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Research Paper

A New Ontology-Based Multi-Agent System Model for Air Traffic Management

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Abstract
Problems such as flights sequences, flights emergency positions, hijacking, airport controlled space management, and Free Flight are problems that the Air Traffic Management (ATM) are faced with it. Managing a large volume of flights data and their correct interpretation plays a key role in the prevention of air accidents, human errors, and flight interactions. The agent-based systems and ontology are tools that together have attributes such as autonomy, learning, and cooperation to solve ATM's problems. This research proposed a new ontology-based multi-agent system for air traffic management. The design of air agents has been done on the architectural basis of BDI. This model contains five main modules that were designed under Multi-agent Software Engineering (MaSE) methodology in AgentTool tools. Methontology methodology was exploited for the engineering of the ontology of agents and the implementation process was carried out using the Protégé software. The hybrid model ATM ontology-based multi-agent system (ATM-onto-mas) has been implemented with Java Agent Development Framework (JADE). The actual flight data of Mashhad Airport, Iran used to evaluate and test this model. Terminal control area (TMA) of Mashhad Airport was designed and simulated in an ATCsim simulator based on real data. The obtained results of the ATM-onto-mas system in a simulated environment indicate improvement in the evaluated parameters Compared with other methods.

Keywords: Air Traffic Management; BDI Architecture; agent-based; MaSE Methodology; Ontology; Methontology methodology

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1. Introduction

Developing new systems for Air Traffic Management (ATM) is very essential. Such cases as Unpredictable conditions, flights sequences, flights emergency positions, hijacking, airport controlled space management, and Free Flight are Caused numerous problems for air traffic controllers. The air traffic management new methods are designed for the prevention of flight delays. Additionally, fleet fuel and flight delays in airports impose significant costs on the airlines. On the other hand, the diversity of information and its analysis are important challenges in ATM. In general, pilots and air traffic controllers use information, including flight plan, airplane departure, arrival messages, flight delays, changes in the flight plan, flight cancelation, and airplane return, meteorological messages, aviation NOTAMs, snow, ATM messages, airline information messages, and aircraft systems warnings. The analysis of this data is extremely difficult. Multi-agent systems have produced the possibility to simulate air traffic control models to have independence in acts and relative autonomy for planes in the controlled area including airport air space and or other considered spaces. An ontological approach to the words and concepts in a field of aviation knowledge and their correlations is the infrastructure for the formation of the knowledge graphs (ontology) in the air traffic management field. Compatibility between systems and intelligent agents conveys the meaning of information so that the ability to access information is optimal and enables the processing of the information by the machine correctively. The agent-based systems and ontology are tools that together have attributes such as autonomy, learning, and cooperation to solve ATM's problems. This research proposed a new ontology-based multi-agent system for air traffic management. The design of air agents has been done on the architectural basis of BDI. This model contains five main modules that were designed under Multi-agent Software Engineering (MaSE) methodology in AgentTool tools. Methontology methodology was exploited for the engineering of the ontology of agents and the implementation process was carried out using the Protégé software. The hybrid model ATM ontology-based multi-agent system (ATM-onto-mas) has been implemented with Java Agent Development Framework (JADE). The actual flight data of Mashhad Airport, Iran used to evaluate and test this model. Terminal control area (TMA) of Mashhad Airport was designed and simulated in an ATCsim simulator based on real data.

The following sections of the paper have been structured, with Sect2. "Literature review" reviews the previous methods in the agent-based software, ontology, and hybrid systems of ATM field, Sect3. "BDI architecture" and "sect4" Methontology ontology "describe the methodology of the agent system. In Sect5". The Structure of Recommended model of Multi-agent Air Traffic Control System "explains agent and multi-agents design. Then in Sect6." implementation" implementation of the proposed model of air traffic management model .in sect 7 "case study" Analysis and design of the proposed model and evaluates it; in addition, Sect. 8 has been dedicated to a conclusion.

2. Literature Review

The agent-based software system was applied as a solution for developing models that capture air traffic decisions and interactions with an adequate level of detail. Different agent-based approaches were applied in ATM studies concerning air traffic control (ATC). In researchers propose the Air MIDAS model for air traffic management. Also in ACES, AgentFly, and tools such as AirTop and CAST Scientists Scientists have developed agent-based systems for air traffic management. For example, Air MIDAS simulates the behavior of the final approach of aircraft in the terminal airspace and their interaction between the pilots and the flight controllers for risk evaluation. ATM studies related to air traffic flow management (ATFM) have recently been performed using also agent-based approaches.

Ontologies of aviation define a joint concept table for the pilots, aviation autonomous machine, communication-navigation-surveillance (CNS) systems, flight staff, flight dispatchers, and air traffic controllers who need to share information in a specific field and domain. This glossary includes the definitions of basic concepts (understandable by machine), formation of flight safety messages, as well as their interpretation and communication. These ontologies are defined in the official and processing language of the machine for semantic commonalities in automated systems. In [12] researchers propose an approach to Decision-Support Systems (DSS) in Air Traffic Management (ATM) based on an ontology including concepts and instances of trajectories and meteorology.

