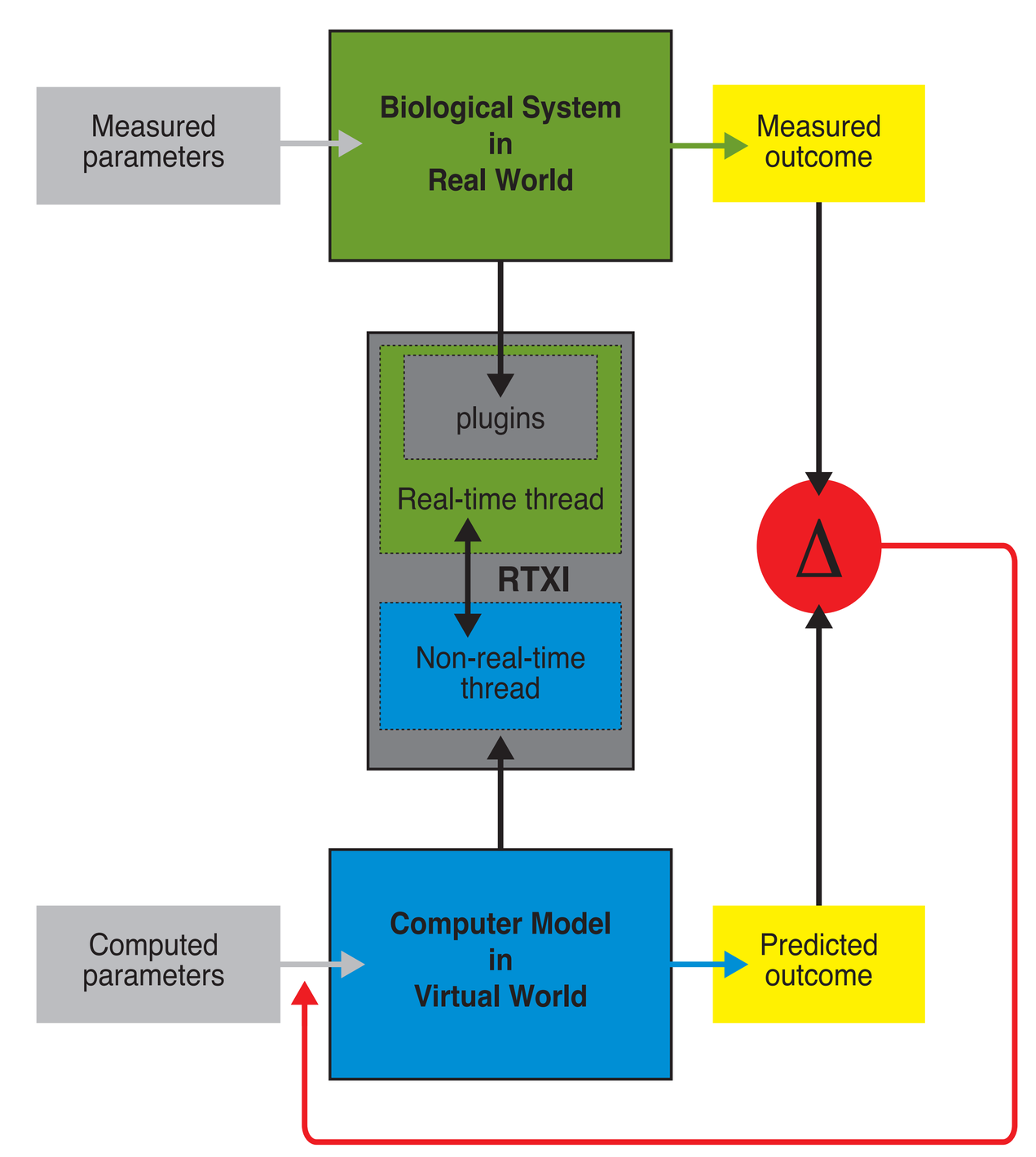
MUBI delicious social bookmarking

Electronic Publication

Currently, electronic publication consists primarily of a combination of PDF files and online supplementary materials. This does not exploit the full potential of current technologies.

Detailed Example: RTXI

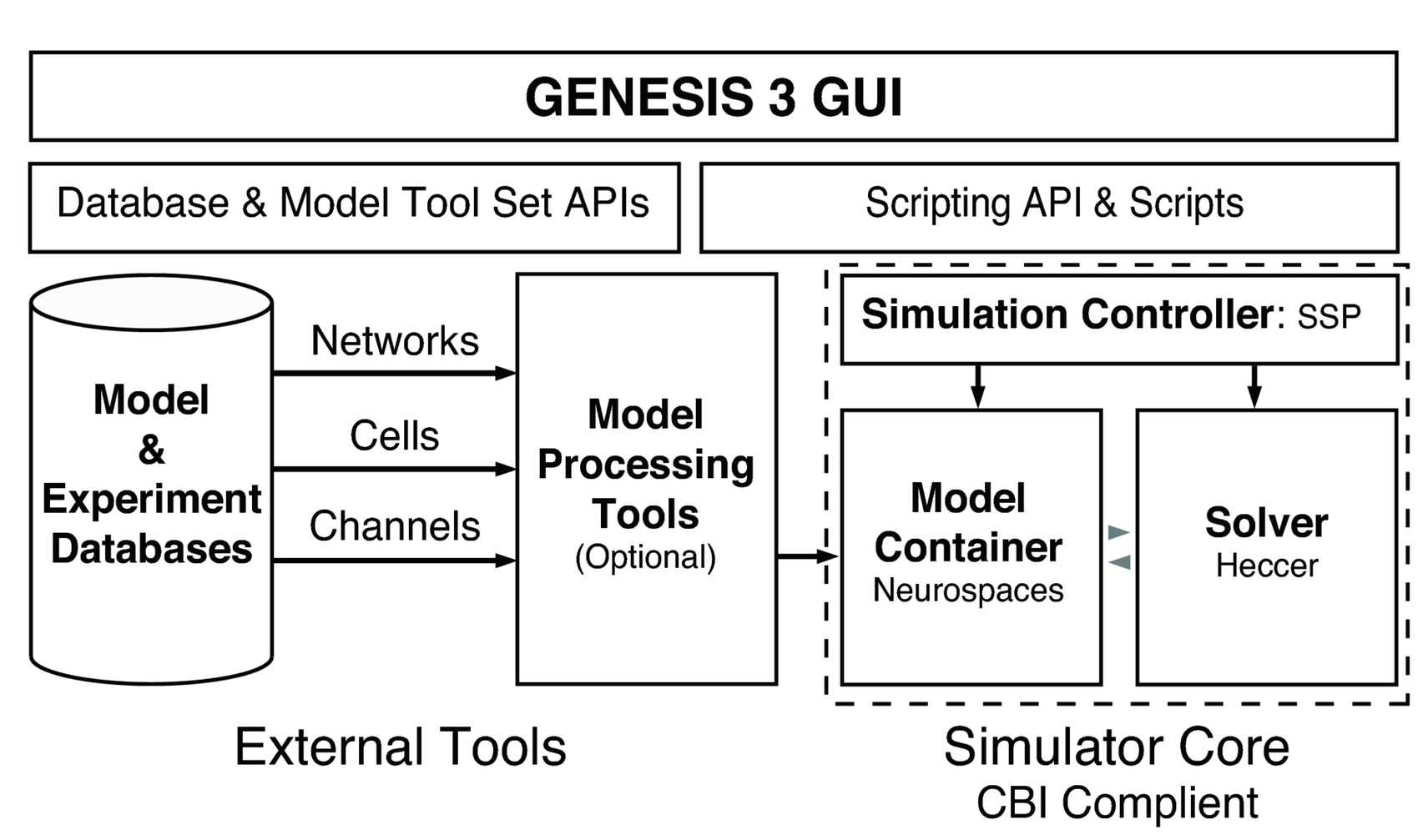
A mature modular dynamic clamp implementation for hard real time data acquisition that has grown from previous work by Butera [1] and White [2]. RTXI is modular to the extent that user-supplied function-specific code modules can be combined to build custom experimental protocols and interfaces. It provides an event delivery system that allows these plugins to signal the occurrence of user-defined events amongst themselves as required. This has the potential to provide online model validation and tuning.

