Extending Ptolemy II

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Ptolemy II Extension Points

- Define actors
- Interface to foreign tools (e.g. Python, MATLAB)
- Interface to verification tools (e.g. Chic)
- Define actor definition languages
- Define directors (and models of computation)
- Define visual editors
- Define textual syntaxes and editors
- Packaged, branded configurations

- All of our “domains” are extensions built on a core infrastructure.

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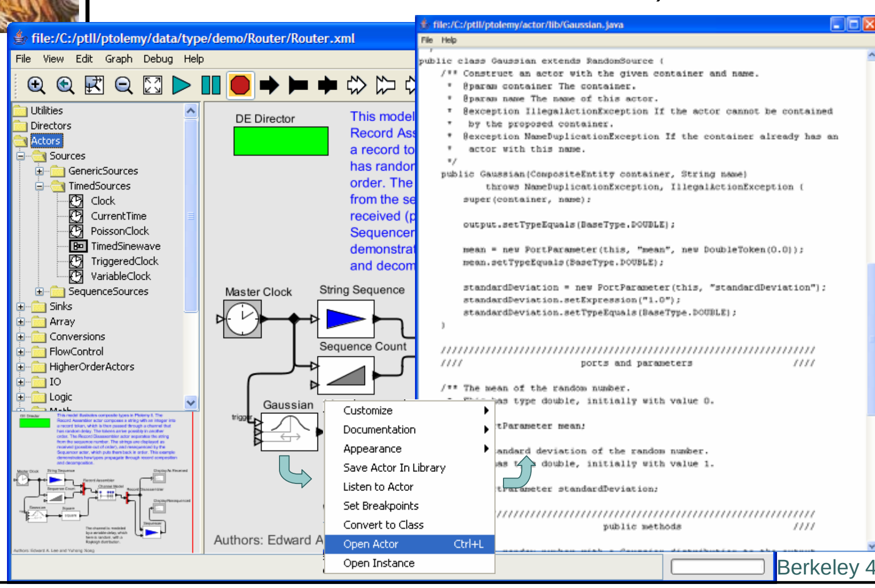
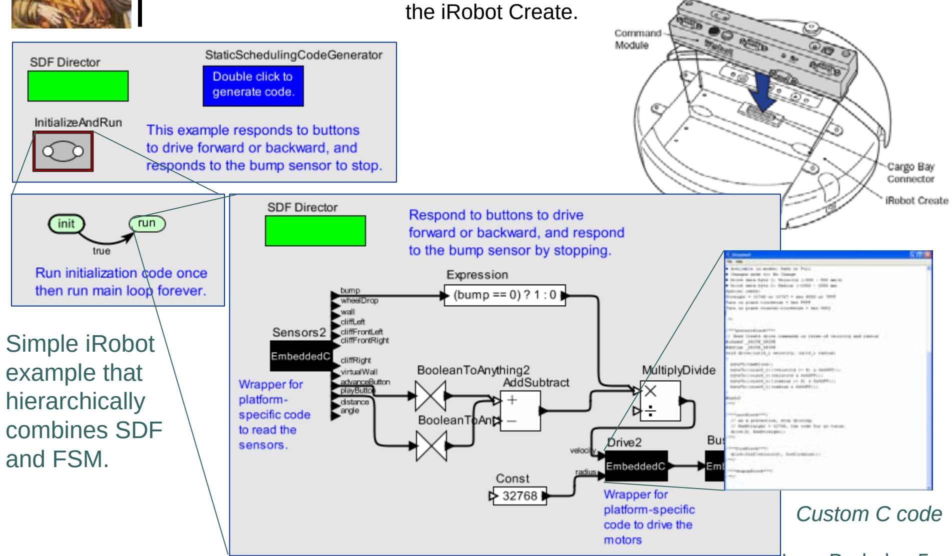
Ptolemy II: Functionality of Components is Given in Standard Java (which can wrap C, C++, Perl, Python, MATLAB, Web services, Grid services, …) and/or in C



Models-to-C

A still experimental, rapidly evolving capability supports embedding C code in Ptolemy models, and generating standalone C programs from Ptolemy models. This example produces embedded C code for the iRobot Create.