In a group of researchers describes a study comparing two recently released and independently-developed complex ontologies focused on Air Traffic Management (ATM) - the NASA ATM Ontology and an ontology derived from the ATM Information Reference Model. They develop a methodology for manually comparing two ontologies and identifying what we describe as exact, light, and mismatches between concepts in the two ontologies.

3. BDI Architecture and Its Role in Designing Air Agent

Belief-Desire-Intention (BDI) architecture programs are based on three conceptions such as belief, desire, and program. Belief is what an agent thinks of the environment. BDI agents have a collection of beliefs that are based on law, Desire is a state of goal which an agent likes to achieve it and agent programs are designs that tell the agent how behaves to achieve its desires.

Based on performed research, it is more proper to build the design and main architecture of the model of our agents based on its infrastructure. Besides this, the agent should decide like a human and exactly like him in such an environment. Therefore, in this given model, these measurements are considered. The suggested agents which are classified into three agent groups are as follows:

1. Aircraft Agent Group
2. Navigational Agent Group
3. ATC Agent Group (figure 1)

Figure 1 ATC Agent structure for example has been drawn

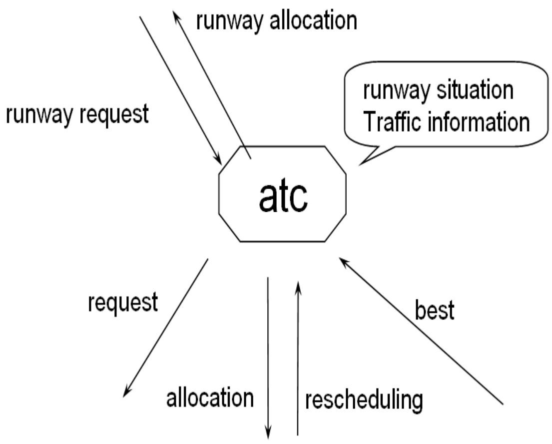

Figure 1. ATC Agent structure based on BDI architecture

4. Methontology Ontology

In the current research, we applied the Methontology methodology considering the numerous advantages for the preparation of ontologies in specialized application domains. Furthermore, the methodology exploits a thesaurus of an organized source of knowledge provided by experts in the field. The semantic relations (general/specific) in the thesaurus allowed us to create the hierarchical structure required for the ontology. Notably, we applied the

Methontology methodology with 11 stages as depicted in Figure 2.

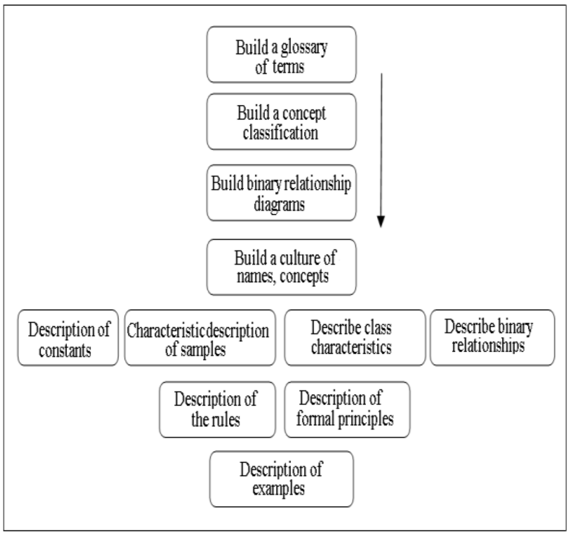

Figure 2. Eleven stages of ontology engineering based on Methontology methodology

4.1. Glossary of Terms

The glossary of terms was formed based on the terms existing in the thesaurus. In the current research, these terms were extracted and selected by the subject matter experts from various sources in each field. Table 3 shows the concepts used in the scope of the ontology, along with the relationships, examples, and characteristics of the examples (table1).

Table 1. Dictionary of concepts, examples, relationships, and features

Concept Name	Class Attribute	Instance Attribute	Relation
Iran Air 461	-	-	Same Flight as
Iran Air Flight	Company Name	-	-
Zagros Airlines Flight	Company Name	-	-
Airport	-	Name	Is Arrival airport of Is Departure airport of
Flight Plan	-	Arrival Airport Company Name Departure Airport Type of Flights Time of Flights Alternative Airport	Arrival airport Departure airport
Delay	-	Arrival Airport Company Name Departure Airport Delay Time	Arrival airport Departure airport
Change	-	Arrival Airport Company Name Departure Airport Type of Flights Time of Flights	Arrival airport Departure airport
Iranian Airports	-	-	-

5. The Structure of Recommended Model of Multi-agent Air Traffic Control System

The structure of the air traffic control model contains 5 main modules that the proposed model has been depicted in Figure 2. In this model, concerning considering all the involved parameters in the process of Air traffic control have been designed. The aims which are considered are as follows (figure 3):

1. Prevention from encountering planes with each other in controlled space based on agent methodology
2. Accelerate and create order in the traffic flow of flights.
3. Giving necessary and useful information to make flights secure.
4. Assistance to aircraft that are located in an emergency.
5. Designing agents system to achieve the best traffic control situation