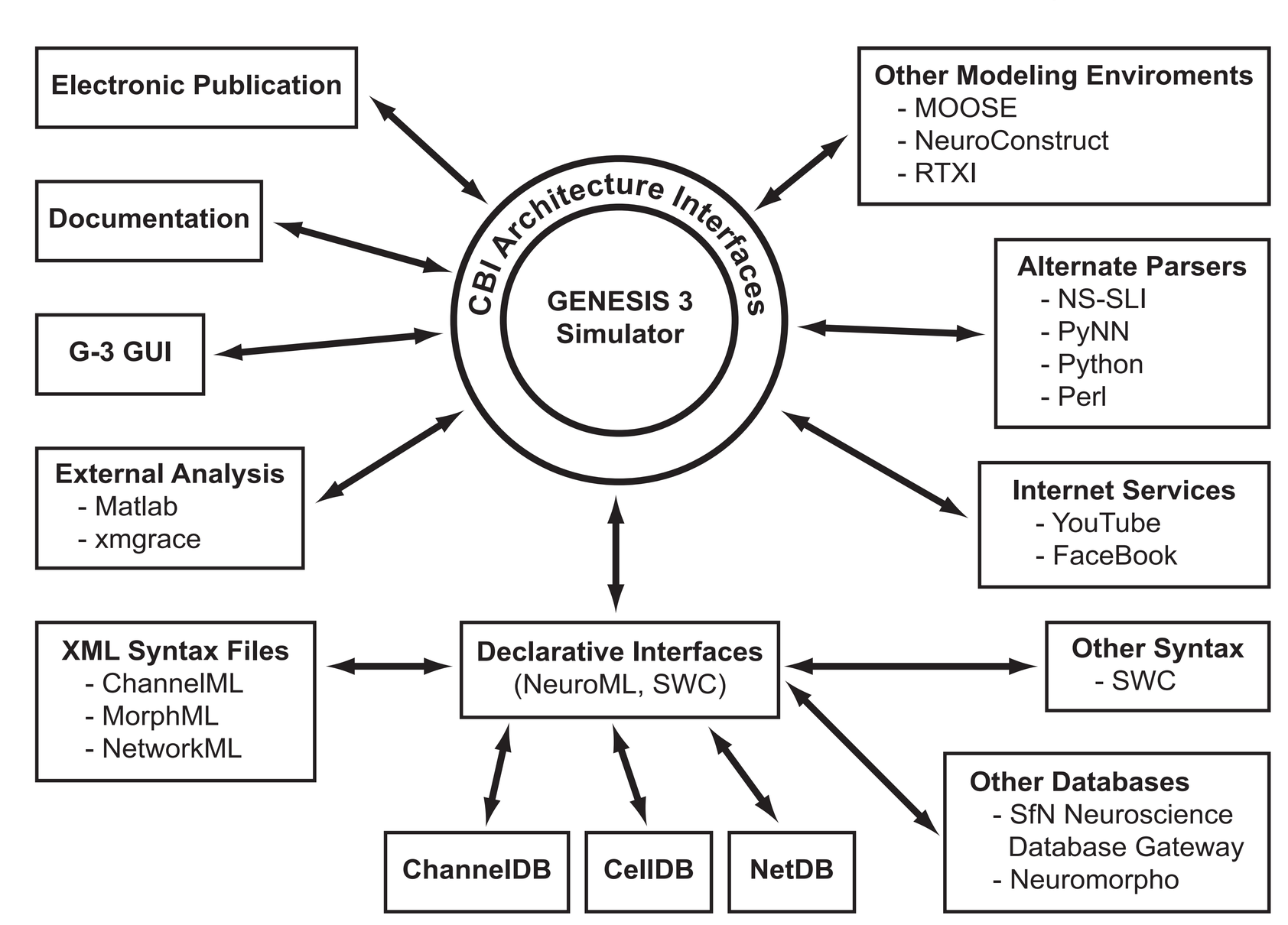


Block diagram illustrates the long-term goal of an integrated RTXI/GENESIS software platform. Note that this component acts as an iterator in the User Workflow.

CBI Architecture

The Computational Biology Initiative (CBI) federated software architecture provides a modular paradigm that places stand-alone software components into logical relationships. It is referred to as being 'federated' as it extends the modular approach associated with the development of single applications to the functional integration of otherwise independent applications. In doing so, it provides multi-level 'plugability' and aims to deliver a unified interface to diverse applications and mask from the user the differences, idiosyncracies, and implementations of the underlying applications and data sources. The first implementation based on this architecture is the reconfigured GENESIS [ref].

