AGENT-BASED SIMULATION FRAMEWORK FOR AIRPORT COLLABORATIVE DECISION MAKING

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Our Work

• **First steps** in the development of agent-based simulation framework for Airport Collaborative Decision Making, following EUROCONTROL guidelines.

• Aiming to study the **emerging behaviour** of the system.
Index

- What is A-CDM?
- Agent Based Modelling
- Simulator Structure and Models
- How does the simulator work?
- Future works
- Conclusions
What is A-CDM?

AIRPORT COLLABORATIVE DECISION MAKING
Airport Collaborative Decision Making basics

- Sharing timely and accurate flight, network and airport data
- Use standard systems, procedures and data structure

Objectives:
- Improve predictability and efficiency of the system
- Anticipate situations and facilitate better decision in advance
CDM in Europe and in the U.S.

CDM in the U.S.

- Shared decisions between Air Traffic Providers and the Aircraft Operators
- Used during Ground Delay Programs (ATFM)
- Focus on the improvement of the assigned delay when airlines do cancellation and substitution
- Fully implemented and operative

European A-CDM

- Defined by EUROCONTROL
- Shared Information between all the stakeholders involved in airport operations
- Focus on improve the efficiency and prediction of Turn-Around process
- Part of SESAR Master Plan
CDM in Europe and in the U.S.

CDM in the U.S.
- Shared decisions between Air Traffic Providers and the Aircraft Operators
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European A-CDM
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Work Focused on European A-CDM
A-CDM Airports

Fully implemented Airports:

- Munich
- Brussels
- Paris CDG
- Frankfurt
- London Heathrow
- Helsinki
- Düsseldorf
- Zurich
- Oslo

Source: EUROCONTROL webpage (20 May 2014)
European A-CDM

Air Traffic Control

CFMU

Aircraft Operators

Ground Handling

Airport Operations
A-CDM Implementation

- Information Sharing
- Turn Around Process (Milestone Approach)
- Variable Taxi Time Calculation
- Pre-departure Sequence
- Collaborative Management of FUM
- CDM in Adverse Conditions
Information Sharing

- Airlines’ schedule
- Planning information
- Flight progress information
- Predictions messages
- Status messages
- Operational planning information
- Advisories
- Alerts
- Maintenance of environmental information (aeronautical and meteorological)
- Data recording and archiving
Information Sharing

- Examples of input data from the different stakeholders:

  - **Aircraft Operator/Handling Agent**
    - planning data
    - turn-round times
    - flight plans
    - movement data
    - priority of flights
    - aircraft registration and type changes
    - TOBT
    - movement messages

  - **Airport Operations**
    - stand and gate allocation
    - environmental information
    - special events
    - reduction in capacity
    - airport slot data
    - ADES
    - SOBT

  - **Air Traffic Control**
    - ELDT
    - ALDT
    - TSAT
    - TTOT
    - runway and taxiway conditions
    - taxi times
    - SID allocation
    - runway capacity

  - **Service Providers**
    - de-icing companies
    - MET office
      - forecast & actual met. info
    - and others
      - (fire, police, customs, fuel, etc...)

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Milestone Approach

Turn-Around Process divided in 16 milestones
Why develop a simulator?

- Many actors involved with different behaviours and interactions
- Actual effect on daily operations of the A-CDM implementation for a specific airport is hard to quantify
- Simulation framework will help to evaluate the impact of using different strategies
Agent Based Modeling
Why using ABM?

- Stakeholders → Agents modelled independently
- Agents run autonomously and interact via messages
- Important goal: capture the interactions between agents

- Example of interaction capturing
  - Arrows → Messages between agents
Modelling and Programming

GAIA Methodology
- Models of Roles and interactions to define the agents

JADE
- Framework to implement the agents
- **Java** middleware for agent oriented platforms
- Communications → FIPA specifications
Simulator Structure and Models

ABM applied to A-CDM
Agent Model

- A-CDM Agents
- Software Agents
A-CDM Agents

Agent Based Simulation Framework for Airport Collaborative Decision Making

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SIMULATOR Information Sharing graphical interface example
Software Agents

Graphical Interface:
- Aircraft Data Updates
- Number of Aircrafts in ACDM

Simulator Output Database:
- Saves simulation results

Simulator Input:
- Handles input data
- Generate initial data for simulation

Milestone Trigger:
- Starts every milestone in chronological order
- Responsible of simulation timing
Communications Model

Types of Communications:

1) Start Simulation
2) Start Milestone
3) Update Aircraft Information
4) Broadcast Aircraft Data Info.
5) Update Graphical Interface
6) Update Log File
How does the simulator work?
Exchanged Data

* Inside a message

Delays

IS: BroadcastInformation
Aircraft: IBE220
STATUS: LANDED
Times:
  ETOT' = 930
  ELDT = 1045
  ETOT = 1155
  EIBT = 1100
  EOBT = 1135
Milestone: 6
Secondary times:
  ACGT: 1103
  ASBT: 1110
  ARDT: 1128
  ASRT: 1129
  TSAT: 1130
Warnings:
  EOBT delayed from 1125 by 1135 by GH
  ASBT delayed from 1100 by 1110 by AO-IBE
  ARDT delayed from 1110 by 1128 by AO-IBE
  ASRT delayed from 1119 by 1129 by AO-IBE
Simulator architecture

