Agents to the Rescue

Creating Artificial Labs for Evaluating Complex Systems

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Engineering ABSS

- Problem
  - Agent-Based Social Simulation (ABSS) partially suffers from the fact that despite of its increasing popularity there is no standard way of addressing model development
  - This becomes even more of a problem for:
    - Larger projects
    - Collaborative projects
    - Multi disciplinary projects

Engineering ABSS

- Proposed solution
  – Using focus group discussions with stakeholders (group size 4-5)
  – Using a framework (a set of predefined tables and UML diagrams) to capture information and stimulate debates between stakeholders

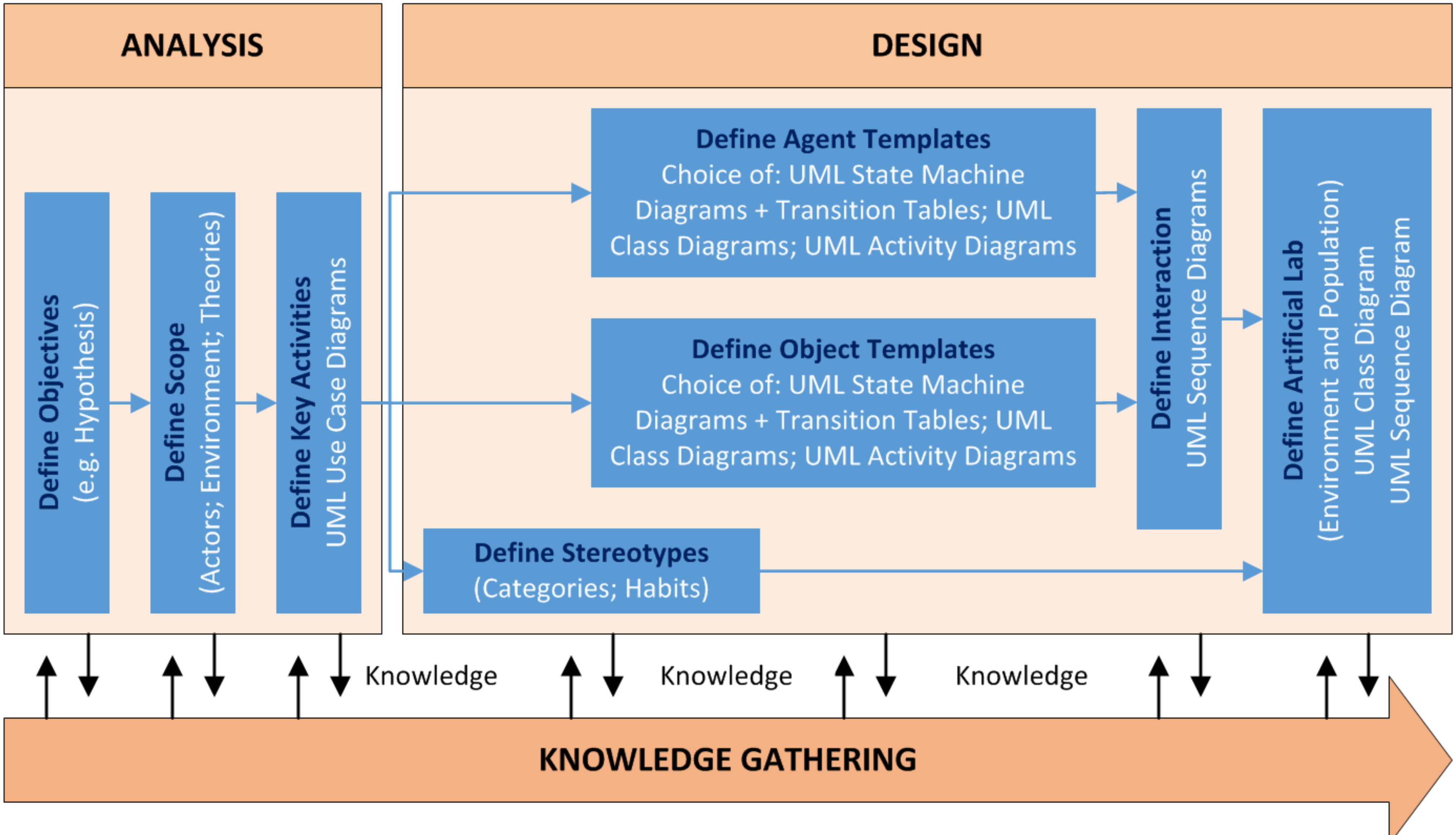
- We found that ...
  – Using a graphical notation reduces linguistic boundaries
    - Everyone can equally be part of the model development process
  – Different viewpoints can be easier unearthed and captured
  – Model development is an evolutionary process driven by input from stakeholders and not led by the way the modeller sees the world

Engineering ABSS

- Agents
  – What are they?
- Agent-Based Models
  – What are they?

- Can we have a common conceptual way of developing these?
  – To support multi disciplinary collaboration
  – To work for all kinds of stakeholders
  – For exploratory and explanatory studies
  – For communication; conceptual modelling; reverse engineering

Engineering ABSS



Siebers and Klügl (2017)

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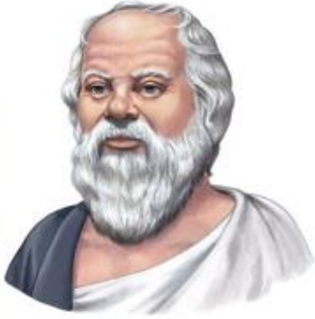
- Things to take into consideration to make this a success
  - Socrates vs Confucius
    - Collaborative brainstorming
    - Information capturing
  - Moderators
    - Will try their best to guide you
    - Will act as stakeholder
  - Iterative process
    - Important to go forward and backwards



Knowledge Gathering

- Knowledge gathering happens throughout the structured modelling approach through
  - Literature review
  - Focus group discussions
  - Observations
  - Surveys

- Either a prerequisite for tasks (e.g. a literature review) or is embedded within the tasks (e.g. focus group discussions)

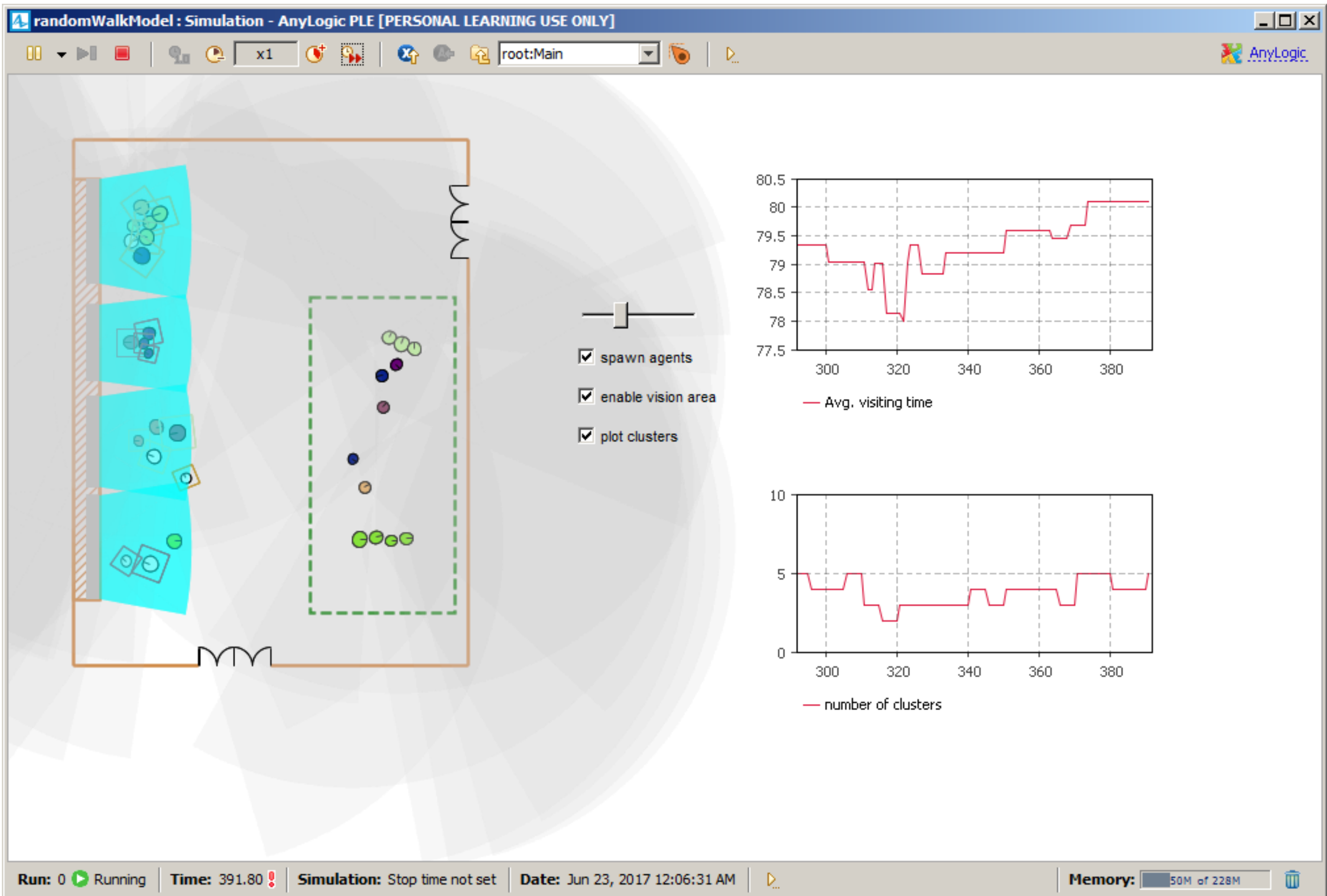
Case Study 1

Adaptive Architecture

Case Study 1: Context

- 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.

