AN ONTOLOGY DRIVEN MULTI-AGENT SYSTEM FOR CLIENT ASSIGNMENT IN A BANK QUEUE

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Abstract: This paper presents an ontology driven multi-agent system that uses a negotiation process for decision-support in a Bank Queue. The system assists queue client assignment based on the client profile and the cashiers' workload in order to guarantee a minimum time response in client attention. The multi-agent system has a direct positive impact in the quality of service. Simulations of service providers' management are presented in order to optimize the use of the resources. Our ontological user profiling and multi-agent system approach can be easily extended and adapted to other domains by adding client profile characteristics and adapting agent behaviours. The ontology proved to be useful when sharing content between agents and performing semantic checks.

1 INTRODUCTION

High quality customer service is one of the key ingredients for success when marketing products and services. Enterprises all over the world recognize that offering a good service even attached to a product sell is most likely to determine their competitive advantage. For that matter, knowing the customer better can help many service providers to improve and customize their service delivery and development. To model user preferences, interests, and requirements is a very important research area for several applications, like Web usage and content mining and Web search personalization (Jin, 2000; Sieg, 2007), Service Marketing (Chen, 2009), Personalized Information Services (So, 2009) among many others. Ontological user profiling and adaptive multi-agent systems attempts have been made providing decision-support in gathering and presentation on information. Harvey & Decker (2005), demonstrate that the influence of the user models on content selection and presentation improves system output, (Harvey, 2005).

The quality of service in a bank is determined in a large proportion by the time customers have to wait in a queue before he or she receives attention and the way the service provider recognizes their special needs. Time of response restrictions and user requirements have to be taken into consideration in a client assignment system in order to guarantee a fair quality of service.

In this paper, we present an ontology driven multi-agent system that uses a Contract Negotiation Process between a manager agent and several cashier agents (service providers) for a Bank Queue management. The system supports the decision on the assignment of a new client to a cashier based on the cashiers' workload and the user profile to guarantee a 20 minutes time response. The system simulates the service providers' management with the purpose of optimizing the number of cashiers opened considering the number of clients, the arrival and service rates, and the clients' profile.

In Section 2, the multi-agent system architecture and its approach in client assignment are introduced. In the Section 3 the client profiling and the ontology development for user profiling as well as the evaluation function derived from user characteristics are presented. Agents bid summiting and negotiation process is presented in Section 4. In Section 5 the implementation is described, and in Section 6 the

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experiments and results of the simulation are explained. Finally, in the last section main conclusions and suggestions for future work are presented.

2 MULTI-AGENT SYSTEM CLIENT ASSIGNMENT IN A BANK QUEUE

In ordinary bank branches clients arrive in the day when just a few cashiers are necessary, however, at the busiest times, the bank has to open every cashier they have. Bank personal must foresee the changes in the frequency of client arrivals in order to optimize resources, in this case, the number of open cashiers.

Some banking institutions establish policies and rules on attention time of response. For example, in Bolivia and Argentina a client must not wait in line more than 30 minutes before he or she receives attention,(Central,2010)(NoticiasOnline.org,2010).
Based on banking policies, for the purpose of this system, we considered a policy of 20 minutes attention time of response. A new cashier should open if some client is near to that time limit in order to fulfil this policy. Additionally, for our purposes, we consider six cashiers available in view of an average bank branch.

To simulate the process we develop a multi-agent system. In this system, agents provide us with autonomy and decision-making capacity as well as social ability for cooperation and negotiation needed to provide a solution to this problem.

2.1 Multi-agent System Architecture

Our multi-agent system has three types of agents with two distinctive roles. These agents are described in the following paragraphs:

A. The cashier agents are responsible for providing banking services for the customers assigned to their queue. They should always be in contact with the manager agent to receive future clients and to constantly verify if some client waiting time is near to 20 minutes. If so, the client must be reassigned for immediate attention.
B. The executive agents are responsible of providing banking services as well. The differences in the services provided by the cashiers are not relevant for this work because the 20 minutes policy on attention time of response also applies in spite of these differences. The agent role is considered the same.
C. The manager agent, only one, is responsible of opening and closing cashiers i.e. creating and destroying cashier agents when needed. He or she is also responsible for assigning every incoming client to the most convenient cashier agent in order to provide attention to the customer as fast as possible. The Manager Agent receives the client´s profile information, evaluates these characteristics and negotiates with the active cashier agents, and assigns the client to a cashier queue.

