

Ventity™

*and Entity based
system dynamics modelling*

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Ventity

- New simulation software from Ventana
- Helps teams collaborate to build complex models with modularity, dynamic creation of structure, sparse matrix relationships and agents

Why disaggregate?

- Some problems demand it (can't aggregate in principle)
- Sometimes it's hard to draw a stock-flow diagram (too many dimensions)
- Sometimes it's easier (hard to decide a priori what aggregation is appropriate)
- Exploit big data and individual event statistics
- Integrate the work of distributed teams
- Show decision makers the granularity they live with (project tasks, portfolios, ...)

The traditional approach: arrays

- Fast and familiar for simple replication of structure

But ...

- Makes detail a property of an equation, when it is generally a property of a larger system ...
an entity

Entity Types

- AKA object, class, subsystem, sector, agent
- Organises a group of equations with similar detail and function into a single container, without the distraction of subscripts
- Defines the structure of a generic entity, to be instantiated later

Creating Entities

- Instantiate from data, e.g., a relational table
- Create on the fly, during a simulation

Distinguishing Entities

- Attributes tag entities
- Attributes are like array dimensions, but...
 - No need to define all combinations of elements, so sparse matrices are easy to handle
 - Mapping from one to many and back is easy

Collections

- Collections are lists of entities
- Sub-collections slice and dice collections by an attribute, like all the restaurants in a city
- Aggregate functions take sums, products, etc. of variables in the members of a collection

References

- References are special attributes that connect entities of the same or different types
 - Restaurants <-> Cities
 - People <-> Friends (a social network)
 - Project tasks <-> Prerequisites, Resources

