

Co-Creation of Agent-Based Simulation Models



Practice

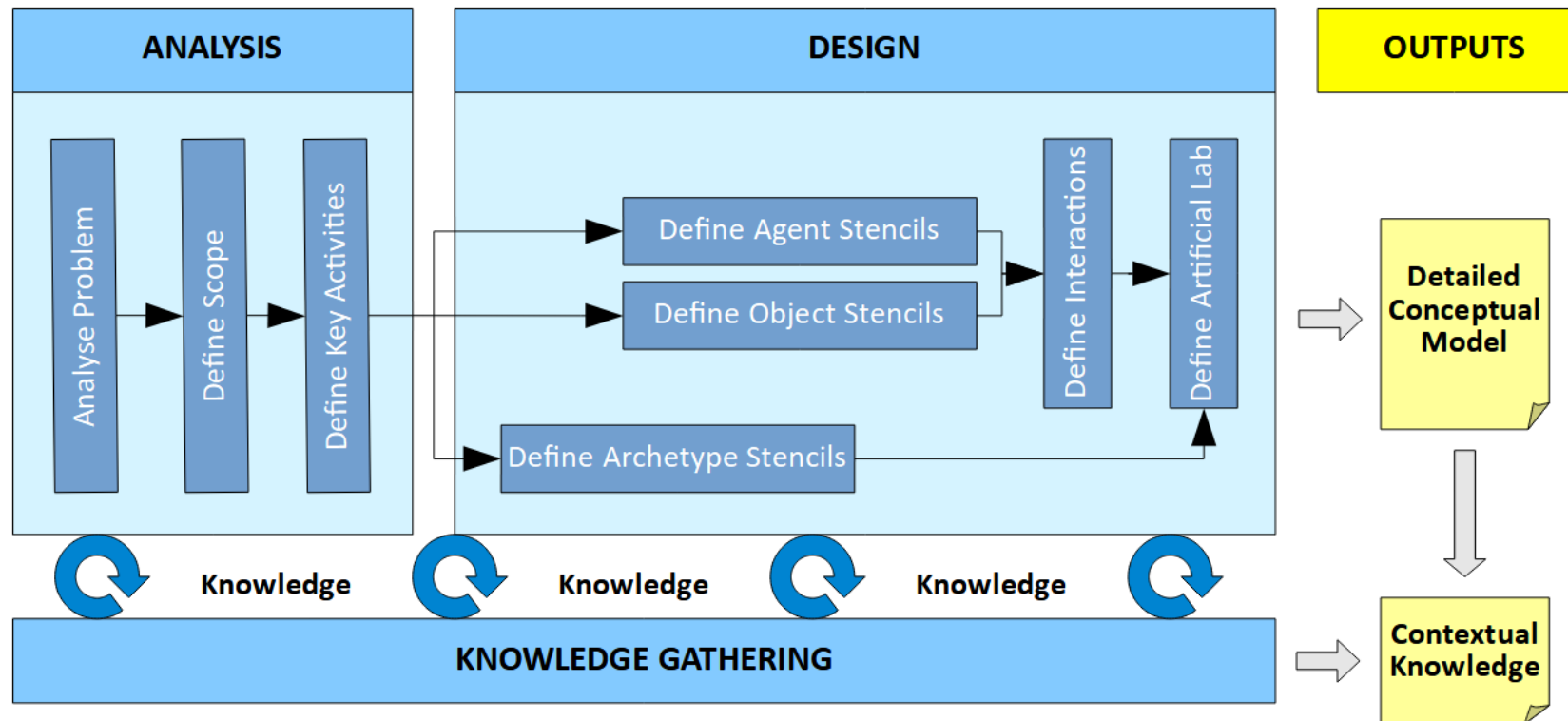
A Structured Approach to AB/Hybrid Model Development

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



The EABSS Framework [Siebers 2019]

- 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

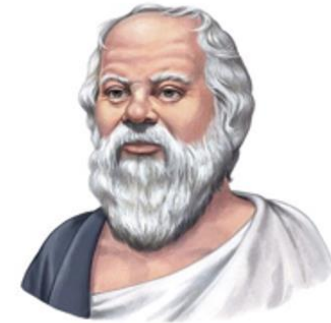




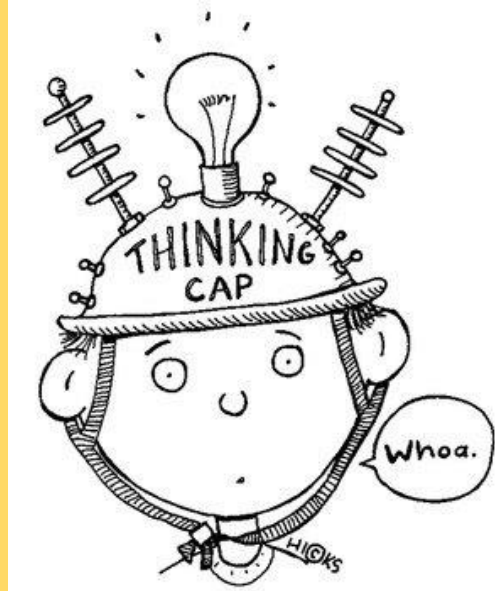
Image source: <https://imgflip.com/i/1ohsr9>

Example: Preparation

- Title: Exploring Adaptive Architecture Design [Siebers et al 2018]
- Context (background information that provides a framework for understanding the research problem and its significance)
 - 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 (a broad statement indicating the general purpose of your simulation study)
 - Study the impact of an adaptive screen (including several display windows) in a museum exhibition room