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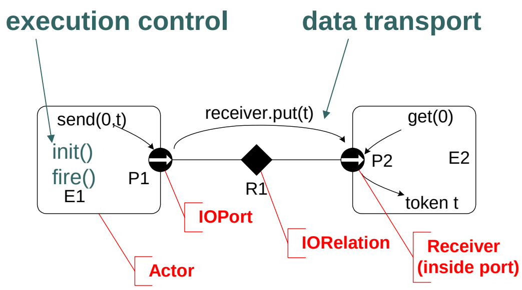
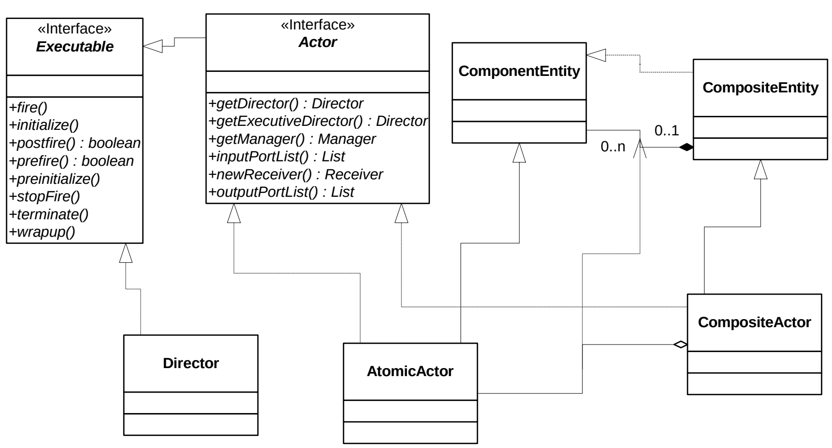
Recall Abstract Semantics of *Actor-Oriented* Models of Computation



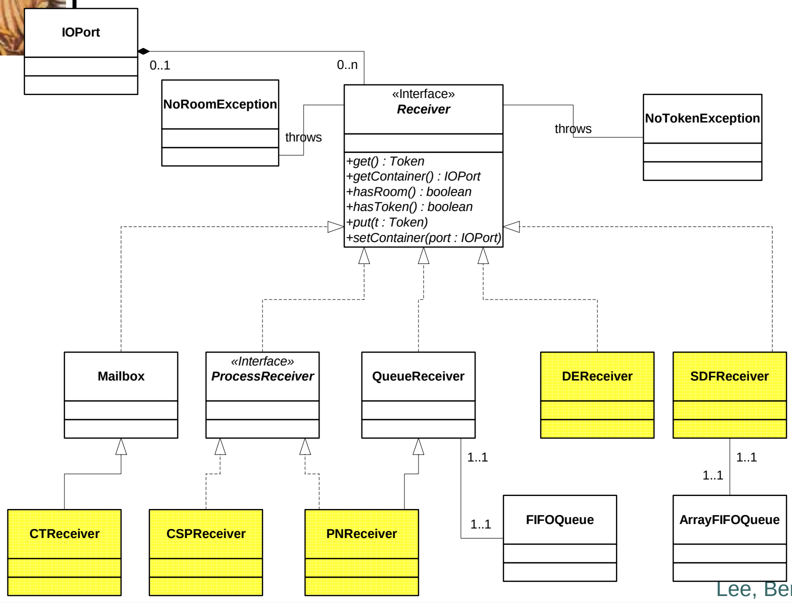
Actor-Oriented Models of Computation that we have implemented:

- dataflow (several variants)
- process networks
- distributed process networks
- Click (push/pull)
- continuous-time
- CSP (rendezvous)
- discrete events
- distributed discrete events
- synchronous/reactive
- time-driven (several variants)
- …

Object Model for Executable Components



Object Model (Simplified) for Communication Infrastructure



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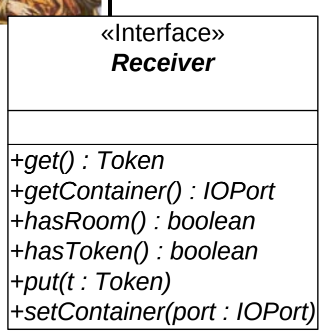
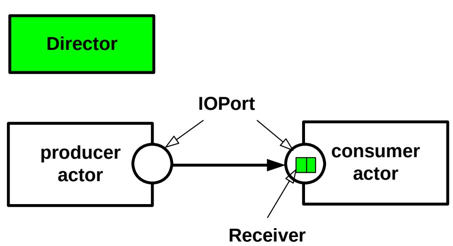
Object-Oriented Approach to Achieving Behavioral Polymorphism



These polymorphic methods implement the communication semantics of a domain in Ptolemy II. The receiver instance used in communication is supplied by the director, not by the component.



