

# Documentation — Programmer-Oriented



## Volume 3

### Programmer's Manual

software organization

writing stars

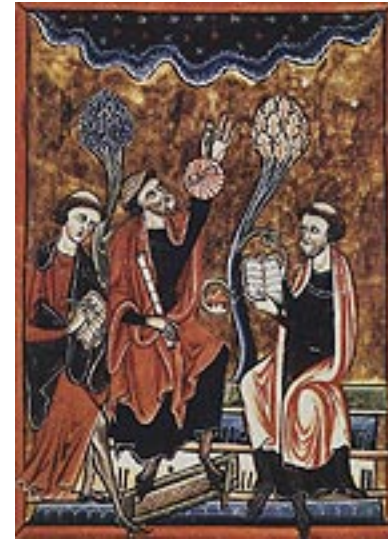
infrastructure

data types

Tcl/Tk

domains

code generation



## Volume 4

### Kernel Manual

detailed documentation

of all C++ classes

defined in the kernel.

Essential for defining

Targets and Domains.

# Documentation — User-Oriented

## The Almagest



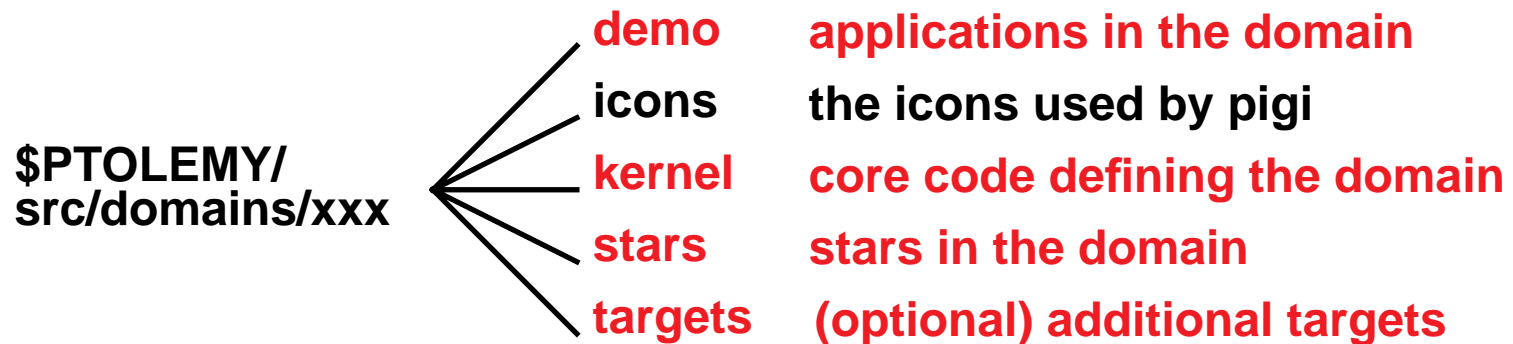
### Volume 1 User's Manual

pigi  
ptcl  
domains  
vem  
pxgraph  
installation



Volume 2  
Star Atlas  
detailed documentation  
of all stars  
(not up-to-date)

## Within Each Domain Directory



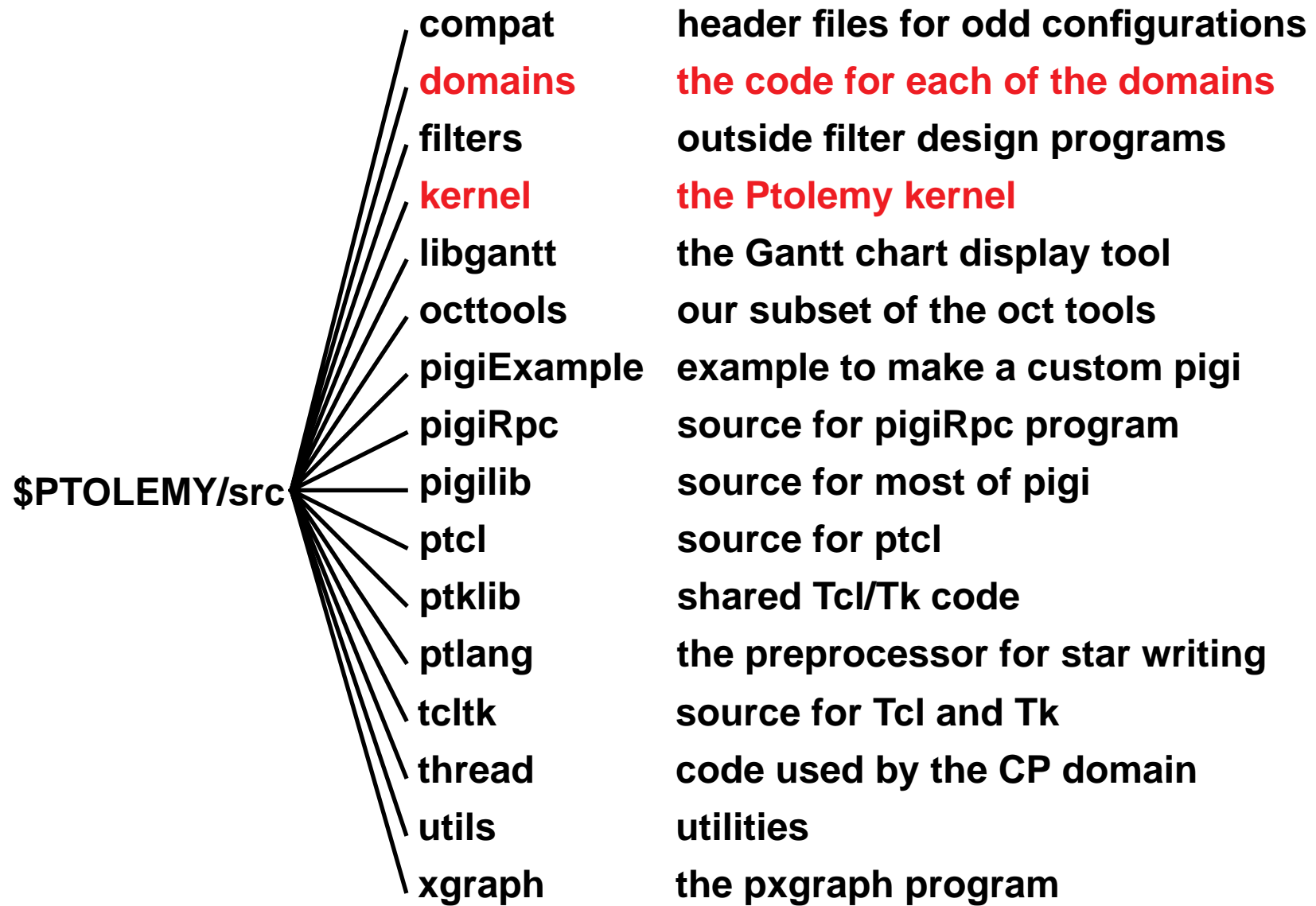
The stars in a domain are an excellent resource for learning about how to write custom stars for the domain.

