Case Studies in Multiagent Systems: The Aircraft Turnaround Case Study with Jeppesen

Prof Kuldar Taveter, Tallinn University of Technology, Estonia
The purpose of the course

- Learn how to **design** by **AOM** in an **agile** way a **software-intensive composite artifact** that delivers the overall solution for the end users through interactions between its components and where each component follows the execution loop of an abstract agent.
Logistics

- Lectures on Wednesdays at 10.00-11.30 in the main building of TUT, lecture hall U06A-229
- Workshops/lab classes for stationary students on Wednesdays at 12.00-13.30 in the ICT building of TUT at Akadeemia Road 15A, computer class ICT-501
- Consultation times by Prof Kuldar Taveter: on demand in the ICT building of TUT at Akadeemia Road 15A, Room ICT-634
- Consultation times by Dr Alex Norta: on demand in the ICT building of TUT at Akadeemia Road 15A, Room ICT-639
  - or Skype: alexbafana
Communication

Course webpage:
http://maurus.ttu.ee/sts/?page_id=1891

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Miniproject

- Design and prototyping or simulation of a software-intensive social product *(up to 3 team members)*

- Range of topics:
  - Crowdsourcing applications
  - Intelligent digital assistants
  - Social applications

- Mektory ([http://www.ttu.ee/mektory](http://www.ttu.ee/mektory)) projects *(up to 5 team members)*, examples from 2013:
  - Healthminer
  - Phoenix
Miniproject

Design by agent-oriented modelling and prototyping or simulation of a sociotechnical system

Desired features:
- Open
- Social
- Intelligent
- Adaptive
- Solves a real-world problem – no dating services!

Interdisciplinary examples from 2013: Two Mektory projects:
- Healthminer
- Phoenix
Today

- Short lecture “The Transformation of the Little Black Book” on possible M.Sc. theses topics by Mr. Nico Zimmer, Market & Solutions Research, Jeppesen GmbH (subsidiary of Boeing)

- Lecture “Case Studies in Multiagent Systems: The Aircraft Turnaround Case Study with Jeppesen”, Prof Kuldar Taveter
Next time

- The Tropos and MaSE Agent-Oriented Software Engineering Methodologies
Pre-announcement

- Guest lecture on software quality over a direct videoconference by Professor Leon Sterling, Swinburne University of Technology Pro Vice-Chancellor (Digital Frontiers), Melbourne, Australia, on **Wednesday, 8 April at 10.00-11.30** in the lecture hall **U06A-229**

- Please come and invite your colleagues and friends, this will be an open lecture!
The conceptual space
A software engineering methodology
An excerpt of the project motivation model

- Agent-oriented
- Testable
- Usable

Develop airfact turnaround simulator

Jeppesen

University of Melbourne
High-level motivation model for the ATS

Figure 2 presents the project motivation model for the ATS system. Three quality goals were noted. Figure 3: The high-level motivation model for the ATS system.
The aircraft turnaround process

High-level motivation model for the aircraft turnaround process

- Efficient
  - Simulate aircraft turnaround
    - Airport Ground Staff
      - Prepare arrival
      - Disembark passengers
      - Service aircraft
        - Maintain aircraft
        - Embark passengers
        - Prepare departure

Q4
- Maintain aircraft
- Take part in the maintenance of the aircraft, so we add a pilot, to investigate a potential problem. Only the engineers performed by engineers only if requested; for example, by the engineer after every flight. Non-routine maintenance is turnaround.

Q4.2
- Eliciting a solution: hiring new staff
  - Figure 8 shows the role model for this role.

Q4.2.3
- Eliciting a solution: hiring new staff
  - The flight plan, staff schedule, and aircraft information. The resources required are aircrafts and on the air-bridge.

Q4.3
- Eliciting a solution: hiring new staff
  - ID, the gate number at which the aircraft is parked, and that inform it that non-routine maintenance should be performed.

Q4.4
- Eliciting a solution: hiring new staff
  - The stakeholders are prompted to consider how their problem is shown.

Q4.5
- Eliciting a solution: hiring new staff
  - The stakeholders are prompted to consider how their problem is shown.

6

Note
- The goal model.
- The stakeholders are prompted to consider how their problem is shown.
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4.2.3 Eliciting a solution: hiring new staff
- The flight plan, staff schedule, and aircraft information. The resources required are aircrafts and on the air-bridge.

