

Multi-method modeling

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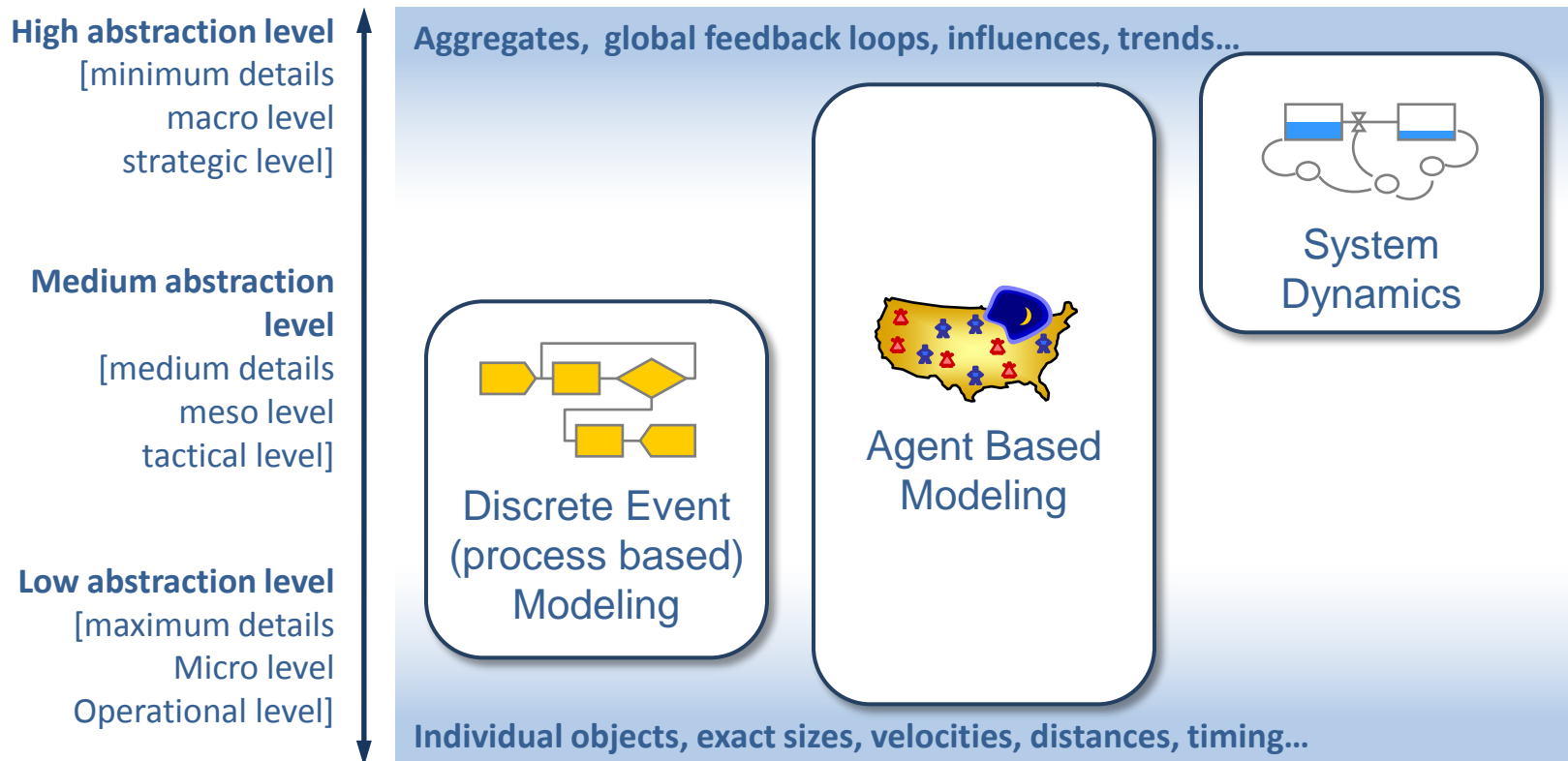
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The three methods in simulation modeling

- The three modeling methods are the three different viewpoints
 - ...the modeler can take when mapping the real world system to its image in the world of models



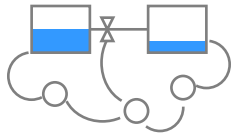
Why multi-method modeling?

