EABSS Workshop 2023

Co-Creation of Agent-Based Social Simulation Models

Case Study (Siebers and Aickelin 2011)

A First Approach on Modelling Staff Proactiveness in Retail Simulations

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Context

- Developing some tools for understanding the impact of management practices on company performance
  - Operational management practices are well researched
  - People management practices are often neglected
    - Difficult to simulate people as they are often unpredictable in their individual behaviour
- Case study sector:
  - Retail (department store operations)
- Problem encountered:
  - When using real staffing rota we could not produce the transaction values of the real system; we had to use some optimised data instead
  - Can we solve this problem by adding proactive behaviour?
  - How can we add proactive behaviour?

Context

- Modelling proactive service behaviour in OR type models
  - The OR literature does not provide any guidance
  - Management literature defines proactive customer service as self started, long term oriented, and persistent service behaviour that goes beyond explicitly prescribed requirements
  - Artificial intelligence literature states that proactive behaviour can be modelled in terms of goals that the agents pursue
    - Declarative: a description of the state sought
    - Procedural: a set of plans for achieving the goal
  - Short waiting times are key to high service quality
  - Therefore: A staff agent goal is to provide best service by proactively balancing the different queues that appear in the department store.

Conceptualisation

- Two case studies at two different locations
  - Two departments (A&TV and WW) at two department stores
- Knowledge gathering
  - Informal participant observations
  - Staff interviews
  - Informational sources internal to the case study organisation

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Conceptualisation

- Agent Oriented DES (AO-DES)
  - In combined AO-DES models we represent the process flow with the help of a DES model and then add some active entities to replace the passive DES ones
    - Active entities are autonomous and can display proactive behaviour