For statistical purposes, the manager agent registers the client profile and arrival time in a blackboard and the corresponding cashier agent updates this record when the client leaves. Both types of agents can read these records.
With some interval the cashier agents verify from the records, how long has each client really been waiting.

3 CLIENT PROFILE

There are many client characteristics worthy of consideration to provide a personalized service and speed up the client attention. In order to classify the clients that arrive to a bank branch, we considered the following characteristics:

1) The type of service required which determine if the client needs to be attended by a cashier or an executive.
2) Type of client: VIP or regular customer
3) Physical condition: handicapped, pregnant women, elderly.
4) Number of intended transactions.

The type of service required determines the first client categorization: *Temporary client* if the client is going to be attended by a cashier or *repeat client* if he or she is going to be attended by an executive. Each section queue is separated. In this paper we only describe the cashiers queue but the process of managing the executives queue is similar and the implementation is straightforward. The manager cooperates with the executive agents in the same manner as it works with the cashiers.

Depending of the type of client, physical condition and number of intended transactions, an expected time of attention (t_{attn}) is calculated. This variable (1) describes how long it takes a cashier to serve a particular client. If we calculate an expected time of attention for each client, it is possible to estimate how long each client must wait in line.

$$t_{attn} = \frac{(NumTr + w_1 Ha + w_2 Pr + w_3 El)}{(1 + Tc)} \quad (1)$$

Where

t_{attn} = client expected time of attention

$NumTr$=Number of transactions and $\{NumTr \in +\mathbb{Z} | 0 < NumTr < 4\}$

Ha= Handicapped and $\{Ha \in \{0,1\}\}$

Pr= Pregnant and $\{Pr \in \{0,1\}\}$

El= Elderly and $\{El \in \{0,1\}\}$

Tc=Type of client (vip or regular) and $\{Tc \in \{0,1\}\}$

$\{w_i \in +\mathbb{Z} | 0 > w_i > 2\}$ i=1,2,3

Each w_i represents a weight that can be considered for each physical condition attribute with the intention of doing a more accurate estimation. The value of the attribute itself is 1 when the characteristic is present in a client or 0 if it is not.

We suppose that certain client attributes add delay to the normal time spend in making one operation and when clients are VIPs clerks make an extra effort to speed up the execution of their transactions.

Each cashier or executive agent has a queue and the manager agent has to decide taking the current state of the system and the client profile, which agent is the best choice for assigning each arriving client, in order to minimize the expected time of response. The equation 1 applies to the cashier agents, but equation for executive agents is similar.

$$t_{attn} = \frac{(\sum k_i NumTr_i + w_1 Ha + w_2 El)}{(1 + Tc)} \quad (2)$$

Where

t_{attn} = client expected time of attention

$NumTr_i$=Number of transactions of service$_i$ required and

$\{NumTr \in +\mathbb{Z} | 0 < NumTr < 2\}$

k_i = minutes taken to perform service$_i$ required

Ha= Handicapped and $\{Ha \in \{0,1\}\}$

El= Elderly and $\{El \in \{0,1\}\}$

Tc=Type of client (vip or regular) and $\{Tc \in \{0,1\}\}$

$\{w_i \in +\mathbb{Z} | 0 > w_i > 2\}$ i=1,2

Transactions in the cashier equation are considered to last one minute each plus the client's profile increase. This is not likely to be true for executive transactions due to the nature of the service required. To calculate the expected time of attention of a client served by an executive agent, we considered the type of service the client requires and the minutes taken to perform each service *(k_i)*.

The *k* constants should be determined by a bank expert and are intended to be system parameters. Examples of bank services performed in a bank branch by bank tellers (executive agents) are shown in figure 1.