- Sometimes, at the beginning of the project it is not clear which abstraction level and which method should be used
 - The modeler may start with, say, a highly abstract system dynamics model and switch later on to a more detailed discrete event model
- Frequently, the problem cannot completely conform to one modeling paradigm
 - Different components may be best described by using different methods.
- Using a traditional single-method tool, the modeler inevitably
 - Either starts using **workarounds** (unnatural and cumbersome language constructs), or
 - Just leaves part of the problem outside the scope of the model (treats it as **exogenous**).
- If we want to capture business, economic, and social systems in their natural complexity and interaction, "thinking single-method" becomes a serious limitation

Simulation modeling software

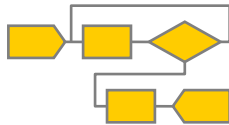
- Traditional tools are designed to support one particular modeling approach

System dynamics



VenSim
PowerSim
iThink

Discrete event modeling



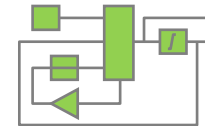
Arena
ExtendSim
Simul8
AutoMod
PROMODEL
Simio
Witness
FlexSim
...

Agent based modeling



[Academic tools:]
Swarm
RePast
NetLogo
ASCAPE
MASON

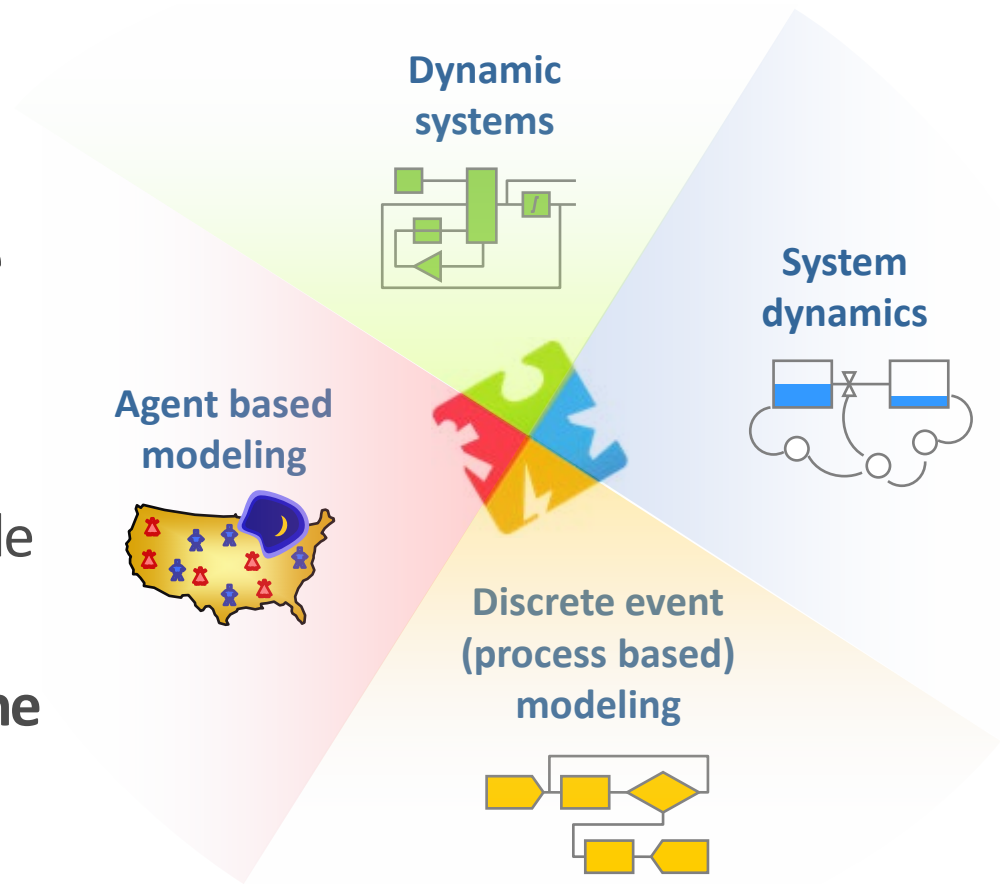
Dynamic systems



MATLAB
VisSim
LabView
Easy5
...

