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SCOPE

The Advances in Distributed Computing and Artificial Intelligence Journal (ADCAIJ) is an open access journal that publishes articles which contribute new results associated with distributed computing and artificial intelligence, and their application in different areas.

The artificial intelligence is changing our society. Its application in distributed environments, such as the Internet, electronic commerce, mobile communications, wireless devices, distributed computing and so on, is increasing and becoming and element of high added value and economic potential in industry and research. These technologies are changing constantly as a result of the large research and technical effort being undertaken in both universities and businesses. The exchange of ideas between scientists and technicians from both academic and business areas is essential to facilitate the development of systems that meet the demands of today's society.

We would like to thank all the contributing authors for their hard and highly valuable work. Their work has helped to contribute to the success of this special issue. Finally, the Editors wish to thank Scientific Committee of Advances in Distributed Computing and Artificial Intelligence Journal for the collaboration of this special issue, that notably contributes to improve the quality of the journal. We hope the reader will share our joy and find this special issue very useful.

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A Group Recommendation System for Movies based on MAS

Christian Villavicencio, Silvia Schiaffino, J. Andrés Díaz-Pace, Ariel Monteserin

ISISTAN (CONICET - UNCPBA), Campus Universitario, Tandil, Argentina

{christian.villavicencio, silvia.schiaffino, andres.diazpace, ariel.monteserin}@isistan.unicen.edu.ar

KEYWORD

Multi-Agent Systems; Recommender Systems; Group Recommendation

ABSTRACT

Providing recommendations to groups of users has become popular in many applications today. Although several group recommendation techniques exist, the generation of items that satisfy all group members in an even way still remains a challenge. To this end, we have developed a multi-agent approach called PUMAS-GR that relies on negotiation techniques to improve group recommendations. We applied PUMAS-GR to the movies domain, and used the monotonic concession protocol to reach a consensus on the movies proposed to a group.

1. Introduction

Recommender systems provide assistance to users by identifying items that match a user's needs, preferences, and goals from a usually long list of potentially interesting items. Several recommendation techniques have been proposed in the literature (Ricci, et al., 2010). The aim of a group recommender system is to make item recommendations that are "good" for a group of users as a whole, i.e., the items satisfy, as much as possible, the individual preferences of each group member (Jameson & Smyth, 2007). Group recommendation brings new challenges, since users might have competing interests within a group, and thus issues beyond individual recommendation have to be considered. In the literature we can see that most approaches developed to produce group recommendations usually rely on aggregation techniques for: (i) the generation of a group profile combining individual profiles (Christensen & Schiaffino, 2014); (ii) the integration of recommendations obtained for each member separately, such as in ranking aggregation (Baltrunas, et al., 2010); or (iii) the aggregation of individual ratings using, for example, approaches such as minimizing misery or maximizing average satisfaction. The problem with this kind of approaches is that the aggregation techniques often fail to satisfy the whole group in an even way and there is still no agreement regarding how to assess the utility of recommendations (Baltrunas, et al., 2010; Masthoff, 2011).

Other authors have applied MAS to recommendation systems both for individuals and groups. Some examples are the systems proposed in (Blanco-Fernandez, et al., 2004), (Skocir, et al., 2012), (Bekkerman, et al., 2006), (Garcia, et al., 2009), among others. However, particularly for group recommendation, there are not many systems and from those which do use MAS for generating group

recommendations only one of them (Garcia, et al., 2009) avoids the use of aggregation techniques in the recommendation process.

In this work, we present a multi-agent approach, called PUMAS-GR, for group recommendation. The novelty of our approach is that it leverages on negotiation techniques in order to integrate recommendations (previously) obtained for each group member into a list of recommendations for the group. Each user is represented by a personal agent that works on her behalf. The agents carry out a cooperative negotiation process based on the multilateral Monotonic Concession Protocol (MCP) (Endriss, 2006). We argue that this negotiation process can generate recommendations that satisfy the different group members more evenly than traditional group recommendation approaches, since it mirrors the way in which human negotiation seems to work (Wooldridge, 2009). We have applied PUMAS-GR to the movies domain (MovieLens), but the approach is applicable to other domains as well.

The rest of the article is organized as follows. In Section 2 we present the details of PUMAS-GR. Then, in Section 3 we explain the negotiation process and depict the functionality of the application with an example. In Section 4 we describe some related works. Finally, in Section 5 we give the conclusions and outline some future work.