**READ THE SOURCE**

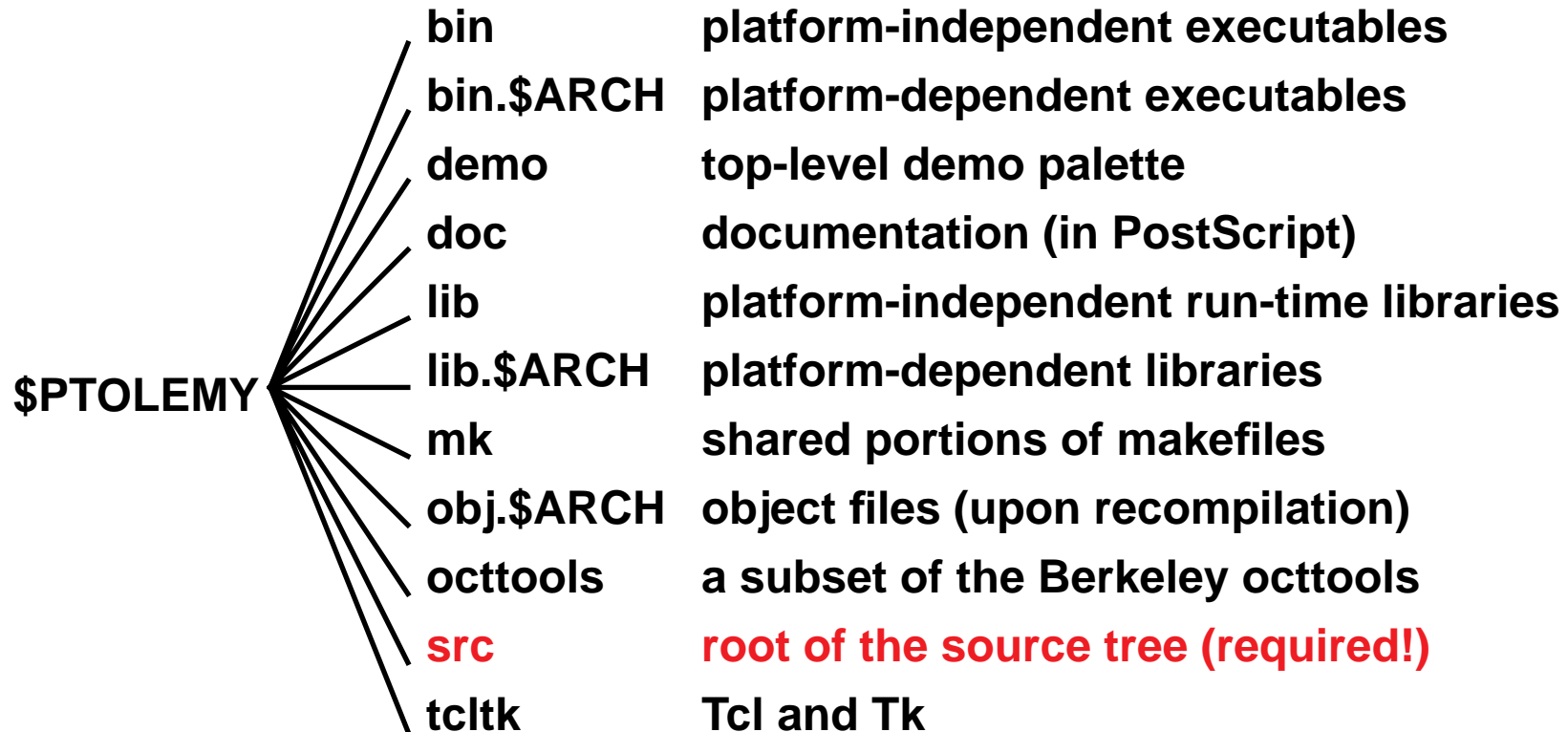
## The Domains Directory

\$PTOLEMY/ src/domains	<b>bdf</b>	<b>Boolean dataflow domain</b>
	cg	base classes for code generation
	cg56	Motorola DSP56000
	cg96	Motorola DSP96000
	<b>cgc</b>	<b>code generation in C</b>
	cp	communicating processes (sun)
	<b>ddf</b>	<b>dynamic dataflow</b>
	<b>de</b>	<b>discrete-event</b>
	mq	message queue
	<b>sdf</b>	<b>synchronous dataflow</b>
	silage	Silage code generation
	sproc	Sproc DSP (obsolete)
	thor	hardware simulation
	<b>vhdlb</b>	<b>behavioral modeling in VHDL</b>
	<b>vhdlf</b>	<b>functional modeling in VHDL</b>
	xxx	demonstration new domains

## The Source Tree



## File Organization



To run ptolemy, set the environment variable **PTOLEMY** to the root directory of the installation and put **\$PTOLEMY/bin** in your path.

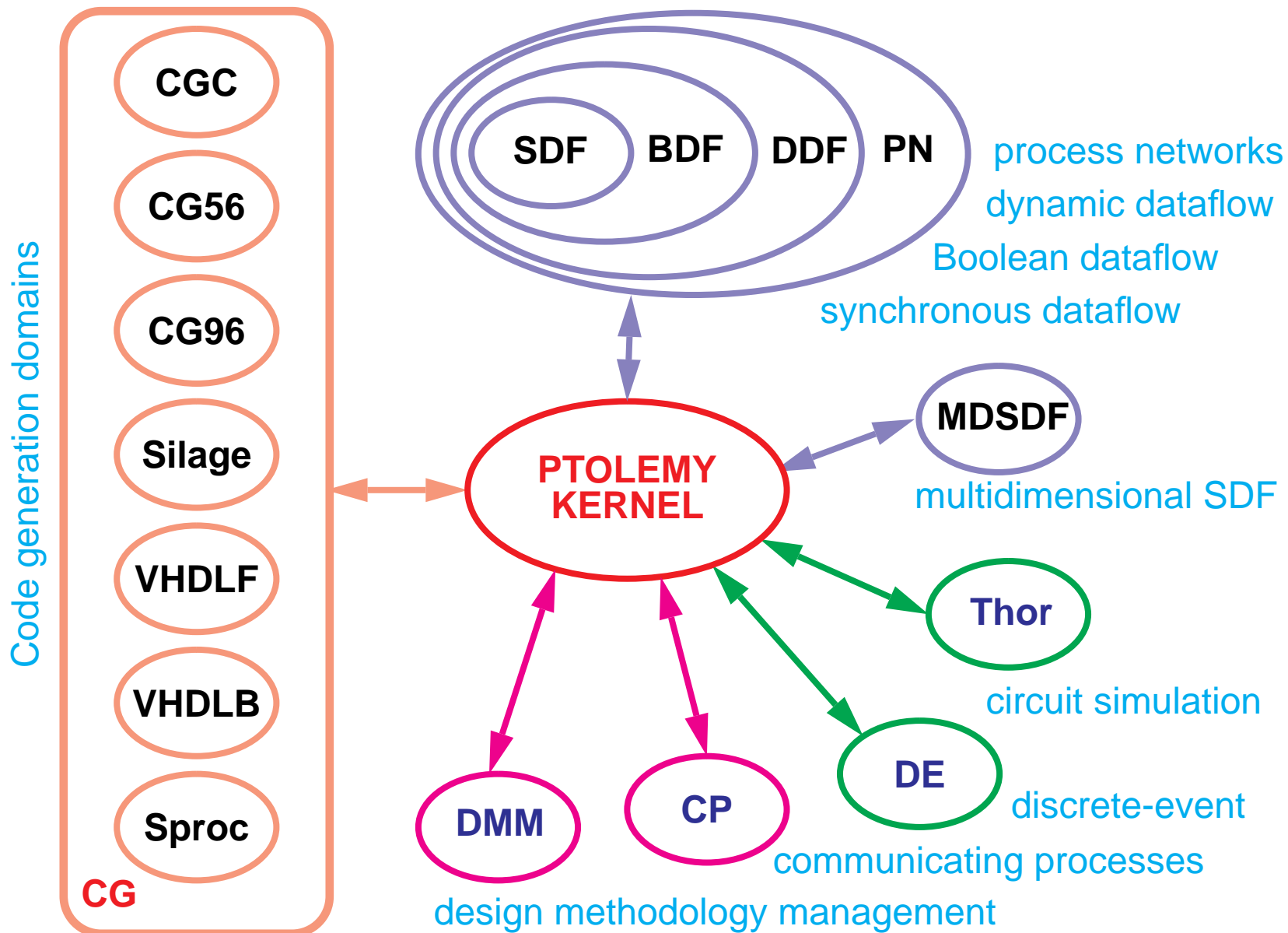
The preferred installation location is **/users/ptolemy**.

## Ptolemy is an Extensible Open Architecture

### Extensions that are possible:

- applications
- a library of galaxies
- application builders (using ptcl)
- a library of custom stars
- customized user interfaces (using Tcl/Tk)
- simulation managers (Targets)
- domains
- foreign simulators and/or synthesis tools

# Domains in Ptolemy





## Standard forms of the Ptolemy Executables

### **pigi**

- All domains and targets plus the GUI.

### **ptrim**

- SDF, BDF, DDF, DE, CGC and HOF domains plus GUI.