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High-level scenario

- Aircraft lands and proceeds to gate
  - Aircraft parked
    - Aircraft maintained
    - Passengers disembark
    - Baggage unloaded
  - Aircraft refueled
  - Aircraft serviced
  - New baggage loaded
  - New passengers embark
  - Aircraft leaves gate and takes off
Role models: Pilot

Role ID: R1

Name: Pilot

Description: The pilot is a person who operates an aircraft and directs the airline staff, including the crew.

Responsibilities:

1. Operate aircraft
2. Direct airline staff
3. Indicate when aircraft is in position to initiate turnaround

Constraints:

1. N/A
Role ID: R2

Name: Crew

Description: The crew directs and provides services to passengers.

Responsibilities:

1. Instruct passengers to embark the aircraft
2. Instruct passengers to disembark the aircraft
3. Check cabin service

Constraints:

1. N/A
Role ID: R6

Name: Manager

Description: The manager is responsible for allocating resources and coordinating staff.

Responsibilities:

1. Coordinate airport staff
2. Allocate resources

Constraints:

1. N/A
Role model: Ground staff

Name: Ground staff

Description: The ground staff prepares the aircraft for arrival and departure, and loads and unloads the baggage.

Responsibilities:

1. Load baggage
2. Unload baggage
3. Position airbridge
4. Remove airbridge
5. Position wheel chocks
6. Remove wheel chocks
7. Attach tug

Constraints:

1. N/A
Role model: Passenger

Role ID: R10

Name: Passenger

Description: The passenger is a person who embarks and disembarks the aircraft to fly between destinations.

Responsibilities:

1. Board the aircraft
2. Disembark the aircraft

Constraints:

1. Check-in on time
2. Cooperate with the crew and airline ground staff
Organisation model: Aggregation

Aggregation relationships

- Airline staff
  - Pilot
  - Crew
  - Airline ground staff
  - Airline cleaning staff
  - Airline catering staff

- Airport staff
  - Manager
  - Ground staff
  - Engineer
  - Fueller

- Passenger
Organisation Model

Control relationships

Peer relationships
Domain model

Domain Model

- **Airport**
  - located in **Gate**
  - located in **Ramp area**

- **Ground staff**
  - positions **Wheel chock**
  - positions **Airbridge**
  - attaches **Tug**

- **Aircraft**
  - manoeuvres
  - hosted by **Airport**
  - carries **Baggage**

- **Pilot**
  - handles **Baggage**

- **Baggage**
Agent model

Agent Model

Agent Pilot
Agent Crew
Agent Airline ground staff
Agent Airline cleaning staff
Agent Airline catering staff
Agent Manager
Agent Ground staff
Agent Engineer
Agent Fueller
Agent Passenger

1
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Acquaintance model

Acquaintance Model

- Agent Passenger
- Agent Airline ground staff
- Agent Crew
- Agent Airline catering staff
- Agent Manager
- Agent Airline cleaning staff
- Agent Ground staff
- Agent Pilot
- Agent Engineer
- Agent Fueller
Interaction diagram: Prepare arrival

Interaction Model

Interaction Diagram

Prepare arrival

Manager

Ground staff

Pilot

Please go to location A

Can I position the wheel chocks?

Yes, please

Can I position the airbridge?

Yes, please

Airbridge positioned +

Note: Only for the Interaction Diagram, interactions marked with ‘+’ were added to facilitate the handovers in the implemented multi-agent system.
Interaction diagram: Handle baggage

Interaction Model

Interaction Diagram
Handle baggage

Manager

Ground staff

Please unload the baggage
OK, baggage unloaded
Please load the new baggage
OK, new baggage loaded
Interaction diagram: Deboard
Interaction diagram: Board

Interaction Model

Interaction Diagram

Board

Manager

Please commence the embarking +

Crew

Please commence the passenger embarking

Airline ground staff

Passenger embarking completed

Passenger embarking completed +

Passenger

Please embark the aircraft

Embarking completed +
Interaction diagram: Prepare departure

Interaction Model
Interaction Diagram
Prepare departure

Manager

Pilot

Ground staff

Please prepare the aircraft for departure +

Please remove the airbridge

OK, airbridge removed

Please remove wheel chocks

OK, wheel chocks removed

Please attach the tug

OK, tug attached

Aircraft ready for departure +
Interaction sequence diagram: Maintain aircraft

Interaction Model
Interaction-Sequence Diagram
Maintain aircraft

1. Please commence the aircraft routine maintenance
2. Please commence the aircraft non-routine maintenance
3. Please commence the aircraft refuelling
Interaction sequence diagram: Service aircraft

