

OIST Towards a Generic and Open Software for Building Digital Brains

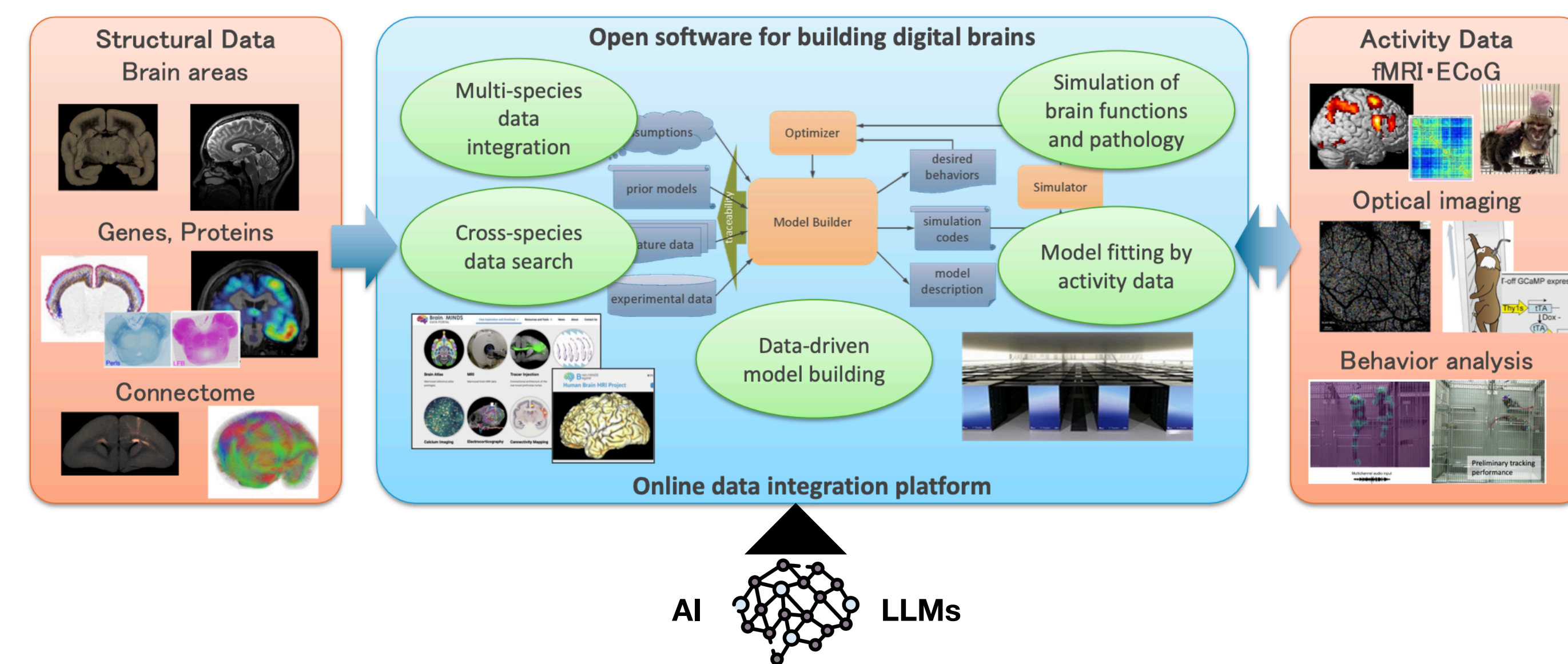
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Brain/MINDS 2.0 - The Digital Brain Project