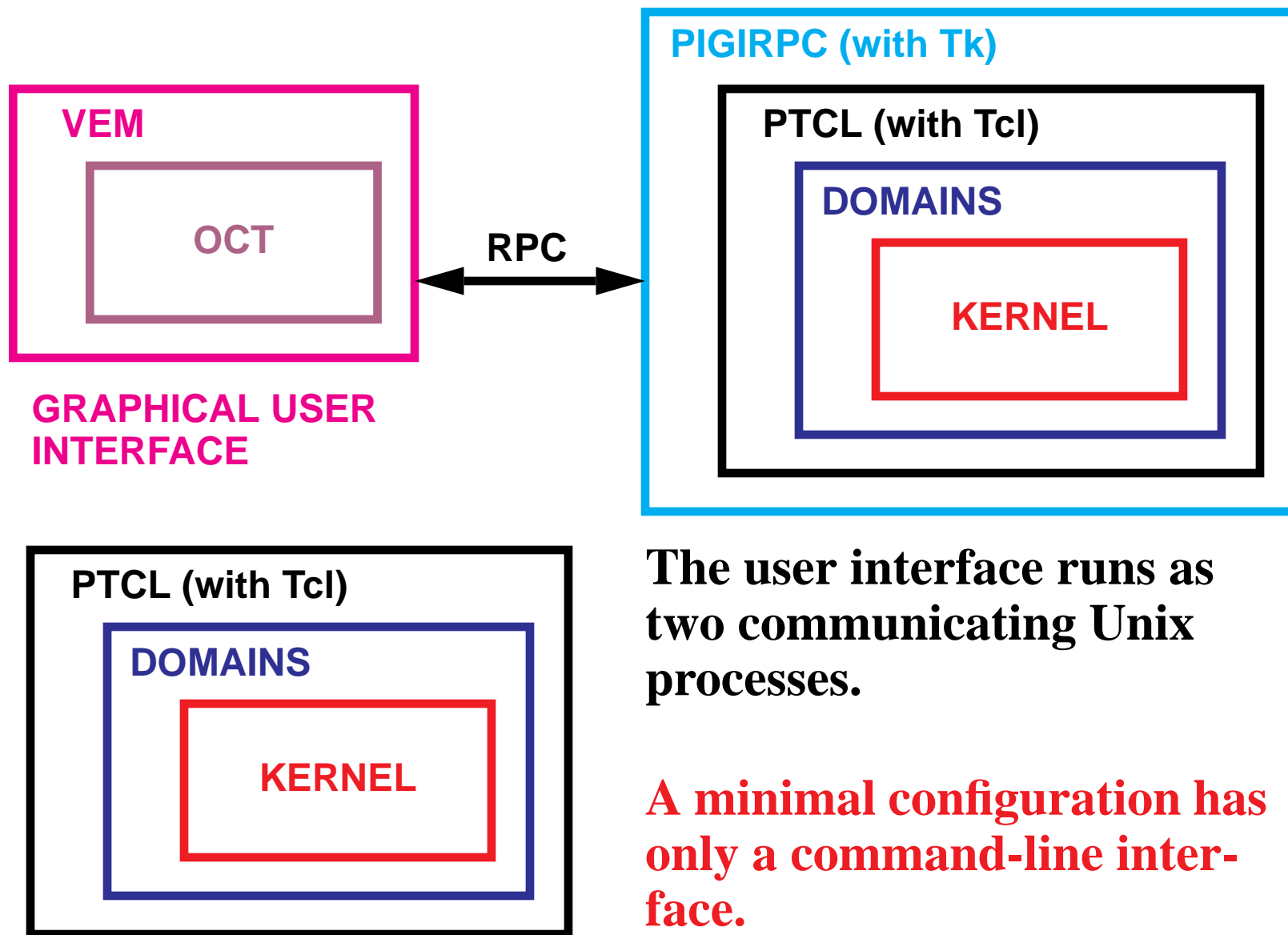
### **ptiny**

- SDF and DE domains plus GUI.

### **ptcl**

- All domains, no GUI.