Conceptualisation

Communication layer

Direct interactions
Network activities

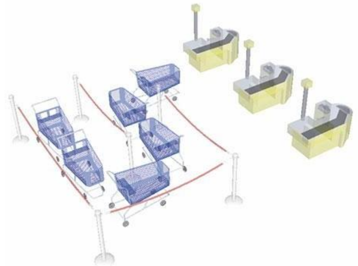
Let entities interact + communicate

Agent layer

Active entities
Behavioural state charts

Replace passive entities by active ones

Discrete Event layer



Passive entities Queues
Processes Resources

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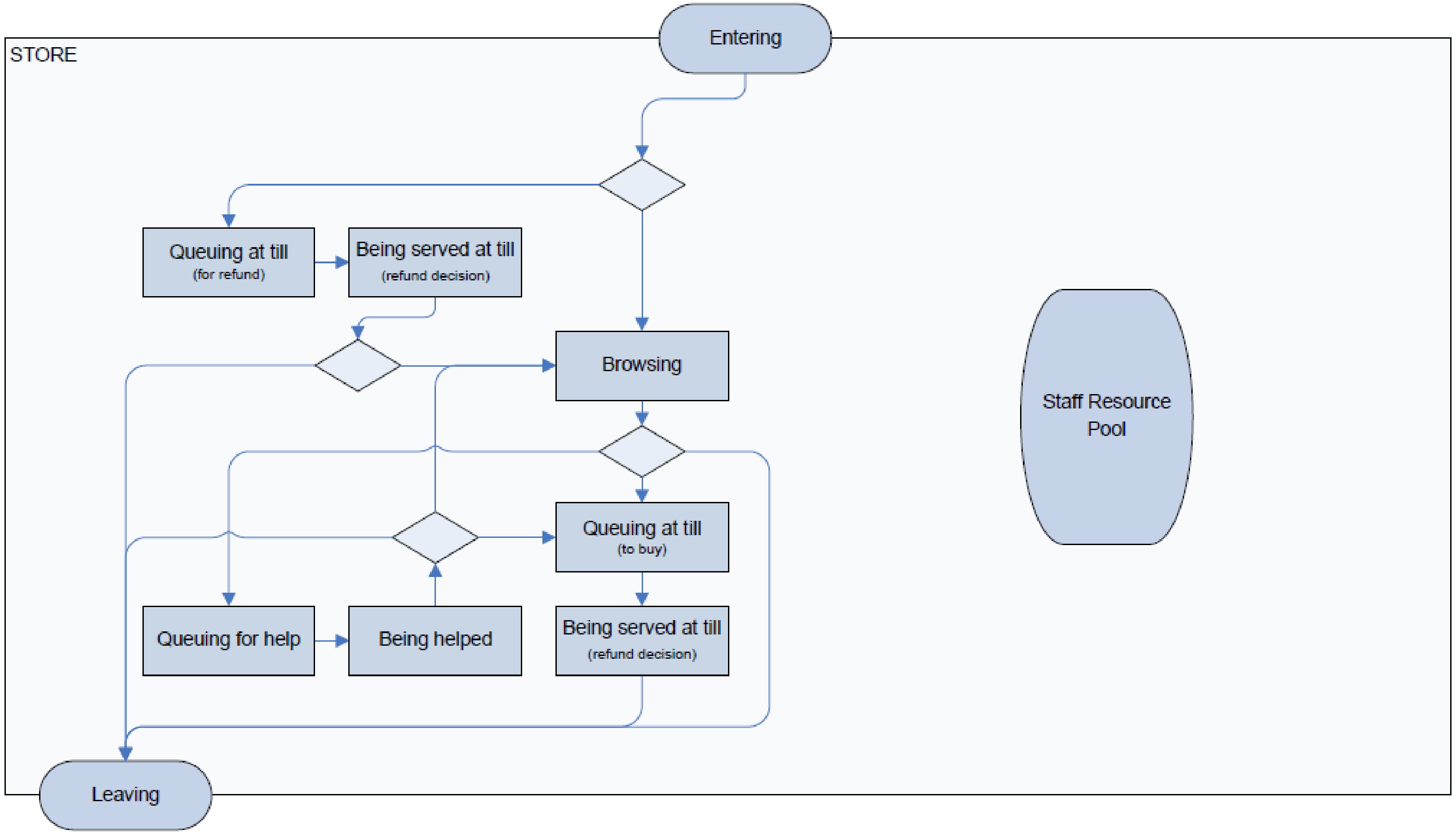
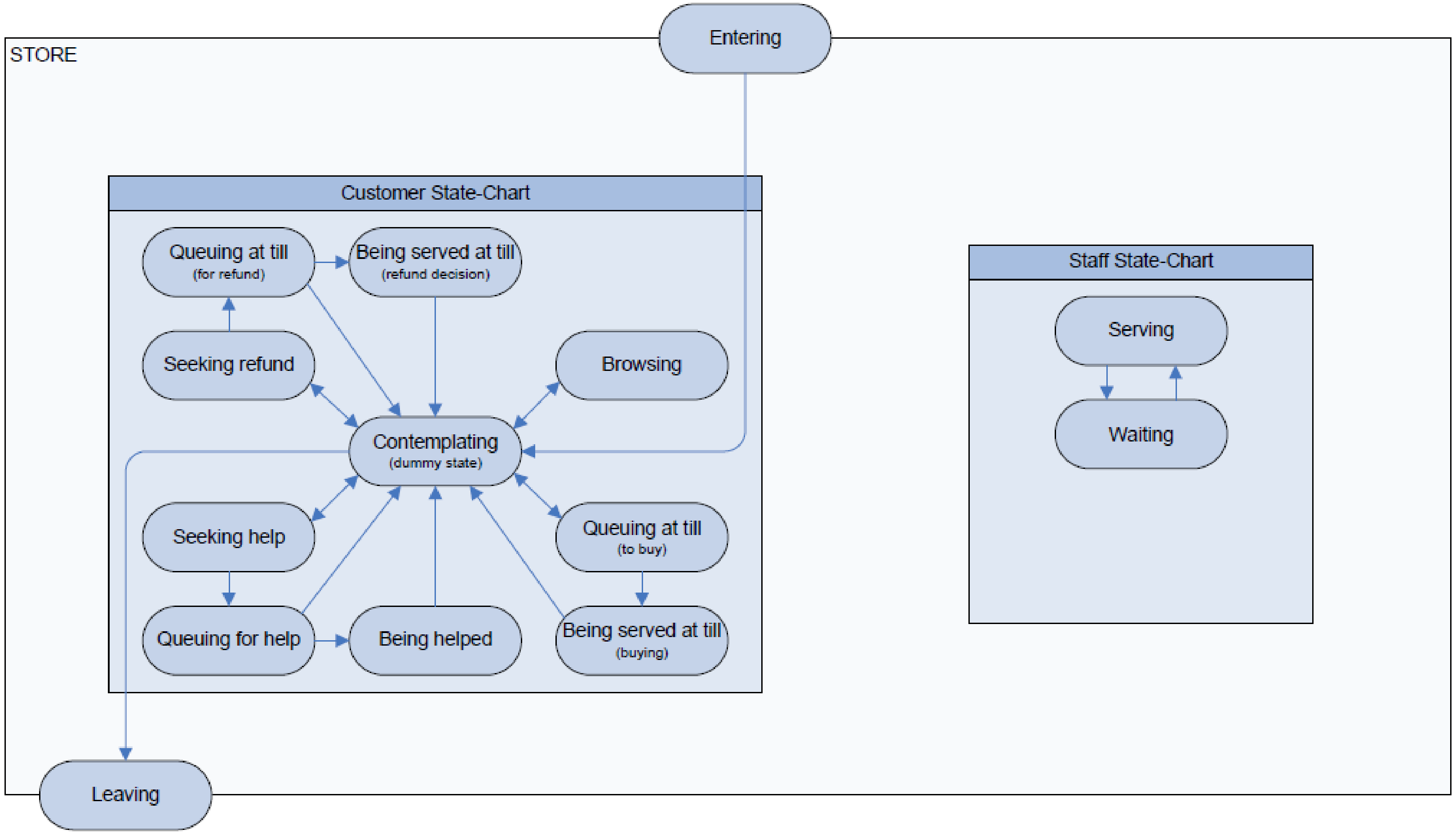
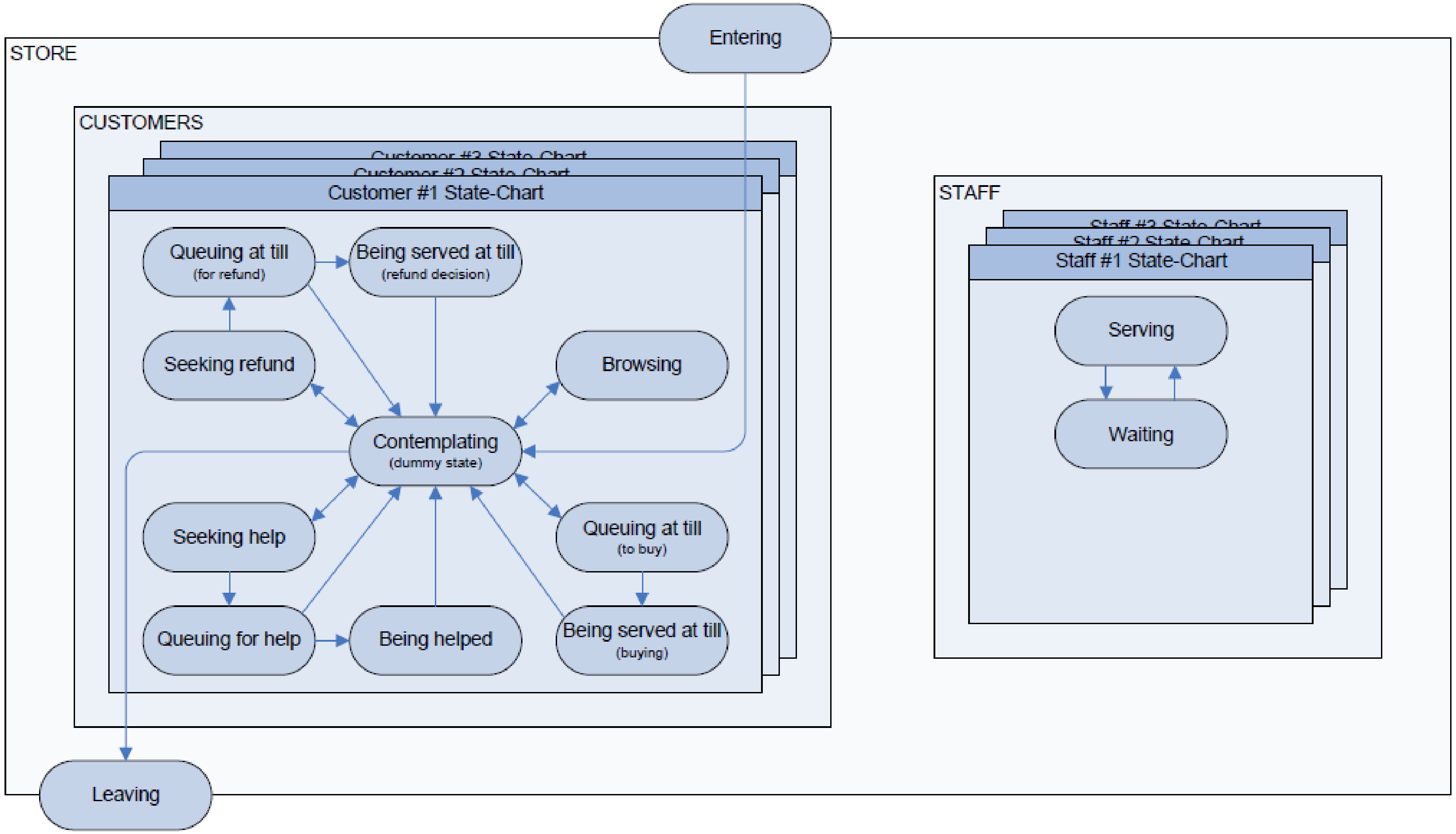
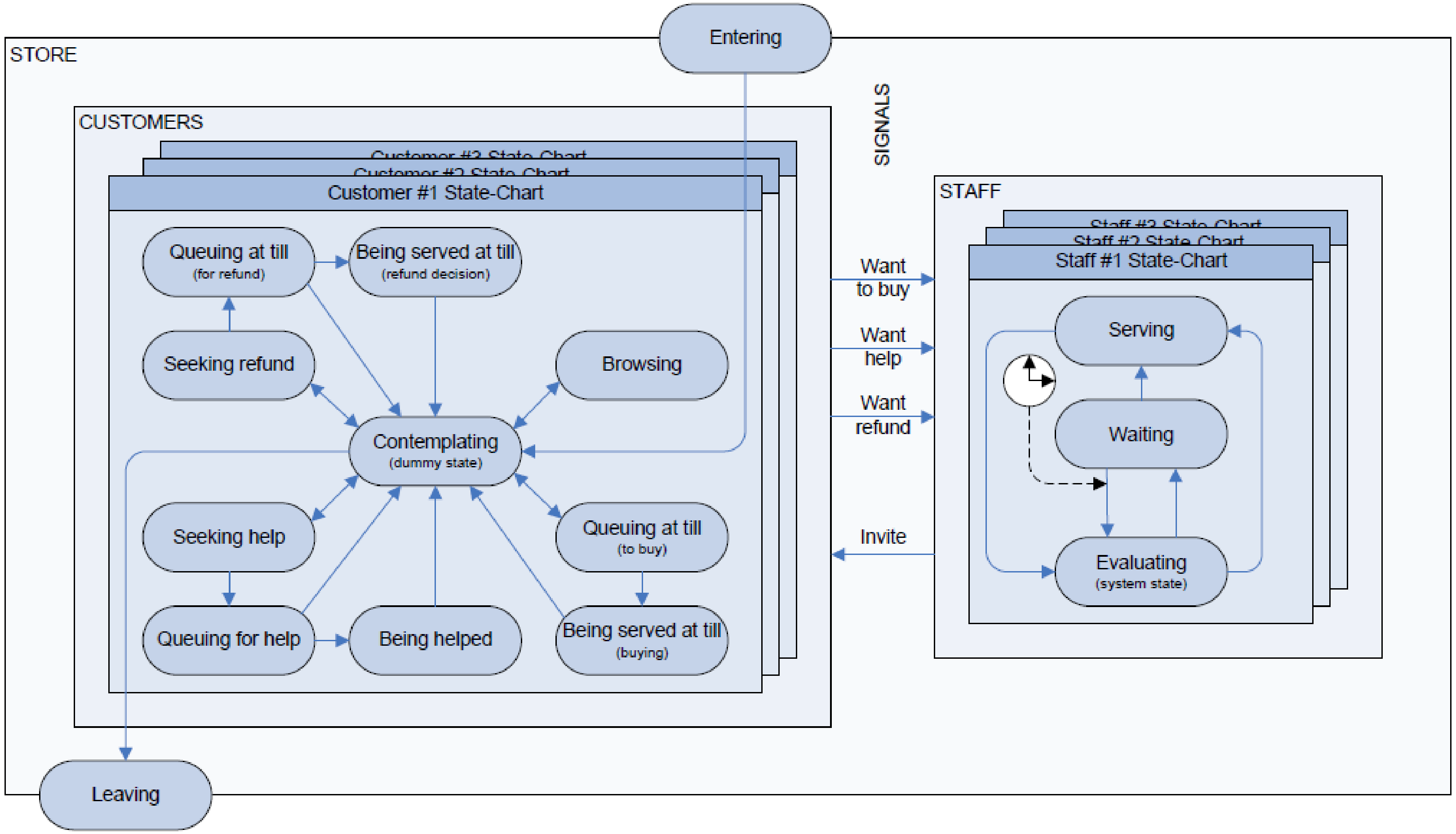

