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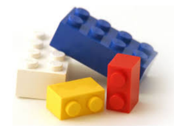
Oberlin Modeling Initiative (OMnI)

- NSF funded program to introduce **dynamic systems thinking** across the Oberlin curriculum
  - *How do you think about complex problems where key elements interact and feed back into each other?*

- Challenge
  - Build a tool to support dynamic systems thinking for a broad, multi-disciplinary user group
  - Teach ***thinking*** not ***programming***
  - Support collaborative, multi-disciplinary problem solving

Nova concept



- Flexible modeling platform suitable for student exercises but powerful enough for serious research applications
- Capable of a full range of dynamic models
  - Stock and flow
  - Spatial
  - Agent based
- Multi-platform
- Modular

No cost license!

Nova: A Java-based platform that operates at multiple levels

Agent based and spatial modeling on a stock & flow core

Netlogo or Agentsheets

OM I
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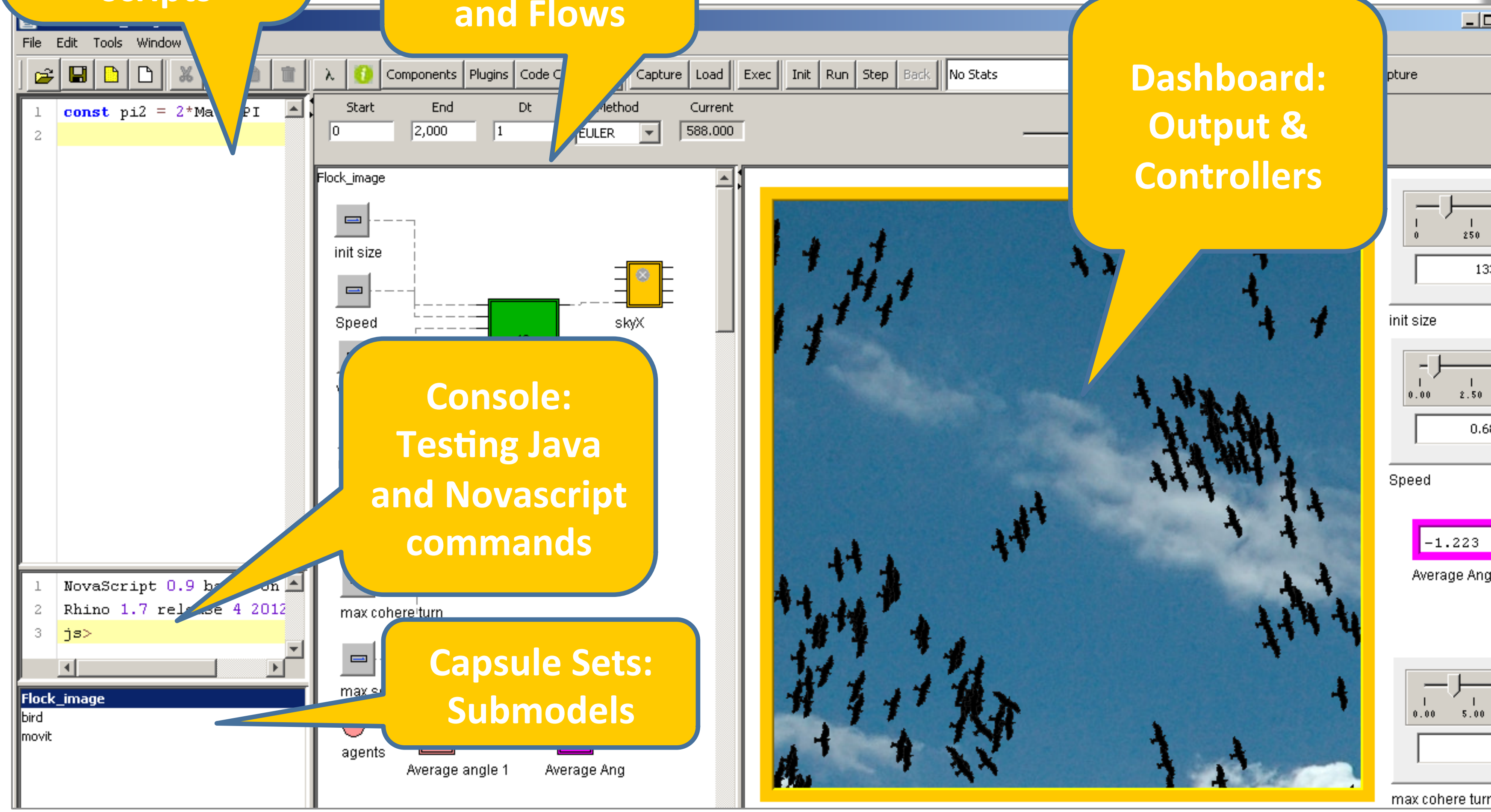
ew: Nova can operate entirely

he

Stella, Vensim, Madonna



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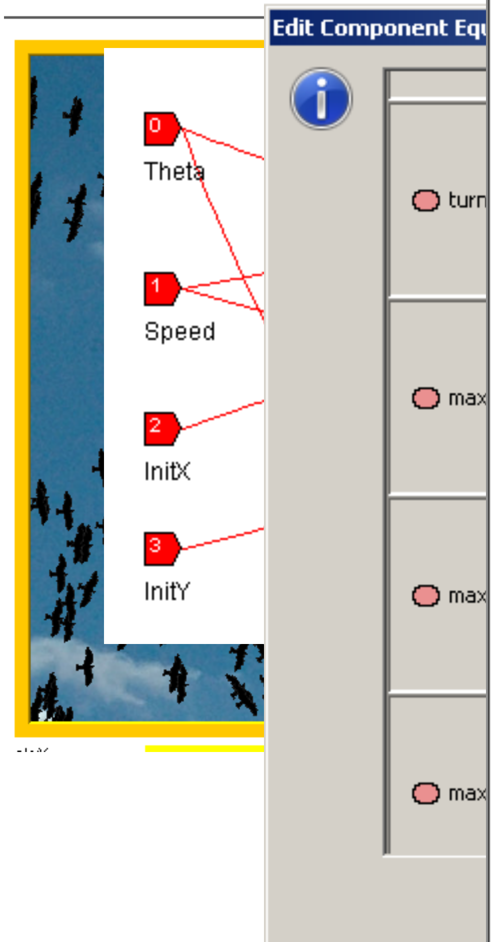
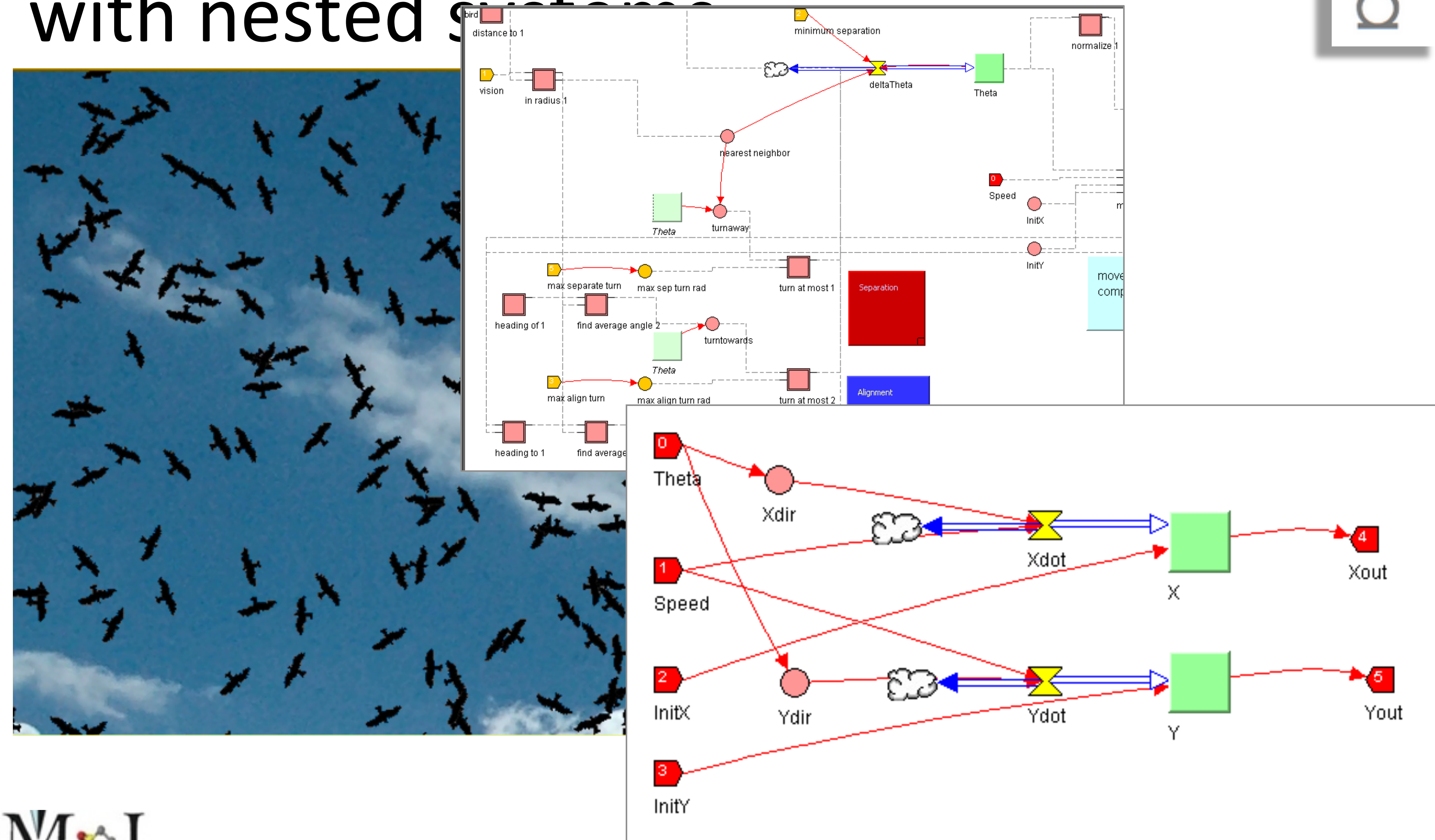
Overview: You can work with Nova at multiple le




```
      function() {
        var f;
        f = function(other) {
          var theta = other.Theta;
          var phi = theta % pi2;
          if (phi > Math.PI) phi -= pi2;
          else if (phi <= -Math.PI) phi += pi2;
          return phi;
        }
        return {f:f};
      },
      ['f'], true, false),
    in_radius: Dynamic(
      function(rad,distanceTo) {
        var all,closest;
        var best = Infinity;
        var closest = 0;
        var all = [];
        for (var i = -rad; i < rad; i++)
          for (var j = -rad; j < rad; j++) {
                var coords = CELL_COORDS();
                var y0 = coords.row + i;
                var x0 = coords.col + j;
                if (x0 < 0) x0 = cols + x0;
            if (y0 < 0) y0 = rows + y0;
                if (x0 >= cols) x0 = x0 - cols;
                if (y0 >= rows) y0 = y0 - rows;
            var agentset = AGENTS_AT(y0, x0);
                for (var k = 0; k < agentset.length; k++) {
                var z = agentset[k];
```