Case Study 1: Outcome



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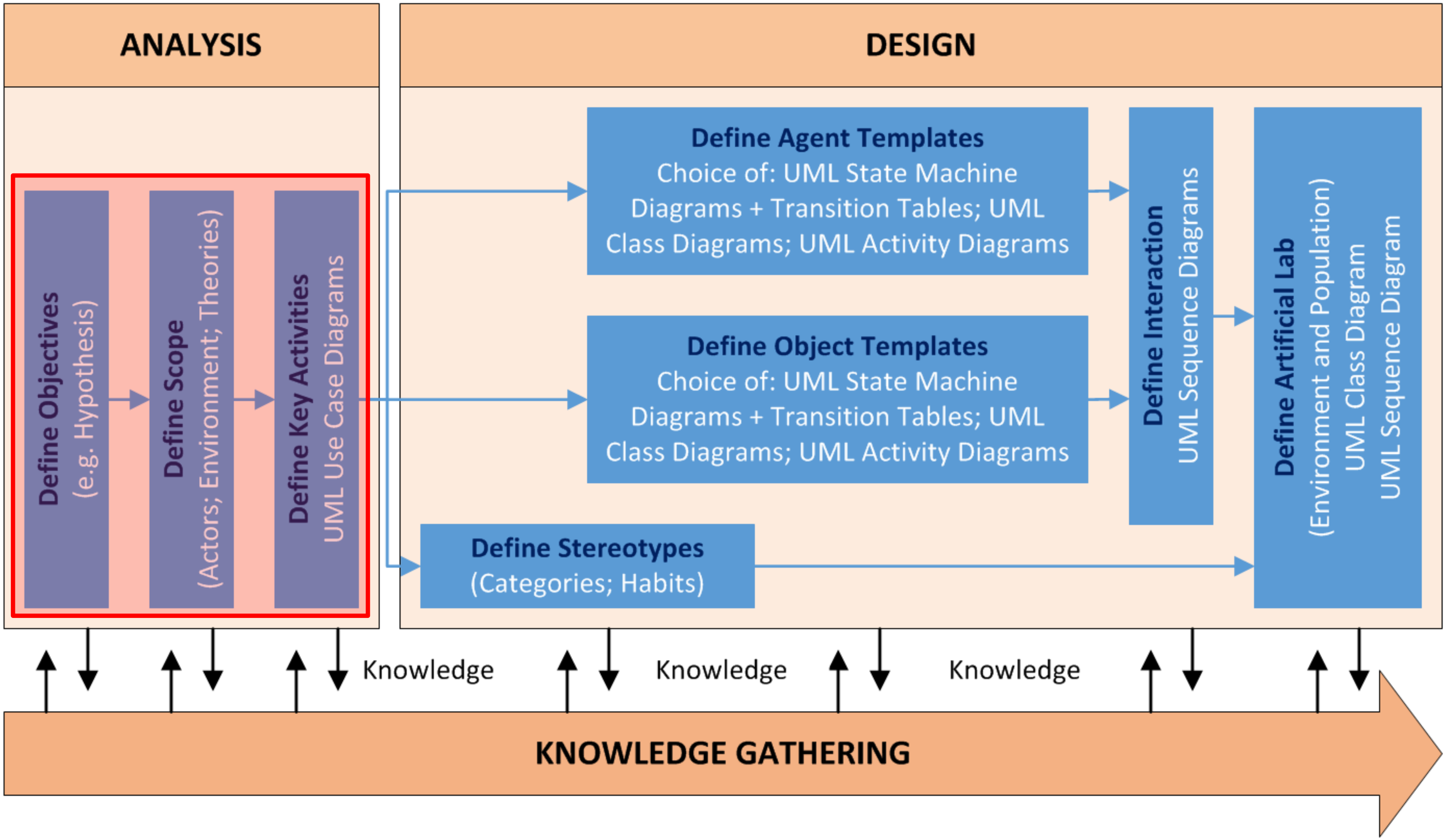

Siebers and Klügl (2017)

Defining the Objectives

- Define objectives in relation to the aim of the study
  - Literature review or focus group discussions or given by client
  - Alternative: Defining hypotheses

- How can we test these objectives?
  - Consider relevant experimental factors and responses
    - Experimental factors are simulation inputs that need to be set initially to test different scenarios related to the objectives
    - Responses are simulation outputs that provide insight and show to what level the objectives have been achieved
  - Objectives and hypotheses are very helpful for defining an initial set of experimental factors and responses

Case Study 1: Analysis

- Aim
  - Study the impact of an adaptive screen (including several display windows) in a museum exhibition room
- Objectives / Hypotheses
  - Objectives
    - Study if engagement of visitors is influenced by window size
    - Study if engagement of visitors is influenced by space availability
    - 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)

Case Study 1: Analysis

- Objectives / Hypotheses (cont.)
  - 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
    - Architects enjoy interacting with the simulation models to better understand new concepts
- Experimental Factors
  - A subset of parameters of the underlying theoretical movement model; visitors arrival rate; initial number of windows
- Responses
  - Number of groups of visitors; position of centroids of these groups; visitor; average time spend in the museum; visual representation of the system and its dynamics

Defining the Scope

- We are interested in specifying the model scope
  - Often requires some initial knowledge gathering
    - Literature review and observation of the existing system
  - With the help of the knowledge gathered one can then define the scope of the model by defining a scope table
    - Focus group discussions
  - In order to make decisions about including/excluding elements one needs to answer the following questions:
    - What is the appropriate level of abstraction for the objective(s) stated before?
      - This would define the level of abstraction acceptable
    - Do the elements have a relevant impact on overall dynamics of the system?
      - Then they should be included
    - Do the elements show similar behaviour to other elements?
      - Then they should be grouped

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Case Study 1: Analysis

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

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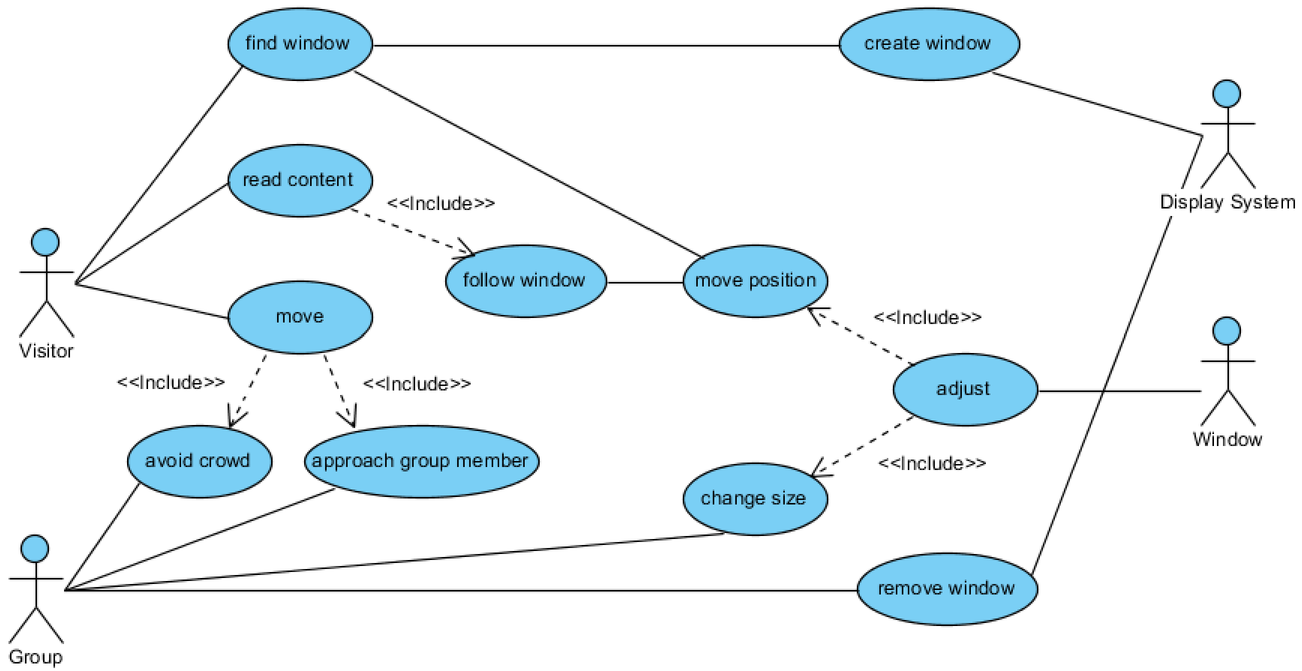
Defining Key Activities