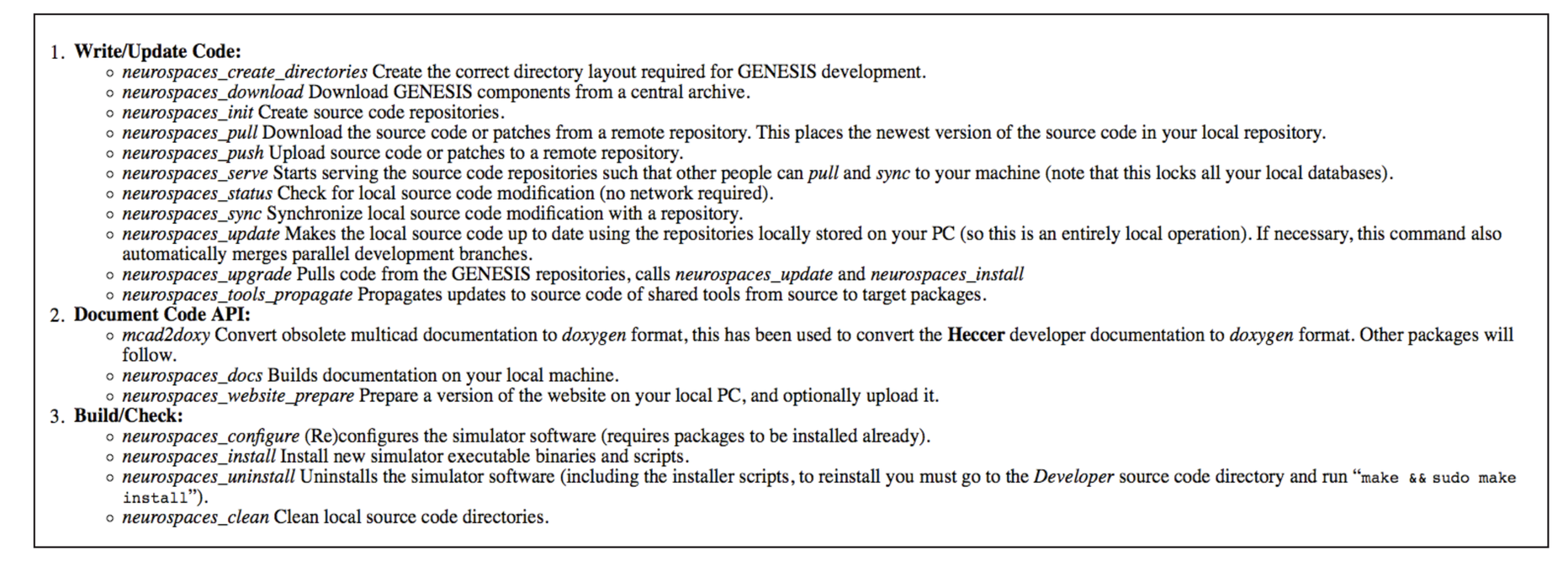


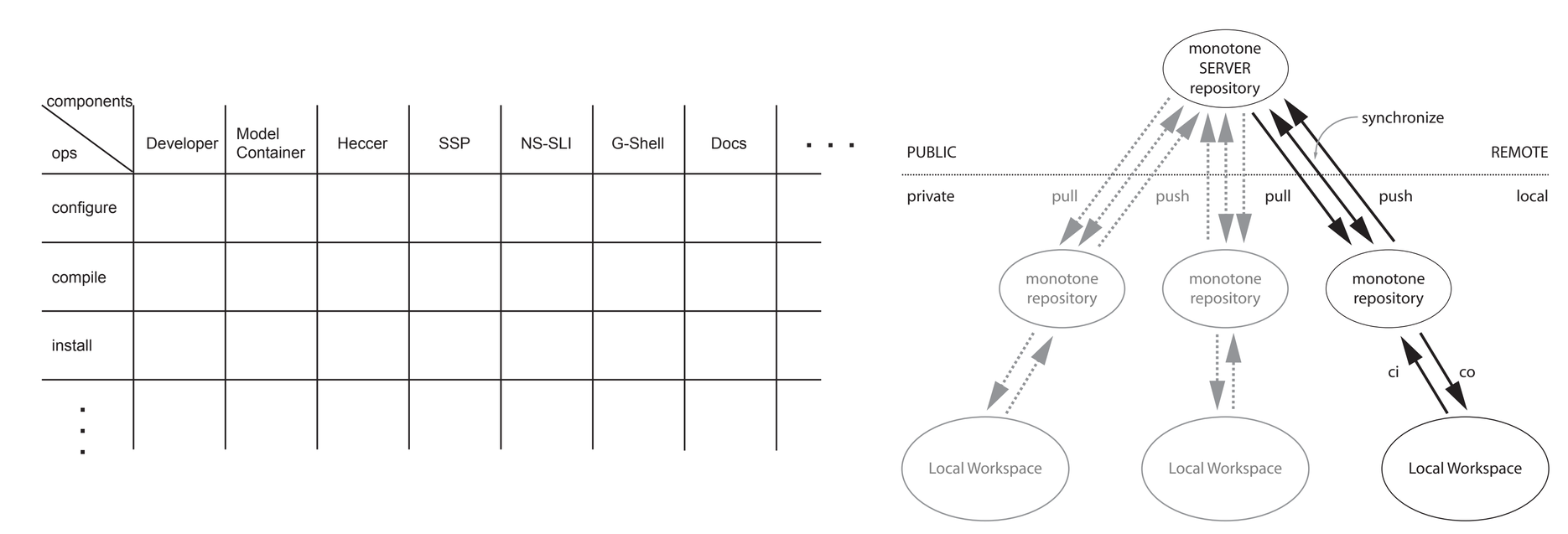


A toolset is required for the development, integration, maintenance, and documentation of such an application.

Developer Package

The Developer package provides developer utilities that comply with CBI development standards. The package automates the management of multiple software projects. It automates updates to local source code, synchronization between distributed repositories, compilation, testing and installation, packaging and releases, serving monotone repositories, amongst other things. Tracking changes to these systems is overseen by the monotone and mercurial version control systems.