Overview: Capsules are what makes **Nova** interesting for people who work with nested s



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Advantages of Nova as a platform

- Allows people with different expertise to work at different components of the problem
- Allows stock & flow, spatial, and agent models simultaneously, allowing modeling of contagion
- Nested models through capsules and code chips, so you can move from the individual to group level and back down again
- Does not assume homogeneity of the population
- Automated runs across a range of distributions
- Output results graphically, csv, or directly into R
- Allows full integration of R and Java functions

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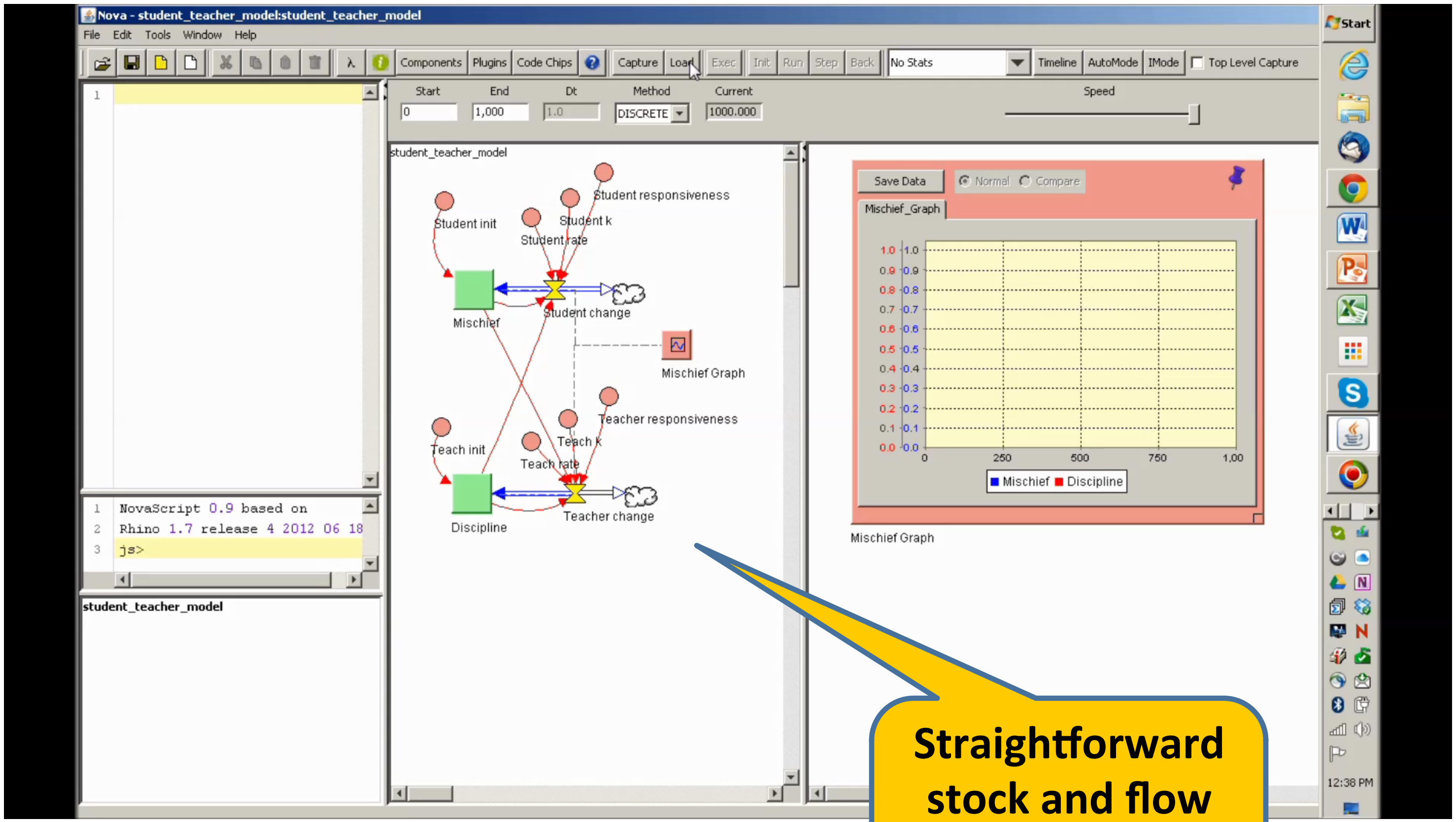
Modularity in the Predator-Prey Model:

Mischievous Students in a Classroom



Straightforward stock and flow model with output

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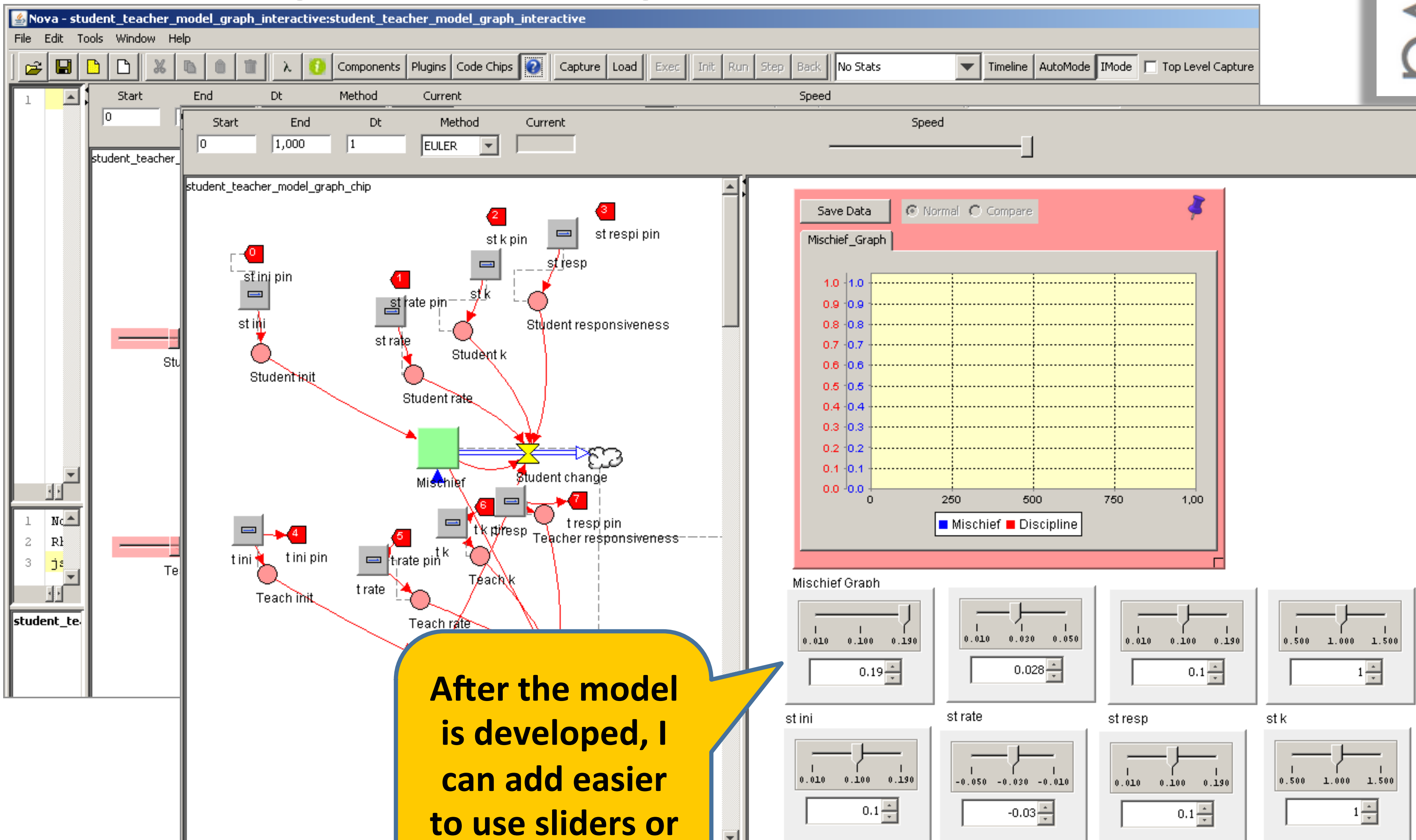
Working and Configured Controllers