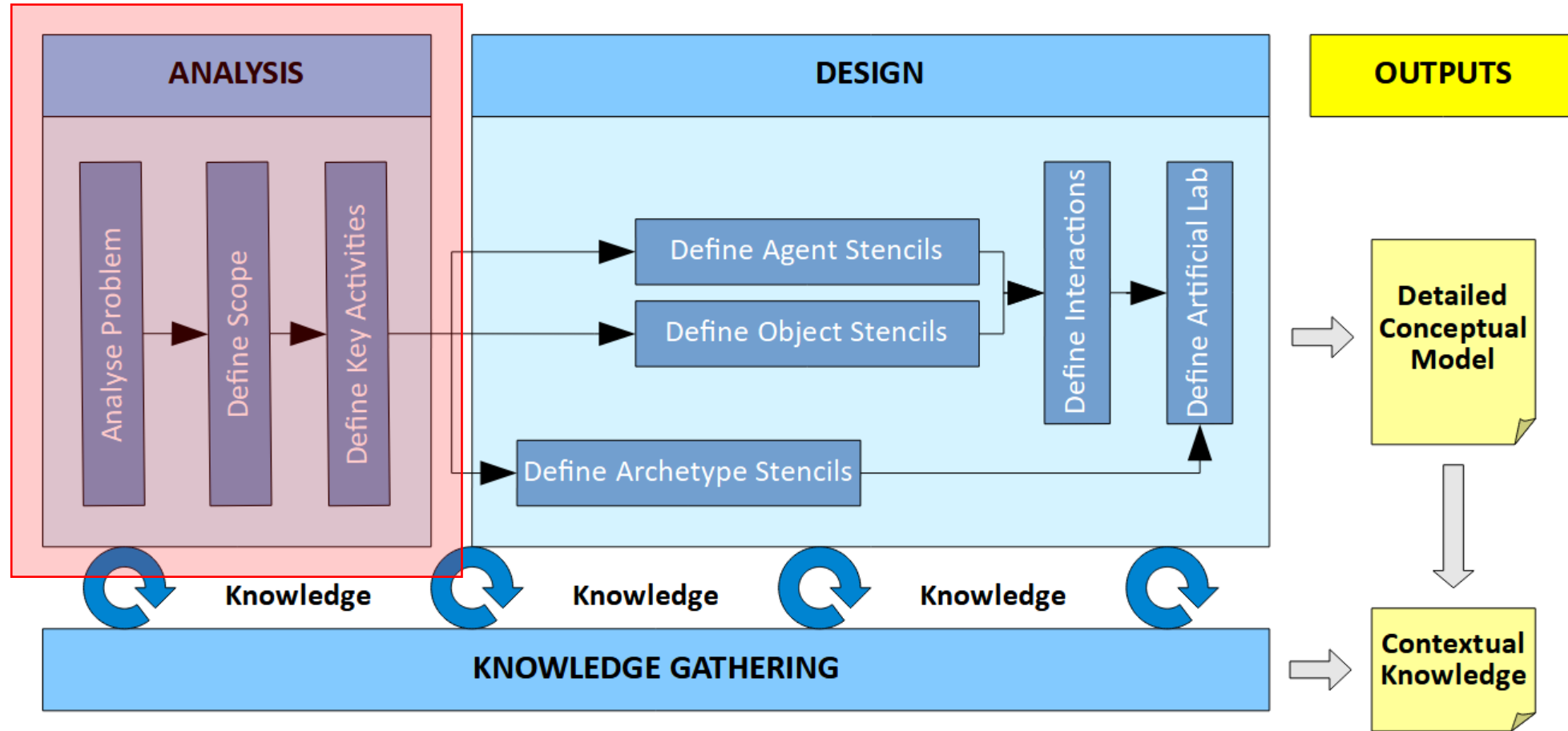
Case Study: Preparation



Let's define title, context, and aim

These are often given by the moderator, except in "blue-sky thinking" exercises, where the aim is not given

Engineering ABSS



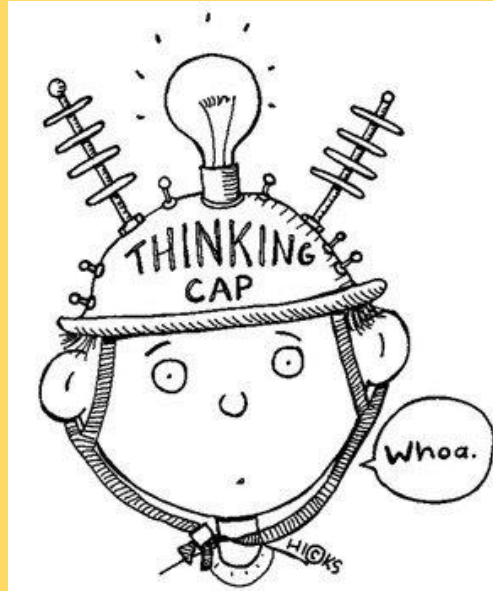
Example: Analyse Problem

- Objectives (how you plan to achieve your aim)
 - 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 (an attempt at explaining a phenomenon or the relationships between phenomena/variables in the real world)
 - 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: Analyse Problem



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

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

Example: Define Scope

- Level of abstraction? Strategic vs Tactical vs Operational ... or ... Exploratory vs Explanatory
- Scope (Original): What and Why? (what do we need to represent to fulfil the aim; look for nouns in previous text)

Category		Element	Decision	Justification
Actor	Human	Visitor	Include	Main research subject
		Group	Include	Important for capturing group behaviour
		Staff	Exclude	Have no impact on the dynamics
	Intelligent Object	Window	Include	Intelligent display unit that can make proactive decisions
		Display system	Include	Controls the life cycle of each window
Physical Environment	Service	Projector	Exclude	Considered by the windows
		Screen	Include	Home of the windows
	Structure	Wall	Include	Used by social force model
		Door	Include	Used by social force model
		Lighting	Exclude	Not necessary for testing hypotheses
		Furniture	Exclude	Not necessary for testing hypotheses
	Weather	Temperature	Exclude	Not necessary for testing hypotheses
		Natural light	Exclude	Indoor environment
	Building	Exhibition room	Include	Location where visitors move around
		Corridor	Exclude	Not necessary for testing hypotheses
Toilet		Exclude	Not necessary for testing hypotheses	
Social and Psychological Aspects	Visitor behaviour	Social force model	Include	Modelling visitor movement
		Vision area	Include	Will affect visitor movement behaviour
	Window behaviour	Social force model	Include	Part of the AI to be tested
		Vision area	Include	Area that visitors are able to read clearly
		Hammer algorithm	Exclude	Alternative to SFM but to be ignored due to time constraints
Other		N/A	N/A	N/A

Example: Define Scope

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

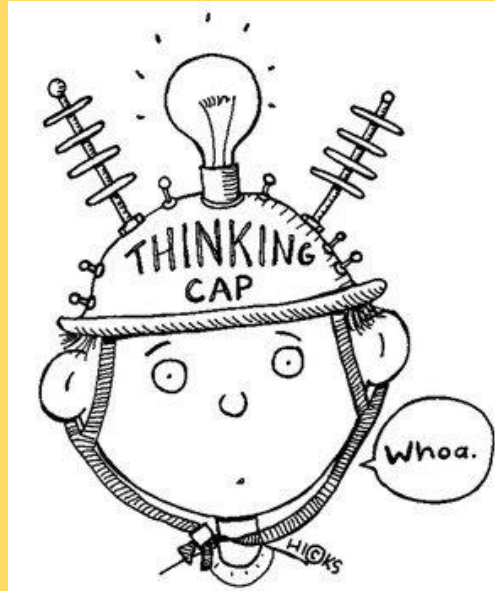
Category		Element	ID	Decision	Justification
Actor	Human	Visitor	A01	include	Main research subject
		Group	A02	include	Important for capturing group behaviour
		Staff	A03	Exclude	Have no impact on the dynamics
	Intelligent Object	Window	A04	include	Intelligent display unit that can make proactive decisions
		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

