OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Welcome

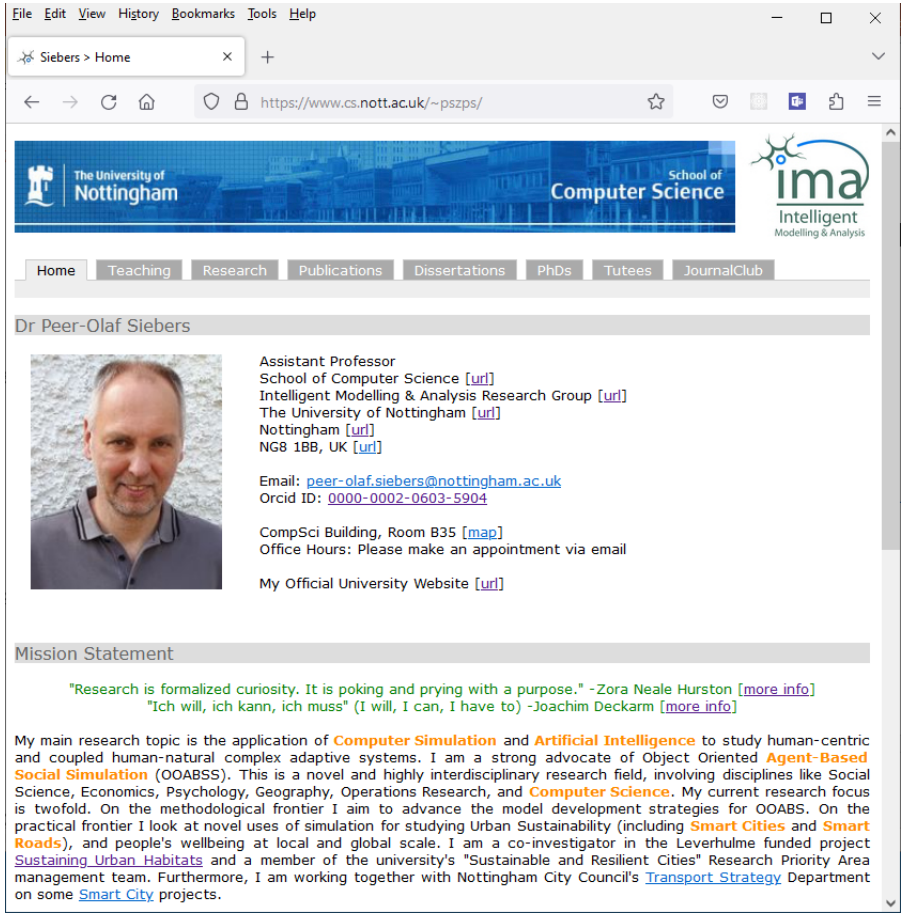
Personal Introductions (15 min)

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Training Course Convenor

- Peer-Olaf Siebers
  - Homepage
    - https://www.cs.nott.ac.uk/~pszps/
  - Email
    - peer-olaf.siebers@nottingham.ac.uk
  - Medical Condition
    - Functional (Dissociative) Seizure



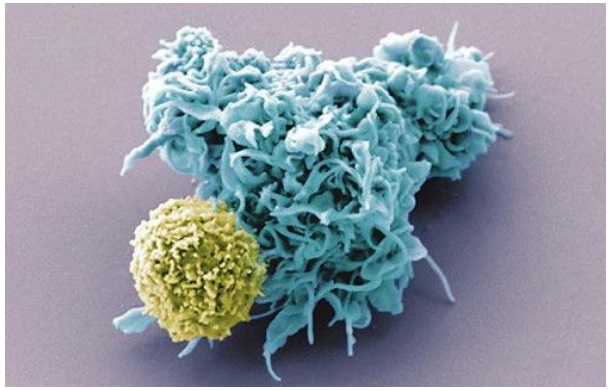
My Research Interests

- Technical Aspects
  - Engineering Social Simulations and other Multi-Agent Systems
    - Using Software Engineering methods and tools to define all sorts of agents and their interactions

My Research Interests

- Applications
  - My Mission: Applying OO-ABM to as many fields as possible

    - Business studies (Risk Assessment; CBA; MCDA)
    - Economics (Game Theory; Agent Based Computational Economics)
    - Social Sciences (Political Science; Social Simulation)
    - Engineering (Manufacturing; Urban Modelling; Energy; Transportation)
    - Computer Science (Robotics; Game Development)
    - Operations Research (Healthcare)
    - Systems Biology (Immunology)
    - Medicine (Digital Technology for Mental Health)

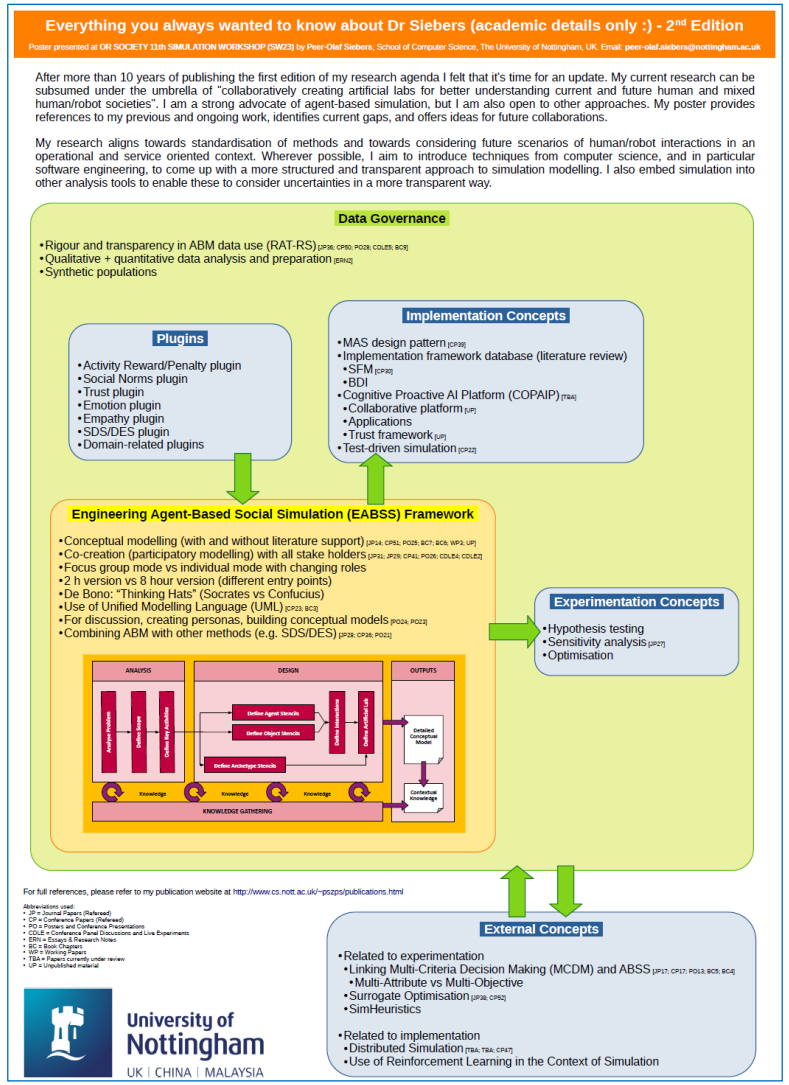


My Research Interests

- Simulating the future of service

My Research Interests

- Summary [Siebers 2023]



What About You?

Agenda

- Introduction
  - 09:30-09:45 Personal introductions (15 min)
  - 09:45-10:45 Lecture: Introduction to AB and Hybrid Modelling (60 min)
  - 10:45-11:00 Short break (15 min)
  - 11:00-12:00 Lecture: A Structured Approach to AB/Hybrid Model Development (60 min)
  - 12:00-13:00 Lunch (60 min)
- Practice
  - 13:00-14:00 Joint activity: Co-creating a conceptual AB model (60 min)

Agenda

- Software
  - 14:00-15:00 Lecture: Introduction to AB modelling in AnyLogic PLE (60 min)
  - 15:00-15:15 Short break (15 min)
- Presentation
  - 15:15-15:45 Research case studies summary (30 min)
- Practice
  - 15:45-16:30 Small groups: Develop modelling ideas for your own problems (45 min)
  - 16:30-16:45 Joint activity: Summarise outcome of previous activity (15 min)
- Wrap Up
  - 16:45-17:00 General discussion and Q&A (15 min)

OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Lecture

Introduction to AB and Hybrid Modelling (60 min)

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Agent-Based Modelling

Agent-Based Modelling

Heroes and Cowards

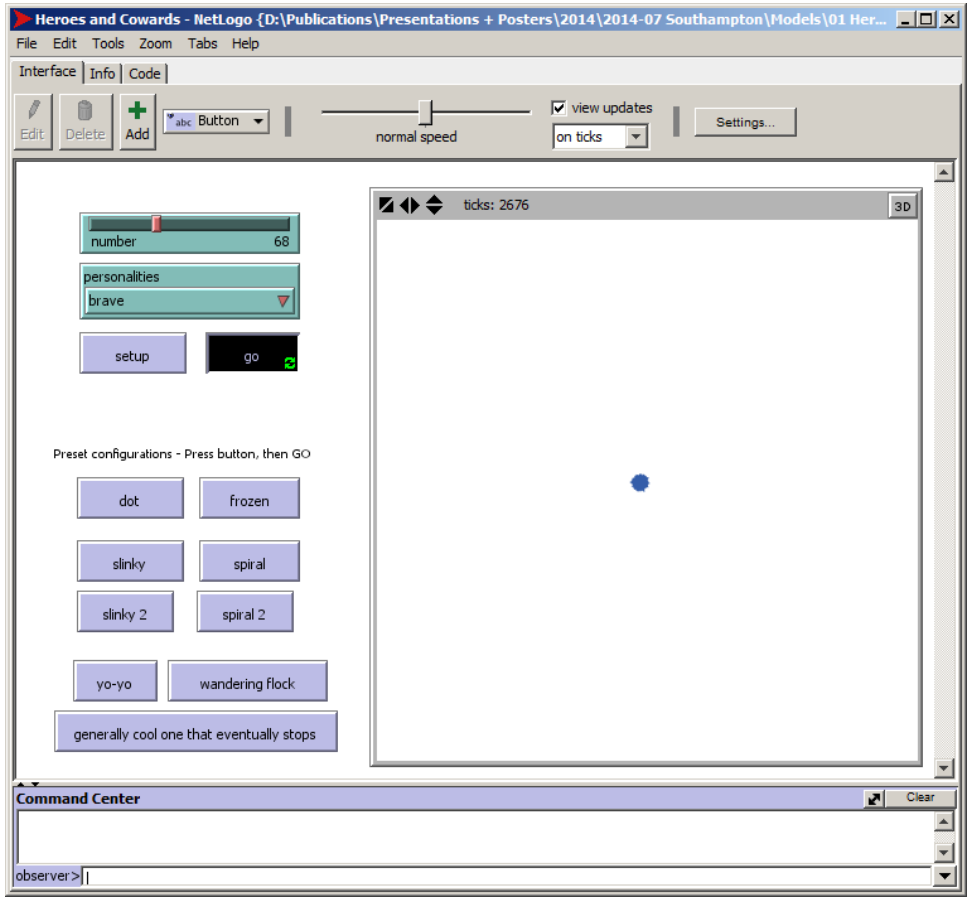
- Consider the following gaming scenario [Wilensky and Rand 2015]
  - 20 people scattered in a room - no communication
  - Game 1: Everyone takes on the role of a **Hero** by following a simple rule
    - Pick two participants and always locate yourself between them to shield one from the other

- What happens when everyone starts moving?

Agent-Based Modelling

Heroes and Cowards

- Heroes and Cowards Game : All heroes



Agent-Based Modelling

Heroes and Cowards

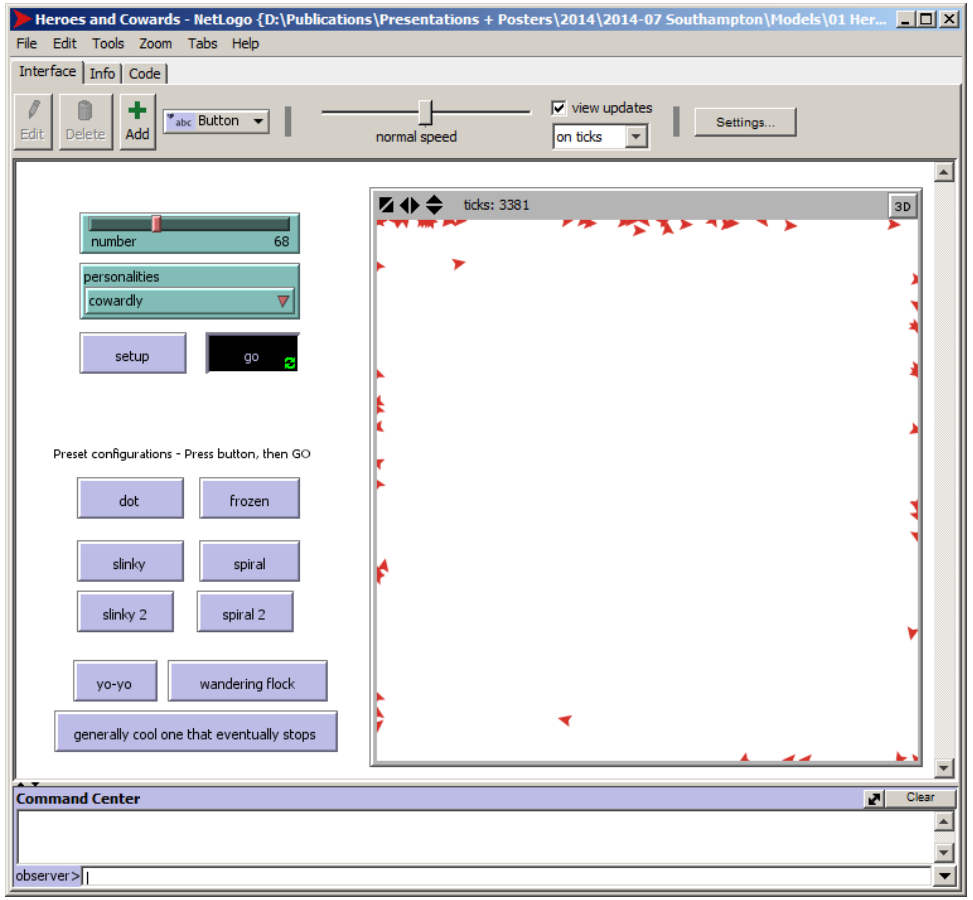
- Consider the following gaming scenario [Wilensky and Rand 2015]
  - 20 people scattered in a room - no communication
  - Game 2: Everyone takes on the role of a **Coward** by following a simple rule
    - Pick two participants and always use one to shield yourself from the other

- What happens when everyone starts moving?

Agent-Based Modelling

Heroes and Cowards

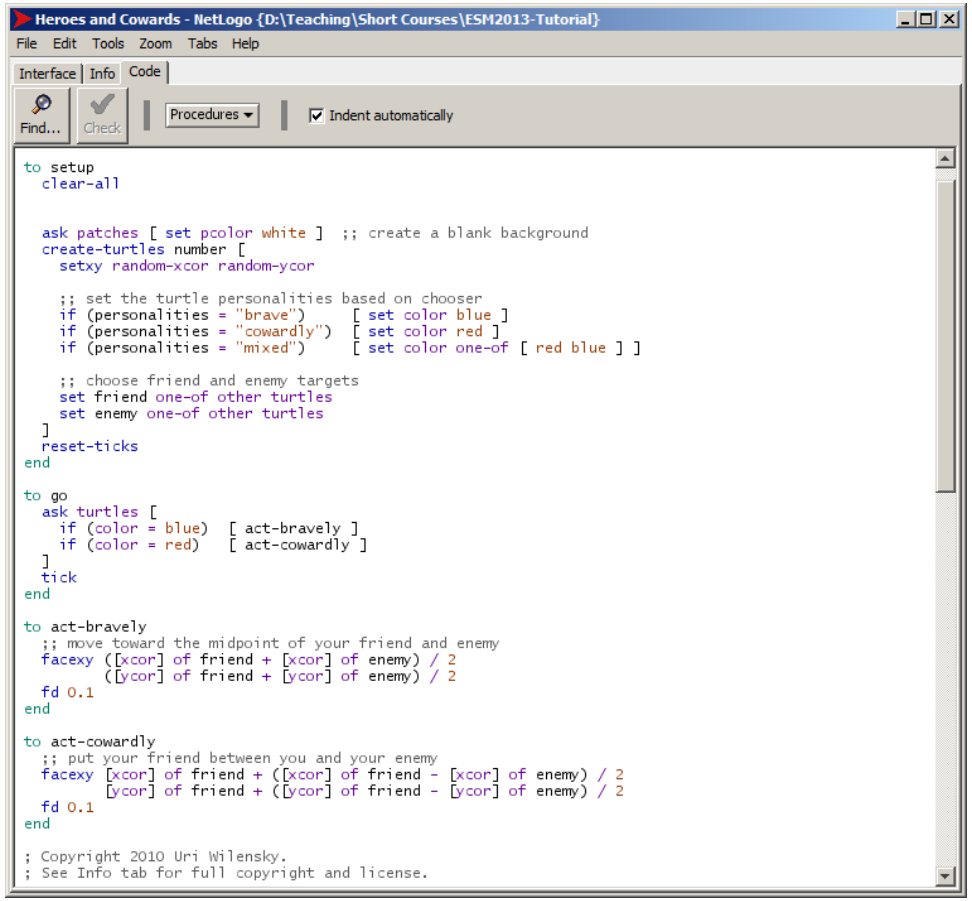
- Heroes and Cowards Game: All cowards



Agent-Based Modelling

Heroes and Cowards

- Heroes and Cowards Game: Source Code




```
to setup
  clear-all


  ask patches [ set pcolor white ]  ;; create a blank background
  create-turtles number [
    setxy random-xcor random-ycor

    ;; set the turtle personalities based on chooser
    if (personalities = "brave")     [ set color blue ]
    if (personalities = "cowardly")  [ set color red ]
    if (personalities = "mixed")     [ set color one-of [ red blue ] ]

    ;; choose friend and enemy targets
    set friend one-of other turtles
    set enemy one-of other turtles
  ]
  reset-ticks
end

to go
  ask turtles [
    if (color = blue)  [ act-bravely ]
    if (color = red)   [ act-cowardly ]
  ]
  tick
end

to act-bravely
  ;; move toward the midpoint of your friend and enemy
  facexy ([xcor] of friend + [xcor] of enemy) / 2
         ([ycor] of friend + [ycor] of enemy) / 2
  fd 0.1
end

to act-cowardly
  ;; put your friend between you and your enemy
  facexy [xcor] of friend + ([xcor] of friend - [xcor] of enemy) / 2
         [ycor] of friend + ([ycor] of friend - [ycor] of enemy) / 2
  fd 0.1
end

; Copyright 2010 Uri Wilensky.
; See Info tab for full copyright and license.
```

Agent-Based Modelling

Heroes and Cowards

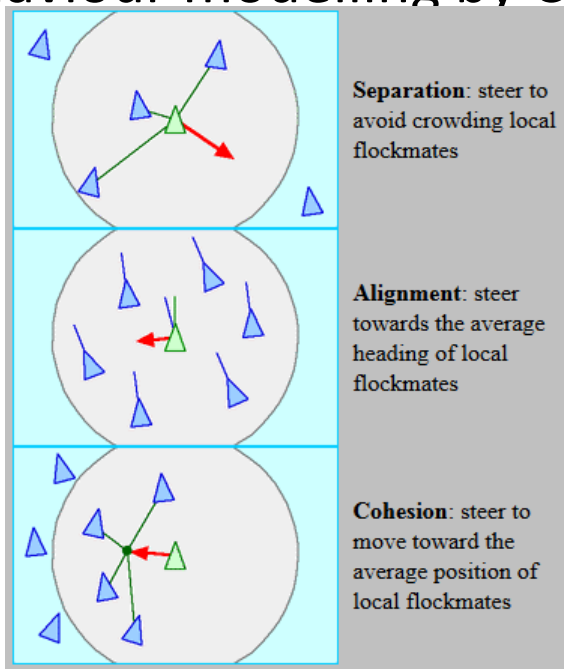
- Software used: NetLogo
  - https://ccl.northwestern.edu/netlogo/

Agent-Based Modelling

- Flocking behaviour

Agent-Based Modelling

- Flocking behaviour modelling by Craig Reynolds [url]



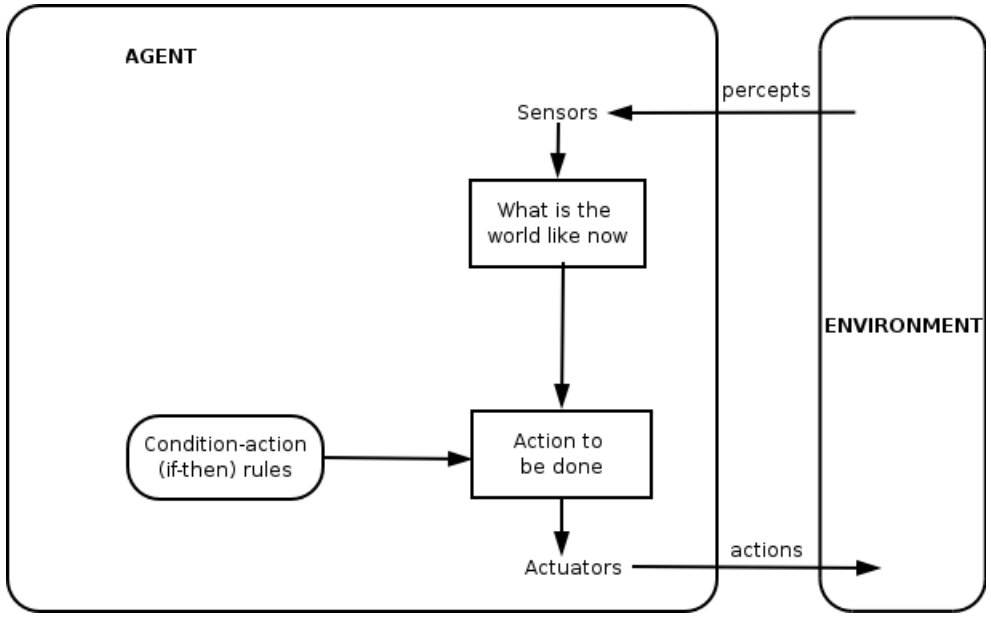
http://ayearincode.tumblr.com/post/107414487116/this-morning-i-added-some-new-rules-to

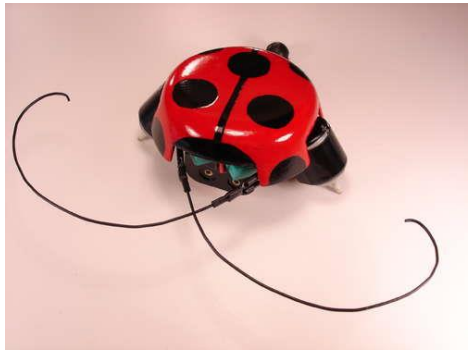
Agent-Based Modelling

- In Agent-Based Modelling (ABM), a system is modelled as a collection of **autonomous decision-making entities** called agents. Each agent individually assesses its situation and makes decisions on the basis of a **set of rules**.
- ABM is **a mindset more than a technology**. The ABM mindset consists of describing a system from the perspective of its constituent units. [Bonabeau 2002]
- ABM is **well suited to modelling** systems with heterogeneous, autonomous and proactive actors, such as **human-centred systems**.

Agent-Based Modelling

- Borrowing from Artificial Intelligence: From simple to complex
  - Simple reflex agent

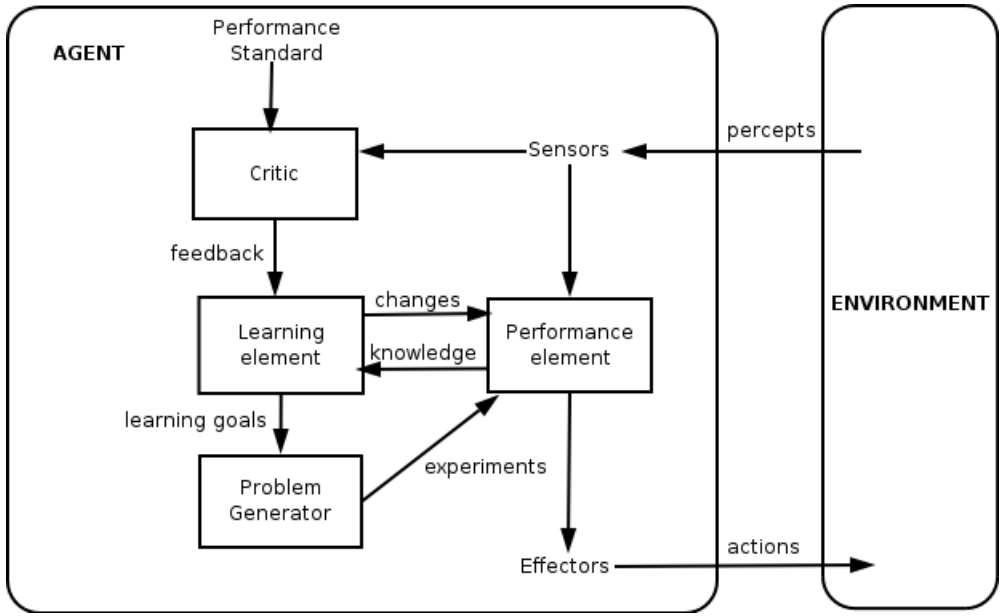




[Russell and Norvig 2003]

Agent-Based Modelling

- Borrowing from Artificial Intelligence: From simple to complex
  - Learning agent



[Russell and Norvig 2003]

Agent-Based Modelling

- What do we mean by "agent"?
  - Agents are **"objects with attitude"** [Bradshaw 1997]

- Properties:
  - Discrete entities
    - With their own goals and behaviours
    - With their own thread of control
  - Autonomous decisions
    - Capable to adapt
    - Capable to modify their behaviour
  - Proactive behaviour
    - Actions depending on motivations generated from their internal state

Agent-Based Modelling

- Agents can represent individuals, households, organisations, nations ...
  - Discrete entities; autonomous decisions; proactive

- ABMs are essentially **decentralised**; there is no place where global system behaviour (dynamics) would be defined

- Instead, the individual agents **interact** with each other and their environment **to produce complex collective behaviour** patterns

Agent-Based Modelling

- Benefits of ABM
  - ABM provides a natural description of a system
  - ABM captures emergent phenomena

- Emergence
  - Emergent phenomena result from the interactions of individual entities. **The whole is more than the sum of its parts** [Aristotle BC] because of the interactions between the parts
  - An emergent phenomenon can have properties that are decoupled from the properties of the part (e.g. patterns appearing)
  - Example: Traffic Jam Dynamics

Agent-Based Modelling

- When to use ABM (examples)? [Siebers et al. 2010]
  - When the problem has a **natural representation as agents** - when the goal is modelling the behaviours of individuals in a diverse population
  - When entities have **relationships with other entities**, especially **dynamic relationships**
  - When it is important that entities have **spatial or geo-spatial aspects** to their behaviours
  - When it is important that entities **learn or adapt**, or populations adapt
  - When entities engage in **strategic behaviour**, and anticipate other entities' reactions when making their decisions

Agent-Based Simulation

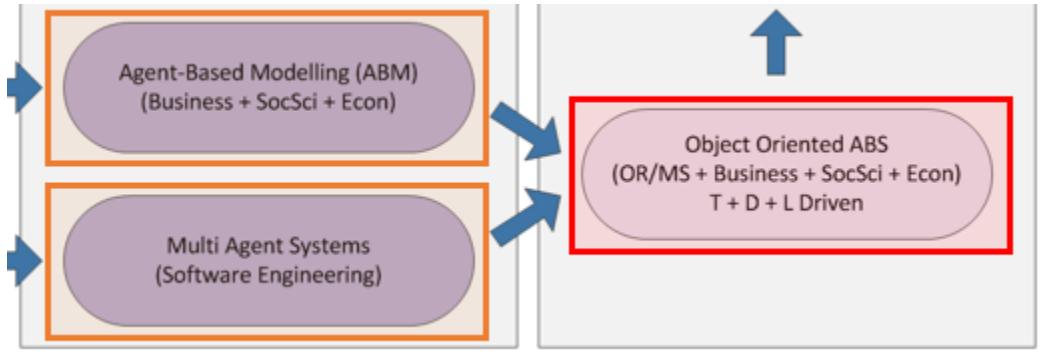
Agent-Based Simulation

- Little Computer People (LCP) @ C64 @ 1985
  - This "House on a Disk" is based on the theory that every computer has an "occupant"; every occupant is different
  - You could communicate with your occupant by asking him what you want him to do
    - "Please play with me"
    - "Please play piano"
    - "Please write a letter to me"
    - "Please talk to me"

Agent-Based Simulation

- The Sims: Interactive Organisational Agent-Based Simulation

Object Oriented ABM (OO-ABM)



Building and Validating Agent-Based Models

- Different purpose of ABMs [Edmonds et al 2019]
  - Prediction
  - Explanation
  - Description
  - Theoretical exploration
  - Illustration
  - Analogy
  - Social interaction

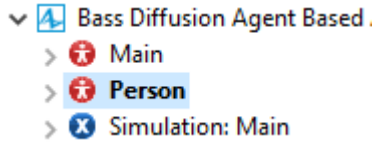
Building and Validating Agent-Based Models

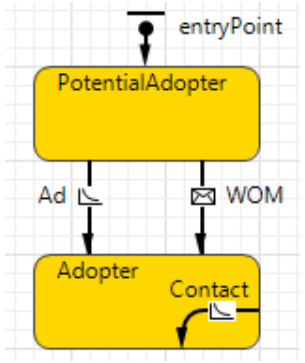
- Different flavours of ABMs [Achter et al 2022]
  - Theory driven
  - Empirical (data) driven
  - Model driven
  - Participatory