Bank service	Minutes taken
Open an account	k_1
apply for a credit card	k_2
buy traveler's checks	k_3
check or withdrawal authorization	k_4
check your account balance	k_5
ask for information	k_6
financial advisement	k_7
collect or ask for a checkbook	k_8
rent a safety deposit box	k_9
review your bank statement	k_{10}
take out a loan	k_{11}
transfer money	k_{12}

Figure 1: Examples of bank services performed by the executive agents.

3.1 Ontology Development for Client Profiling

We develop the multi-agent system using JADE (Java Agent Development Framework) to simplify the implementation of the agents and their communication through JADE's tools that complies with FIPA specifications (Bellifemine,1999).

Agents in our multi-agent system have to share content with the purpose of cooperation in order to reach the common goal of fulfilling the 20 minutes policy on attention time of response. For that matter, we designed the following ontology (Figure 2) so JADE can perform the proper semantic checks on given content expressions. Exploiting the JADE content language and ontology support included in the jade.content package includes developing proper Java classes for concept, predicate and agent actions (Bellifemine, 2001).

The type of service required at arrival time determines what information is needed to considered at the moment. This means that a client is classified as a temporary client even though he has remained several years as a client if he or she asks for a cashier's service. For a temporary client we consider

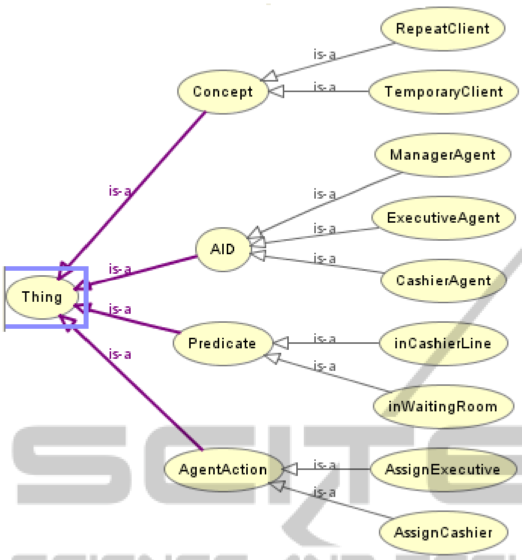

Figure 2: Ontology for client profiling.

just the type of client, physical condition and number of intended transactions attributes. These attributes are dynamic and vary for almost each time a client arrives to a bank branch. For a repeated client, a client that is looking for executive, more long-term information is needed in addition to the dynamic attributes described in equation 2. The attributes in the long term scenario are age, gender, salary, current investments, credit and general historic records in the bank. These attributes can be exploited also for other purposes.

Two concepts are designed with their corresponding slots from the categories mentioned: *RepeatClient* and *TemporaryClient*.

There are two agent actions used in manager agent and cashier or executive agent negotiation: *AssignCashier* and *AssignExecutive*. *AssignCashier* action includes a slot with type *TemporaryClien* , and *AssignExecutive* includes a slot with type *RepeatClient* with the purpose of sharing the corresponding client information between manager and the service agent (cashier or executive). One of these two actions is sent in the manager agent´s proposal.

Two relevant predicates were designed to enable the service agents (cashier or executive) to respond the manager agent´s proposal. An *inCashierline* predicate is used in the manager agent and cashier agent negotiation, and an *inWaitingRoom* predicate is used if the service agent is an executive. With the purpose of sending information relevant to the proposal response, the predicates described include the cashier or executive agent´s information, the proposed client information and the expected occupation time for the state of the service agent queue.

4 CLIENT ASSIGNMENT NEGOTIATION PROCESS

The presented multi-agent system gives decision-support assistance in a Bank scenario based on client's profile and service provider agents' workload. For that matter a negotiation process is used. When a new client arrives the manager agent receives his or her profile and calculates the expected time of attention with equation 1. A Contract Net Protocol is developed since the manager agent wishes that the best suited cashier agent assigns the client to its queue. The expected time of attention among the client profile is sent in the *assign* content of a FIPA cfp (call for proposal) message to all active cashier agents. Each active cashier agent receives the client profile and the expected time of attention and evaluates the expected occupation time given its current queue status and the received information. The expected occupation time (t_{occ}) is the time the cashier agent calculates a new client must wait in line before he or she receives attention, if the current client prospect is assigned to its queue. In other words, the cashier agent calculates its workload if the proposed client were to be assigned to its queue.

$$t_{occ} = t_{attn}^{0} + \sum_{i=1}^{n} t_{attn}^{i}$$

Where t_{occ}= expected occupation time
t_{attn}^{0}= expected time of attention of the proposed client.