2. Proposed Approach

Our approach conceives the multi-agent system (MAS) as the group recommender system, according to the client-server architecture of *Figure 1*. The user interacts with a Web-based client, which can make different functional requests to a server, such as: log into a session, rate sequences of movies presented by the system, or ask for a group recommendation. The latter is what actually triggers the agent negotiation. On the server side, the *Group Recommender* hosts a collection of *Agent* instances along with a *Moderator* component. This *Moderator* is responsible for coordinating the agents according to the MCP rules the MCP. Information about user credentials, membership to different groups, and movies watched by users are stored in the *User Profiles* repository. Information about available movies for recommendation are kept in a separate repository. The Movies Dataset contains data from MovieLens[1].

Each *Agent* is a process that implements a number of negotiation commands, which are enacted by the *Moderator*. The negotiation commands refer to three aspects:

(i) computation of the agent utility function, which is used for determining agreements;
(ii) computation of the agent "willingness" to risk a conflict, and
(iii) the concession strategy (e.g., Nash, egocentric), in case the Moderator decides that the agent must concede.

Furthermore, each agent is able to generate a ranking of movies of interest for its associated user. This ranking only contains movies that the user has not watched before. Internally, each agent relies on a basic (single-user) recommender system that generates the rankings (the instance of the recommender is shared between the agents). To do so, we relied on the Duine framework[2], as it provides predefined prediction techniques for estimating movie scores. These techniques use item and user similarity models to feed predictors, which are then able to estimate the rating a user would have given to a movie, using

[1] http://grouplens.org/datasets/movielens/
[2] http://www.duineframework.org/

information from the user profile (e.g., looking for similar users and assessing the ratings they have given to the movie) and information about movies she rated in the past (e.g., assessing the similarity between those movies and the target movie).

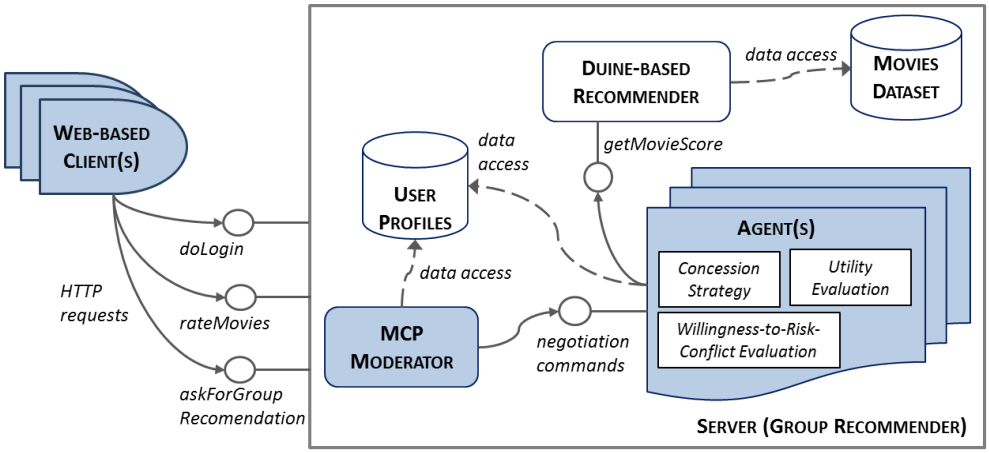

Figure 1: Architecture of PUMAS-GR.

3. PUMAS-GR application at work

In this section we firstly explain the negotiation process carried out by the agents when PUMAS-GR is asked to produce a group recommendation, and then we propose a usage example of the prototype of the tool.

3.1. Negotiation process

At the beginning, each agent makes an initial proposal with its favorite (top-ranked) movie, which is the movie with the highest score (step 1 of Figure 2). Then, proposals are interchanged among the agents in order to determine if an agreement can be reached. The notion of agreement is defined in terms of the utility of a given proposal for the agents. To do so, each agent computes a utility function that maps agreements to non-negative values. If the user already watched a given movie, then she probably assigned a score (utility) to it. If a user did not rate (or watched) a movie, it is possible to compute an estimated utility via Duine. Specifically, the utility is the product of the prediction score for the movie and the certainty of that prediction. There is an agreement if one agent makes a proposal that is at least as good (regarding utility) for any other agent as their own current proposals. If so, the proposal that satisfies all the agents is chosen (if several proposals meet this criterion, the Moderator simply picks one of them randomly).

If an initial agreement is not possible, the agents engage in rounds of negotiation, each one making movie proposals that need to be assessed by the other agents, until an agreement is reached or the negotiation finishes with a conflict (step 2 of Figure 2). The agents abide by a set of predefined MCP

rules, which specify the range of legal moves available at each agent at any stage of the negotiation process. These rules correspond to the negotiation commands discussed for Figure 1. In case a round of negotiation ends up in a conflict, one of the agents must make a concession (step 3). A concession means that an agent seeks an inferior proposal with the hope of reaching an agreement. If none of the agents can concede, the process finishes with no-agreement. Several concession strategies are possible (Endriss, 2006).