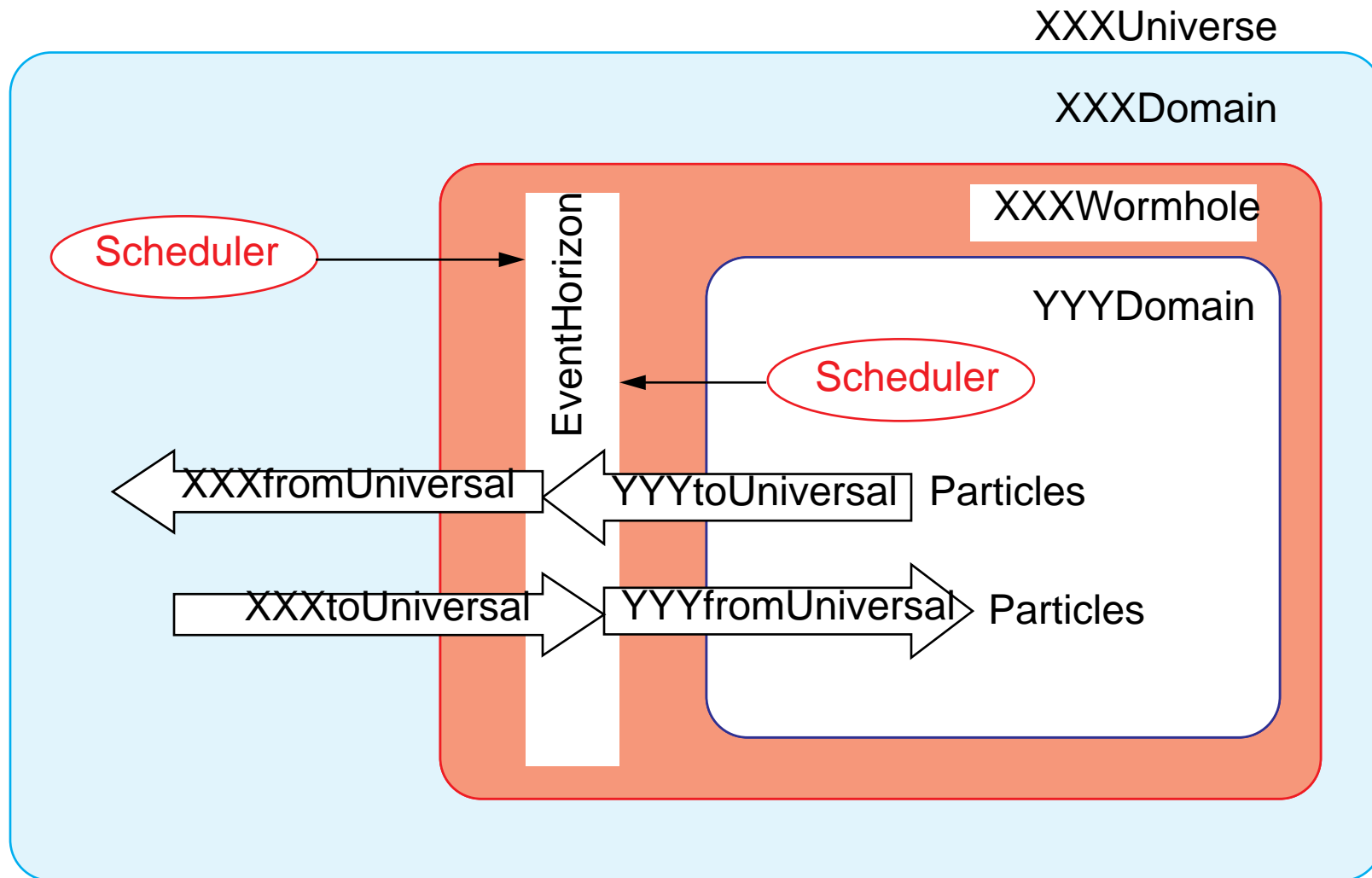
# Overall Software Organization



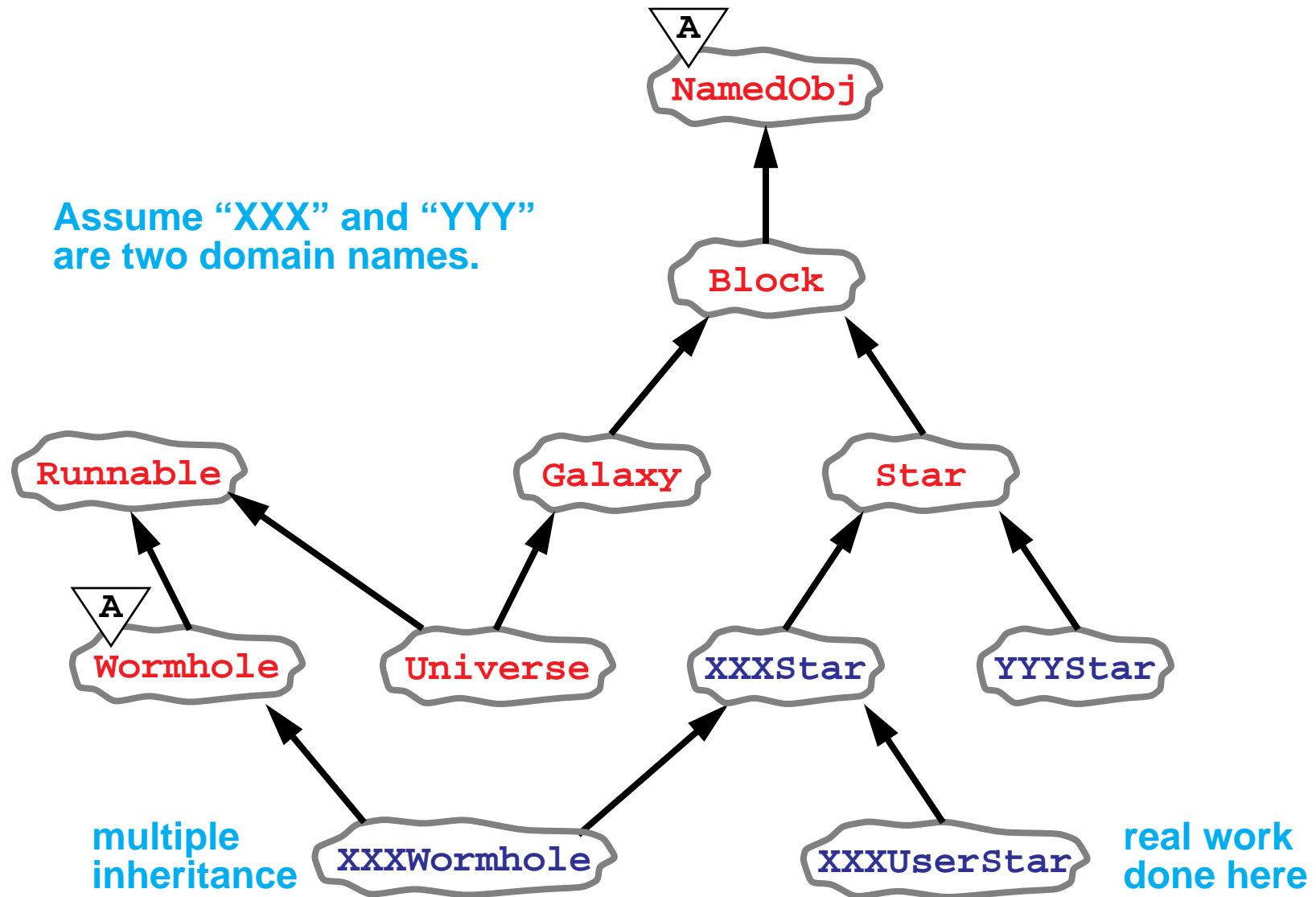
**The user interface runs as two communicating Unix processes.**

**A minimal configuration has only a command-line interface.**

# Interaction Across Models of Computation



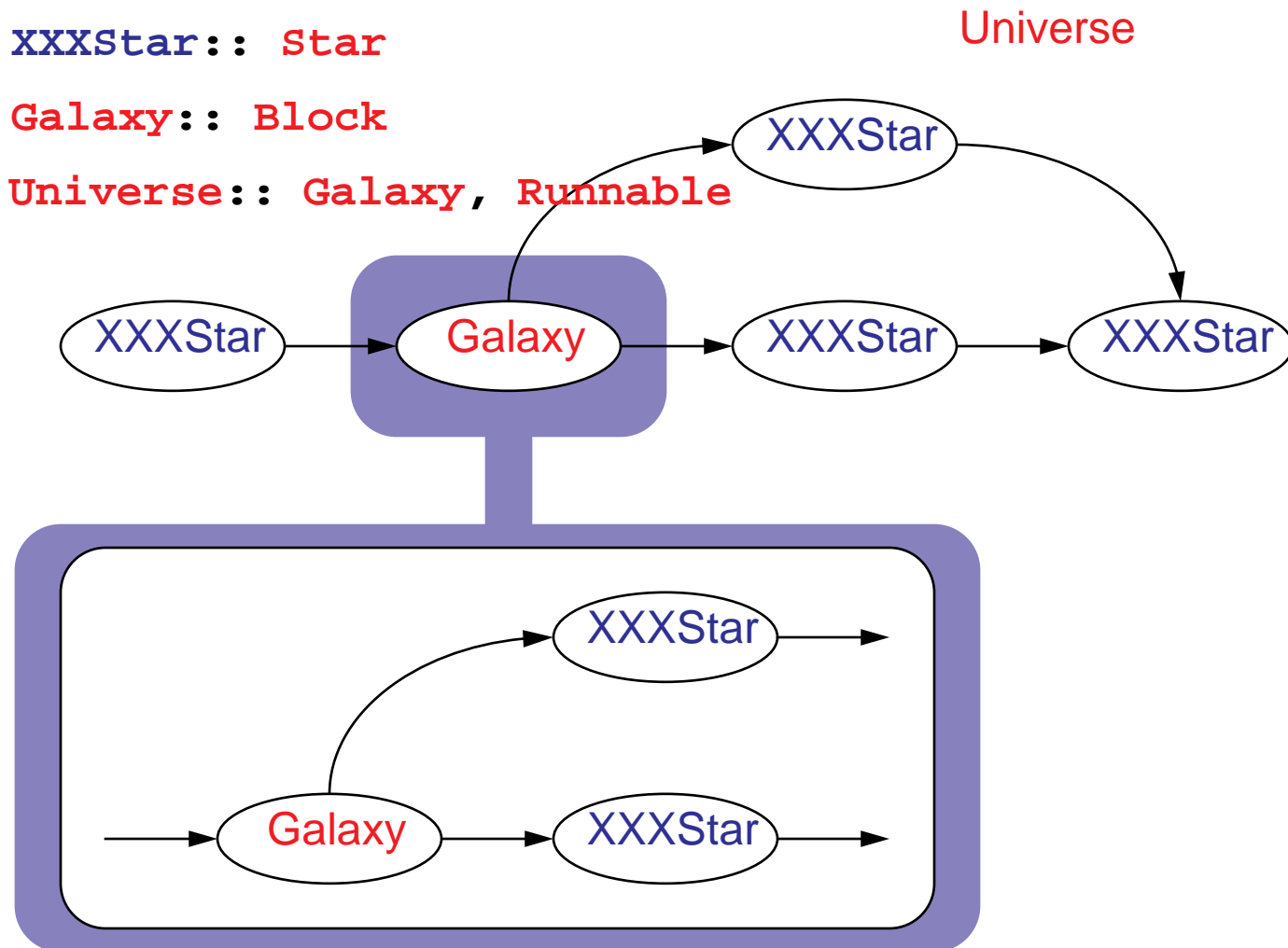
## Domain Classes Derived from Kernel Classes



# Hierarchical Abstraction

## Examples of Derived Classes

- `class Star:: Block`
- `class XXXStar:: Star`
- `class Galaxy:: Block`
- `class Universe:: Galaxy, Runnable`



## Example: NamedObject

```
class NamedObj {  
public:  
    NamedObj ();  
    NamedObj (const char* n,Block* p,const char* d);
```

The return value cannot be modified.    The string will not be modified

```
    const char* name() const;  
    const char* descriptor() const;  
    Block* parent() const;
```

```
    void setParent (Block* my_parent);  
    void setName (const char* my_name);
```

```
    virtual const char* className() const;  
    virtual int isA(const char* cname) const;
```