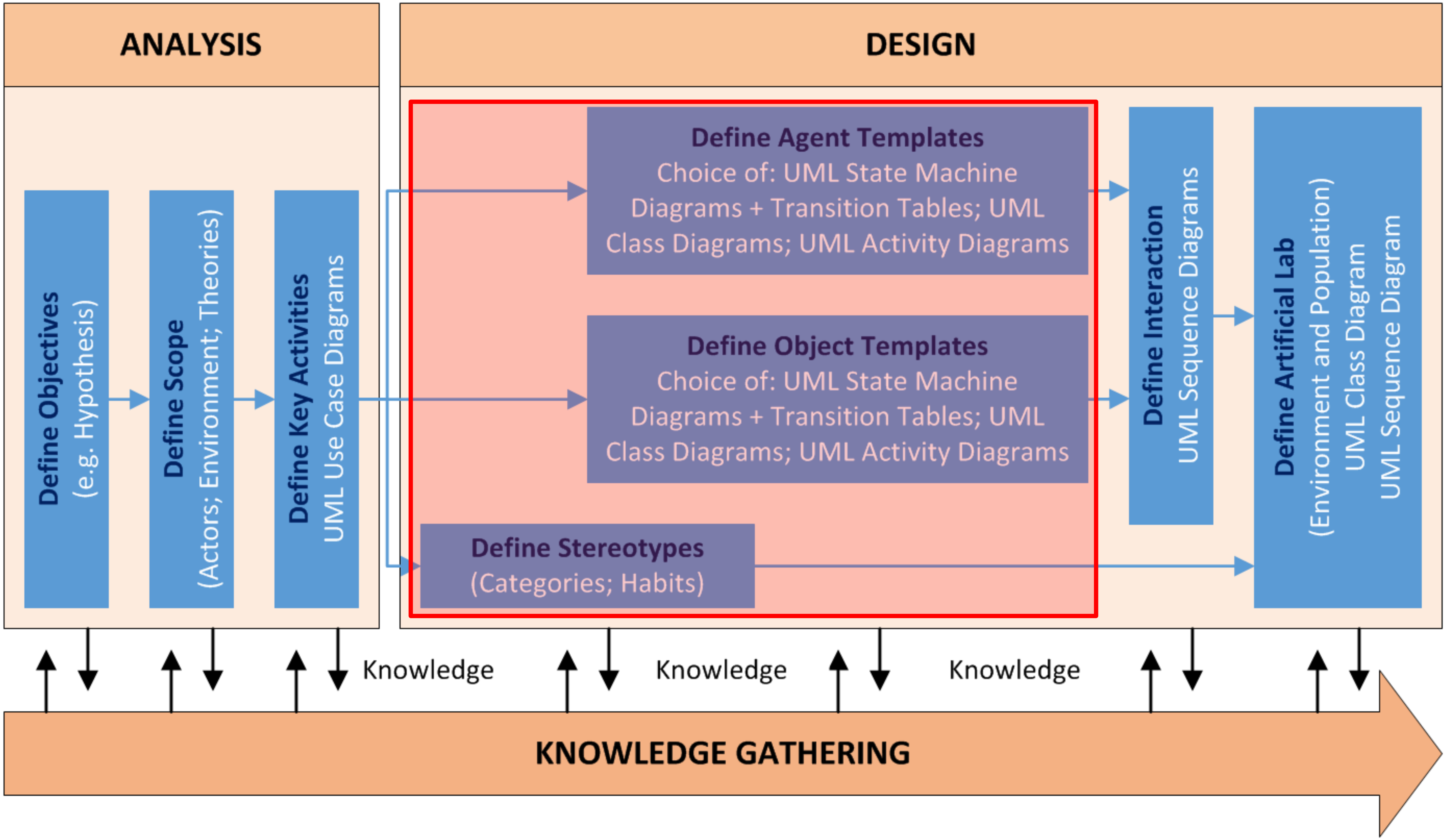
- Interaction can take place between actors and between actors and the physical environment they are in
- Capturing these at a high level can be done with the help of UML use case diagrams
  - When using use case diagrams in an ABSS context the actors are inside the system; they represent the humans that interact with each other and the environment; the system boundaries are the boundaries of the relevant locations
- Derived through focus group discussions

Case Study 1: Analysis

- Key activities



Engineering ABSS



Siebers and Klügl (2017)

Defining Stereotypes

- In order to be able to represent a specific population in our simulation models we define stereotypes that allow us to classify the members of this population
  - Habit templates (derived from focus group discussions)
  - Utility function (derived from the literature)
  - Demographics
  - Advanced data analytics.

- Data for classifying the population can be collected through surveys

Case Study 1: Design

- Stereotypes

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

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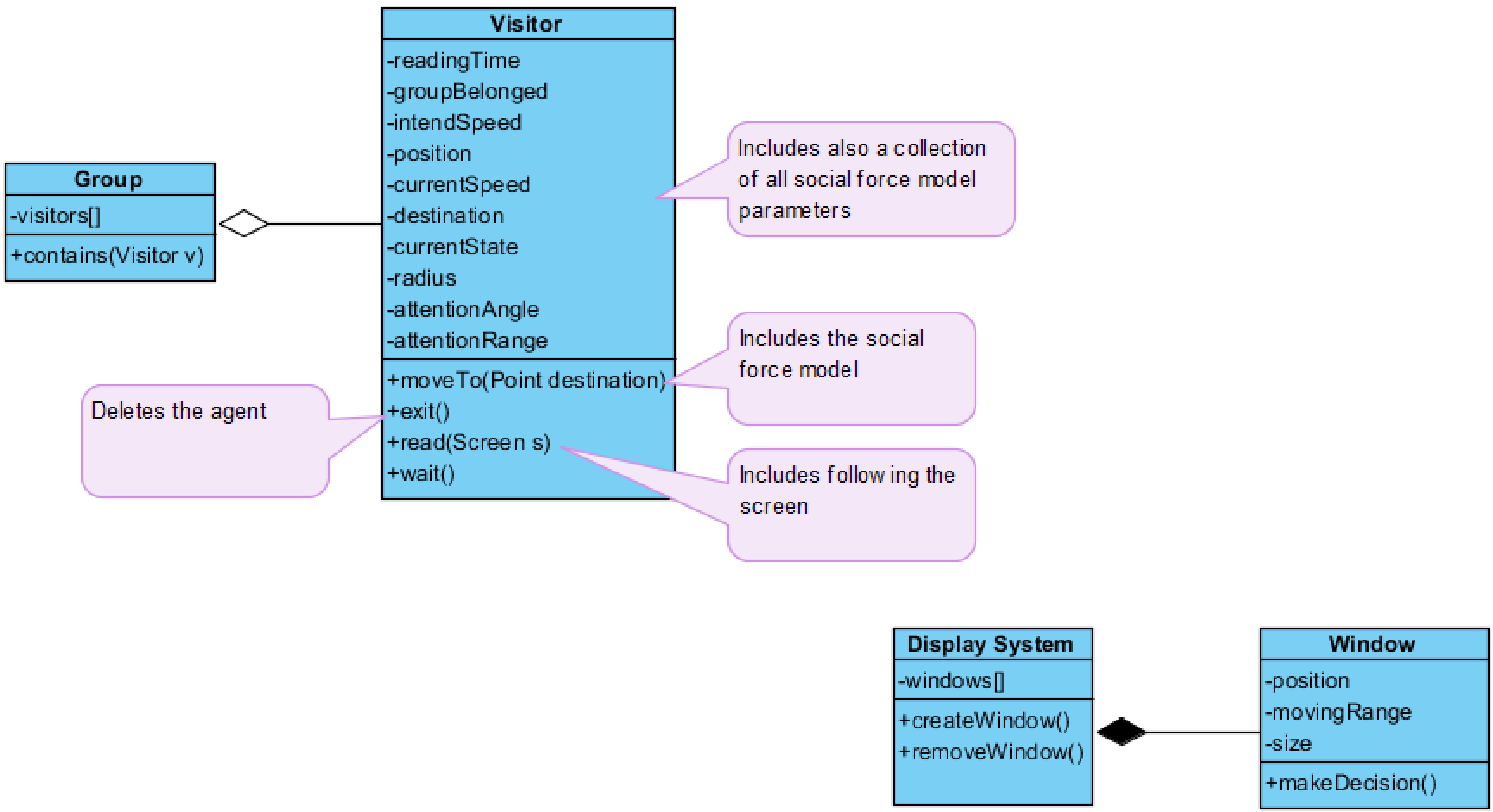
Defining Agent and Object Templates