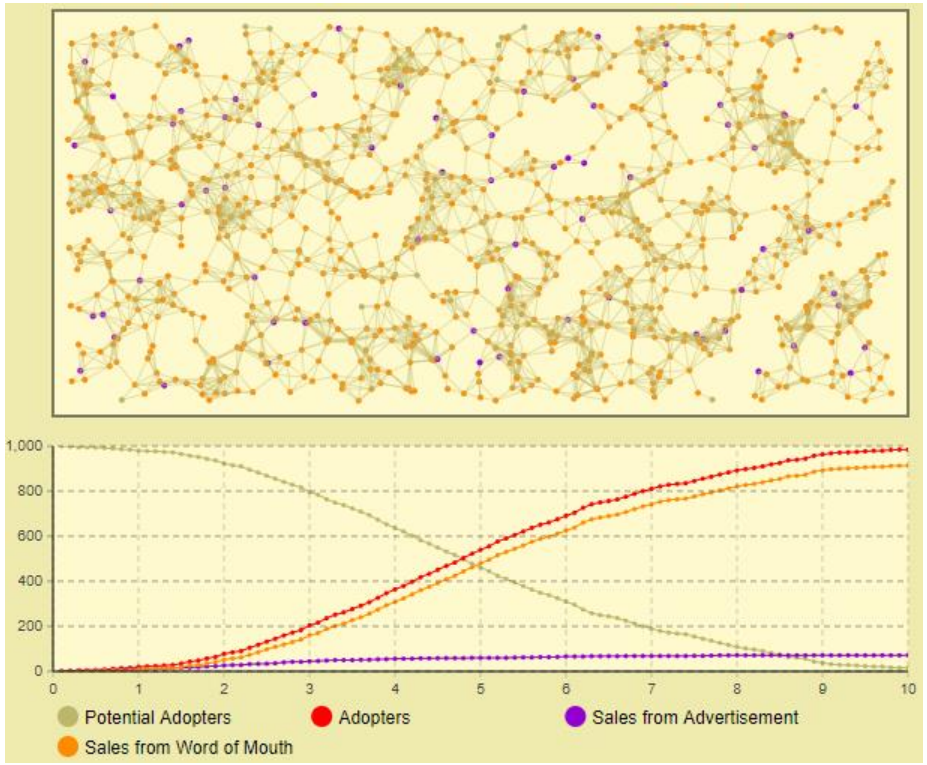
Building and Validating Agent-Based Models

- Building an ABM (OR/MS)
  - Identify active entities (agents)
  - Define their states and behaviour
  - Put them in an environment
  - Establish connections
  - Test the model

AnyLogic Help (2013)



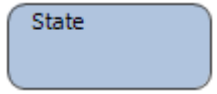




- Validating an ABS
  - System behaviour is an emergent property
  - Validation at micro level
  - Plausibility check of emerging patterns at system level (e.g. comparison to observations)

Graphical Notation to Capture Agent States/Behaviours

- Typical elements of a state chart
  - States
    - Represents a location of control with a particular set of reactions to conditions and/or events
    - Examples
      - Cup can be in state **full** or **empty**
      - Person can be in state **idle** or **busy**

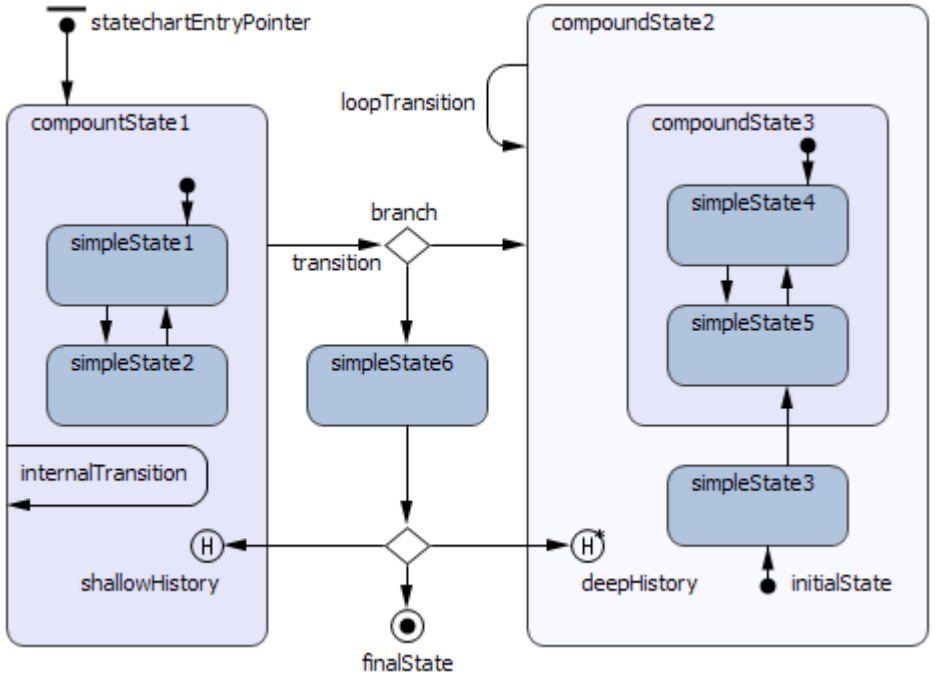


  - Transitions
    - Movement between states, triggered by a specific event

      - In AnyLogic such event can be: timeout; rate; condition; message; agent arrival

Graphical Notation to Capture Agent States/Behaviours

- Typical elements of a state chart

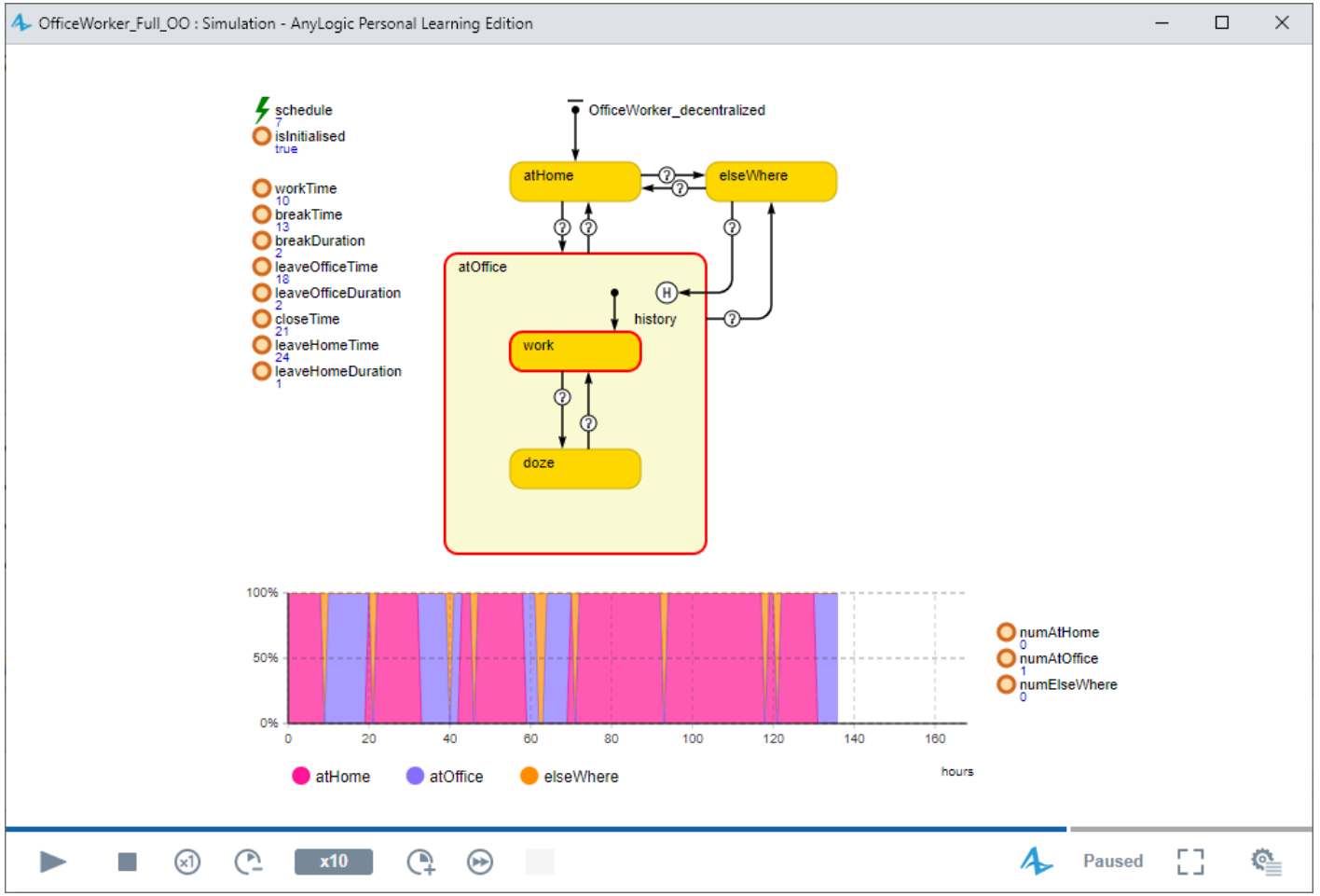


- Shallow History: Reference to the most recently visited state on the same hierarchy level within the composite state
- Deep History: Reference to the most recently visited simple state within the composite state

Building Simple State Charts Step-by-Step

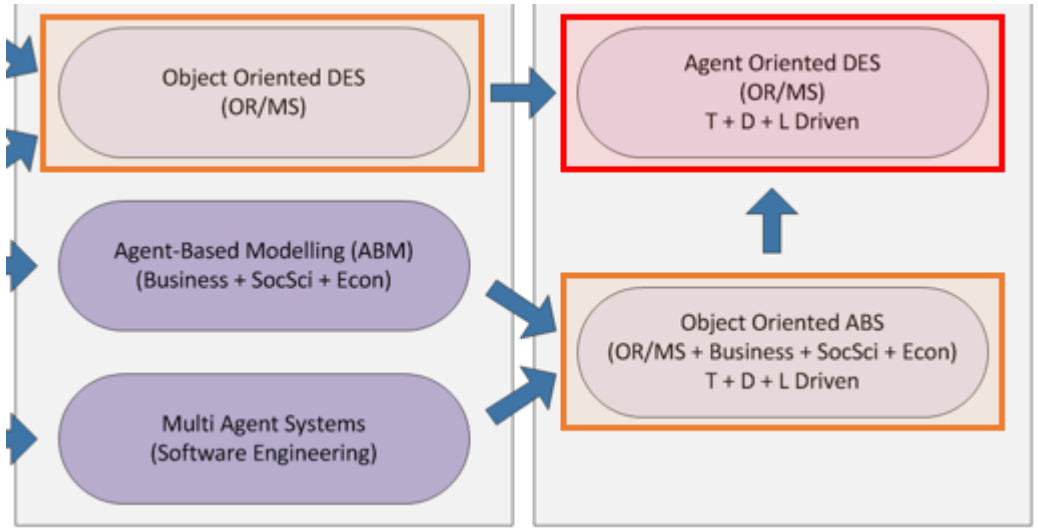
- Simulating an office scenario
  - What question would you like to answer?
    - Consider "What-If" or "How Many" type of questions and choose one to continue
  - Who are the actors relevant to your question?
    - Come up with 2-3 actor types based on their roles
  - What are the key locations you can find them?
    - Keep it simple (approx. 3 locations)
  - What are key time consuming activities they get involved in?
    - Keep it simple (approx. 3 activities)
  - Define a state chart for one of your actor types
    - Consider key locations and key time consuming activities relevant for this actor type

Building Simple State Charts Step-by-Step



Hybrids: AO-DES

Agent Oriented Discrete Event Simulation



Concept of AO-DES

- AO-DES is a hybrid simulation paradigm; we represent the **process flow** with the help of a **discrete event simulation** model and add some **active entities** to replace the passive entities commonly used in discrete event simulation
  - Passive entities are told what to do
  - Active entities can act autonomously and can (often) be proactive

Concept of AO-DES

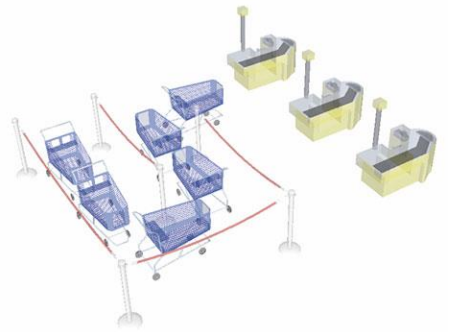
Direct interactions
Network activities

Let entities interact + communicate

Active entities
Behavioural state charts

Agent layer

Replace passive entities by active ones



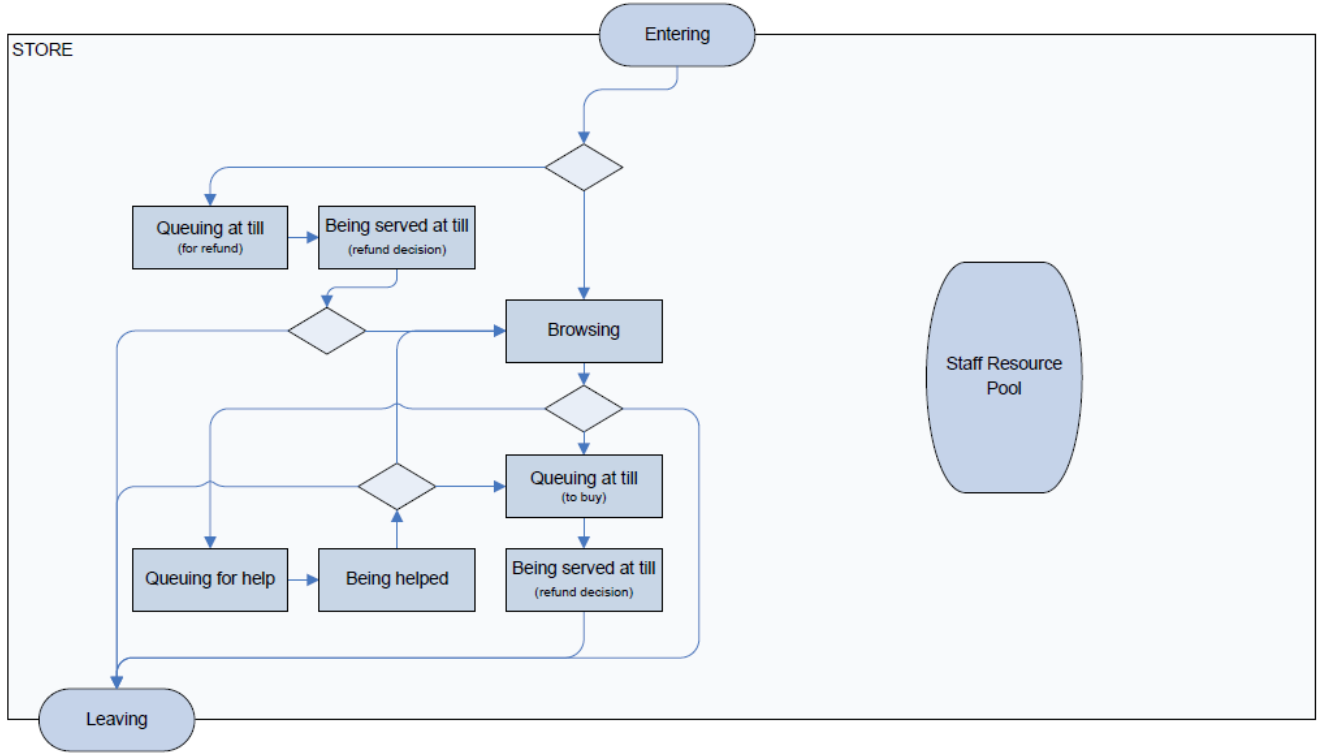
Passive entities
Queues
Processes
Resources

DES layer

AO-DES Example

Modelling Staff Proactiveness in Retail Simulations [Siebers and Aickelin 2011]

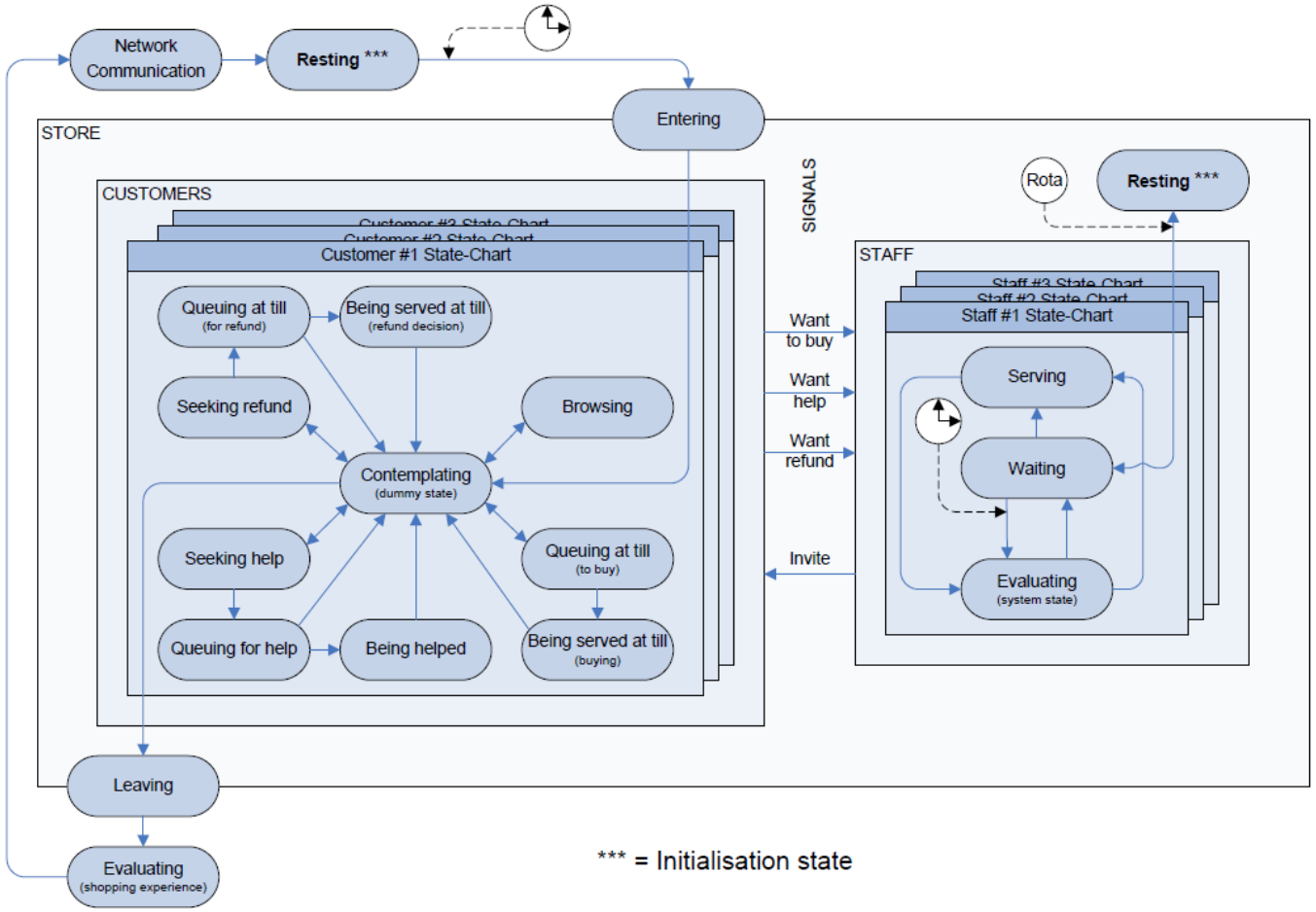
- Modelling a department queuing system



AO-DES Example

Modelling Staff Proactiveness in Retail Simulations [Siebers and Aickelin 2011]

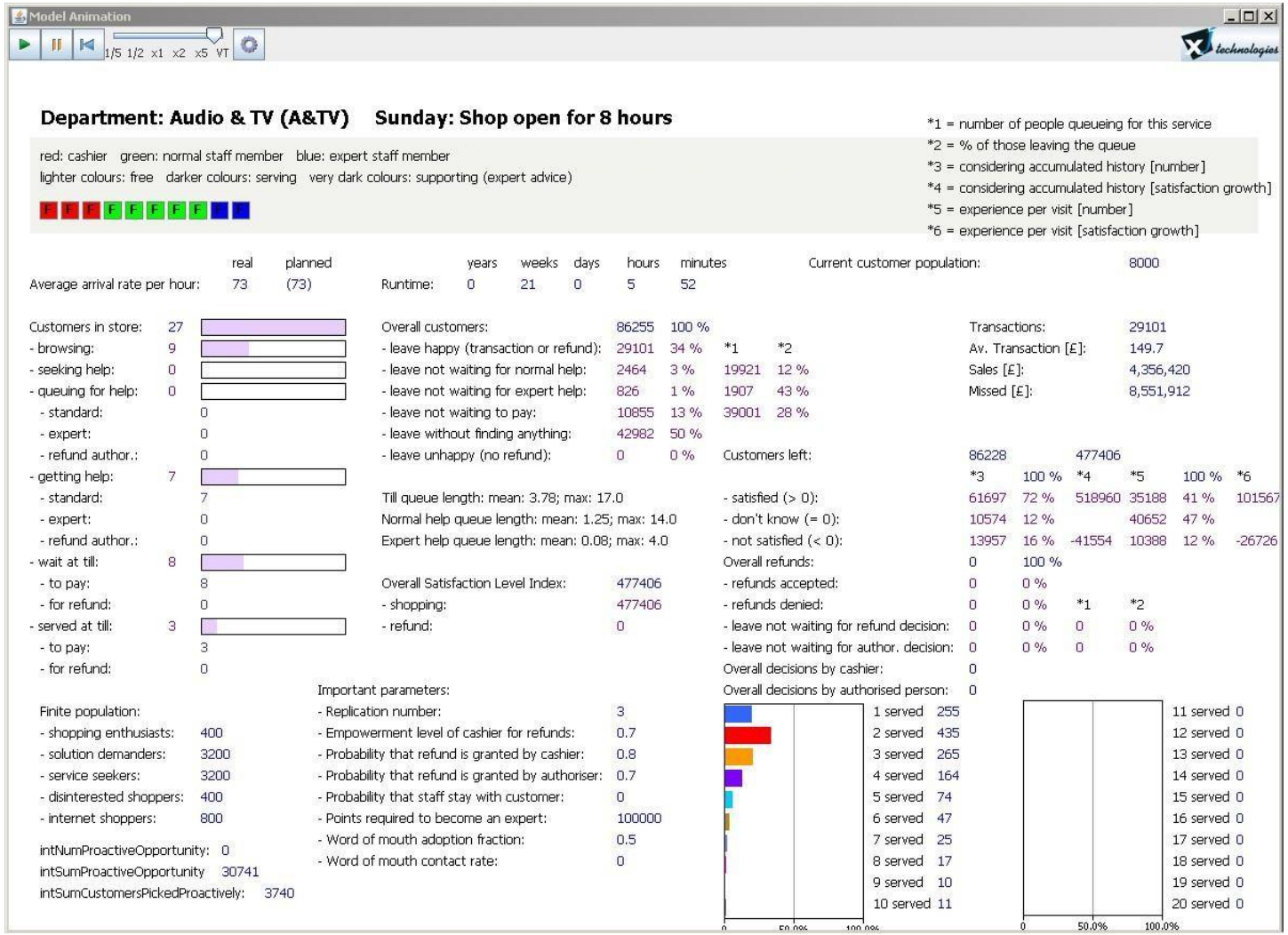
- Modelling proactive customer/staff behaviour



AO-DES Example

Modelling Staff Proactiveness in Retail Simulations [Siebers and Aickelin 2011]

- Implementation

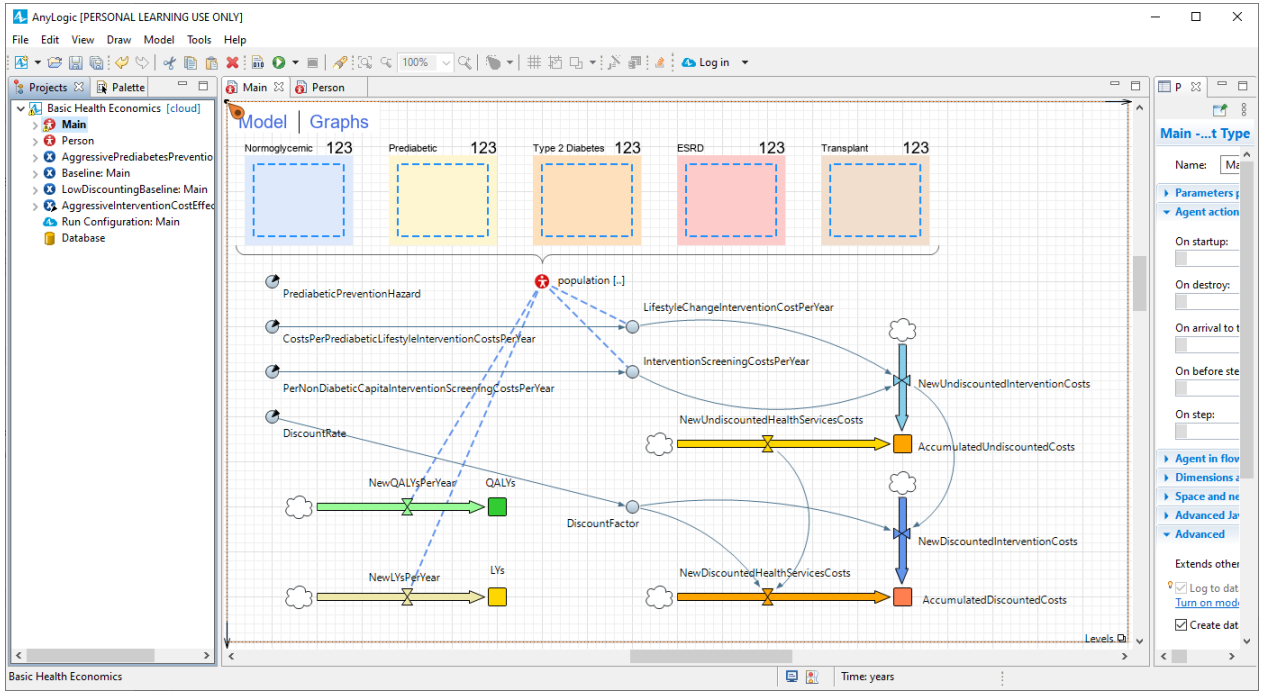


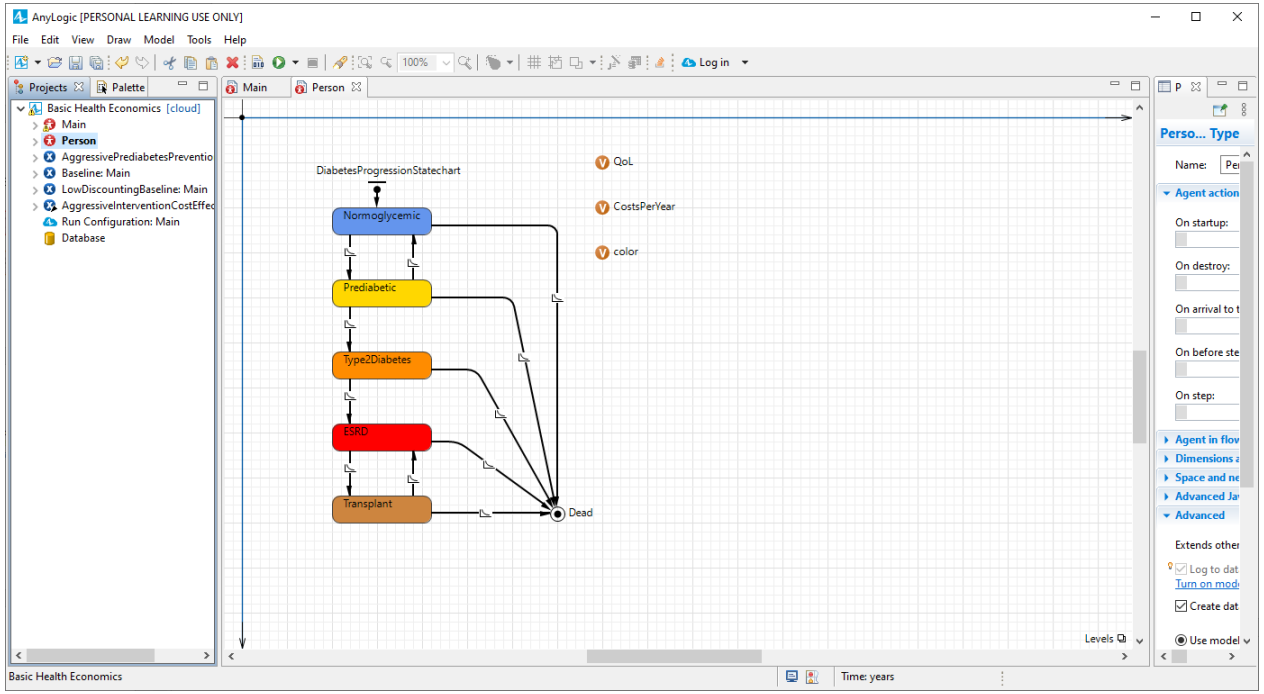
Hybrids: ABM & SDM

Agent-Based Modelling and System Dynamic Modelling

ABM & SDM

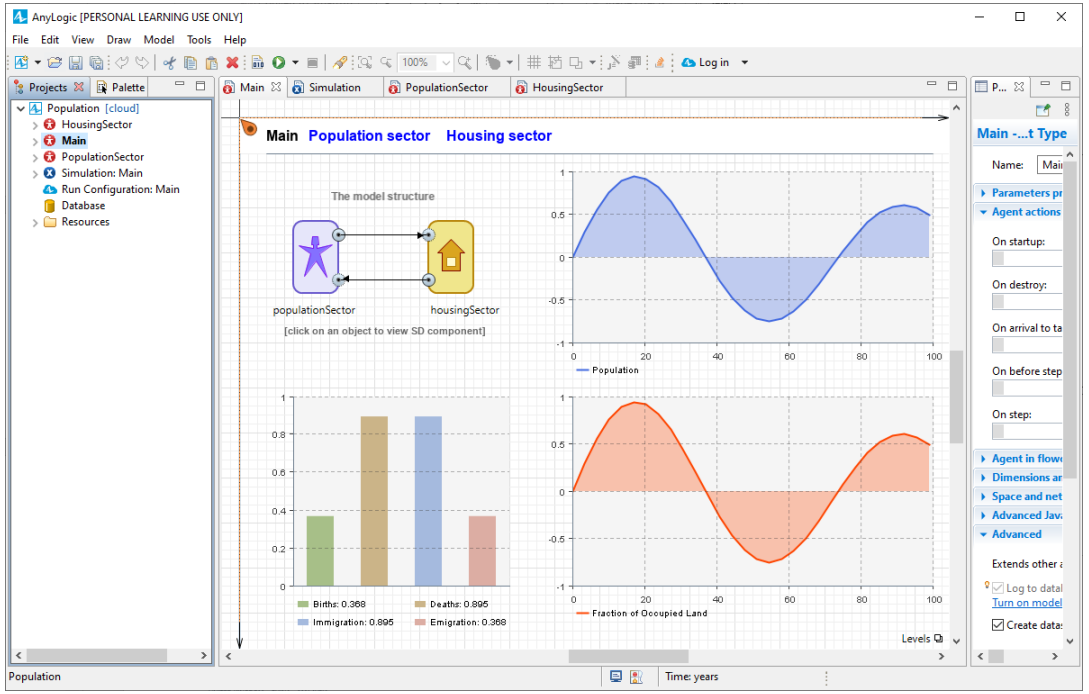
- Agents in an SD environment
  - AnyLogic Help Example Model: "Basic Health Economics"

