On the Search for Novel Simulation Applications to Support Airport Operations Management

EMSS 2014

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Personal Introduction

- My Research Interest
  - Developing human behaviour models which can be used to better represent people and their behaviours in simulation models
  - Combining ideas from OR, Social Science, Psychology, Sociology, and Software Engineering to achieve this
    - More interested in developing frameworks and testing them
    - Less interested in solving/investigating specific cases
  - Promote the application of ABM/S

The Task

MSc Dissertation Project

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- Simulating Human Centred Airport Operations
  - Part 1: Classification and new opportunities
  - Part 2: Implement a proof of concept model of an opportunity

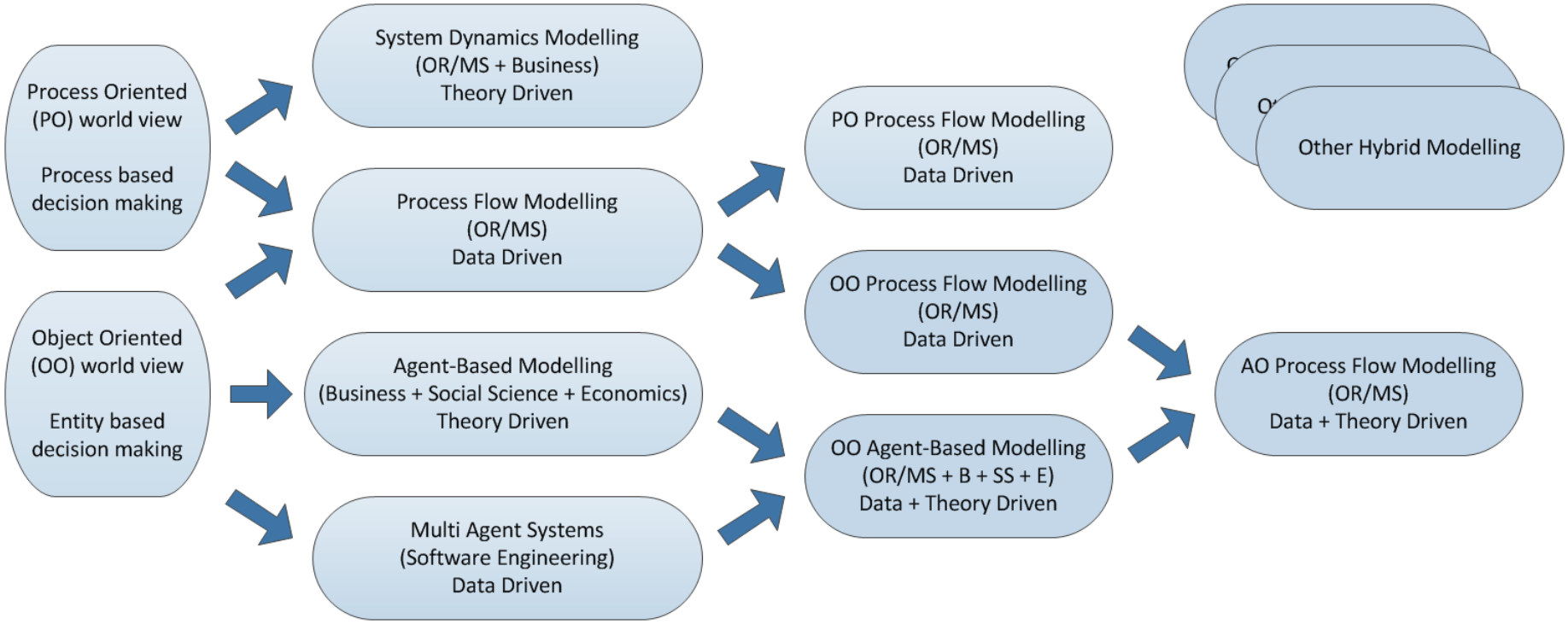
Simulating Human Centred Airport Operations using Different World Views

An airport is a large complex system. Simulation is a useful aid when it comes to understanding and improving the operations of such a system. There are many different stakeholders that have different views and needs that have to be considered when trying to find solutions. There are several simulation methods (system dynamics modelling and simulation, discrete event modelling and simulation, agent-based modelling and simulation, and mixed modelling and simulation) that are used differently by researchers from different fields to answer different types of questions.