- Actor types identified in scope table
  - We have to develop an agent template
- Physical environment identified in the scope table
  - We have to develop object templates where appropriate
  - For other things we need to consider other modelling methods
- Relevant UML diagram types:
  - UML class diagram (to define structure)
  - UML state machine diagram (to define behaviour)
  - UML activity diagram (to define logic)

- Derived through focus group discussions

Case Study 1: Design



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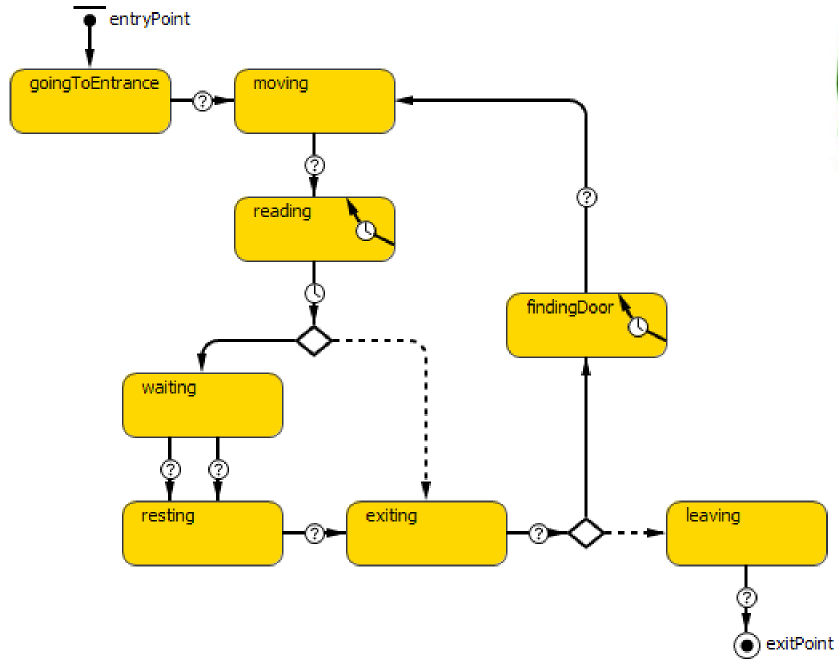

- State machine diagram of visitor

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

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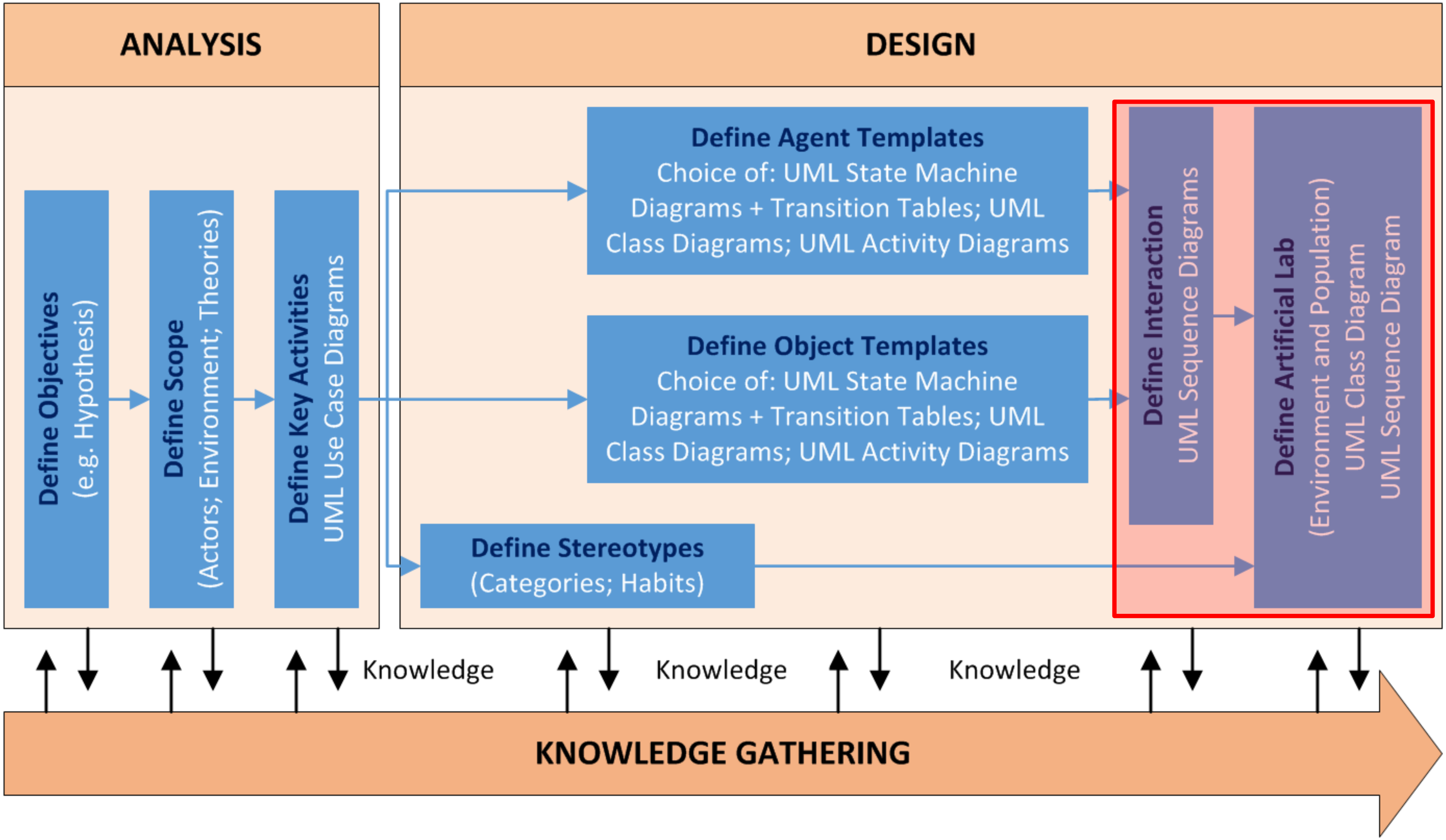