Recall: Behavioral polymorphism is the idea that components can be defined to operate with multiple models of computation and multiple middleware frameworks.

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Extension Exercise 1

Build a director that subclasses PNDirector to allow ports to alter the “blocking read” behavior. In particular, if a port has a parameter named “tellTheTruth” then the receivers that your director creates should “tell the truth” when hasToken() is called. That is, instead of always returning true, they should return true only if there is a token in the receiver.

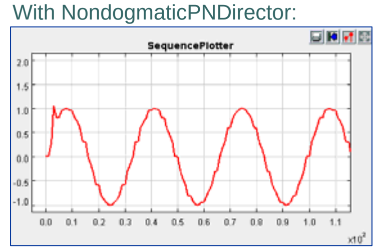
Parameterizing the behavior of a receiver is a simple form of communication refinement, a key principle in, for example, Metropolis.

Implementation of the NondogmaticPNDirector

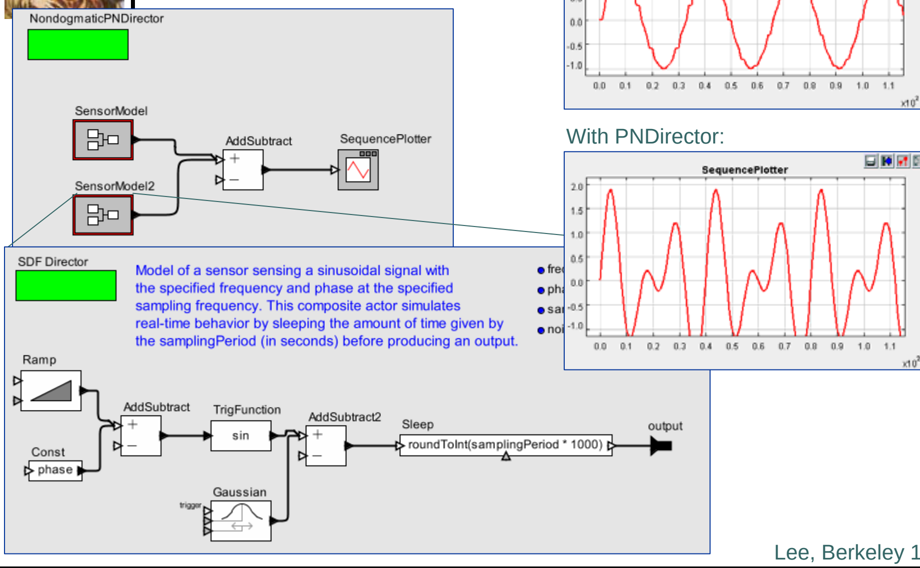
```
package doc.tutorial;
import …
public class NondogmaticPNDirector extends PNDirector {
    public NondogmaticPNDirector(CompositeEntity container, String name)
            throws IllegalActionException, NameDuplicationException {
        super(container, name);
    }
    public Receiver newReceiver() {
        return new FlexibleReceiver();
    }
    public class FlexibleReceiver extends PNQueueReceiver {
        public boolean hasToken() {
            IOPort port = getContainer();
            Attribute attribute = port.getAttribute("tellTheTruth");
            if (attribute == null) {
                 return super.hasToken();
            }
            // Tell the truth...
            return _queue.size() > 0;
        }
    }
}
```

Using It

With NondogmaticPNDirector:



With PNDirector:



Extension Exercise 2

Build a director that subclasses Director and allows different receiver classes to be used on different connections. This is a form of what we call “amorphous heterogeneity.”