What kind of insight does each of the available simulation methods give us? What are the different ways/opportunities we can use simulation for our investigation? Your job will be to consider the airport as a socio-technical system and to find out what kind of questions the different simulation methods allow us to answer and what kind of input data would be required for this. Then you will develop and implement some proof of principle models to support/validate your previous findings. **UG and PGT dissertation:** You will focus on human centred aspects of the airport operation. This project requires some Java programming skills.

Part 1: Classification and New Opportunities

Dynamic Simulation Modelling Approaches



Data Driven: Data for model formulation (in Social Sciences can be quantitative and qualitative); data for model validation
Theory Driven: Theories for model formulation; data for model validation

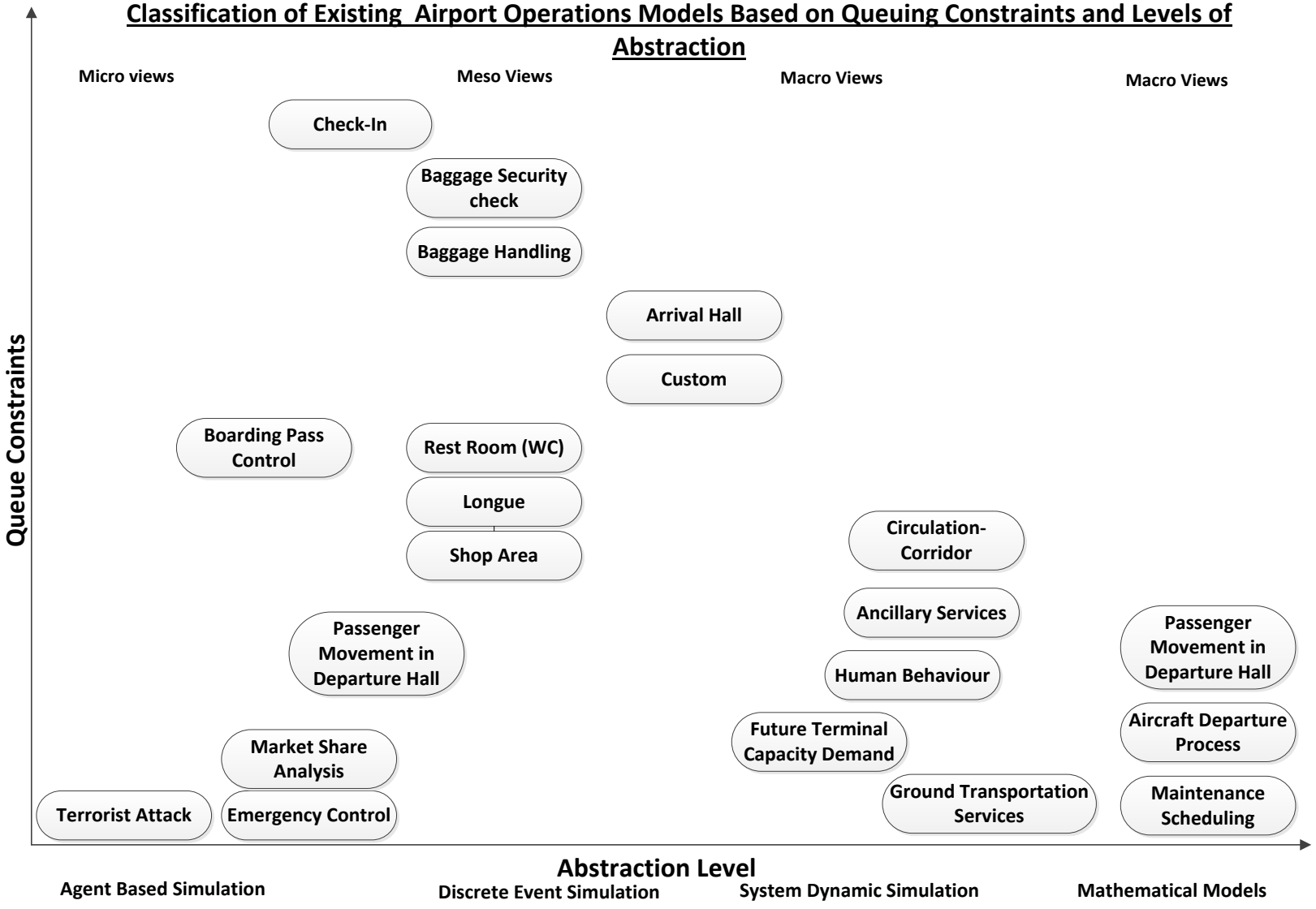
Airport Operation Modelling Studies

- Passenger Terminal Models
  - Using analytical, SD, or DE modelling
  - Limited capability in representing passengers' behaviour