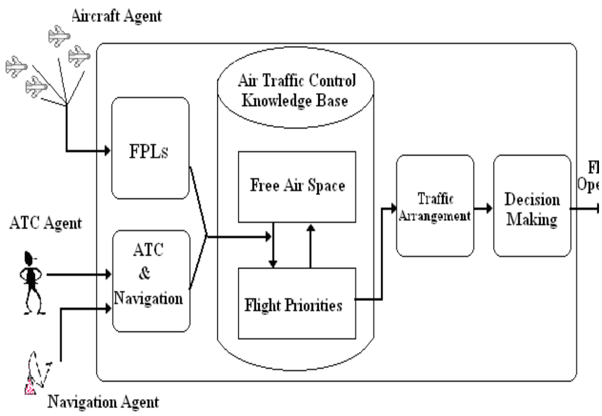

Figure 3. Structure model

5.1. Determine Free Space and Priorities Flights

Air space control in ATMs, divided into several areas that are classified in the arrangement of traffic players the determining important role. The division of space is different for various points and is invariable based on risk temporal geography Points, restricted area, danger area, prohibited area, gun area, and fire play. Application to provide air traffic control services:

class A ,class B ,class C ,class D ,class E ,class F, class G

Flight priorities, which were flying and landing are major priorities to bipartite priority traffic and aircraft type that will be divided as follows be given (table 2).

Table 2. The main the flight priorities

Arrival aircraft	a) Emergency Landing b) Air Ambulance c) Search and Rescue (SAR) d)VIP e)flight check
Departure aircraft	a) Scramble b) Air Ambulance c) Special Mission d) Search and Rescue (SAR) e) VIP f) Other traffic by the first contact with ATC and normal priority
Aircraft type priorities	a) Heavey: All types of aircraft with 136000 Kg or more b) medium: All types of aircraft between 7000-13600 Kg c) light: All types of aircraft with 7000 Kg or less
Aircraft's speed	Group a: less than 91KT Group b: 91KT or more but less than 121KT Group c: 121KT or more but less than 141KT Group d: 141KT or more but less than 166KT Group e: 166KT or more but less than 211KT Note: Usually fighters are placed in Group E

5.2. Rules of Arranging Traffic

Available space contains the rules of classification of spaces and determining the right of going first out of main rules of air control in the different stages of landing, take-off, and approach, which is done in various processes. This module which contains the way of attributing free space and determining flight majors after passing the previous stages is performed based on stated rules under the traffic process. The knowledge base of agents forms based on these rules. Each agent should have a knowledge base of rules to be performed in situations based on their goals and factors. The agent has a higher value, the corresponding laws with greater frequency than does the operating head (Table 3&4).

Table 3. Flight rules in the agent-based system

1-If aircraft arrival or departure from runway then aircraft movement into the wind
2-arrival aircraft has high preference than departure aircraft
3-If aircraft arrival into the holding area then {If aircraft input from part 1 then aircraft turn left and proceed to procedure "a" of holding area If aircraft input from part 2 then aircraft turn right till radial 30 degree and proceed to procedure "b" of holding area If aircraft input from part 3 then aircraft turn right and proceed to procedure "c" of holding area}
4-in arrival or departure if medium aircraft behind

heavy aircraft then 2 minute (minima time separation) shall be applied
5- in arrival or departure if light aircraft behind medium or heavy aircraft then 3 minutes (minima time separation) shall be applied
6-fighter aircraft same as light aircraft in priority.
7-hijack and emergency must be away from the city.

Table 4. The main if-else laws governing the flight priorities

8-if(aircraft[i][3].compareTo("arr")==0;
9-if(aircraft[i][1].compareTo("emergency")==0 aircraf[i][6]=5;
10-if(aircraft[i][1].compareTo("air-amb")==0 aircraf[i][6]=4;
11-if(aircraft[i][1].compareTo("sar")==0 aircraf[i][6]=3;
12-if(aircraft[i][1].compareTo("vip")==0 aircraf[i][6]=2;
14-if(aircraft[i][3].compareTo("dep")==0;
13-if(aircraft[i][1].compareTo("acft")==0 aircraf[i][6]=1;
15-if(aircraft[i][1].compareTo("scramble")==0 aircraf[i][6]=5;
16-if(aircraft[i][1].compareTo("air-amb")==0 aircraf[i][6]=4;
17-if(aircraft[i][1].compareTo("sm")==0 aircraf[i][6]=3;
18-if(aircraft[i][1].compareTo("sar")==0 aircraf[i][6]=2;
19-if(aircraft[i][1].compareTo("vip")==0 aircraf[i][6]=1;
20-if(aircraft[i][1].compareTo("normal")==0 aircraf[i][6]=0;
21-if(aircraft[i][2].compareTo("heavy")==0 aircraf[i][7]=0.3;
22-if(aircraft[i][2].compareTo("medium")==0 aircraf[i][7]=0.2;
23-if(aircraft[i][2].compareTo("light")==0 aircraf[i][7]=0.1;
24-for(i=1;i<=6;i (++ aircraf[i][8]=aircraf[i][6]+aircraf[i][7];

6. Goal Hierarchy Diagram and Sequence Diagrams

The goals of a multi-agent air traffic system are based on the ICAO organization scenario which is to arrange traffic efficiently and avoid any accidents that have been pampered. The goals of the suggested model have been classified based on methodology MaSE and given in a structured Diagram. The goals have been regulated in the form of three sub-collection which are indications of agent groups' goals in system and system goals. To determine the goals, the situation of the system should be cooperative and or competitive, because, in competitive multi-agent systems, there is a contradiction between agents goals and total goals system and the interest of an agent out of system contradicts with its total interest, but in a multi-agent system, this problem is rare. Here, our system has been determined with the kind of cooperative multi-agent systems because our main goal is in the direction of stall speed and secure air traffic control.