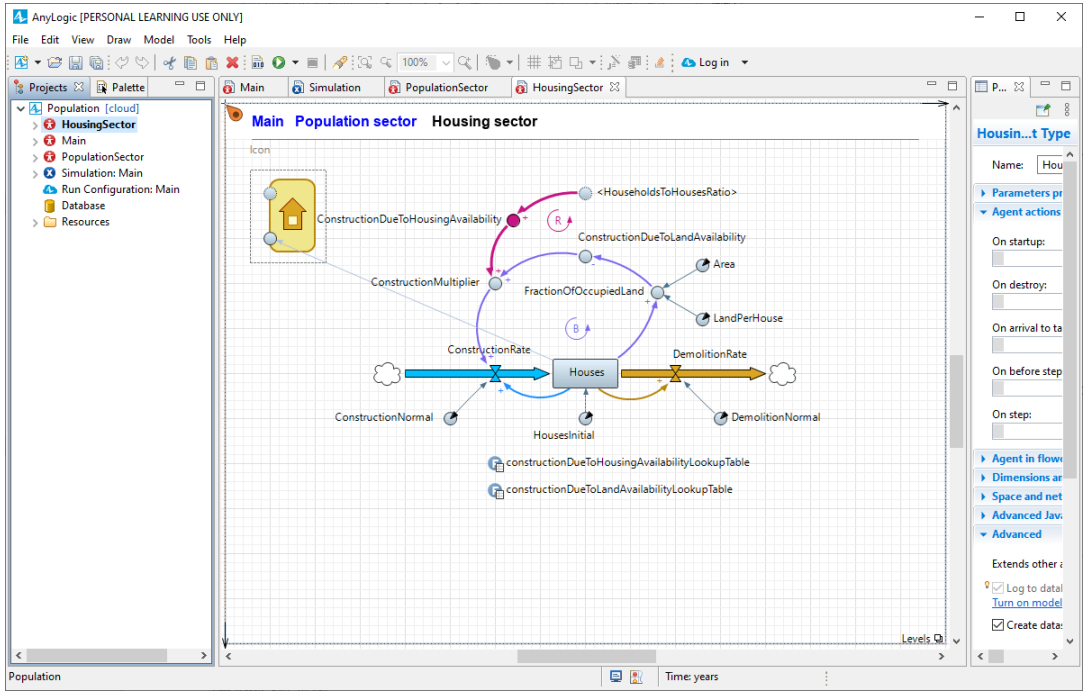




ABM & SDM

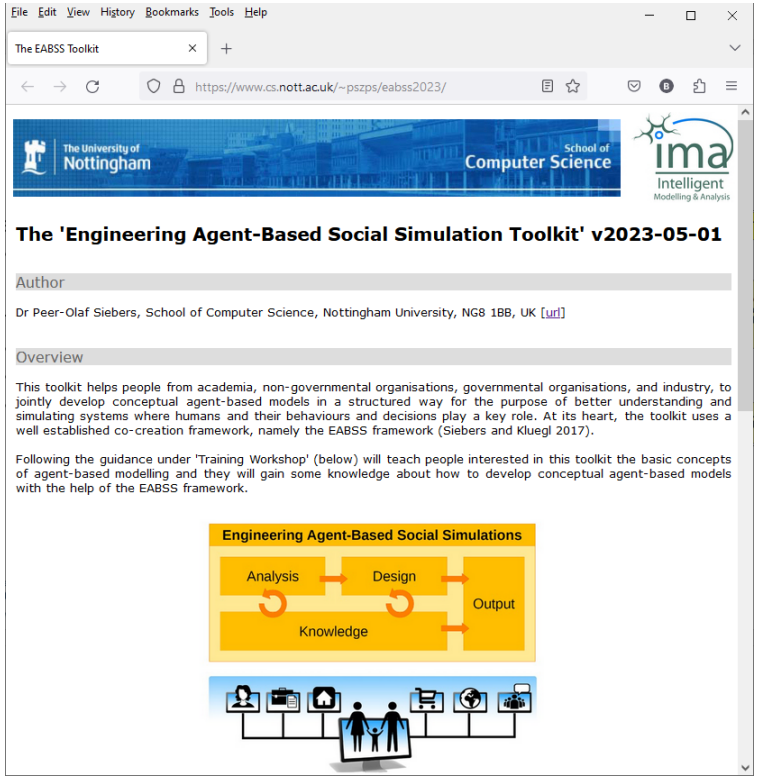
- SD inside agents
  - AnyLogic example: "Population" (Population/Housing Model)

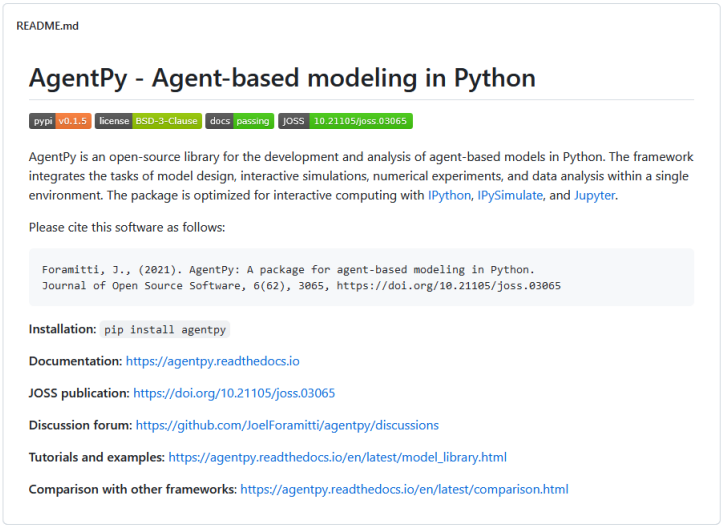




Agent-Based Modelling and Simulation Tools

- Design
  - EABSS
- Implementation
  - NetLogo
  - AnyLogic
  - AgentPy





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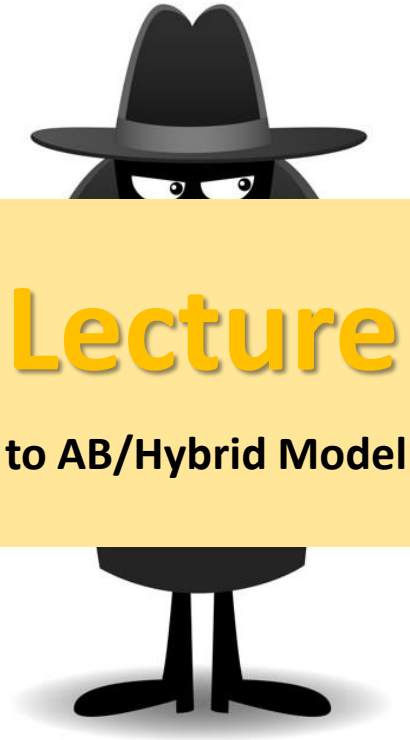

Lecture

A Structured Approach to AB/Hybrid Model Development (60 min)

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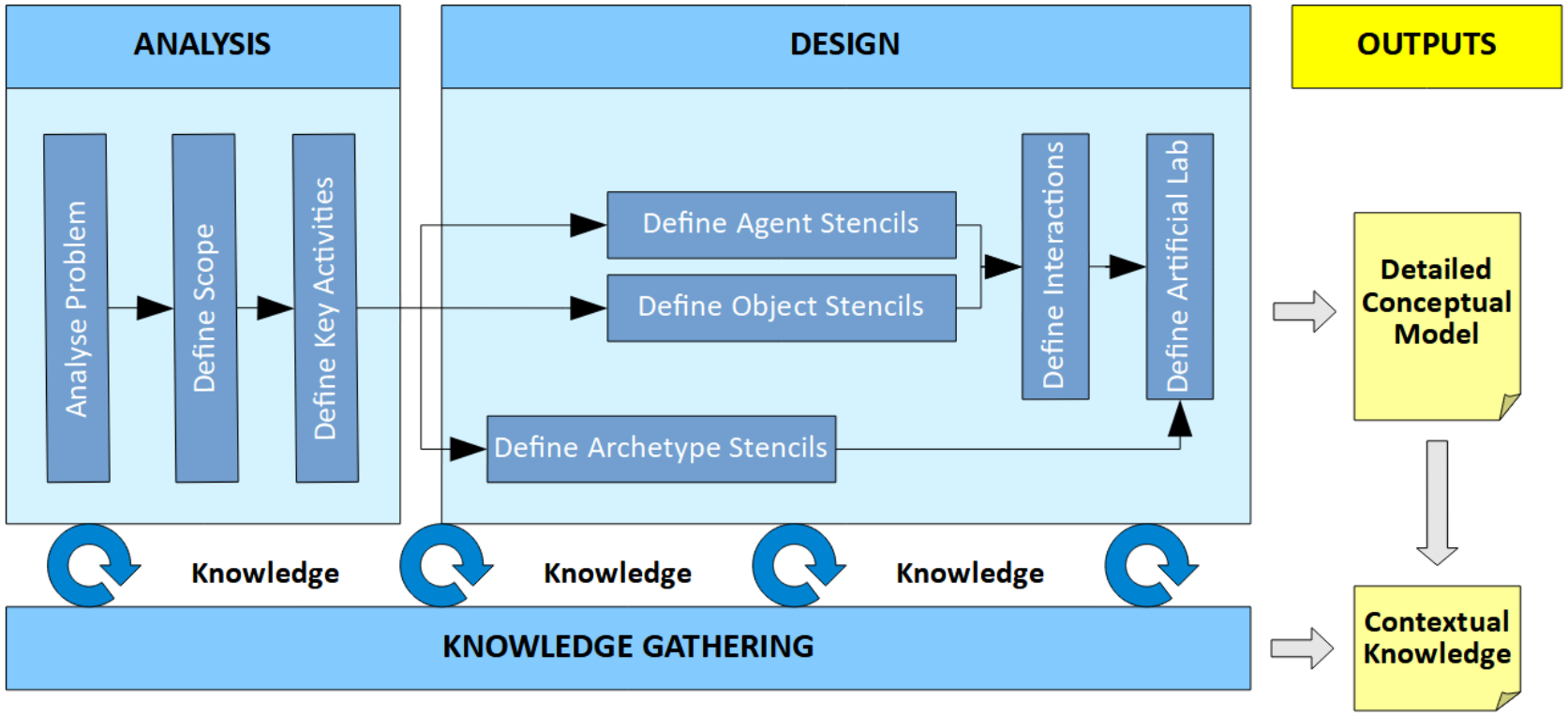
What is this all about?

- Social Simulation (formal definition)
  - Studies **socio-economic phenomena** by investigating the social macrostructures and **observable regularities** generated by the behaviour and relationships between individual **social agents**, and between agents and **the environment** in which they act.

- Agent-Based Social Simulation (ABSS)
  - Example from the Gaming World
    - SIMS4: Promotion Video (https://www.youtube.com/watch?v=dcDy1CCd-F8)
    - SIMS4: Hands-On Gameplay (https://www.youtube.com/watch?v=pXLEAHpzFks)

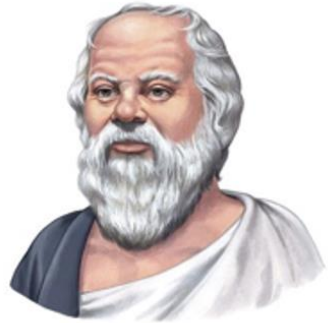
The EABSS Framework

- A structured approach



The EABSS Framework

- Using mini focus groups
  - Group sizes of **4-5 participants** (including moderator) work best
  - Estimated time to get through the whole process: **8h** (but there is a shorter version of **2h**)
  - Socrates vs Confucius
    - Collaborative brainstorming
    - Information capturing
    - Debates only when needed
  - Moderators
    - Will guide
    - Will act as stakeholder (modeller)
  - Iterative process
    - Reuse of information
    - Important to go forward and backwards



Focus Groups

- A focus group is …
  - A **small group** getting together for a **carefully planned discussion** in order to obtain perceptions of a defined area of interest in a permissive and **non-threatening environment**, organised either by specific stakeholder type or as mix of relevant stakeholder types, **conducted by a trained interviewer** (moderator; facilitator) to **collect qualitative data** that allow to **determine feelings, perceptions and manner of thinking** of participants regarding products, services, and programs or opportunities, and to **promote self-disclosure** among participants

- A focus group is not …
  - A debate; group therapy; a conflict resolution session; a problem solving session; an opportunity to collaborate; a promotional opportunity; an educational session

Focus Groups

- Moderator's role
  - Stays relaxed and sets tone; introduces and guides the discussion; actively and carefully listens; does NOT participate, or share views, or engage in the discussion; does NOT editorialise comments; promotes everyone's participation; is non-judgmental and respectful

- Limitations
  - Risk of biases introduced by the moderator(s)
  - Domineering and/or passive participants
  - Usually does not provide depth of information compared to other methods, such as key informant interviews

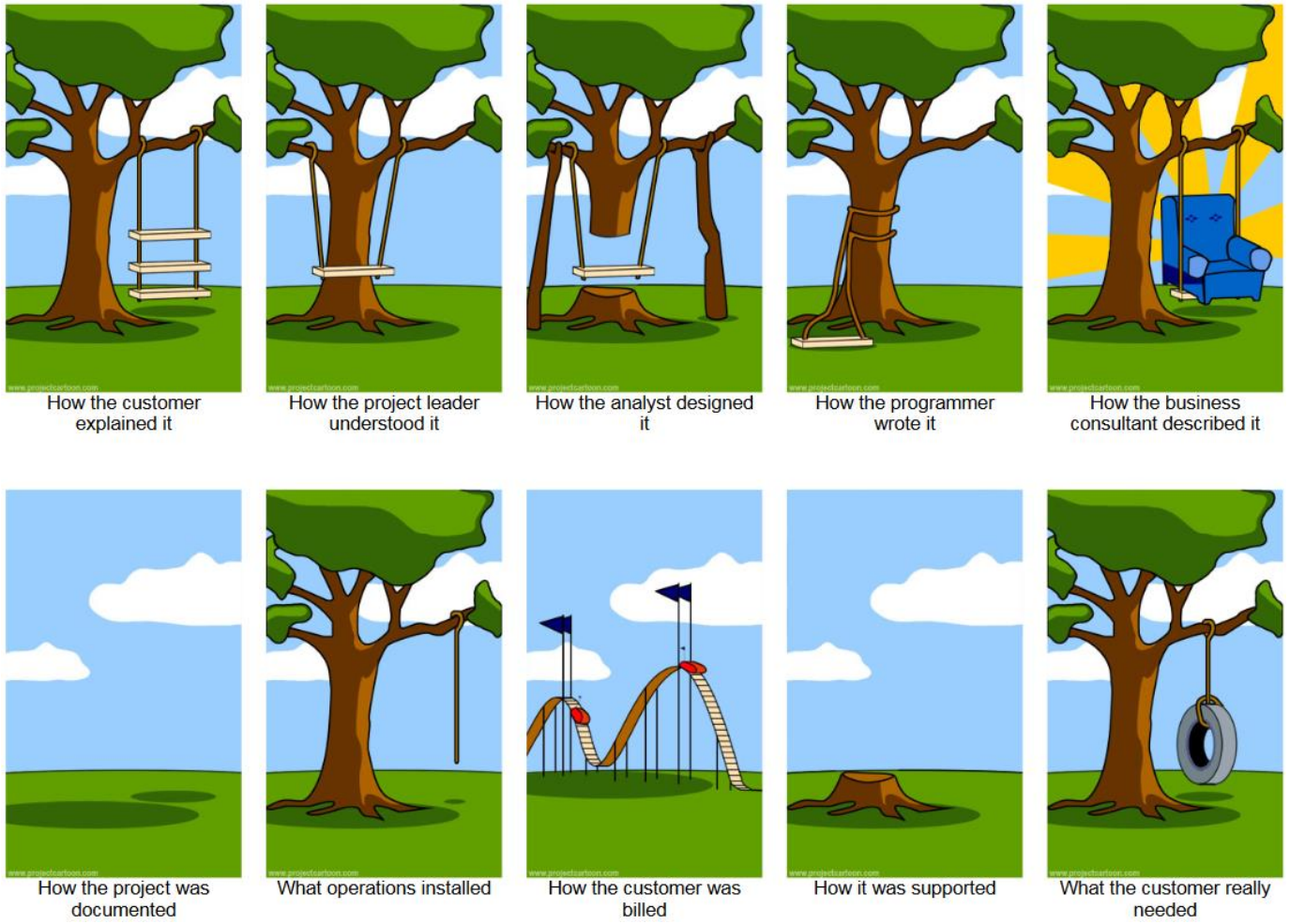
Focus Groups

- Types of questions
  - Engagement questions
    - Introduce participants to and make them comfortable with the topic of discussion
  - Exploration questions
    - Get to the meat of the discussion
  - Exit questions
    - Check to see if anything was missed in the discussion

https://www.youtube.com/watch?v=Auf9pkuCc8k

UML

- Different views

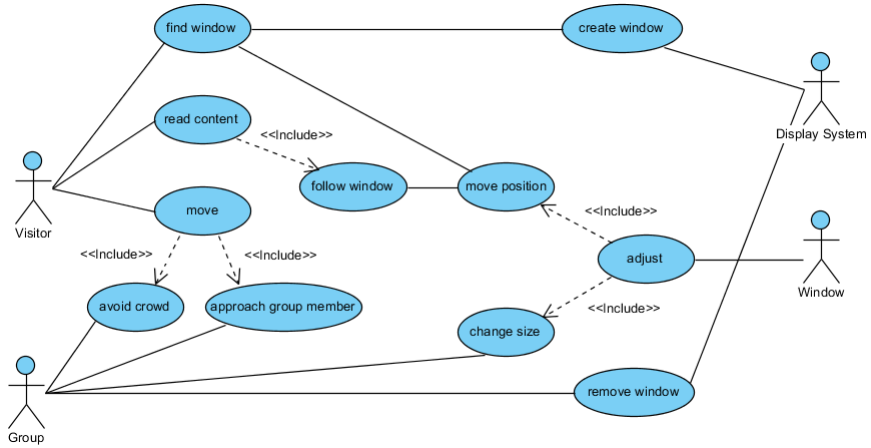


UML

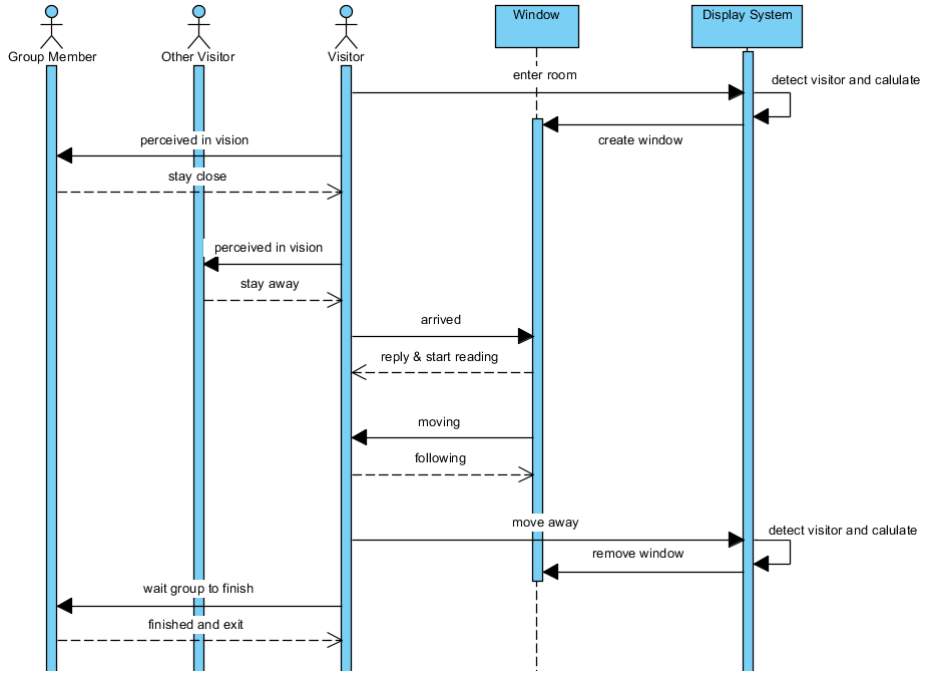
- Advantages of using UML
  - Enhances communication and ensures the right communication
  - Captures the logical software architecture independent of the implementation language
  - Helps to manage the complexity
  - Enables reuse of design

UML

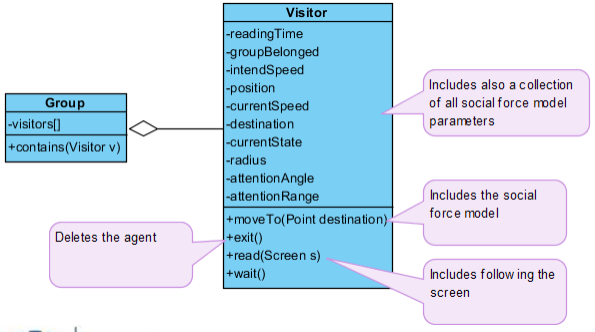
Use case diagram



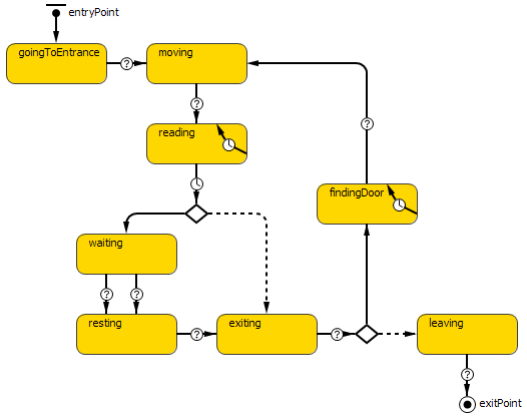
Sequence diagram



Class diagram



State chart



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Available Guidance (Siebers 2019a)

Engineering Agent-Based Social Simulations

User Guide v2023-02-21

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Brief Summary

What is it all about? What are successful model development strategies for complex social systems modeling? How does modelling work in large, collaborative, and multi-disciplinary projects in academia, non-governmental and governmental organisations, and industry? How do we derive new and general insights from modelling complex social systems? Anecdotal evidence suggests that the community of agent-based modellers partially suffers from a lack of structured and standardised ways for model development. In order to close this gap, we have created a model development framework, namely the Engineering Agent Based Social Simulation framework (or EABSS for short) which supports model development and model documentation in a structured way. Figure 1 shows a high level overview of the latest version of the framework. Full details together with an illustrative example can be found in Siebers and Klügl (2017) and some guidance on how to use the framework can be found in Appendix A.

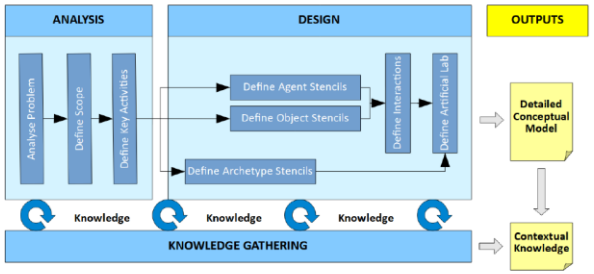

Figure 1: High level overview of the EABSS

How does it work? The EABSS is grounded in the concept of co-creation (Mitleton-Kelly 2003) and ideas from Software Engineering (Sommerville 2015). In addition it draws on elements of Kankainen's focus group approach to service design (Kankainen et al 2012). The framework implicitly provides ground rules, which is something commonly done when working with children but often forgotten when working with grownups. These grounded rules are in line with De Bono's philosophy of parallel thinking (De Bono 1985), and state that people are going to listen to each other and that people respect each other's point of view. To capture information it uses predefined table templates, and UML (a graphical notation used in Software Engineering) as main forms of stimulating and documenting contributions from all participating stakeholders during problem analysis and model design. It is this combination of tools and methods that makes it approachable for everyone.

use it? The EABSS can be used for two different purposes: (1) for collaborative model (from scratch or to extend/validate existing models) and (2) to stimulate and formally ussions about philosophical questions of societal issues that need to be addressed. We the framework in several domains, including Architecture, Geography, Organisational bers et al 2020), and Digital Mental Healthcare (Vallejos et al 2019; Siebert et al 2020; iebers 2020). It is designed with the aim to look at a complex system in more detail with step. There is always information from previous steps that can be used to get started t step. This principle serves validation, as getting stuck in the current step is a good t something in previous steps is not quite right and needs to be amended.

get out of it? The outcome of an EABSS session is a structured record of the key points of up discussions, in a format that is easy to understand by all stakeholders, and easy to a little effort this can often be translated into an agent-based social simulation model, en be used by the stakeholders as a "what-if" analysis tool.

xperience so far? Interestingly we found that each of the academics involved in running ups finds EABSS supportive in a different way, perhaps embedded within the research d in their domain. So the concept itself can be seen as interdisciplinary, while it was y intended to support social simulation model development. It has now been used for opment, reverse engineering of existing models for validity checking, discussions to ng models and confirm their validity, debates to analyse research topics and work on directions for research.

e going from here? More recently I got interested in the philosophical debates of Richard a German Philosopher who debates about "the digital revolution of society". I would like ABSS to test some of his future visions and to see if we can visualise his worlds with the . I would like to approach this in a more systematic way - i.e. to build a kind of toolbox s to build this new genre of models easier. In the end we could have a collection of at allow the community to put together models for tackling philosophical questions - rm of a toolbox as an extension to existing simulation packages.

ences

O and Siebers PO (2020) 'Opportunities for Using Agent-Based Social Simulation and Fuzzy ic to Improve the Understanding of Digital Mental Healthcare Scenarios'. In: Proceedings of 10th OR Society Simulation Workshop (SW20), 30 Mar-1 Apr, Loughborough, UK.