- Maintenance Scheduling Models
  - Using methods with high abstraction levels such as integer programming, queuing theory, Monte Carlo Simulation or SD
  - Focus on optimisation
  - Limitations when it comes to modelling some maintenance scheduling problems where high levels of agents' interactions and message passing between objects of the systems are relevant to study system operations

Airport Operation Modelling Studies

- Human Behaviours Models
  - Human behaviour in a normal situation
    - Passenger flow movement models
    - Using mathematical and AB modelling
  - Human behaviour in an extreme situation
    - Passenger egress models for closed spaces (e.g. aeroplanes) and emergency evacuation models for airport
    - Using AB modelling
- Airport Marketing Models
  - Assist market share analysis and help the investment analyst to develop earnings forecasts for the year ahead
  - Using SD and AB modelling

Classification of Existing Airport Operations Models Based on Queuing Constraints and Levels of Abstraction



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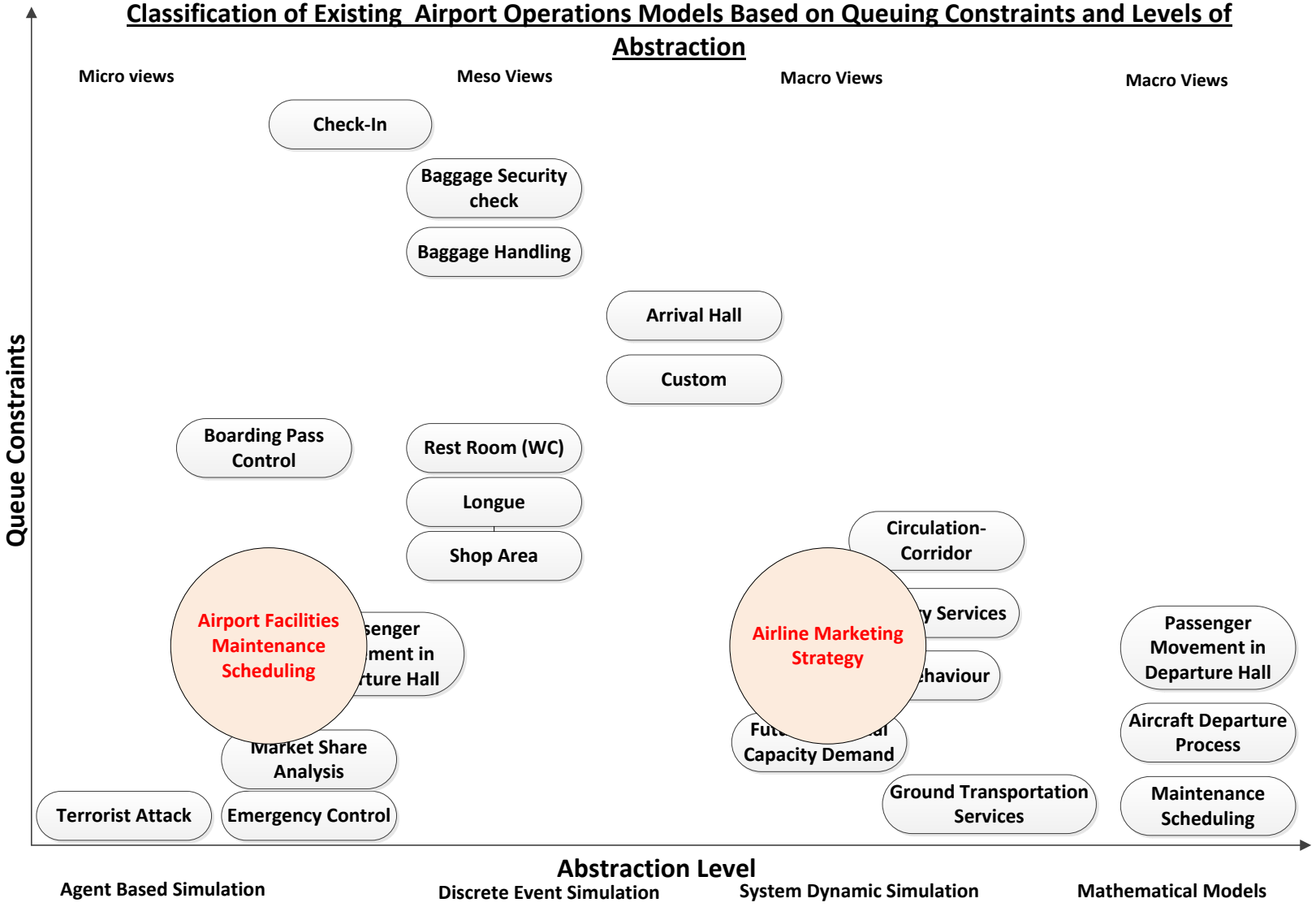