1. Aircraft agent group goals
2. Air navigational agent group goals
3. ATC agent group goals

This part aims to classify a collection of available roles in the system and the way to communicate among them. Application issues have defined a collection of events that occur possibly in the system. The building of sequence diagrams is done based on performed application issues. Which the use sequence diagram the order of events among various roles is shown. The Five sequence diagram which results in goals and explanation of system function is as follows (Figure 4 & 5):

- A sequence diagram of Arrival aircraft agent landing operations
- A sequence diagram of Departure aircraft agent taking-off operation
- A sequence diagram of Arrival aircraft agent into holding area
- A sequence diagram of operation faced with aircraft agent in an emergency
- A sequence diagram of operation faced with aircraft agent when hijacking

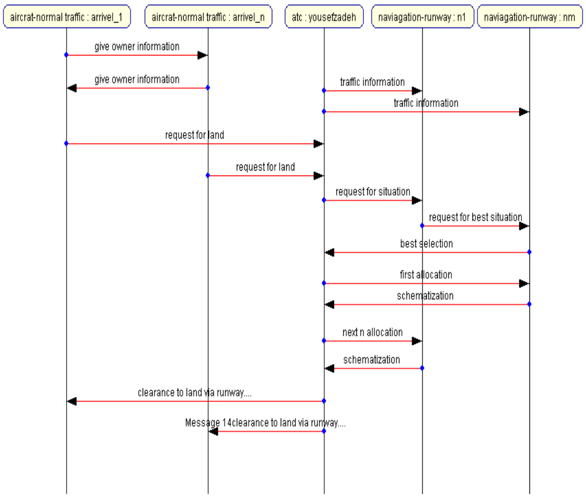

Figure 4. Arrival chart of the incoming airplane landing operation

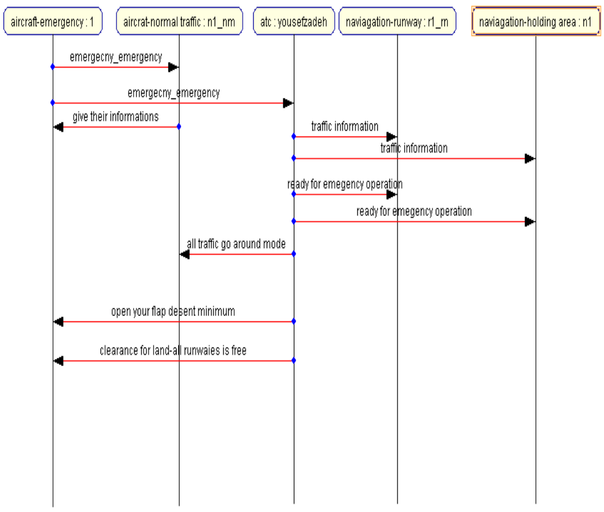

Figure 5. Operations diagram of emergency operations

6.1. Classification of Concepts with a Taxonomic Structure in Ontology-based Multi-Agent System

In the ontology-based multi-agent system for developing the ontology for agents, Description Framework (RDF) was originally designed as a metadata data model. It has come to be used as a general method for conceptual description or modeling of information that is implemented in web resources, using a variety of syntax notations and data serialization formats. It is also used in knowledge management applications. The body of knowledge modeled by a collection of statements may be subjected to reification, in which each statement (that is each triple subject-predicate-object altogether) is assigned a URI and treated as a resource about which additional statements can be made that help from Borrowing from concepts available in logic (and as illustrated in graphical notations such as conceptual graphs and topic maps) can be used. The classification of the concepts was based on the conceptual system in the thesauruses. In the present study, each reference term was intended as a concept or class, and the relationships (general/specific) were converted into relationships (subclass/class) using taxonomy or the graph theory in the four sections of the subclass, disjoint, exhaustive, and partition (figure 6).