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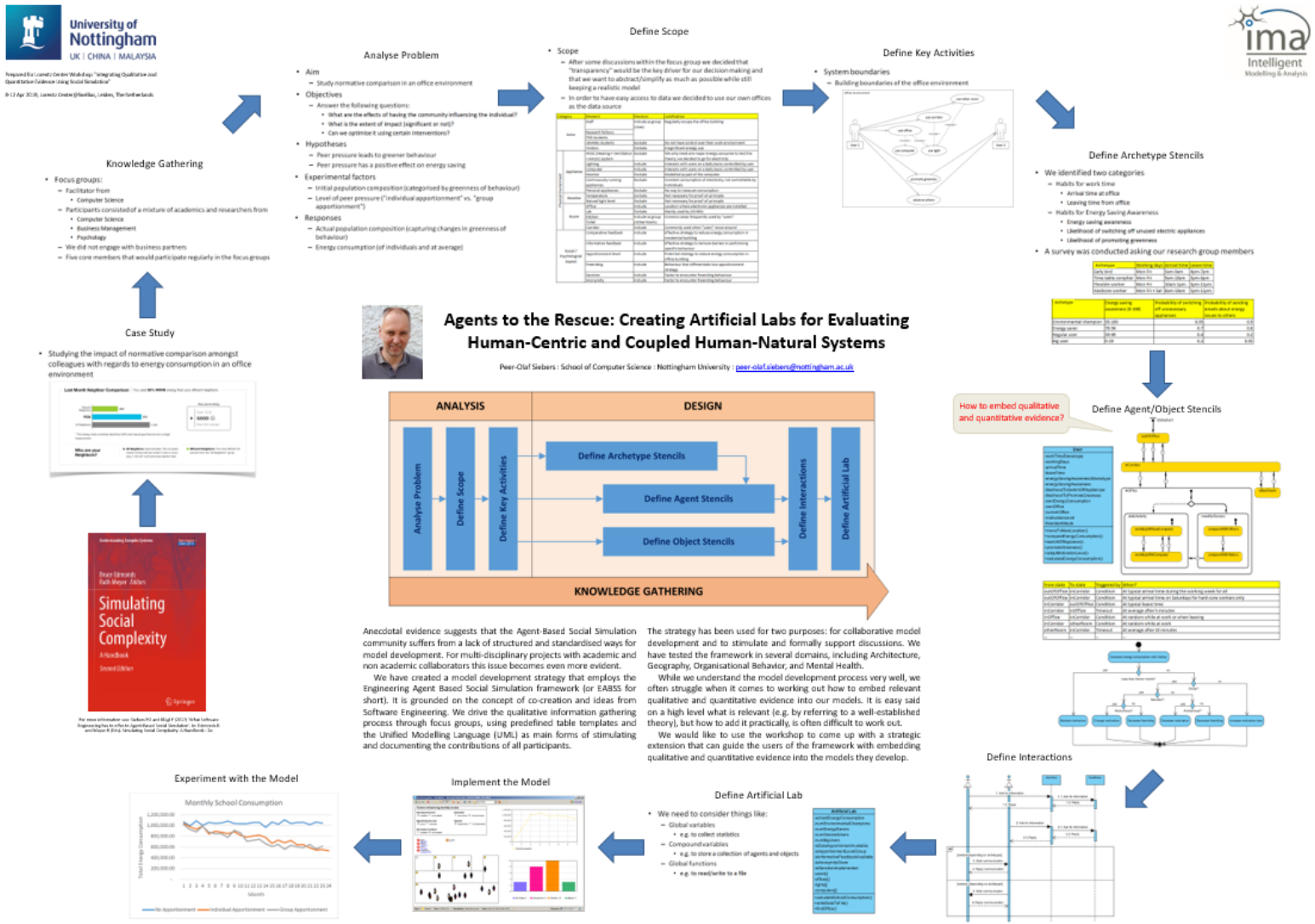
ABSS Guidance

remarks are meant to guide the focus group moderator regarding the re-use of le remarks list the tools to be used in that particular step

also clarify terminology and come up with a common pool of term definitions)
"Purpose" of the model
st of "Hypotheses" to be tested
ist of "Experimental Factors" to allow creating scenarios relevant to testing those es (look at objectives/hypotheses to work these out)
st of "Responses" to accept/reject hypotheses (look at objectives/hypotheses to work these out)
or nouns in previous text to find elements)
level of abstraction
es (key actors - represented by the role they play, and key objects) and concepts n also represent social/economic units, as for example families or firms)
these should be included/excluded in the model and justify your decision
efined table (headers: Category; Sub-Category; Element; Decision; Justification (while e provided, sub-categories are flexible and depend on the context); categories: Actor; Physical ent; Social and Psychological Aspects; Other)
es (actors come from scope table; use cases come from hypotheses and by creating user stories)
actors to relevant activities (use cases)
use case diagram
Stencils (these allow to define behaviour of actors)
with categorisation schemata for relevant key actors (agents) that will allow to a simulated population into behaviourally different groups
template(s) and/or demographics and/or utility function(s)
nt/Object) Stencils (attributes can be derived from archetype criteria, theory parameters, methods can be the related state charts) (states can often be derived from use cases)
mplates by defining key states an entity can be in, how these are linked, and what ansitions (note that this might not be required for all entities)
les that ought to be tracked at the micro/meso level in order to gain insight about identified during the problem analysis
state machine diagram(s); transition table(s); class definition(s)/diagram(s)
s (all elements defined in the agent/object stencil step need to be listed on the horizontal axis) (use cases could be)
quences of interactions that can take place between agents and between agents and specific use case realisations
sequence diagram(s)
b (attributes provide storage for all agents/objects and initialisation parameters required for experimental factors; oses)
es that need to be created; listing variables that ought to be tracked at the macro der to gain insight about the issues identified during the problem analysis
der of execution (if relevant)
class definition(s)/diagram(s) and sequence diagram(s)

Available Guidance (Siebers 2019b)



OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Practice

Joint Activity: Co-Creating a Conceptual AB Model (60 min)

Small printed orange remarks in the following are meant to guide the moderator

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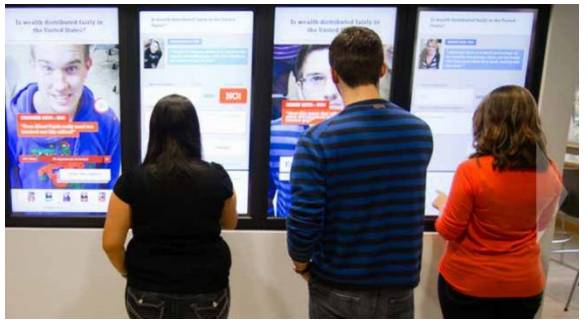
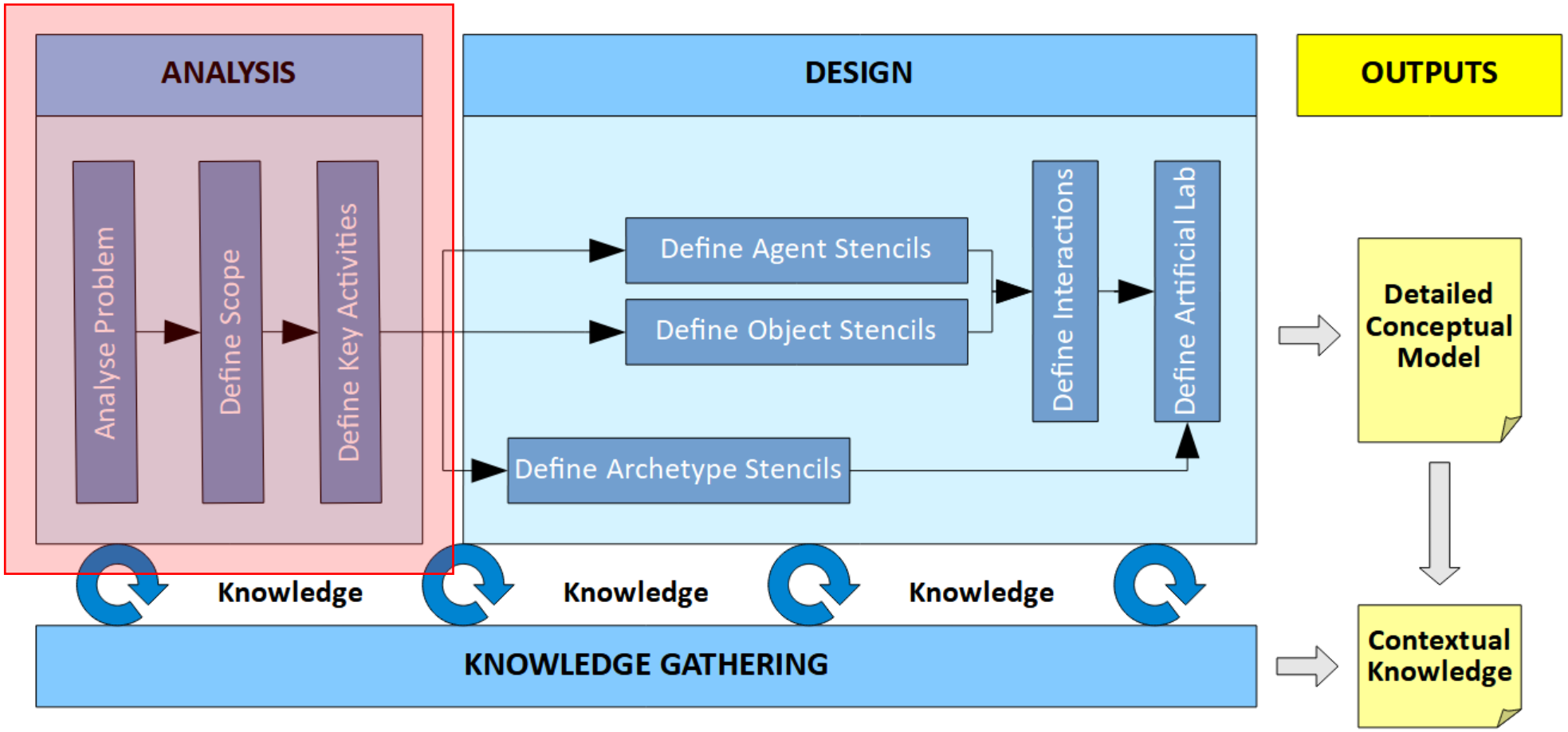
Example: Exploring Adaptive Architecture Design [Siebers et al 2018]

- Context
  - The purpose of the study is to explore Adaptive Architecture design in the context of a **novel museum visit experience**, in particular the idea of having a large screen with a set of **intelligently adaptive moving content windows** that adapt position and size in response to movement and grouping of people in front of them.
- Aim (of the simulation study)
  - Study the impact of an adaptive screen (including several display windows) in a museum exhibition room



Engineering ABSS



Example: Analyse Problem

- Objectives
  - Study the interaction of "artificial intelligent" windows and visitors' movement
  - Use the model to demonstrate to architects the idea of adaptive screens (artificial intelligent windows)

- Hypotheses
  - A larger window size has a positive effect on visitor engagement
  - Space availability has a positive effect on visitor engagement
  - Screens with artificial intelligent windows attract viewers for longer

Example: Analyse Problem

- Experimental factors (look at objectives/hypotheses to work these out)
  - Visitor arrival rate {derived from hypothesis; relates to space availability}
  - Initial number of windows {derived from hypothesis; relates to space availability}
  - Window size {derived from hypothesis}
  - A subset of parameters of the underlying theoretical movement model (Note: This was added later)

- Responses (look at objectives/hypotheses to work these out)
  - Number of groups of visitors (visitor clusters) {derived from objective; relates to demonstrating to architects}
  - Average time of visitors spend in the museum {derived from hypothesis; measures visitor engagement + attraction}
  - Visual representation of the system and its dynamics {derived from objective; relates to demonstrating to architects}

Case Study

- Title (usually given)
  - Exploring Future Scenarios of Health Service Provision

- Context (usually given)
  - We want to discuss ideas about the evolution towards a mixed human/robot society in an operational and service-oriented context, focusing on health service provision. We want to uncover what it means to have a future where health services will be provided by doctors (GPs and Hospital) and nurses and (or in collaboration with) proactive machines. What is the impact of technology on the mental state and the opinion of staff/patients?

Case Study: Analyse Problem

Let's define aim, objectives, hypotheses, experimental factors and responses

For experimental factors and responses: Look at objectives/hypotheses to work these out

Example: Define Scope

- Scope: What and Why? (what do we need to represent to fulfil the aim; look for nouns in previous text)

Category		Element	ID	Decision	Justification
Actor	Human	Visitor	A01	Include	Main research subject
		Group	A02	Include	Important for capturing group behaviour
		Staff	A03	Exclude	Have no impact on the dynamics
	Intelligent Object	Window	A04	Include	Intelligent display unit that can make proactive decisions
		Display system	A05	Include	Controls the life cycle of each window
Physical Environment	Service	Projector	PE01	Exclude	Considered by the windows
		Screen	PE02	Include	Home of the windows
	Structure	Wall	PE03	Include	Required for motion algorithm of visitors
		Door	PE04	Include	Required for motion algorithm of visitors
		Lighting	PE05	Exclude	Not necessary for testing hypotheses
		Furniture	PE06	Exclude	Not necessary for testing hypotheses
	Weather	Temperature	PE07	Exclude	Not necessary for testing hypotheses
		Natural light	PE08	Exclude	Indoor environment
	Building	Exhibition room	PE09	Include	Location where visitors move around
		Corridor	PE10	Exclude	Not necessary for testing hypotheses
		Toilet	PE11	Exclude	Not necessary for testing hypotheses
Category		Aspect/Phenomena	ID	Decision	Justification
Social and Psychological Aspects / Phenomena	Visitor behaviour	Movement	SPAP01	Include	Required to trigger the window AI
		Vision area	SPAP02	Include	Will affect visitor movement behaviour
	Window behaviour	Movement	SPAP03	Include	Part of the AI to be tested
		Vision area	SPAP04	Include	Defines area that visitors are able to read clearly
Category		Detail to be modelled	ID	Decision	Justification
Other		N/A	O01	N/A	N/A

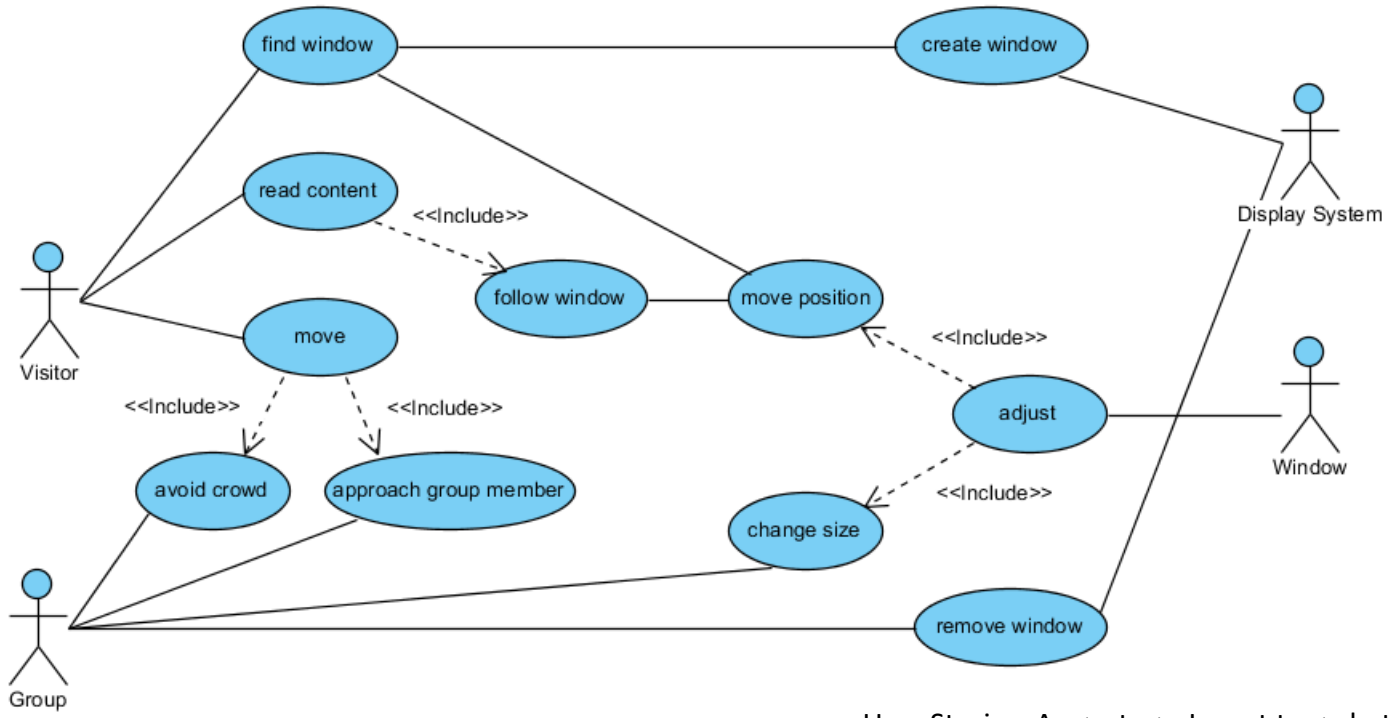
Case Study: Define Scope

Let's define the scope for our case study

What do we need to represent to fulfil the aim? Look for nouns in previous text

Example: Define Key Activities

- Key activities (actors come from scope table; use cases come from objectives/hypotheses and by creating user stories)



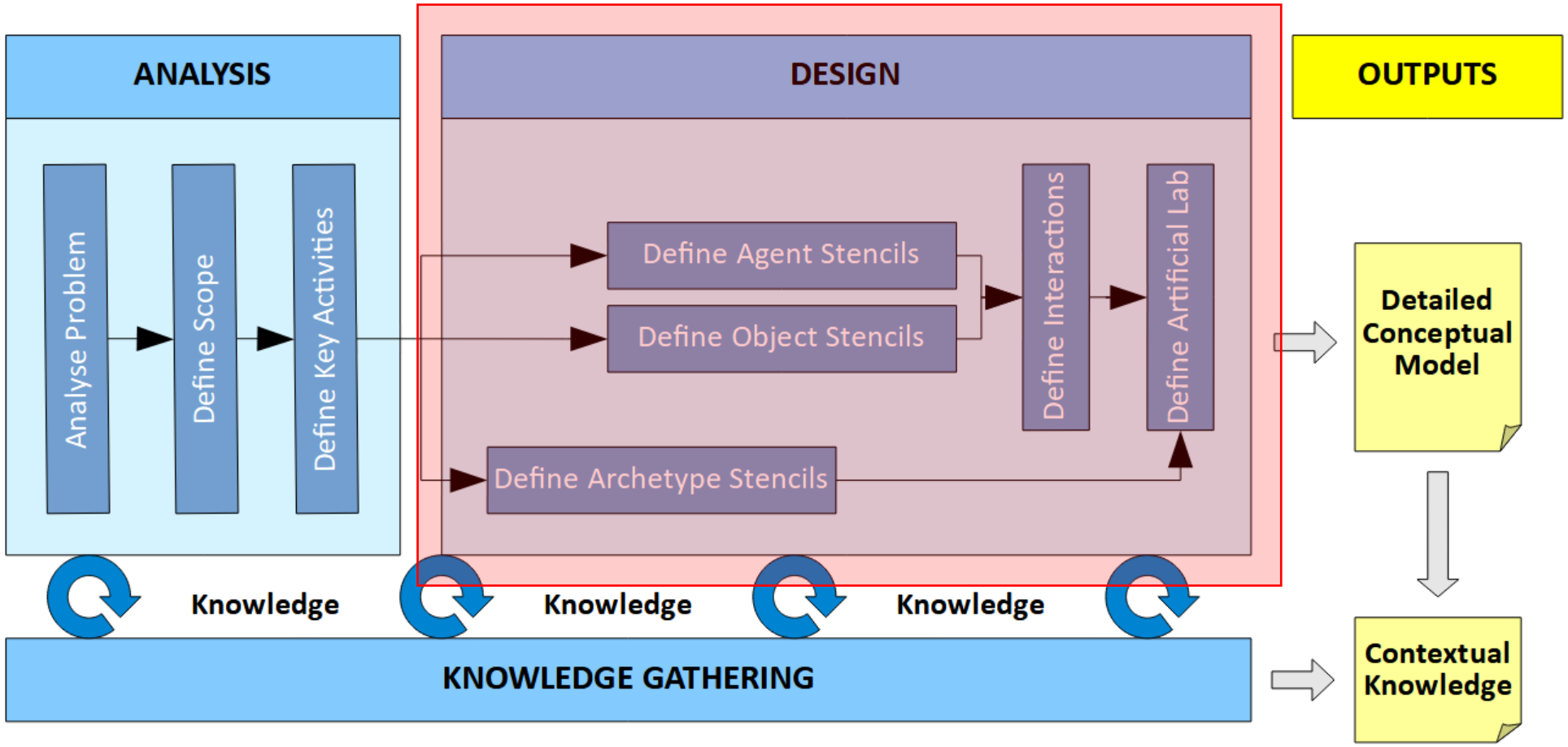
User Stories: As <actor>, I want to <what?> (so that <why?>)

Case Study: Define Key Activities

Let's define the key activities for our case study

Actors come from scope table; use cases come from objectives/hypotheses and by creating user stories

Engineering ABSS



Example: Define Archetype Stencils

- Categorisation schemata for key actors (these allow to define behaviour of actors; use habits/demographics for characterisation)

Stereotype	Reading time(second)
Not-interested	3-10
General-visitor	10-40
Researcher	40-90

Stereotype	Speed(meter per second)	Collision radius(meter)
Child	1.4-1.8	0.11-0.15
Adult	1.2-1.4	0.20-0.25

Note: The values are not really required at this stage, but you should capture them if they emerge from the discussion

Case Study: Define Archetypes Stencils

Let's define the archetype stencils for our case study

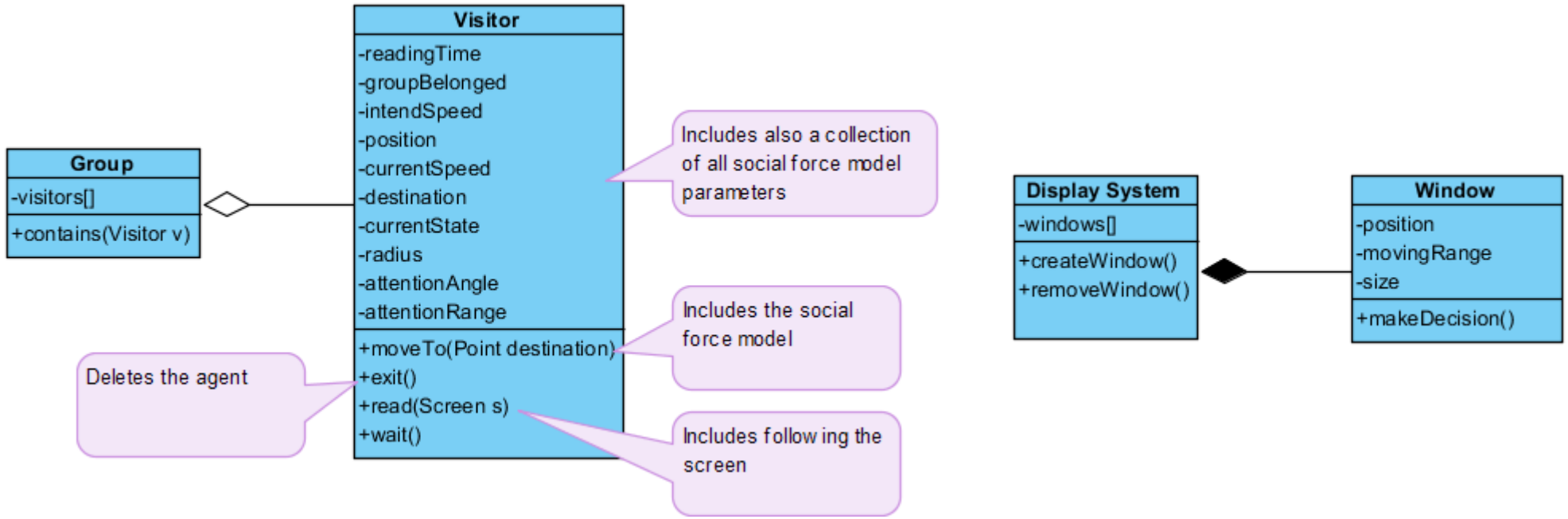
These allow to define behaviour of actors. Use habits/demographics for characterisation.

Example: Agent and Object Stencils

- The following are generated in parallel (or iteratively)
  - Classes for defining attributes and possible operations of individual/group agents/objects
  - State charts for defining possible states/transitions of agents/objects
  - Transition tables for detailing transitions in these state charts

Example: Agent and Object Stencils

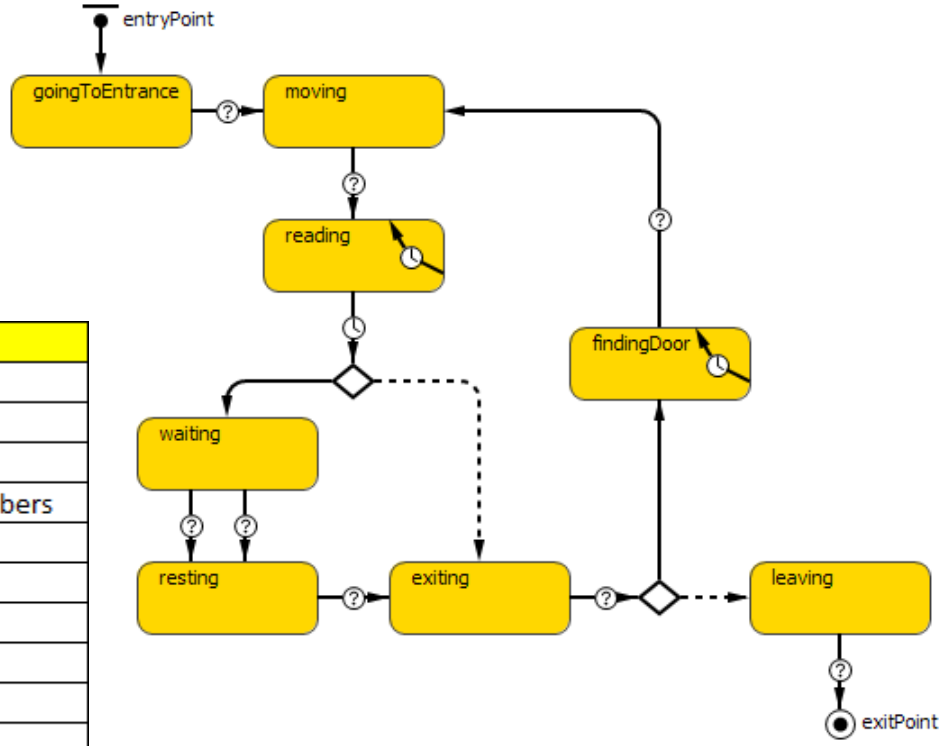
- Agent and object classes (attributes can be derived from archetype criteria and by looking at the scope table; operations can be derived from the states in the related state charts)



Note: Some of the attributes/operations will only be known once the implementation strategy is known (e.g. implementing "Movement" by using the Social Force Model)

Example: Agent and Object Stencils

- State chart of **visitor agent** (states can often be derived from use cases)



- Transition table of **visitor agent**

From state	To state	Triggered by	When?
goingToEntrance	moving	Condition	Agent arrived at destination
moving	reading	Condition	Agent arrived at destination
reading	reading	Timeout (Internal)	Agent follows the nearest window
reading	waiting	Timeout+Condition	After reading time elapsed and agent needs to wait for group members
waiting	resting	Condition	Agent arrived at destination
waiting	resting	Condition	Agent is close to destination and is part of a group
resting	exiting	Condition	All group members have finished reading
reading	exiting	Timeout+Condition	After reading time elapsed and agent is individual
exiting	findingDoor	Condition+Condition	There are other rooms available
findingDoor	findingDoor	Timeout (Internal)	Agent looks for nearest door
findingDoor	moving	Condition	Agent arrived at destination
exiting	leaving	Condition+Condition	This was the last room to go

Case Study: Define Agent and Object Stencils

Let's define the agent and object stencils for our case study

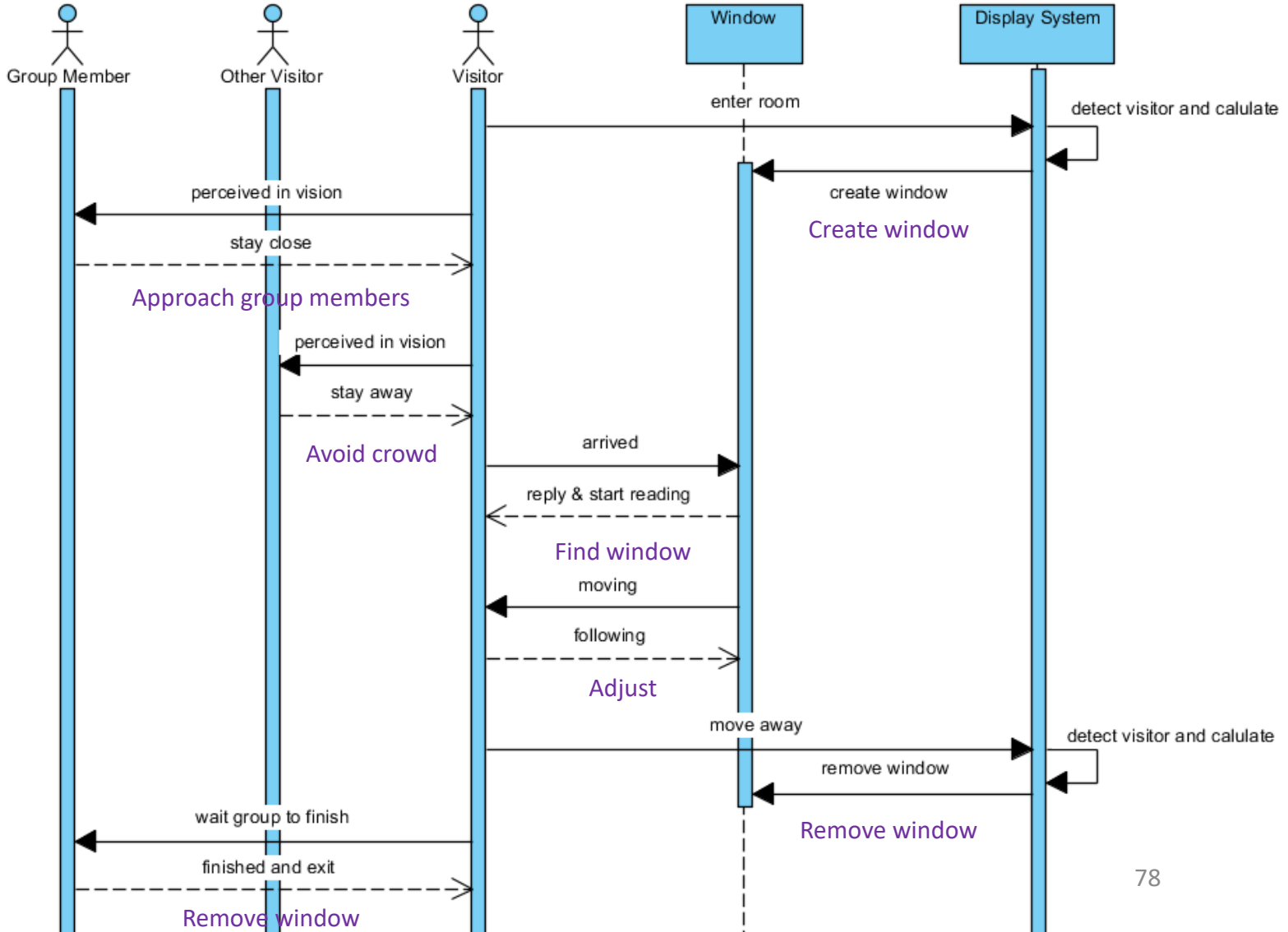
Agent and object classes: Attributes can be derived from archetype criteria and by looking at the scope table. Operations can be derived from looking at the states in the related state charts.

State charts: States can often be derived from use cases

Example: Define Interactions

- Interaction (all elements defined in the Agent and Object Stencils step need to be listed on the horizontal axis; use cases could be listed on the vertical axis; alternatively, a separate diagram could be created for each individual use case)

Note: We should also consider the "Other Visitor" actor earlier in the Scope Table and the Key Activities Diagram. Whenever we consider interaction rules between actors of the same type we require an additional actor group "Other actor" to be able to define the interactions.