Entering
STORE
Queuing at till
(for refund)
Being served at till
(refund decision)
Browsing
Staff Resource Pool
Queuing at till
(to buy)
Queuing for help
Being helped
Being served at till
(refund decision)
Leaving

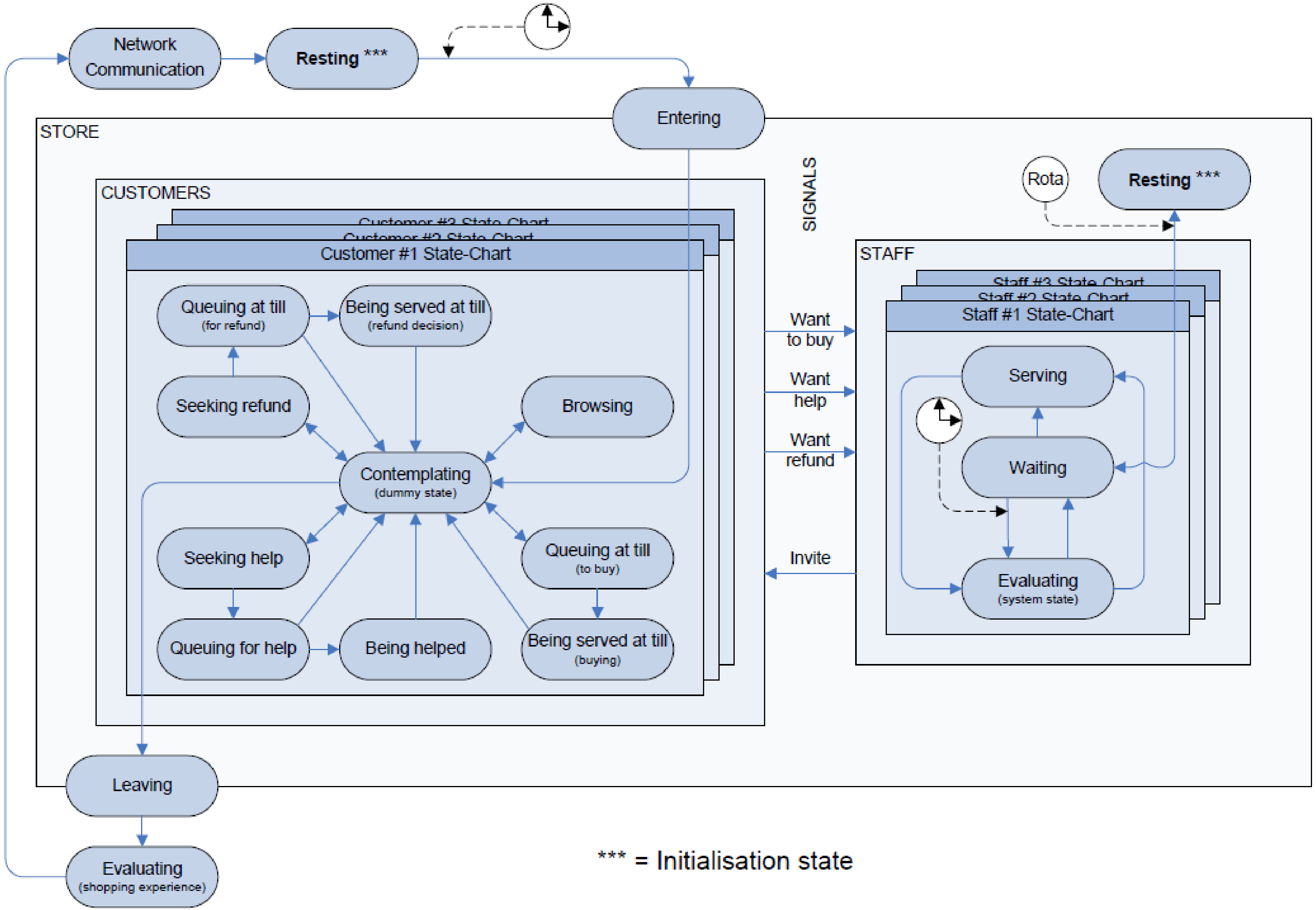


Entering
STORE
Customer State-Chart
Queuing at till
(for refund)
Being served at till
(refund decision)
Seeking refund
Browsing
Contemplating
(dummy state)
Seeking help
Queuing at till
(to buy)
Queuing for help
Being helped
Being served at till
(buying)
Staff State-Chart
Serving
Waiting
Leaving



Entering
STORE
CUSTOMERS
Customer #3 State-Chart
Customer #2 State-Chart
Customer #1 State-Chart
Queuing at till
(for refund)
Being served at till
(refund decision)
Seeking refund
Browsing
Contemplating
(dummy state)
Seeking help
Queuing at till
(to buy)
Queuing for help
Being helped
Being served at till
(buying)
Leaving
STAFF
Staff #3 State-Chart
Staff #2 State-Chart
Staff #1 State-Chart
Serving
Waiting


Entering
STORE
CUSTOMERS
Customer #1 State-Chart
Queuing at till
(for refund)
Being served at till
(refund decision)
Seeking refund
Browsing
Contemplating
(dummy state)
Seeking help
Queuing at till
(to buy)
Queuing for help
Being helped
Being served at till
(buying)
Leaving
SIGNALS
Want
to buy
Want
help
Want
refund
Invite
STAFF
Staff #1 State-Chart
Serving
Waiting
Evaluating
(system state)