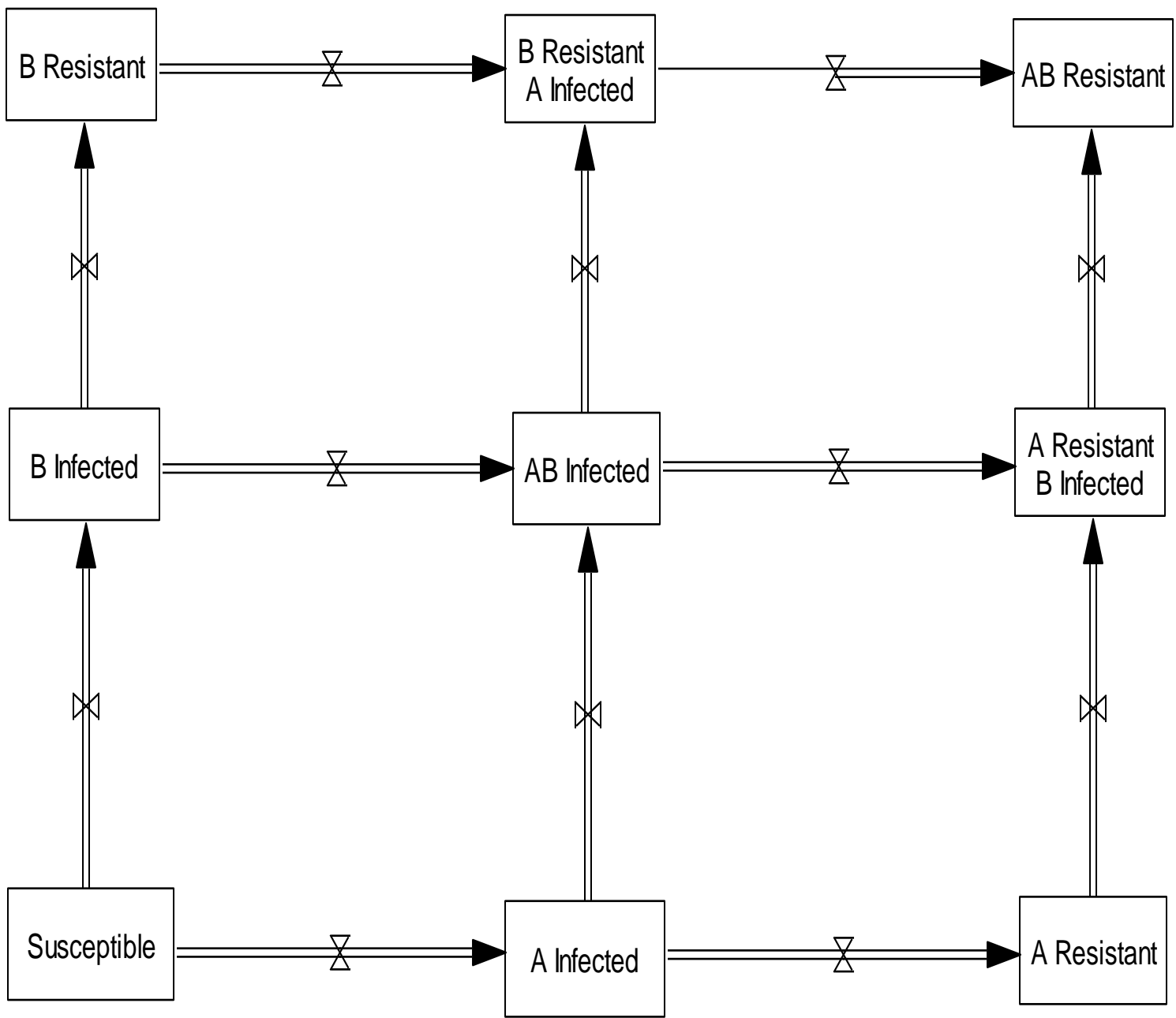
These problems are ubiquitous

- Beer Game with arbitrary supply chain organization
- Project model, with task prerequisite matrix loaded from data
- Competitive dynamics, with new firms or products introduced midway through a simulation
- Climate integrated assessment with physical and economic sectors delegated to different teams

Today's example: A family of infection models

- Infection1 – Classic SD; a single chain of susceptible-infectious-recovered people
- Infection2 – Multiple populations (humans, monkeys) interacting for a single disease strain
- Infection3 – Multiple disease strains in a single population, with overlapping infections and dynamic introduction of mutations
- Infection4 – Individuals interacting, with stochastic infection

Much of this can be achieved in a tool like Vensim, but how do you add diseases C and D to this diagram?



Infection Models

PRACTICAL EXAMPLES

Infection 1

- Classic SD; a single chain of susceptible-infectious-recovered people
- Single population (humans)
- single strain
- Simplified model to show essence of Ventity
 - Add a new population (monkeys)

