Accelerating Parameter Sweep Workflows by Utilizing Ad-hoc Network Computing Resources: an Ecological Example

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Outline

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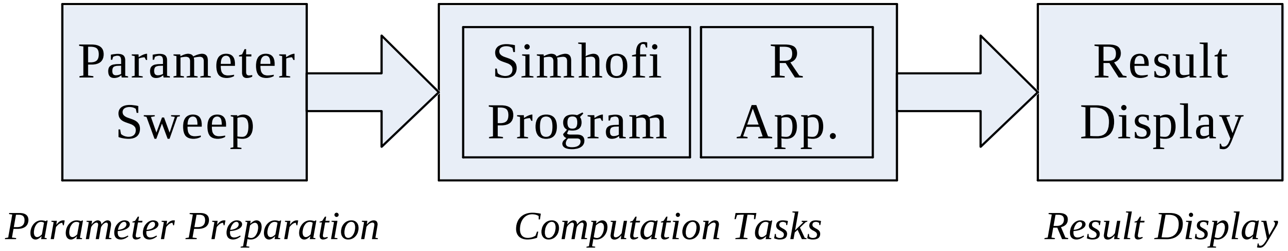
Introduction

- Many scientific computing problems have linear or greater time complexity based on parameter configuration ranges
- Domain scientists should be able to easily leverage distributed computing resources with little knowledge of the underlying techniques
- We will discuss a distributed execution framework, called Master-Slave Distribution, to distribute sub-workflows to ad-hoc network computing resources