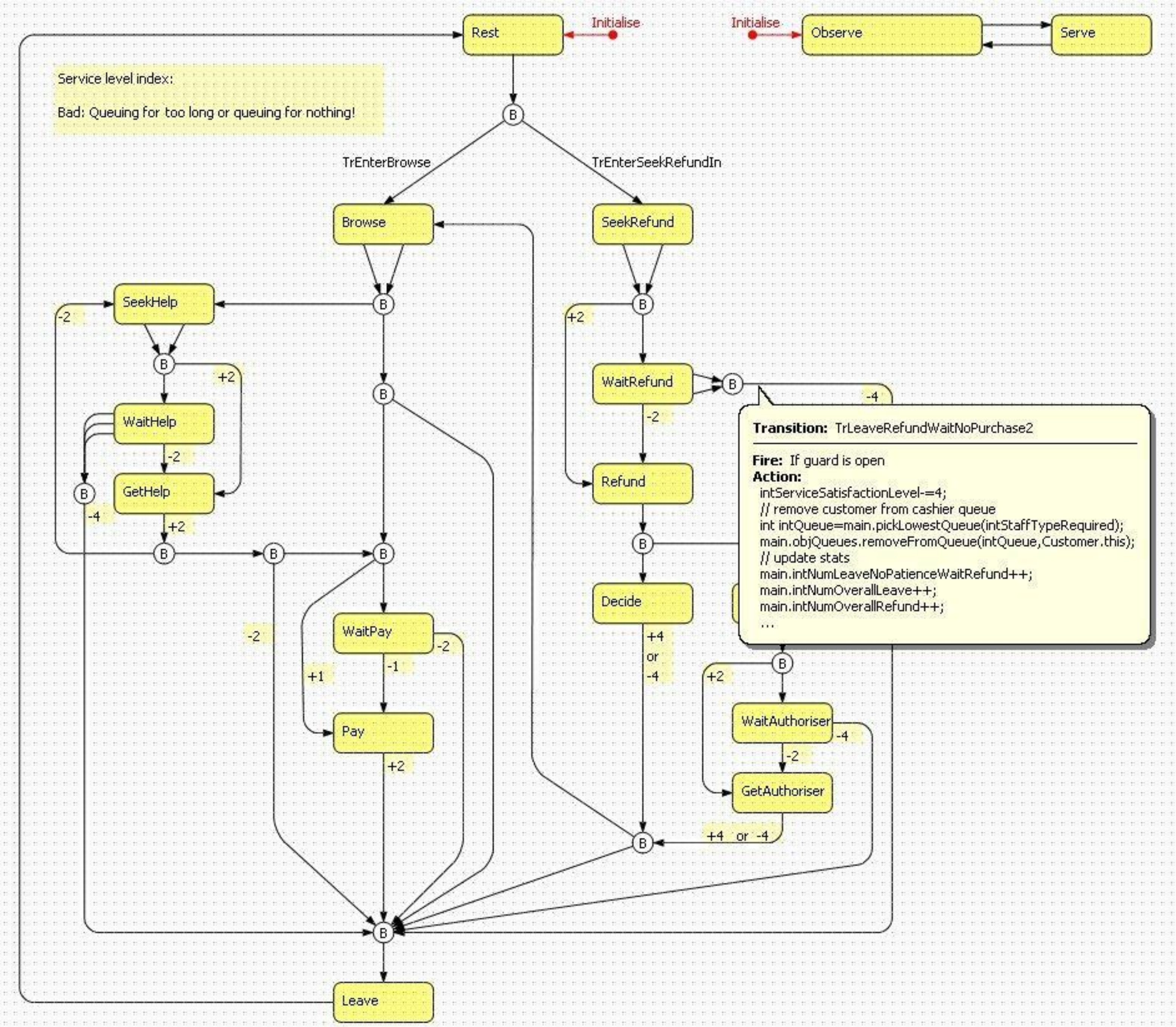


*** = Initialisation state

Implementation

- Software: AnyLogic v5.5
  - Multi-method simulation software (SD, DES, ABS, DS)
  - State charts + Java code

- The model is available at the openabm.org website [Siebers 2011]



Rest
Initialise
Initialise
Observe
Serve
Service level index:
Bad: Queuing for too long or queuing for nothing!
TrEnterBrowse
TrEnterSeekRefundIn
Browse
SeekRefund
SeekHelp
WaitHelp
GetHelp
WaitRefund
Refund
Decide
WaitPay
Pay
WaitAuthoriser
GetAuthoriser
Leave
+4 or -4
+4 or -4
Transition: TrLeaveRefundWaitNoPurchase2
Fire: If guard is open
Action:
intServiceSatisfactionLevel-=4;
// remove customer from cashier queue
int intQueue=main.pickLowestQueue(intStaffTypeRequired);
main.objQueues.removeFromQueue(intQueue,Customer.this);
// update stats
main.intNumLeaveNoPatienceWaitRefund++;
main.intNumOverallLeave++;
main.intNumOverallRefund++;
...

Implementation

- Knowledge representation
  - Frequency distributions for determining state change delays

Situation	Min.	Mode	Max.
Leave browse state after …	1	7	15
Leave help state after …	3	15	30
Leave pay queue (no patience) after …	5	12	20

  - Probability distributions to represent decisions made

Event	Probability of event
Someone makes a purchase after browsing	0.37
Someone requires help	0.38
Someone makes a purchase after getting help	0.56

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Implementation

- Implementation of customer types

Customer type	Likelihood to			
	buy	wait	ask for help	ask for refund
Shopping enthusiast	high	moderate	moderate	low
Solution demander	high	low	low	low
Service seeker	moderate	high	high	low
Disinterested shopper	low	low	low	high
Internet shopper	low	high	high	low

```
for (each threshold to be corrected) do  {
   if (OT < 0.5) limit = OT/2 else limit = (1-OT)/2
   if (likelihood = 0) CT = OT – limit
   if (likelihood = 1) CT = OT
   if (likelihood = 2) CT = OT + limit
}
where:      OT = original threshold
            CT = corrected threshold
            likelihood: 0 = low, 1 = moderate, 2 = high
```

Implementation

- Implementation of staff proactiveness (1/2)
  - Non-cashier staff opening and closing tills proactively depending on demand and staff availability; expert staff helping out as normal staff
  - Task priorities that need to be considered
    - 1: Continue as temporary cashier unless a stop strategy has come true
    - 2: If expert staff, help out as section manager (might be required for
    - refund process)
    - 3: If normal service staff or expert staff, help out as temporary cashier
    - 4: If expert staff, help out as normal service staff
    - If none of these is applicable, wait for a given time and then check again if role swap is required

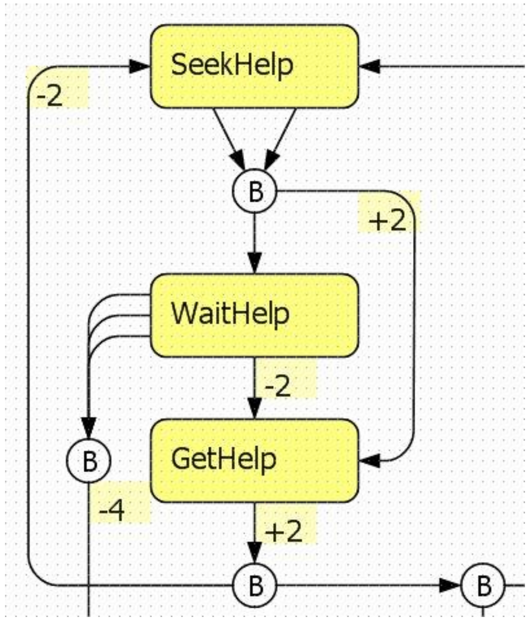
Implementation

- Implementation of staff proactiveness (2/2)

  - Parameters to control proactive behaviour
    - P1: Maximum number of customers to serve as a temporary cashier
    - P2: Critical queue length for opening/closing additional tills
    - P3: Minimum number of staff required to cope with original task
    - P4: Maximum numbers of open tills
    - P5: Stop strategy: Stop service as temporary cashier when either P1 or P2has been reached
    - P6: Check if support at the till is needed every 2 minutes (deterministic or random checks)

Implementation

- Performance measures
  - Service performance measures
    - Service experience
  - Utilisation performance measures
    - Staff utilisation; staff busy times in different roles
  - Level of proactivity
    - Frequency and duration of role swaps
  - Monetary performance measures (productivity and profitability)
    - Overall staff cost per day; sales turnover; sales per employee …