$\sum_{i=1}^{n} t_{attn}^{i}$= Sum of expected time of attention of the n current clients in the cashiers queue.

Each cashier agent sends a proposal if the expected occupation time is less than or equal to 20 minutes, or rejects the proposal if the expected occupation time is longer. The occupation time with the cashier's agent identification and the client profile is sent in an *inline* predicate content to the manager agent.

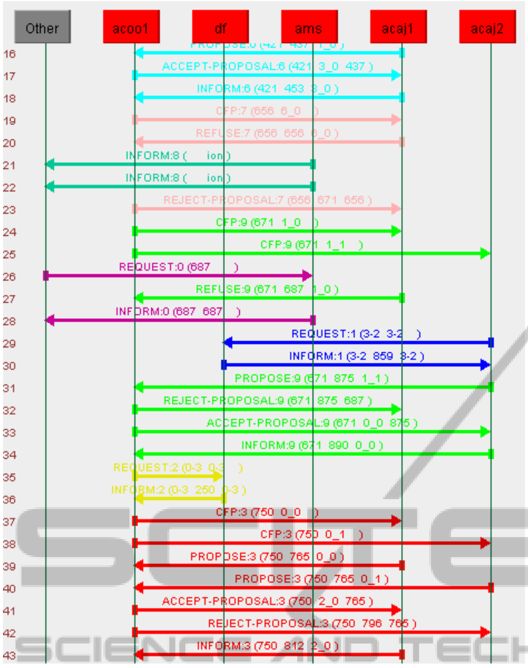

Figure 3: Partial view of agents' negotiation.

The manager agent receives all the cashier agent bids and evaluates which cashier agent has the minimum occupation time for the given client profile and accepts the best offer.

The main decision the manager agent can make as a result of this negotiation, is which cashier agent is the best suited to provide service to the incoming client. However, other decisions can follow this negotiation. If all cashiers reject the proposal, it means that everybody is too busy and a new cashier agent should be opened. On the contrary, if all bids on the proposal are too low or even some of them are zero, it means that at least one cashier agent should be closed. The "low" threshold should be determined by the bank based on an expert opinion and is intended to be a system parameter.

5 IMPLEMENTATION

As we described earlier, the multi-agent system was implemented using Jade (Java Agent Development Framework). The ontology was first designed with Protégé platform (http://protege.stanford.edu) and afterwards, corresponding Java classes were generated using the Ontology Bean Generator for Jade (van Art, 2002). For preliminary experimentation two swing-based Graphical User Interfaces (GUI) were designed in Java. The first interface of the manager agent (Figure 4) allows the user to determine the arriving client attributes and initiate its process simulating the bank branch device that prints a turn number for the clients.

The second interface of the cashier agent (figure 5) allows the user to visualize how the clients are been assigned to the agent´s queue and the client´s attributes. The process of providing a service to the client is implemented in the cashier agent GUI with a button that simulates the event of finishing the attention of a client and deleting its information from the queue. In order to proof the multi-agent system performance, two procedures were implemented to simulate automatic entrance and exit of clients.

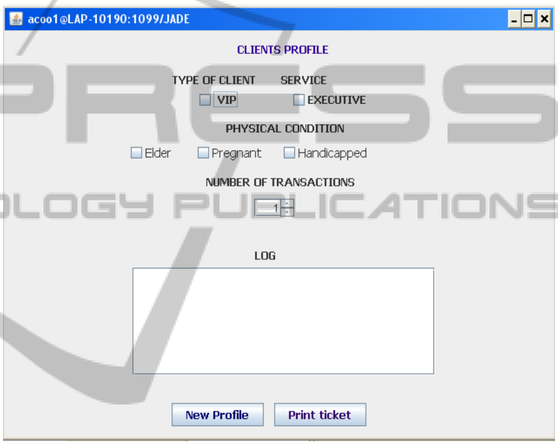

Figure 4: Manager agent GUI.