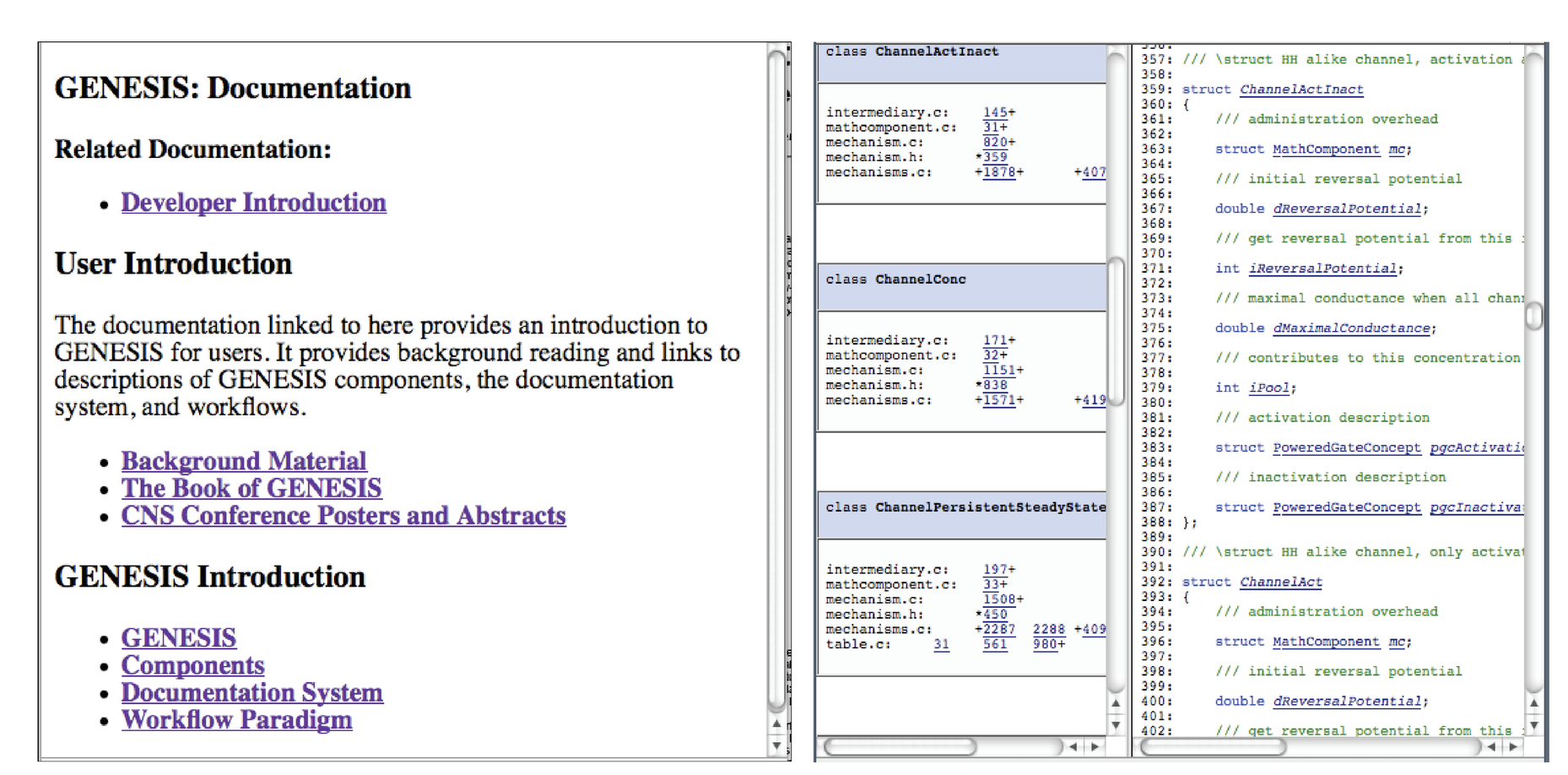




Documentation System

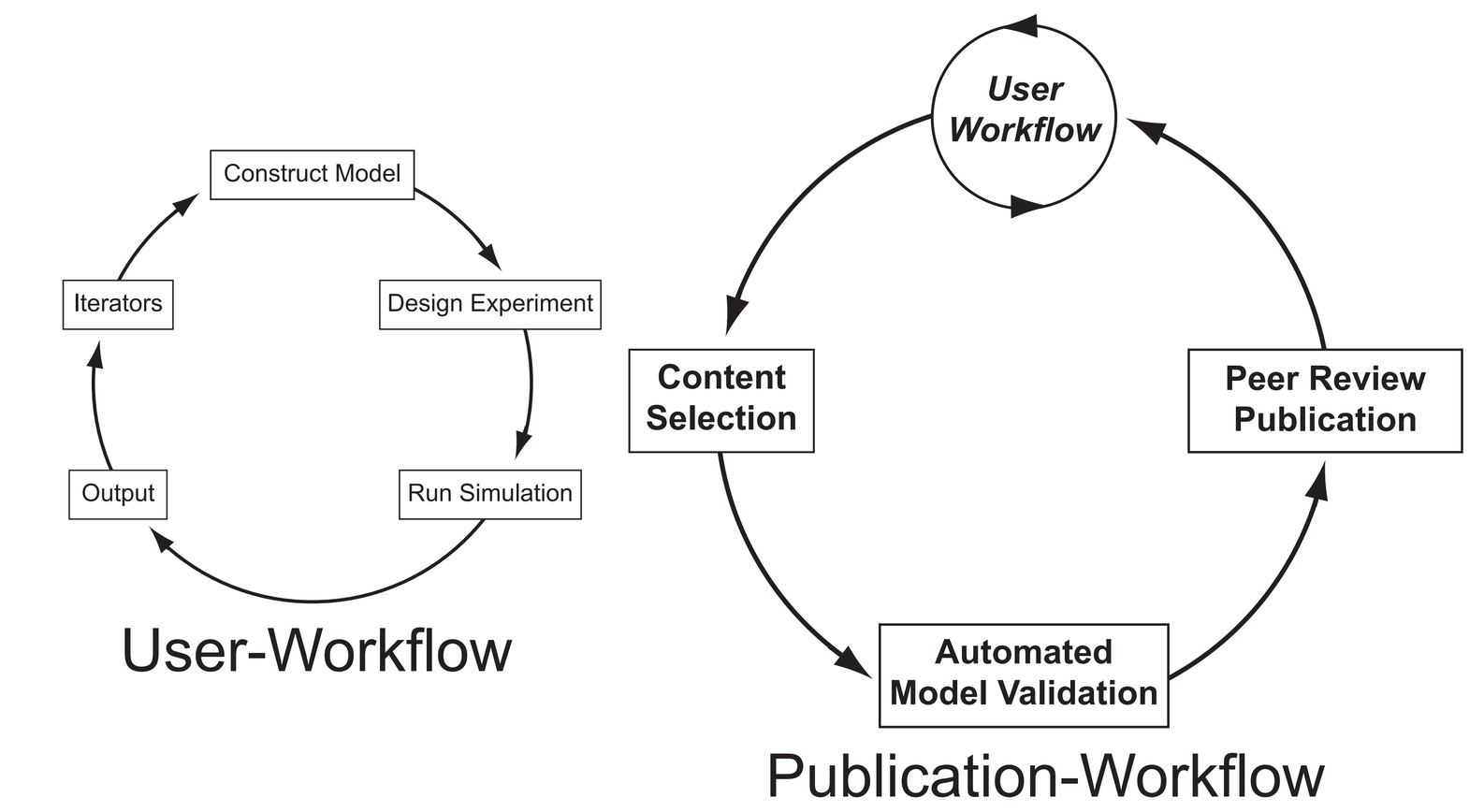
Documentation is key to the use of this system. We have recently developed a comprehensive multilevel documentation system that supports both users and the extension of simulator functionality by developers through the integration of appropriately configured stand alone software modules.

