The ERATO *Systems Biology Workbench*: Enabling Interaction and Exchange Between Tools for Computational Biology

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Motivations

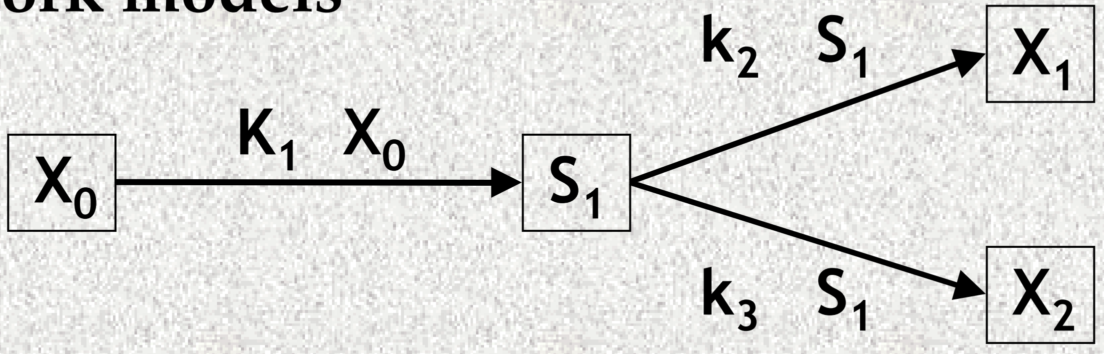
- **Observation:** ***proliferation of software tools***
- **No single package answers all needs**
  - Different packages have different niche strengths
  - Strengths are often complementary
- **No single tool is likely to do so in the near future**
  - Range of capabilities needed is large
  - New techniques (new tools) evolve all the time
- **Researchers are likely to continue using multiple packages for the foreseeable future**
- **Problems with using multiple packages:**
  - Simulations & results often cannot be shared or re-used
  - Duplication of software development effort

Project Goals & Approach

- **Develop software & standards that**
  - Enable sharing of simulation & analysis software
  - Enable sharing of models
- **Goal: make it easier to share tools than to reimplement**
- **Two-pronged approach**
  - Develop a common model exchange language
    - SBML: Systems Biology Markup Language
  - Develop an environment that enables tools to interact
    - SBW: Systems Biology Workbench

Systems Biology Markup Language (SBML)

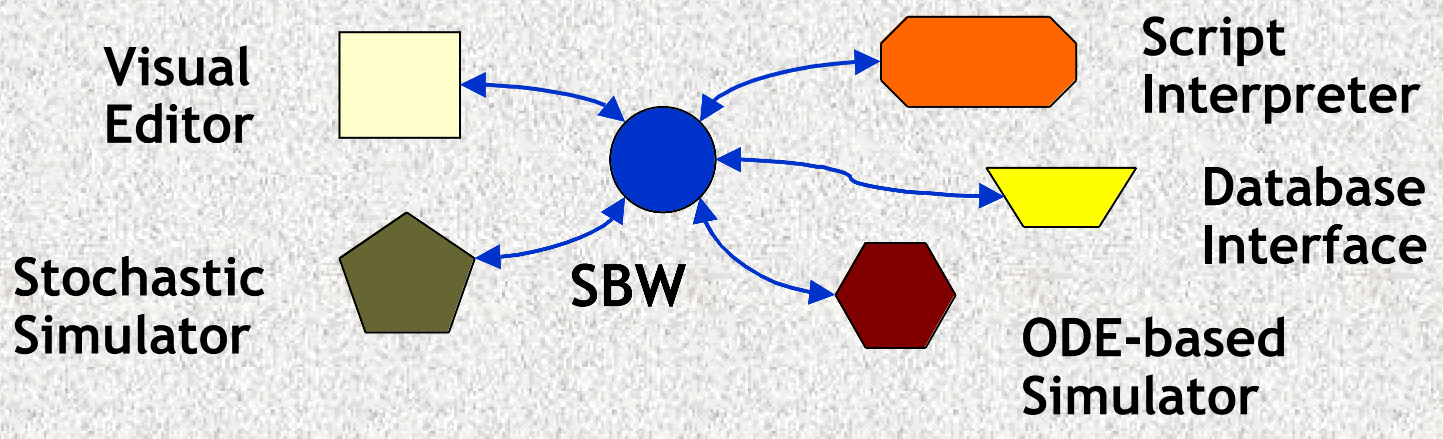
- **Biochemical network models**



- **A model is described using a list of components:**
  - Beginning of model definition
    - » List of unit definitions (optional)
    - » List of **compartments**
    - » List of **species**
    - » List of parameters (optional)
    - » List of rules (optional)
    - » List of **reactions**
  - End of model definition