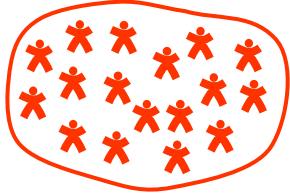
The main idea behind AnyLogic

- **Support all three** modeling methods on a single modern object-oriented platform
- **The modeler can choose** from a wide range of abstraction levels/methods and can efficiently vary them while working on the model
- **The modeler can combine** different methods in one model

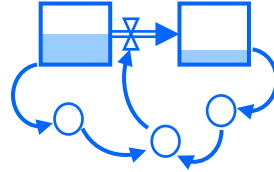


Model architectures

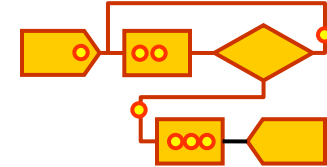
Agents



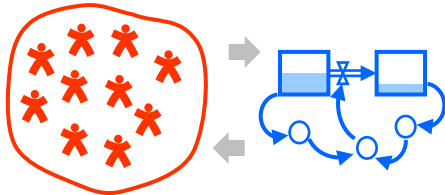
SD



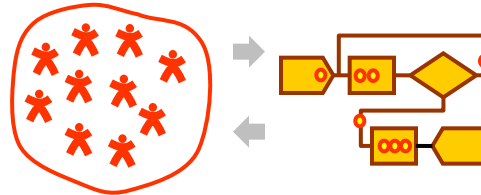
DE (Process model)



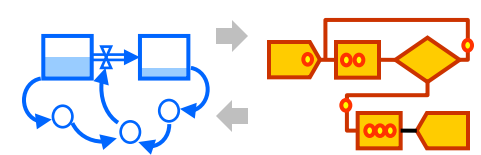
Agents + SD environment
(e.g., population + city infrastructure)



Agents + process model
(e.g., clients + service)



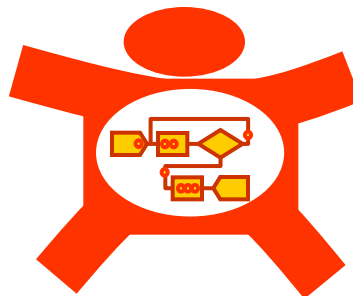
SD + process model
(e.g., demand + production)



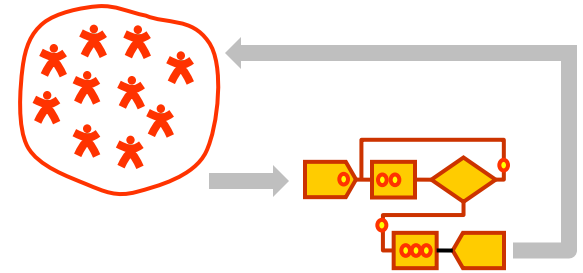
SD inside agent
(e.g. consumer's individual decision making)



Process model inside agent
(e.g. business process in a company in a bigger supply chain model)



Agents become entities
(e.g., patients with chronic diseases return to hospital)