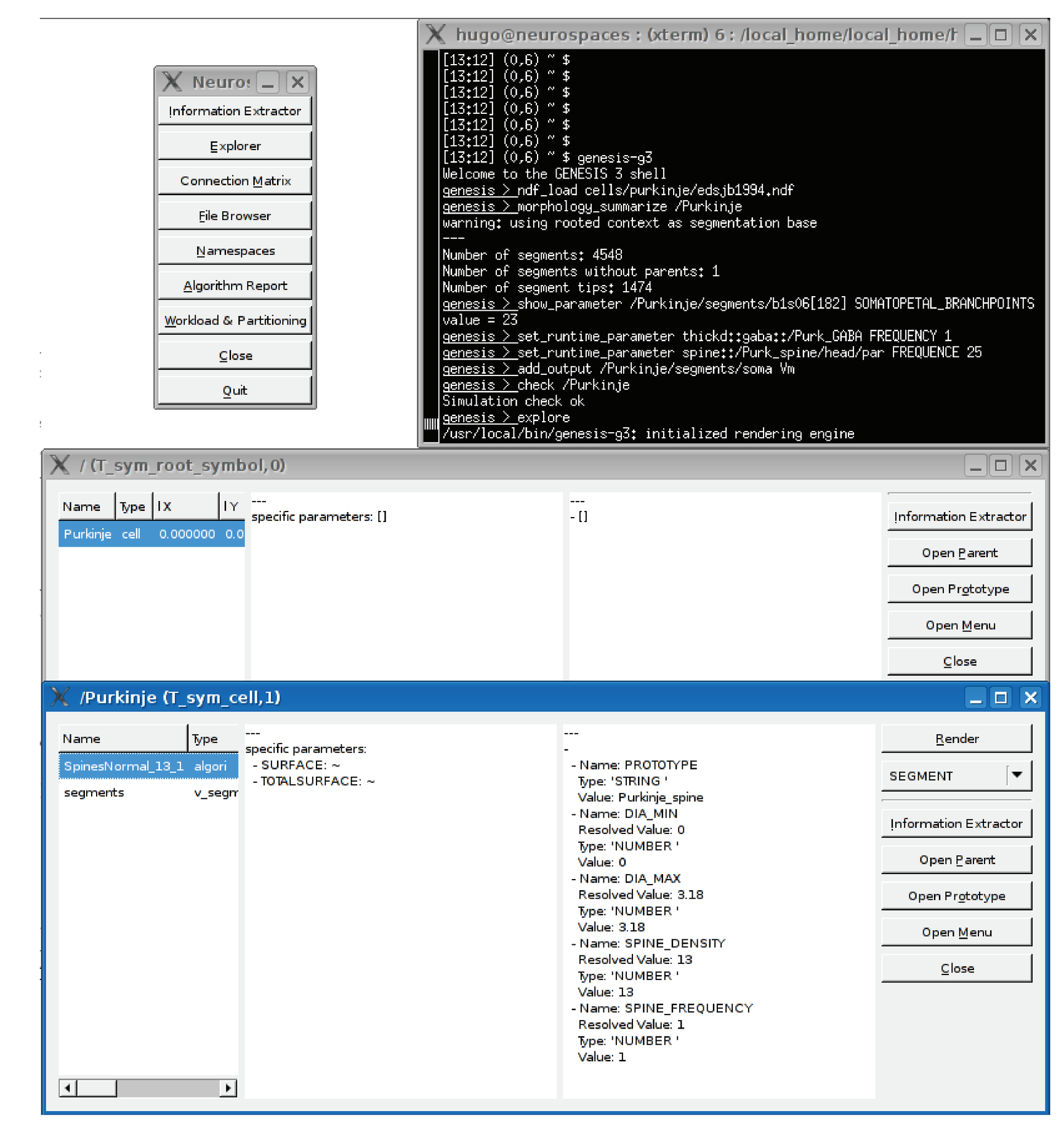
The system is divided into seven levels that range from introductory background material and tutorials for users, to Doxygenized APIs and HTMLified browsable source code for developers, including, Level 1: Introductory material, Level 2: User guides and documentation, 3. Automated use cases, 4. Technical guide specification, 5. Algorithm documentation, 6. Algorithm API documentation, and 7. Inline source code documentation.



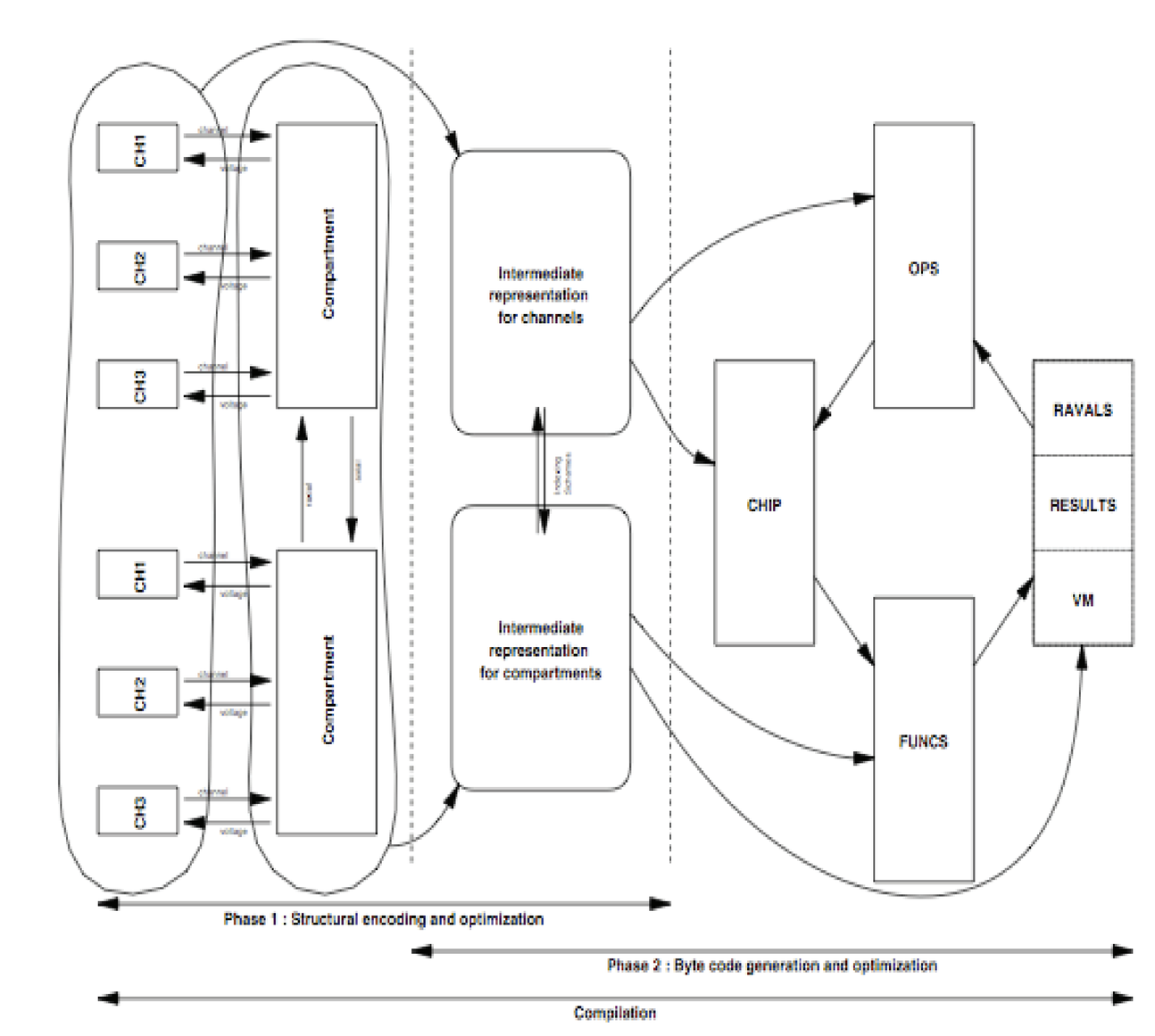
Examples of Left: Level 1 and Right Level 7 documentation.