Infection 1

Main model overview panel

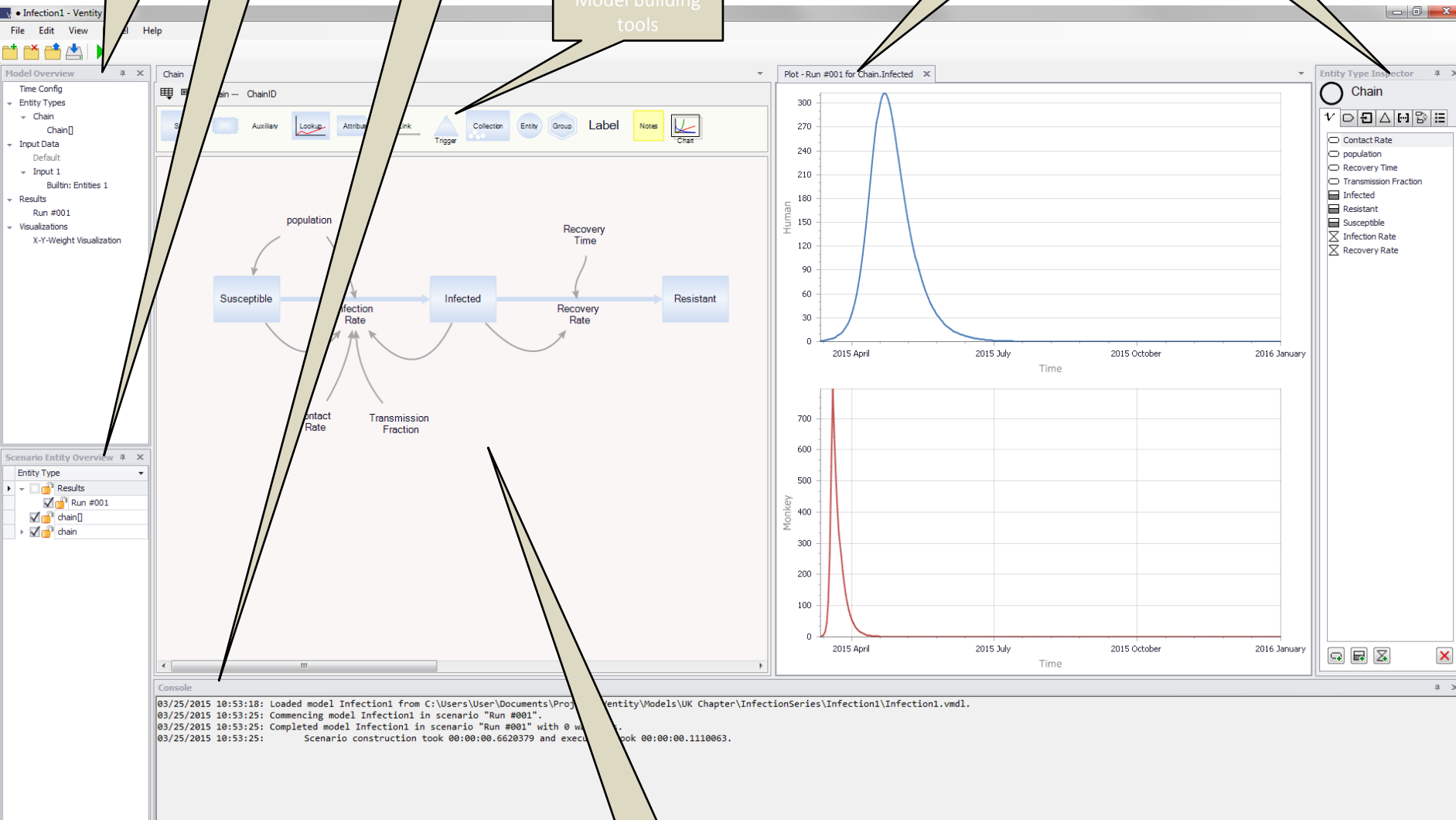
Output selection panel

Console

Model building tools

Graphics panel (pinned)

Inspector Panel



Model view for an entity

Infection 1

- We have seen;
 - Adding new population types is through DATA and not model structure / equations
- However, multiple populations do not interact, what if there is crossover?
 - Let's see “Infection 2” - multiple populations (humans, monkeys) interacting for a single disease strain

Infection 2

- Multiple populations (humans, monkeys) **interacting** for a single disease strain
- Add a new entity to handle the relationships between interacting populations
 - Human -> human
 - Animal -> animal
 - Animal -> human
- Note: Human -> animal interaction missing
 - In Vensim would necessitate a lot of 0's for the combinations not modelled

Species Infection Crossover

	Human	Monkey
Human	Human bites human	Humans don't bite monkeys
Monkey	Monkey bites human	Monkey bites monkey