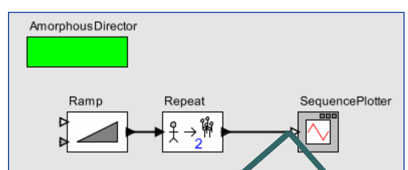
Implementation of the AmorphousDirector

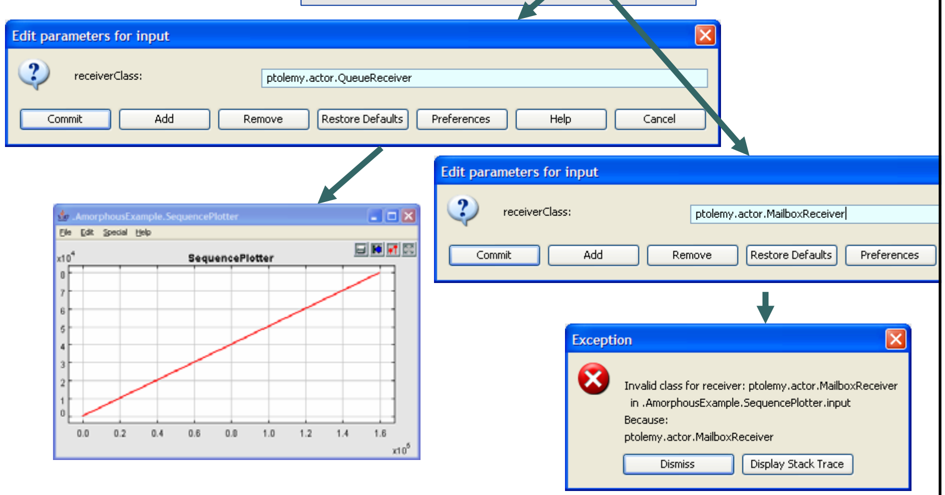
```java
package doc.tutorial;
import …
public class AmorphousDirector extends Director {
    public AmorphousDirector(CompositeEntity container, String name)
            throws IllegalActionException, NameDuplicationException {
        super(container, name);
    }
    public Receiver newReceiver() {
        return new DelegatingReceiver();
    }
    public class DelegatingReceiver extends AbstractReceiver {
        private Receiver _receiver;
        public DelegatingReceiver() {
            super();
            _receiver = new SDFReceiver();
        }
        public DelegatingReceiver(IOPort container) throws IllegalActionException {
            super(container);
            _receiver = new SDFReceiver(container);
        }

        public void clear() throws IllegalActionException {
            IOPort container = getContainer();
            if (container != null) {
                StringParameter receiverClass = (StringParameter)
                        container.getAttribute("receiverClass", StringParameter.class);
                if (receiverClass != null) {
                    String className = ((StringToken)receiverClass.getToken()).stringValue();
                    try {
                        Class desiredClass = Class.forName(className);
                        _receiver = (Receiver)desiredClass.newInstance();
                    } catch (Exception e) {
                        throw new IllegalActionException(container, e,
                        "Invalid class for receiver: " + className);
                    }
                }
            }
            _receiver.clear();
        }

        public Token get() throws NoTokenException {
            return _receiver.get();
        }
        …
```


Using It





Extension Exercise 3

Build a director that fires actors in left-to-right order, as they are laid out on the screen.


```
package doc.tutorial;
import java.util.Comparator;
import …
public class LeftRightDirector extends StaticSchedulingDirector {
    public LeftRightDirector(CompositeEntity container, String name) … {
        super(container, name);
        setScheduler(new LeftRightScheduler(this, "LeftRightScheduler"));
    }
    public class LeftRightScheduler extends Scheduler {
        public LeftRightScheduler(LeftRightDirector director, String name) … {
            super(director, name);
        }
        protected Schedule _getSchedule() … {
            StaticSchedulingDirector director = (StaticSchedulingDirector) getContainer();
            CompositeActor compositeActor = (CompositeActor) (director.getContainer());
            List actors = compositeActor.deepEntityList();
            Iterator actorIterator = actors.iterator();
            TreeSet sortedActors = new TreeSet(new LeftRightComparator());
            while (actorIterator.hasNext()) {
                Actor actor = (Actor) actorIterator.next();
                sortedActors.add(actor);
            }
            Schedule schedule = new Schedule();
            Iterator sortedActorsIterator = sortedActors.iterator();
            while (sortedActorsIterator.hasNext()) {
                Actor actor = (Actor) sortedActorsIterator.next();
                Firing firing = new Firing();
                firing.setActor(actor);
                schedule.add(firing);
            }

            return schedule;
        }
        public class LeftRightComparator implements Comparator {

            public int compare(Object o1, Object o2) {
                ...
            }
            public boolean equals(Object o) {
                …
            }
        }
    }
}
```