Theoretical Ecology Use Case

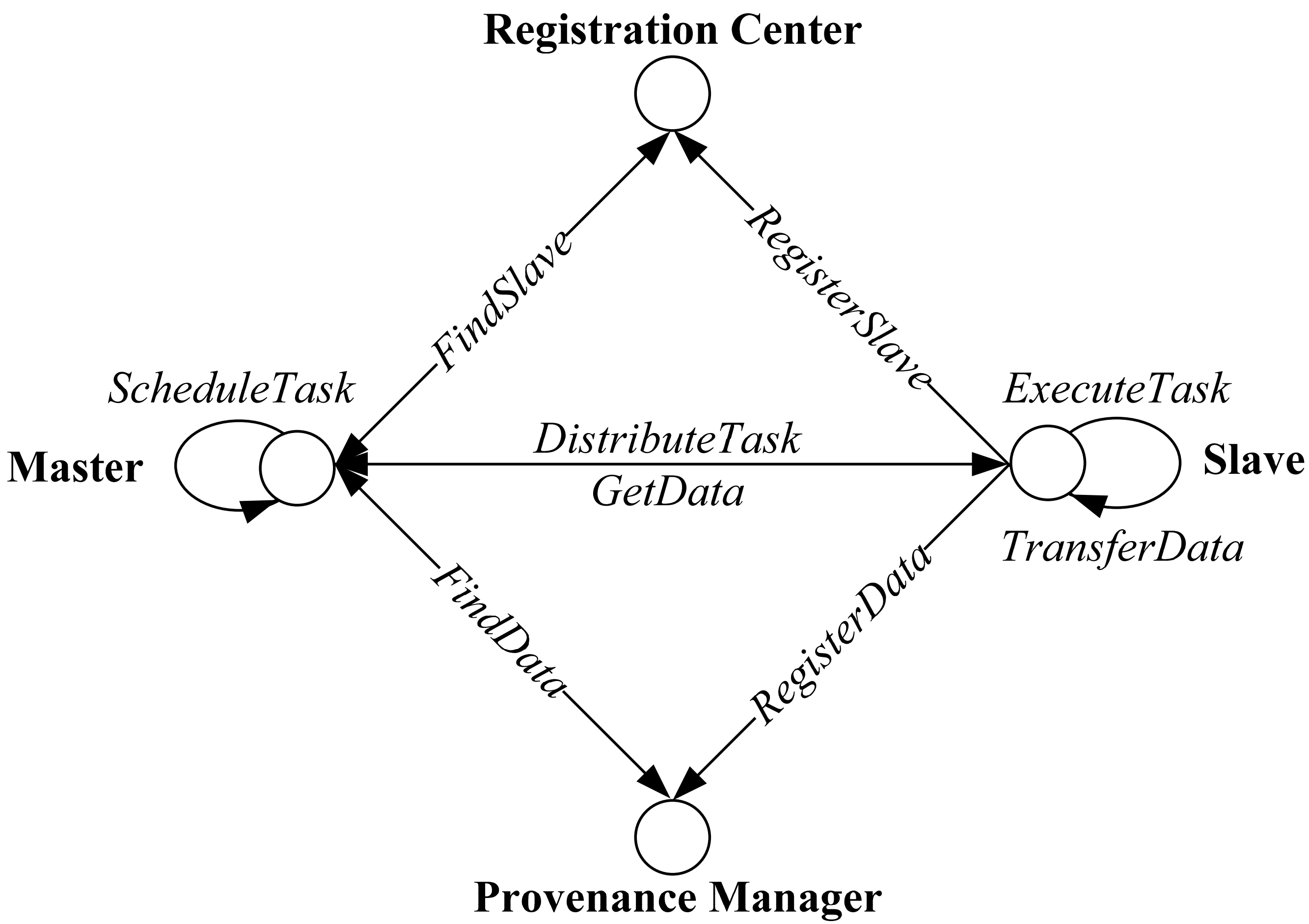


- **Characteristics of the use case**
  - Parameter Sweep: independent multiple execution, i.e., "embarrassingly parallel problems"
  - Smooth Transition of Computation Environments
  - Partial Workflow Distribution
  - Provenance Collection

Background – Kepler