Calling a virtual method gives the version in the derived class

```
    virtual void initialize() = 0;
```

```
private:                    Pure virtual method  
    const char* nm;  
    Block* prnt;  
    const char* myDescriptor;  
}
```

## Example: NamedObject

```
class NamedObj {  
public:  
    NamedObj ();  
    NamedObj (const char* n,Block* p,const char* d);  
  
    const char* name() const;  
    const char* descriptor() const;  
    Block* parent() const;  
  
    void setParent (Block* my_parent);  
    void setName (const char* my_name);  
  
    virtual const char* className() const;  
    virtual int isa(const char* cname) const;  
  
    virtual void initialize() = 0;  
private:  
    const char* nm;  
    Block* prnt;  
    const char* myDescriptor;  
}
```

Two possible constructors

Methods to access private members

Methods to set private members

Methods to get class information

Private members

## Example: NamedObject

```
class NamedObj {
public:
    NamedObj ();
    NamedObj (const char* n,Block* p,const char* d);

    const char* name() const;
    const char* descriptor() const;
    Block* parent() const;

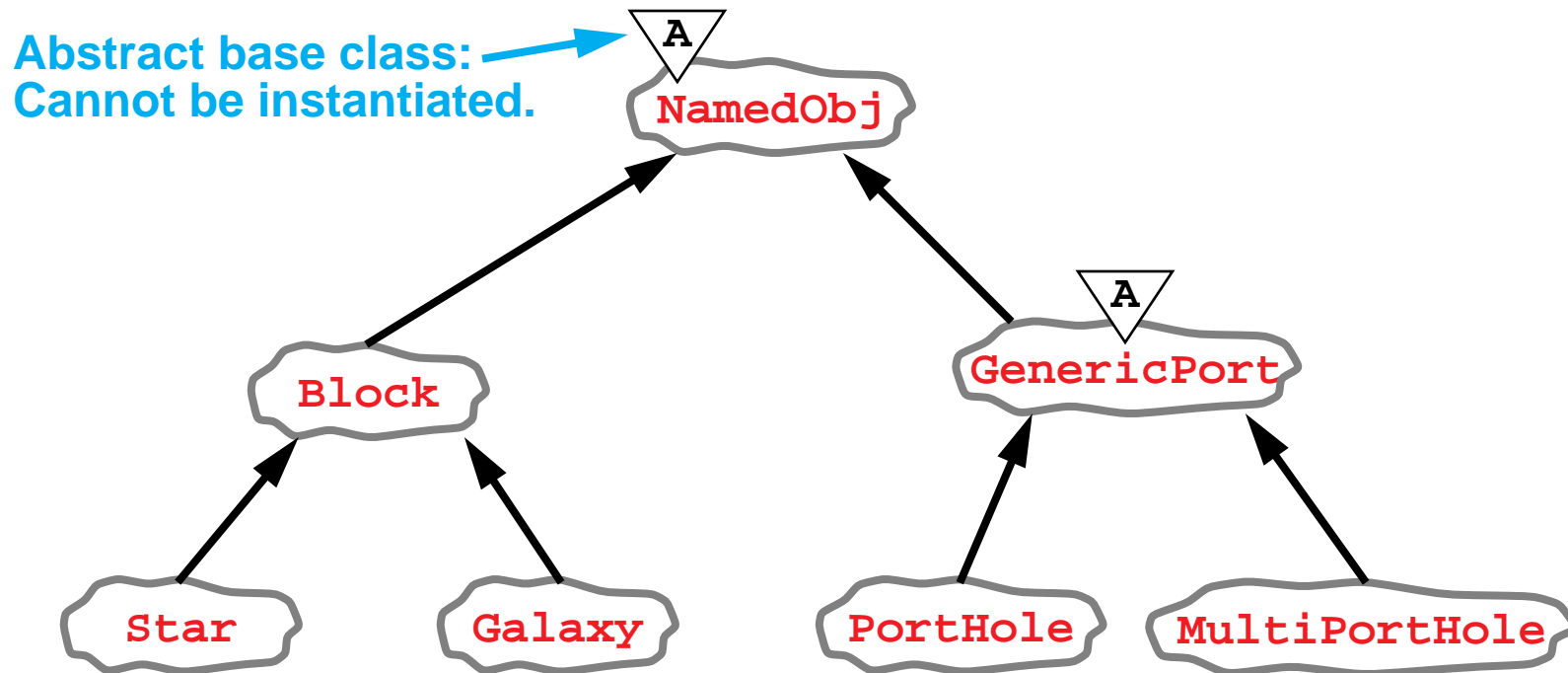
    void setParent (Block* my_parent);
    void setName (const char* my_name);

    virtual const char* className() const;
    virtual int isA(const char* cname) const;

    virtual void initialize() = 0;
private:
    const char* nm;
    Block* prnt;
    const char* myDescriptor;
}
```



## Some Kernel Classes (Booch Notation)



C++ class:

- Members & Methods
- Public, Protected, Private

**Inheritance:** A derived class has all the properties of the parent, plus more.

**Data abstraction:** Hiding the irrelevant and amplifying the essential.

**Polymorphism:** Objects with identical interface have different implementations.

## Object-Oriented Programming

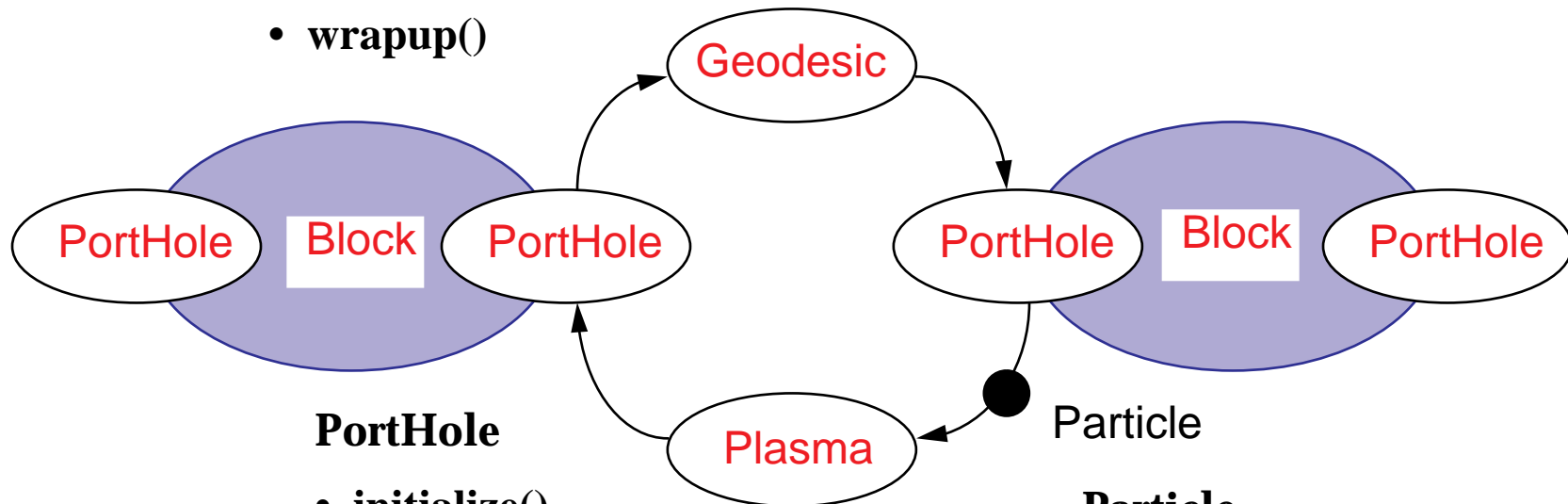
- inheritance
- data abstraction
- polymorphism

**The idea is to use a heterogenous software environment to develop heterogeneous designs. The interaction between different modules in the software environment is managed through object-oriented principles.**

# Ptolemy C++ Base Classes Support this Abstract Syntax

## Block

- initialize()
- run()
- wrapup()