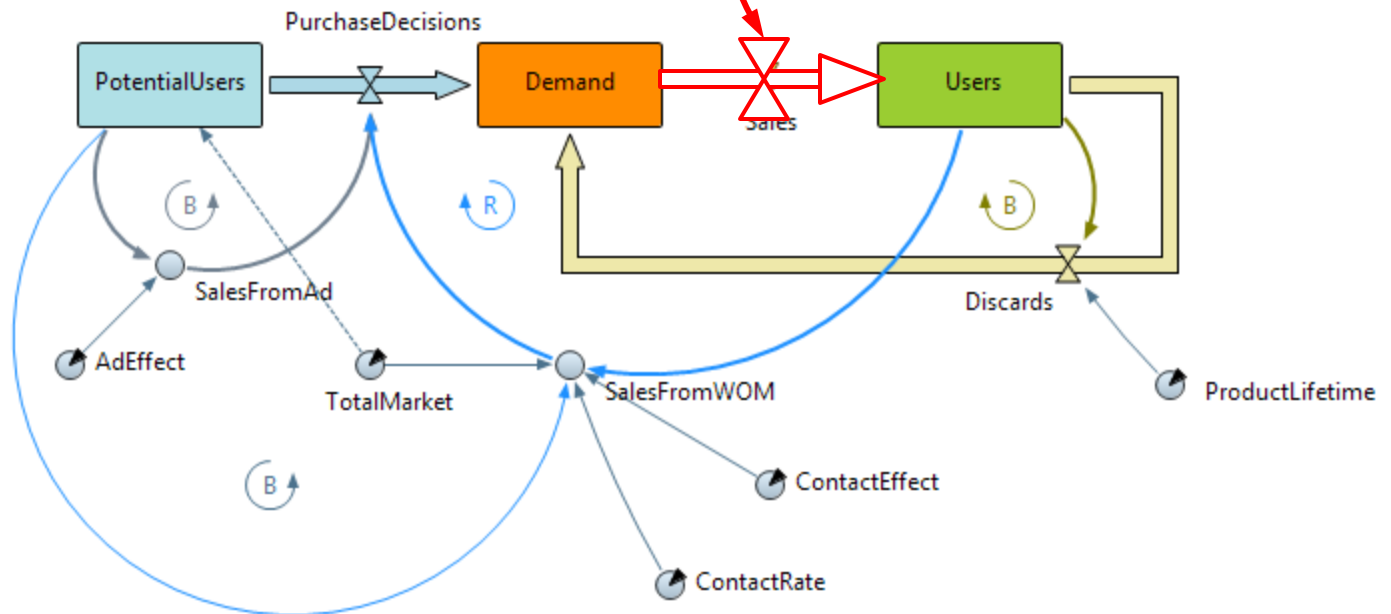
and so on in any combination...