After the model is developed, I can add easier to use sliders or spinners

the model

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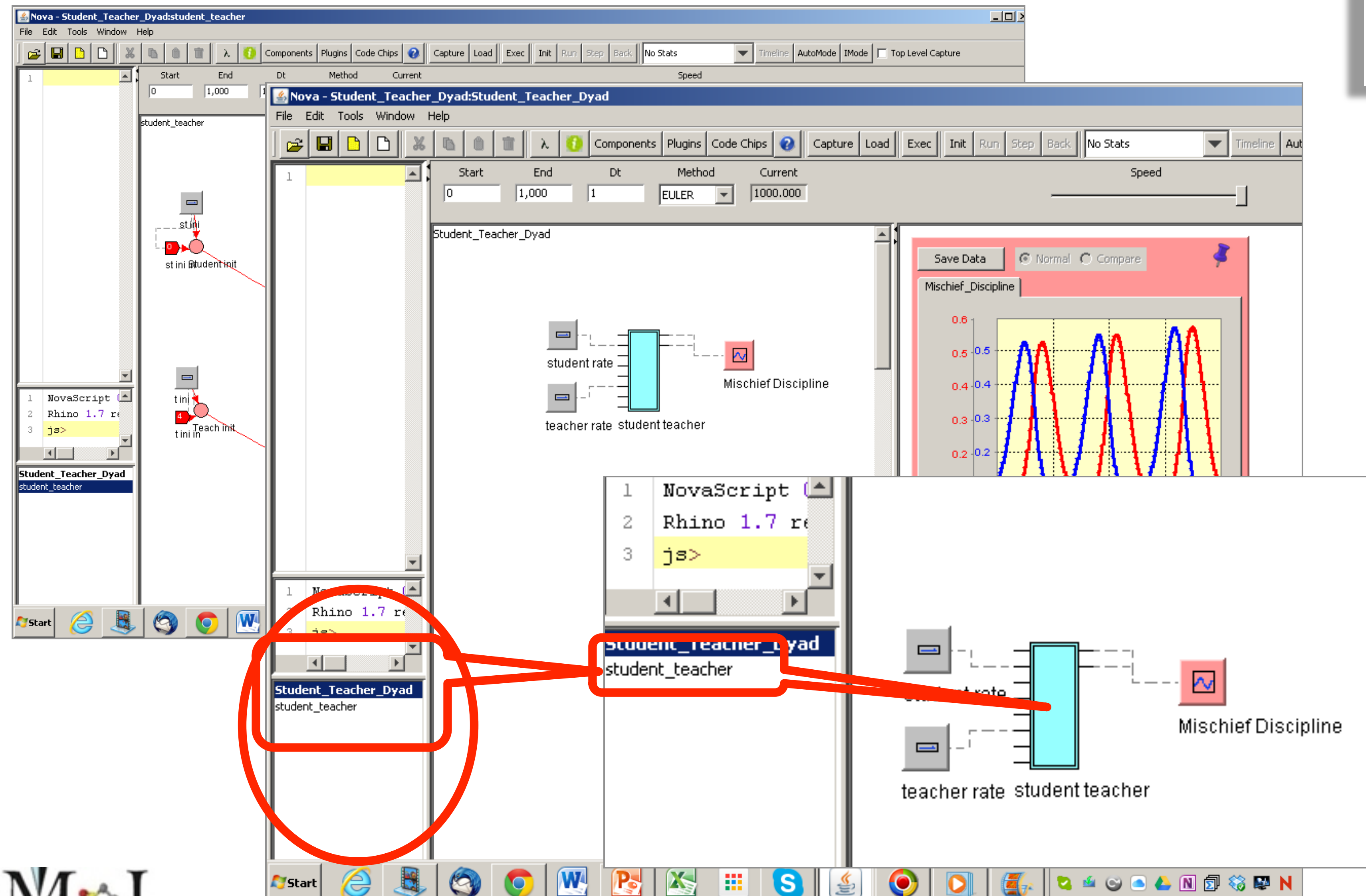
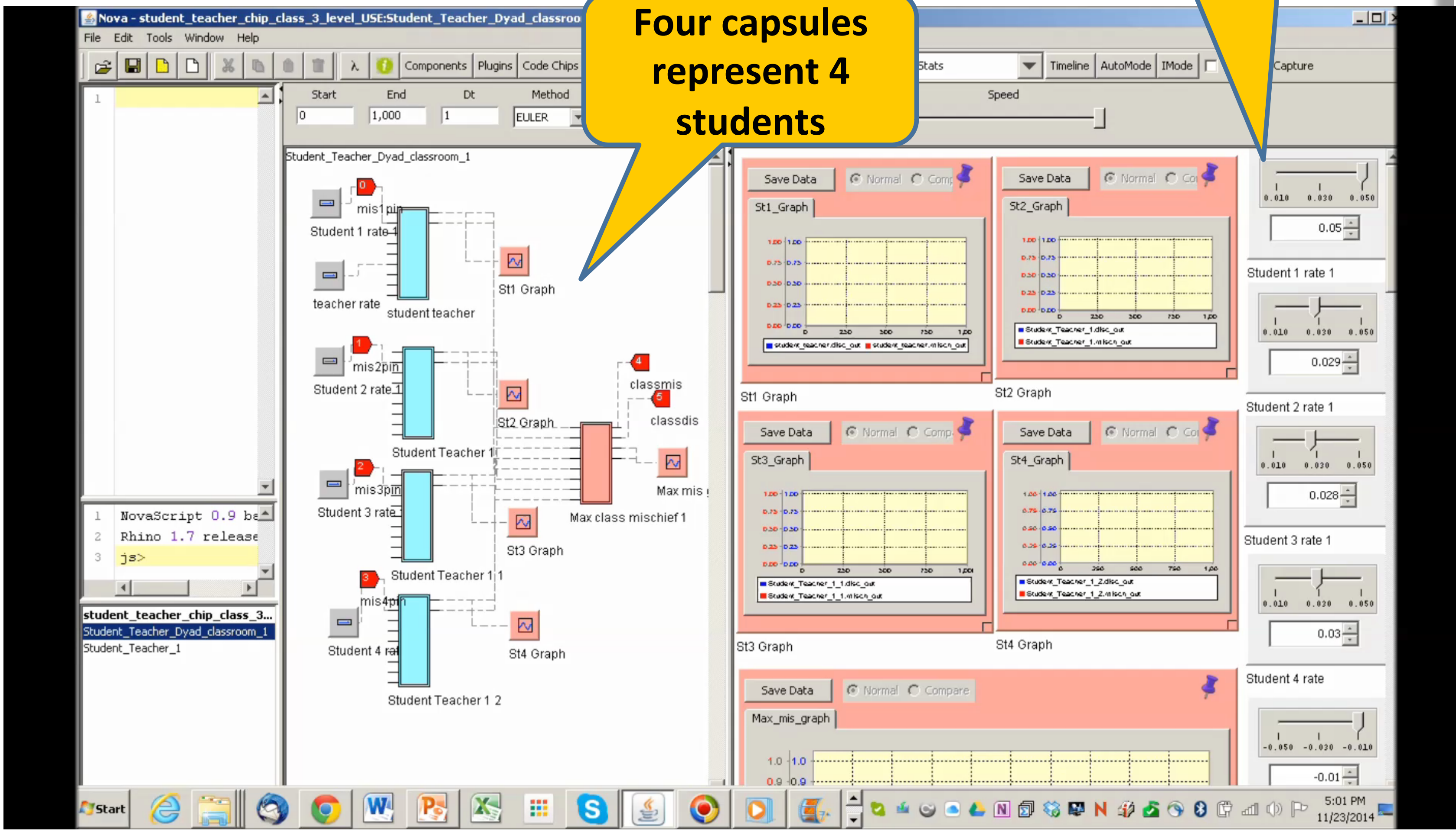
A simpler interface: capsules & chips