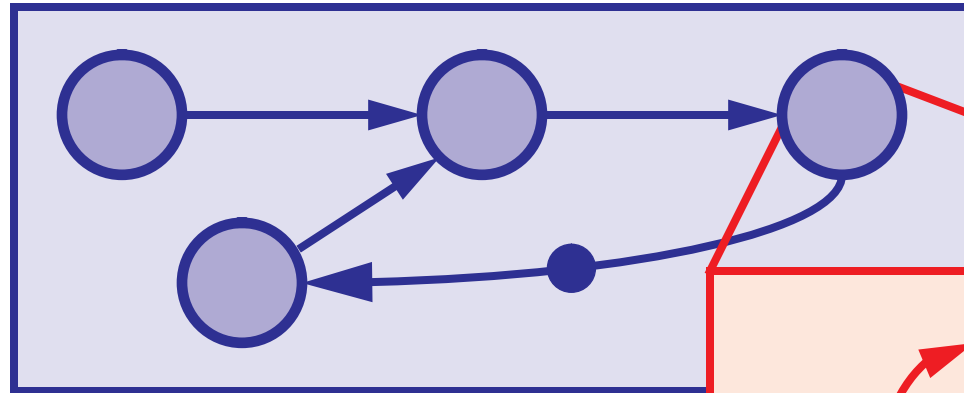
## PortHole

- initialize()
- receiveData()
- sendData()
- type()

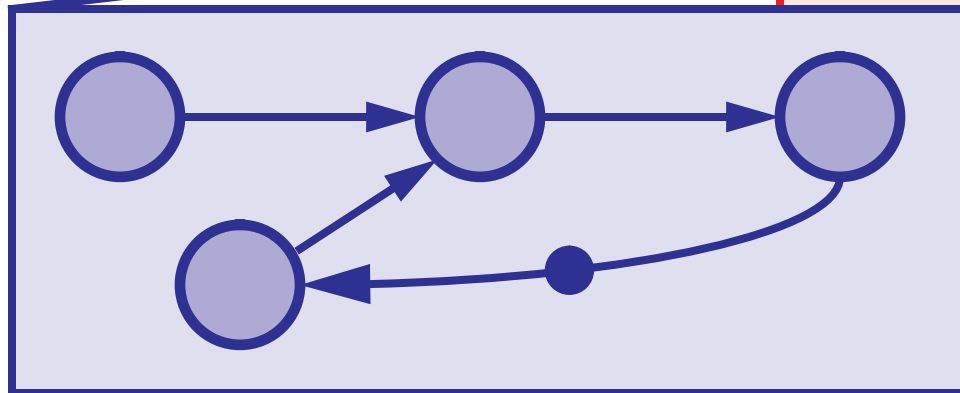
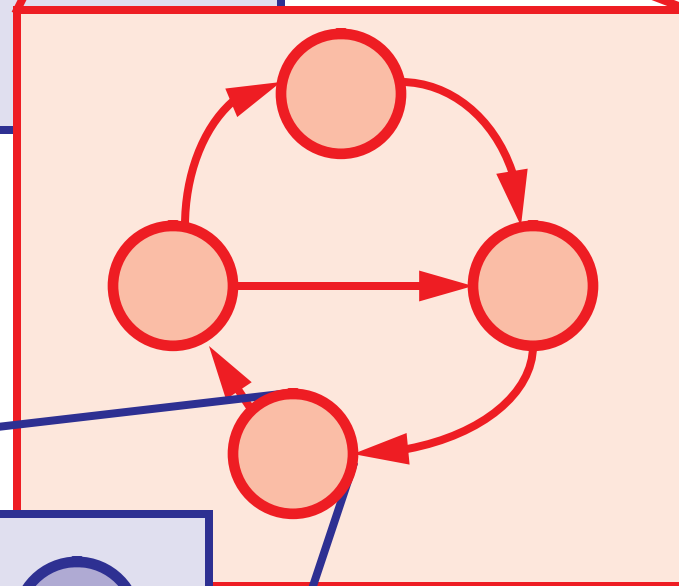
## Particle

- type()
- print()
- initialize()