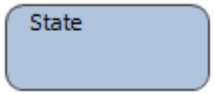
Part 2: Airport Facilities Maintenance Scheduling using OO ABM

Hypothetical Case Study

- Airport Facilities Maintenance Scheduling
  - A group of airport facilities are distributed geographically within the airport mostly in the terminal area where passengers and well-wishers spend most of their time.
  - Also there is an airport hangar that houses a fleet of aircrafts that need routine maintenance and various levels of service.
  - To service these facilities, there are facilities maintenance crews (facilities-technicians) and aircraft maintenance experts (aircraft-technicians) in the airport estates office who service the facilities and aircrafts based on certain management policies (replacement and maintenance policies).

Defining Behaviour Using State Charts

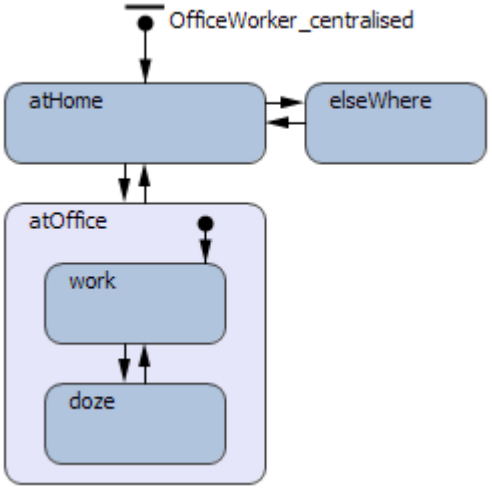
- Typical elements of a state chart diagram
  - States
    - Represents a location of control with a particular set of reactions to conditions and/or events



    - 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

Defining Behaviour Using State Charts

- Example: The Office
  - Who are the actors?
  - What are the key locations you can find them?
  - What are key time consuming activities they get involved in?