What capsules and chips are really useful for is aggregation

1 mischievous and 3 average students

Four capsules represent 4 students



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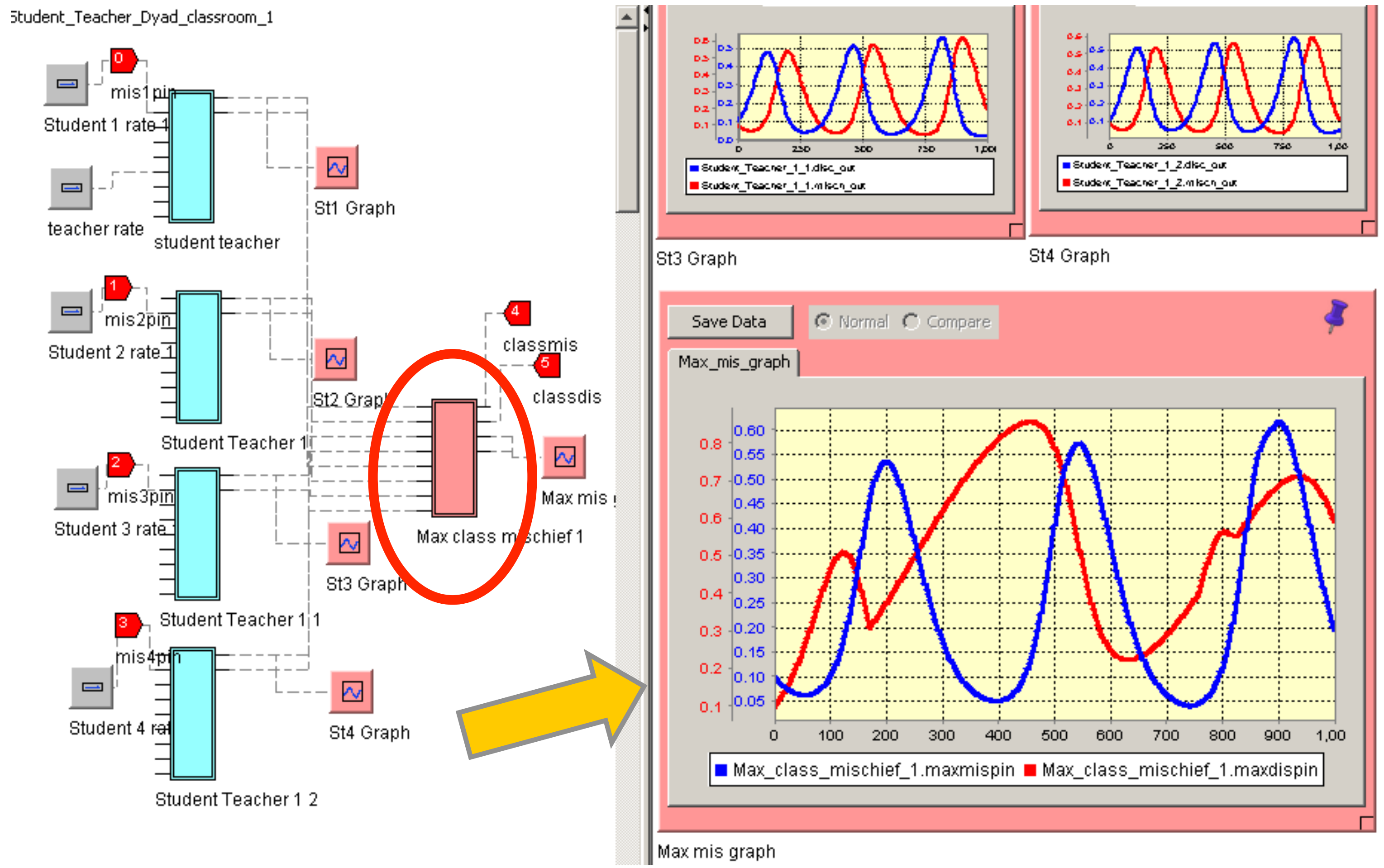
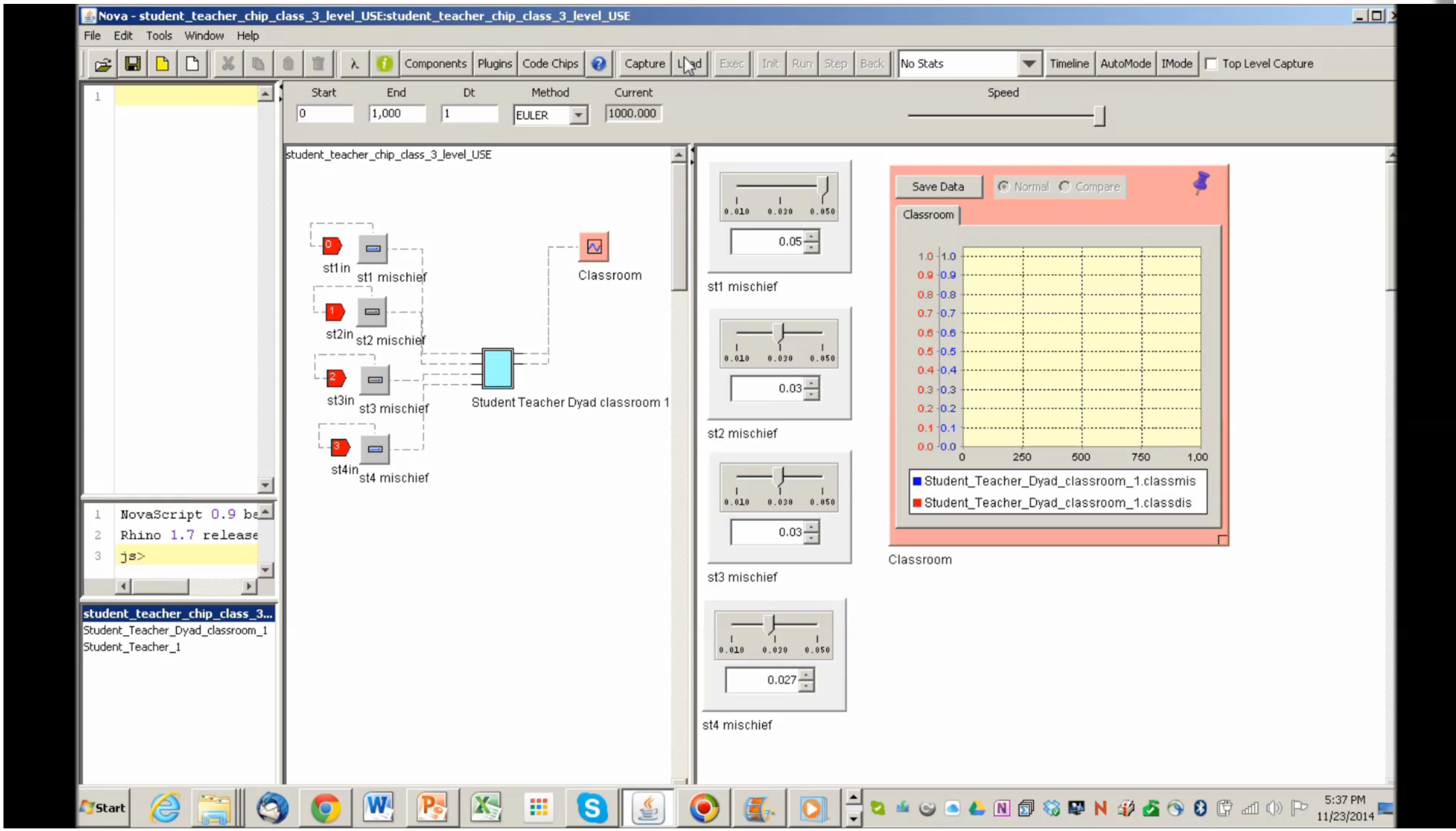
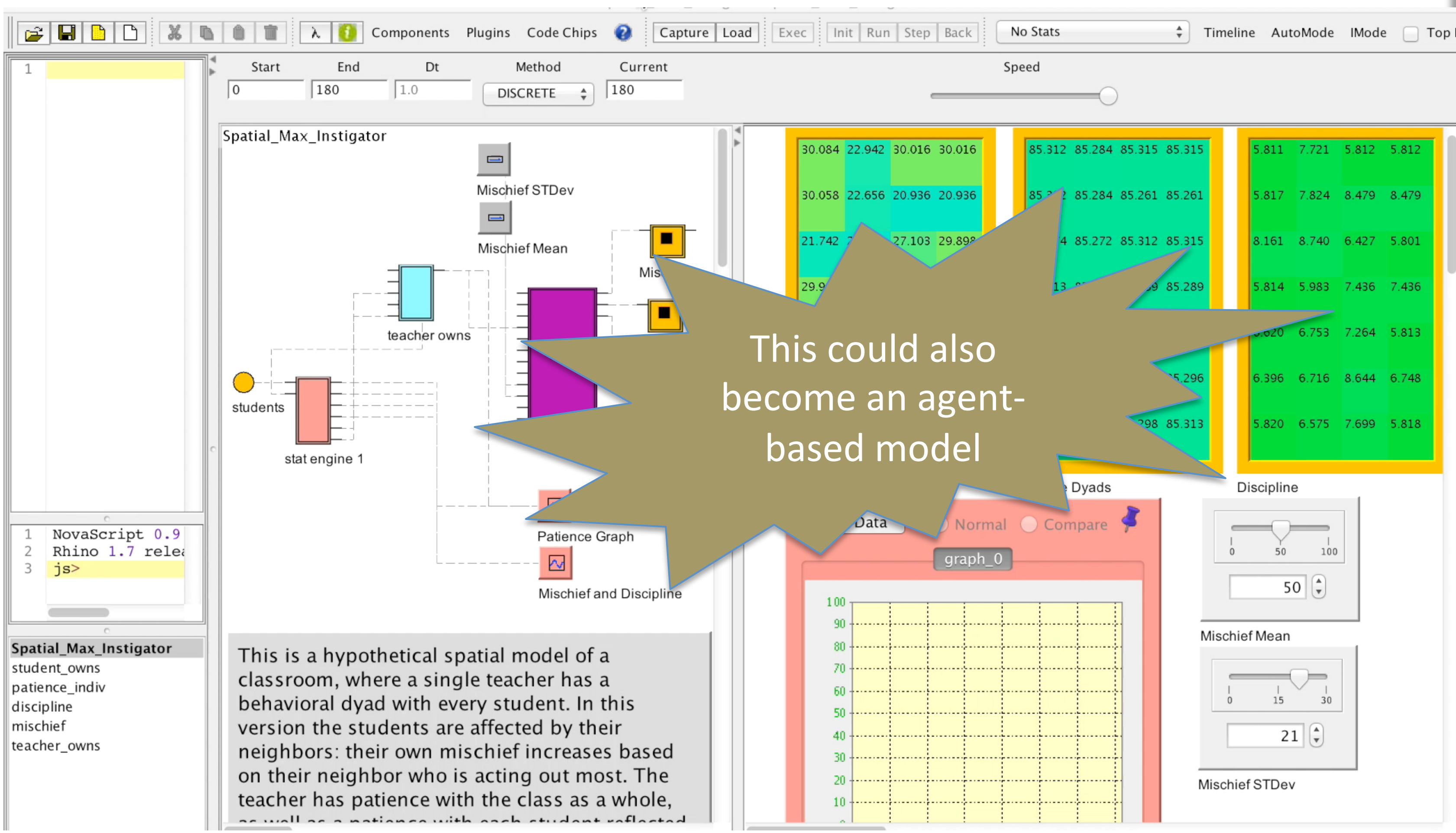
Another chip takes the output from individual dyads and aggregates them at the classroom level. Now I have a **nested model**.