Example: Define Scope

- Some implementation details (derived from the original table)
 - This is not part of the conceptual model but useful information to preserve for later

ID	Implementation Detail	Decision	Justification
SPA01	Movement algorithm: Social Force Model	Include	Well established in Social Simulation
SPA03	Movement algorithm: Social Force Model	Include	Well established in Social Simulation
SPA03	Movement algorithm: Hammer Algorithm	Exclude	Alternative to SFM but to be ignored due to time constraints

Case Study: Define Scope

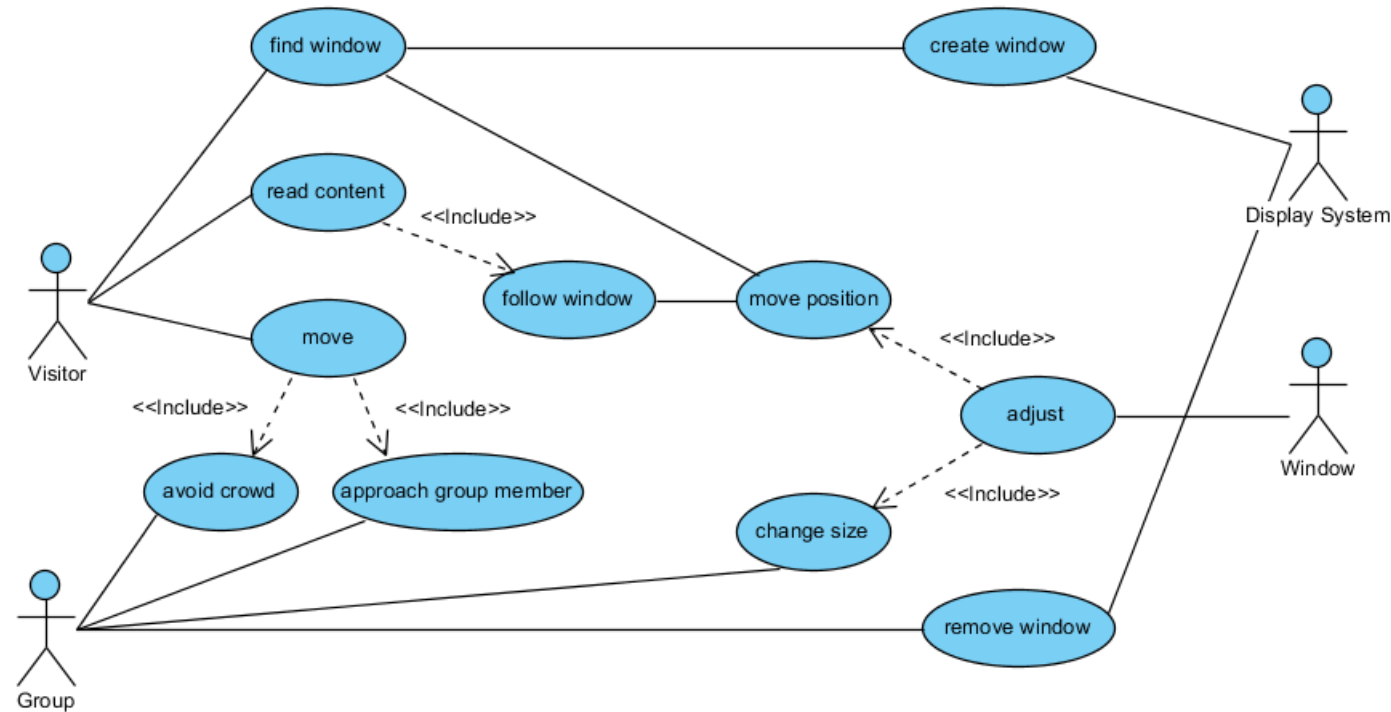


Let's define the scope for our case study

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

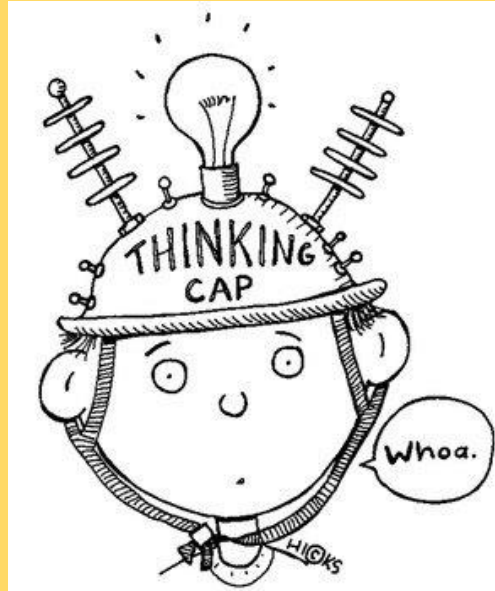
Example: Define Key Activities

- 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?>)