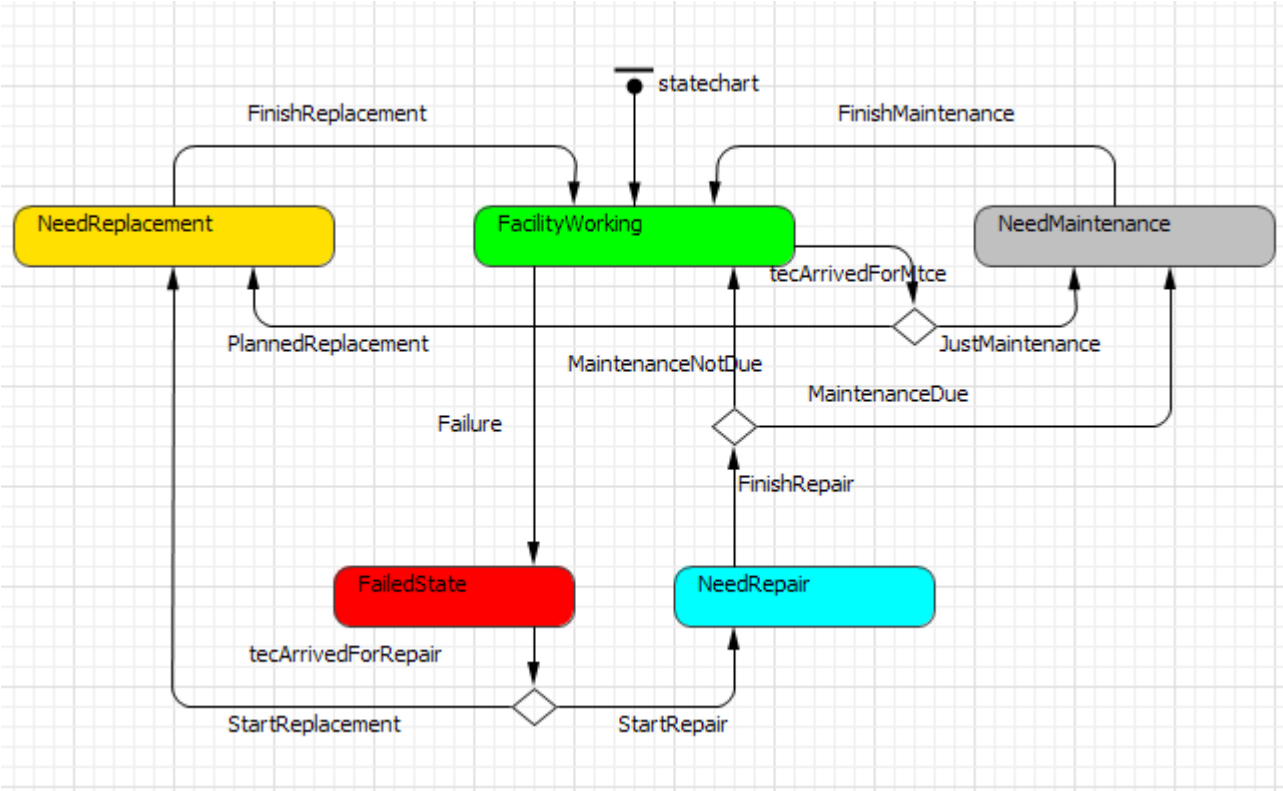


Hypothetical Case Study

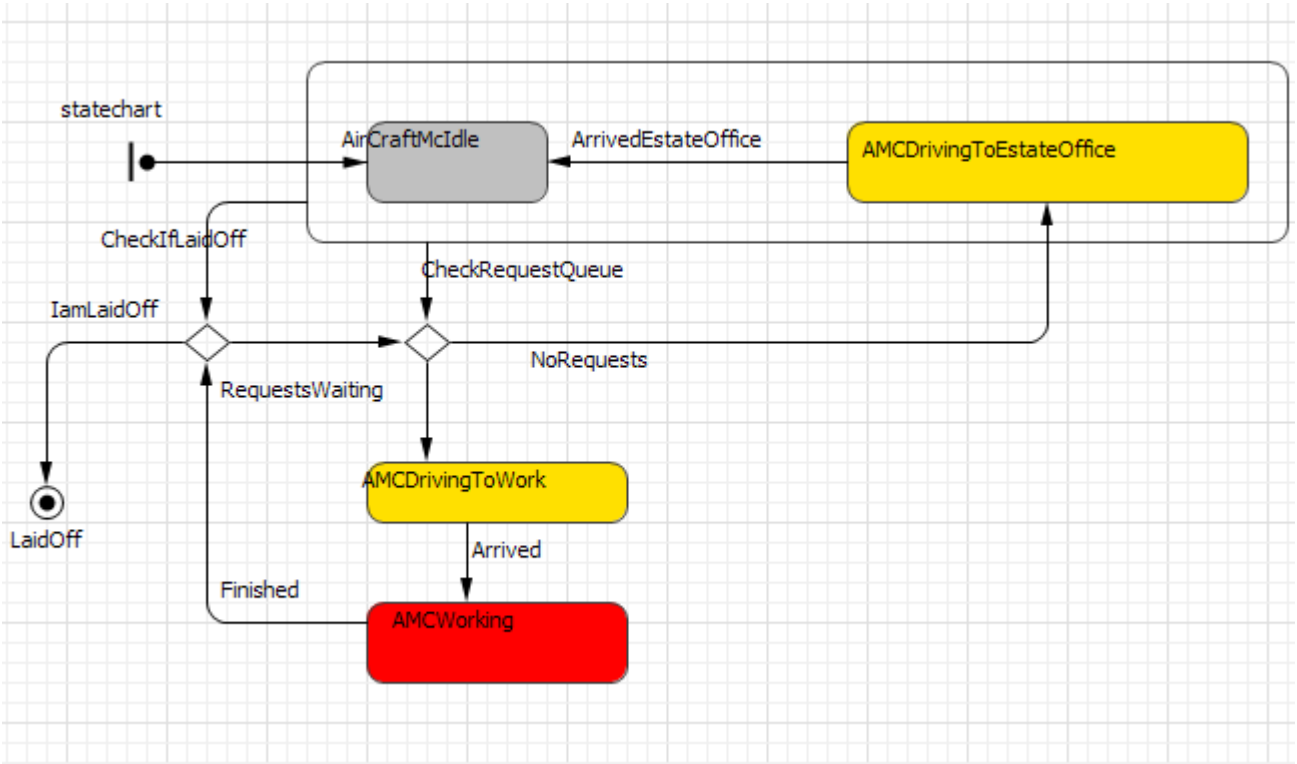
- We have two agent template classes
  - AirportFacilities (airport facilities and aircraft facilities)
  - MaintenanceCrew (facilities technician and aircraft technician)

- The different types of agents in an agent template class use the same state chart but different set-up parameters for transitions