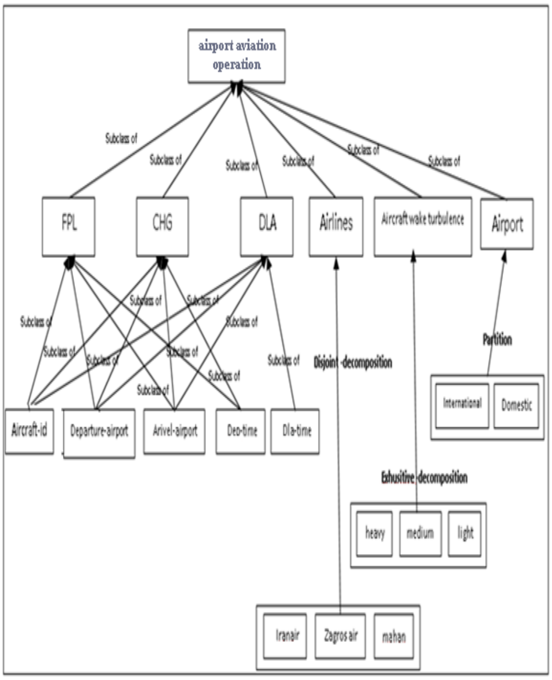

Figure 6. The diagram to design agent classes and state their combination

In this stage, based on roles that have been determined in the analysis stage, agent classes are created. Agents would have various roles in the process of performing the system. In the suggested model, to manage air traffic control based on mentioned factors, three agent class groups have been considered which include the ATC agent group, aircraft agent group, and air navigational agent group. Agent group is facilitator agent. The reactive agent would have an attribute of the response of the simulator to the environment. Architectures are based on specific rules (Figure 7 & 8).

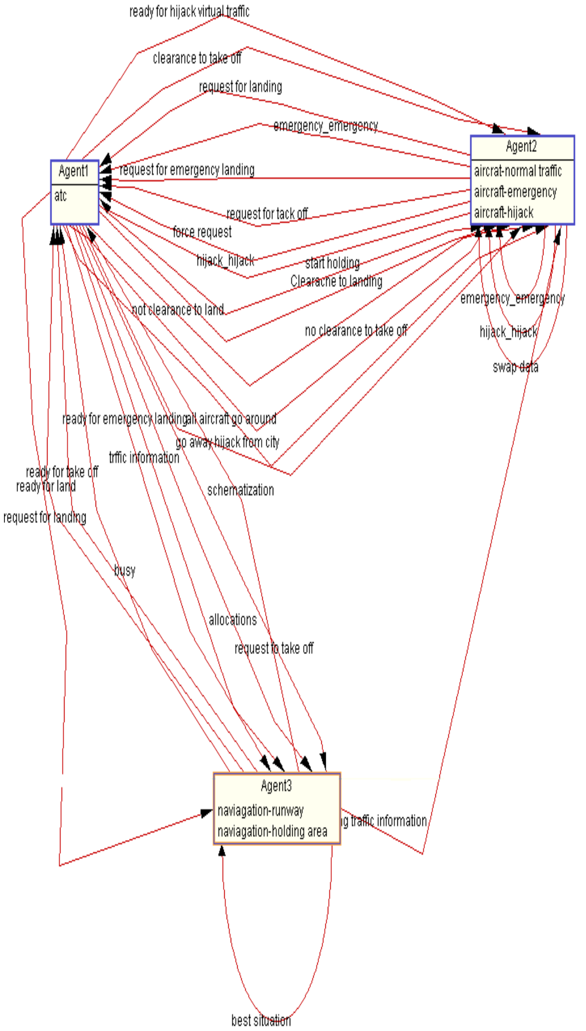

Figure 7. The diagram to design agent classes and state their combination

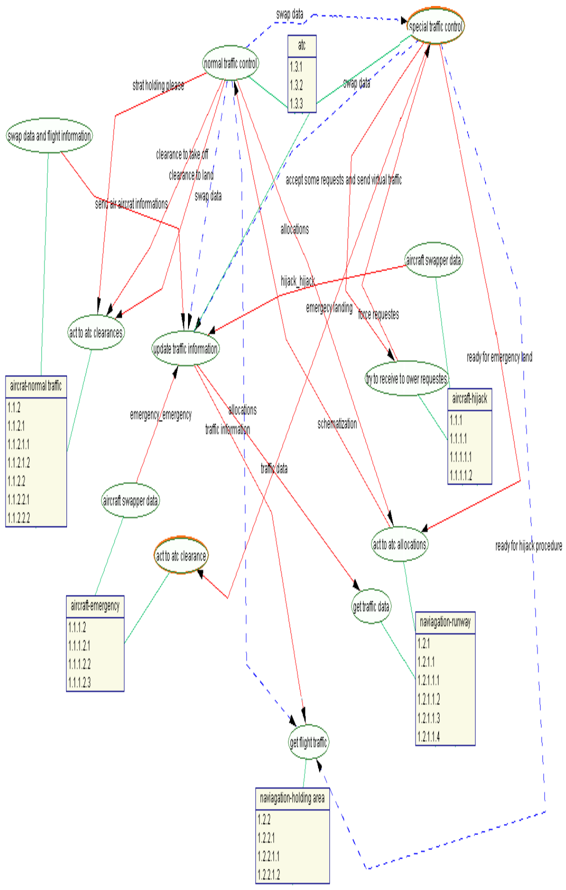

Figure 8. The diagram to design agent classes and state their combination

7. Implementation

Implementation of the proposed multi-agent system model for air traffic management has been designed under Multi-agent Software Engineering (MaSE) methodology with the aid of Agent-Tool emulator. Methontology methodology was exploited for the engineering of the ontology of agents and the implementation process was carried out using the Protégé software. The hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas) has been implemented with Java Agent Development Framework (JADE) in Netbeans integrated development environment (IDE). The real flight data of Mashhad Airport, Iran used to evaluate and test this model. Terminal control area (TMA) of Mashhad Airport was designed and simulated in an ATCsim2k simulator based on real data. To design a schematic terminal maneuvering area (TMA) environment for airports and as a case study of Mashhad airport, a practical tool. Design and implementation of the above application using C # language in MS Visual Stadiouo.net programming environment have been done. The output of the above application is the production of a standard datasheet file with the extension asd, which is used for use in an open-source simulator simulation environment called atcsim2k (figure 9).