And that classroom can be turned into a capsule so it's cleaner



Chips can be configured spatially, so that each student influences the other and the teacher responds to individual and classroom characteristics



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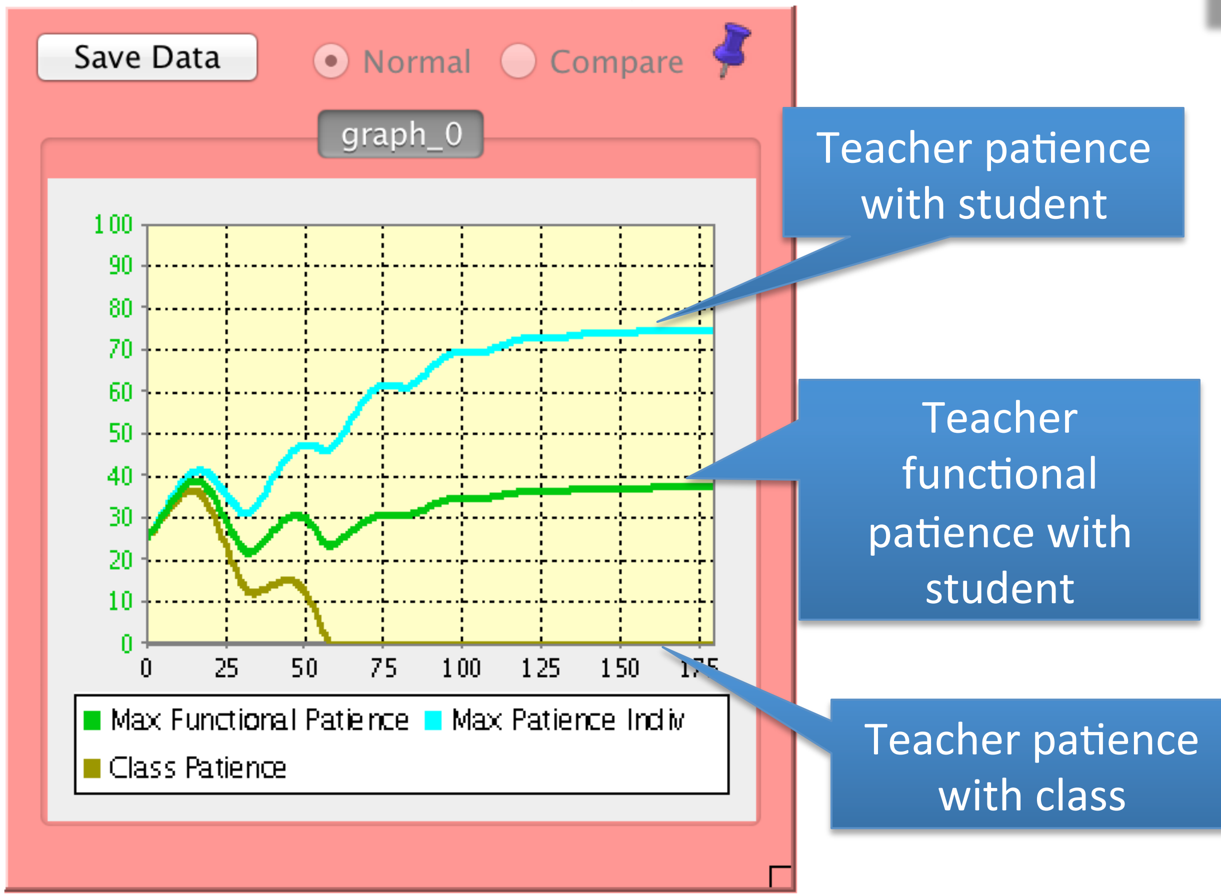
You can model individual dyads within the classroom



Patience Graph

Why is that cool? More complex models

- You can take the aggregated classroom mischief and create a stock called ‘stress’ that decreases a stock called ‘patience’ that changes the teacher’s dyadic reactivity
- You can create contagion effects so each student’s behavior changes depending on classroom context
- You could create an agent based model with many more children who find others like themselves and create pockets of mischief through contagion

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Running simulations and outputting data

- Nova has the capacity to automatically run through a range of possible values
- Data can be viewed as:
  - Graphs
  - Tables
- Data can be exported as csv or directly to R

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Teams Capsules and Modularity: An Example

- Nova Online:
  - Multiple stakeholders working to optimize solutions
- Expertise:
  - How do students respond to teachers?
  - How do teachers respond to individual students?
  - How do teachers respond to classroom dynamics?
  - Peer influence on deviant behavior
  - Classroom dynamics

Teams Capsules and Modularity: An Example

- Working with modeling novices: Attachment
- Process:
  - Sketching ideas
  - 3 different model components, 3 different teams
  - Combining and refining
  - Moving from the individual to the couple