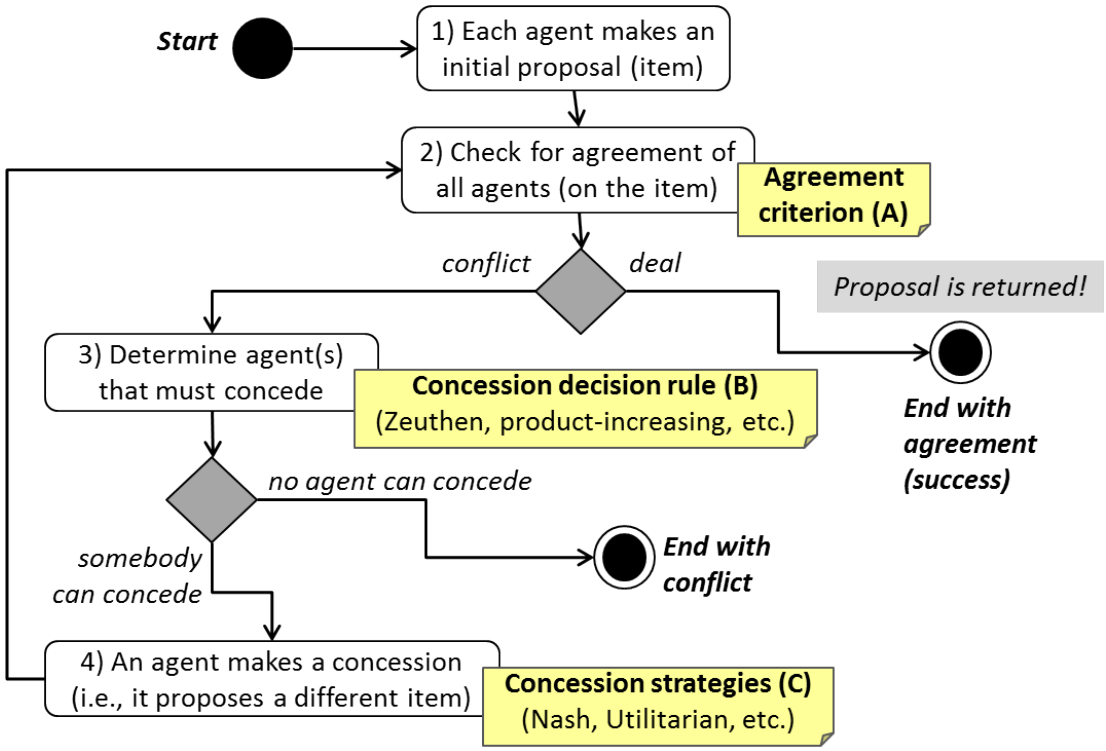

Figure 2: Negotiation Steps.

Selecting the agent(s) that must concede is determined by applying the Zeuthen strategy (Zeuthen, 1930) around the concept of willingness to risk conflict (WRC). In the bilateral MCP (i.e., two agents), both agents evaluate their WRC value and the agent with the lowest value makes the next concession. The strategy can be generalized to a multilateral setting (i.e., more than two agents), in which Zeuthen evaluates the loss in utility in case of concession assuming the worst possible outcome for the agent. As for the concession itself (i.e., the new proposal made by the agent/s determined by the Zeuthen generalization), various strategies are discussed in the literature (Endriss, 2006). For our work, we selected the so-called Nash concession, because it guarantees termination and deadlock-freedom. In this kind of concession, an agent makes a proposal such that the product of utilities of the other agents increases (Nash product).

3.2. Usage example

When using the tool for the very first time, the users should register in order to be able to log in.