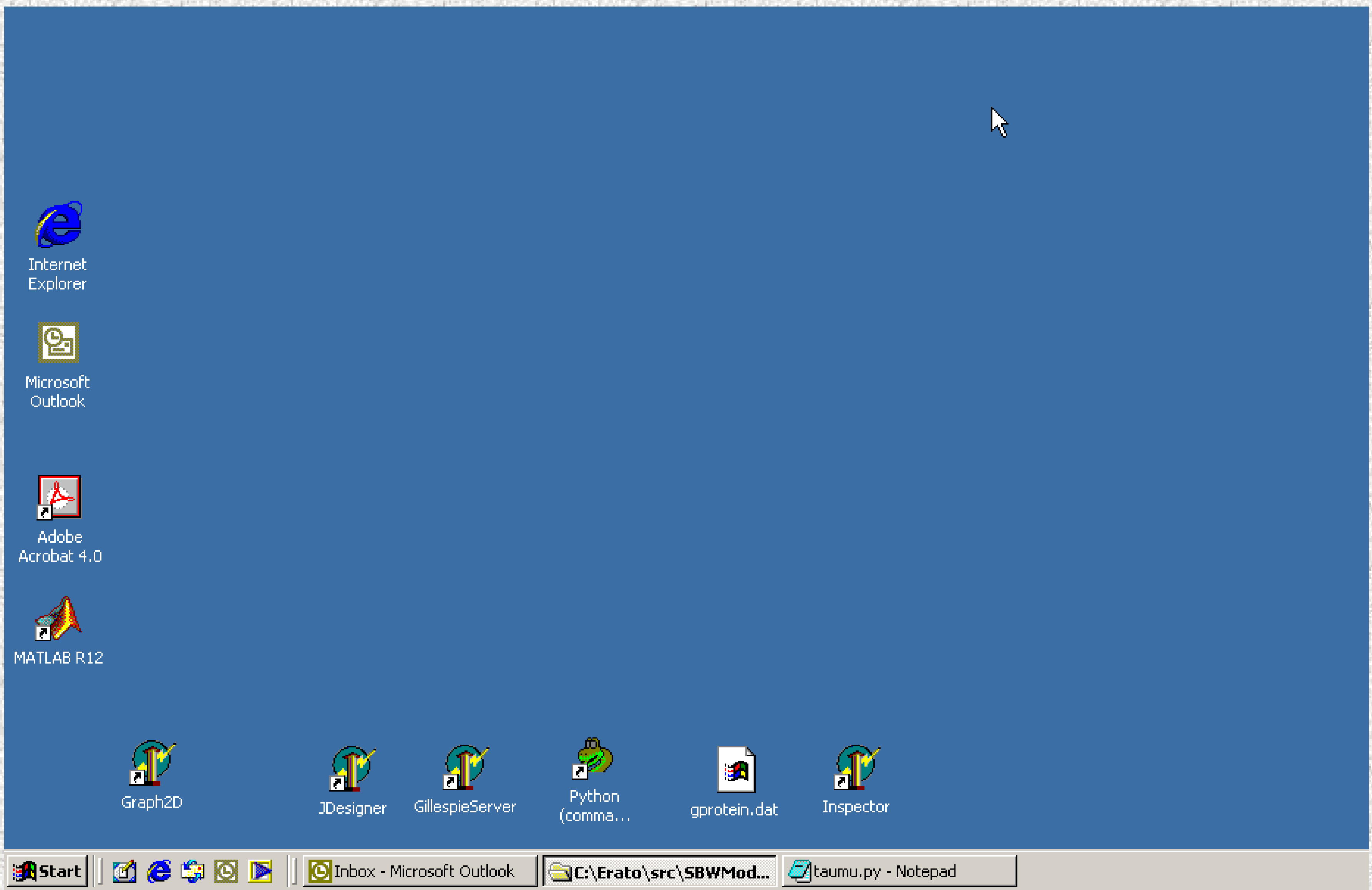
Systems Biology Workbench (SBW)