Infection 2

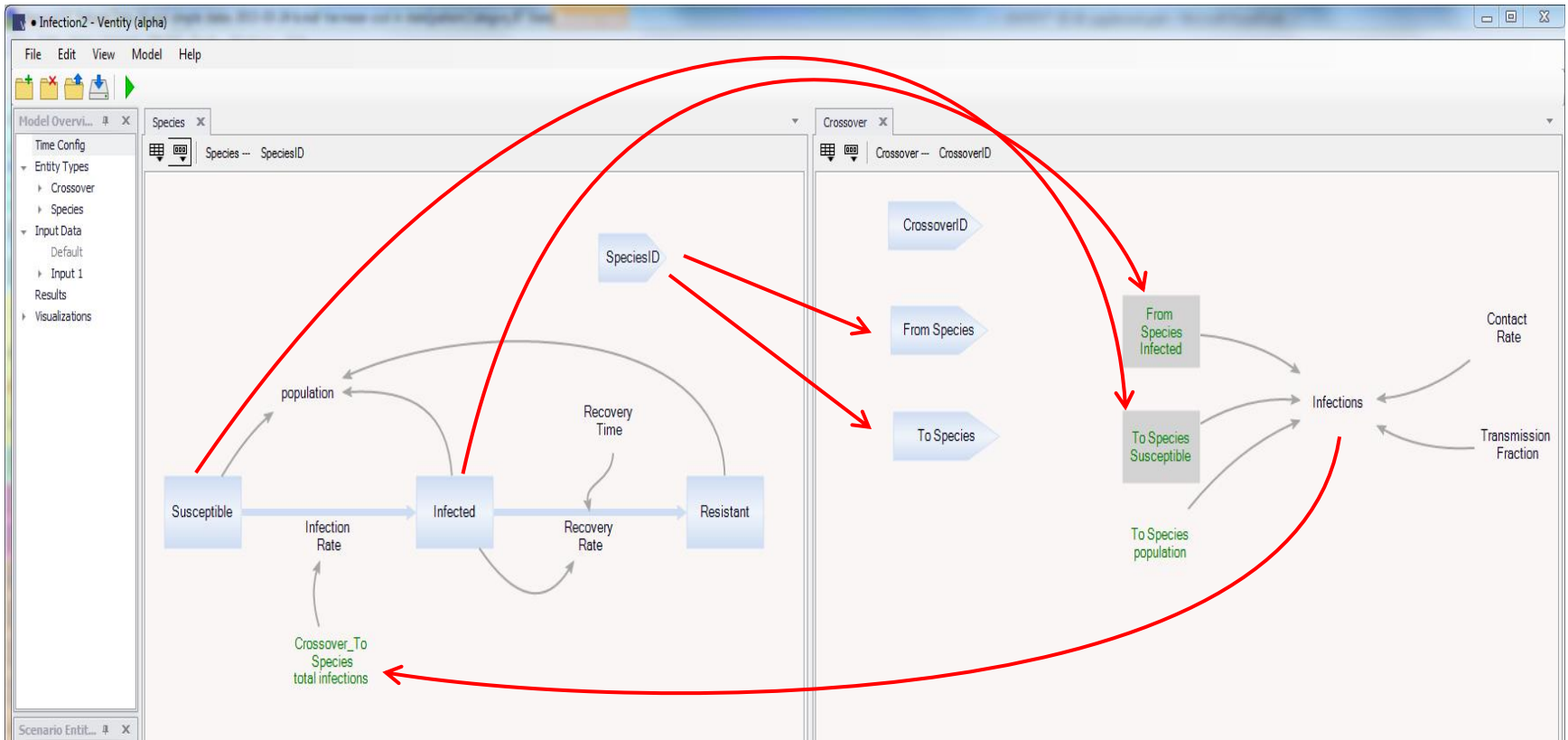
The screenshot displays the Ventyty software interface for a model named "Infection2". The main workspace shows a compartmental model diagram with three states: Susceptible, Infected, and Resistant. Transitions are labeled with rates: Infection Rate (Susceptible to Infected), Recovery Rate (Infected to Resistant), and Recovery Time (Resistant to Infected). A feedback loop labeled "Crossover_To Species total infections" connects the Infected state back to the population. The interface includes a Model Overview sidebar on the left, a Scenario Entity Overview sidebar on the bottom left, and a Console window at the bottom showing execution logs.

```
graph LR; Susceptible -- Infection Rate --> Infected; Infected -- Recovery Rate --> Resistant; Resistant -- Recovery Time --> Infected; Infected -- "Crossover_To Species total infections" --> population; population --> Susceptible;
```

Console Output:

```
03/25/2015 11:38:53: Loaded model Infection2 from C:\Users\User\Documents\Projects\Ventyty\Models\UK Chapter\InfectionSeries\Infection2\Infection2.vmdl.
03/25/2015 11:39:12: Commencing model Infection2 in scenario "Run #005".
03/25/2015 11:39:12: Completed model Infection2 in scenario "Run #005" with 0 warnings.
03/25/2015 11:39:12: Scenario construction took 00:00:00.5260300 and execution took 00:00:00.0490028.
```