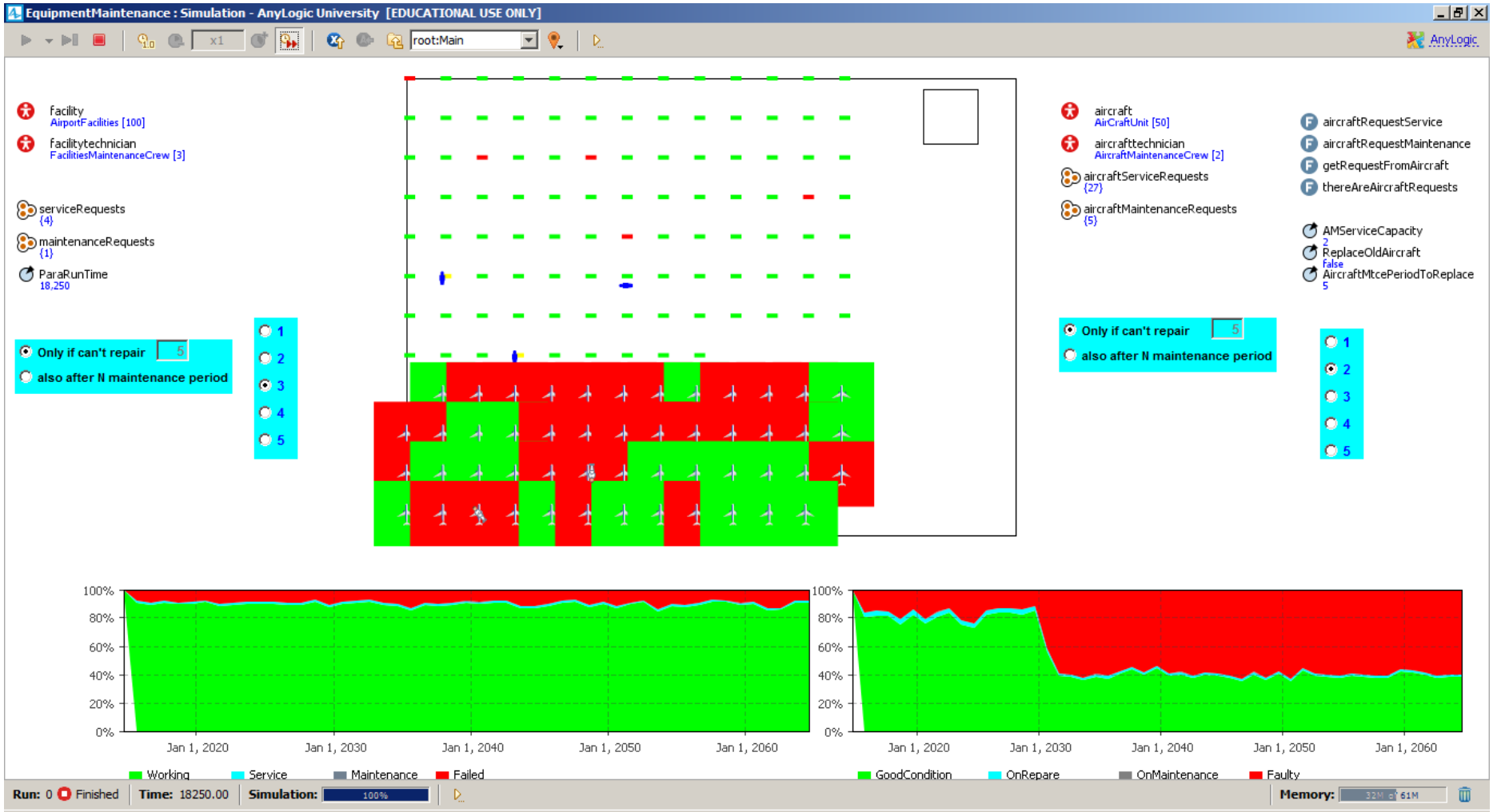
AirportFacilities Agent State Chart



MaintenanceCrew Agent State Chart



Implementation



Testing

- The model discussed here purely academic and is based on a hypothetical situation due to non-availability of real world data.

- It has been thoroughly verified (e.g. code debugging) and model design and implementation have been validated by domain experts (face validation).

Test Experiment

- Objective
  - To determine the number of technicians required to ensure that 90% of the airport facilities and 95% of the aircrafts are in good working condition
  - To ensure that 80% of airport facilities and 95% aircrafts are available all of the time
  - To determine the replacement policy that will give the optimum result at minimum cost.