- **Simple framework for enabling application interaction**
  - Free, open-source (LGPL)
  - Portable to popular platforms and languages
  - Small, simple, understandable



- **From the user's perspective, SBW is invisible**

SBW From the User's Perspective

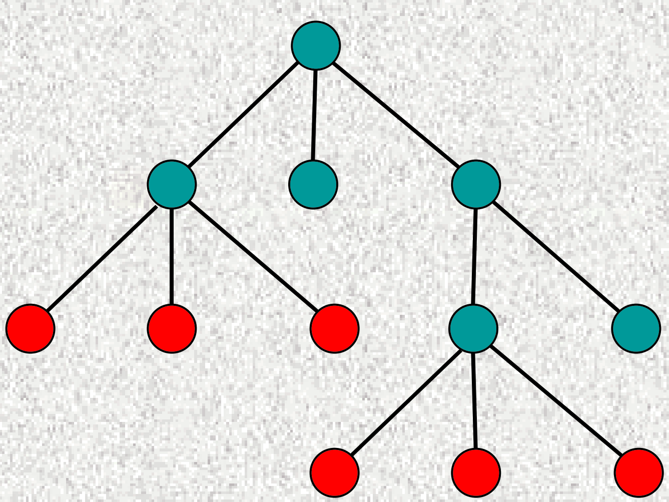


From the Programmer’s Perspective

- **Simple, lightweight, message-passing architecture**
  - Cross-platform compatible & language-neutral
- ***Modules*** **are separately-compiled executables**
  - A module defines *services* which have *methods*
  - SBW native-language libraries provide APIs
    - C, C++, Java, Delphi, Python available now
    - … but can be implemented for any language
- ***SBW Broker*** **acts as coordinator**
  - Remembers services & modules that implement them
  - Starts modules on demand
    - Broker itself is started automatically
  - Notifies modules of events (startup, shutdown, etc.)

The SBW Broker's Registry

- **Registry records information about modules**
  - Module name
  - How to start module
  - What services the module provides
  - The categorization of those services
- **Hierarchy of service categories**



Service Categories (Interface Hierarchy)

Services (Interfaces)

Example of Service Categories

Service	Methods

Simulation	`void loadModel(string SBML)`
	`void setStartTime(double time)`
	`void setEndTime(double time)`
	`void run()`

	+

ODESimulation	`void setIntegrator(int method)`
	`void setNumPoints(int num)`

Service Categories Group Applications

- **Clients can be written to interact with classes of modules in a generic way**

(Java)

```
interface ODESimulation {
     void loadModel(string SBML)
     void setStartTime(double time)
     void setEndTime(double time)
     void run()
     void setIntegrator(int method)
     void setNumPoints(int num)
}
```

- **User menus can be grouped by categories**
- **Need help from community to define common categories of interfaces**

Why?

- **Why not use CORBA?**
  - Complexity, size, compatibility
  - Could not find fully-compliant open-source CORBA ORB that supports all required programming languages
  - SBW scheme does not require a separately compiled IDL
  - But: planning to have gateway between CORBA & SBW
- **Why not use SOAP or XML-RPC?**
  - Performance, data type issues, implementation quality
- **Why not Java RMI?**
  - Java-specific
- **Why not COM?**
  - Microsoft-specific, low portability

SBW Status & Future

- **Beta release: http://www.cds.caltech.edu/erato**
  - **Java, C, C++, Delphi, Python libraries**
  - **Windows & Linux**
  - **Developer's manuals & tutorials, examples**
  - **Modules:**
    - SBML Network Object Model
    - MATLAB model generator
    - Plotting module
    - Jarnac ODE simulator
    - Optimization module
    - Stochastic simulator
    - JDesigner visual editor
- **Spring 2002: production release 1.0**
  - Perl and C# libraries
  - Secure distributed operation
  - CORBA gateway
  - More modules: Bifurcation analysis, Gillespie "Tau-Leap"