Implementation

- Other noteworthy features of the model
  - Realistic footfall and opening hours
  - Staff pool (static)
  - Customer pool (dynamic)
  - Customer evolution through internal stimulation (triggered by memory of ones own previous shopping experience)
  - Customer evolution through external stimulation (word of mouth)

- Modular design
  - Features can be switched on/off

Static customer pool

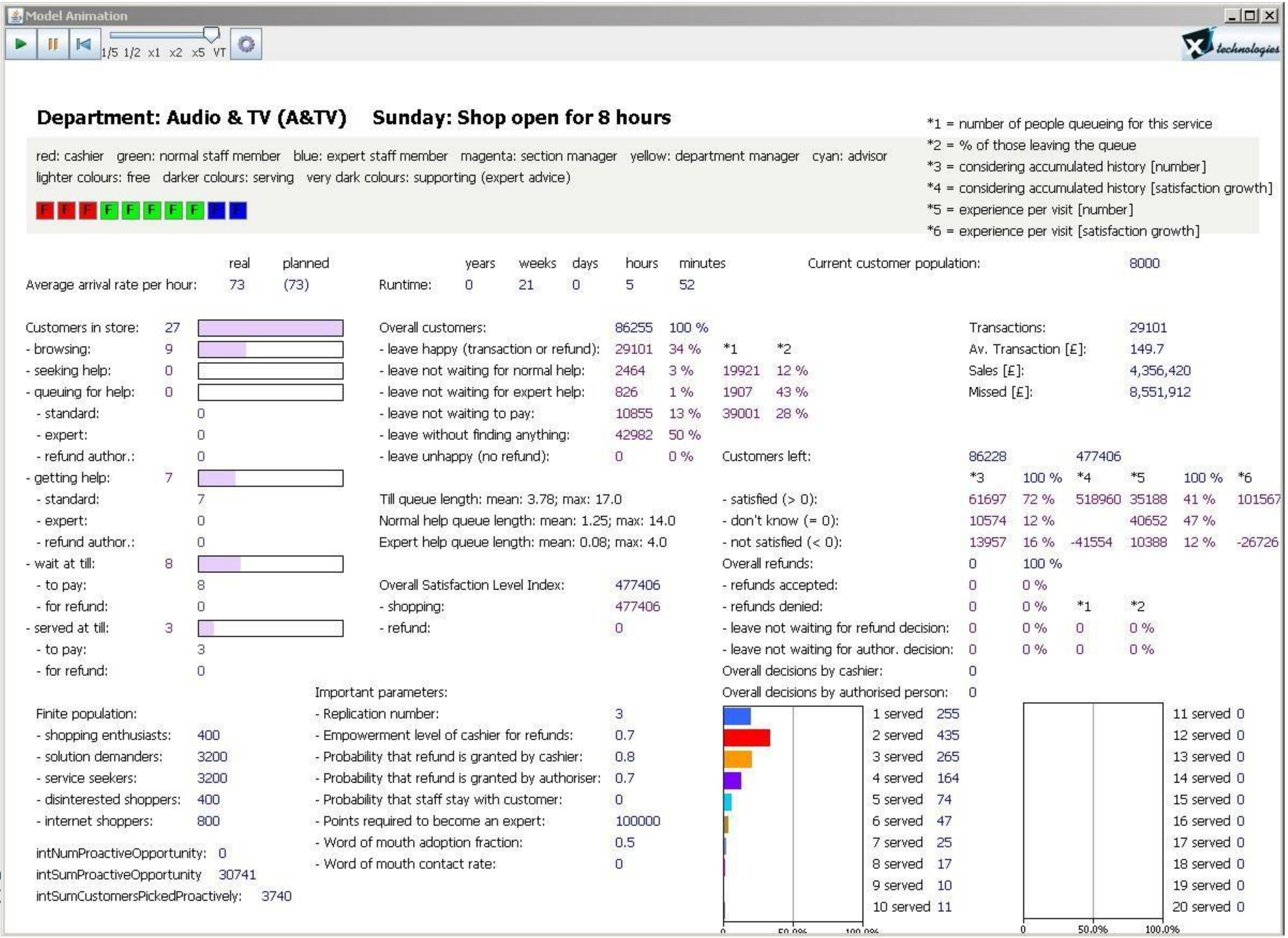
$$n_{additional\ customers\ per\ day} = (n_{satisfied(d-1)} - n_{dissatisfied(d-1)}) * af * cr$$

$$n_{customers\ per\ day} = n_{known\ customers\ per\ day} + n_{additional\ customers\ per\ day}$$

Dynamic customer pool

$$n_{core\ customers\ per\ day} = \frac{dynamic\ pool\ size * n_{known\ customers\ per\ day}}{static\ pool\ size}$$

$$n_{customers\ per\ day} = n_{core\ customers\ per\ day} + n_{additional\ customers\ per\ day}$$