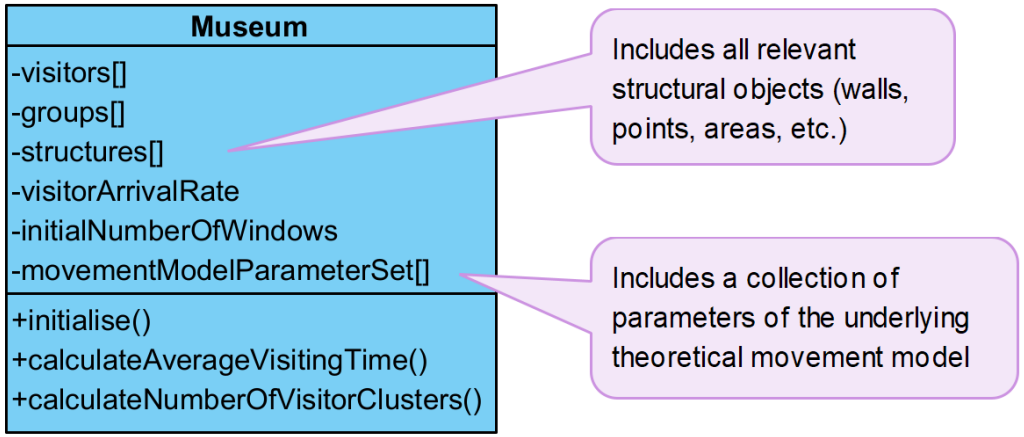
Case Study: Define Interactions

Let's define the interactions for our case study

All elements defined in the Agent and Object Stencils step need to be listed on the horizontal axis. Use cases could be listed on the vertical axis. Alternatively, a separate diagram could be created for each individual use case.

Example: Define Artificial Lab

- Artificial Lab (attributes provide storage for all agents/objects and initialisation parameters required for experimental factors; operations are related to responses)

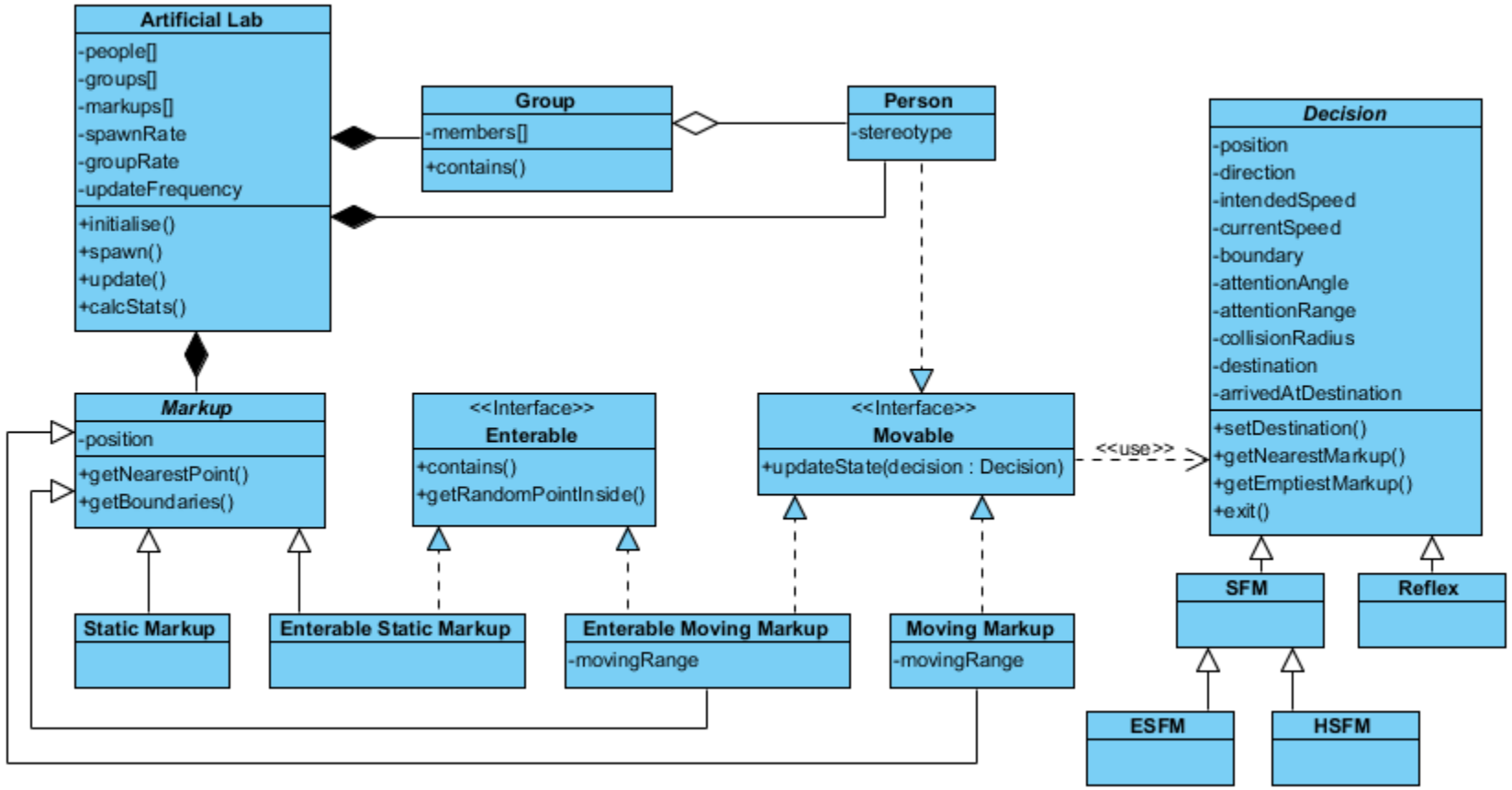


Case Study: Define Artificial Lab

Let's define the artificial lab for our case study

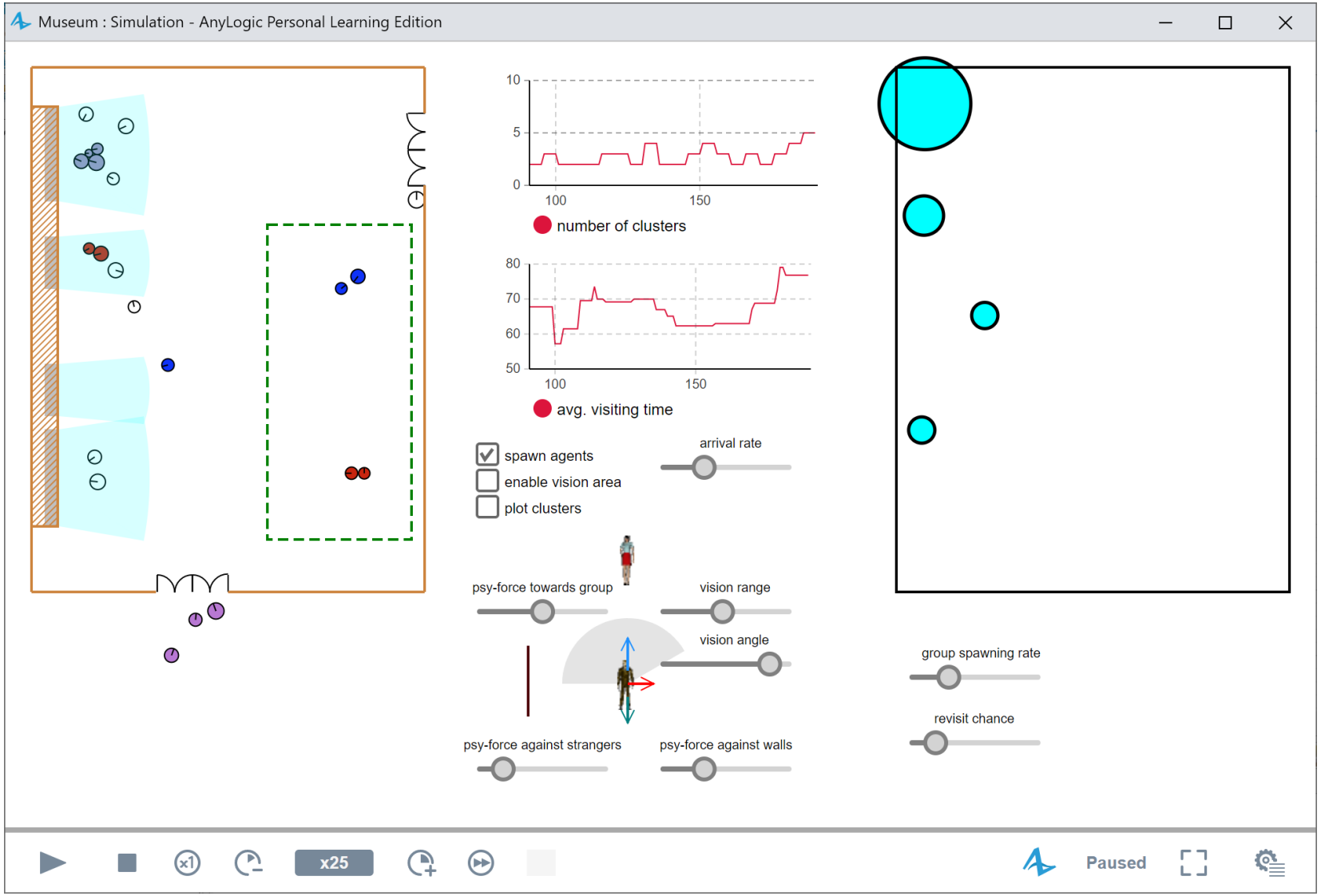
Attributes provide storage for all agents/objects and initialisation parameters required for experimental factors.
Operations are related to responses.

Example: The Implementation Strategy

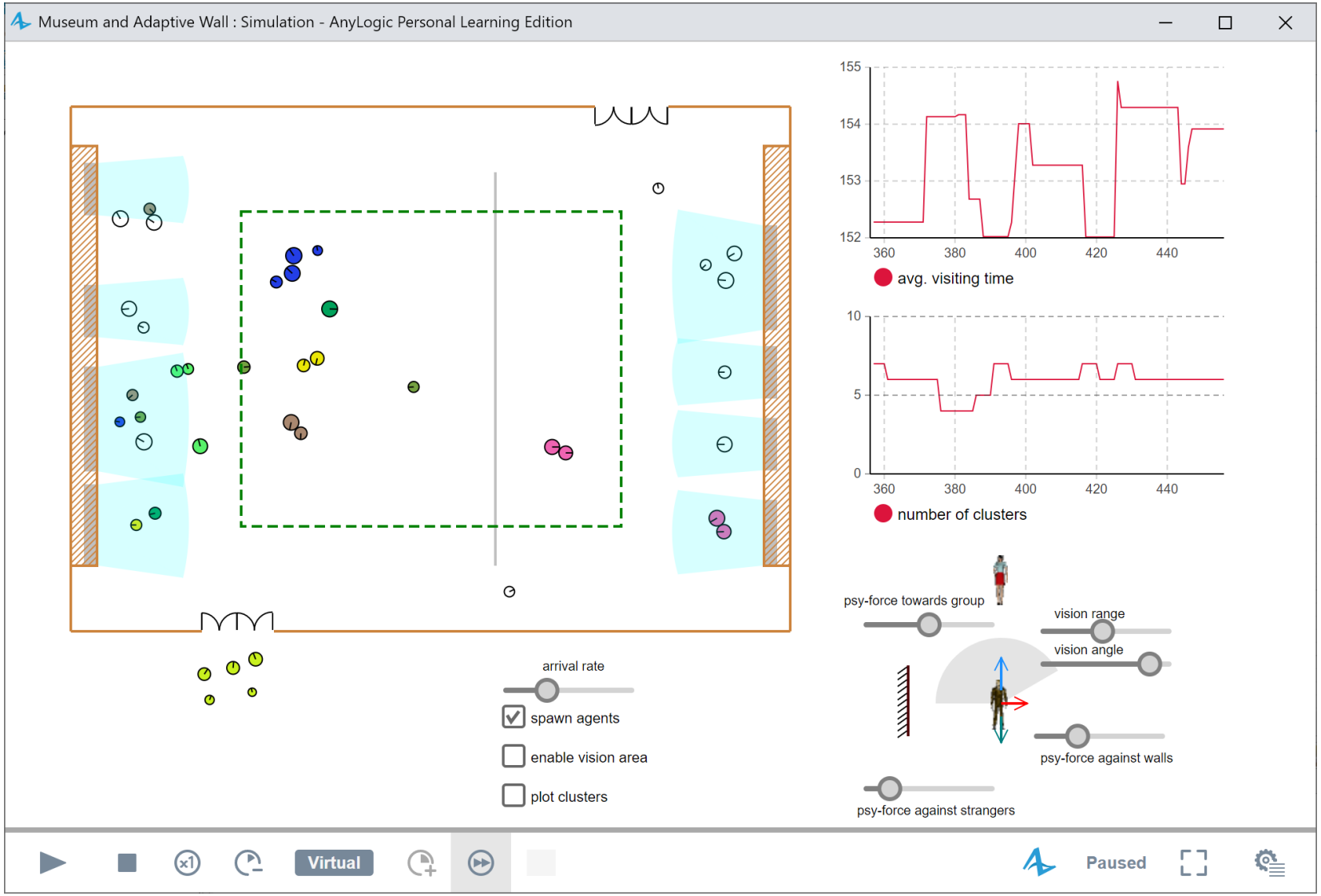


Siebers et al (2018)

Example: The Implemented Model



Example: Extended Version (Moving Wall)



Case Study: How Others Solved It

There were actually two very different outcomes. We will look at these later!

Service provision in the hospital of the future

Service provision in the GP practice of the future

OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Lecture

Introduction to AB Modelling in AnyLogic PLE (60 min)

The University of Nottingham

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AnyLogic

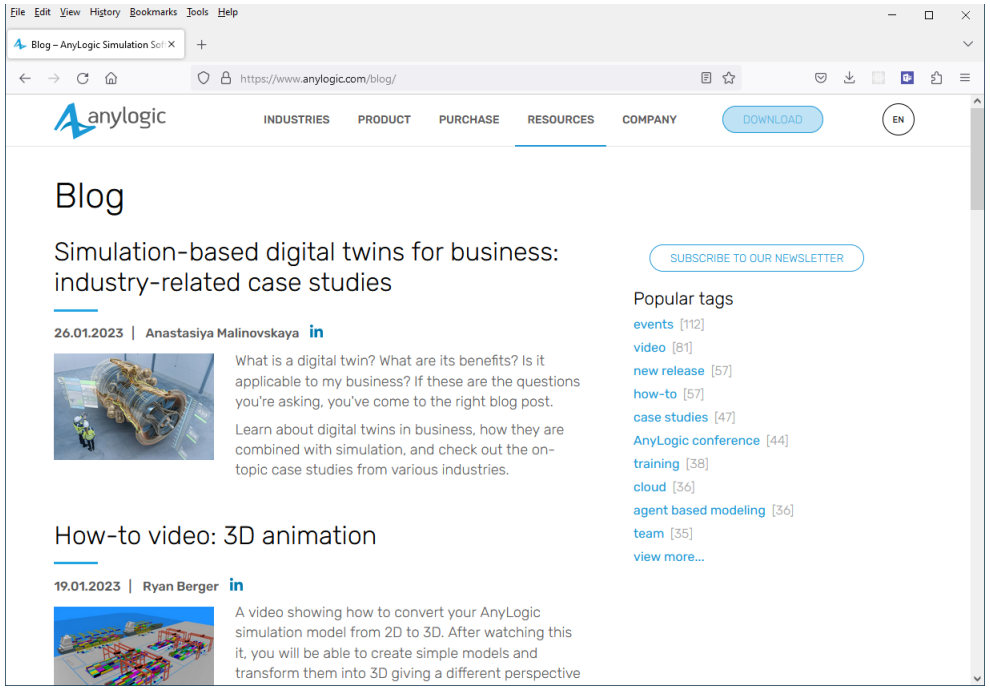
AnyLogic

- The latest version available for download is AnyLogic 8.8.1 PLE
  - Win: https://files.anylogic.com/anylogic-ple-8.8.1.x86_64.exe
  - Mac: https://files.anylogic.com/anylogic-ple-8.8.1.dmg
  - Linux: https://files.anylogic.com/anylogic-ple-8.8.1.linux.x86_64.tgz.bin

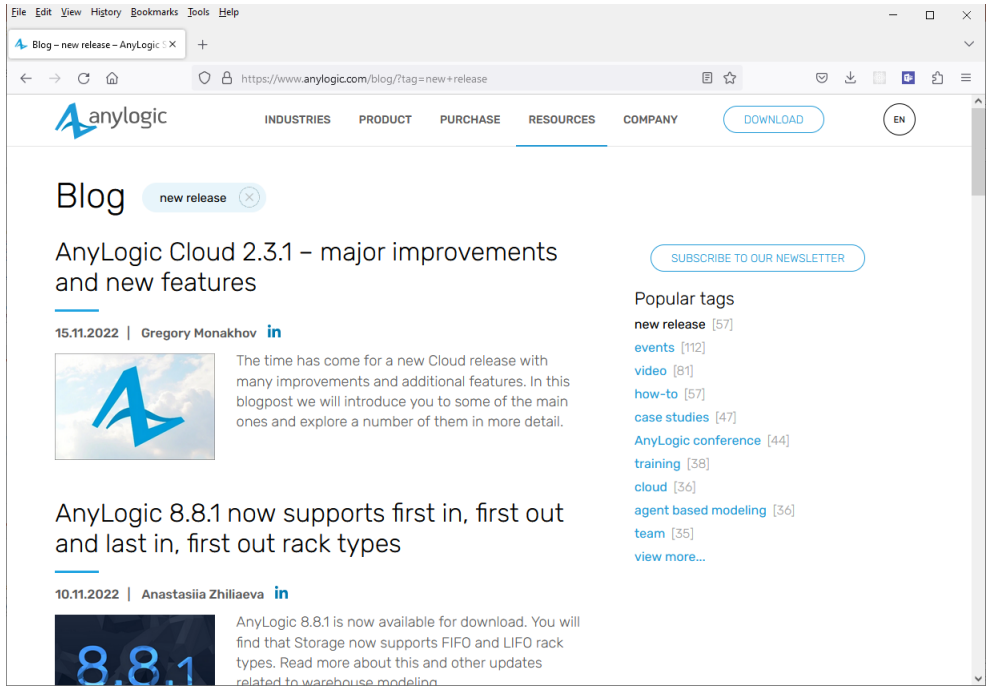
- In AnyLogic you are not writing the full code of Java classes from the beginning to the end; instead you are entering pieces of code and expressions in numerous small edit boxes in the properties of various model elements

AnyLogic

- AnyLogic Blog
  - https://www.anylogic.com/blog/

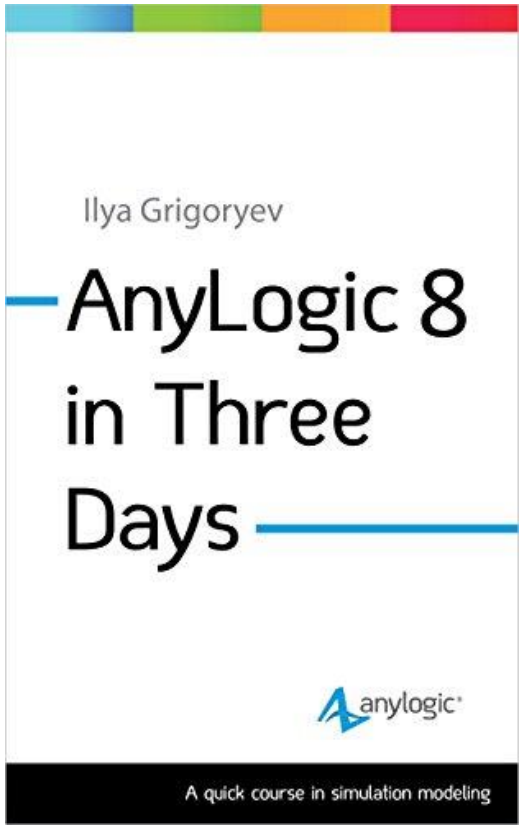


- AnyLogic Blog (new releases)
  - https://www.anylogic.com/blog/?tag=new+release



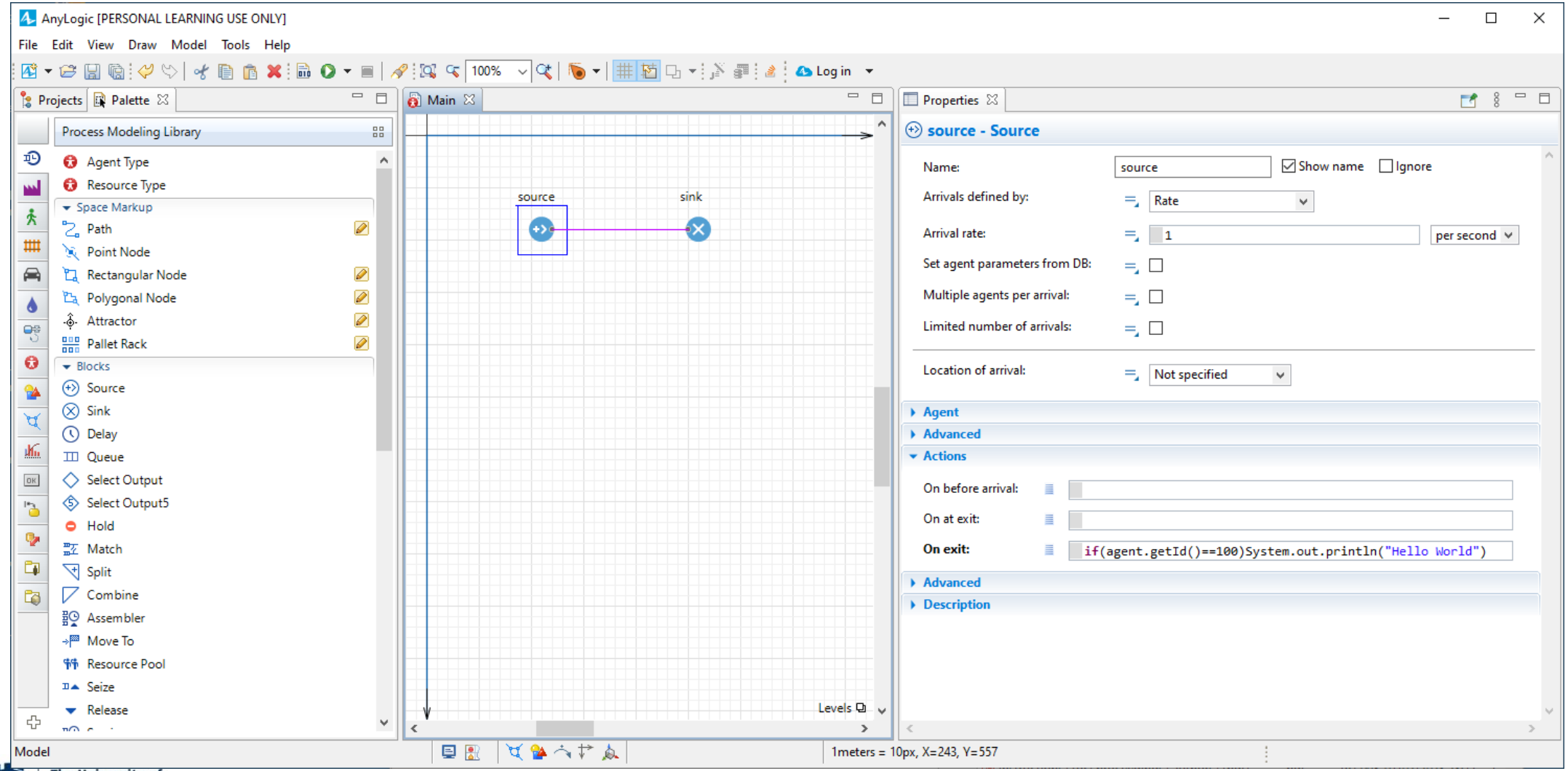
AnyLogic

- Free tutorial book

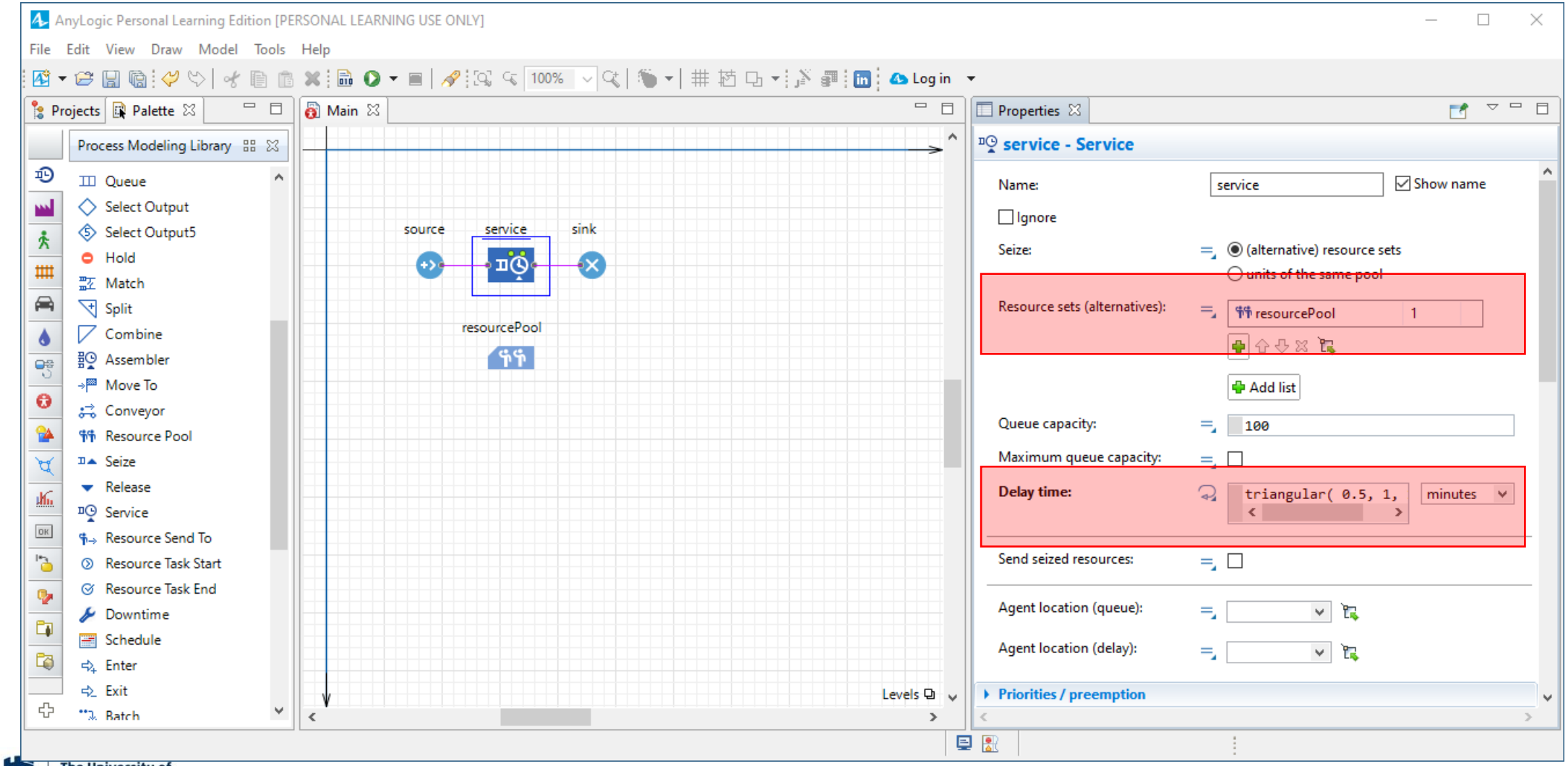


https://www.anylogic.com/upload/book.php?lang=English

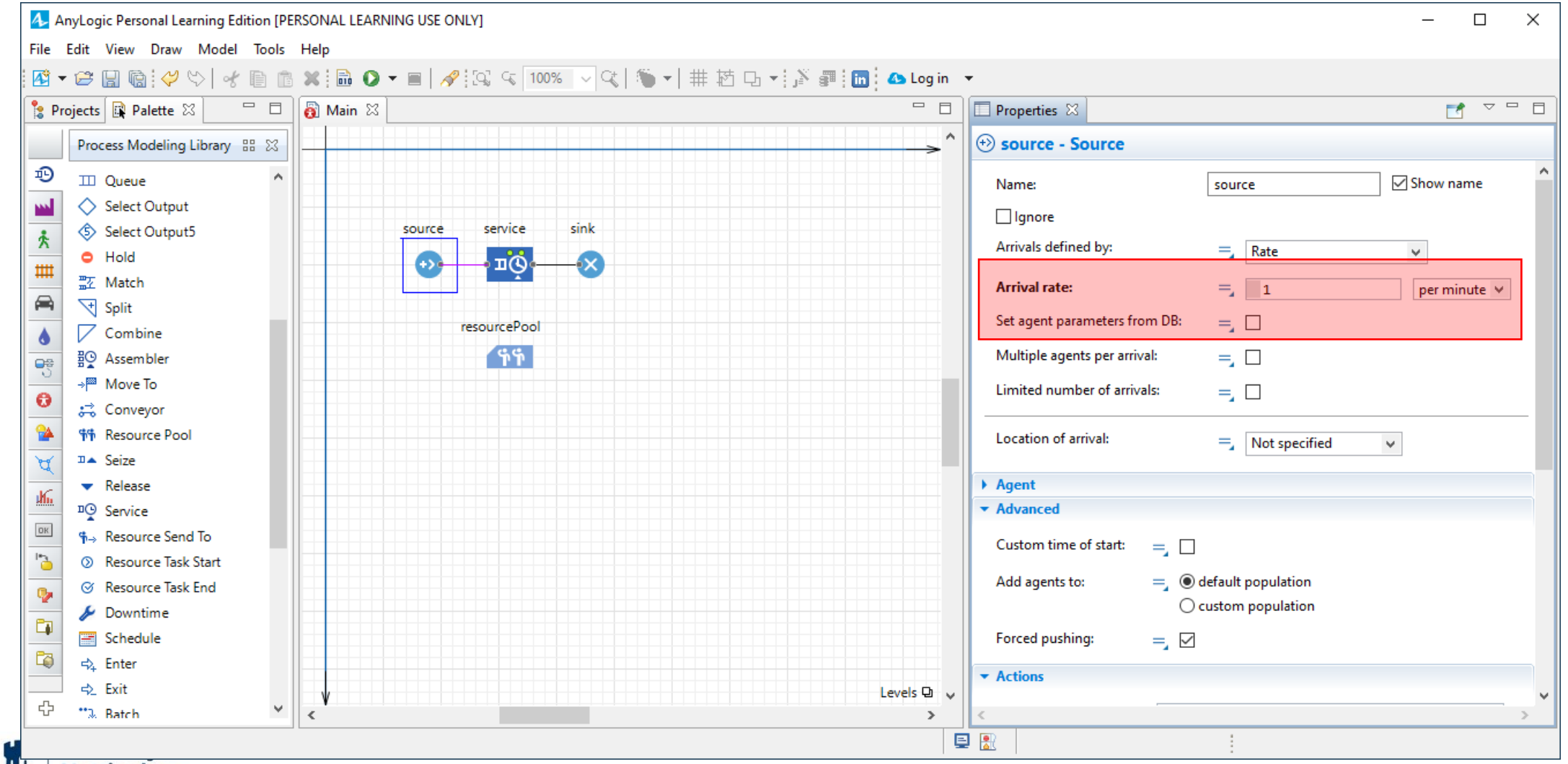
AnyLogic "Hello World!"



