استخدام نظام متعدد الوكلاء (MAS) لتنظيم المفاوضات بين سلطات الحج ومنظمي الحملات لتفويج الحجاج خلال أوقات الذروة

Using a multi-agent architecture to handle the negotiation between the Hajj authorities and the Hajj travel agents

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Abstract ملخص البحث

أحد أكبر المشاكل التي تواجه السلطات خلال الحج هي الاختناقات المرورية التي تحدث خلال انتقال الحجاج من عرفة إلى مزدلفة. ويرجع ذلك إلى العدد الهائل من الحجاج الذين يهدفون إلى الوصول إلى مزدلفة في أقرب وقت، مما يؤدي إلى ازدحام الطريق الذي يهدد سلامة الحجاج .
في هذه الورقة يقترح المؤلفون حل قائم على الذكاء الصناعي (AI) يستخدم بنية نظام متعدد الوكلاء (MAS) لأتمتة التفاوض بين سلطات الحج ومنظمي الحملات والوصول إلى جدول زمني ينظم تفويج الحجاج خلال هذا الوقت .
تقترح الورقة أيضًا استخدام بوابات RFID الآلية والتي بدورها ستكتشف تلقائيًا وتغرم أي حافلة لا تحترم الجدول الزمني المسند إليها. يتوقع من خلال استخدام نظام معلن يوزع الجدول الزمني بين منظمي الحملات بطريقة واضحة وعادلة، ستتمكن السلطات من فرض الجدول الزمني مما يسمح بفرض غرامات على أولئك الذين لا يحترمون الجدول الزمني.

One of the biggest problems facing the Hajj Authorities is the traffic jams that occurs when pilgrims go from Arafah to Muzdalifah.
In this paper the authors propose the use of Multi Agent System's (MAS) architecture to automate the negotiation between the Hajj Authorities and the hajj travel agents to obtain a schedule regulating the transport of pilgrims during this time.
The paper proposes also the use of automated RFID gates that will automatically detect and fine any bus that does not respect the schedule. By using an open system that distributes the schedule between the hajj travel agents in a clear and fair way, the authorities will be able to enforce the schedule and will allow them to impose fines on those who do not respect the schedule.

Research Aims أهداف البحث

- Propose a solution based on Artificial Intelligent (AI) that regulates the flow of pilgrims during peak times. The proposed solution uses a Multi Agent System's (MAS) architecture to automate the negotiation between the Hajj Authorities and the Hajj travel agents.
- Propose techniques to enforce buses to respect the schedule and to penalize who do not abide to the assigned schedule.

Research Methodology منهجية وطرق البحث

There is consensus that one of the biggest problems facing pilgrims is overcrowding during peak periods. The first step for enforcing Hajj travel agents to abide to the schedule is create the schedule assigned to each travel agent through negotiation. The Hajj authorities need the schedule finalized long before the start of Hajj to prepare for the services needed to accommodate the large number of pilgrims. Direct human negotiation will not possible due to the large number of Hajj travel agents and due to the fact that many of them do not have a representative in the Kingdom. Hence, the negotiation between the Hajj authorities and the Hajj travel agents need to be automated.
This paper proposes the use of automated negotiation methodology which has been an active field of Artificial Intelligent research as a reliable approach for coordination between agents. The Hajj travel agents participated in the automated negotiation as Agents. Agents are software entities that act on behalf of a user to achieve the user's goal within the constrains determined by the user. A multi-agents system allows agents to work together to find answers to problems that are beyond the individual capabilities or knowledge of each agent. Automated negotiation implemented as an Auction that is forms of negotiation between agents and widely used for selling and buying items by offering them up for bid.
After the automation of the negotiation, the next step is to implement a practical method to force the Hajj travel agents to abide to the assigned schedule. This paper proposes the use of Radio Frequency Identification (RFID) cards that is assigned to each bus. The RFID contains a key that uniquely identifies the Hajj travel agent that has participated in the automated negotiation and has reserved a place in the schedule. Automated gates will be placed at the exit of Arafah that would only allow buses to pass if the time slot they have reserved have already started. Any bus without a valid RFID for the current time slot will be fined. This fine should exceed the maximum possible value for any time slot. Using a fair and open system to distribute time slots and implementing a strict system that would penalize complain organizers that do not abide to the schedule is expected to resolve the problem of traffic congestions and improve the quality of the Hajj experience for all pilgrims.

Results and Discussion النتائج والمناقشة

An overview of the system shown in the Figure below:

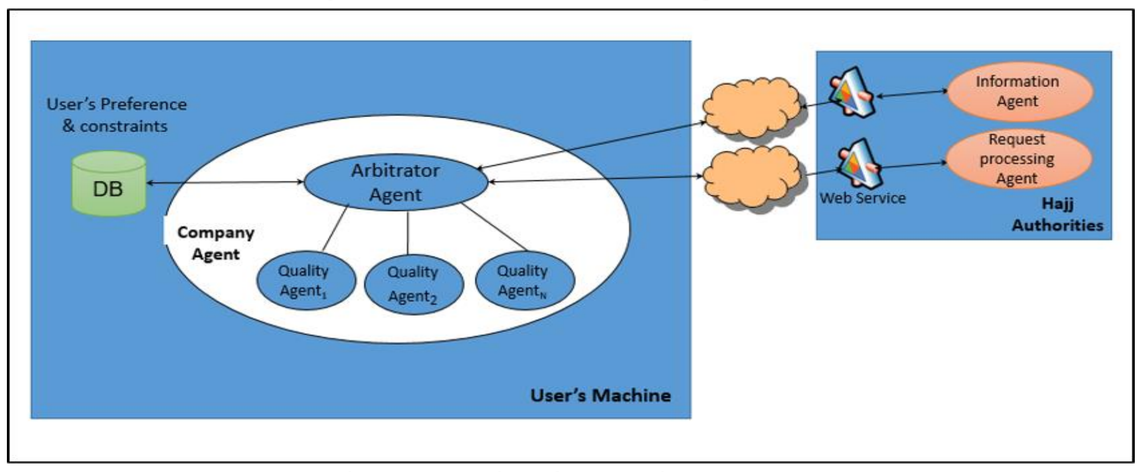

Figure 1: Overview of proposed system

In this research we propose to automate the negotiation between the Hajj Authorities and the Hajj Travel Agents using Artificial Intelligent (AI). The time of travel of pilgrims from Arafah to Muzdalifah will be divided into several time slots. The Hajj Authorities will use the Dutch auction for each time slot and will publicize the number of available places. At each iteration, if the number of demand made by the Hajj Travel Agents for each time slot is lower than the number of available places, the requested places will be sold and the next iteration will require a lower price for each time slot. If the number of demand is higher than the number of available places, no sale will be performed and the next iteration will have a higher price.
Each Hajj travel agent will have an Intelligent Agent acting on his behalf. The agent is decomposed into multiple broker agent, one for each time slots. Using the preference of each travel agent, the broker agents will use fuzzy rules to decide whether to make a proposal to buy places at a specific time slot or not. A sample of fuzzy rules and fuzzy system used shown in the next figures:

```
RULEBLOCK No1
  AND : MIN;          // Use 'min' for 'and' (also implicit use 'max' for 'or' to fulfill DeMorgan's Law)
  ACT : MIN;          // Use 'min' activation method
  ACCU : MAX;     // Use 'max' accumulation method
         RULE 1 : IF risk   IS  low AND priceSatisfaction IS low THEN proposalSatisfaction IS low;
         RULE 2 : IF risk IS low AND priceSatisfaction is medium THEN proposalSatisfaction IS low;
         RULE 3 : IF risk IS low AND priceSatisfaction is high THEN proposalSatisfaction IS medium;

         RULE 4 : IF risk IS medium AND priceSatisfaction is low THEN proposalSatisfaction IS low;
         RULE 5 : IF risk IS medium AND priceSatisfaction is medium THEN proposalSatisfaction IS medium;
         RULE 6 : IF risk IS medium AND priceSatisfaction is high THEN proposalSatisfaction IS high;

         RULE 7 : IF risk IS high AND priceSatisfaction is low THEN proposalSatisfaction IS medium;
         RULE 8 : IF risk IS high AND priceSatisfaction is medium THEN proposalSatisfaction IS high;
         RULE 9 : IF risk IS high AND priceSatisfaction is high THEN proposalSatisfaction IS veryHigh;

         RULE 10 : IF risk IS critical AND priceSatisfaction is low THEN proposalSatisfaction IS high;
         RULE 11 : IF risk IS critical AND priceSatisfaction is medium THEN proposalSatisfaction IS veryHigh;
         RULE 12 : IF risk IS critical AND priceSatisfaction is high THEN proposalSatisfaction IS veryHigh;



END_RULEBLOCK
```

Figure 2: Sample of fuzzy rules used by broker Agent

```
FUZZIFY risk
// Fuzzify input variable 'risk': {'low', 'medium' , 'high', 'critical'}
   TERM low := (0, 1) (20, 0) ;
   TERM medium := (10, 0) (20,1) (30,1)(40,0);
   TERM high := (30, 0) (40, 1) (50, 1)(70,0);
              TERM critical := (50, 0) (70, 1) (100, 1);
END_FUZZIFY

FUZZIFY priceSatisfaction
// Fuzzify input variable 'priceSatisfaction': {'low', 'medium' , 'satisfied'}
   TERM low := (0, 1) (10, 0.8)  (30,0);
   TERM medium := (0,0) (30, 1) (50,1) (80,0);
   TERM high := (60, 0) (100, 1) (120, 1);
END_FUZZIFY

DEFUZZIFY proposalSatisfaction
// Defuzzify output variable 'proposalSatisfaction' : {'low', 'medium', 'high', 'veryHigh' }
   TERM low := (0, 1) (20, 0.75) (40,0) ;
   TERM medium := (20, 0) (40,1) (60,1)(80,0);
   TERM high := (50, 0) (70, 1) (80, 1)(100,0);
              TERM veryHigh := (80,0)(100,1);
   METHOD : COG;     // Use 'Center Of Gravity' defuzzification method
   DEFAULT := 0;     // Default value is 0 (if no rule activates defuzzifier)
END_DEFUZZIFY
```

Figure 3: Sample of used Fuzzy-Logic system

The Intelligent Agent of the travel agent will collect the result for the inner broker agents and using the set of fuzzy rule to decide if it should bid in the next iteration or not. This process is repeated for each iteration till all the Hajj travel agents have reserved the required places.

Recommendations التوصيات

The problem of congestion is not the result of infrastructure's limitations, but instead it is due to the difficulty of organizing the process of crowding and enforcing the pilgrims to respect the schedule allocated to them. This research propose one of the possible solution based on Artificial Intelligent. We are expecting that by using an open system that distributes the schedule between the hajj travel agents in a clear and fair way, the authorities will be able to enforce the schedule and will allow them to impose fines on those who do not respect the schedule. This research propose also make use of automated RFID gates to prevent buses without a permission to access the holy city and to fine those buses that do not abide to the assigned schedule.

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