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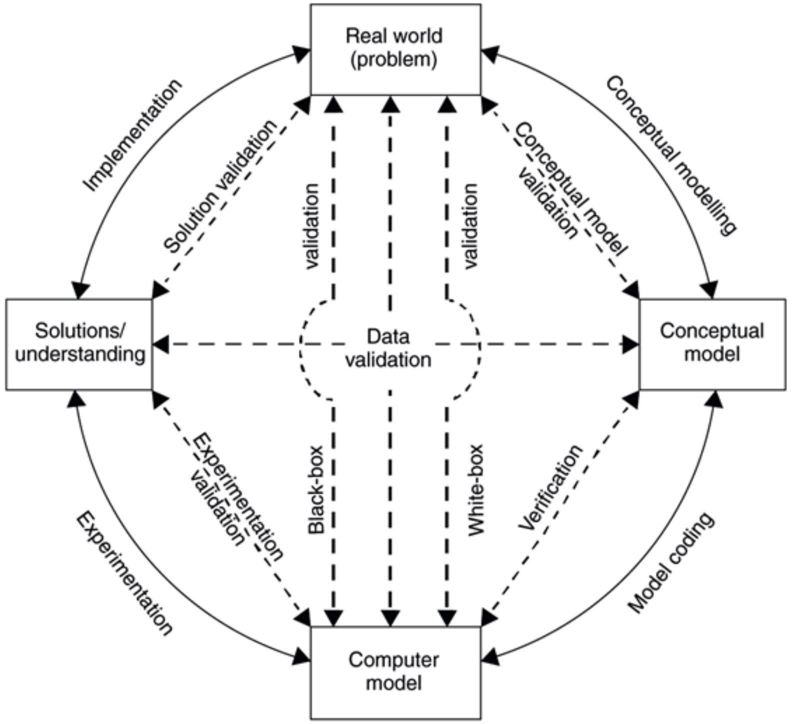
Validation

- We used the V&V framework proposed by Robinson (2004)
  - Conceptual model validation
  - Data validation
  - White box (micro) validation
  - Black box (macro) validation
  - Experiment validation
  - Solution validation (not possible)
  - Verification



Experimentation

- Real world (practical)
  - Staffing levels
  - Staff autonomy (refund, learning)
  - Staff training requirements
- Abstract (theoretical)
  - Extreme populations (customer types)
  - Level of detail (noise vs. noise reduction mode)
  - Different forms of customer pool implementations
  - Advertisement through spread of the word of mouth
- Validation
  - Testing parameters

Experimentation

- Proactivity Experiments [Siebers et al 2011]
  - Validation

Parameter Settings	Audio & TV (outputs: means of weekly averages; deviations: relate to the real world value)								
Scenario	real world	a		b		c		d	
Staffing	real	optimised		optimised		real		real	
Number of {cashiers; normal staff; expert staff}	{1;10;1}	{2;6;2}		{2;6;2}		{1;10;1}		{1;10;1}	
Proactive	yes	no		yes		no		yes	
Outputs	**Mean**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**
Transactions	1787.09	1203.43	32.66%	1387.25	22.37%	615.70	65.55%	1346.22	24.67%

Parameter Settings	Womenswear (outputs: means of weekly averages; deviations: relate to the real world value)								
Scenario	real world	a		b		c		d	
Staffing	real	optimised		optimised		real		real	
Number of {cashiers; normal staff; expert staff}	{2;13;1}	{3;8;2}		{3;8;2}		{2;13;1}		{2;13;1}	
Proactive	yes	no		yes		no		yes	
Outputs	**Mean**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**	**Mean**	**Deviation**
Transactions	3172.35	2931.43	7.59%	3138.00	1.08%	2004.97	36.80%	2977.20	6.15%

Experimentation

- Proactivity Experiments [Siebers and Aickelin 2011]
  - Sensitivity Analysis

Parameter Settings	Audio & TV (outputs: means of weekly averages)									
Number of {cashiers; normal staff; expert staff}	{4;7;1}		{1;10;1}		{1;10;1}		{1;10;1}		{1;10;1}	
Proactive	no		yes		yes		yes		yes	
Critical queue length	-		1		2		3		4	
Outputs	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Number of customers that leave happy (purchase)	1875.47	5.16	1833.18	6.99	1627.22	3.77	1348.48	2.85	1161.97	3.16
% of customers that leave happy (purchase)	45.87%	0.15%	44.84%	0.17%	39.85%	0.07%	32.99%	0.09%	28.42%	0.08%
% of customers that leave not waiting for normal help	2.35%	0.04%	1.08%	0.05%	0.75%	0.03%	0.46%	0.02%	0.32%	0.02%
% of customers that leave not waiting for expert help	1.86%	0.04%	1.95%	0.03%	1.92%	0.03%	1.89%	0.04%	1.88%	0.03%
% of customers that leave not waiting to pay	0.43%	0.03%	2.27%	0.05%	7.40%	0.09%	14.56%	0.05%	19.23%	0.10%

Conclusions and Future Outlook

- Conclusions
  - Combined DES/ABS allows the consideration of proactive behaviour in service system models which has a positive impact on the accuracy of the simulation outputs
  - To find the right settings for proactivity parameters is difficult (due to the high correlation of the parameters)

- Future outlook
  - Study the impact of teamwork related management practices
  - Exploring other ways for implementing the agent decision making processes
  - Reusable ABS components (archetypes; templates)
  - From academia to business: What is needed?
    - Clients should be involved in the whole process

References

- Siebers PO (2011) Department store simulation model at http://www.openabm.org/model/2441/

- Siebers PO and Aickelin U (2011) A first approach on modelling staff proactiveness in retail simulation models. Journal of Artificial Societies and Social Simulation (https://www.jasss.org/14/2/2.html)