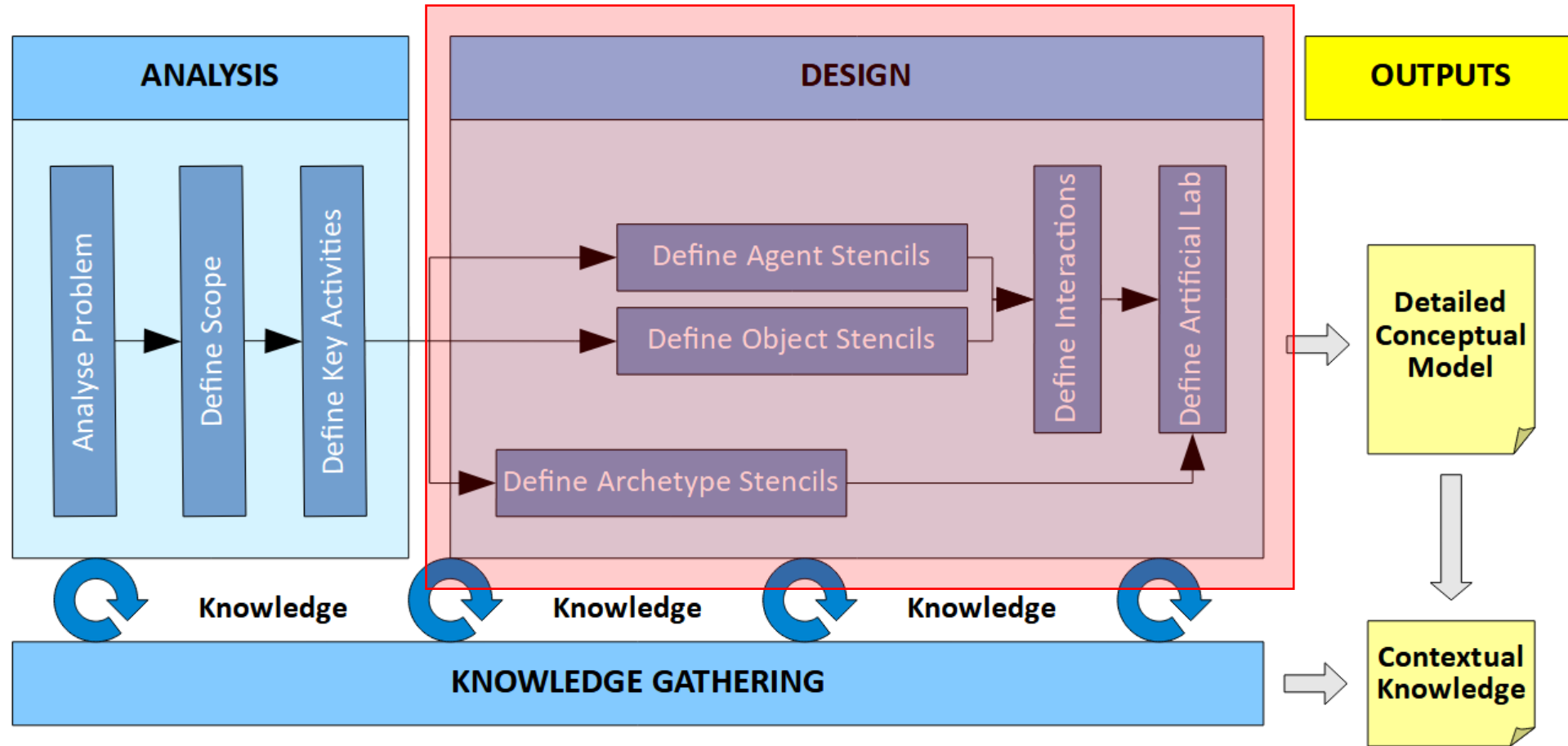
Case Study: Define Key Activities



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)

- Visitor: Interest related behaviour

Archetype	Reading time (seconds)
Disinterested visitor	3-10
Average visitor	10-40
Researcher	40-90

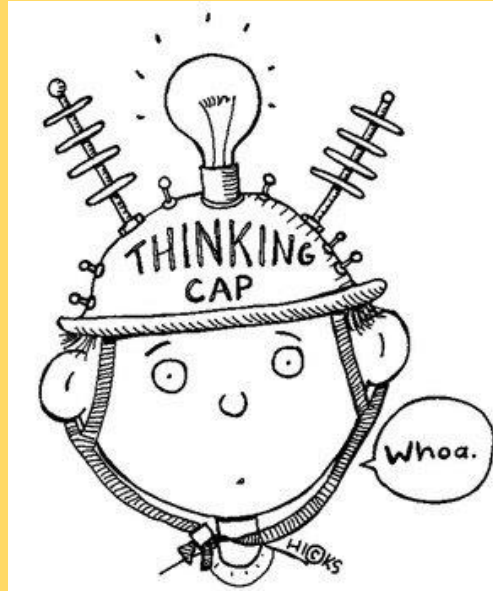
- Visitor: Age related behaviour

Archetype	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 units and 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

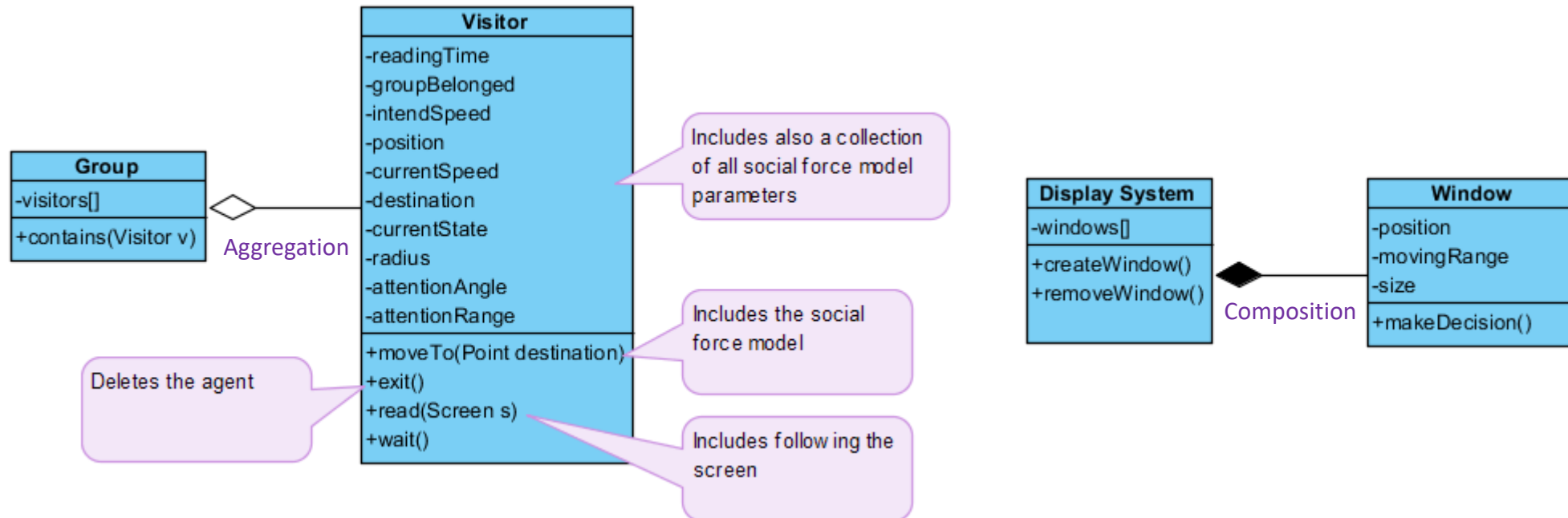
These allow to define behaviour of actors. Use habits/demographics for characterisation.