Figure 5: Cashier agent GUI.

The arrival and service rates are simulated with Java timers, and random client profiles are generated for each input.

Interfaces can be used for a particular sequence of client entrance and attention or the timer procedures and random generated clients for a batch simulation can be employed.

6 EXPERIMENTATION AND RESULTS

For our experimentation, we considered a dynamic number of parallel service providers; the system will open and close cashier agents as needed and will serve with First-come, First-served (FCFS) service discipline.

When a client arrives, the manager agent assigns him/her to the agent cashier's queue with minimum workload. No client should be assigned to a queue were the expected occupation time is more or equal 20 minutes consequently the queue capacity does not depend on the number of clients but on the expected occupation time calculated with equation 3. This is related with each client's profile and determines the cashier´s workload. For the client expected time of attention given w_1=2, w_2=1 and w_3=2 we implemented the following instance of equation 1. With this weight values we suppose that a handicapped or an elder client would cause a greater delay than a pregnant women when been served. When using the interfaces, client attributes are captured or randomly generated using the batch simulation process.

We verified the multi-agent system performance in three basic scenarios that differ only in the constant arrival and service rates. These rates are measured in clients per minute. We simulated the equivalent of eight hours of bank activity for each scenario.

Given the expected time of attention of all randomly generated profiles, the mean is 3.04 minutes with a standard deviation of 1.97.

6.1 First Scenario: Arrival Rate is Slower than the Service Rate

In the first scenario we performed several experiments in which the arrival rate is slower than the service rate, simulating a very slow day.

First, we experimented with the following rates: each 6 minutes a client arrives and each minute a client can be served. In eight hours 80 clients arrived. As expected, the system opened the first cashier agent and began to serve clients. Even though there was some delay in the service due to the client's profile, no other cashier agent was needed. Most clients were served upon arrival.

When varying the service rate but keeping it faster or equal than the arrival rate, the result remains the same: just one cashier was needed and no client had to wait more than 20 minutes.

Figure 6 shows the time in minutes that clients waited in a queue when the arrival rate was 6 clients per minute and each 3.5 minutes a client can be served, simulating the average service delay due to the clients profile.

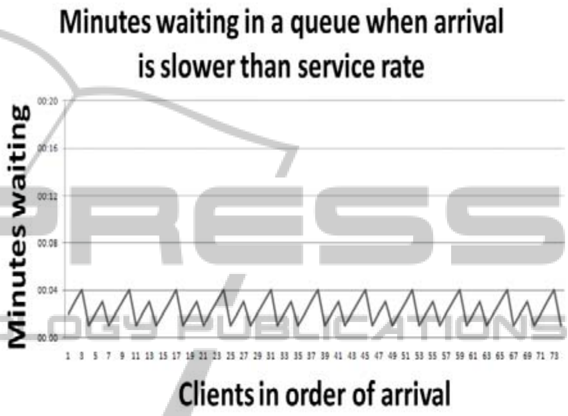

Figure 6: Minutes waiting in a queue in the first scenario.

6.2 Second Scenario: Arrival Rate is Faster than the Service Rate

The arrival rate in this scenario was faster than the service rate; this simulates very busy hours with service for average clients.

In the first experiment of this scenario, the arrival rate is 3.5 times faster than the service rate, therefore each 3.5 minutes a client can be served and one client arrives every minute. This service rate was chosen to be a bit greater than the expected time of attention mean, in order to simulate serving delay depending on the client's profile. In eight hours, 480 clients arrived and were served.

The system began with one cashier open and because of the difference in the arrival and service rates; more cashiers were almost immediately needed. We observed that the system opened cashiers one by one, and the clients waited a long time until enough cashiers for the service rate given were available. Five cashier agents opened in total, to speed up the service.