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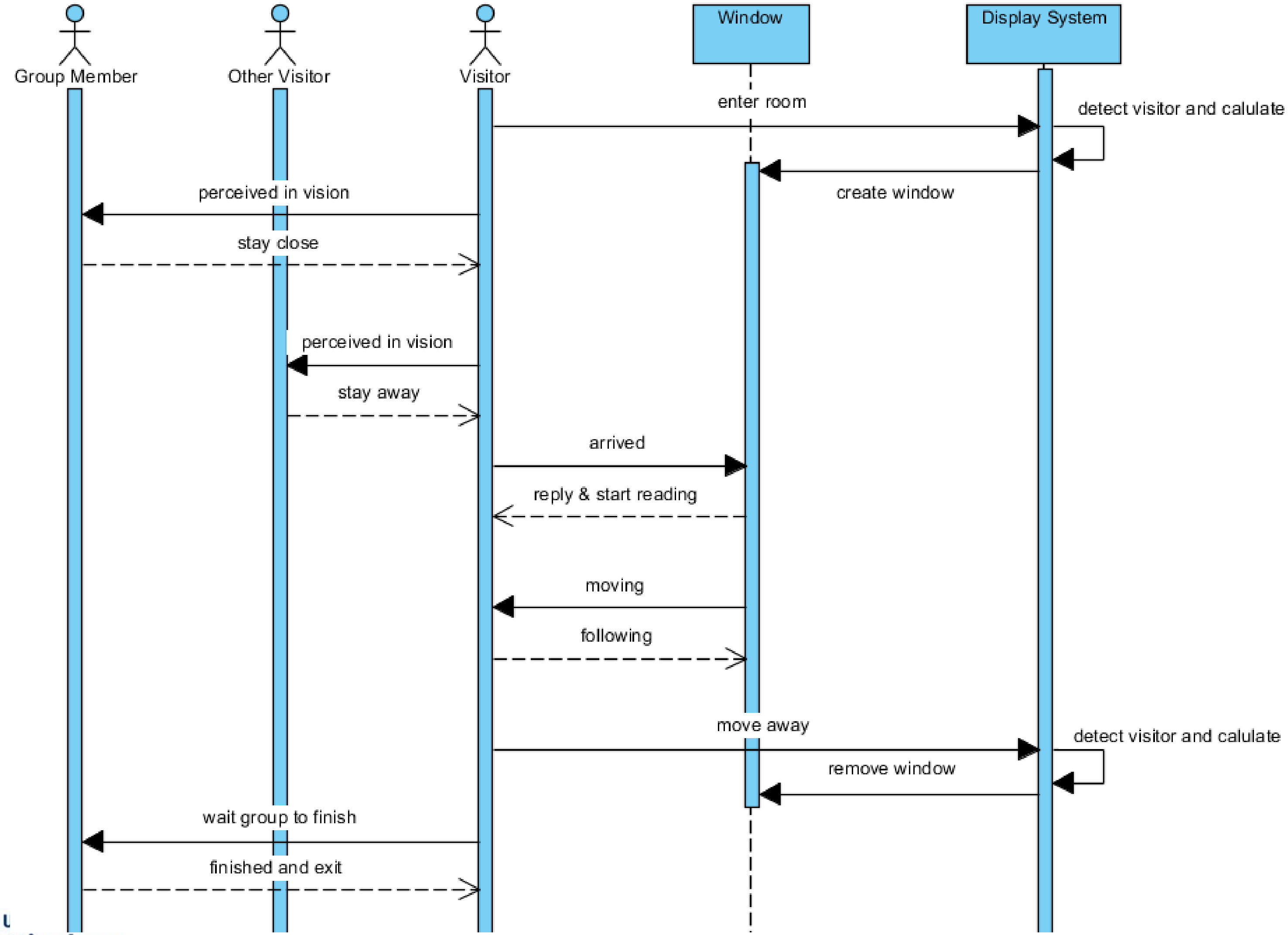
Defining Interactions

- Capturing interactions in more detail can be done by using UML sequence diagrams; this can be used to further specify use cases that involve direct interactions (usually in form of message passing) between entities (agents and objects)

- Derived through focus group discussions

Case Study 1: Design



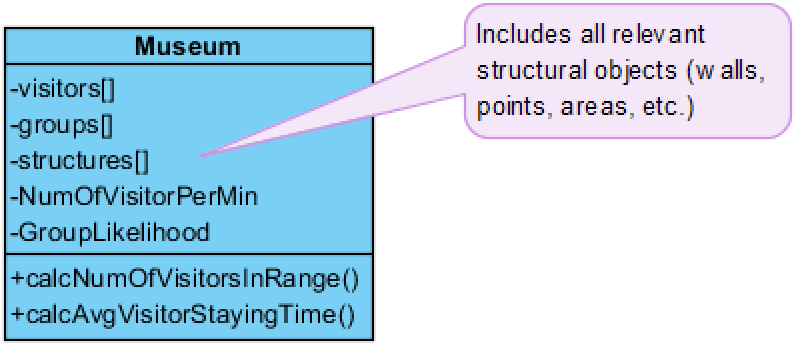
Defining the Artificial Lab

- Finally we need to define an environment in which we can embed all our entities and define some global functionality
  - We need to consider things like:
    - Global variables (e.g. to collect statistics)
    - Compound variables (e.g. to store a collection of agents and objects)
    - Global functions (e.g. to read/write to a file)
  - We also need to make sure that we have all variables in place to set the experimental factors and to collect the responses we require for testing our hypotheses

- Derived through focus group discussions and by looking at the list of objectives and the scope table

Case Study 1: Design

- Artificial Lab



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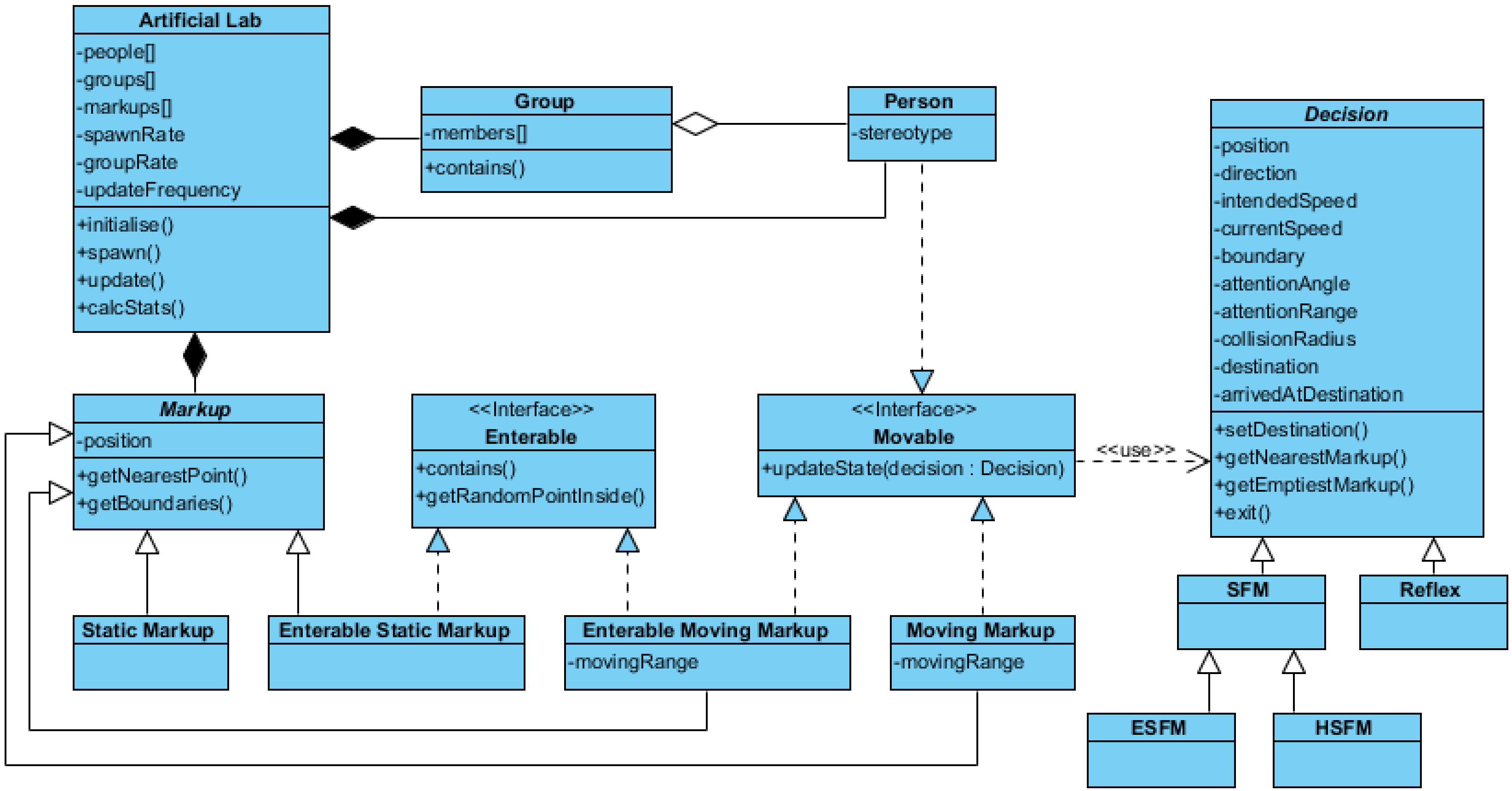
Defining the Artificial Lab

- Sometimes it can be helpful to create a sequence diagram to visually show the order of execution describing the actions taken on various elements at each step of the simulation from a high level approach

- The way and order in which all entities are initialised, as well as the way and order how they are updated and how their interactions are handled, is often not trivial and a major source of artefacts

Case Study 1: Implementation Design Pattern



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Case Study 2 (for home study)