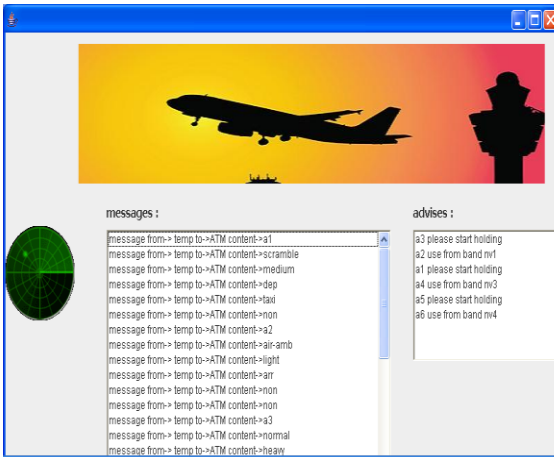

Figure 9. The hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas)

7.1. ATC Agent and Aircraft Agent

Agent ATC performs in a multi-agent air traffic control system as follows:

1. Facilitator agent role
2. Perform the module of arranging traffic and modules of flight priorities in a common state with aircraft agents and air-navigation
3. Manage and match emergency states and hijack aircraft agents would deliver their requests to ATC agents to landing and take-off and use of air navigational agents such as flight Runways and or Holding Area.

The ATC agent first surveys the use situation and attribution able of air navigational agents flight priorities on the attributes of flying agents, then, delivers the necessary information to the mentioned agents. In the case of specific flying agents such as emergency flying agents and hijack besides performing the mentioned functional process, The specific preparations of emergency land in operation and allowed traffic creation to check flight is done, also would receive, flight agents and air navigational momentary information of ATC Agent.

The aircraft agent. First introduces its request based on an allocation of the band for landing or take off to the ATC agent according to its attribution (Arrival, Departure), using its related request. After, accepting Request and related band and flight operation sequence is attributed. If the request rejects, it is directed into the Holding area. In the case of emergency flight agents and hijackers, more freedom in action has been predicated. The mentioned agent is to deliver and introduce its situation to ATC agents and other flight agents in the air traffic control space. Emergency flight agents would perform the emergency landing operation under the control and supervision of ATC. But in the case of hijacked aircraft flight agents, the situation is completely different. This agent is not under ATC control and there is a possibility to request illogically from hijackers. In this way, the necessary autonomy should be considered for this flight agent. Using tools such as the creation of virtual traffic and limitations for air traffic control space, the above flight should be controlled. (Figure 10)

```
public class ATC Agent extends Agent
{String address="@YOUR-
OVTH7EIKUA:1099/JADE";
   String aircraft[][]=null,field,  tto, temper;
   int [][]num;
   ACLMessage msg2,msg;
   /* Creates a new instance of bazar    */
   protected void setup() {
      aircraft=new String[10][20];
      num=new int[10][3];
      output out=new output();
      msg= new
ACLMessage(ACLMessage.INFORM);
      msg.addReceiver(new
AID("nv1"+address,AID.ISLOCALNAME));
      int i,j,k,tempint;
      for(i=0;i<6;i++)
         for(j=0;j<6;j++)  {
         msg2= blockingReceive();
         out.print("message","message  from->
"+msg2.getSender().getLocalName()+" to-
>ATM content->"+msg2.getContent());
   //     wait(100);
         //System.out.println("<><>sms  from
"+msg2.getSender().getLocalName()+msg2.getC
ontent());
         aircraft[i][j]=msg2.getContent();
         }
```

Figure 10. ATC-agent Pseudocode

7.2. Ontology for the Hybrid Model Air Traffic Management (ATM) Ontology-Based Multi-Agent System (ATM-Onto-Mas)

The proposed Methontology methodology was implemented for the engineering of the ontology of agents using the Protégé software for the hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas). The IPS-based aviation network standard and the Methontology methodology were applied for the engineering of the ontology of flight messages. The Protégé software was also used to implement the ontology. The system was tested based on the actual data of Mashhad Airport, which were obtained from the outbound and inbound flights of the airport, collected through the radar system and FDS, and finally normalized. By conducting a case study on several flight data samples, we demonstrated the implementation of the flight message ontology, the development of which as an application based on the ATN aviation network could lead to its exploitation. In the present the study, the ontology engineering was based on a top-down approach to ontology construction (methodology), the main stages of which included:

- Building a glossary of terms;
- Unification of the concepts;
- Building a concept classification;
- Diagram of the binary relations between the concepts.