Example 1: Supply chain and market

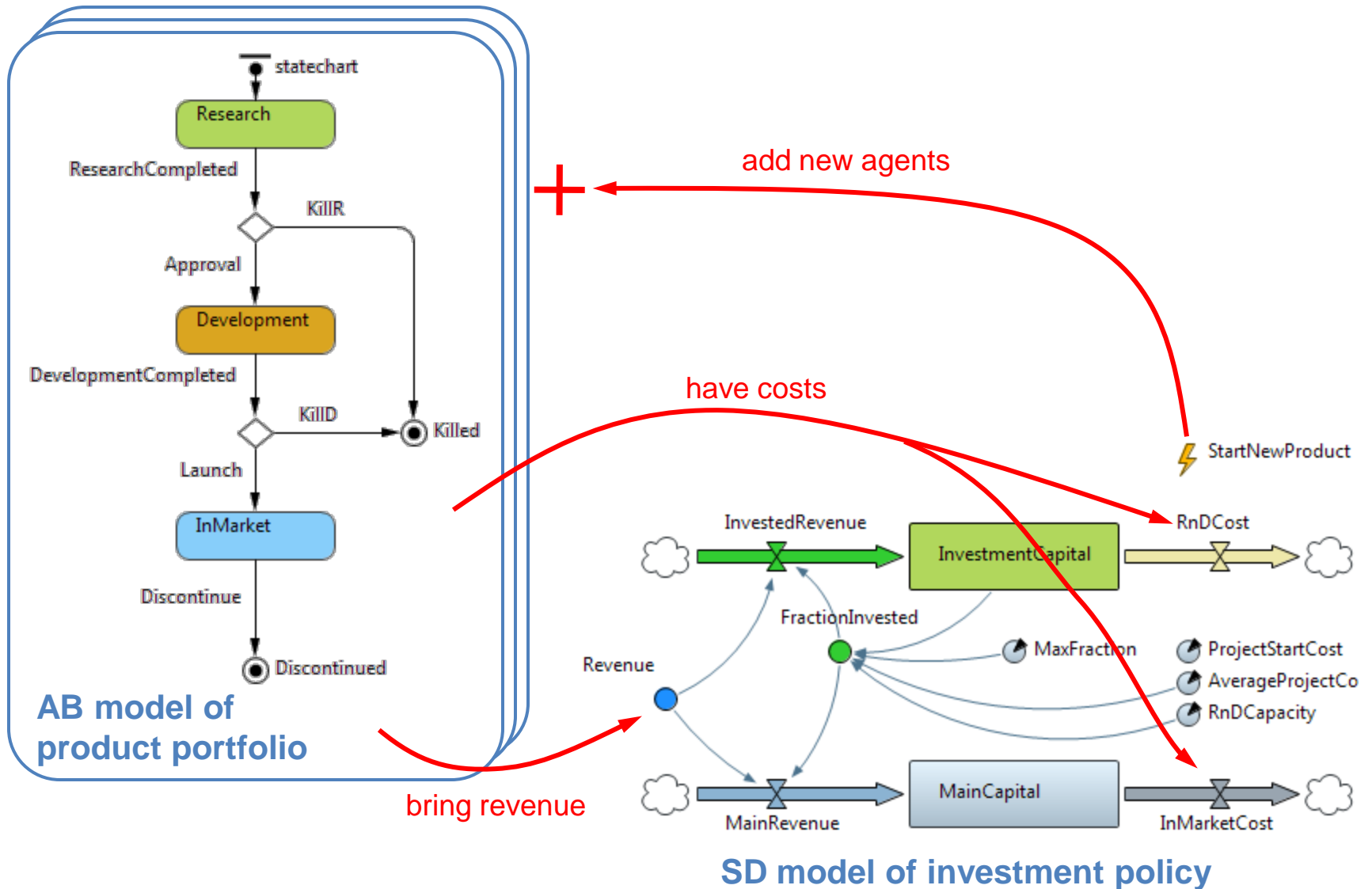
DE model of a supply chain



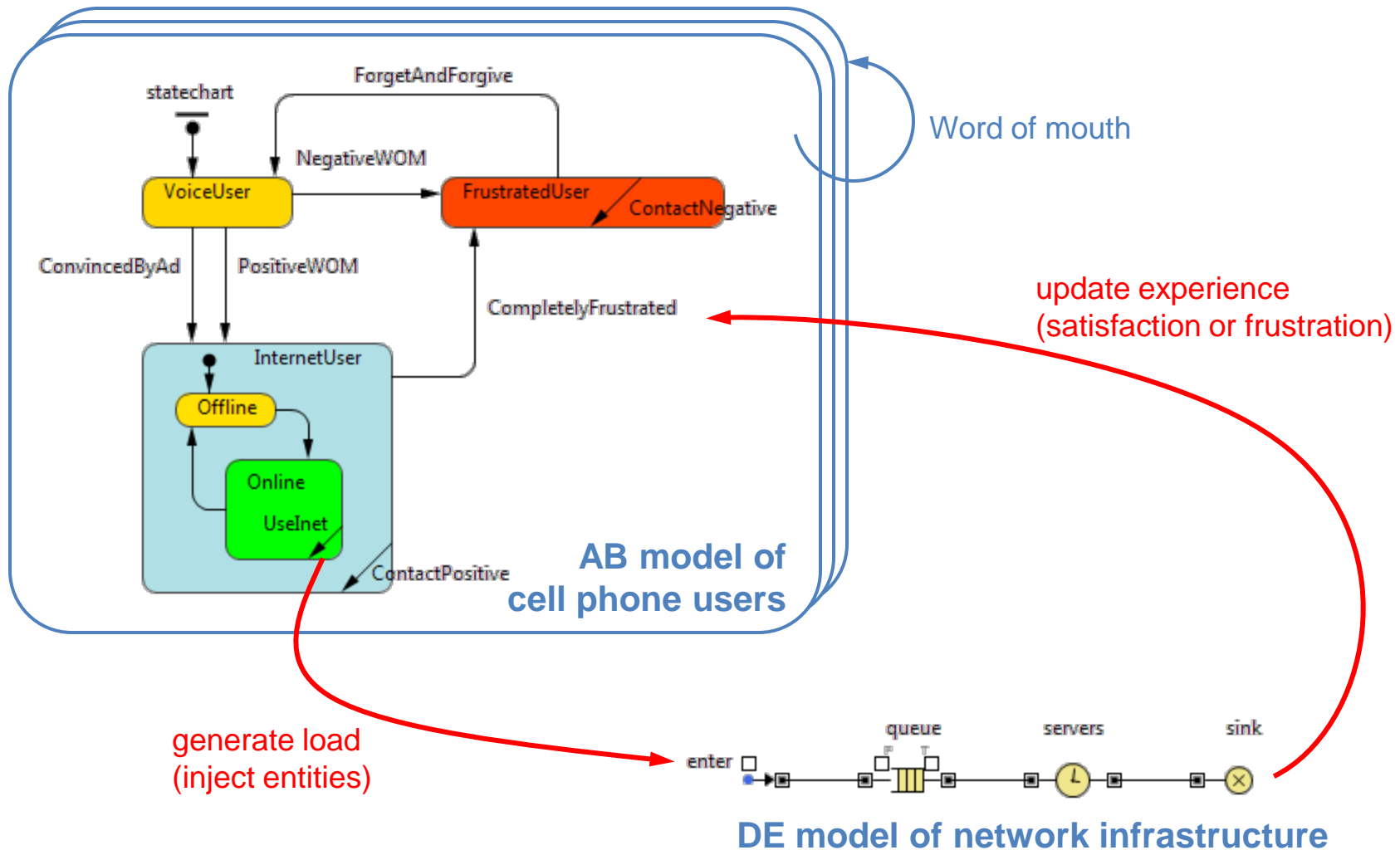
SD model of new product diffusion



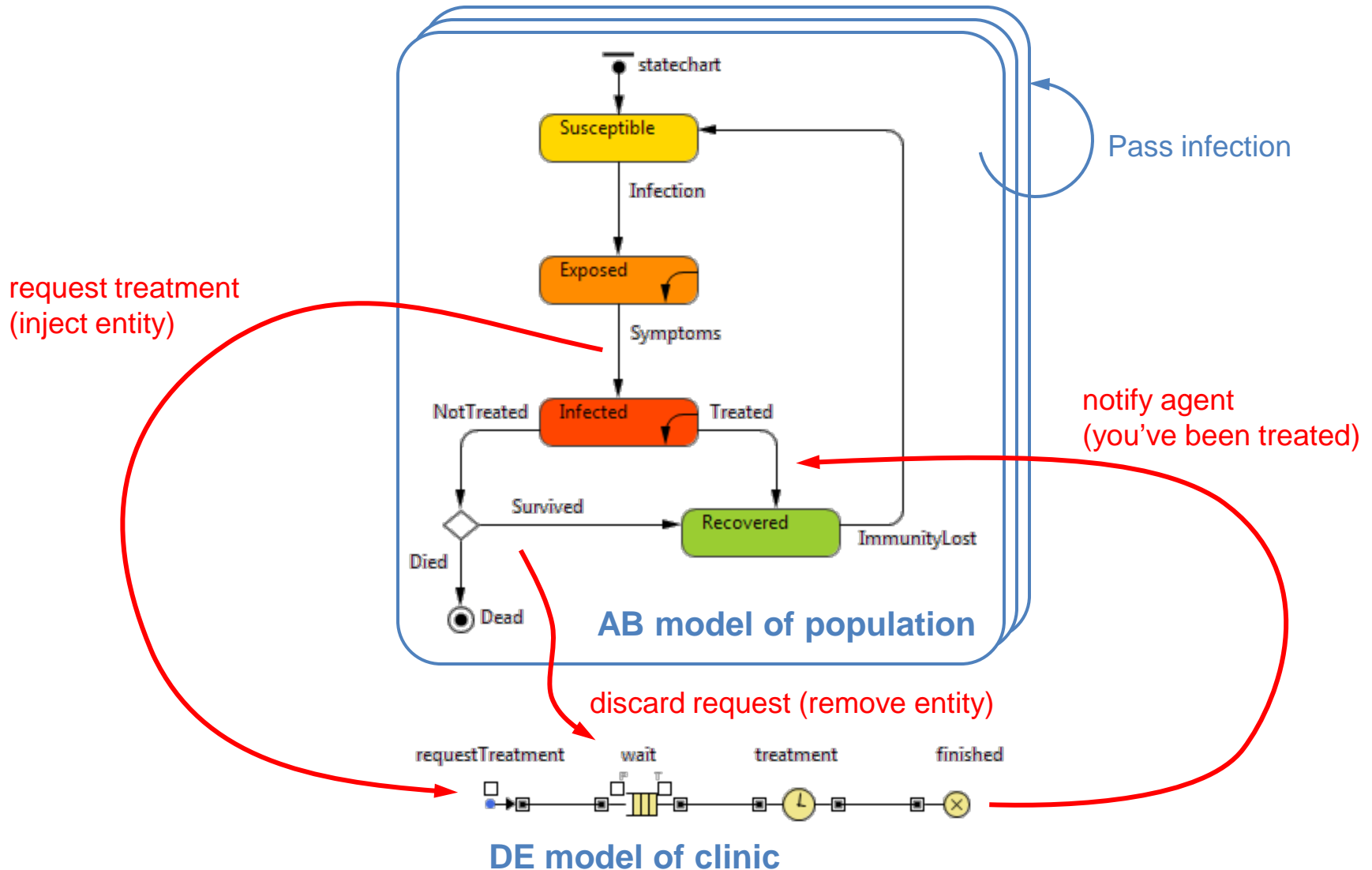
Example 2: Product portfolio and investment policy



Example 3: Cell phone users and network capacity



Example 4: Epidemic and clinic



The choice of architecture and methods

- You can develop models:
 - Simple or complex
 - Flat or hierarchical
 - Single-method or multi-method
 - With unique or replicated components
 - With static structure or with dynamically changing structure
 - Hardcoded or configured from external data sources
- The model structure does reflect the structure of the system being modeled – however, not "literally", but as seen from the problem viewpoint
- The choice of modeling method should be governed by the criterion of *naturalness*
 - Compact, minimalistic, clean, beautiful, easy to understand and explain – if the internal texture of your model is like that, then you chose the right method

The problem of model boundary

- When developing, say, a discrete event model of:
 - a supply chain, IT infrastructure, or a contact center...(having chosen DE) the modeler would typically ask the client to provide:
 - the arrival rates of the orders, transactions, or phone callshe would then be happy to get:
 - some constant values, periodical patterns, or trends, and treat arrival rates as variables **exogenous to the model**
- In reality, however, those variables are **outputs of another dynamic system**, such as a market, or a user base
 - Moreover, that other system can, in turn, be affected by the system being modeled
- The choice of the **model boundary** therefore is very important
 - The only methodology that explicitly talks about the problem of model boundary is system dynamics
 - However, the system dynamics modeling language is limited by its high level of abstraction, and many problems cannot be modeled with the necessary accuracy

Thank you!

- Questions?
- Links:
 - AnyLogic website: www.anylogic.com
 - AnyLogic models online: www.runthemodel.com