Disruption Management in Airline Operations Control
An Intelligent Agent-Based Approach

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Airline Operations Control
Flight 103 with a schedule ETA in Rio at 11:00 did not depart yet from Lisbon due to a missing crew member. The new ETD is 20:00 and the new ETA is 12:30. It has 230 passengers on board with the following connections:

20 to flight 231 – ETD 12:15
34 to flight 350 – ETD 12:00
60 to flight 412 – ETD 12:45

What is the best solution to solve this unexpected event?
Operational Control Center with HCC
Disruption Management Process

act Disruption Management Process

Start

Operation Monitoring

Event

Take Action?

Generate and Evaluate Solutions

Apply Decision

Take Decision

No

«flow»

Yes
The Vision
A new Concept for Airline Operations Control

Future Airline Operations Control Centres should be **Automatic, Autonomous** and include **Learning** capabilities. **Monitoring** the operation, **Detecting** Problems that might affect the operation, **Finding** solutions to the problems, **Choosing** the best solution, **Updating** the operational plan accordingly and increase **Robustness** of future plans, should be done **Without** or with the **Minimum Human Intervention**.
Automation:

• Repetitive tasks:
  – Monitoring, Detecting, Finding, Updating...

Autonomy:

• Decision:
  – When to consider an event as a problem
  – Choose the best solution

Learning:

• Solving similar problems
• Increase robustness by avoiding repetitive problems
Is this Vision an Utopia?

B707 – 50, 60,70’s – 3 Crew

L1011 – 1968 ... - 3 Crew
Is this Vision an Utopia?

A330 – 1994 ... – 2 Crew

A350 – 2013 - 2 Crew
What about the future cockpit?

How are they doing it?

- Computers perform tasks that were done by humans
- More than one computer to perform the same task
- When two computers disagree a third makes the final decision

Very soon (according to Airbus) one man crew!
Automation
- Repetitive tasks

Autonomy
- Decision

Learning
- Robustness

Redundancy:
- Agents performing same task in parallel
- A third agent that decides when two disagree
Future AOCC – New Concept
Can We Do It in One Step?

Step 1: Automation
- Keep humans in the loop to validate info.

Step 2: Autonomy
- Ask humans for final approval.

Step 3: Learning
- Get humans opinion.

Step 4: Redundancy
- On our way to full autonomy....

Human Factors are Very Important!
Agent-Based System for AOC
1 instance
Monitors all operation
Solves problems in all Hubs

1 instance = 1 HUB (LAX)
Monitors LAX Ops

1 instance = 1 HUB (EWR)
Monitors EWR Ops
Solves EWR problems
Cooperates with others by exchanging information between agents
Distributed Problem Solving approach
Decision Mechanisms and Criteria
1. **Manager Agents Level**
   - Agents cooperate (by exchanging information) to **find** an **integrated solution** (one that considers the impact on the three dimensions problem)
   - Select the **best candidate solutions** with **lowest Total Operational Costs** (we are studying other criteria)

2. **Specialist Agents Level**
   - Each **agent** has a **specific expertise** (different resolution algorithm)
   - **Run in parallel** trying to **find** the **best candidate solutions**
   - **Total Operational Cost** is the **criteria**
Event_time: 18-09-2009 12:39
Event_type: AC
Resource_Affected: CS-TTG
Resource_Type: A319
ETR: 110
Flt_date: 18-09-2009
Flt_Nbr: 686
STD: 13:20
STA: 15:50
ETA: 16:10
From: LIS
To: LUX
Dep_Delay: 20
Bus_Pax: 1
Econ_Pax: 128
Schd_Trip_Time: 02:30
Est_Trip_Time: 02:50
Schd_AC_Cost: 1084
Schd_Crew_Cost: 1745
Schd_Pax_Cost: 0

\[ E_{\text{round}} = \frac{\alpha}{\alpha + \beta + \gamma + \delta} \left( \frac{da}{D_{\text{max}}} + \frac{dc}{D_{\text{max}}} + \frac{dt}{H_{\text{max}}} + \frac{ca}{C_{\text{max}}} + \frac{cc}{C_{\text{max}}} + \frac{pc}{P_{\text{max}}} \right) \]
Team Level – Contract.Net (Simplified)

Send CFP/Propose Feedback

Supervisor

Prepares CFP

Manager

Chooses Best from All solution received

Propose

Replies with accept

CFP

Search Best Solution

SimMAnneal

Search Best Solution

HillClimbing

Search Best Solution

BruteForce

Propose

Propose

Propose

NIAD&R - Distributed Artificial Intelligence and Robotics Group
Total Operational Cost

\[ tc = dc + \beta qc \quad \beta \in R, \beta \geq 0 \]

\[ dc = \text{Direct Operational Costs} \]
\[ qc = \text{Quality Costs} \]
What is Keeping us Busy
We are Working on

• Finish implementation **GQN Negotiation Protocol**

• Implementing more Specialist Agents:
  • Different Scheduling Algorithms.
  • Include Planning Algorithms.

• Add **learning capabilities** to the MAS:
  • Apply similar solutions to similar problems
  • Improve the **robustness of future schedules**

**Good Topic**
2D and 3D Data Visualization

Good Topic
We are Working on

- Include more metrics and restrictions/costs in our MAS:
  - Airport operational restrictions/costs
  - Airport Peak Performance
- Developing a framework that captures the commonalities of disruption management.
- Developing an IDE (Integrated Development Environment) that allows to visual build MAS for disruption management in airline operations control and other similar domains.
# Problem Resolution Strategies Applied on Airline Operations Control Centers

**Description**

At LIACC/NIADR we have developed a MAS that represents an AOCC (MASDIMA). We want to study the best strategies (through the use of heuristics or meta-heuristics) to be used by the agents to solve the problems that appear during daily operations and integrate it in our negotiation protocol. There is already an agent that implements a SA algorithm to the aircraft problem.

**Possible methods to use**

Dijkstra (shortest path), Simulated Annealing, Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Genetic Algorithms (GA), Other .....  

**Additional Information**

This work can be used totally or partially on the dissertation according to some of the thesis proposals presented by LIACC/NIADR.

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Thanks for your attention!

Any Questions?

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