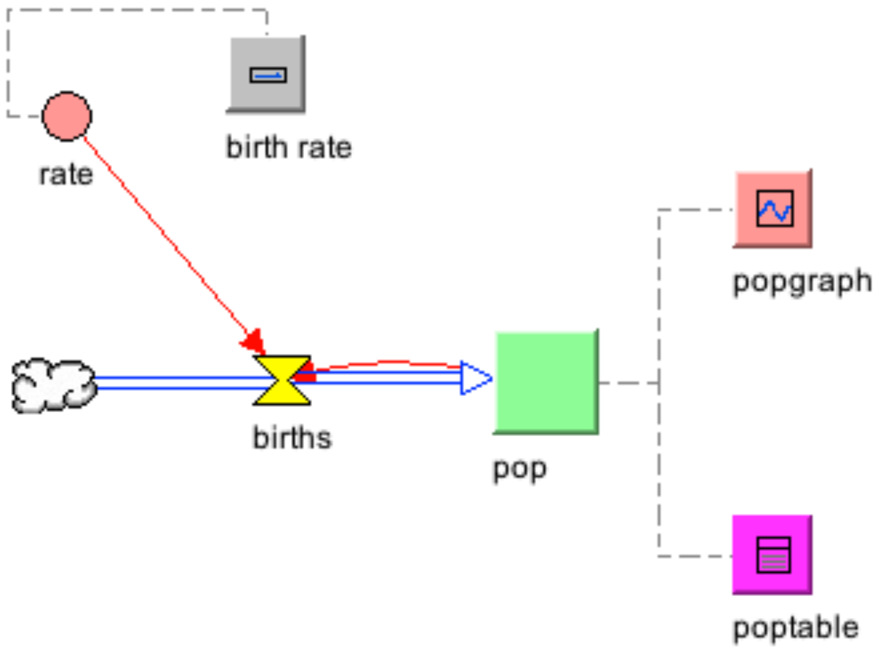
Summary

- Nova is a free, flexible program:
  - Stock and flow
  - Spatial
  - Agent based models
- Strengths:
  - One platform for multiple purposes minimizes learning time
  - Nested models
  - Heterogeneous populations with different distributions
  - Good entry-level tutorials
- Weaknesses:
  - Beta
  - Weak documentation of some features

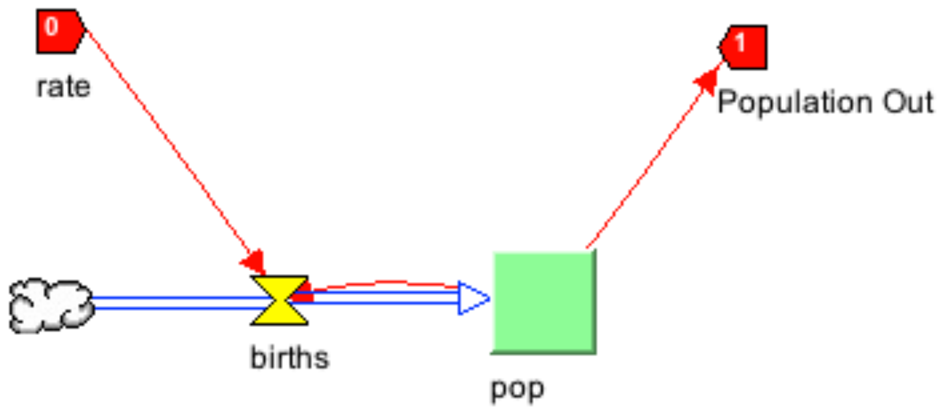
NUTS AND BOLTS

- A single framework for an eclectic set of systems.
- Expressive power derives from
  - modularity
  - abstraction
  - extensibility

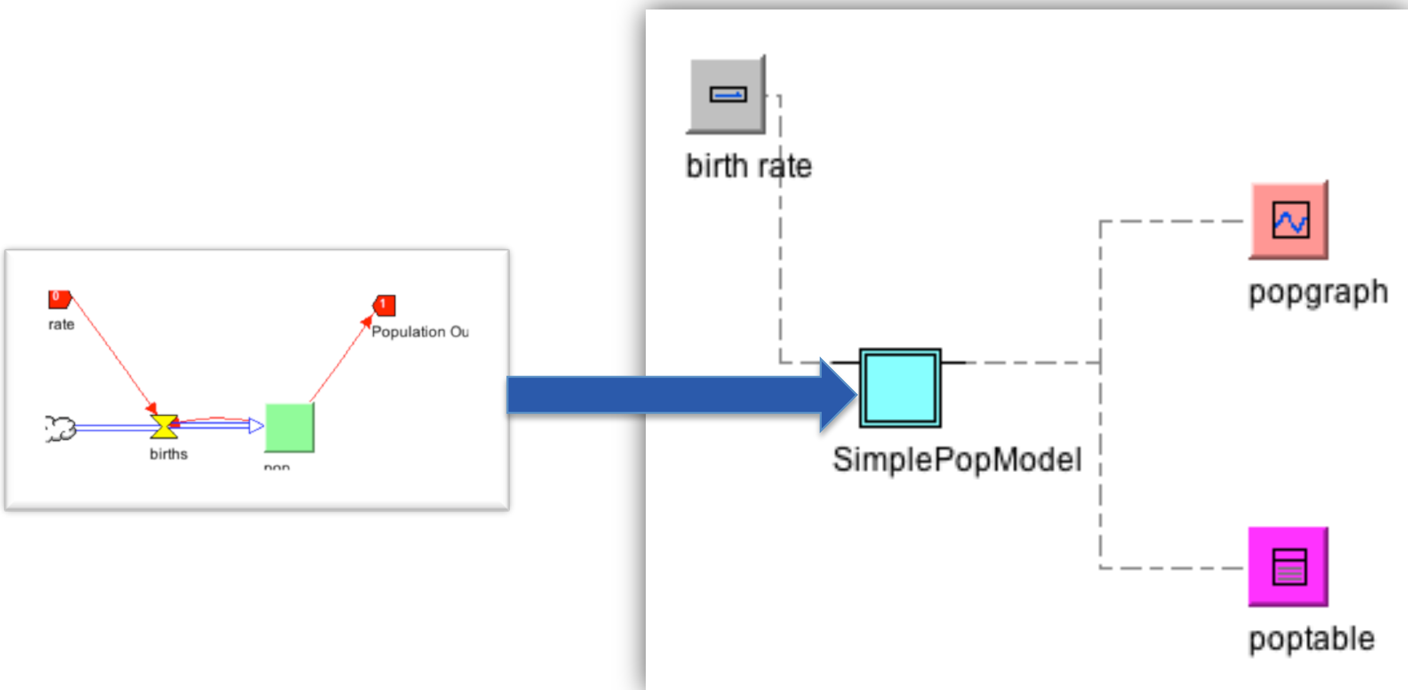
Capsule



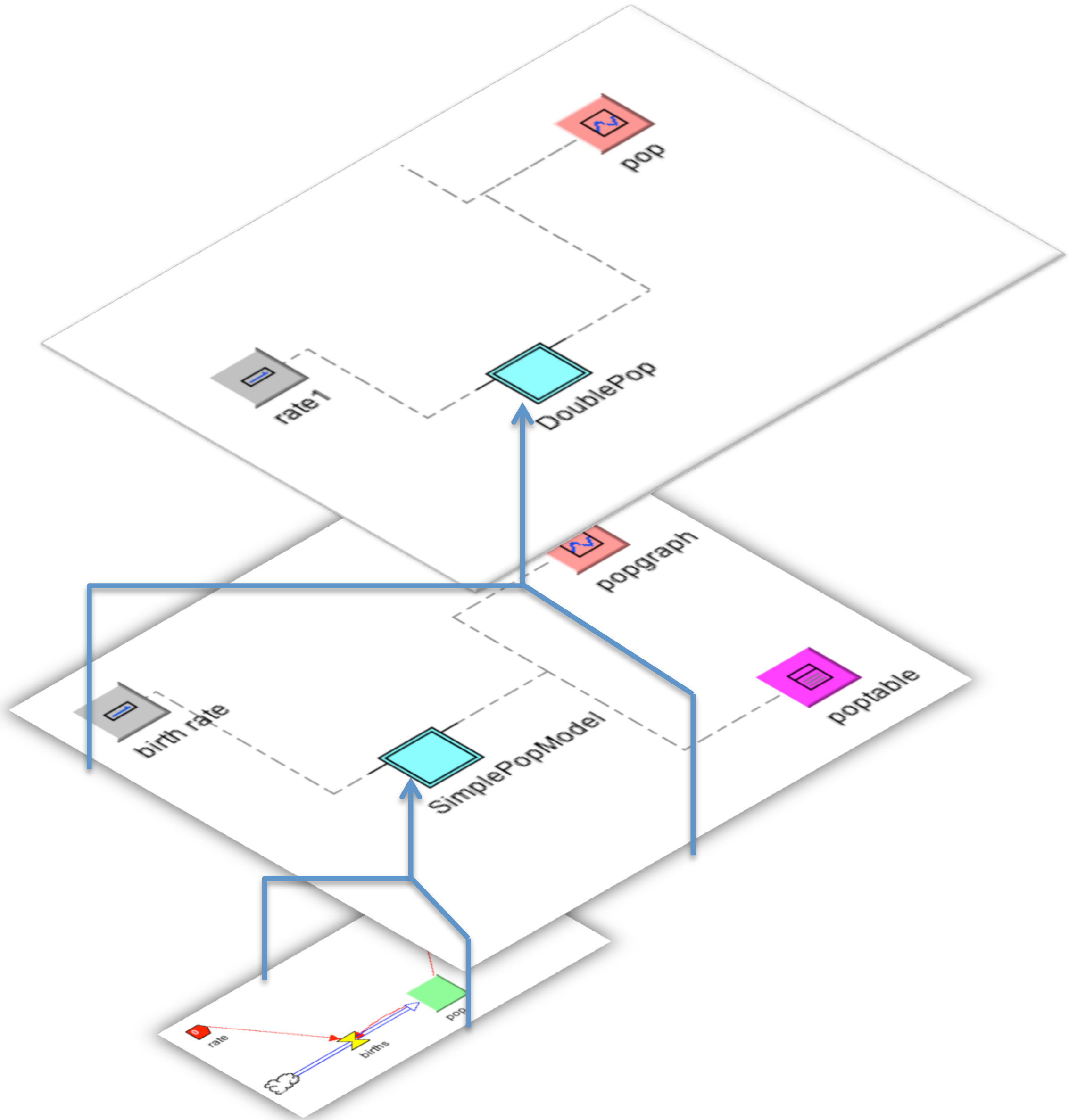
Capsule with Pins



Chip



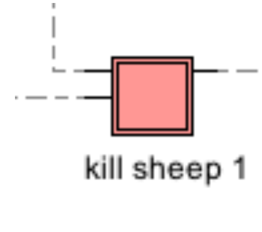
rate
Population Ou
births
birth rate
popgraph
SimplePopModel
poptable