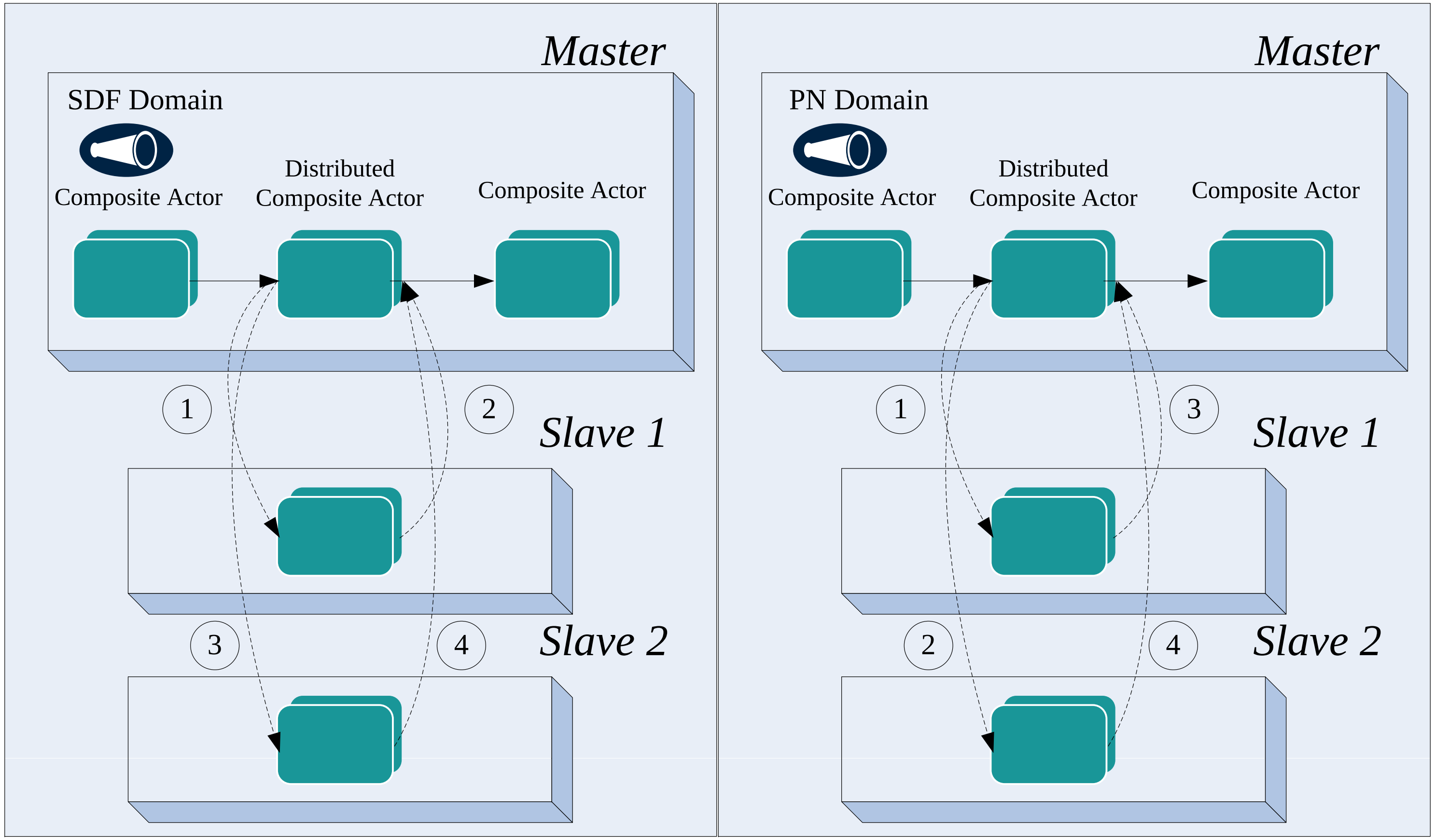
- **Actor-oriented Modeling**
  - All these actors inherit the same interfaces, such as *prefire()*, *fire()* and *postfire()*
- **Model of Computation**
  - Synchronous Data Flow (SDF) director: actors execute sequentially
  - Process Network (PN) director: each actor has its own execution thread and execute in parallel