Starting the simulation
Simulator architecture

Starting the simulation
Simulator architecture

During the simulation
Simulator architecture

During the simulation

Agent Based Simulation Framework for Airport Collaborative Decision Making

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Simulator architecture

During the simulation
Simulator architecture

During the simulation

For every Milestone
Simulator architecture

Ending the simulation
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 0
- ELDT = 0
- ETOT = 0
- EIBT = 0
- EOBT = 0
Milestone: 1
Secondary times:
- ACGT: 0
- ASBT: 0
- ARDT: 0
- ASRT: 0
- TSAT: 0
Incidents:
Example: Inside milestone 1

Milestone Trigger | CFMU | Airport | ATC | AO | GH | IS

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
(2a)

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
    ETOT' = 0
    ELDT = 0
    ETOT = 0
    EIBT = 0
    EOBT = 0
Milestone: 1
Secondary times:
    ACGT: 0
    ASBT: 0
    ARDT: 0
    ASRT: 0
    TSAT: 0
Incidents:
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
  ETOT' = 930
  ELDT = 1045
  ETOT = 0
  EIBT = 0
  EOBT = 0
Milestone: 1
Secondary times:
  ACGT: 0
  ASBT: 0
  ARDT: 0
  ASRT: 0
  TSAT: 0
Incidents:
Example: Inside milestone 1

**IS:** Broadcast Information
**Aircraft:** IBE220
**STATUS:** INITIATED

**Times:**
- \( ETOT' = 930 \)
- \( ELDT = 1045 \)
- \( ETOT = 0 \)
- \( EIBT = 0 \)
- \( EOBT = 0 \)

**Milestone:** 1
**Secondary times:**
- \( ACGT = 0 \)
- \( ASBT = 0 \)
- \( ARDT = 0 \)
- \( ASRT = 0 \)
- \( TSAT = 0 \)

**Incidents:**

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Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1145
- EIBT = 1100
- EOBT = 0
Milestone: 1
Secondary times:
- ACGT: 0
- ASBT: 0
- ARDT: 0
- ASRT: 0
- TSAT: 0
Incidents:
Example: Inside milestone 1

Milestone Trigger | CFMU | Airport | ATC | NO | GH | IG

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1145
- EIBT = 1100
- EOBT = 0

Milestone: 1
Secondary times:
- ACGT: 0
- ASBT: 0
- ARDT: 0
- ASRT: 0
- TSAT: 0

Incidents:
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1145
- EIBT = 1100
- EOBT = 1125
Milestone: 1
Secondary times:
- ACGT: 0
- ASBT: 0
- ARDT: 0
- ASRT: 0
- TSAT: 0
Incidents:
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
ETOT' = 930
ELDT = 1045
ETOT = 1145
EIBT = 1100
EOBT = 1125
Milestone: 1
Secondary times:
ACGT: 0
ASBT: 0
ARDT: 0
ASRT: 0
TSAT: 0
Incidents:
Example: Inside milestone 1

Milestone: 1
Secondary times:
- ACGT: 1103
- ASBT: 1100
- ARDT: 1118
- ASRT: 1119
- TSAT: 1120

Incidents:

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1145
- EIBT = 1100
- EOBT = 1125
Example: Inside milestone 1

* Example of Delay
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220

STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1145
- EIBT = 1100
- EOBT = 1135

Milestone: 1
Secondary times:
- ACGT: 1103
- ASBT: 1100
- ARDT: 1118
- ASRT: 1119
- TSAT: 1120

Incidents:
EOBT delayed from 1125 to 1135 by GH

* Example of Delay
Example: Inside milestone 1

IS: Broadcast Information
Aircraft: IBE220
STATUS: INITIATED
Times:
- ETOT' = 930
- ELDT = 1045
- ETOT = 1155
- EIBT = 1100
- EOBT = 1135
Milestone: 1
Secondary times:
- ACGT: 1103
- ASBT: 1110
- ARDT: 1128
- ASRT: 1129
- TSAT: 1130
Incidents:
- EOBT delayed from 1125 to 1135 by GH
- ASBT delayed from 1100 to 1110 by AO-IBE
- TSAT delayed from 1120 to 1130 by ATC
- ARDT delayed from 1118 to 1128 by AO-IBE
- ASRT delayed from 1119 to 1129 by AO-IBE
Current status & Future works
Current Status

- 16 Milestones
- Multi-Aircraft
- Delay in any time/milestone
Future Works

Work on the reality of Agent Behaviours!!

- Realistic data of A-CDM agents
- Statistical distributions
  - Montecarlo methods
- Realistic data for airspace traffic

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Conclusions

- ABM → Suitable to model complex systems like A-CDM
- Structure and communications defined for a simulator framework
- Real data → needed to be able to calibrate and validate our models, simulations and results
Thank you!

Do you have any questions?