Species-Crossover References



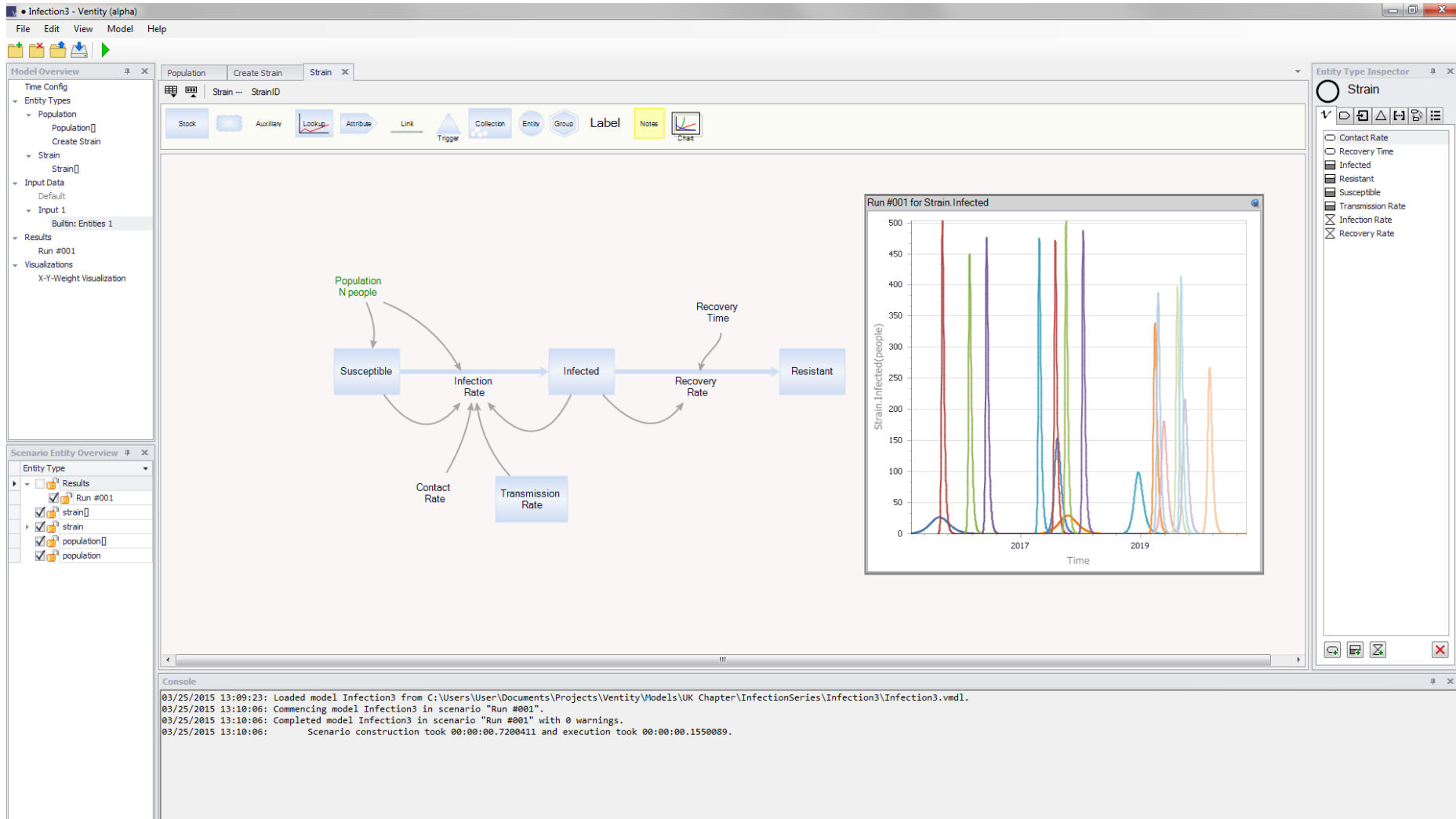
Infection 2

- We have seen;
 - Addition of a second entity type to handle crossover interaction
 - Attributes of crossover
 - The use of references to enable interaction between entities
 - Calculations using variables of multiple entities
 - Adding another species interaction through data
- How about multiple strains?
 - Let's see "Infection 3" - Multiple disease strains in a single population, with overlapping infections and dynamic introduction of mutations