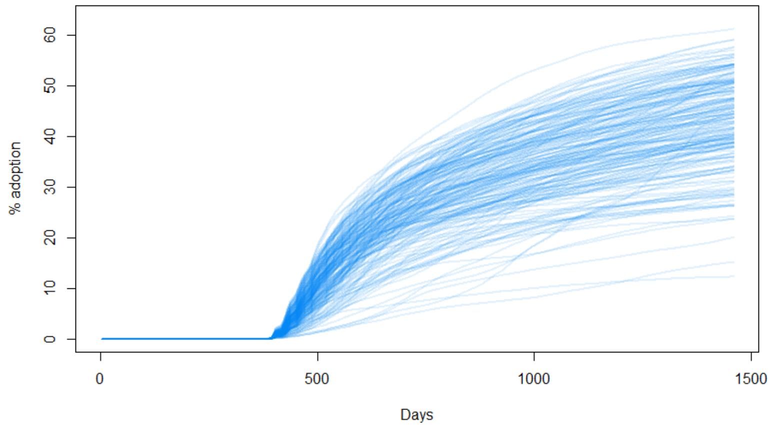
PV Panel Uptake

Case Study 2

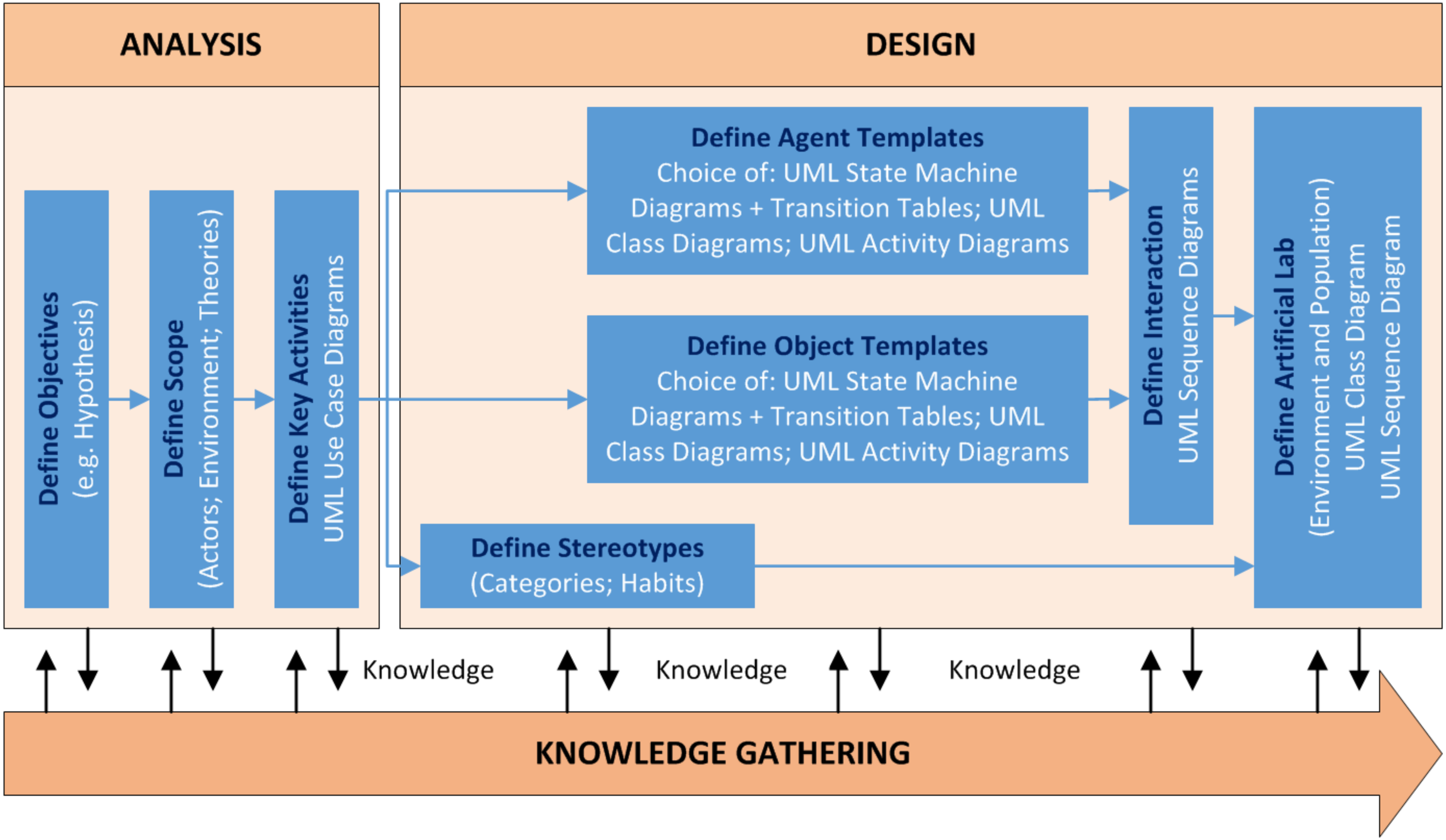
- Context
  - Technology Adoption in the Transition to a Smart Grid: The Case of Photovoltaic (PV) System Adoption in the UK

(after Snape 2015)

Case Study 2: Outcome



Engineering ABSS



Siebers and Klügl (2017)

Case Study 2: Analysis

- Aim
  - Study the effect of policy on adoption patterns of photo voltaic systems (PVs) on people's roof-tops
- Objectives
  - Study the effect of introduction of Feed-in-Tariff (FiT)
  - Study the effect of change of FiT
  - Study the effect of neighbourhood observation
  - Impact of "hassle" on willingness to adopt
- Hypotheses
  - Introduction of FiT would incentivise a high rate of adoption
  - If a system is too difficult to install > this will act like a block
  - Observation of neighbours would encourage individuals to adopt

Case Study 2: Analysis

- Experimental factors
  - Initial population composition
    - Categorised by greenness of behaviour
  - Radius that each agent can observe
  - Level of tariff paid for PV generation
  - The level of "hassle" that installation caused to households

- Responses
  - Percentage of households adopting
  - Timing of household adoption

Case Study 2: Analysis

- Scope
  - Explanatory model
    - Answer real world policy questions
  - Low level (individual households)
    - But ...
      - Computational limitations (limited use of HPC)
      - Manpower and time constraints for conducting the study
      - Data availability limited

Category		ID	Element	Decision	Group	Name	Justification
Actor		1	Household	Group	1+7	Household	
		2	Houshold member (occupant)	Exclude			Considered by household (abstraction)
		3	Installer	Exclude			Installation assumed to be equally priced and competent
		4	Government	Group	4+13	Government	
		5	Electricity supplier	Include		Supplier	
		6	Manufacturer	Exclude			Not relevant for achiving study aim
		7	Neighbouring household	Group	1+7	Household	Same as 1; neighbourhood determined by spatial proximity
		8	Neighbouring household member	Exclude			Considered by neighbouring household (abstraction)
		9	Neighbourhood	Exclude			Not an explicit separate entity
		10	Consumer Group	Exclude			Considering only individual owned PV systems
		11	Community	Exclude			Considering only individual owned PV systems
		12	Firm	Exclude			Not relevant for achiving study aim
		13	Regulator	Group	4+13	Government	
Physical Environment	Technology + Appliances	14	PV panel	Group	14+15+16	PV System	Low level tech separation not relevant for achiving study aim
		15	Inverter	Group	14+15+16	PV System	
		16	Meter (smart)	Group	14+15+16	PV System	
		17	Computer	Group	17+18+19 +20+21	Household Appliances	Represented as "Demand"
		18	Light	Group	17+18+19 +20+21	Household Appliances	
		19	Cooker	Group	17+18+19 +20+21	Household Appliances	
		20	Fridge	Group	17+18+19 +20+21	Household Appliances	
		21	Heating	Group	17+18+19 +20+21	Household Appliances	
	Weather	22	Sunshine / natural light	Group	22+23+24	Weather File	Part of the environment
		23	Temperature	Group	22+23+24	Weather File	
		24	Clouds	Group	22+23+24	Weather File	
	Buildings + Rooms	25	House orientation (spatial model)	Include			
		26	Shading	Exclude			Not enough computing power
		27	Visibility of PV	Include			Using approximation
		28	Density of housing	Include			
		29	House interior	Exclude			Assume interior layout does not affect decision