Figure 7 shows how as waiting times increase, new cashier agents start improving clients' waiting times momentarily until the fifth cashier opened and

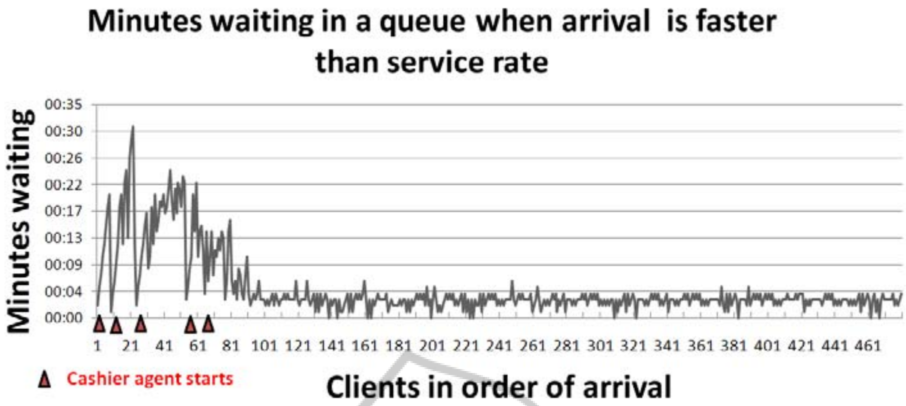

Figure 7: Minutes waiting in a queue in the second scenario.

stabilized the system. Notice that the small triangles on the bottom show when a cashier agent start. Once the required cashier agents provided the service, every client was attended in less than ten minutes.

Analyzing the frequency of clients' waiting minutes in different intervals, we observe that the grand majority of the clients waited up to five minutes, however 3% of the clients waited more than 20 minutes.(Figure 8).

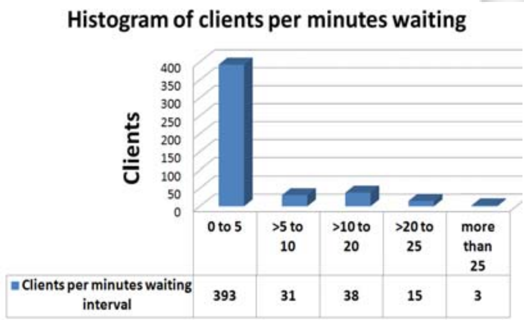

Figure 8: Histogram of clients per minutes waiting in the second scenario.

6.3 Worst Scenario: Clients with High Expected Time of Attention in a Very Busy Day

In this scenario we wanted to simulate what would happen if, due to their profile and number of transactions, all clients required a great deal of time to be served and the number of clients was also large.

We programmed the arrival rate to be one client per minute and service rate so that every five minutes one client can be served. The service rate is calculated considering that the expected time of attention mean is 3.04 minutes with a standard deviation of 1.97. We added the mean plus the standard deviation in order to simulate that all clients will take more than the average time to be served, approximately 5 minutes.

As the difference between the arrival rate and the service rate was much larger, the system took longer to stabilize. Six cashier agents were open altogether. In the mean time, 68 clients out of 480 had to wait more than 20 minutes as a result of the lack of enough cashiers for the arrival rate given (figure 9). Specifically 14.166% of the clients waited more than the allowed 20 minute policy. In the worst case, a client waited up to 48 minutes.

If we compare the graphic of minutes waiting in the second scenario (figure 7) with the same graphic for the worst scenario (figure 10) we can see that as the gap between the arrival and service rates grows, the system needs more time to stabilize. The importance of opening the right number of cashier agents as fast as possible is evident.

In order to choose the right number of cashiers required, three important factors have to be considered: the arrival rate, the service rate, and the cashier's expected occupation time. Actually, the next cashier agent opens if all the currently active cashier agents reject a new proposal for assigning a client.