Background – Conceptual Architecture for Workflow Distributed Execution



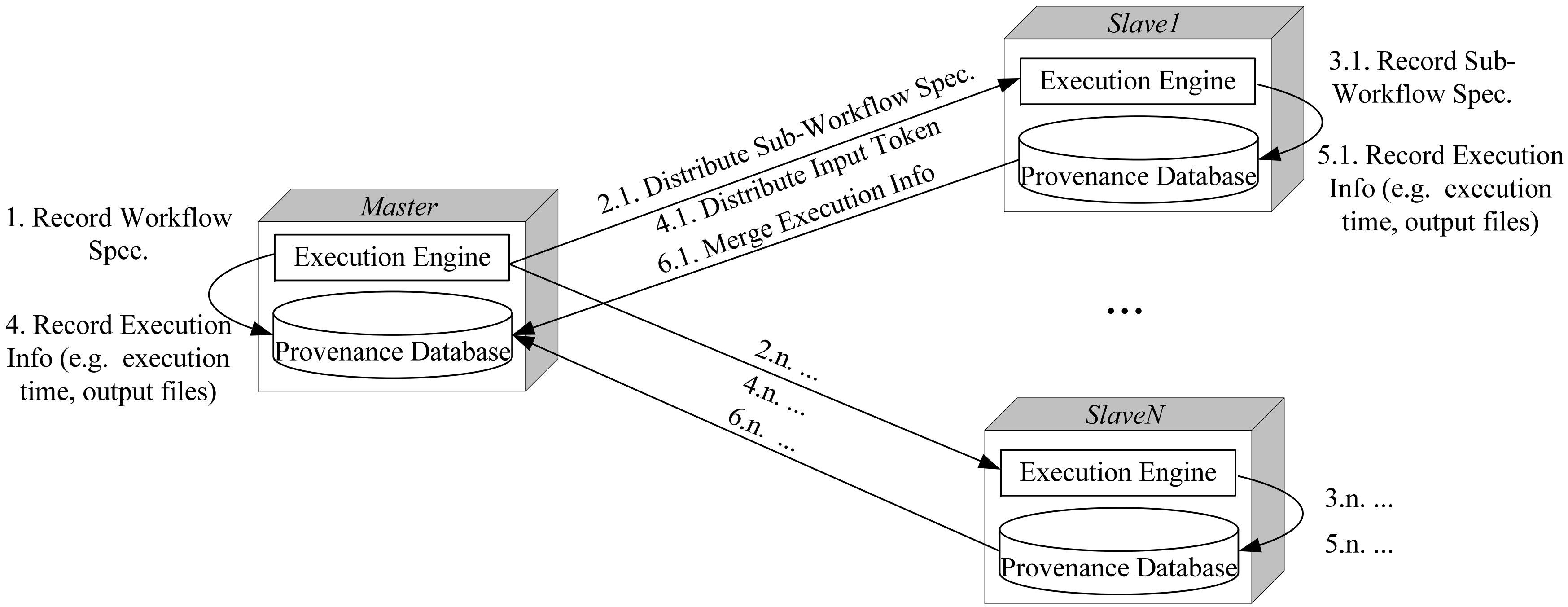
Our Approach – Distributed Composite Actor