Implementation of the LeftRightDirector

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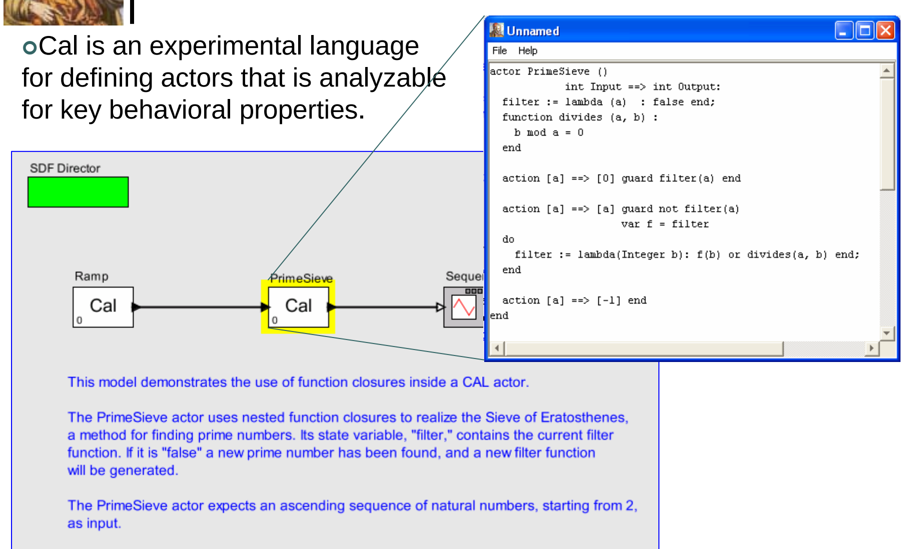
Example Extensions
Python Actors, Cal Actors, MATLAB Actors

- Cal is an experimental language for defining actors that is analyzable for key behavioral properties.



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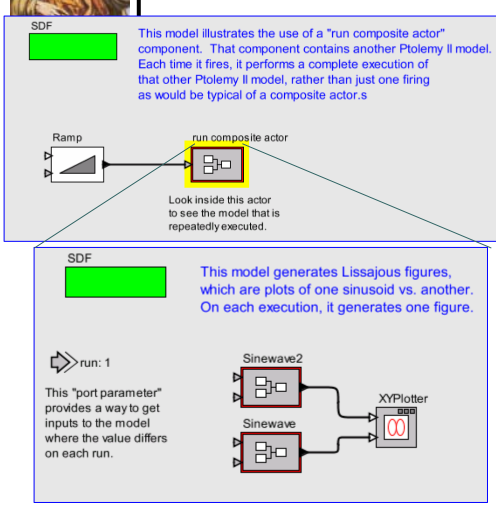
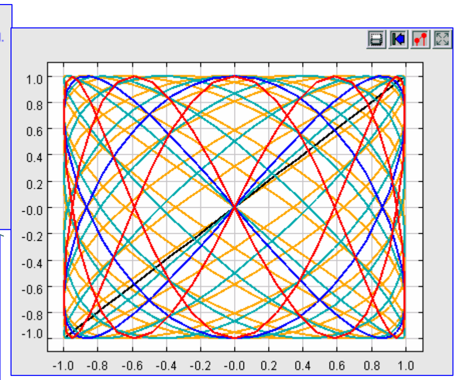
Example Extensions
Using Models to Control Models