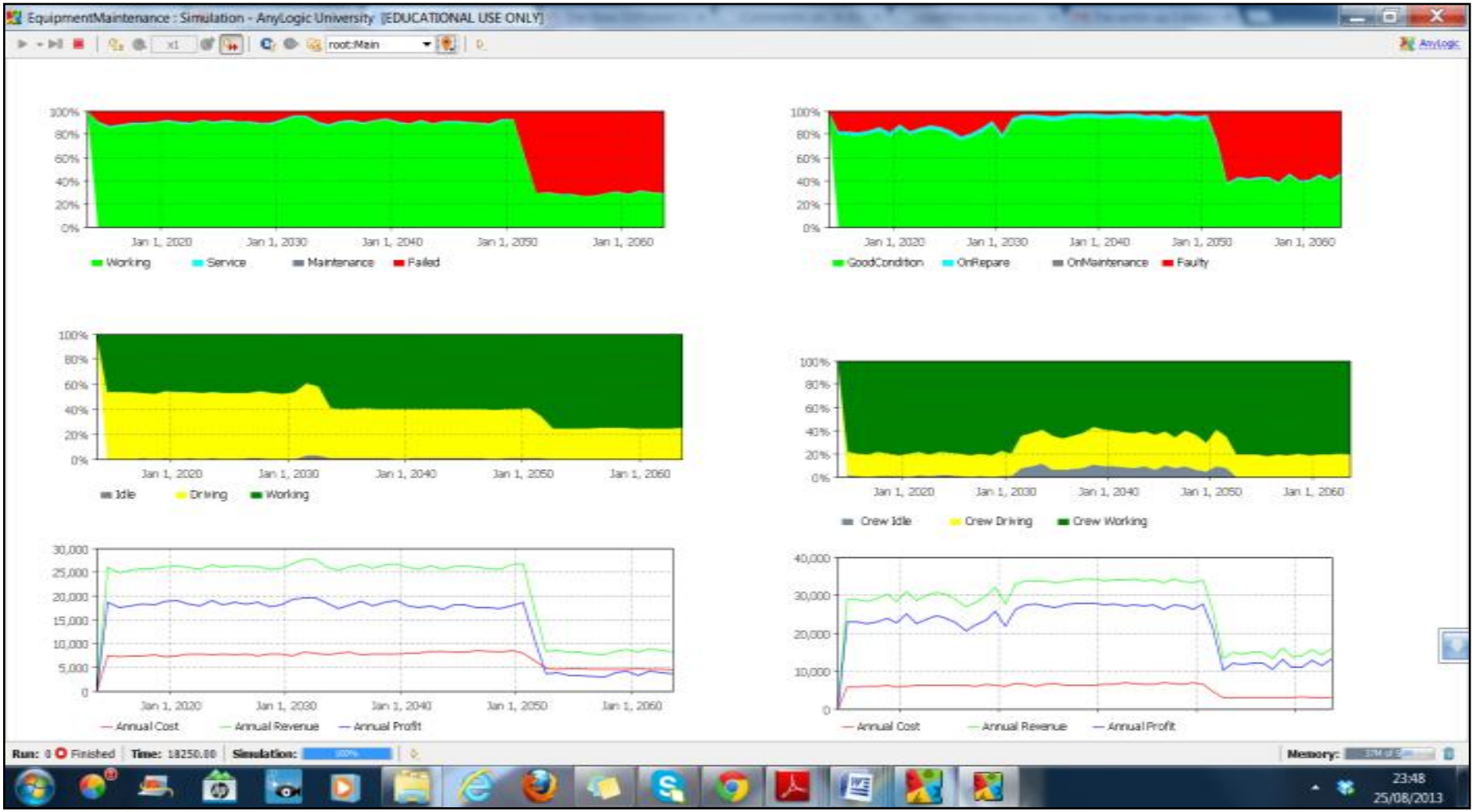
- Constraints
  - At most five technicians can be employed for both, airport facilities and aircrafts

Test Experiment

- Different Manning and Replacement Policies

	Airport Facilities					Aircrafts				
Option	A	B	C	D	E	A	B	C	D	E
Number of technicians	3	3	4	4	2	2	2	3	3	1
Replacement policy	5	3	3	2	2	5	4	4	3	3

Test Experiment



Test Experiment

	Airport Facilities					Aircrafts				
Option	A	B	C	D	E	A	B	C	D	E
Number of technicians	3	3	4	4	2	2	2	3	3	1
Replacement policy	5	3	3	2	2	5	4	4	3	3
Facilities										
Availability (%)	89	91	93	94	25	80	82	97	96	40
Unavailability (%)	11	9	7	6	75	20	18	3	4	60
Technicians										
Utilised (%)	96	96	93	93	100	98	97	89	90	100
Idle (%)	4	4	7	7	0	2	3	11	10	0
Cost/Benefit										
Profit (in 1000s)	26	27	28	27	4	23	24	28	27	12
Cost (in 1000s)	7.5	7.5	7.6	7.6	5	6	6.2	6.2	6.2	4

Questions / Comments

Latest Talk on Agents:

Agent-Oriented Modelling and Simulation of Human Centric Systems

http://www.cs.nott.ac.uk/~pos/docs/pos-SouthamptonPresentation-2014-07-08.pdf