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)



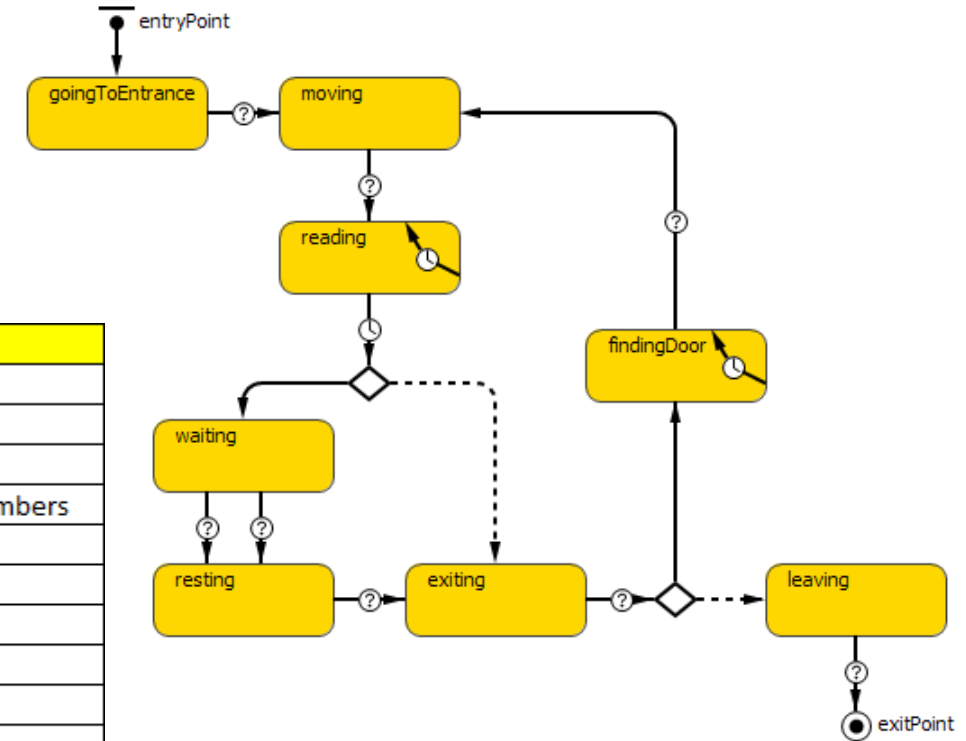
Note: Some of the attributes/operations will only be known once the implementation strategy is known (e.g., implementing "Movement" by using the Social Force Model)

Example: Agent and Object Stencils

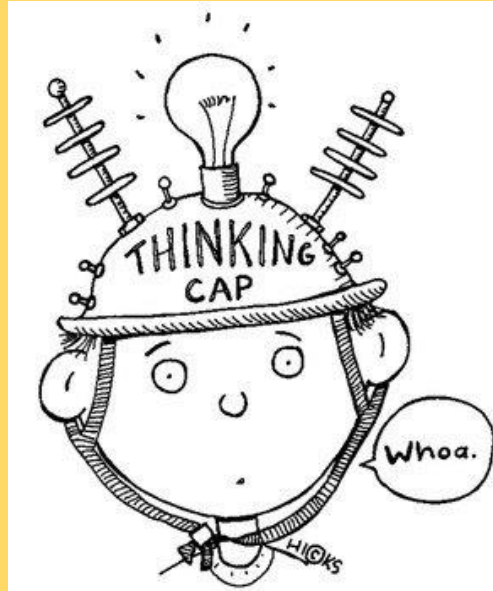
- Visitor agent: State chart (states can often be derived from use cases)

- Visitor agent: Transition table

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

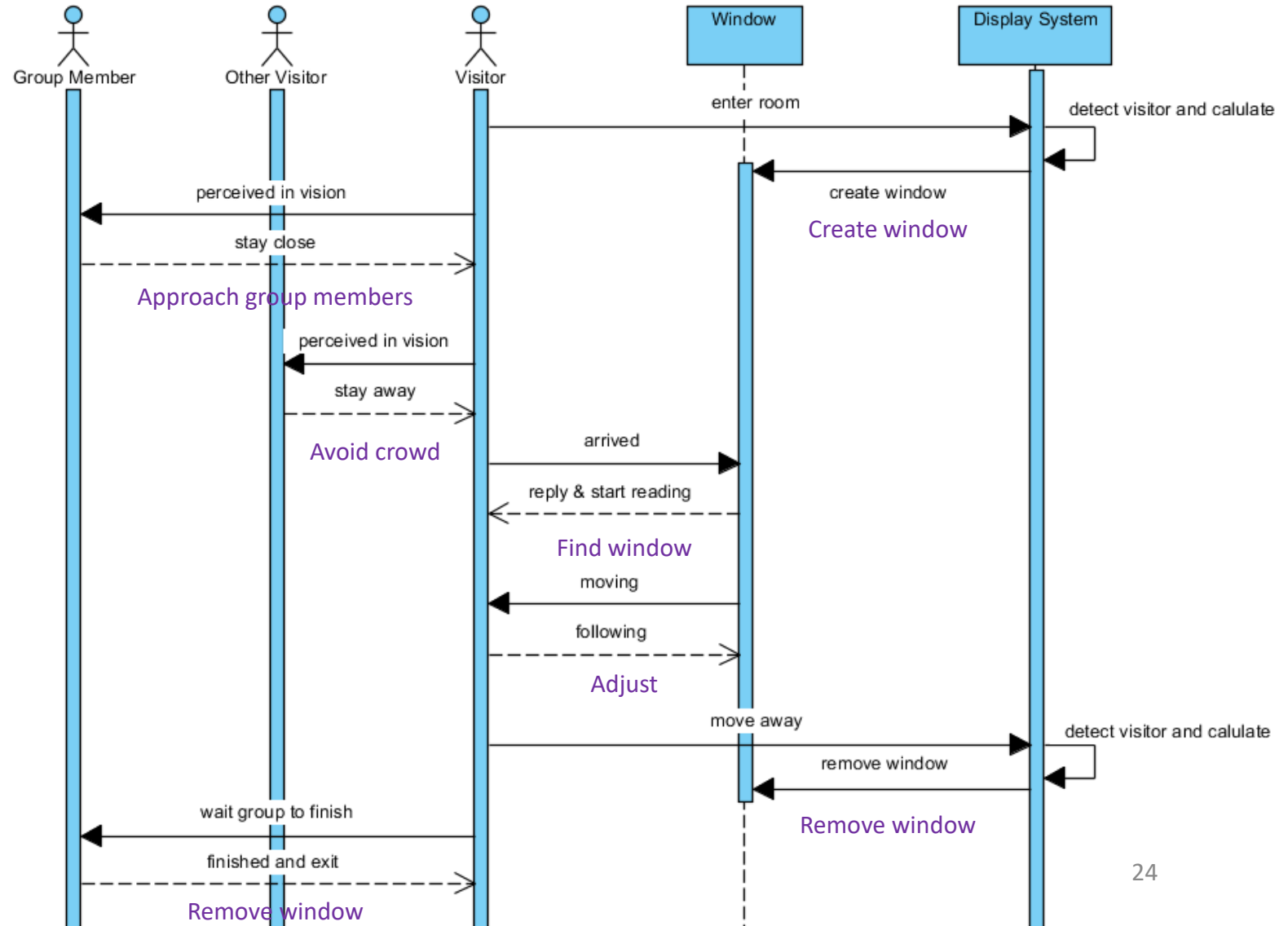
Agent and object classes: Attributes can be derived from archetype criteria and by looking at the scope table.
Operations can be derived from looking at the states in the related state charts.