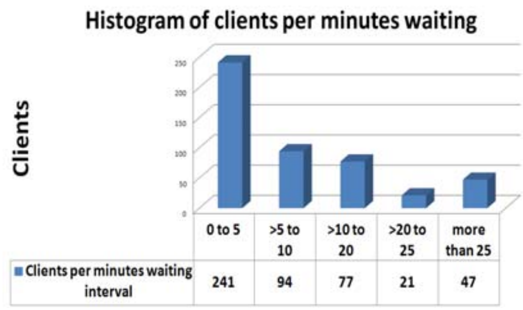

Figure 9: Histogram of clients per minutes waiting in the worst scenario.

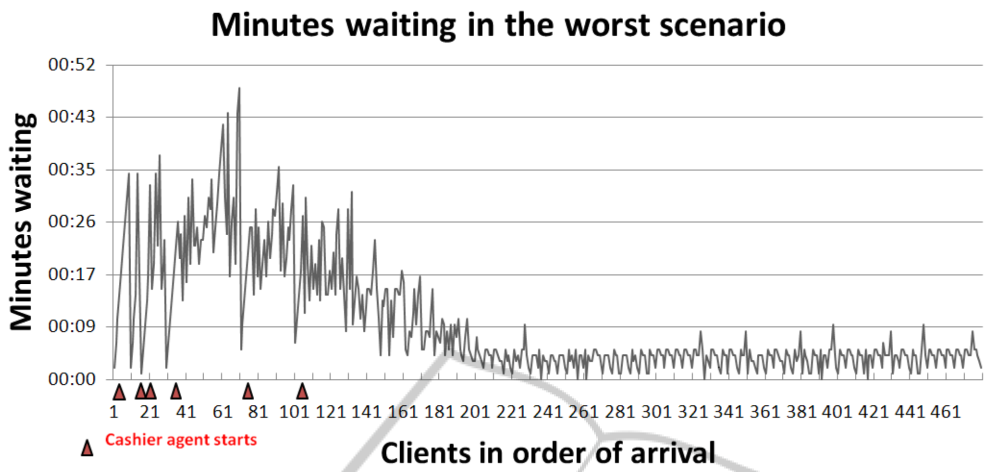

Figure 10: Minutes waiting in a queue in the worst scenario.

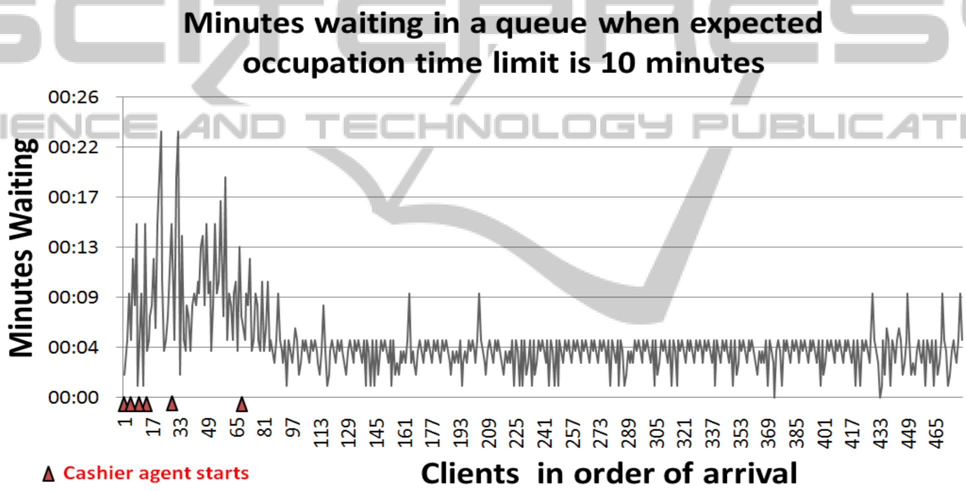

Figure 11: Minutes waiting in a queue in the worst scenario with 10 minute limit in the expected occupation time.

As we described earlier, when the cashier agent's expected occupation time (equation 3) is more than 20 minutes, the agent rejects every new proposal received. Therefore, if we want the system to open new cashier agents more rapidly, this parameter can be lowered.