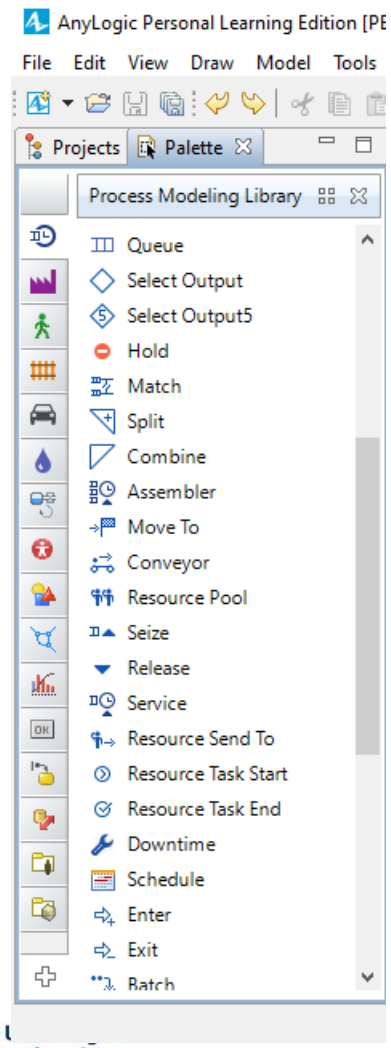
AnyLogic Process Modelling

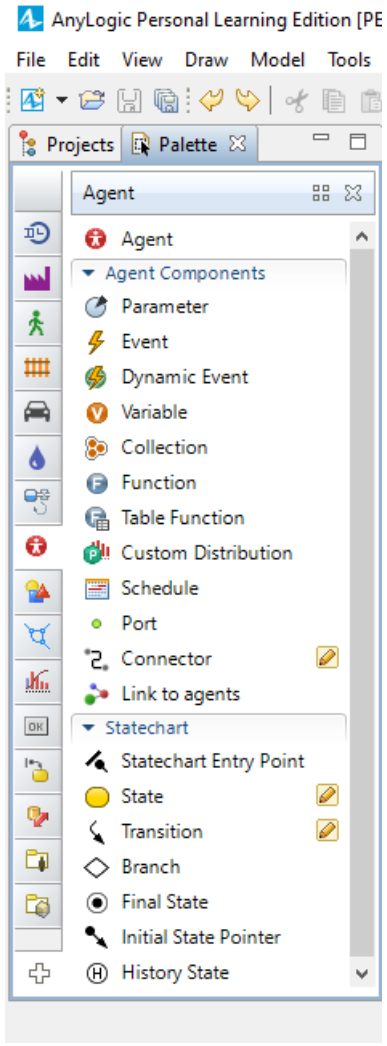


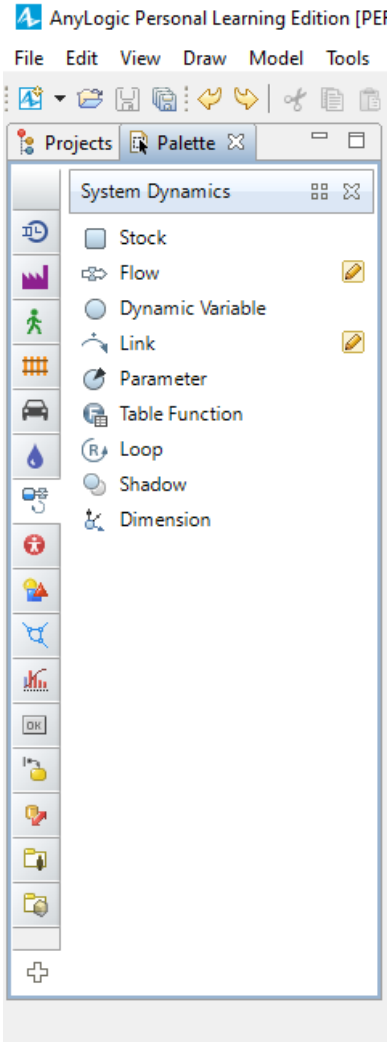
AnyLogic Process Modelling

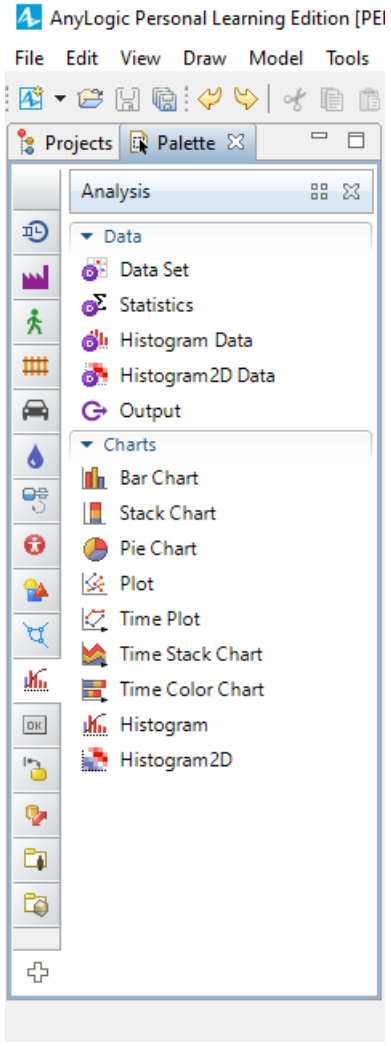


AnyLogic IDE



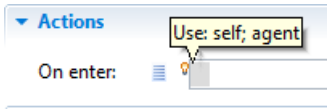


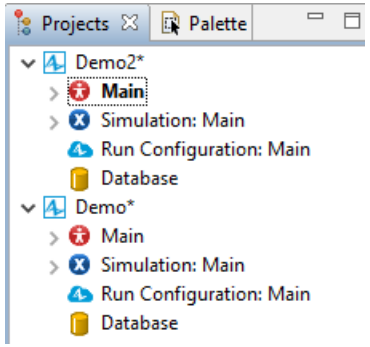




Things to Remember

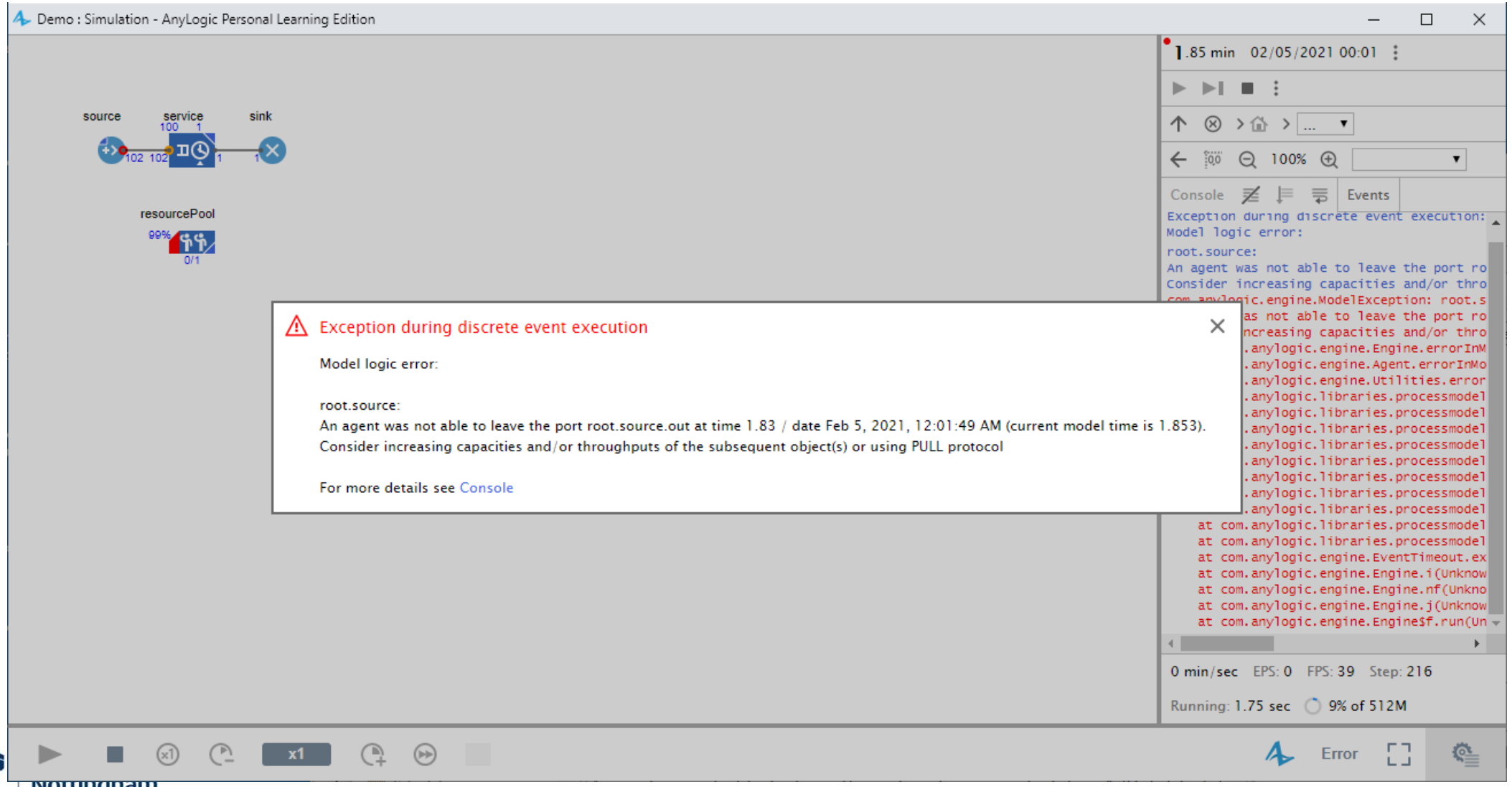
- Important things
  - F1: Help
  - Ctrl-Space: Code completion support
  - Ctrl-Enter: Perform refactoring (replace name occurrences)
  - Make sure you select the correct model when pressing "Run"
  - Make sure you set up model time units correctly in the "Model"
  - Use the "magic lightbulb" ...



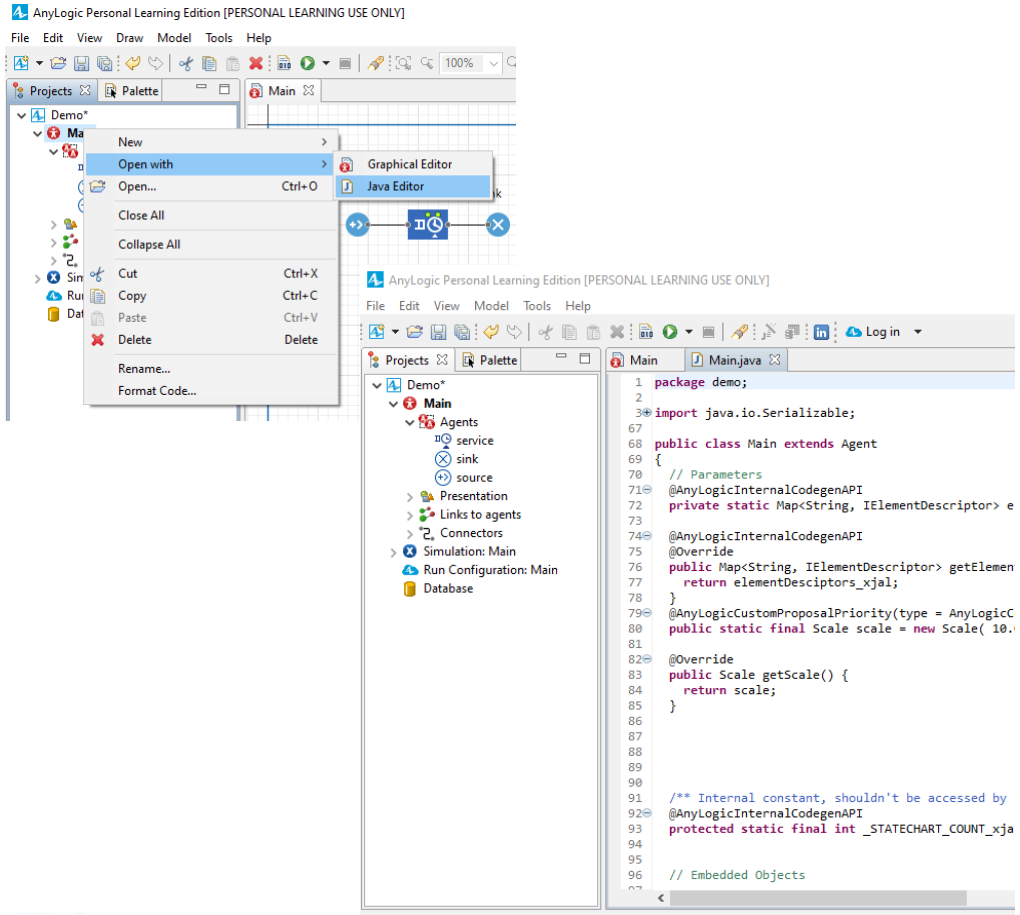


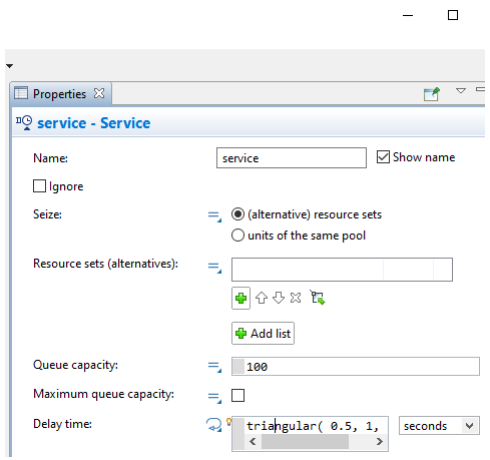
- Since AnyLogic v7
  - Everything is called "Agent" (entities; resources; agents; …)
  - PLE version limits number of agents per simulation run to 50000 (**but you can reuse them**)

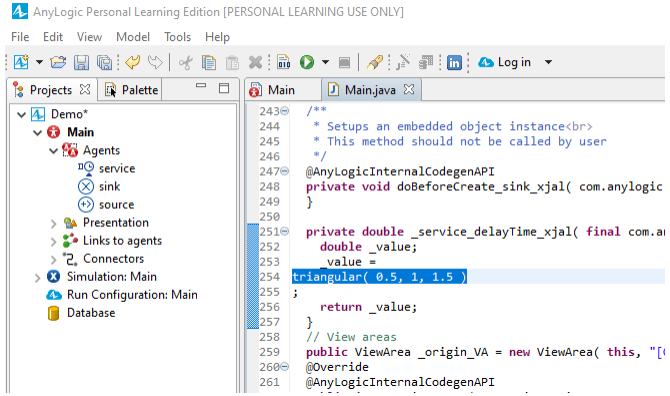
Running AnyLogic



AnyLogic IDE

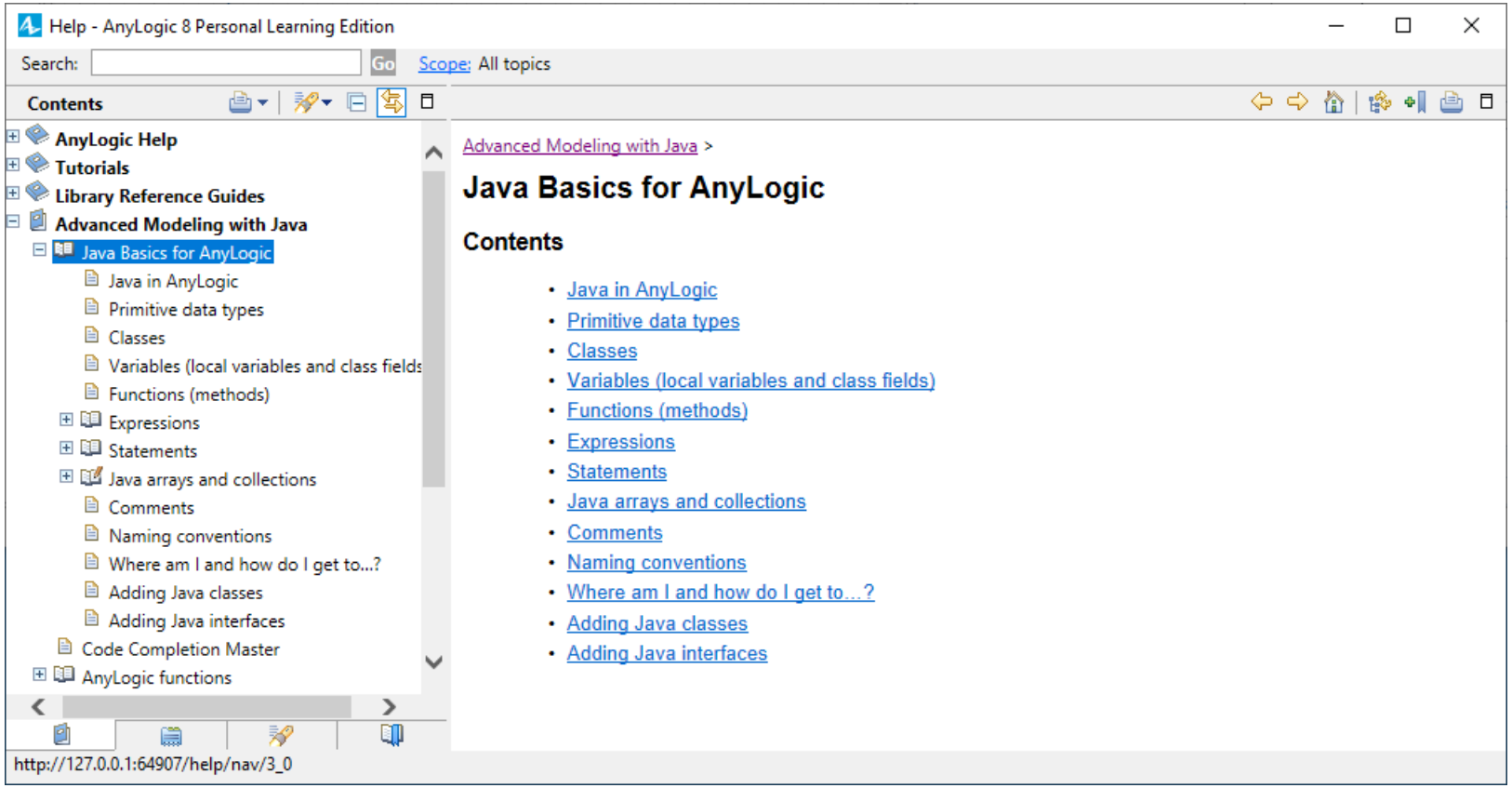




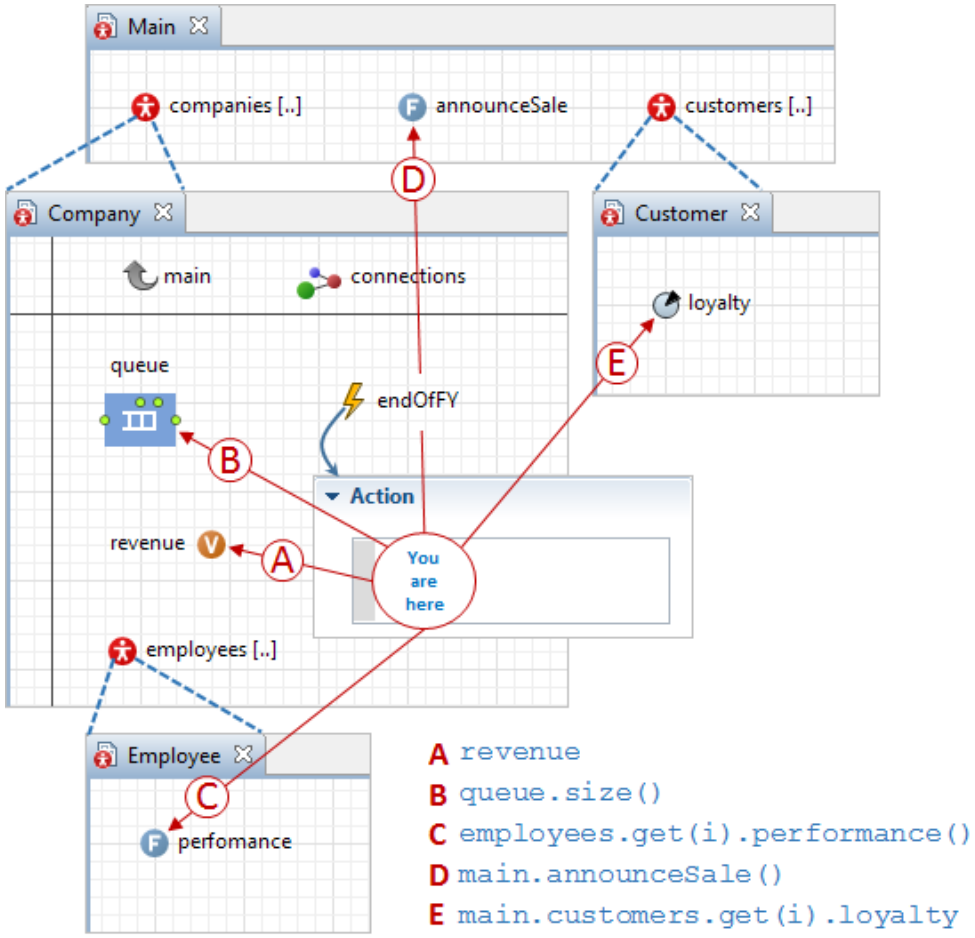


Press {Ctrl+J} to go to the point in the Java code that is associated with the current code snippet highlighted in the Properties window

AnyLogic Help

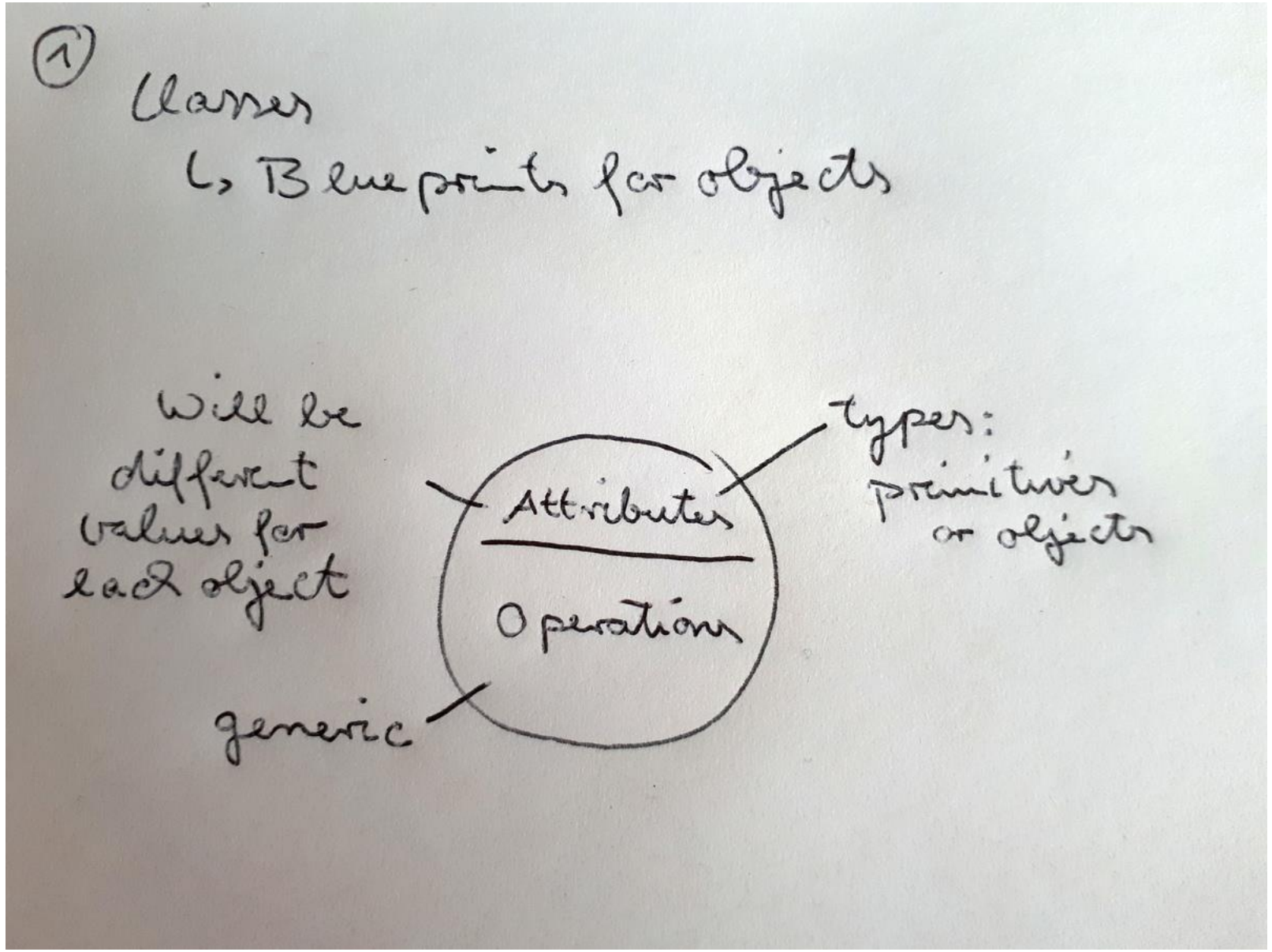


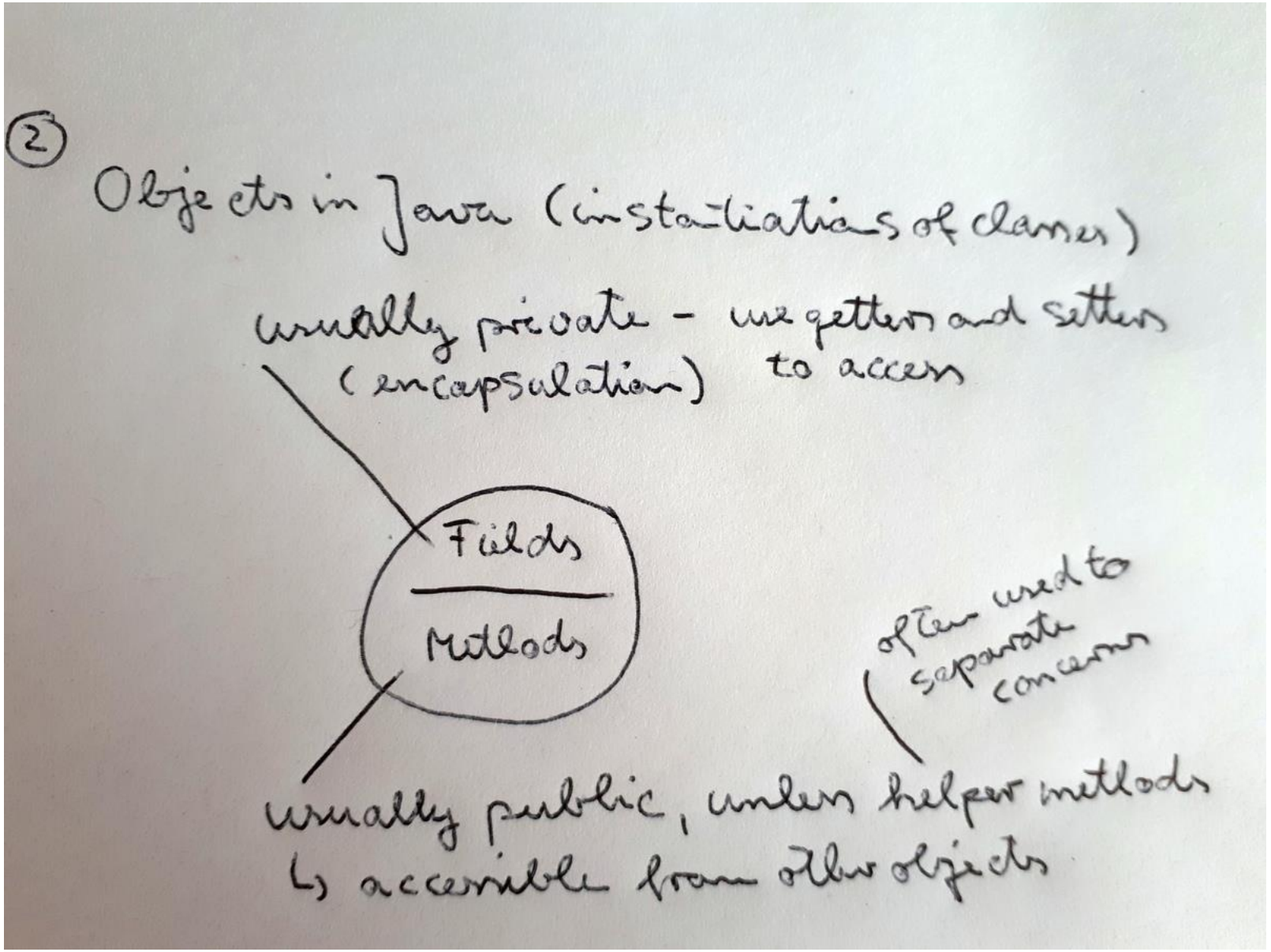
Where am I and how do I get to…?