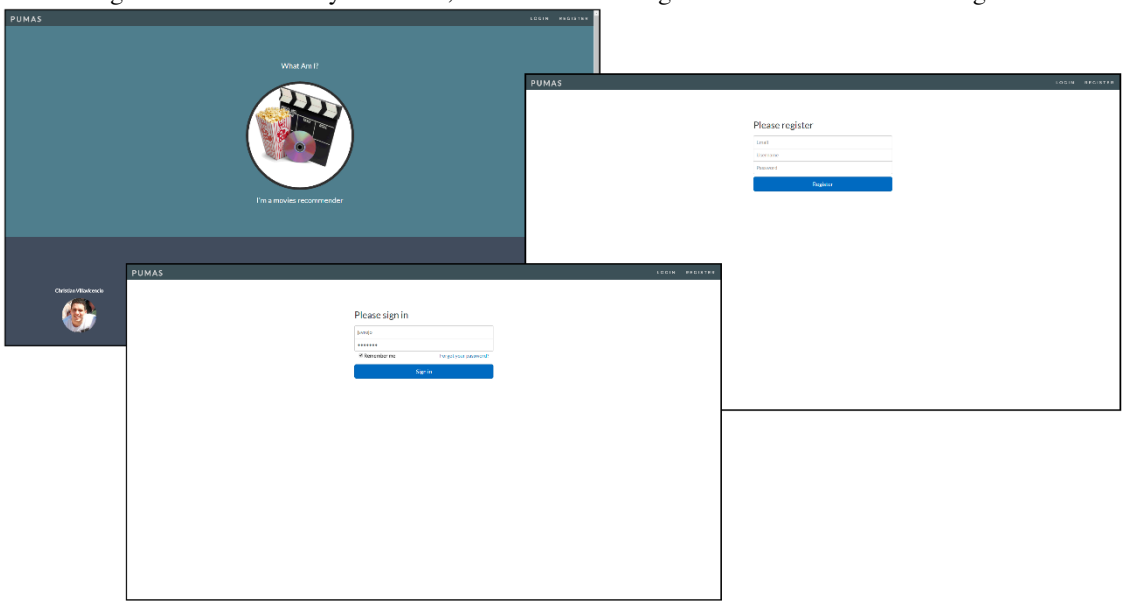

Figure 3: Welcome, Register and Login views.

The registration process only requests an email, a username and a password (Figure 3) (the users can later add some additional information to their profile, using the User Profile menu, accessible through the dropdown menu placed in the top-right corner, within the navigation bar). After a user registers himself, he is automatically logged in and:

- He can complete his user profile (adding more information like: name, surname, etc.)
- He is able to assign rating to movies he has watched in the past (Figure 4)
- He can revise which movies he has already rated, which were the ratings given to those movies, and also remove any of those ratings (so as to be able to rate the movies again) (Figure 4)
- He is able to revise the list of groups they belong to
- He, as a member of a group, can ask for a group recommendation (Figure 6)

In the following paragraphs we present a guideline that contains the basic steps that the users should follow if they want to generate a group recommendation using our tool.

Step 1: Create user's preferences models

When seeking to get a group recommendation the members of the group must build their preference model first. This can be achieved by rating at least 15 movies (Figure 4), including movies from different genres if possible so as to add variety to the preference model and allow the recommender system to produce recommendations that are closer to the user preferences. The number 15 is an empirically-

determined parameter, but we consider that if the users rate less than 15 movies, the estimation of the preferences will not be good enough to produce acceptable recommendations.

Step 2: Create the group

The next step consists in creating a group using the group creator (Figure 5) which is accessible through the *Group Recommendation* view (Figure 6). There are two restrictions that the users must respect when creating groups: (i) every group must have a name, and (ii) every group must be composed of at least 1 member.