State charts: States can often be derived from use cases

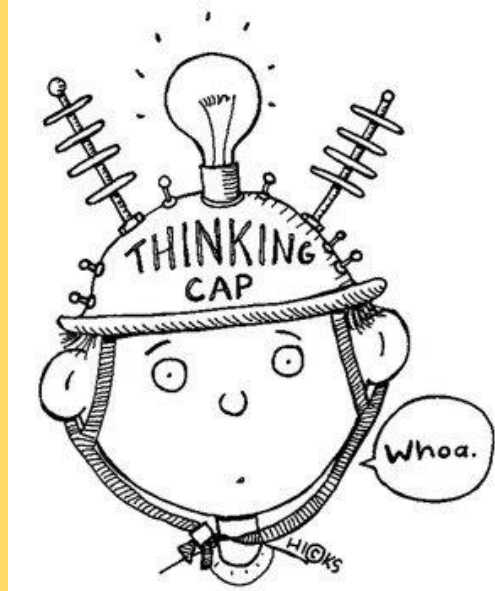
Example: Define Interactions

- **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

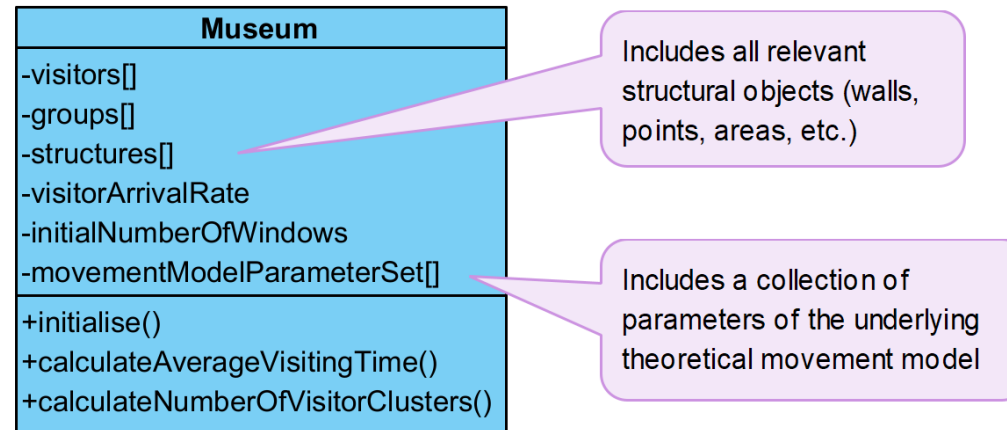


Let's define the interactions for our case study

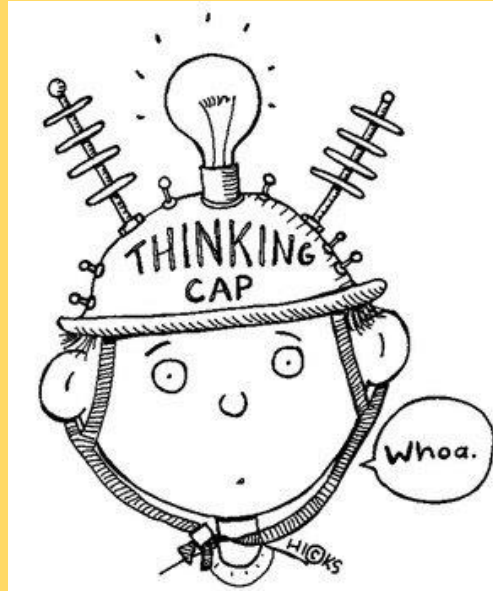
All elements defined in the Agent and Object Stencils step need to be listed on the horizontal axis. Use cases could be listed on the vertical axis. Alternatively, a separate diagram could be created for each individual use case.

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)