G-Shell: Interactive integration environment.

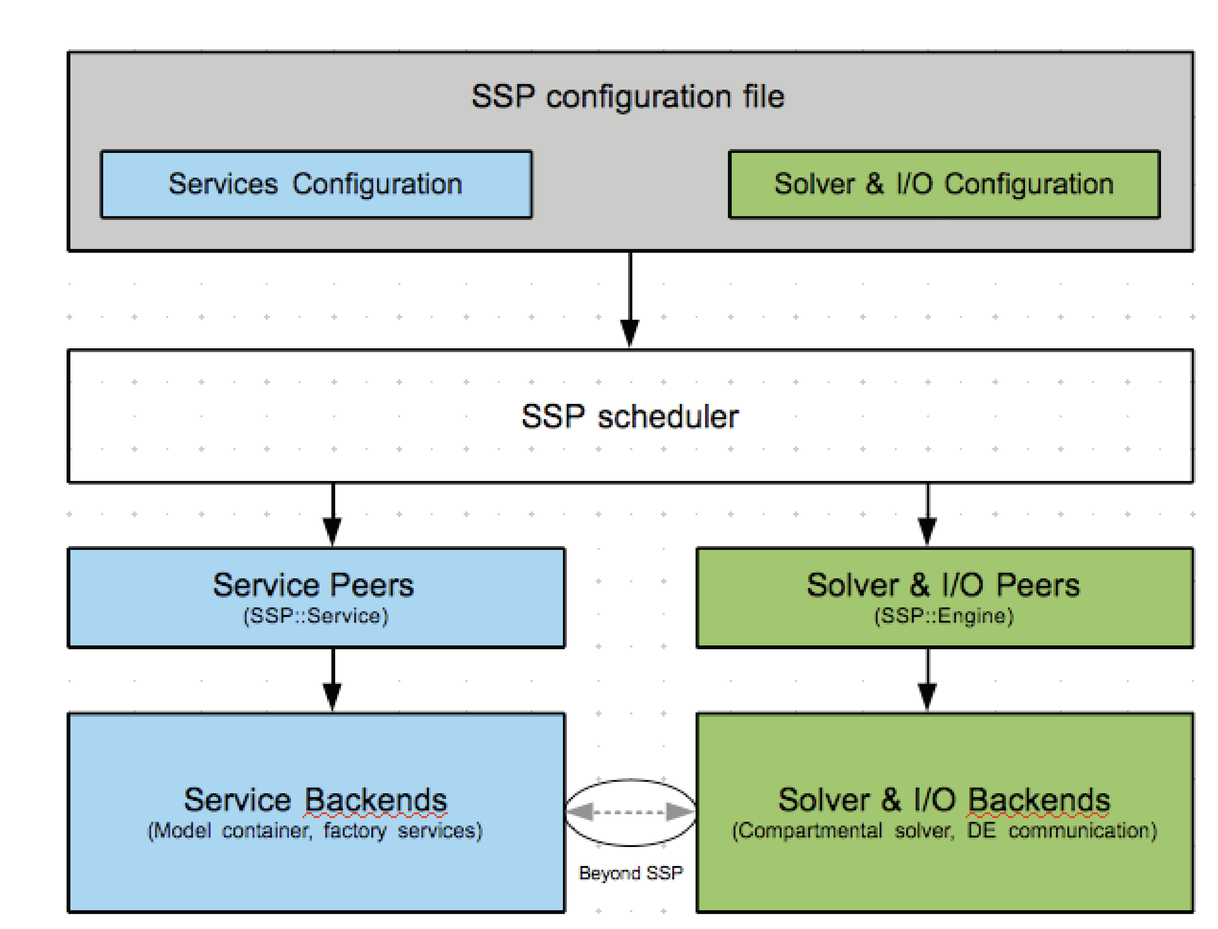




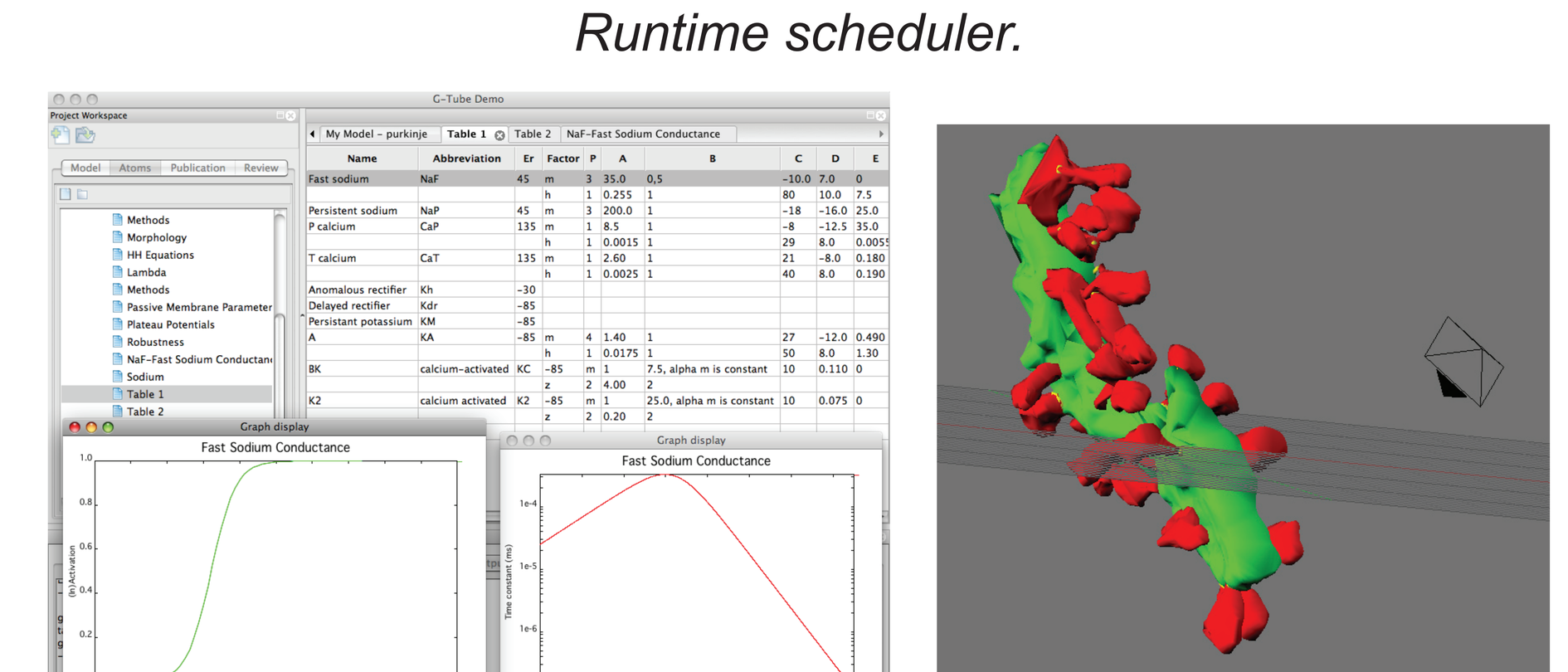