- As the role of Master, each token received by this Actor is distributed to a Slave node, executed, and the results returned.
- Different behavior with different computation models

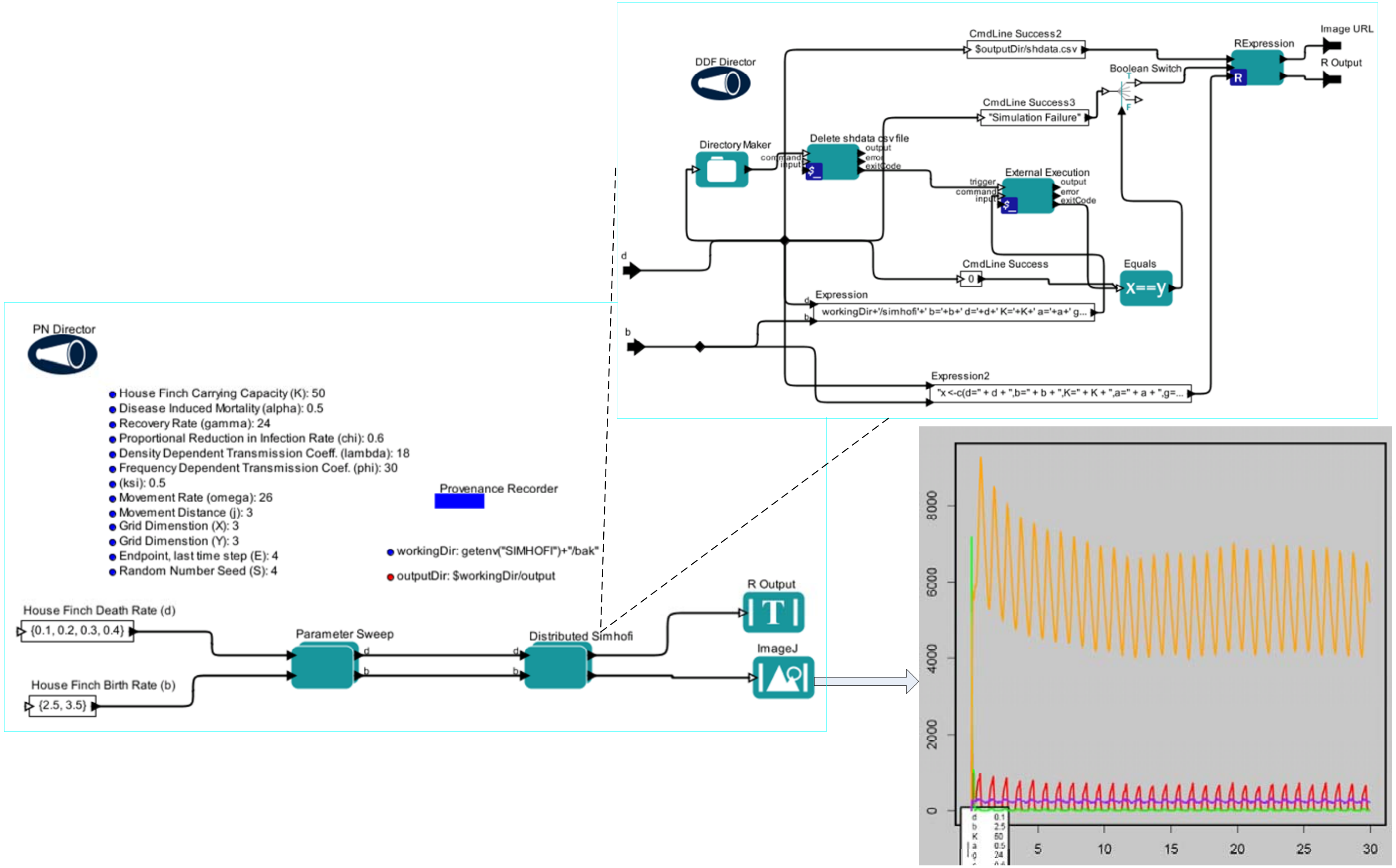


Our Approach – Provenance Collection

- By collecting workflow structure and executions, our provenance framework make it easier for users to track data files for large parameter sweeps
- It can be configured to support centralized or decentralized provenance information recording