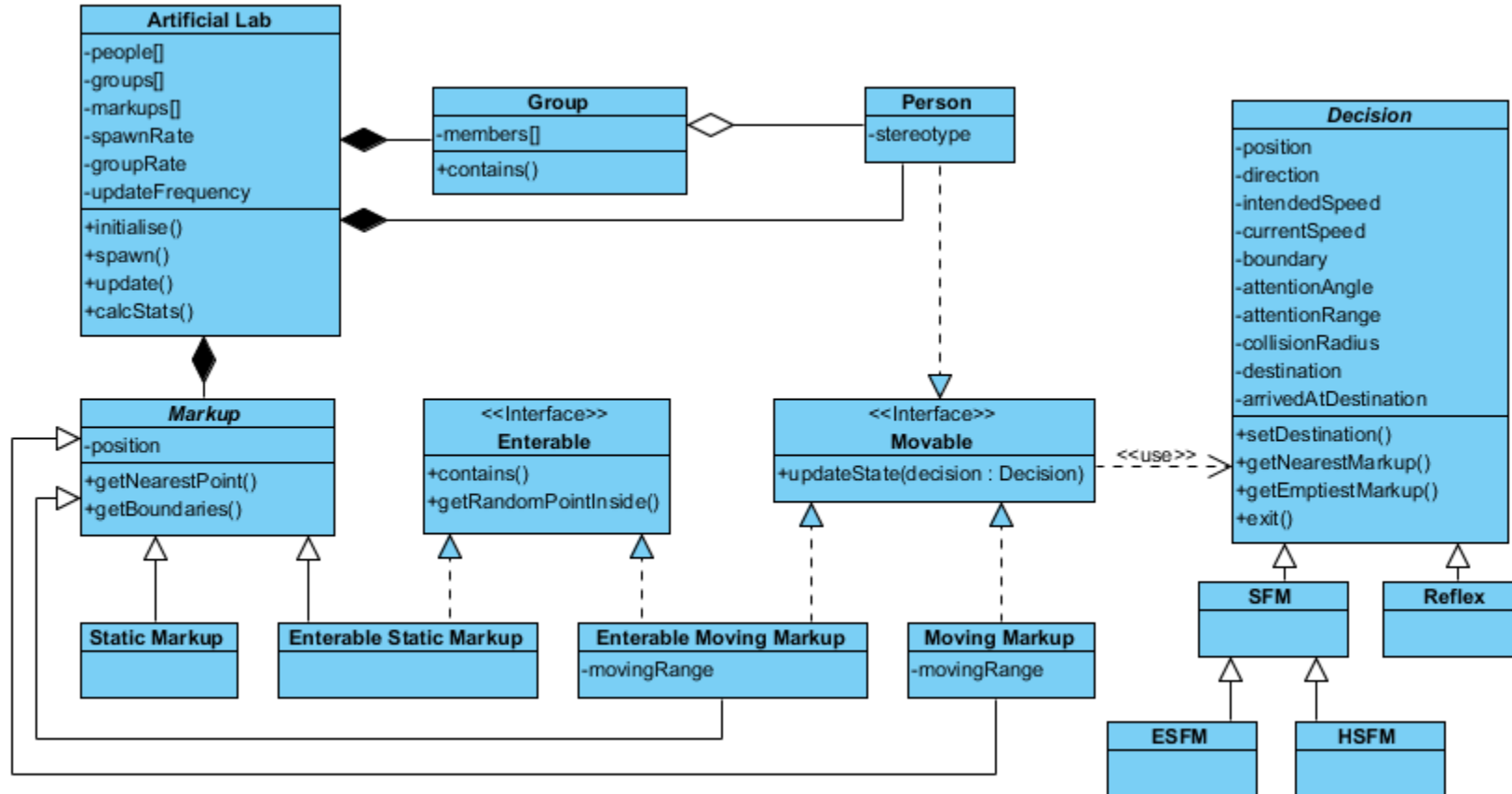
Case Study: Define Artificial Lab



Let's define the artificial lab for our case study

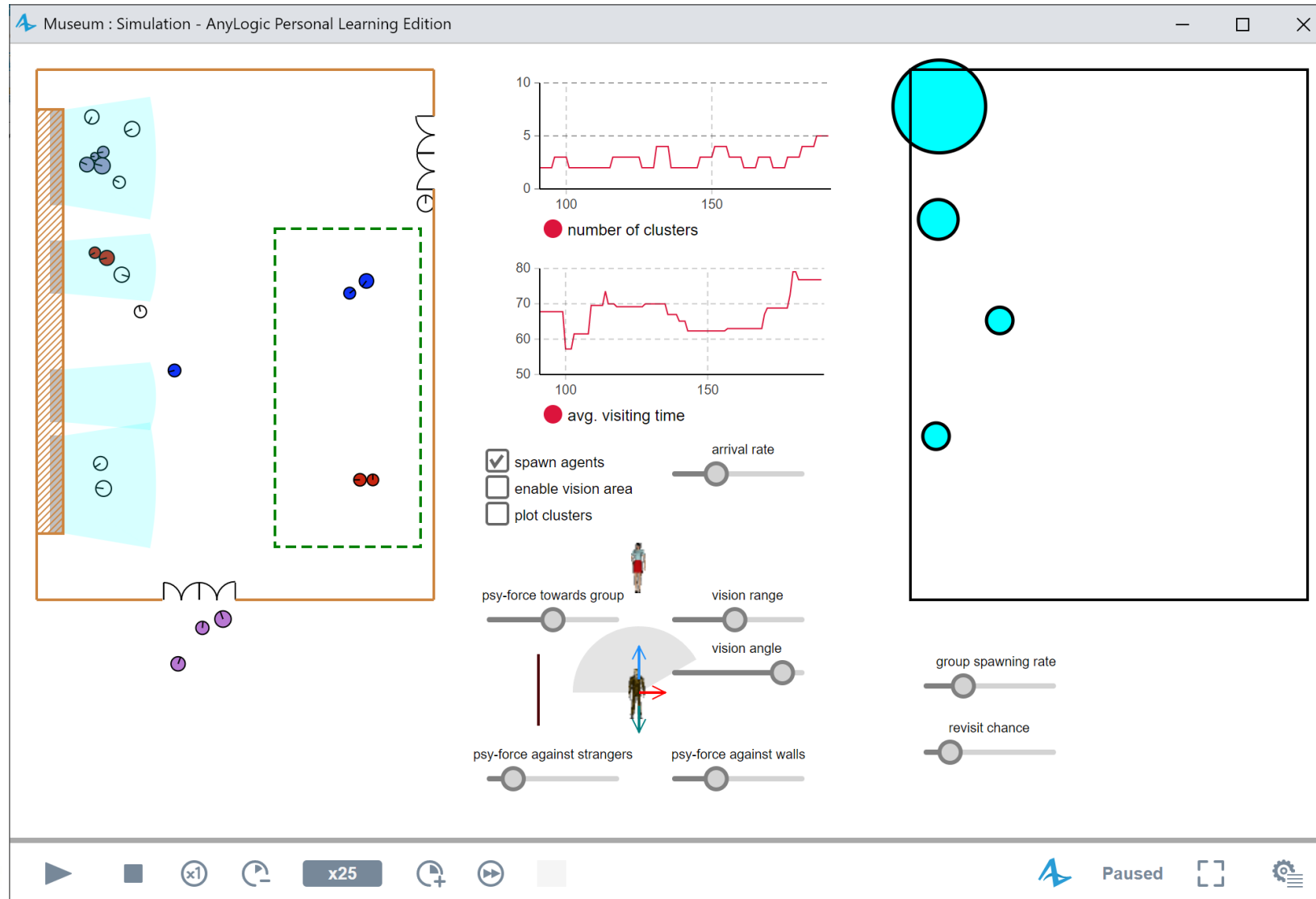
Attributes provide storage for all agents/objects and initialisation parameters required for experimental factors.
Operations are related to responses.