pop
rate1
DoublePop
popgraph
birth rate
SimplePopModel
poptable
rate
births
pop

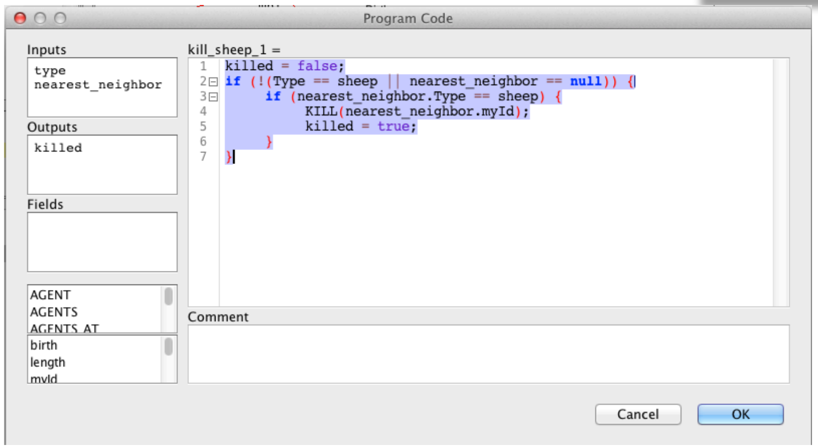
Containers (Aggregators)

- CellMatrix
  - 2 dimensional array of capsules
  - facilitates interaction among cells on a Cartesian grid
- NodeNetwork
  - An array of capsule *nodes* connected by a set of weighted links (equiv. to a mathematical graph)
  - facilitates transmission of data through the network.
- AgentVector
  - Agent = Capsule + location and trajectory parameters
  - AgentVector is 1-dimensional array of agents
  - AgentVector manages a set of agents in a common space
    - spatial position
    - births/deaths
- SimWorld
  - CellMatrix + AgentVector
  - Agent space corresponds to Cell topology
  - facilitates interaction between agent and cell environments
- NetWorld
  - NodeNetwork + AgentVector
  - Agent space correponds to Network topology
  - facilitates interaction between agent and node environments

Code Chips



- Contains code implementing a computational method
- Easy to implement multiple instances
- Easy to export/import into new model



Clocked Chip

- Attach a clock to chip so that each “tick” of the host model corresponds to a complete “run” of the encapsulated model.

Plugins

- API for creating new components
- Visualization
- Other useful extensions

Nova Online

- A visual Nova model is "captured" into a script (NovaScript) before it is executed on the Nova runtime engine.
- A Javascript implementation of this runtime has made possible a browser-based runtime using HTML5 graphics:
  – Nova Online
- Currently under construction: automatic creation of Nova Online Website.
- Also under construction: server-side NovaScript runtime for multi-core and high-performance execution.

Collaboration

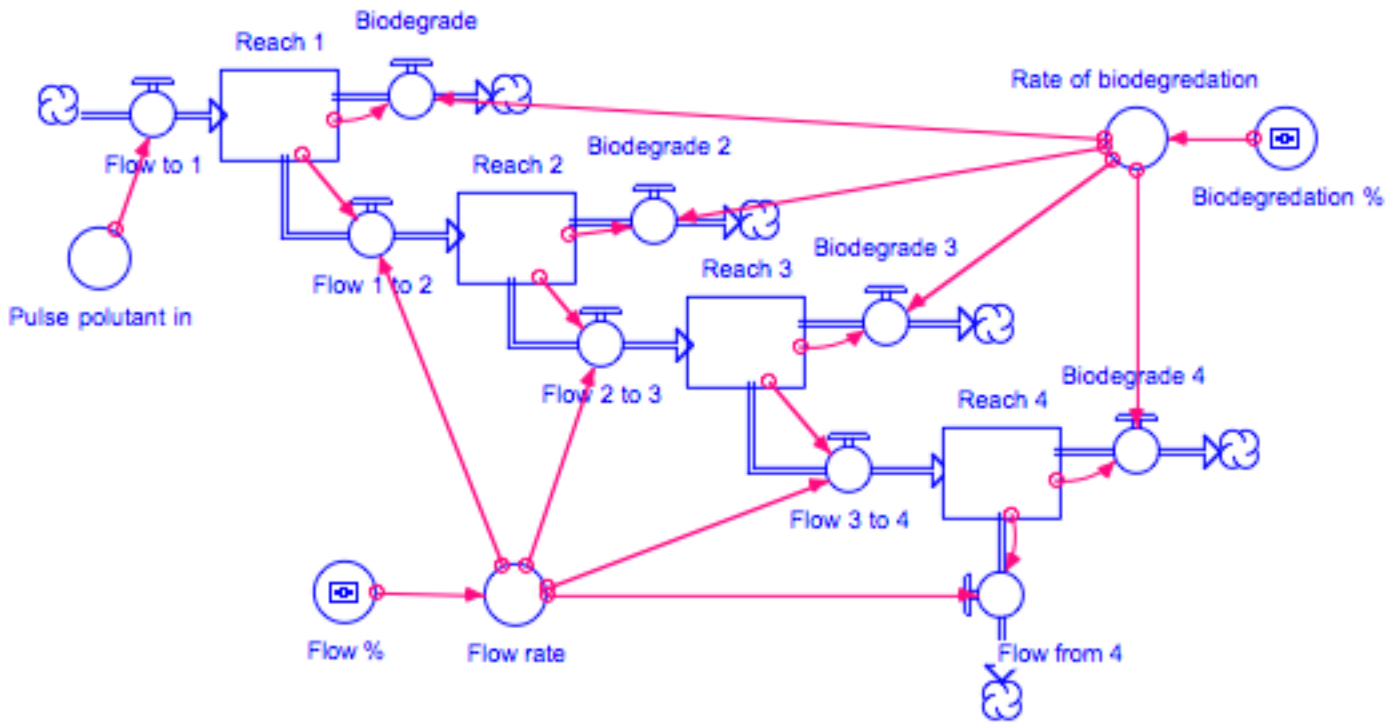
- Sharing of submodels.
- Sharing of codechips.
- Sharing of plug-ins.

- Interaction with R, GIS

- Combining submodels, codechips and plug-ins into a "kit" for a particular application area.

- Nova Website to serve as an archive and marketplace for shared components.