Neurospaces Studio: Model explorer GUI.



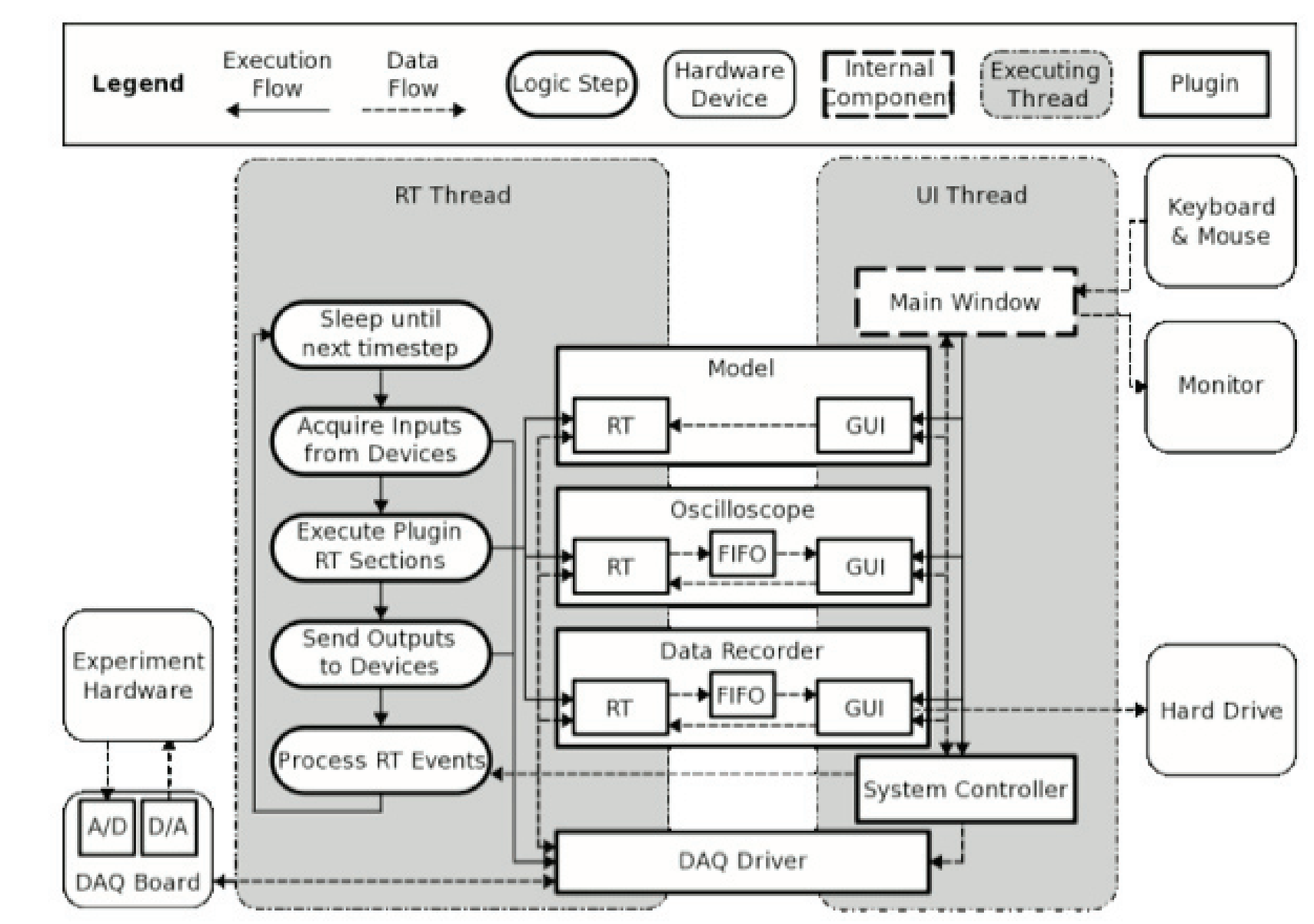
Heccer: Single neuron solver.