Example: The Implementation Strategy

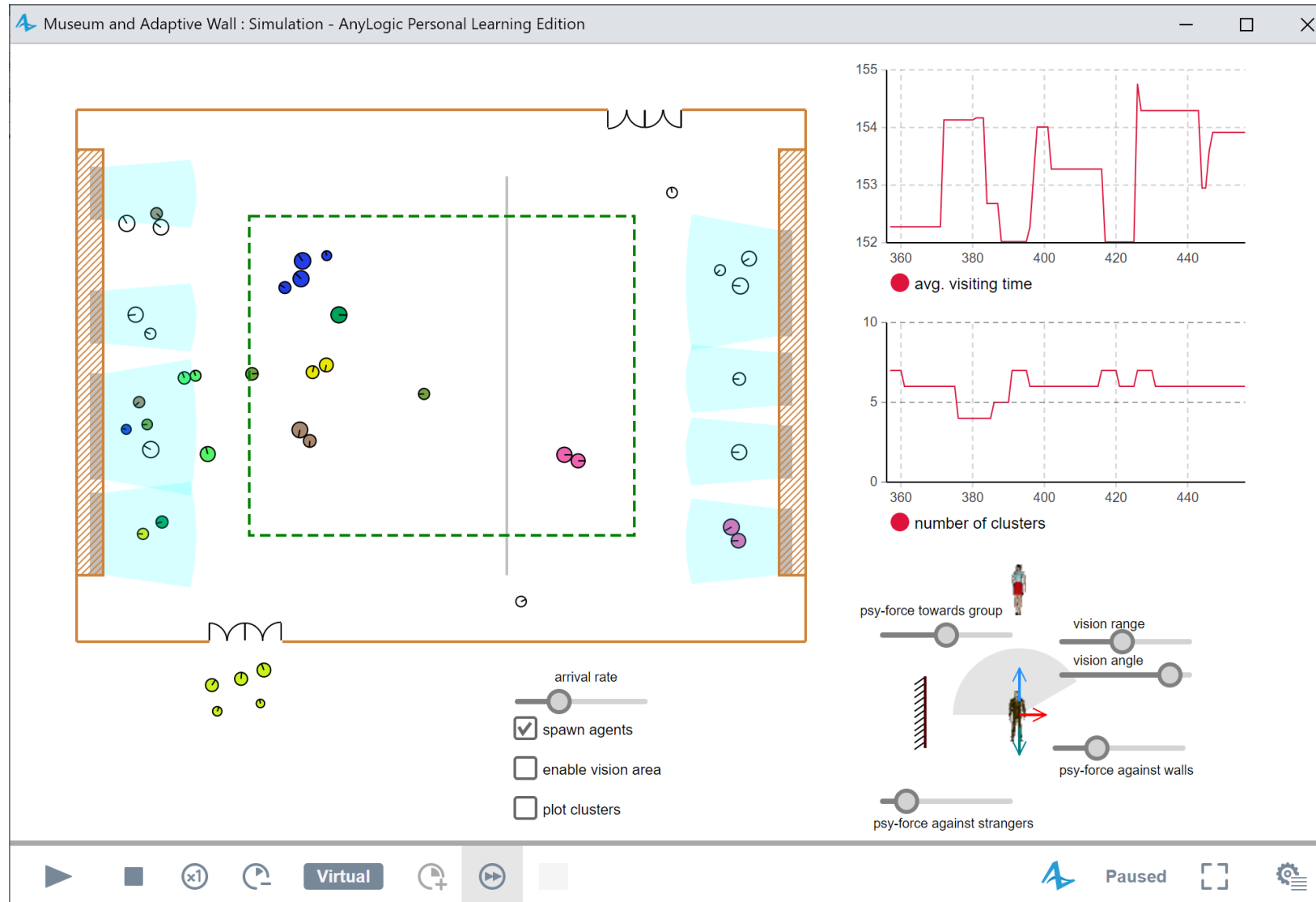


Siebers et al (2018)

Example: The Implemented Model



Example: Extended Version (Moving Wall)



Resources

The EABSS Toolkit

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

The University of Nottingham School of Computer Science ima Intelligent Modelling & Analysis

The 'Engineering Agent-Based Social Simulation Toolkit' v2023-05-01

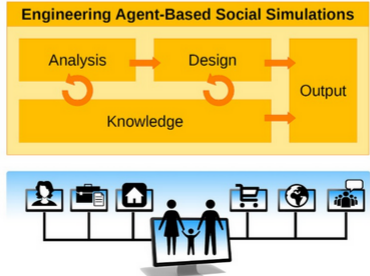
Author

Dr Peer-Olaf Siebers, School of Computer Science, Nottingham University, NG8 1BB, UK [\[url\]](#)

Overview

This toolkit helps people from academia, non-governmental organisations, governmental organisations, and industry, to jointly develop conceptual agent-based models in a structured way for the purpose of better understanding and simulating systems where humans and their behaviours and decisions play a key role. At its heart, the toolkit uses a well established co-creation framework, namely the EABSS framework (Siebers and Kluegl 2017).

Following the guidance under 'Training Workshop' (below) will teach people interested in this toolkit the basic concepts of agent-based modelling and they will gain some knowledge about how to develop conceptual agent-based models with the help of the EABSS framework.



```
graph LR; Analysis --> Design; Design --> Output; Knowledge --- Analysis; Knowledge --- Design; Knowledge --- Output;
```

The EABSS Toolkit

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

Training Workshop

Day 1

1. Welcome [\[slides\]](#)
2. Simulation Modelling Framework [\[slides\]](#)
3. Agent Based Modelling and Simulation [\[slides\]](#)
4. EABSS Introduction [\[slides\]](#)

Day 2

5. Running Focus Groups [\[slides\]](#)
6. UML (Unified Modelling Language) [\[slides\]](#)
7. EABSS Example [\[slides\]](#) [\[model 1\]](#) [\[model 2\]](#)
8. EABSS Practice (recreate and improve an existing model) [\[slides\]](#)

Day 3

9. AnyLogic + OO + Java [\[slides\]](#) [\[model\]](#)
10. EABSS Practice (create your own model)

Case Studies (these are ABM studies not directly related to the EABSS)

- Multi-Method Integrated Assessment Modelling of Global Climate Change [\[slides\]](#) [\[model\]](#)
- Modelling Office Building Energy Consumption [\[slides\]](#) [\[model\]](#)
- A First Approach on Modelling Staff Proactiveness in Retail Simulations [\[slides\]](#)

Resources

- OR Society Short Course 2023 - Flyer + Focus Group Guidance [\[pdf\]](#)
- OR Simulation Workshop 2023 - Poster [\[pdf\]](#)
- Collection of EABSS Workshop Outcomes
 - Coming soon ...
 - Coming soon ...
 - Coming soon ...

References

- Siebers PO and Kluegl F (2017) 'What Software Engineering has to offer to Agent-Based Social Simulation'. In: Edmonds B and Meyer R (Eds). Simulating Social Complexity: A Handbook - 2e

Any Questions?



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

References

- Siebers PO, Deng Y, Thaler J (2018). Proposal of a design pattern for embedding the concept of social forces in human centric simulation models. In: Proceedings of the 9th Simulation Workshop (SW2018), 19-21 Mar, Stratford, Worcestershire, UK.
- Siebers PO (2019). Community modelling and communication with PhiloLab. Presented at the Agent-Based Models in Philosophy - Prospects and Limitations Workshop, 20-22 Mar, Bochum, Germany.
 - Updated version from 2023 available online: https://www.cs.nott.ac.uk/~pszps/eabss2023/OR_ShortCourse_2023.pdf