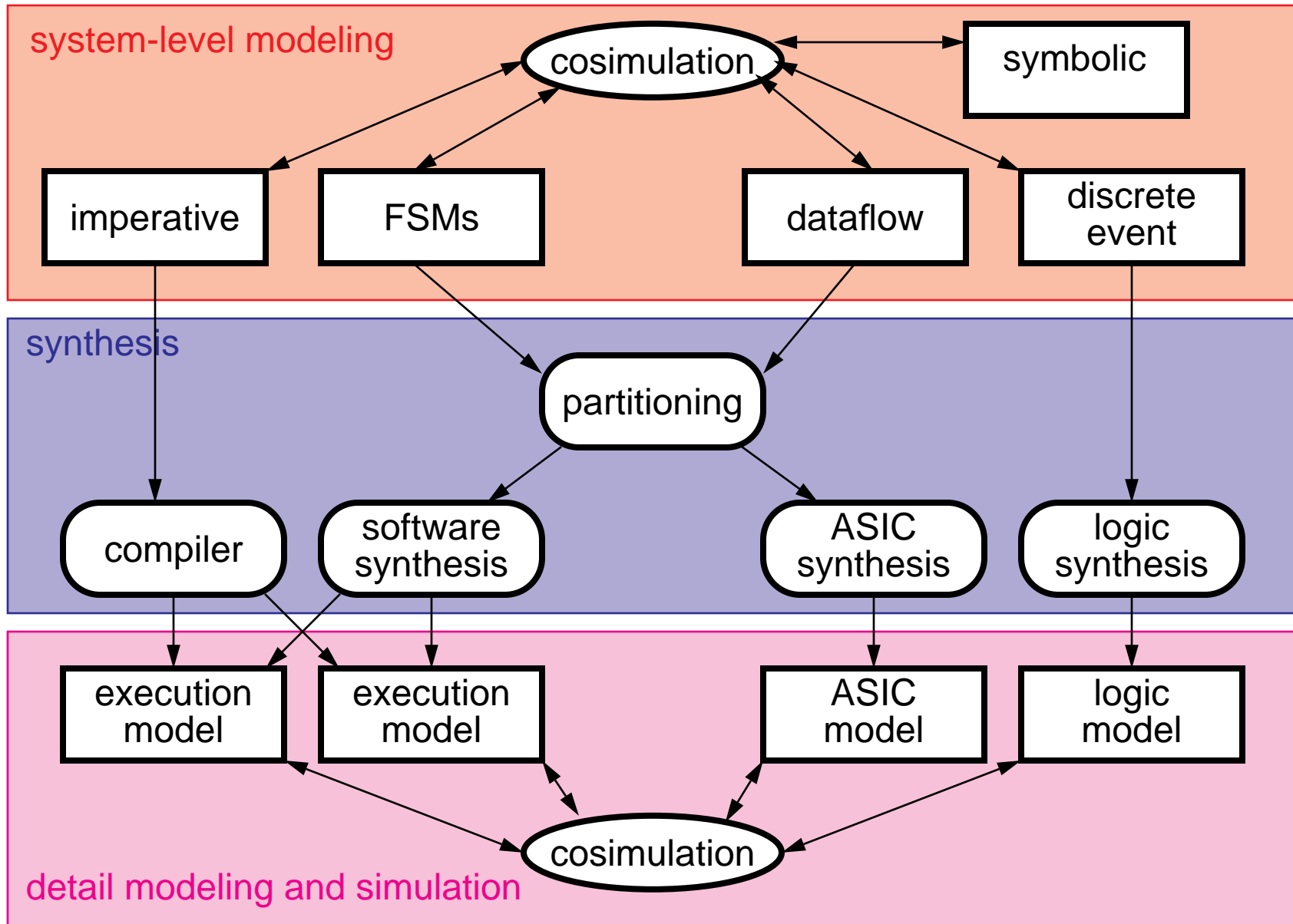
# A Flexible Abstract Syntax



**Hierarchical Graphs**



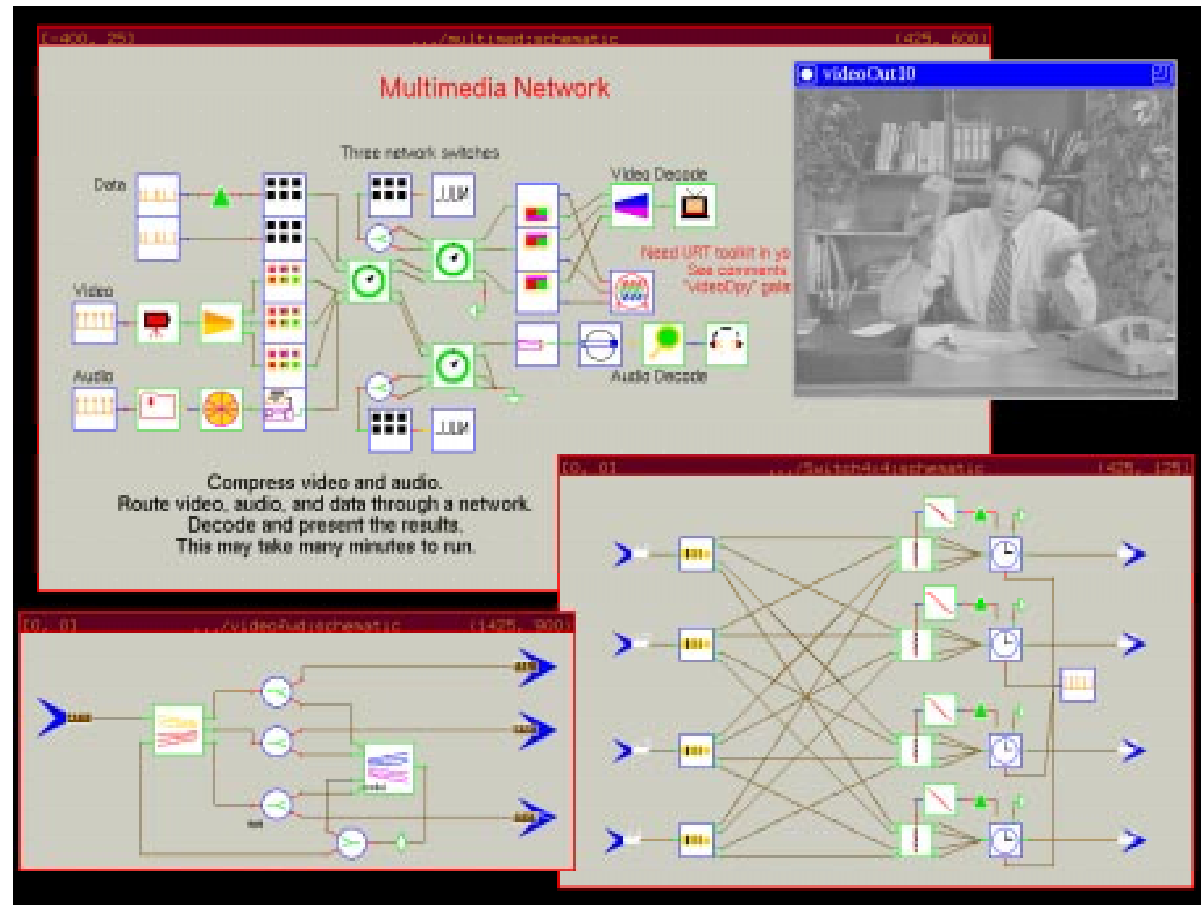
# Heterogeneity in System-Level Design



# Heterogeneous System-Level Design

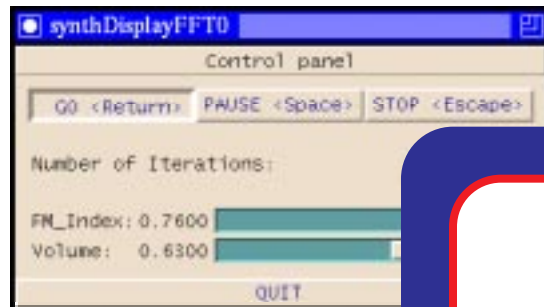
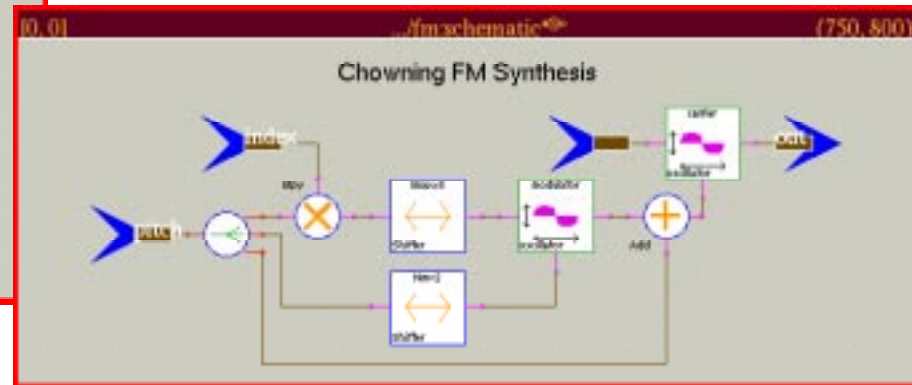
## Ptolemy Simulation

- ATM network with three 4x4 switches
- Detailed model of each switch with queueing and routing protocols.
- Dummy traffic (Poisson arrivals) to create congestion.
- Test traffic (video and audio) to measure subjective performance.



**Multiple models of computation may be used in the same system. Here, dataflow is used for signal processing, while a timed discrete-event system models a communication network.**

# Heterogeneous Real-Time Prototyping



Sparc  
C

DSP Card  
M56K



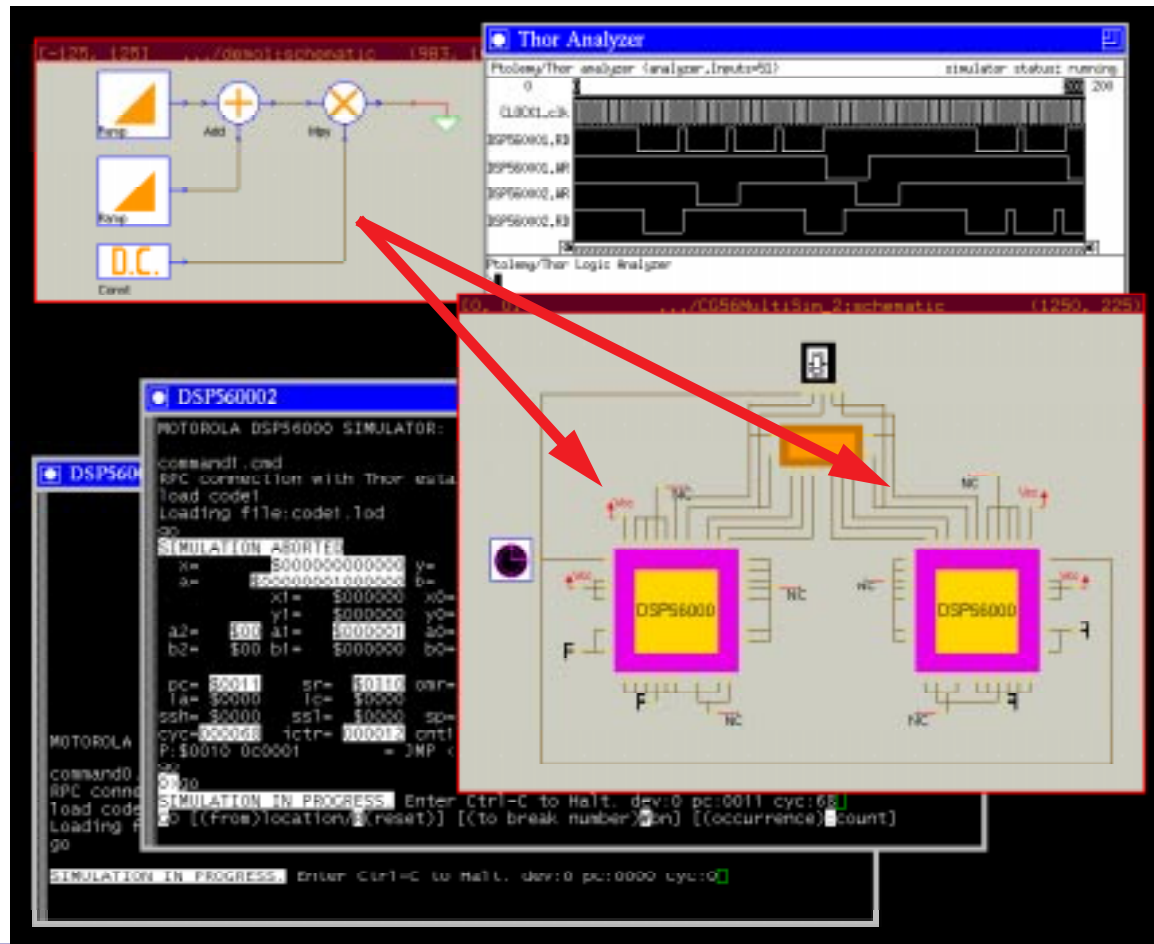
# Baseline Cosimulation

## Features Today

- Instruction set model of the processor.
- RTL model of chip input/output.
- High-level software development.
- Compatibility with ASIC simulators.