In practice, ontology development encompasses the following steps (Figure 10):

- Defining the classes in ontology
- Arrangement of the classes in a hierarchy of 'parent-child classes'
- Defining the features and describing the values that are allowed to be possessed by the features;
- Determining the values of the features for the class samples (Figure 11).

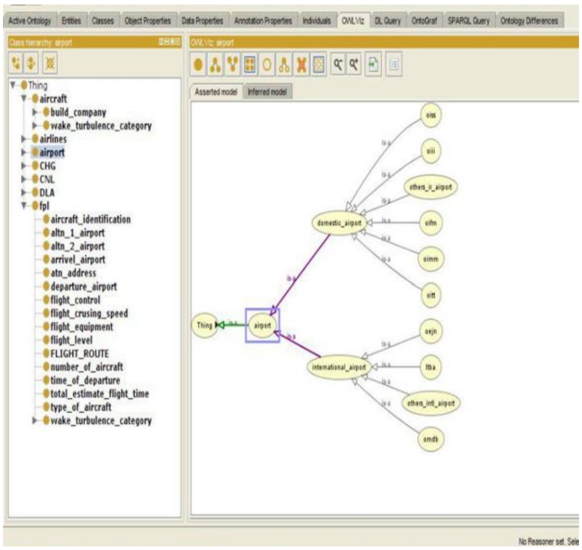

Figure 11. Implementation of classes and subclasses in Protégé software

8. Case Study

To evaluate and test the suggested hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas), the ATCsim simulator environment has been utilized in this research. So, Mashhad International Airport Air Traffic control space (Figure 12). This airport would contain various air accidents internationally and high air traffic and or due to a variety of flights, internally and externally, specific flights, etc., a super environment to set up and test our system and mode, so a data set file MSD-Ap.asd has been produced and contains a series of environment standard information and air control space flights, (delay, inbound, outbound) times of flights, would have the capability of plotting and performing in ATCsim environment (Figure 13).

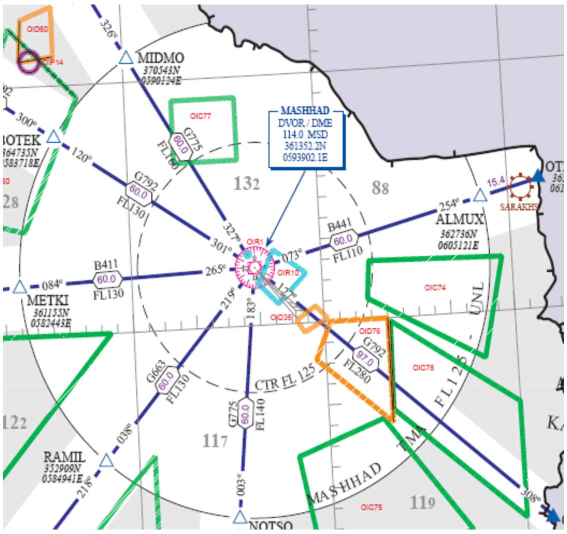

Figure 12. TMA of Mashhad Airport, depicted in Iran FIR

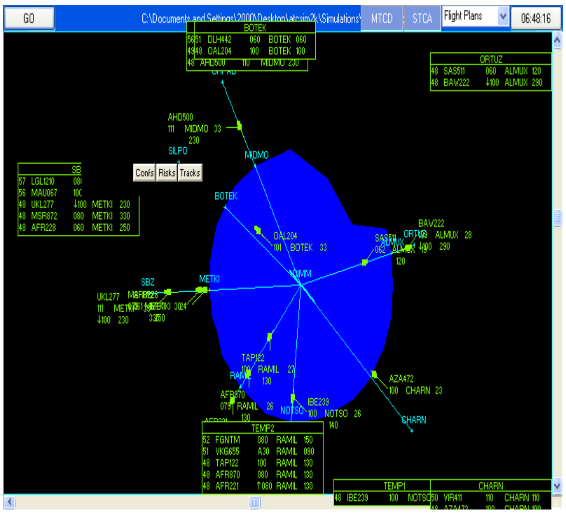

Figure 13. TMA of Mashhad airport, created in ATCsim simulator

8.1. Dataset

The dataset obtained included 10000 records and 15 features according to (Table 5) from Mashhad International Airport Air Traffic control space flights.

Table 5. Applied dataset

Row	Feature	Description
1	Origin_Airport	The airport from which the flight takes off
2	Destination_Airport	The airport where the flight lands
3	Airline	Flight Operations Airlines
4	Month	Moon Flight Date
5	Day	flight date
6	Day_Of_Week	Flight day (number per week)
7	Flight_Number	Flight number registered in the flight plan
8	Departure_Time	Time of departure of the aircraft from the runway
9	Scheduled_Time	Scheduled time for flight departure in flight schedule
10	Elapsed_Time	Predict the time for the plane to leak or take off
11	Air_Time	Flight time in the flight cruise section
12	Distance	The flight distance between the airport of origin and the airport of destination
13	Arrival_Time	Flight landing time at the destination airport
14	Arrival_Delay	Flight delay rate in-flight landing
15	Departure_Delay	Flight delay in departure

In air traffic management factors density and capacity are directly related; If the traffic density is super higher, then the traffic demand may be higher than capacity. The traffic demand, density, and flow conditions directly link the current or potential complexity of the airport. To compare the proposed hybrid model air traffic management (ATM) ontology-based multi-agent system

(ATM-onto-mas), the following flights are considered:

- Number of flights expected to enter the TMA in the next 15 minutes.
- Number of flights departing from OIMM in the next 15 minutes.