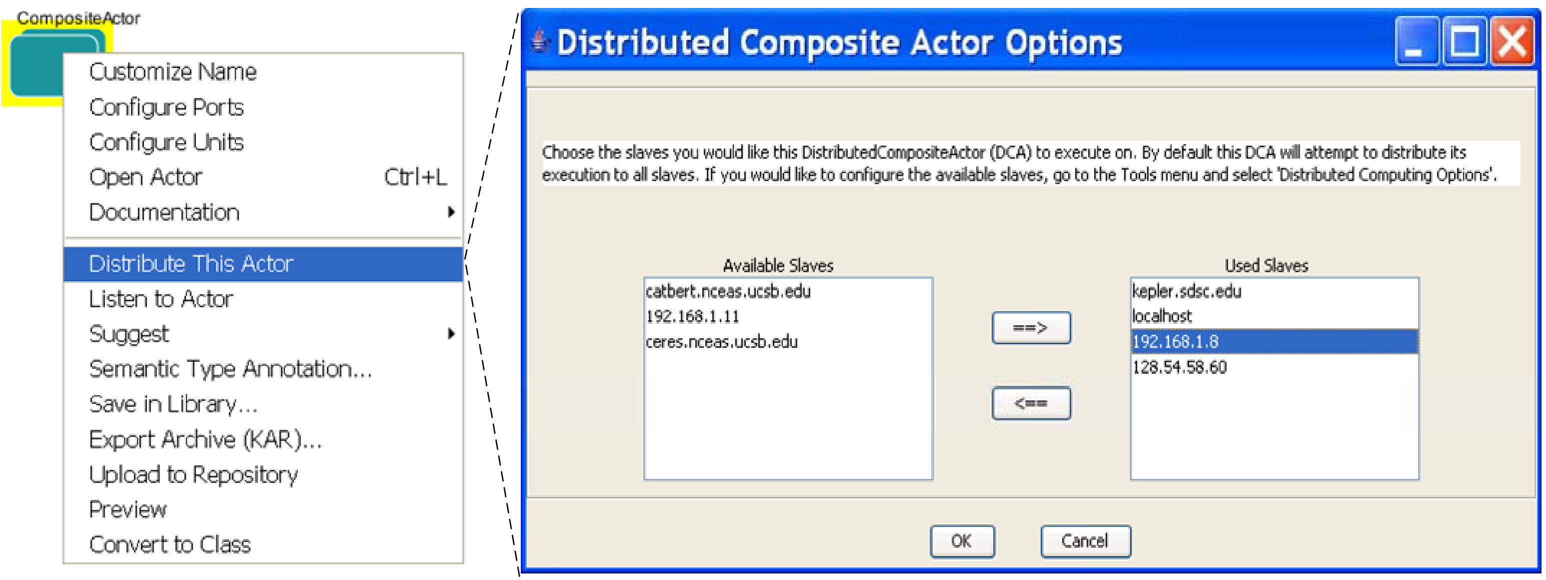


Results – Workflow



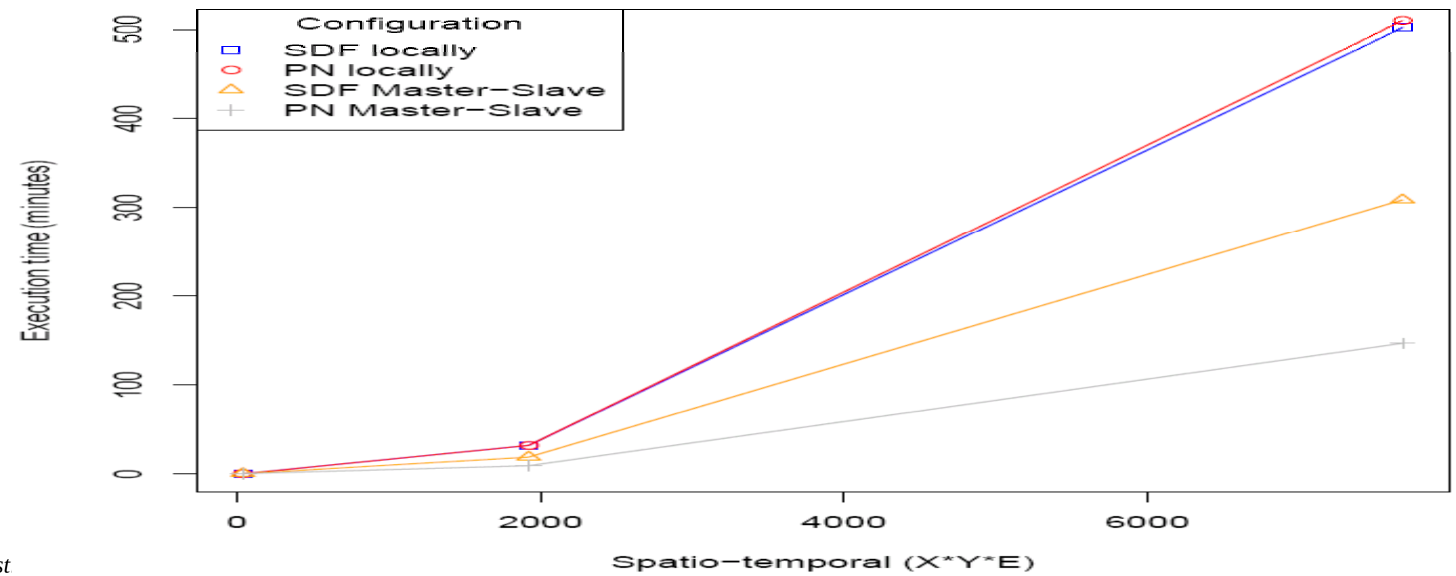
Results – Usability

- **Users use the DistributedCompositeActor just like the common composite actor**
- **Interaction for execution environment transition**



Results – Experiment

Parameters	Execution Time (minutes)			
	SDF locally	**PN locally**	**SDF Master-Slave**	**PN Master-Slave**
b=<0.1, 0.2, 0.3, 0.4>, *d*=<2.5, 3.5>, *X*=3, *Y*=3, *E*=4	0.39	0.35	0.60	0.52
b=<0.1, 0.2, 0.3, 0.4>, *d*=<2.5, 3.5>, *X*=8, *Y*=8, *E*=30	32.21	32.24	19.05	9.38
b=<0.1, 0.2, 0.3, 0.4>, *d*=<2.5, 3.5>, *X*=16, *Y*=16, *E*=30	502.2	510	309	147
Testbed Constitution				
	OS	Memory	CPU	
Notebook	Window XP	2 GB	2.00 GHz Duo Core	
Desktop	Mac OS X	2 GB	2.80 GHz Duo Core	



Conclusion and Future Work

- **A distributed execution framework in the Kepler**
  - Distribute sub-workflows to ad-hoc network computing resources
  - Applicable to parameter sweep applications to realize parallel independent execution

- **Future Work**
  - Generalize for Cluster, Grid, and Cloud platforms.
  - Categorize different distributed approaches in Kepler to match different requirements

- **Thanks!**
- **For More Information:**
  - Distributed Execution Interest Group of Kepler: https://dev.kepler-project.org/developers/interest-groups/distributed
  - Contact: jianwu@sdsc.edu