Interaction Model
Interaction-Sequence Diagram
Service aircraft

1. Please clean the aircraft
2. Please cater the aircraft
3. Aircraft cleaning completed
4. Aircraft catering completed
Interaction protocol: Board

Interaction Model
Interaction Protocol
Board

Board Interaction Protocol

Crew
Aircraft ground staff
Passenger

Please commence the passenger embarking

Loop (1,*):

Please embark the aircraft

Passenger embarking completed
Interaction protocol: Maintain aircraft

Interaction Model

Interaction Protocol
Maintain aircraft

Maintain aircraft Interaction Protocol

Pilot

Engineer

Fueller

Interleaved

Please commence the aircraft routine maintenance

Please commence the aircraft non-routine maintenance

Please commence the aircraft re-fuelling
Knowledge model 2
Agent
Behaviour
Model
Airline Ground Staff

Airline ground staff

The crew has embarked the aircraft

R3. 1

Wait for request to instruct departing passengers to embark

R3. 2

Instruct passengers to embark the aircraft

R3. 3

Confirm the completion of the departing passengers embark

Crew

Please commence the passenger embarking

Passenger embarking completed

Passenger

Please embark the aircraft
Agent Behaviour Model
Airline Catering Staff

1. Airline catering staff
   - The crew has disembarked the aircraft

2. RS. 1
   - Wait for instructions to cater the aircraft

3. RS. 2
   - Please cater the aircraft

4. RS. 3
   - Cater aircraft

5. Confirm the completion of aircraft catering

6. Aircraft catering completed
   - Manager

7. Crew
Agent Behaviour Model

Airline Cleaning Staff

Airline cleaning staff

The crew has disembarked the aircraft

Wait for instructions to clean the aircraft

Clean aircraft

Confirm the completion of aircraft cleaning

Crew

Please clean the aircraft

Manager

Aircraft cleaning completed
Agent
Behaviour
Model
Engineer

The airbridge has been positioned

R9. 1
Wait for instructions to perform aircraft routine maintenance operations

R9. 2
Perform aircraft routine maintenance operations

The airbridge has been positioned

R9. 3
Wait for instructions to perform aircraft non-routine maintenance operations

R9. 4
Perform aircraft non-routine maintenance operations

Please commence the aircraft routine maintenance

Pilot

Pilot

Please commence the aircraft non-routine maintenance
Agent
Behaviour
Model
Fueller

Pilot

Please commence the aircraft re-fuelling

Wait for instructions to re-fuel the aircraft

Re-fuel the aircraft

The airbridge has been positioned

R8. 1

R8. 2
Prototyping

- A prototype by a third-year undergraduate software engineering student at the University of Melbourne, Australia, with no previous experience in agent-oriented software engineering
- A Master’s thesis by a M.Sc. student from Tallinn University of Technology, Estonia, who is an air-traffic controller studying software engineering, and had undertaken one subject on agent-oriented modelling
- A visiting scholar to the University of Melbourne, Australia, who is a software engineer with a master’s degree and over ten years experience specialising in software for air-traffic control, but with no previous experience with agent-oriented software engineering.
Results

- Systematic method for agent-oriented requirements elicitation and modelling
- Three implementations proving the usability of the method: two in Australia and one by a M.Sc. student in Estonia
Two M.Sc. projects with Jeppesen Germany

- Agent-oriented modelling and simulation of airlines:
  - Model an airline
  - Simulate an airline
  - Demonstrate bottlenecks and possible savings by simulation

- Business processes management of airlines
  - Model business processes of an airline
  - Simulate business processes of an airline
  - Demonstrate bottlenecks and possible savings by simulation
Project 1: Overall goal model for an airline

Provide air transportation services

- Safe
- Optimize cost
- Max. revenue
- On-time

Airline

Customer

Plan flight
Manage crew
Manage passengers & cargo
Maintain fleet
Manage flight
Manage finance

Cost-effective
Project 1: Interaction model of filing a flight plan
Today

- Discussion on the progress of mini-projects – knowledge model and behaviour models
MS Visio Stencils for AOM

Available as