Goal: open software for building digital brains

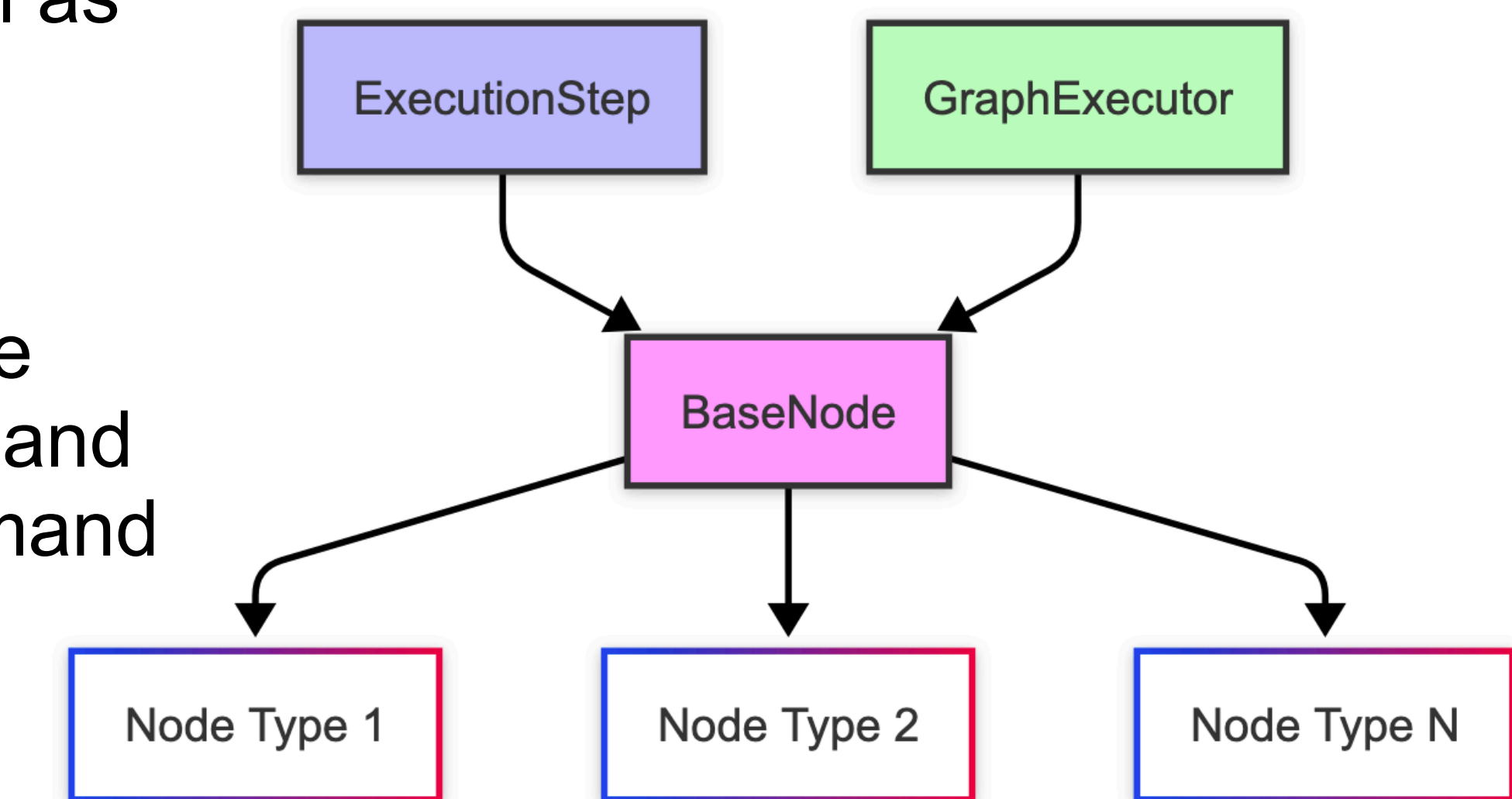
-online platform for data integration, model building and simulations-



The Digital Brain as a graph-based framework

- ▶ The Brain/MINDS 2.0 Digital Brain aims to create a framework that supports interoperability with popular neuroscience tools such as TVB, NEST, NEURON, and others, leveraging their Python interfaces.
- ▶ Modern brain modeling and simulation workflows often require complex sequences of data processing, model configuration, and analysis steps. While powerful tools exist, they frequently demand advanced programming knowledge, limiting accessibility and collaboration potential.
- ▶ We present a graph-based framework that transforms complex scientific workflows into modular, reusable components through a node-edge architecture.

Framework Architecture



Core Components:

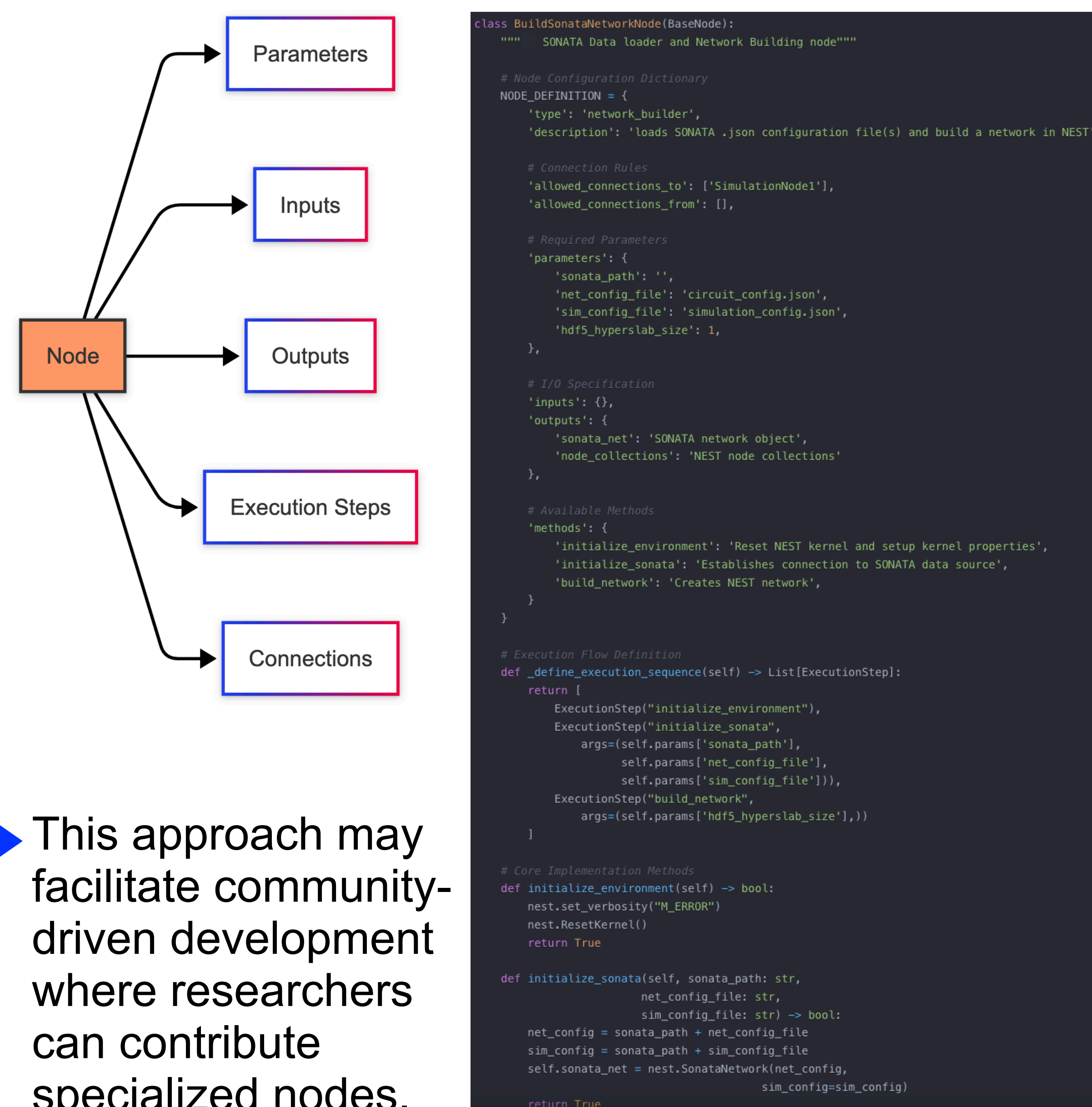
ExecutionStep Class: defines individual execution steps within nodes

BaseNode Class: template for all workflow nodes

GraphExecutor Class: manages workflow execution

Node Structure

- ▶ Our framework enables researchers to encapsulate scientific procedures as self-documenting nodes with standardized interfaces, clear input/output specifications, and automated data flow management.