6.4 Other Experiments

With the purpose of verifying the impact of a lower expected occupation time, we conducted an experiment with the same parameters for the worst scenario but we changed the expected occupation limit for the cashier agents to 10 minutes instead of 20. The results are presented in figure 11.

In this simulation, six cashier agents were opened; the same number of cashier agents as the simulation with 20 minutes expected occupation time limit. Although the cashier agents started earlier as we expected, due to the clients' profile and number of transactions, the system took more time to stabilize.

We can assume from this experiment that the resources i.e. cashier agents, needed for given arrival and service rates are the same, for instance, six cashier agents in this example. The expected occupation time limit impacts the results starting the cashier agents earlier therefore the occurrence of clients waiting more than 20 minutes decreases. Only two clients out of 480 waited more than 20 minutes, representing 0.417%. (Figure 12)

From this last experiment we observe that it is likely to fulfill the goal with little percent of error but resources, i.e. cashier personnel have to be allocated, as soon as the arrival rate increases. In real life situations, the cost of allocating resources to serve versus the institution commitment to the quality of service wanting to provide must be evaluated and balanced.

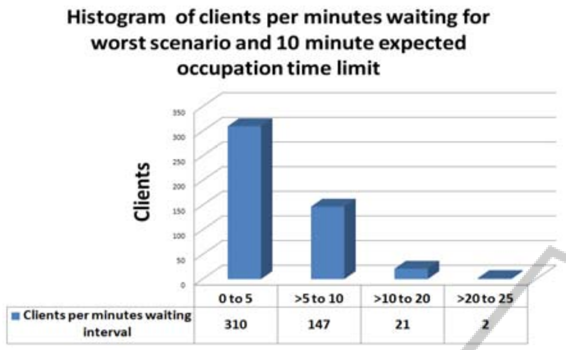

Figure 12: Histogram of clients per minutes waiting in the worst scenario and 10 minutes expected occupation time limit.

7 CONCLUSIONS AND FUTURE WORK

In this paper we presented a Multi-agent system based on an ontology that simulates the service provider's management and the assignment of clients in a bank branch. Experiments and simulation of cashier agents' management were presented.

The results of our experiments show three factors that are important to consider in fulfilling the 20 minute waiting time policy to guarantee the quality of service: 1) the arrival rate, 2) the service rate, and 3) the service provider workload determined by the expected occupation time of each cashier or executive. Regarding the arrival rate, it can be predicted; however this is not in the scope of this paper. The service rate depends on the client's profile and the number of transactions. We presented a way to evaluate the expected time of attention for each client in order to estimate the service rate, assign the client to a queue, and simulate the clients been served. The expected occupation time for each cashier is calculated from the expected time of attention of its clients, thus, each cashier agent workload is estimated. The use of the resources, i.e. starting and closing cashier agents, is determined by the state of all cashier agent queues.

We develop a client profiling ontology with the purpose of cooperation and negotiation between the manager agent and service agents. It proved to be useful when sharing content and performing semantic checks. The client's profile can be modified adding new attributes relevant to this domain.

Some upgrades to the initial version can be made for a more realistic aid in decision-support on client assignment. In order to establish the most significant characteristics for each strategic bank service a feature analysis of client attributes can be made. This analysis would help to enhance and improve client's profile as well as construct service ontology

To conclude, a bank branch can fulfil a 20 minute waiting time policy better manage its resources, and improve the quality of service by estimating the expected attention time according to the client's profile and the number of transactions Our experiments show that it is possible to fulfil the 20 minute waiting time policy if the institution designates the resources needed as soon as the arrival rate increases. The decision maker has to confront the cost of the resources versus the quality of service promised.

In the future we expect to develop new queue models using improved client profiles, using just one queue, or reassigning a client if the agent discovers that one or more of its clients are close to 20 minutes waiting.

The system is designed to admit serving the clients with other priorities instead of always using First-come, First-served (FCFS) service discipline. This is possible using the interactive interface but exhaustive experiments must be done.

In addition, a reinforcement learning model where the manager agent learns based on cashier agents' performance could be implemented. Adding criteria other than the queue workload to the assignment decision

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