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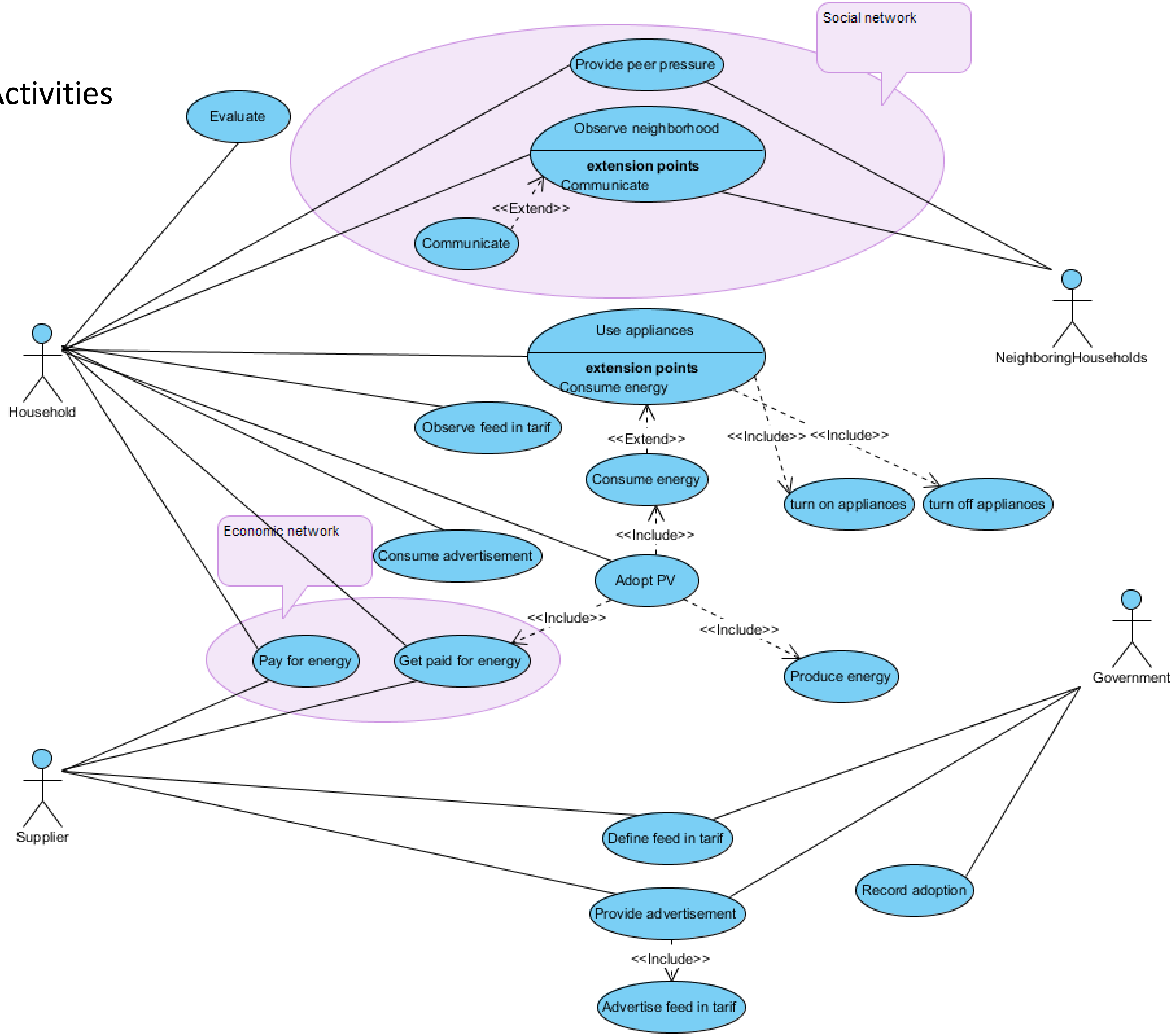
Social and Psychological Aspects		30	Comparative feedback (motivation)	Include			
		31	Reaction to incentives (economic rationality/sensitivity)	Include			
		32	Level of greeness	Include			
		33	Family structure (who makes decisions)	Exclude			Not relevant for achieving case study objectives
		34	Perception of risk	Exclude			Consider for future research
		35	Affectiveness	Include			
		36	Perception of urgency (rushed decision)	Include			
		37	Advertising effectiveness	Include			
		38	Word of mouth (networking)	Include			
		39	Obervation (feeds perceived norm)	Include			
Other	Networks	40	Physical network	Exclude			Network not overloaded in UK
		41	Comms network	Exclude			No smart network
		42	Economic network (supply chain)	Include			
		43	Social network	Include			
	Misc	44	Energy	Exclude			Not explicitly modelled - unit of output