Infection 3

- Multiple disease strains in a single population, with overlapping infections and dynamic introduction of mutations

Infection 3



Infection 3

- We have seen;
 - Trigger used to create new entities
- What about multiple populations and strains?
 - Let's see "Infection 4"

Infection 4

- Model individuals rather than stocks, because it's too hard to draw the stock flow network – aggregate stocks and flows are an emergent property of the individuals

Infection 4

The screenshot displays the Venty software interface for a model named "Infection4". The main workspace shows a causal loop diagram with the following elements and relationships:

- Entities (blue boxes):** Status, Is Susceptible, Is Infected, Probability of Infection, Infection, Fraction of Contacts Infected, and recover.
- Attributes (green text):** recovery time, InfectedPeople Count, Person_Collection Count, Transmission Fraction, and Contact Rate.
- Relationships (arrows):**
 - Status points to Is Susceptible and Is Infected.
 - Is Susceptible points to Probability of Infection.
 - Is Infected points to Fraction of Contacts Infected and Probability of Infection.
 - recovery points to Is Infected.
 - recovery time points to recover.
 - InfectedPeople Count points to Fraction of Contacts Infected.
 - Person_Collection Count points to Fraction of Contacts Infected.
 - Fraction of Contacts Infected points to Probability of Infection.
 - Transmission Fraction points to Probability of Infection.
 - Contact Rate points to Probability of Infection.
 - Probability of Infection points to Infection.

The interface includes several panels:

- Model Overview:** A tree view on the left showing the model structure, including Entity Types, Input Data, Results, and Visualizations.
- Scenario Entity Overview:** A table at the bottom left listing entity types and their status in the current scenario.
- Console:** A log window at the bottom showing the execution process and timing.

Scenario Entity Overview Table:

Entity Type	Checked
Results	<input type="checkbox"/>
Run #001	<input checked="" type="checkbox"/>
person[status]	<input checked="" type="checkbox"/>
person[]	<input checked="" type="checkbox"/>
person	<input checked="" type="checkbox"/>
model[]	<input checked="" type="checkbox"/>
model	<input checked="" type="checkbox"/>

Console Log:

```
03/25/2015 13:31:15: Loaded model Infection4 from C:\Users\User\Documents\Projects\Venty\Models\UK Chapter\InfectionSeries\Infection4\Infection4.vmdl.  
03/25/2015 13:31:24: Commencing model Infection4 in scenario "Run #001".  
03/25/2015 13:31:24: Completed model Infection4 in scenario "Run #001" with 0 warnings.  
03/25/2015 13:31:24: Scenario construction took 00:00:00.7280416 and execution took 00:00:00.1650094.
```

Infection 4

- We have seen;
 - Actions used to create events for individuals
 - Infect
 - Recover
 - Accumulations as emergent stocks

Much more is possible

- Add a social network, so that individuals or populations interact over...
 - A line (e.g., villages along a coast)
 - A grid (more general geography)
 - A hierarchy or network (ring, tree, small world ...)
- Model multiple interacting diseases among multiple subpopulations
- Tag individuals or cohorts with age, gender and other attributes, only adding data (no code)

We are still learning

- Graphical representations for some features?
- Tools for visualizing and managing large volumes of simulation output?
- Causal Tracing™ through collections of entities?
- Best practices for choosing an approach and relating to decision makers?

What's Next

- Publically available beta version early July
 - Trial period ends October 1st
 - Commercial release scheduled October 2015
- Subscription-based model
 - Commercial
 - Academic and public research significantly lower price
 - Free PLE version for students
- This is NOT a Vensim replacement