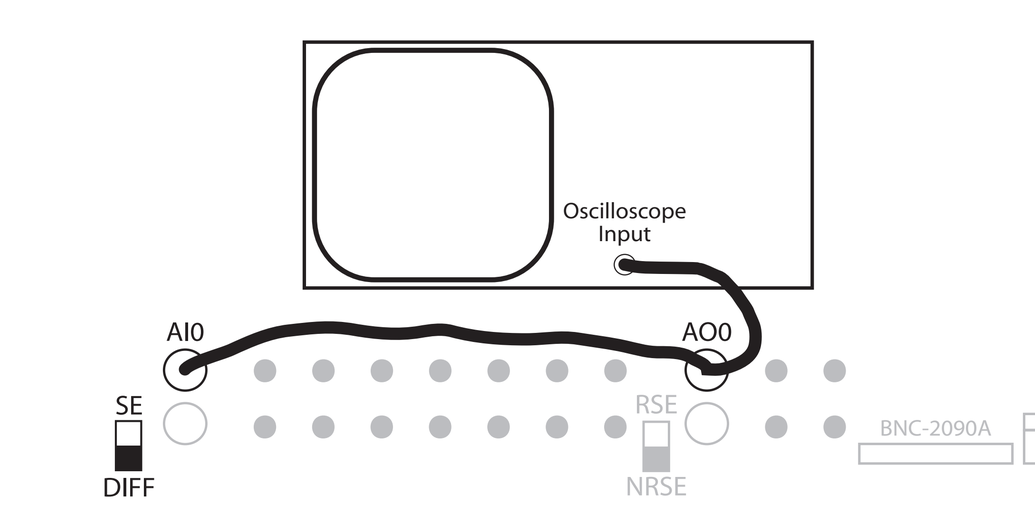
Runtime scheduler.



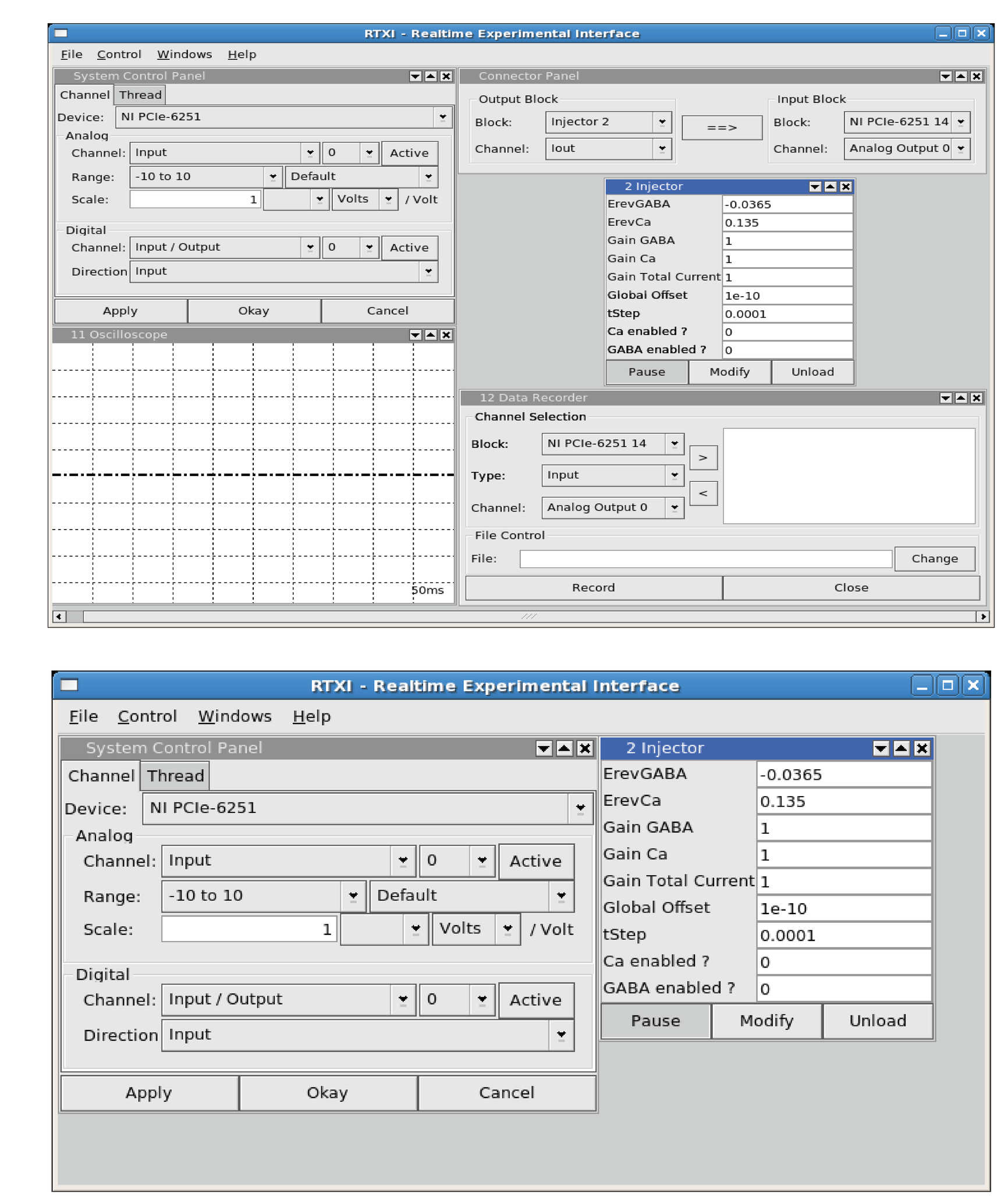
G-Tube and Blender



RTXI internal architecture.



Hardware connectivity for injector module validation.



Screen shots of the RTXI User Interface for control of the injector module.

Ultimately, the extensibility of the CBI federated software architecture provides an extremely plastic environment within which independent components can be integrated with scripting language or other technologies. Employed in this way, its modularized design gives rise to an ecology of software components that can be glued together in a variety of ways to provide for progressive federated software development.

The availability of integrated real time data acquisition (RTXI) and model simulation (GENESIS) will both greatly enhance the value of computational models and contribute to more focused hypothesis development and experiments. The fact that a GENESIS simulation is also formulated as a tutorial provides significant value as electrophysiological concepts and principles can be directly demonstrated on completion of model development.

Acknowledgements

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References

1. Butera Jr., RJ and Wilson, CG and Delnegro, CA and Smith, JC: A methodology for achieving high-speed rates for artificial conductance injection in electrically excitable biological cells. 2001, *IEEE Trans. Biomed. Eng.* **48**:1460-1470.
2. Dorval AD, Christini DJ, White T: Real-time linux dynamic clamp: A fast and flexible way to construct virtual ion channels in living cells. 2001, *Ann. Biomed. Eng.* **29**:897-907.