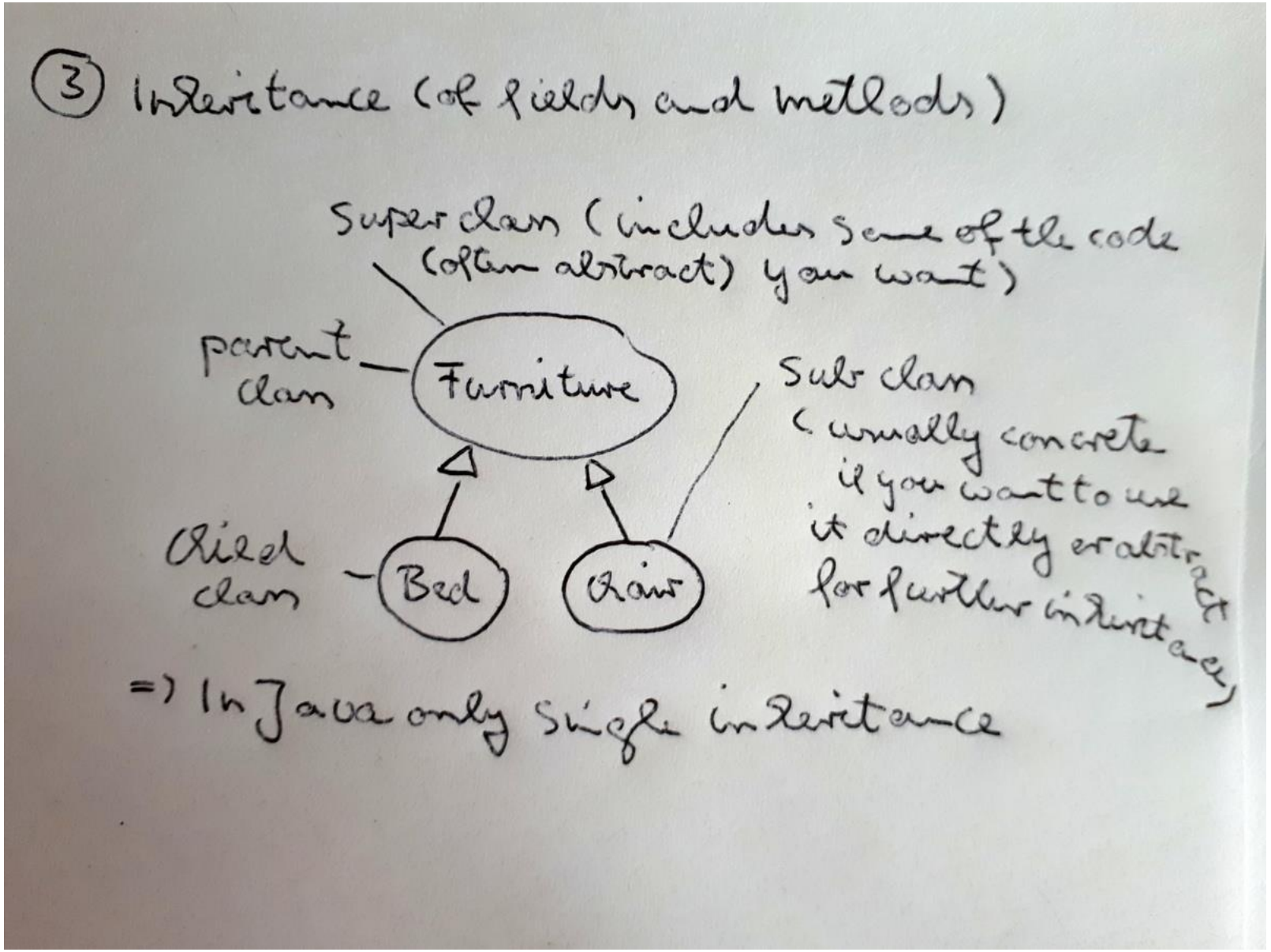


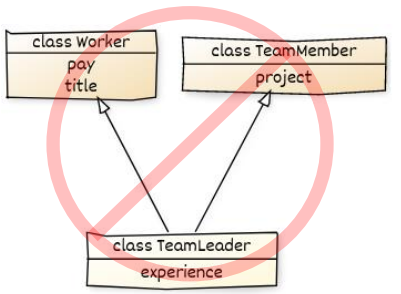
A `revenue`
B `queue.size()`
C `employees.get(i).performance()`
D `main.announceSale()`
E `main.customers.get(i).loyalty`

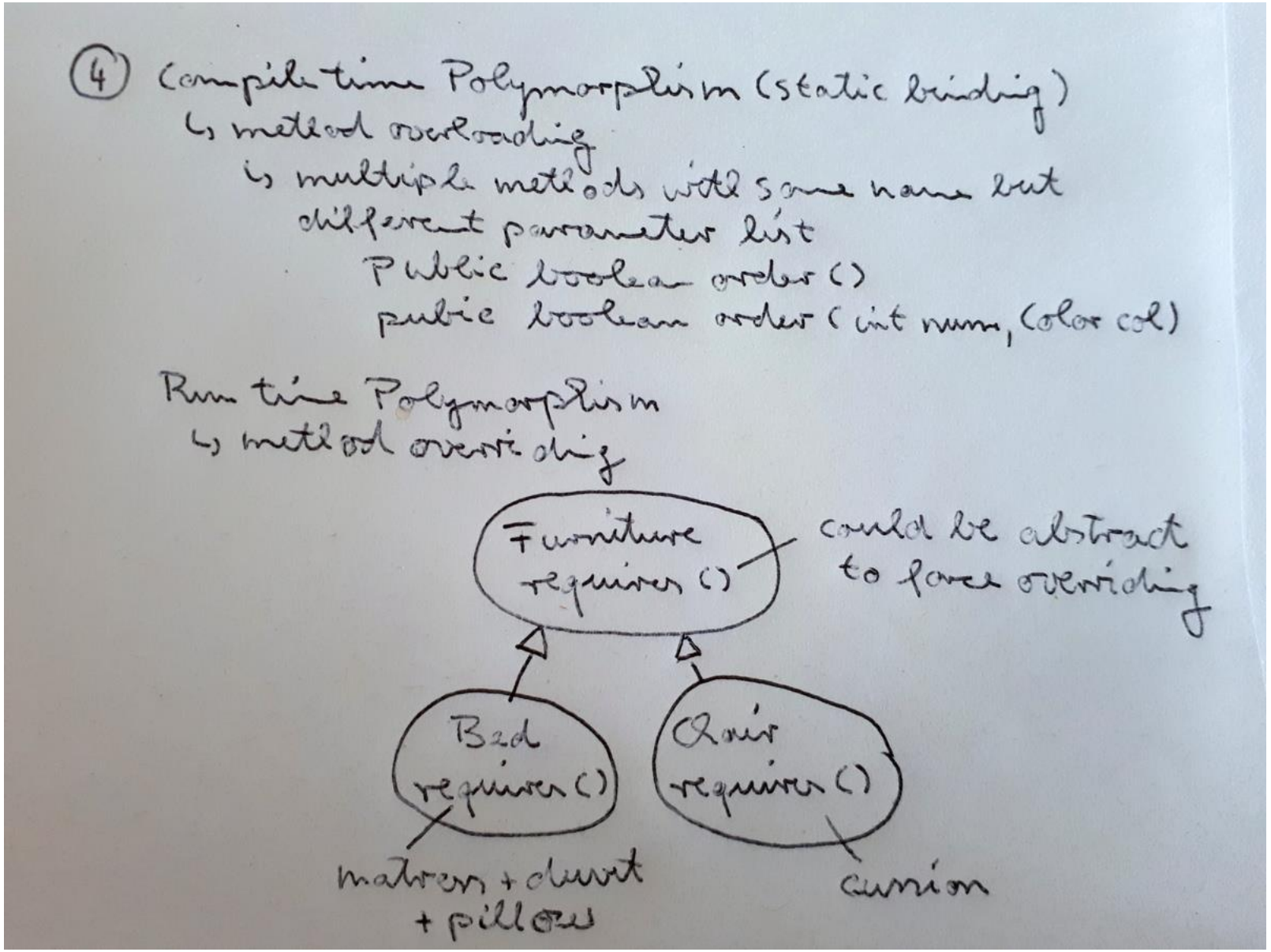
Objects and Java in 10 Minutes ;-)


1
Classes
↳ Blueprints for objects
Will be different values for each object
Attributes
Operations
generic
types: primitives or objects


(2)
Objects in Java (instantiations of classes)
usually private - use getters and setters to access
(encapsulation)
Fields
Methods
often used to separate concerns
usually public, unless helper methods
↳ accessible from other objects


(3) Inheritance (of fields and methods)
Super class (includes some of the code (often abstract) you want)
parent class
Furniture
Sub class (usually concrete if you want to use it directly or abstract for further inheritance)
Child class
Bed
Chair
=) In Java only single inheritance


class Worker
pay
title
class TeamMember
project
class TeamLeader
experience



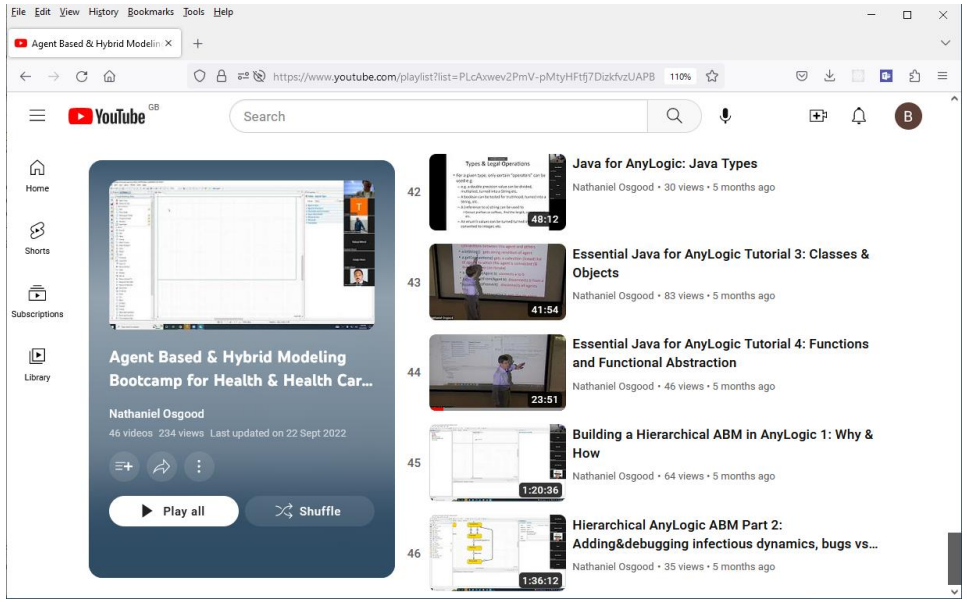
Polymorphism (many forms) in Java is a concept by which we can perform a single action in different ways

Free Java Course

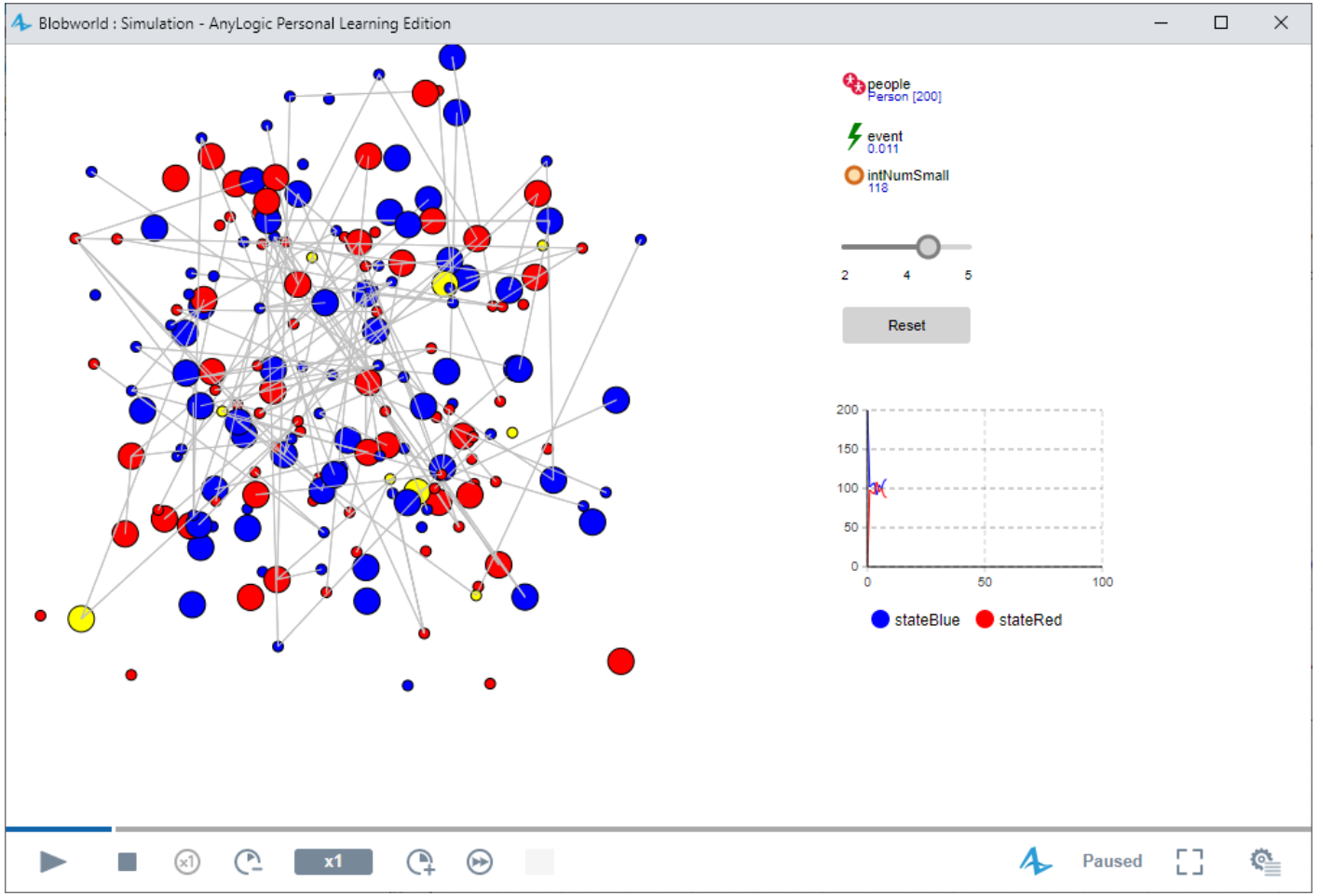
- Amigoscode: Java Full Course - Java Tutorial for Beginners
  - https://www.youtube.com/watch?v=j9VNCI9Xo80

Java Basics for AnyLogic

- For useful advice see Nathaniel Osgood's YouTube videos
  - Check "Agent Based & Hybrid Modeling Bootcamp for Health & Health Care" playlist
    - https://www.youtube.com/playlist?list=PLcAxwev2PmV-pMtyHFtfj7DizkfvzUAPB
    - Towards the bottom of the playlist (video 42 to 46) you find "Java for AnyLogic" tutorials



BlobWorld Tutorial



OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

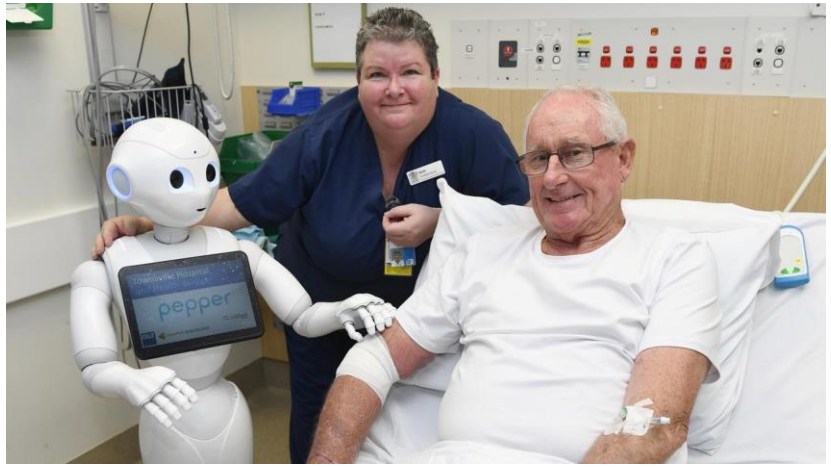
Presentation

Research Case Study (30 min)

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Service Provision in the Hospital of the Future



Stroud et al (2019)

Motivation

- Proactive machines are an idea that in the future hospitals will have automated machines as well as Doctors and Nurses that can help and treat patients. This project uses the idea of proactive machines to test the impact of technology on mental state and opinions of hospital patients.

Analyse Problem

- Aim and objectives
  - Reflect on the consequences of digital mental healthcare

- Hypotheses
  - Trust between machines/humans will affect human-human relationships in a negative way
  - Machine-look influences our decisions

Analyse Problem

- Experimental factors
  - Number of doctors, proactive machines and patients
  - Number of beds

- Responses
  - Mental state of patients, e.g. happiness
  - Opinions of each patient on the doctors and robots
  - The trust of the patients on the robots

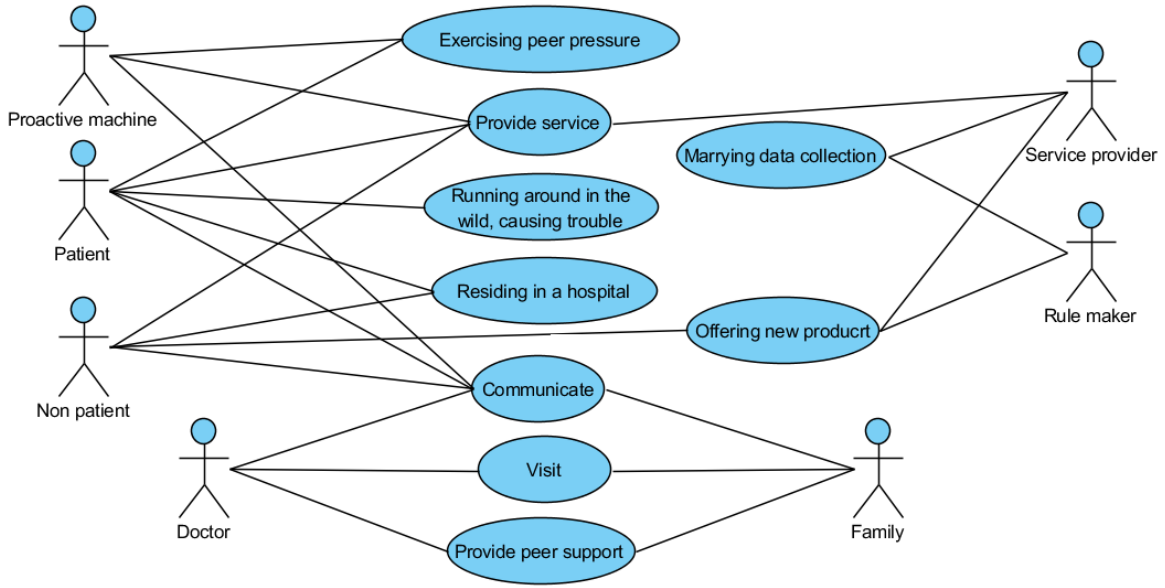
Define Scope

Category		Element	Decision	Justification
Actor	Human	Patient	Include	Patients are the ones who are being tested
		Doctor	Include	Doctors need to be compared against the Robot doctors
		Visitor	Include	Visitors can be used to influence patients
		Nurse	Exclude	Nurse can be viewed as the same as doctors in the simulation
	Proactive machine	Robot doctor	Include	Need to be compared against doctors
Physical Environment	Buildings	Hospital	Include	Location where the model is held
		Home	Include	Location where agents are held when they are being used
	Furniture	Beds	Include	Patients need somewhere to stay
	Structure	Walls	Exclude	Not needed because we are not interested in agents movements or collisions
		Doors	Exclude	Not needed to test the hypotheses

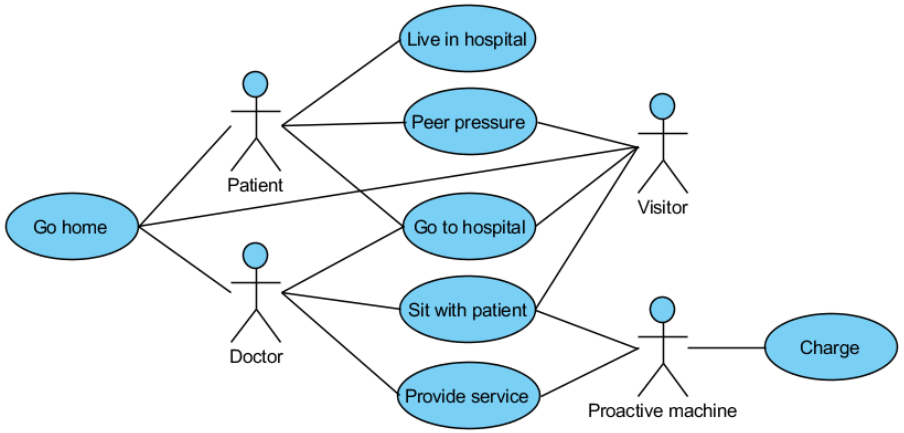
Category		Element	Decision	Justification
Social and psychological aspects	Robot doctor behaviour	Decide how long to treat patient for	Include	Needed for more accurate results
		Accurate movement of robot	Exclude	Movement is not needed to test the hypotheses
	Doctor behaviour	Decide how long to treat patient for	Include	Needed for more accurate results
		Accurate movement of doctor	Exclude	Movement is not needed to test the hypotheses
	Patient behaviour	Random hospital visits	Include	Needed for more accurate results
	Visitor behaviour	Decide whether the visitor should visit the patient	Include	Needed for more accurate results
		Accurate movement of visitor	Exclude	Movement is not needed to test the hypotheses
Other		N/A	N/A	N/A

Defining Key Activities

Initial



Final



Define Archetype Stencils

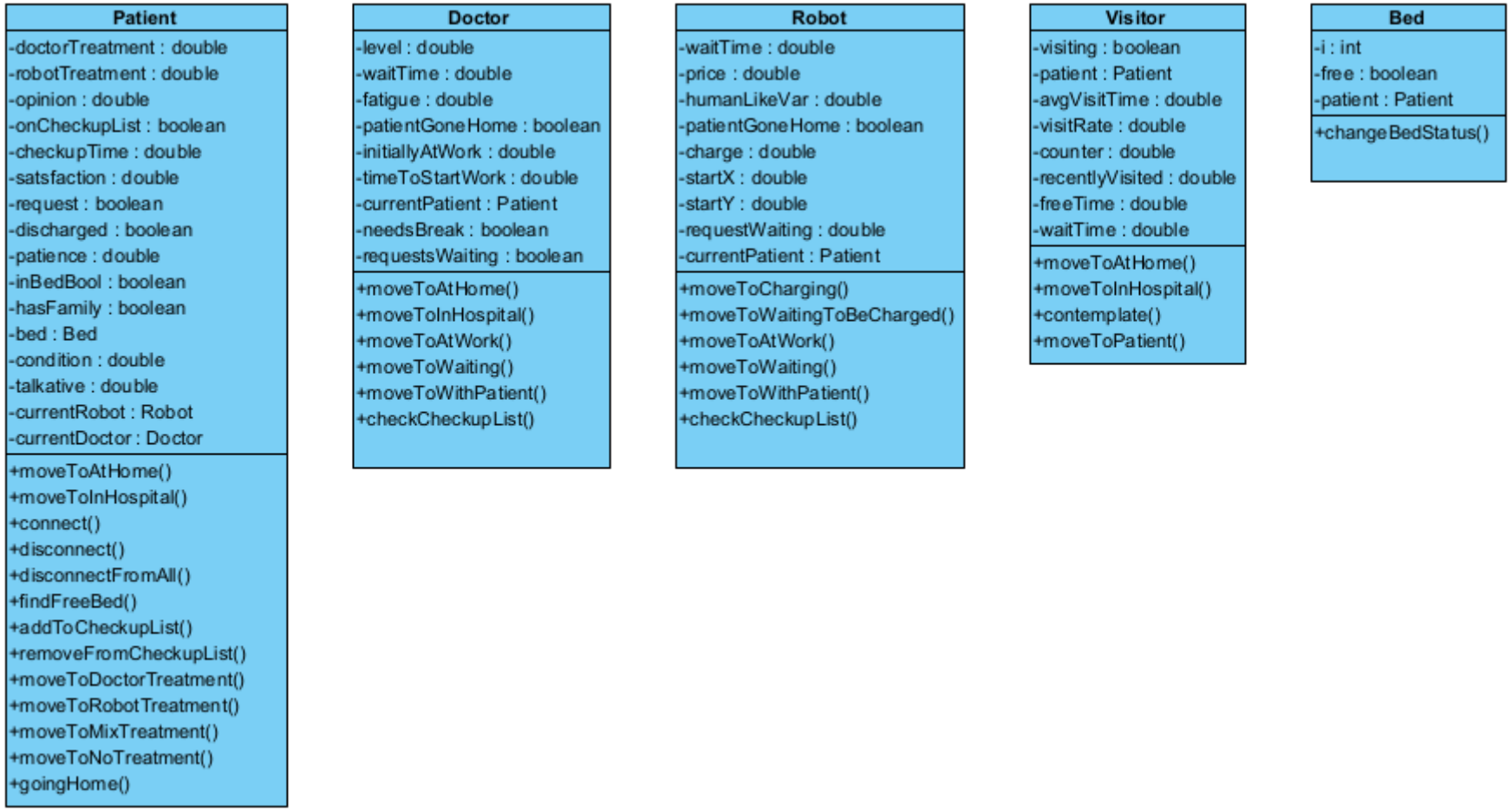
Doctor

Stereotype	Extra time treating patients (Minutes)
Senior	0
Junior	10

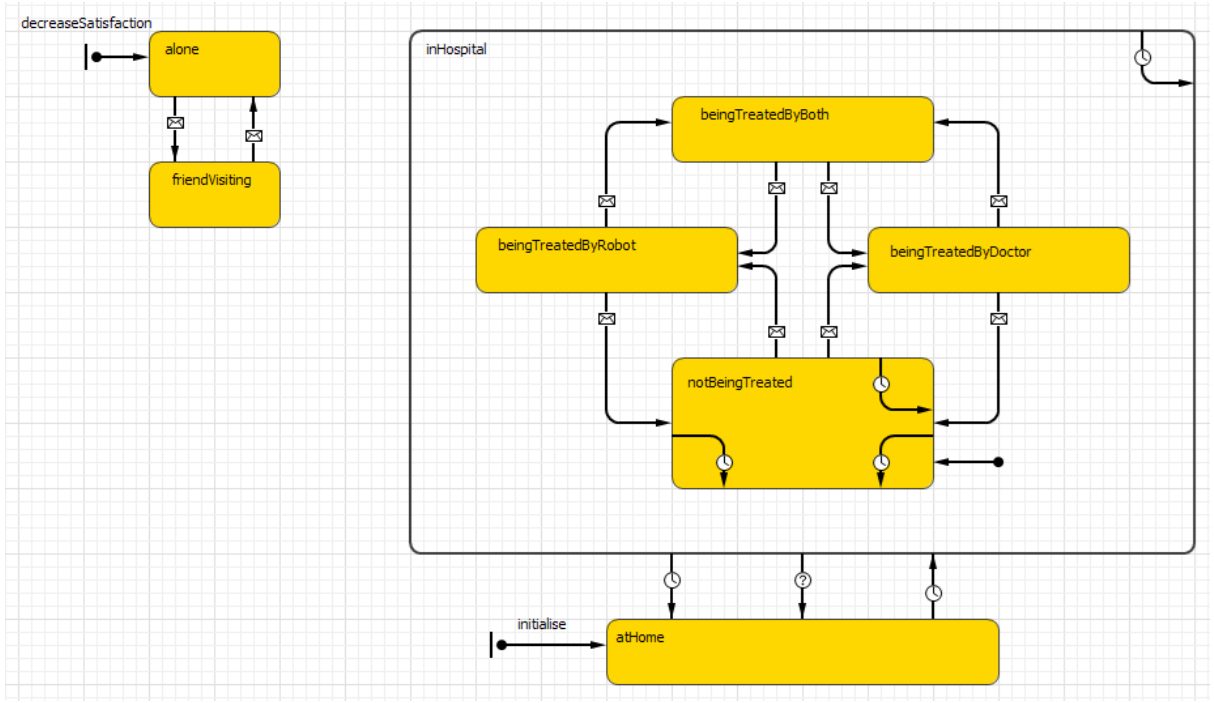
Robot

Stereotype	Humanlike variable	Effect on human opinion
Humanlike	0.5 – 1	Positive effect
Robotlike	0 – 0.5	Negative effect