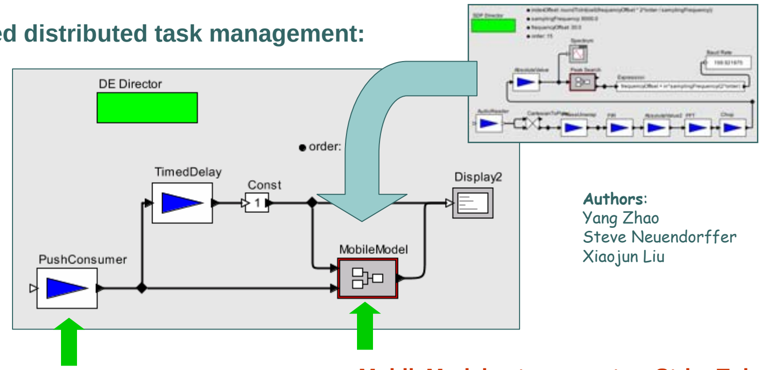




- This is an example of a “higher-order component,” or an actor that references one or more other actors.

Examples of Extensions
Mobile Models

Model-based distributed task management:



Authors:
Yang Zhao
Steve Neuendorffer
Xiaojun Liu

PushConsumer actor receives pushed data provided via CORBA, where the data is an XML model of a signal analysis algorithm.

MobileModel actor accepts a StringToken containing an XML description of a model. It then executes that model on a stream of input data.

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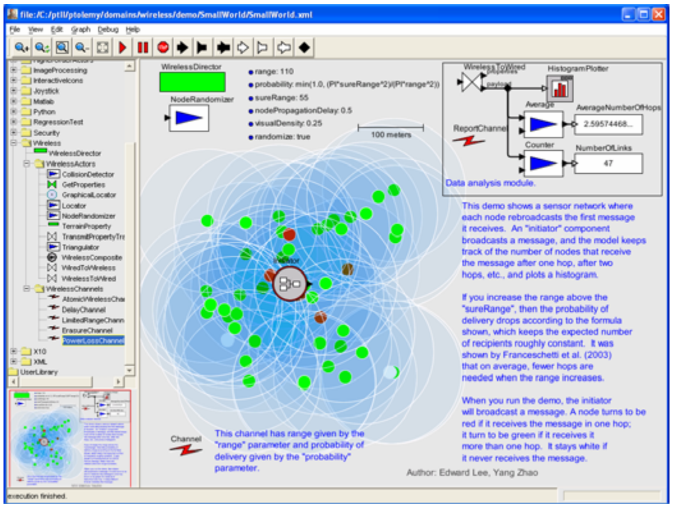
Extension of Discrete-Event Modeling for Wireless Sensor Nets



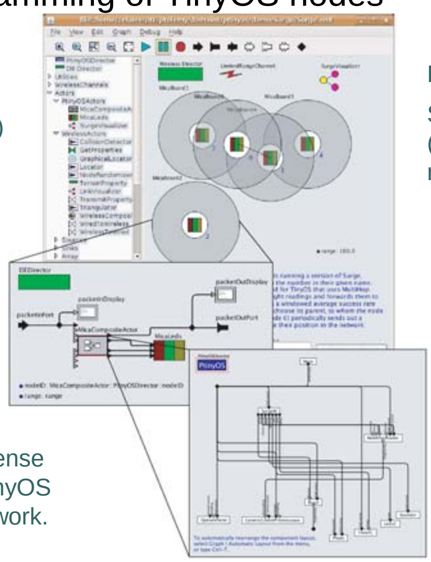
VisualSense extends the Ptolemy II discrete-event domain with communication between actors representing sensor nodes being mediated by a *channel*, which is another actor.

The example at the left shows a grid of nodes that relay messages from an *initiator* (center) via a channel that models a low (but non-zero) probability of long range links being viable.

Viptos: Extension of VisualSense with Programming of TinyOS nodes

Viptos demo:
Multihop routing (Surge)