Landing sequencing is strongly related to the arrival sequencing on the runway. The flight trajectory could be elongated or shortened to satisfy an optimal and safe use of the runway. Therefore, based on First-Come-First-Serve (FCFS) arrival sequencing on the runway, is selected. We considered two methods of air traffic management to evaluate the proposed model.

The first method is called the "**instructional standard air traffic management"** in which air traffic control and separating the issue of flights would just perform based on introduced standards in annexes and country aviation internationally organization journals and based on ability and intelligence of controller. In this method, a voice tool has been utilized to communicate with the pilot and uses ground navigational types of equipment.

The second method is called an "**advisory system air traffic management"** which is based on air traffic control and separating flights according to design standards which are provisions of local instructions. In this method, tools such as radar and voice data links to communicate with the pilot have been utilized and would use ground and satellite navigation equipment. In this method, the controller work stress loads decreased but, in designing responsibility would assign to the controller.

In these tests, parameters such as calculation of related delay on output flights. The spent time to obtain the landing license the extent of work pressure on to controllers, the extent of pilot's satisfaction and controllers, and the following results are as follows.

In these tests, 15 minutes for incoming and outgoing flights in the time window for the air traffic control area of Mashhad Airport is considered. As can be seen in the results, the amount of time for the second scenario is less with the help of the hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas) model (Figure 14).

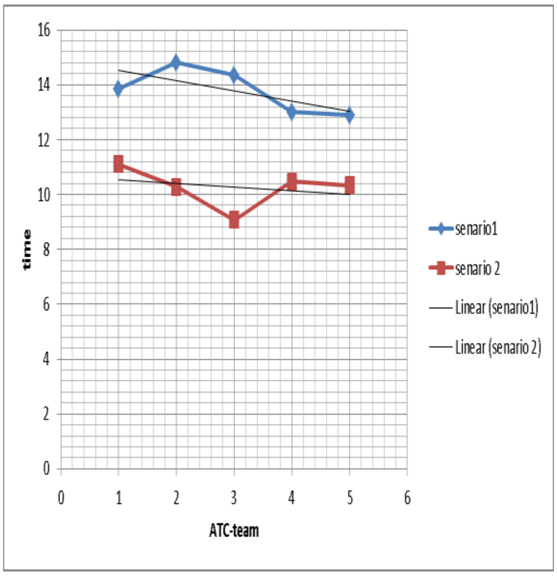

Figure 14. Compare scenario 1 and 2 for TMA of Mashhad airport with hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas) model

9. Conclusion

Use of the intelligent system based on agents to manage air traffic is one of the main issues in the field of intelligent knowledge for air new science. Problems such as flights sequences, flights emergency positions, hijacking, airport controlled space management, and Free Flight are problems that the Air Traffic Management (ATM) are faced with it. Managing a large volume of flights data and their correct interpretation plays a key role in the prevention of air accidents, human errors, and flight interactions. The agent-based systems and ontology are tools that together have attributes such as autonomy, learning, and cooperation to solve ATM's problems. Multi-agent systems have produced the possibility to simulate air traffic control models to have independence in acts and relative autonomy for planes in the controlled area including airport air space and or other considered spaces. An ontological approach to the words and concepts in a field of aviation knowledge and their correlations is the infrastructure for the formation of the knowledge graphs (ontology) in the air traffic management field. Compatibility between systems and intelligent agents conveys the meaning of information so that the ability to access information is optimal and enables the processing of the information by the machine correctively. The agent-based systems and ontology are tools that together have attributes such as autonomy, learning, and cooperation to solve ATM's problems. This research proposed a new ontology-based multi-agent system for air traffic management. The design of air agents has been done on the architectural basis of BDI. This model contains five main modules that were designed under Multi-agent Software Engineering (MaSE) methodology in AgentTool tools. Methontology methodology was exploited for the engineering of the ontology of agents and the implementation process was carried out using the Protégé software. The hybrid model ATM ontology-based multi-agent system (ATM-onto-mas) has been implemented with Java Agent Development Framework (JADE). The actual flight data of Mashhad Airport, Iran used to evaluate and test this model. Terminal control area (TMA) of Mashhad Airport was designed and simulated in an ATCsim simulator based on real data. We considered two methods of air traffic management to evaluate the proposed model. In these tests, 15 minutes for incoming and outgoing flights in the time window for the air traffic control area of Mashhad Airport is considered. As can be seen in the results, the amount of time for the second scenario is less with the help of the hybrid model air traffic management (ATM) ontology-based multi-agent system (ATM-onto-mas) model. In further studies, to increase the ATM accuracy, use deep learning methods such as long short term memory (LSTM) in the implementation of hybrid model ATM ontology-based multi-agent system (ATM-onto-mas).

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