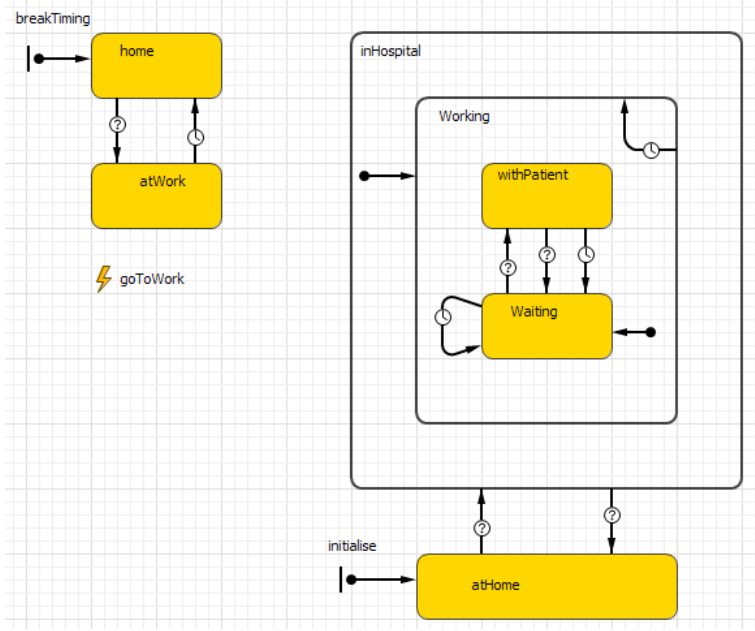
Define Agent/Object Stencils



Define Agent/Object Stencils

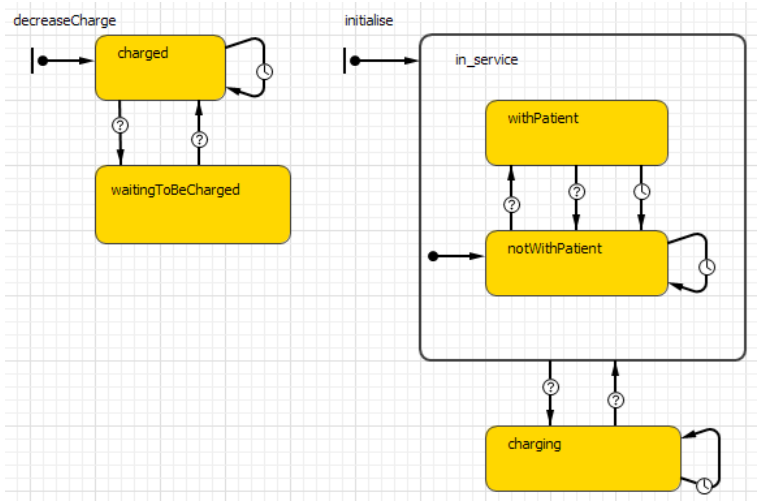


Patient

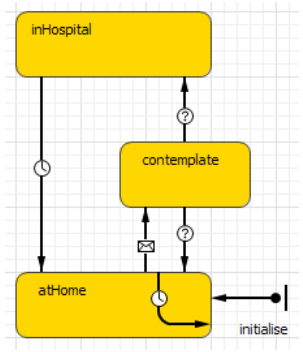


Doctor

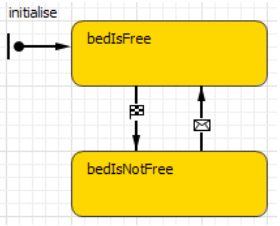
Define Agent/Object Stencils



Robot

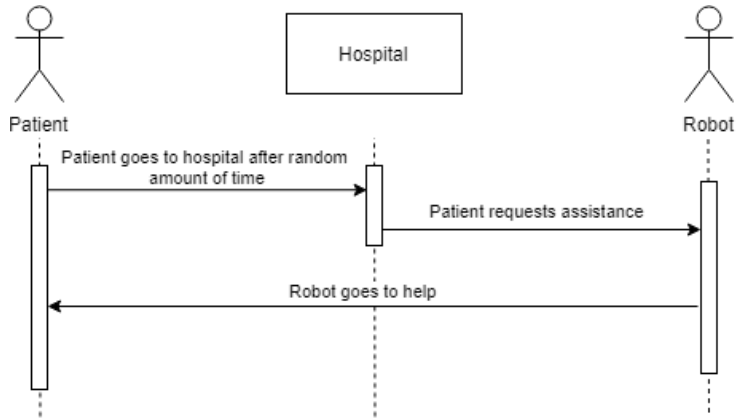


Visitor

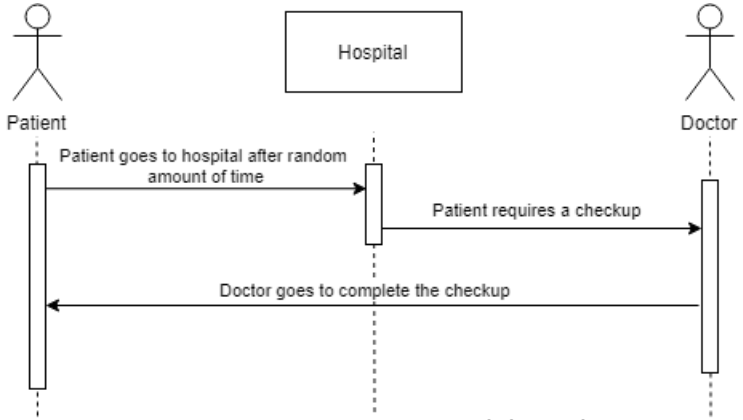


Bed

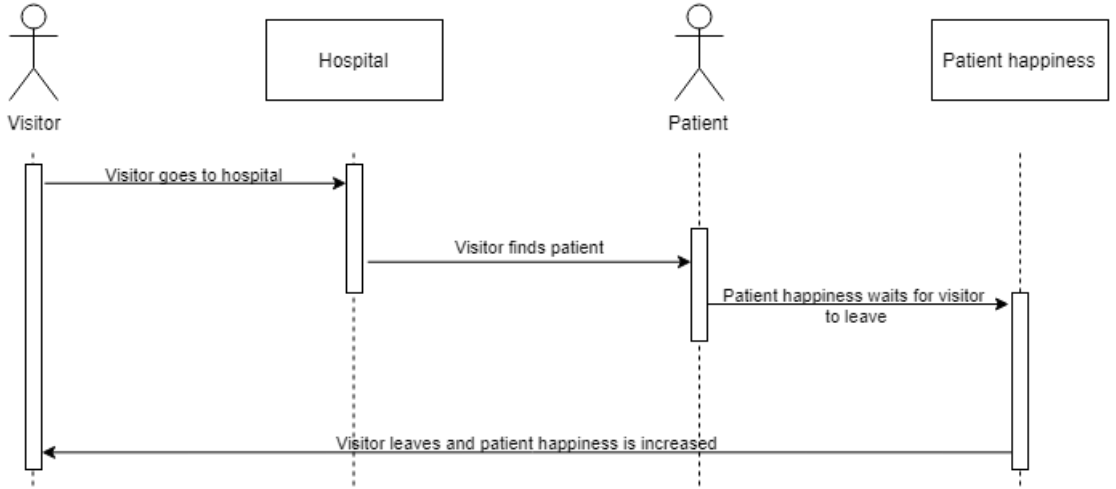
Define Interactions



Patient getting treated by robot

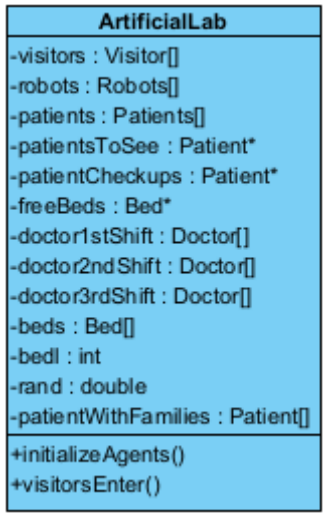


Patient getting treated by doctor

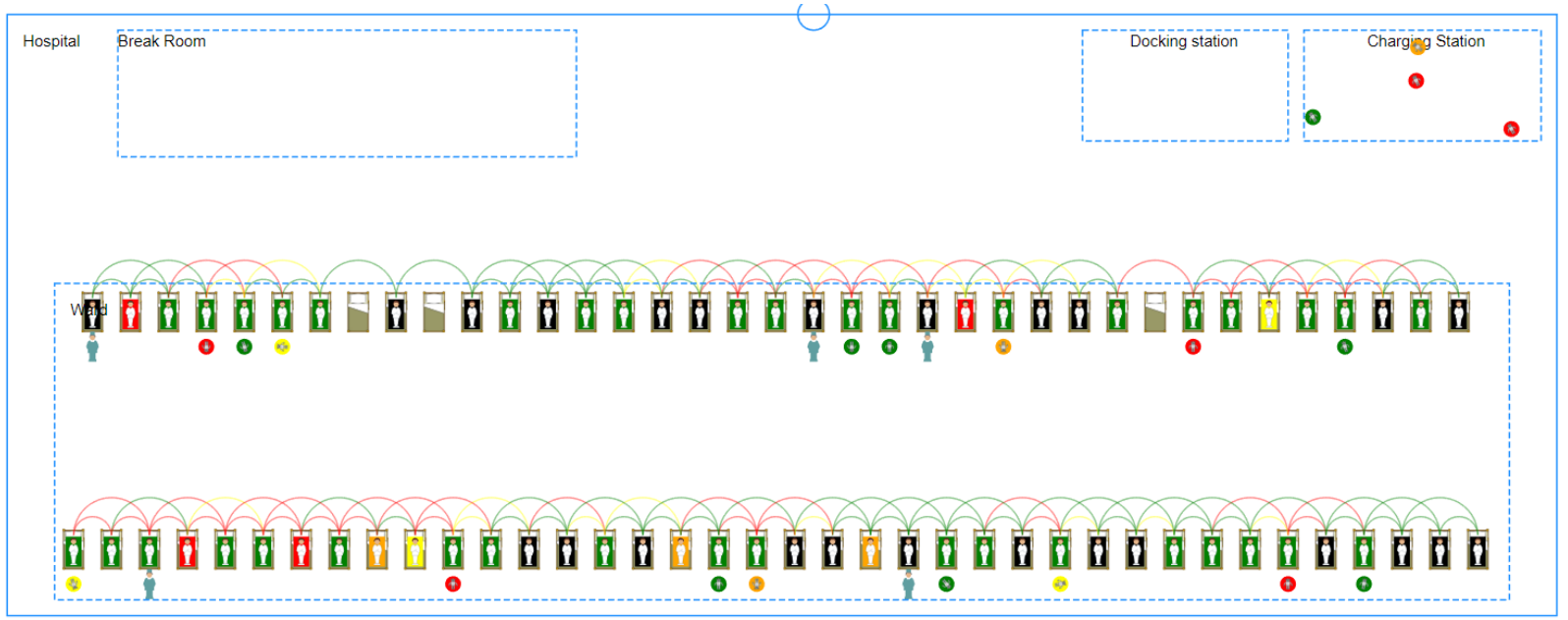


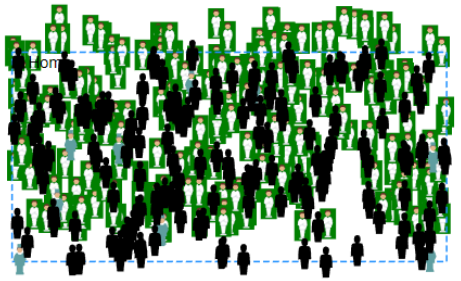
Visitor visits patient

Define Artificial Lab



Implementation





Service Provision in the GP Practice of the Future

Improve the Understanding of Digital Mental Healthcare Scenarios

Barnes and Siebers (2020)

Motivation

- Digital mental healthcare in the context of Social Simulation
  - Digital mental healthcare
    - Consists of AI developed in ways which can help provide alternative methods of treating mental health issues (e.g. depression; anxiety; and dementia) successfully

- Current research focuses on understanding the social and ethical implications of digital mental healthcare, rather than looking at the service provision aspects

Analysing the Problem

- Aim
  - *Case Study*: To better understand how people react towards virtual therapists, with people modelled based on generation groups: Millennials, Generation-X, and Baby Boomers
  - *Methodology*: To test different decision making modelling approaches (crisp vs fuzzy 1/2)

- Hypotheses
  - *Case Study*: Access to social interaction for people increases sensitivity of simulation when certain parameters (e.g. trust) are altered
  - *Case Study*: Competence of the virtual therapists plays a large role in defining the output trust of the population
  - *Methodology*: The different decision making modelling approaches for decision making (crisp vs fuzzy 1/2) deliver similar outputs at micro (individual) as well as macro (population) level

Analysing the Problem

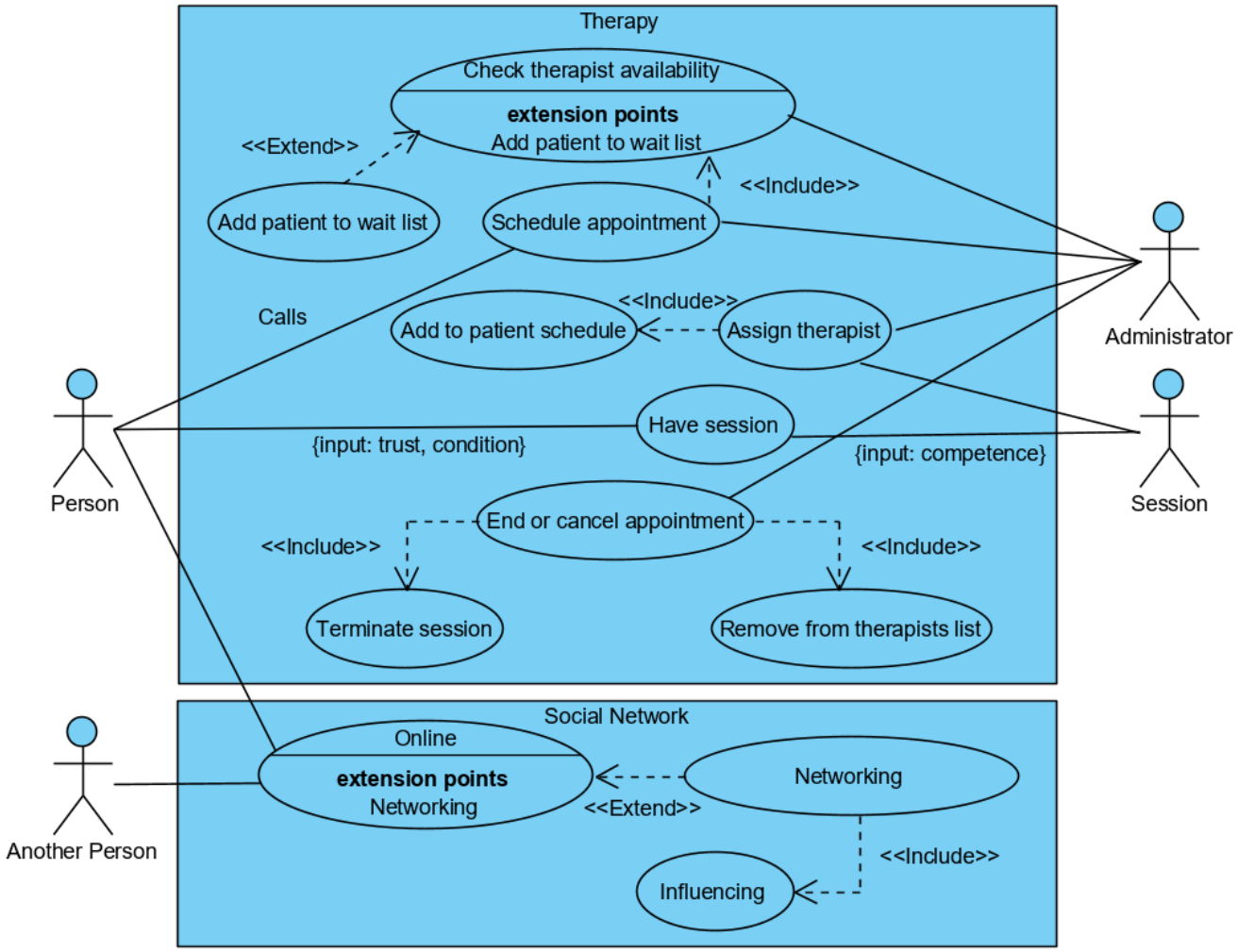
- Experimental factors
  - Proportion of different generations of agents
  - Initial level of trust of the population tested
  - Competence of virtual therapists
  - Level of access agents have to the social network

- Responses
  - Trust
    - Macro-level: Aggregated trust of the population
    - Micro-level: Individual agent's trust level evolution
  - Box plots "Trust/Generation" for different decision making approaches (crisp vs fuzzy 1/2)

Defining the Scope

Category	Element	Decision	Justification
Actor	Person (Patient)	Include	Subject which is being observed
	Session	Include	A virtual 'therapist' providing services to patients
	Administrator	Include	Manages waiting lists, organises and creates sessions on demand
Physical Environment	Hospital	Exclude	No benefits of representing these elements within the environment as physical entities
	Home	Exclude	
	Therapy	Exclude	
	Spatial node	Include	Used to measure distance between agents and defining the location of agents during the simulation
Social and Psych. Aspects	Person social influence	Include	Used to help determine the outcomes of social interactions
	Person condition	Include	Tracks the outcome of session treatment, and is what makes people admit themselves to care
	Person trust	Include	Our primary response (and therefore fundamental to the model)
	Person age	Include	Important for determining social media usage
	Desire	Exclude	Psychological theory was initially considered, but later not used due to time constraints
	Volatility	Exclude	
	Arousal	Exclude	
	Stereotype	Exclude	Captured by person age
Other	Social network	Include	Agents can interact with each other, in a realistic manner through using friendLink networks to send messages
	Therapy system	Include	System boundary used by people who require digital therapy

Defining Key Activities

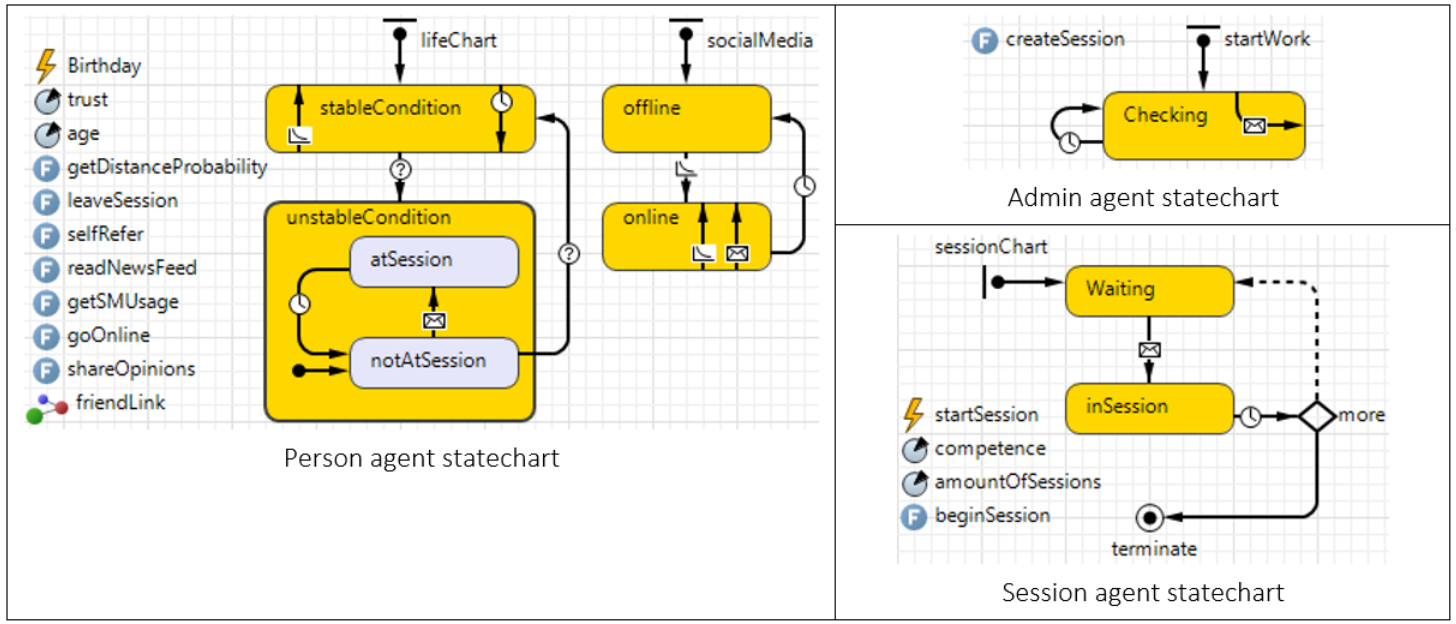


Defining Archetype Stencils

Name	Age range	Social media users [% of age range members]	Use of social media [hours per day]
Millennials	1980-1994	90.4	2.38
GenerationX	1965-1979	77.5	1.49
Baby Boomers	1944-1964	48.2	1.12

Defining Agent/Object Stencils

- Agents
  - Person
  - Admin
  - Session

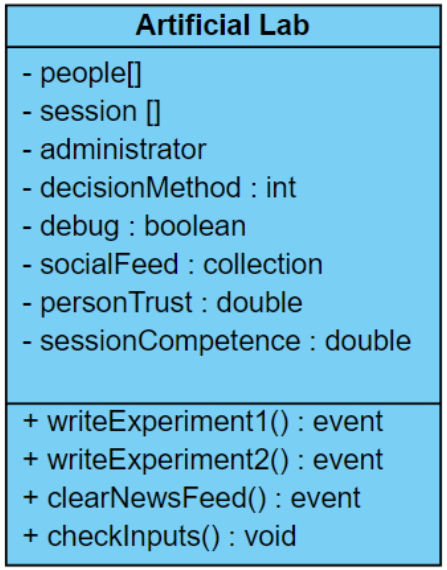


- Objects
  - Spatial nodes in the environment (to measure the distance between Person agents and to graphically represent their location and communication links within a defined space)

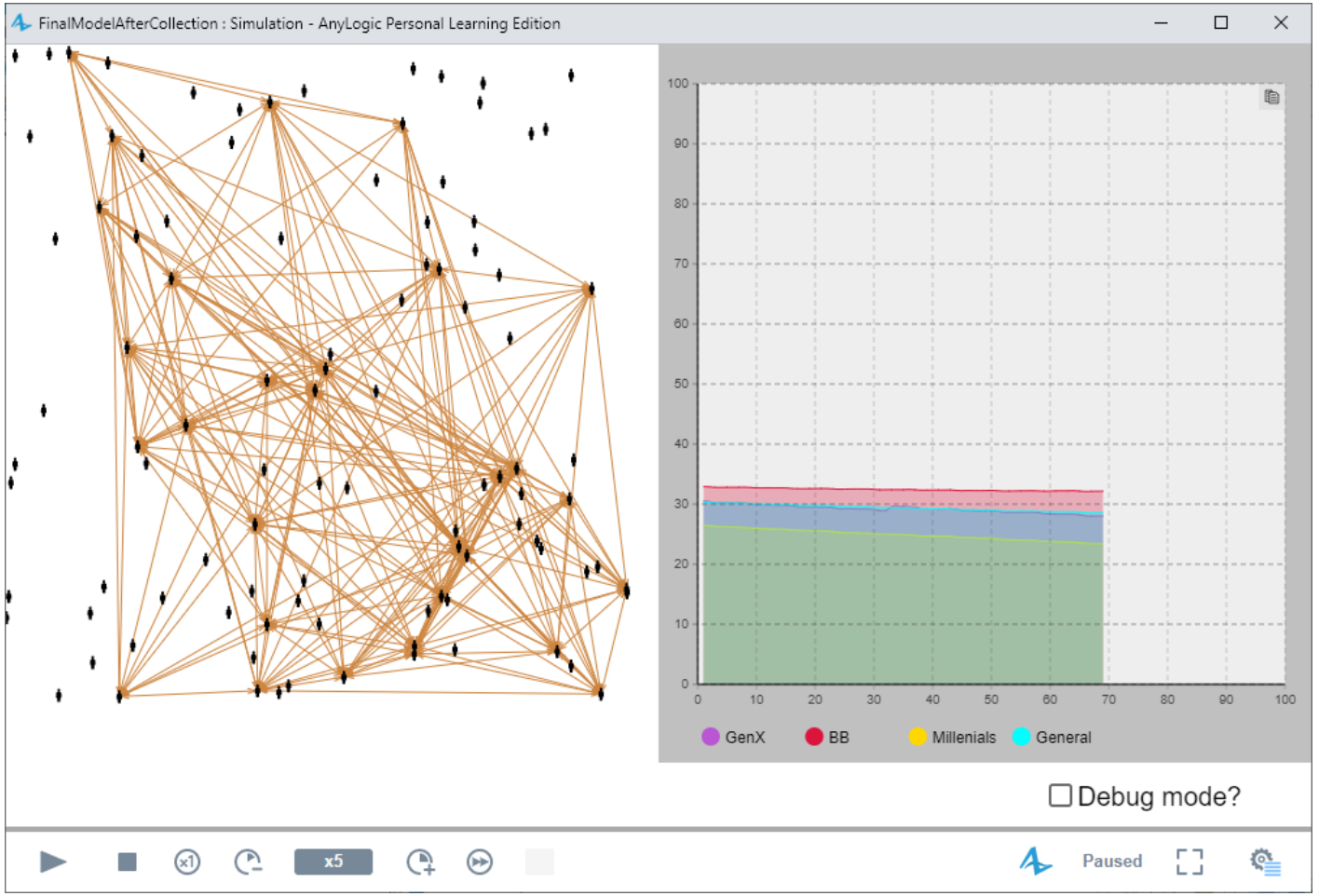
Defining Interactions / Artificial Lab

- Interaction
  - Online communication between Person agents (friend links) effecting opinion dynamics
  - Social media network connects agents depending on their proximity and social similarity

- Artificial Lab
  - Parameters
    - sessionCompetence; personTrust
    - decisionMethod (crisp; fuzzy1; fuzzy2); debug (on/off)
  - Global variables
    - Collections of actors
    - socialFeed (emulates a social media newsfeed)
  - Helper methods



Implementation



OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Practice

Small Groups: Develop modelling ideas for your own problems (45 min)

Joint Activity: Summarise outcome of previous activity (15 min)

What Did You Discuss?

OR Training Course 2023

Co-Creation of Agent-Based Simulation Models

Wrap-Up

General discussion and Q&A (15 min)

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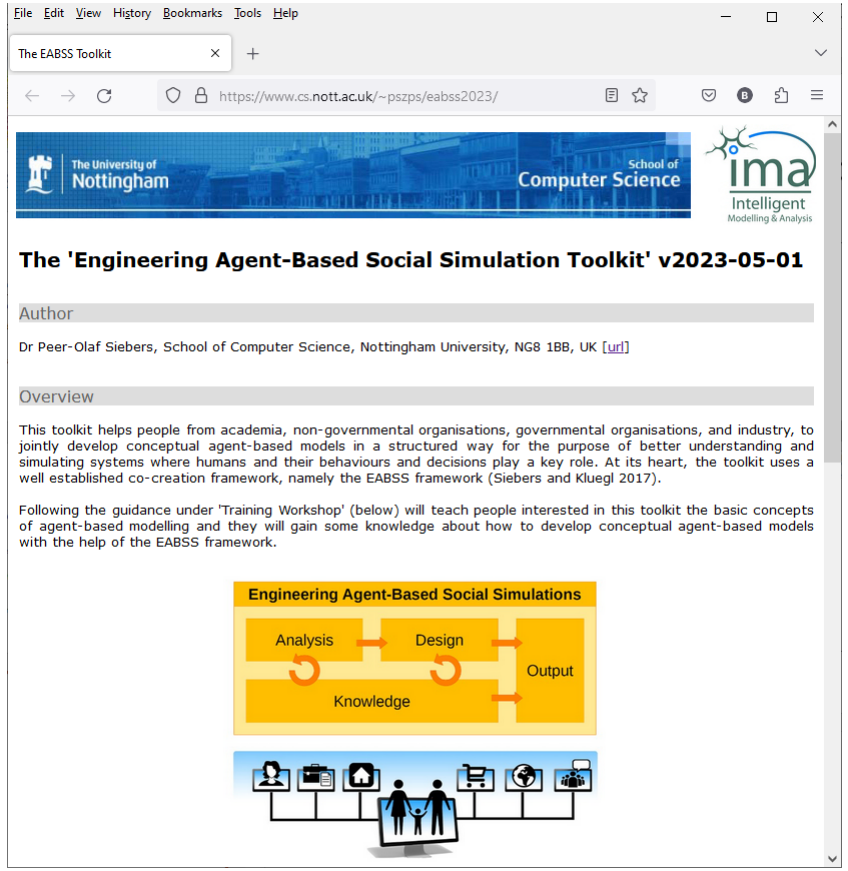
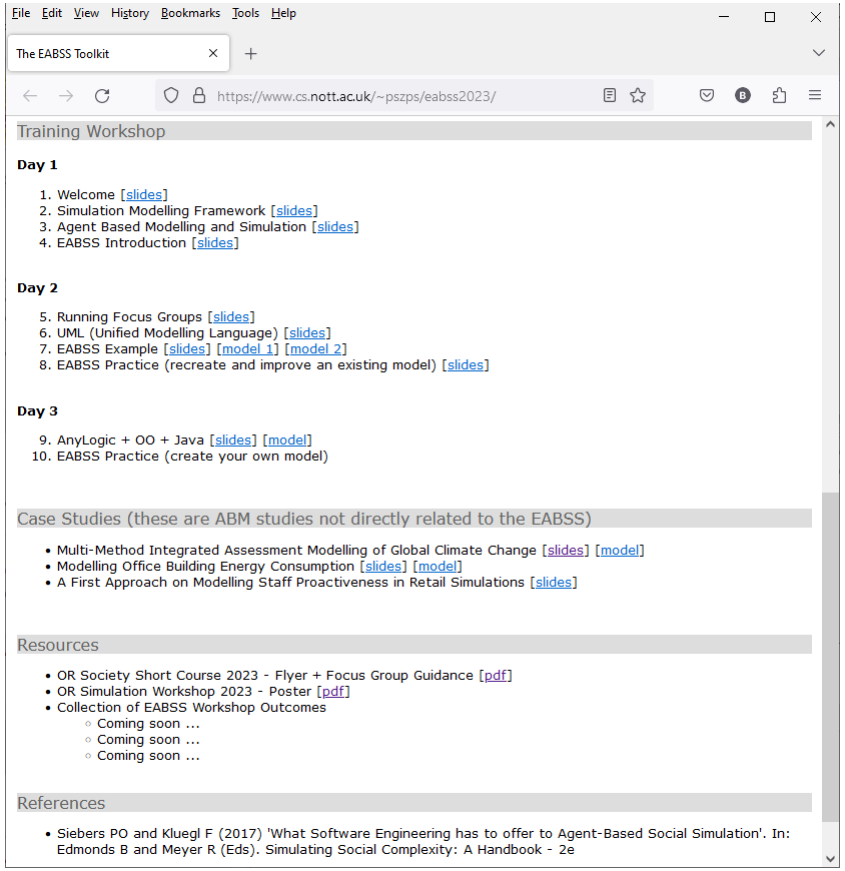
Resources





https://www.cs.nott.ac.uk/~pszps/eabss2023/

Any Questions?

Screenshot taken from Marie-Louise Gay's book "Any Questions?"

References

- AnyLogic (2013). AnyLogic online help [http://www.anylogic.com/anylogic/help/]
- Aristotle (BC). Aristotle quotes [http://www.online-literature.com/aristotle/]
- Barnes and Siebers (2020). Opportunities for using agent-based social simulation and fuzzy logic to improve the understanding of digital mental healthcare scenarios. In: Proceedings of the 10th OR Society Simulation Workshop (SW20), 30 Mar-1 Apr, Loughborough, UK
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