Hardware



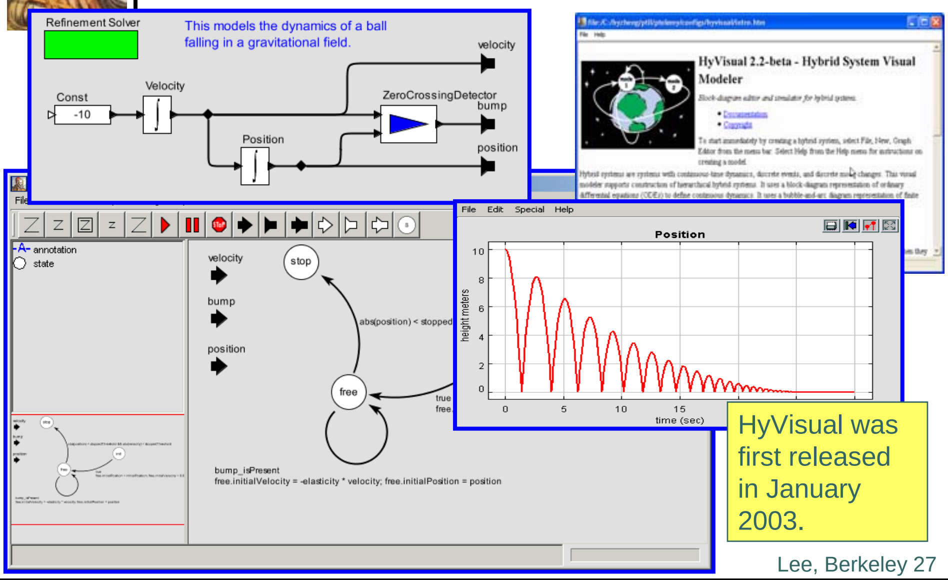
Physical environment

Simulation
(with visualization of routing tree)

Software
Code generation:
Models to nesC.

Viptos extends VisualSense with programming of TinyOS nodes in a wireless network. See the Ph.D. thesis of Elaine Cheong (Aug 2007).

Another Extension: HyVisual – Hybrid System Modeling Tool Based on Ptolemy II



HyVisual was first released in January 2003.

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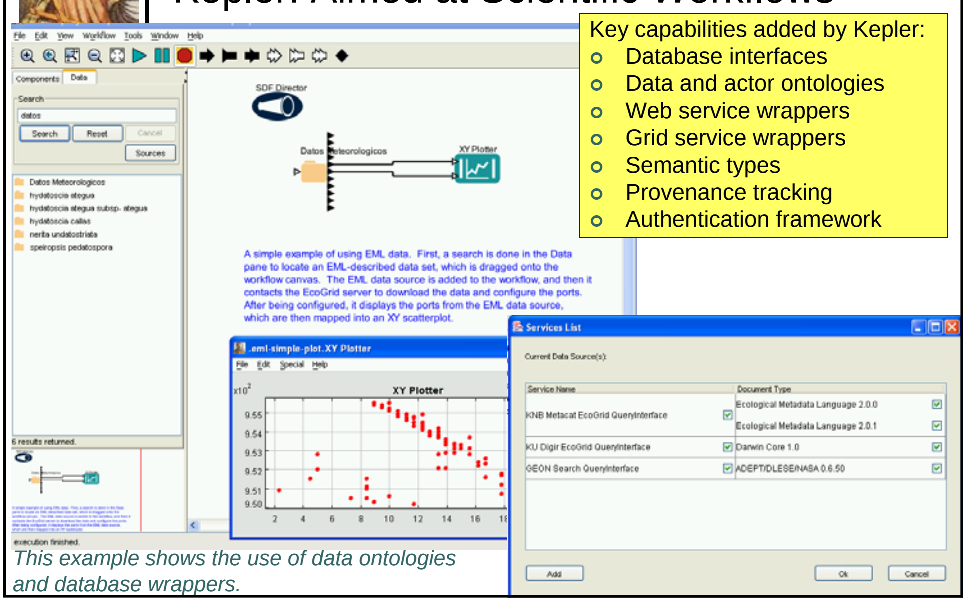
Another Extension:
Kepler: Aimed at Scientific Workflows



Key capabilities added by Kepler:

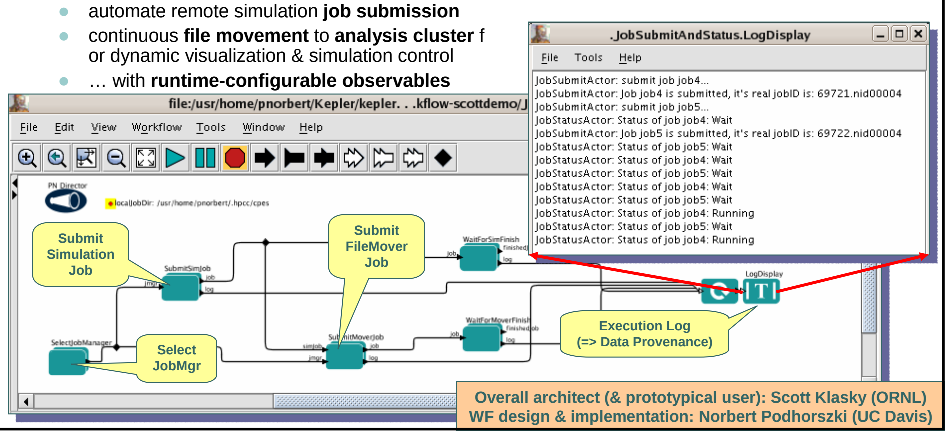
- Database interfaces
- Data and actor ontologies
- Web service wrappers
- Grid service wrappers
- Semantic types
- Provenance tracking
- Authentication framework

This example shows the use of data ontologies and database wrappers.

Kepler as an Interface to the Grid

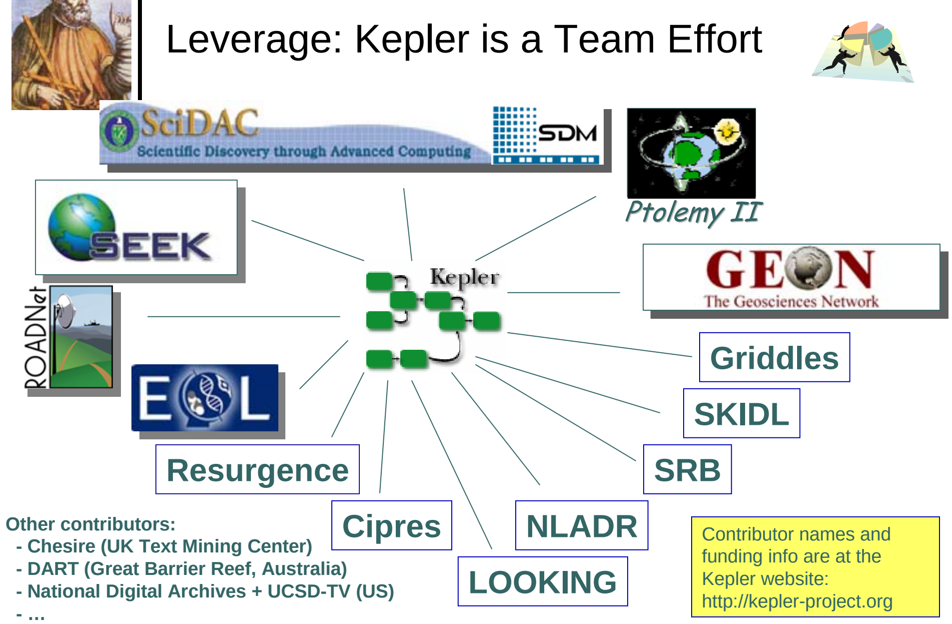
CPES Fusion Simulation Workflow

- **Fusion Simulation Codes**: (a) GTC; (b) XGC with M3D
  - e.g. (a) currently 4,800 (soon: 9,600) nodes Cray XT3; 9.6TB RAM; 1.5TB simulation data/run
- **GOAL**:
  - automate remote simulation **job submission**
  - continuous **file movement** to **analysis cluster** f or dynamic visualization & simulation control
  - … with **runtime-configurable observables**



Overall architect (& prototypical user): Scott Klasky (ORNL)
WF design & implementation: Norbert Podhorszki (UC Davis)

Leverage: Kepler is a Team Effort



Other contributors:
- Chesire (UK Text Mining Center)
- DART (Great Barrier Reef, Australia)
- National Digital Archives + UCSD-TV (US)
- …

Contributor names and funding info are at the Kepler website: http://kepler-project.org

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Getting More Information: Documentation

Volume 1:
User-Oriented

Volume 2:
Developer-Oriented

Volume 3:
Researcher-Oriented

Tutorial information: http://ptolemy/conferences/07/tutorial.htm