## Tomorrow

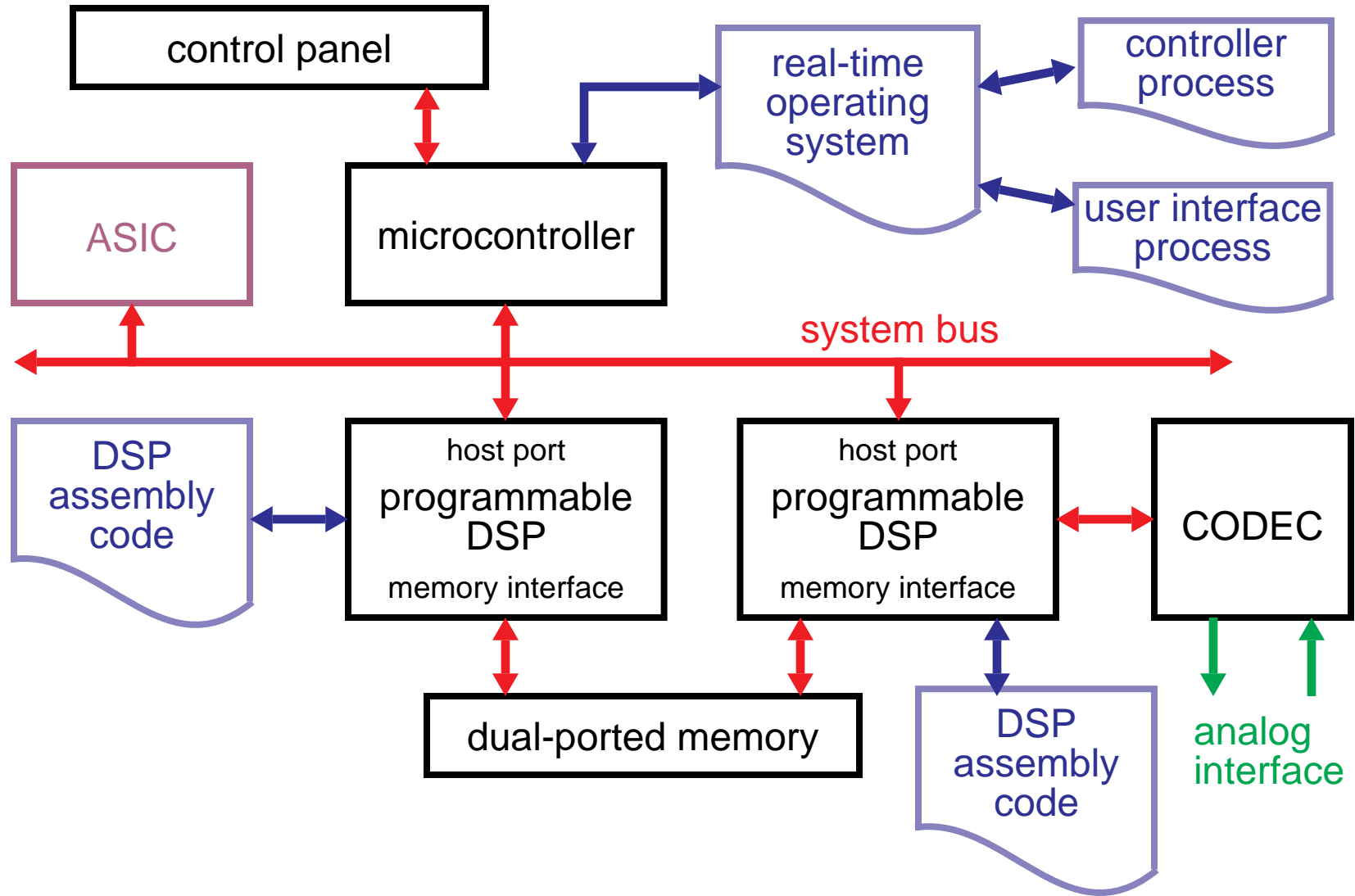
- Compiled simulation.
- More abstract modeling.
- Cycle-based simulation.



The image above shows a Ptolemy simulation of a multiprocessor system where the software is synthesized (including partitioning) from a block diagram.



# Typical Embedded Signal Processing System



# Major Activities

- **Formal methods**
  - **Dataflow** (process networks, synchronous, Boolean, multidimensional, ...)
  - **Control** (hierarchical FSMs, Esterel, synchronous languages, ...)
  - **Partitioning and scheduling of dataflow graphs** (optimize IPC, memory, ...)
  - **Programming languages** (higher-order functions, polymorphism, ... )
- **Algorithm-level design methodology**
  - **Mixing models of computation** (discrete-event, FSMs, dataflow, imperative, ...)
  - **Animation and design visualization** (Tcl/Tk, Matlab, xv, ...)
  - **Mixing domain-specific tools** (filter design, Matlab, Mathematica, ...)
  - **Visual programming** (dataflow, FSMs, regularity, recursive, functional, ...)
- **System-level design methodology**
  - **Synthesis of embedded software** (high-level, assembly, ...)
  - **Design complexity management** (data, tool, flow, methodology, ...)
  - **Hardware/software codesign** (DesignMaker, GCLP partitioning, ...)
  - **Architecture design and performance modeling** (OT principle, VHDL, ...)

## Ptolemy as a Tool and as a Laboratory

### Ptolemy is

- Extensible
- Publicly available
- An open architecture
- Object-oriented

### Allows for experiments with:

- Models of computation
- Domain-specific tools
- Design methodology
- Software synthesis
- Hardware synthesis
- Cosimulation
- Codesign

### Rationale for heterogeneity: specialized models are

- More useful to the system-level designer
- More amenable to hardware and software synthesis.

## Agenda (Afternoon)

**1:30**

- |  |            |
|--|------------|
| 9. Writing Tcl/Tk blocks (15 minutes)                    | Lee        |
| 10.Code generation concepts (30 minutes)                 | Williamson |
| 11.Writing blocks for the CGC and VHDL domains (45 min.) | Williamson |

**2:45 — Break**

**3:15**

- |  |        |
|--|--------|
| 12.Defining Targets (15 minutes)                           | Lee    |
| 13.Defining Domains (30 minutes)                           | Wilson |
| 14.Interfacing to foreign design environments (30 minutes) | Wilson |
| 15.Debugging (15 minutes)                                  | Lee    |
| 16.Preview of Coming Attractions (15 minutes)              | Lee    |

**5:00 Adjourn**

## Agenda (Morning)

**8:30**

- |   |       |
|---|-------|
| 1. Overview of the Ptolemy project (45 minutes) | Lee   |
| 2. Guide to the GUI (30 minutes)                | Evans |
| 3. Higher-Order Functions (15 minutes)          | Evans |

**10:00 — Break**

**10:15**

- |   |     |
|---|-----|
| 4. Dataflow models of computation (30 minutes)          | Lee |
| 5. The synchronous dataflow domain (15 minutes)         | Lee |
| 6. Writing custom stars for the SDF domain (15 minutes) | Lee |
| 7. Boolean and dynamic dataflow domains (15 minutes)    | Lee |

**11:30**

- |   |       |
|---|-------|
| 8. The discrete-event domain (30 minutes) | Evans |
|---|-------|

**12:00 — Lunch**

# Ptolemy Ptutorial



**Brian Evans**  
**Edward A. Lee**  
**Mike Williamson**  
**UC Berkeley**  
**Dave Wilson**  
**Berkeley Design  
Technology, Inc.**