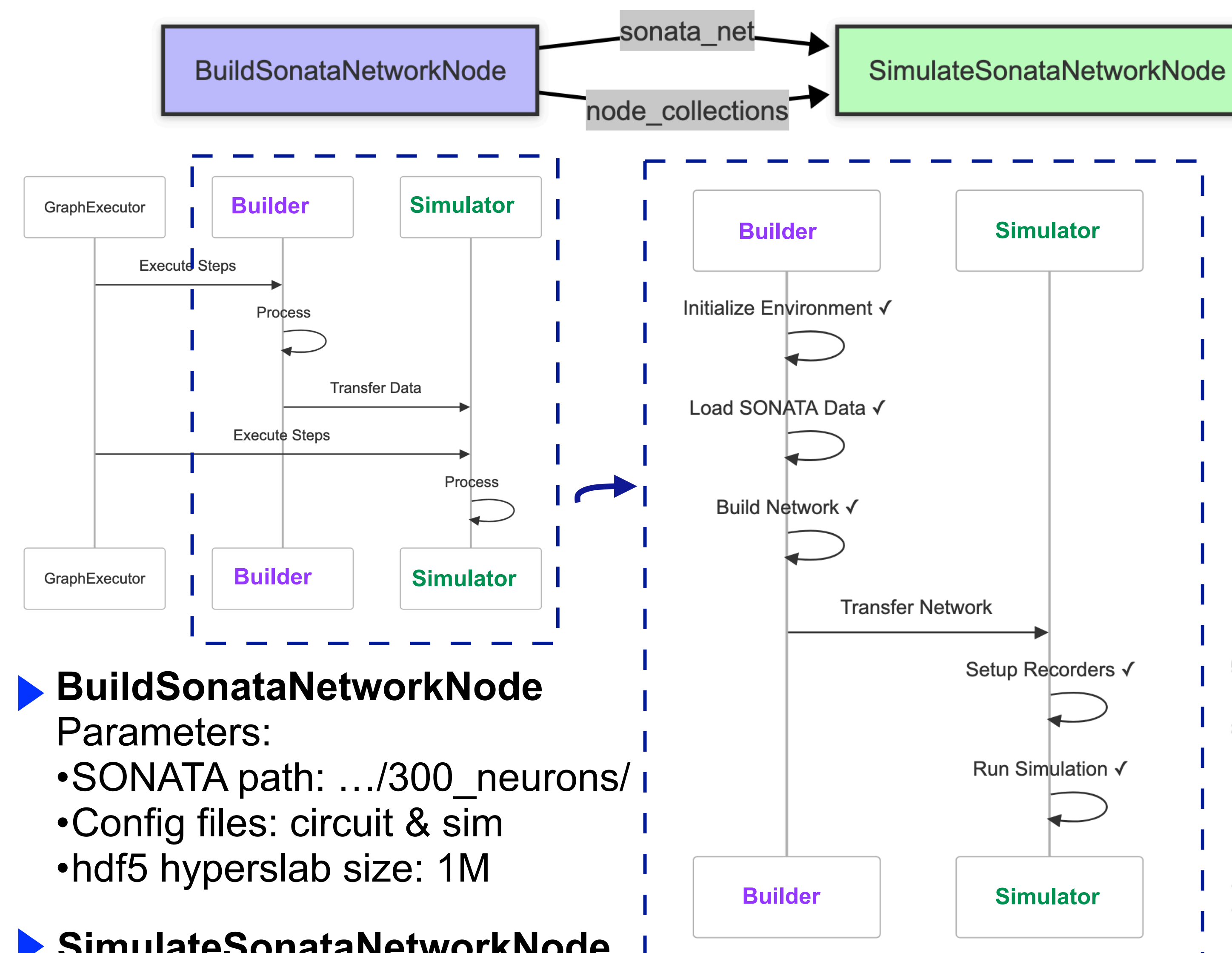
- ▶ This approach may facilitate community-driven development where researchers can contribute specialized nodes.

WorkFlow Example

- ▶ This proof-of-concept demonstrates the framework's potential through a **SONATA-NEST** workflow implementation

BuildSonataNetworkNode: Network construction from SONATA files.

SimulateSonataNetworkNode: Network simulation.



BuildSonataNetworkNode

Parameters:

- SONATA path: .../300_neurons/
- Config files: circuit & sim
- hdf5 hyperslab size: 1M

SimulateSonataNetworkNode

Parameters:

- Simulation time: 1000.0 ms
- Recording: 200 neurons

Network Statistics:

- Nodes: 400
- Connections: 48,432

Example of a Data Analysis Node

```
class DataAnalysisNode(BaseNode):
    """Statistical Analysis Node"""

    # Node Configuration Dictionary
    NODE_DEFINITION = {
        'type': 'analysis',
        'description': 'Performs statistical analysis',

        # Analysis Parameters
        'parameters': {
            'analysis_type': 'basic', # Type of statistical analysis
            'confidence_level': 0.95 # Statistical confidence level
        },

        # I/O Specification
        'inputs': {
            'data': 'Input dataset'
        },
        'outputs': {
            'results': 'Analysis results'
        },

        # Analysis Pipeline Definition
        'define_execution_sequence(self):
        return [
            ExecutionStep("prepare_data"), # Step 1: Data preparation
            ExecutionStep("run_analysis"), # Step 2: Statistical analysis
            ExecutionStep("generate_report") # Step 3: Results reporting
        ]
```

This framework may enable:

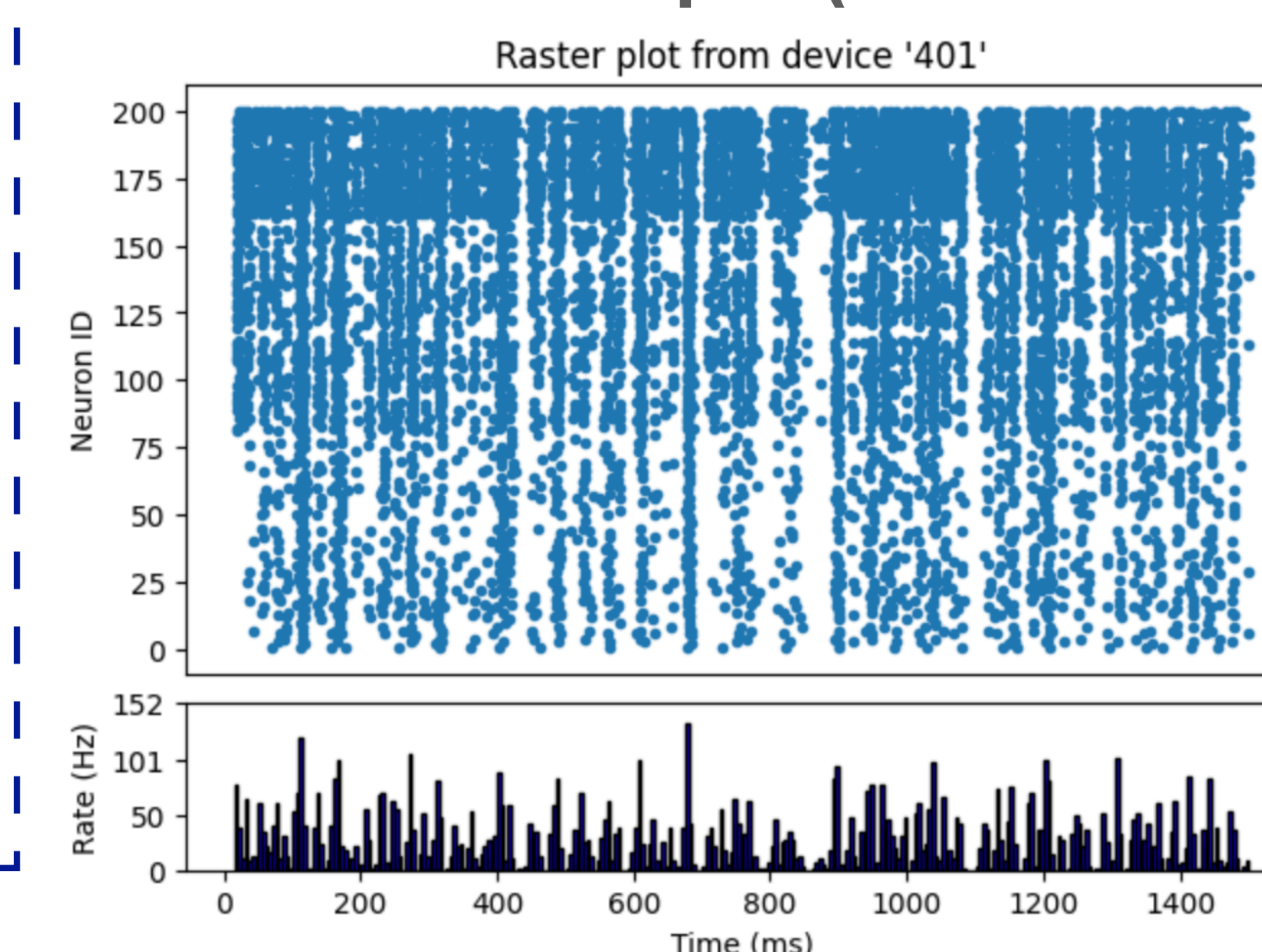
- Rapid development of scientific workflows
- Easy sharing of analysis components
- Reproducible research practices
- Collaborative development
- Clear documentation
- Quality control

Conclusions and Future Work

This modular node-based architecture provides: ♦ Flexibility: Each node is a self-contained unit with clear I/O specifications ♦ Reproducibility: Standardized execution sequences ensure consistent workflow processing ♦ Extensibility: New nodes can be easily added by inheriting from BaseNode ♦ Interoperability: Structured data flow between brain modeling tools ♦ Maintainability: Clear separation between node definition and implementation

Future development will include a web-based graphical interface, enabling scientists to create and modify workflows through drag-and-drop interactions.

Simulation Output (200 neurons)



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