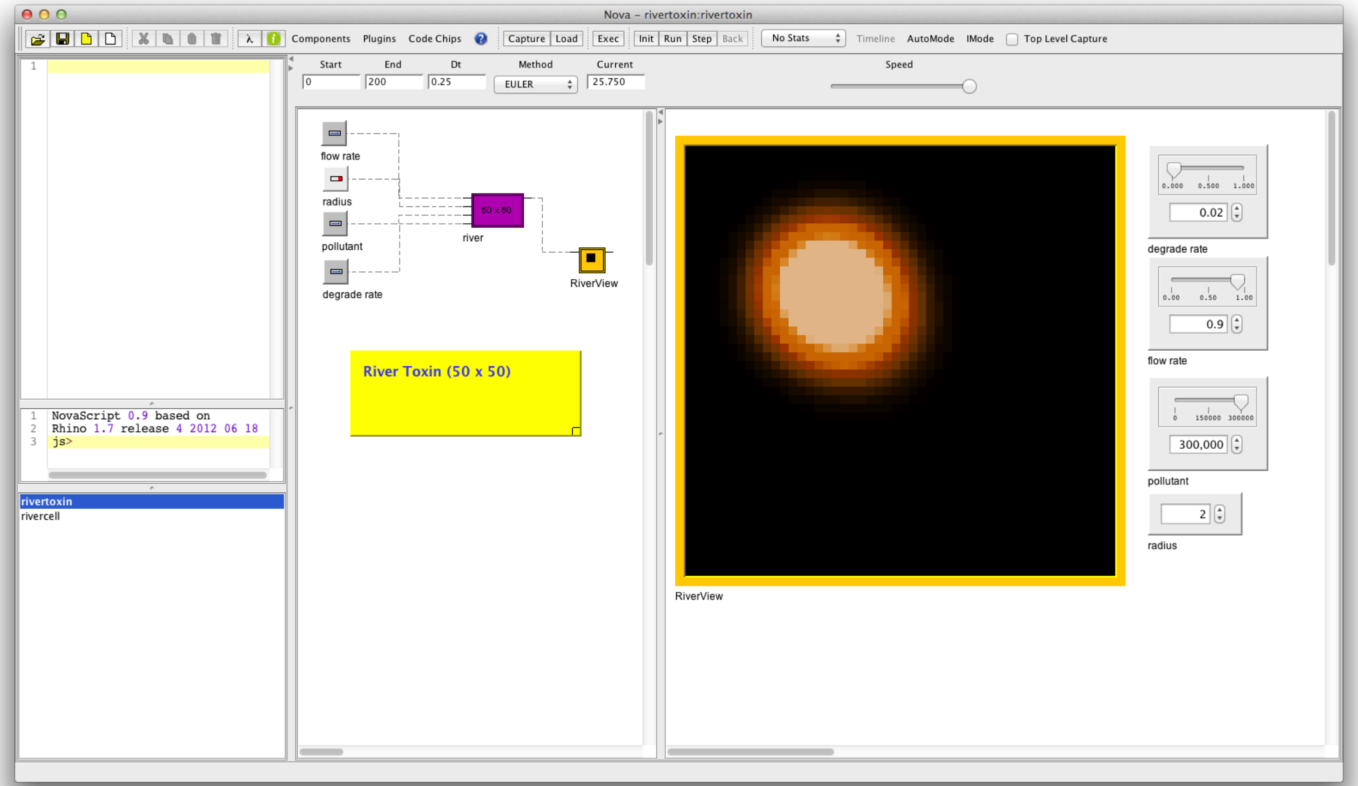
Example 1: River Toxin Advection



STELLA Version

River Toxin: Nova Version

- Model spatially as a grid of cells



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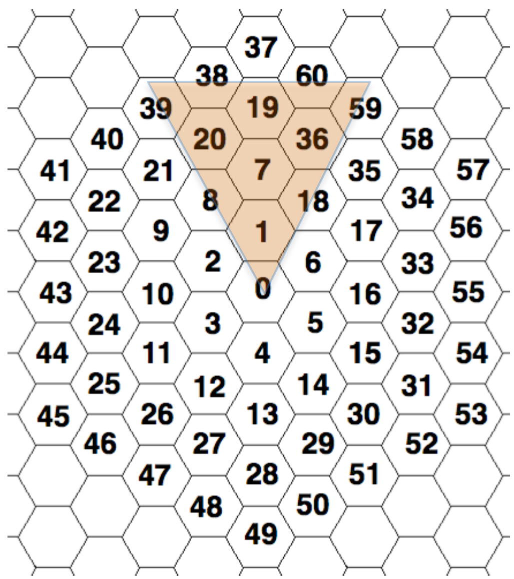
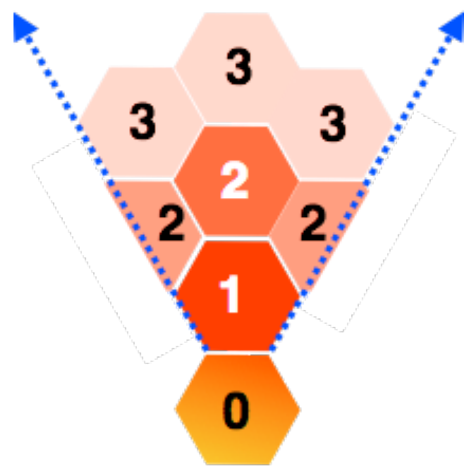
Example 2: Hexagonal Grazing (Getz)

- “World” is a hexagonal grid of cells.
- Agents are animals consuming food from cells.
- Cells contain food for consumption.
- At each time step agent must decide to either
  - Eat in current cell
  - Move to an adjacent cell
  - Decision governed by weight parameters: $q_1, q_2, q_3, \ldots$





$$A_1 = q_1 a_1 + q_2\,((a_8 + a_{18})/2 + a_7) + q_3\,(a_{19} + a_{20} + a_{36})$$

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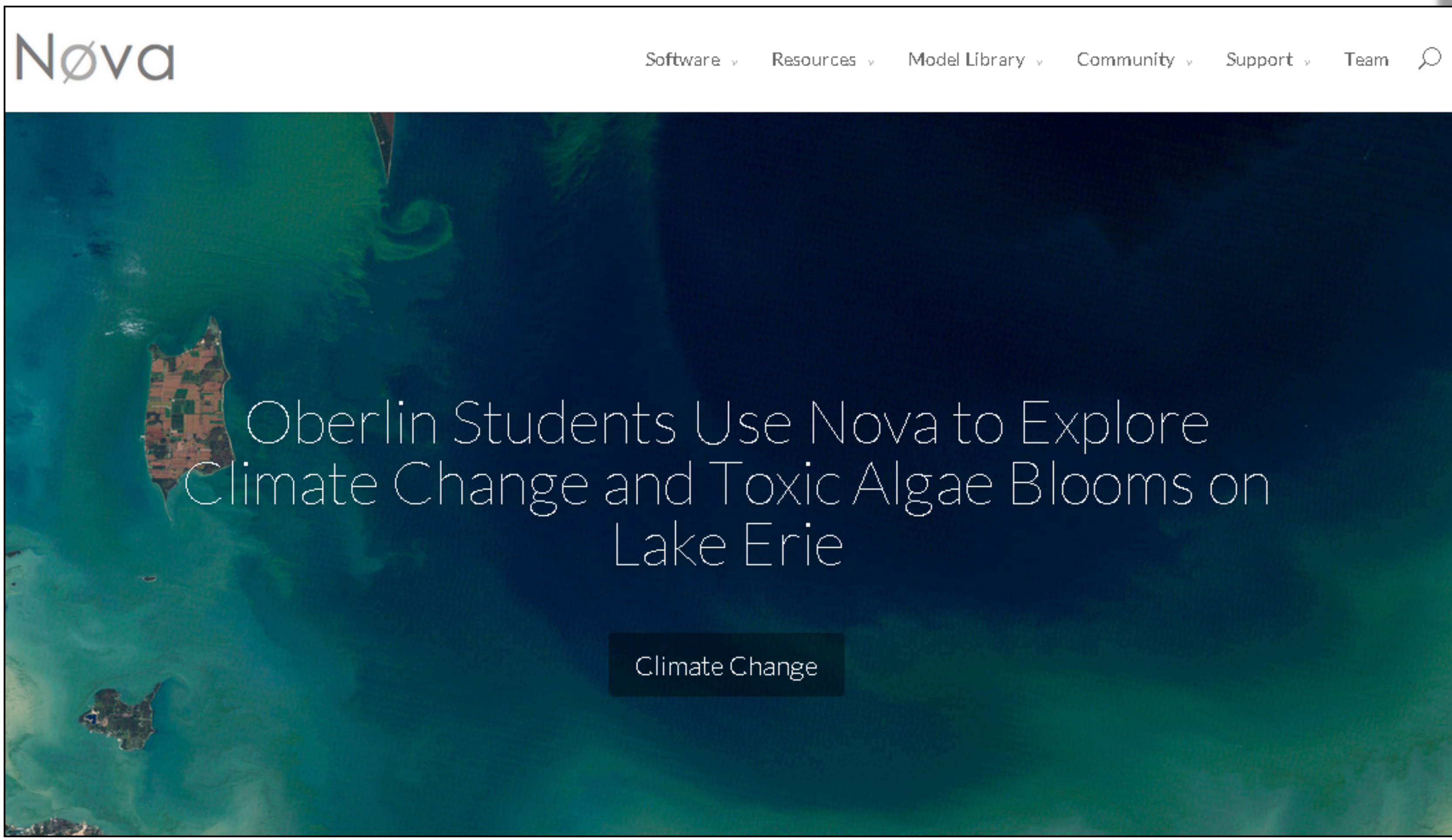
Example 3: Florida invasive snail -- *Pomacea maculata*

- Model depicts a 25 square meter area with patches of size 10^{-2} sq m. Four snail "types" shown:
  - Males (blue)
  - Unfertilized Females (pink)
  - Fertilized Females (red)
  - Juveniles (yellow)
- Once fertilized, female lays an eggcase with up to 1000 eggs every 14 days (laying action depicted as enlarged purple agent token). Eggs hatch in 14 days with a 10% survival rate.
- Juveniles mature to adult status in 120 days (size of juvenile agent token grows with age).
- Separate juvenile/adult movement and consumption rates used.
- Attraction of males to unfertilized females is modeled.
- Carrying capacity is proportional to current biomass.
- Five year timespan modeled with seasonal variation of biomass growth.
- Snail aestivation occurs in December and January.
- Actual GIS-derived terrain is depicted.

www.novamodeler.com



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