Key Activities



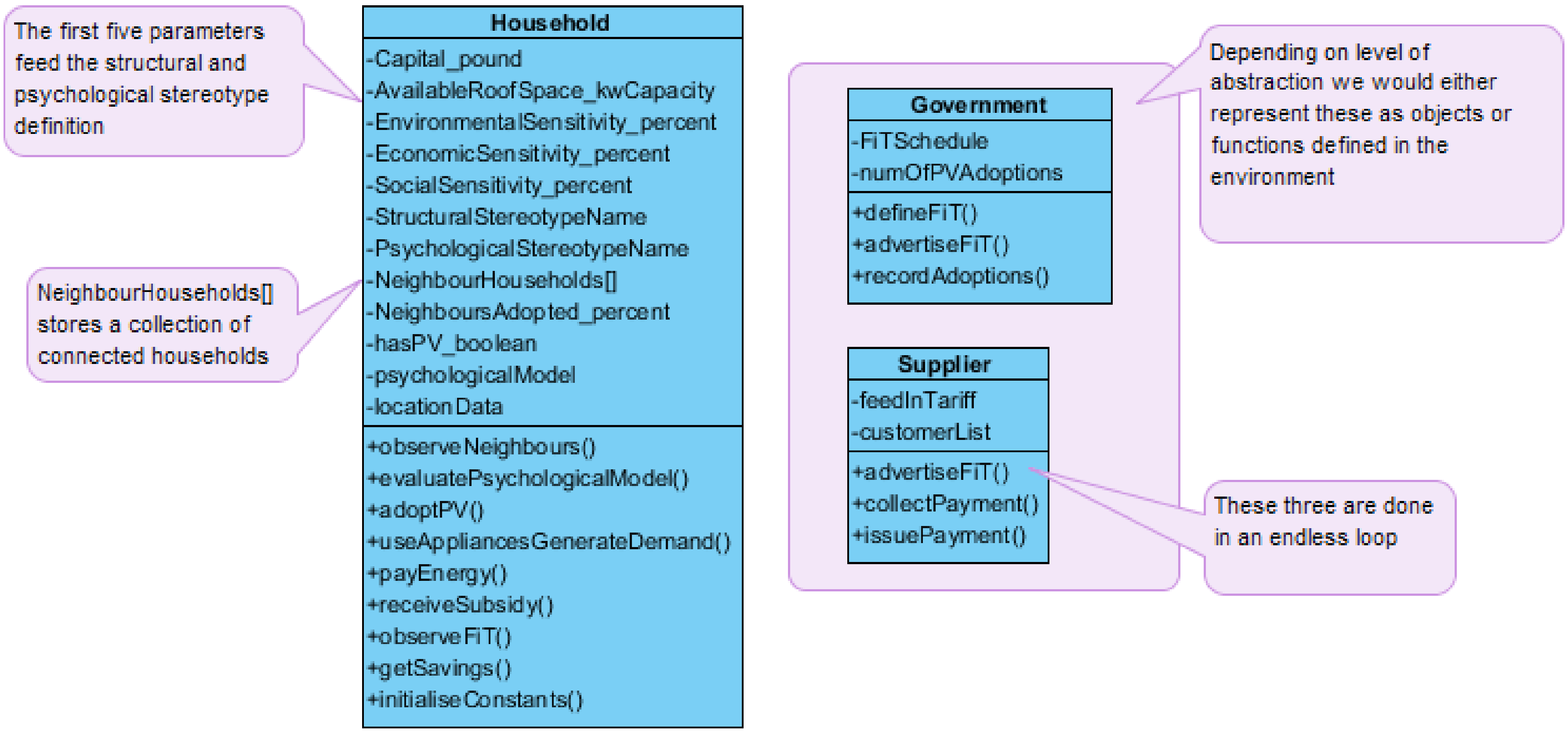
Case Study 2: Design

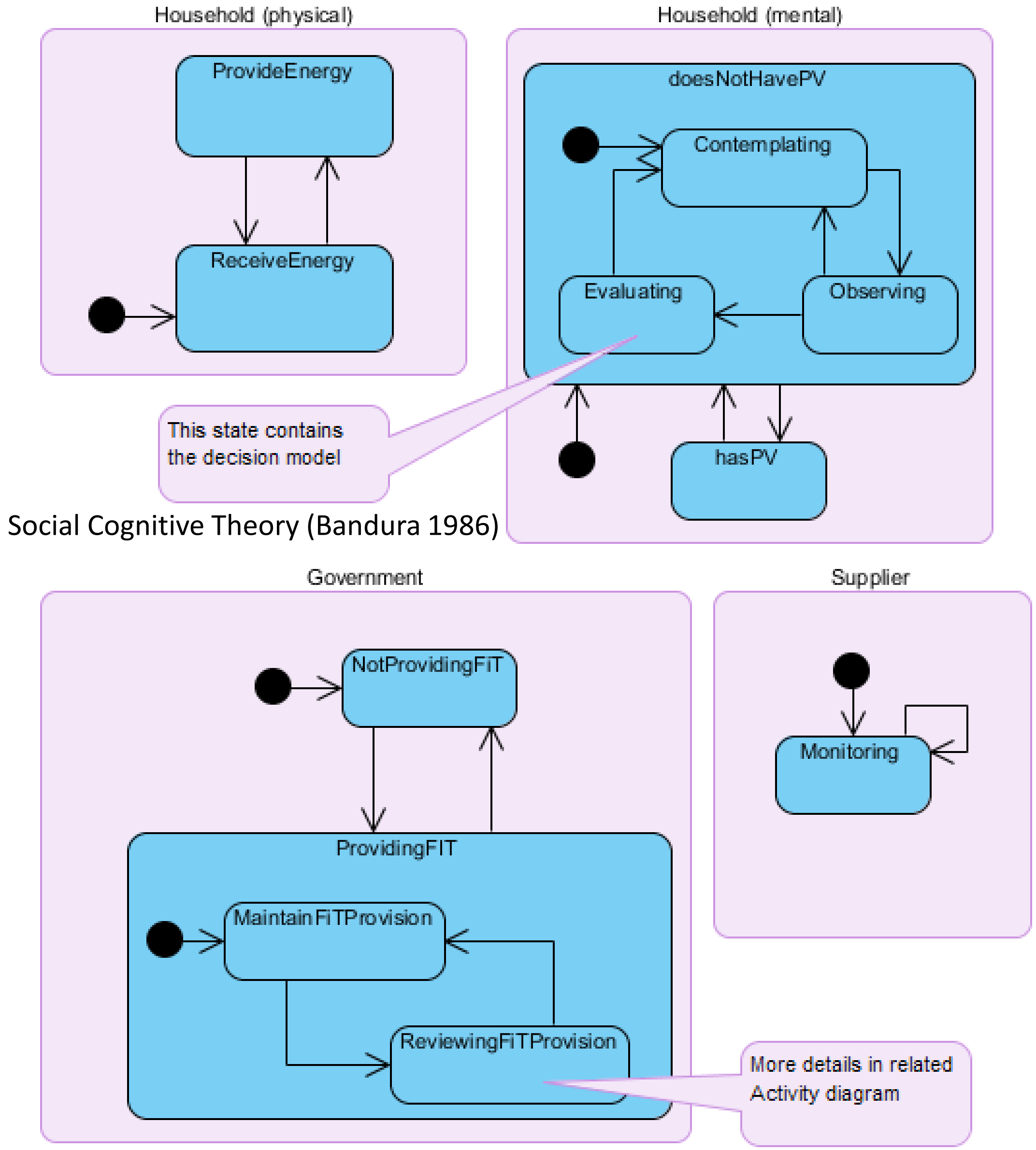
- We identified several categories of stereotypes
  - Structural factors:
    - Demographics
      - Capital
      - Baseline electricity demand
      - Physical house characteristics (orientation, roof capacity for PV)
  - Psychological factors:
    - DEFRA's occupant behaviour model (7 stereotypes)
      - Likelihood of being social
      - Likelihood of being environmental friendly
      - Likelihood of being economically driven

ID	Name
1	Positive Greens
2	Waste watchers
3	Concerned consumers
4	Sideline supporters
5	Cautious participants
6	Stalled starters
7	Honestly Disengaged

Case Study 2: Design

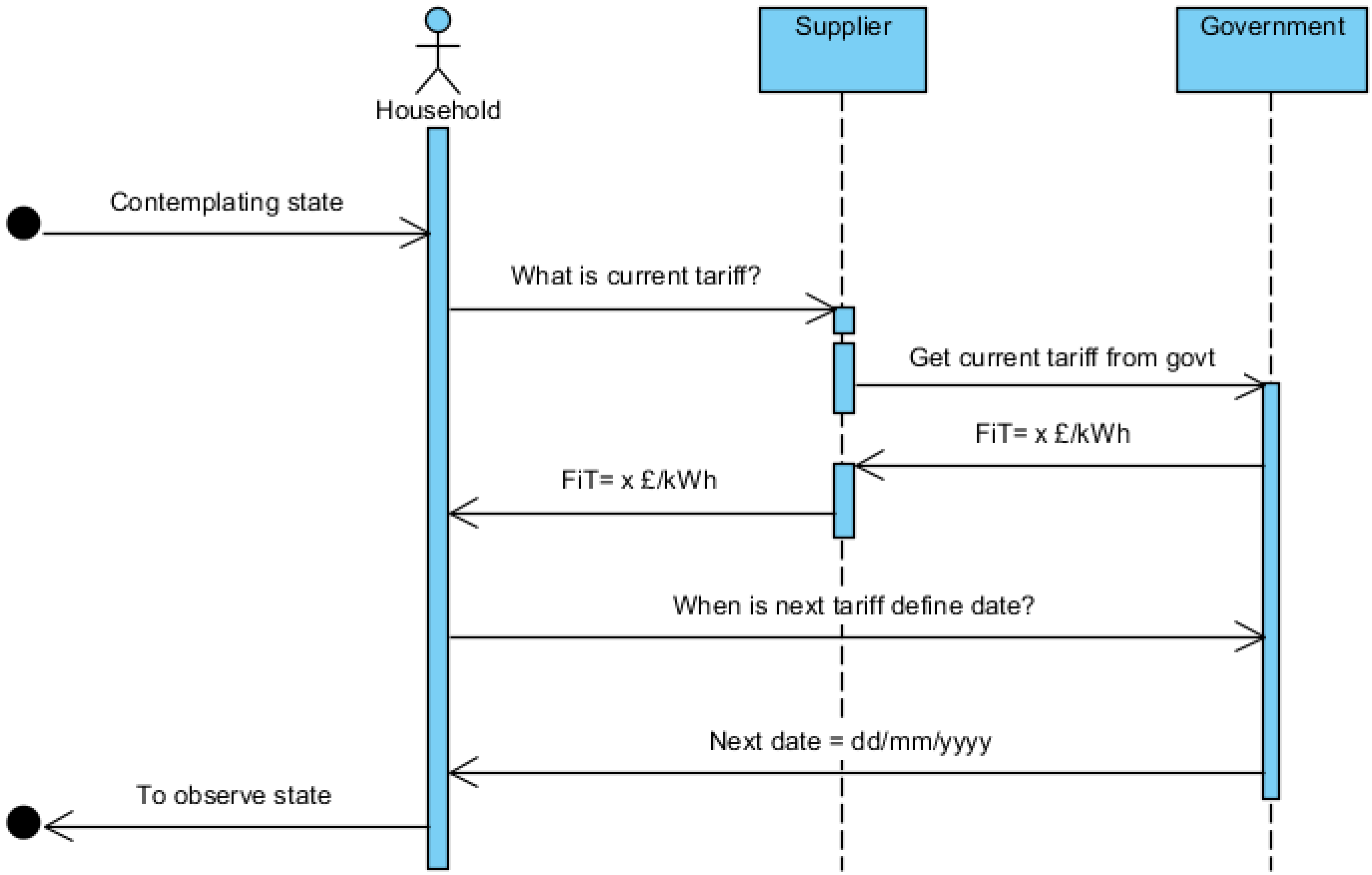
- Agent templates




Household (physical)
ProvideEnergy
ReceiveEnergy
Household (mental)
doesNotHavePV
Contemplating
Evaluating
Observing
hasPV
This state contains
the decision model
Social Cognitive Theory (Bandura 1986)
Government
NotProvidingFiT
ProvidingFIT
MaintainFiTProvision
ReviewingFiTProvision
More details in related
Activity diagram
Supplier
Monitoring

Case Study 2: Design

- Sequence diagram: Observe FiT



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Case Study 2: Design

- Artificial lab

Artificial Lab
-numHouseholds -Geography -numPerStereotype[] -numSuppliers -networkType -weater -choiceModel -isOfferingFiT -initialTariffLevels -FiTAdvertAndUpdateFrequency -capitalPerHousehold -demandPerHousehold
+countAdopters() +countInstalledCapacity() +initialiseHouseholds() +initialiseNetworks() +calculateEnergyProduction() +calculateEnergyConsumption()

References

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