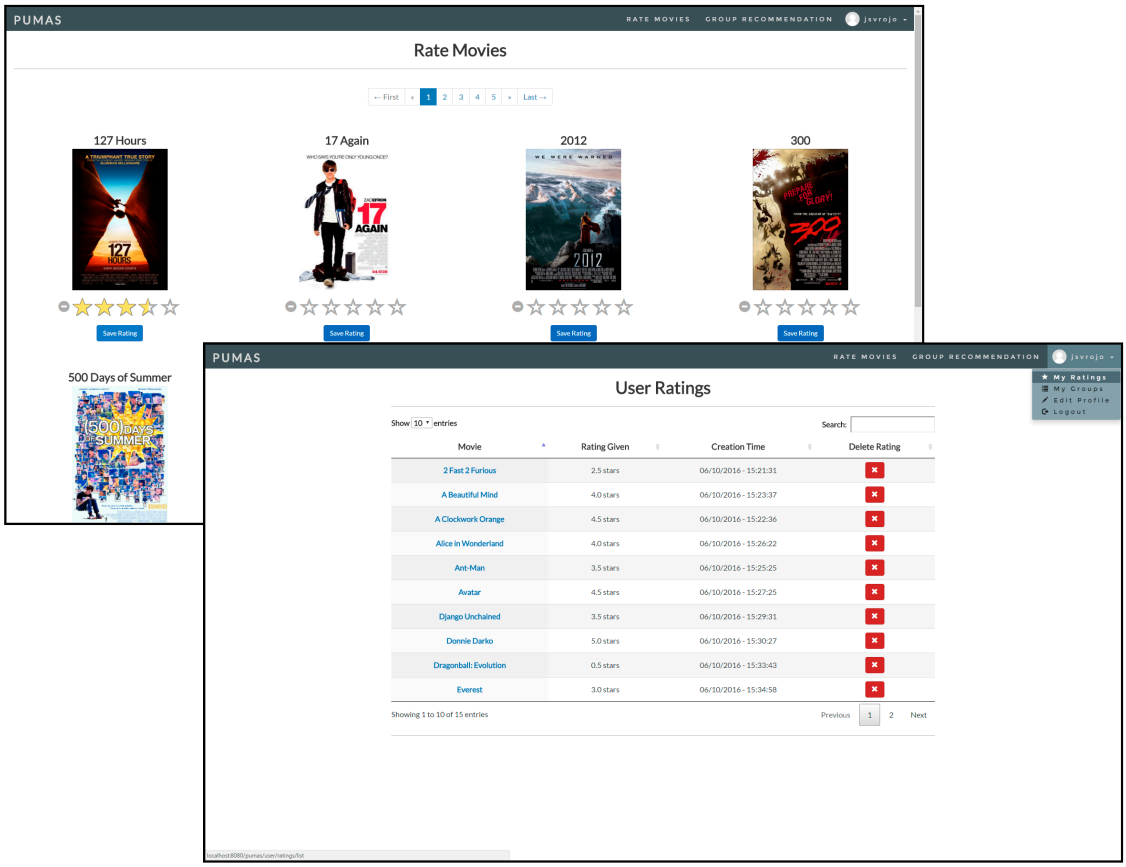

Figure 4: Rate movies and User Ratings views.

Step 3: Define the recommendation process parameters

Once the group was created, it is displayed in the *Group Recommendation* view and the user can use it to ask for a group recommendation. Additionally, the active user (the one who is going to ask for the group recommendation) must select the desired amount of recommendations (k) and the recommendation approach the application should use. Currently, the tool only allows the users to select between 2

approches: the MAS-based approach (denoted by "PUMAS" in the recommender type selector of Figure 6) or the one based on aggregation techniques ("TRADGREC"). In the example of Figure 6 we can see that the active user is already part of 2 groups and he selected the first of them for the recommendation process, and he wants the application to produce 10 recommendations ($k = 10$) using the MAS-based approach.

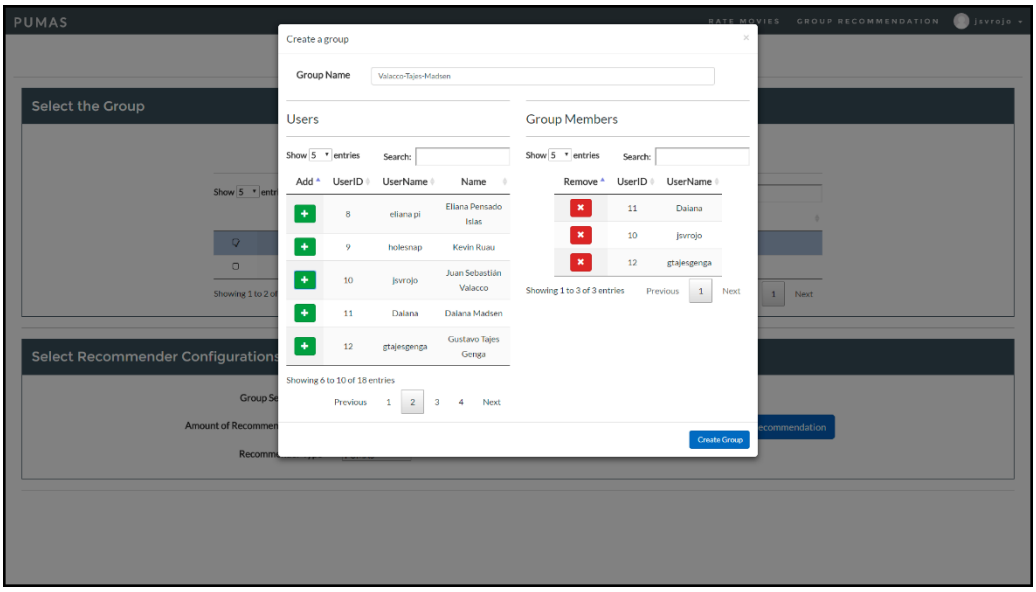

Figure 5: Group Creation (Example).

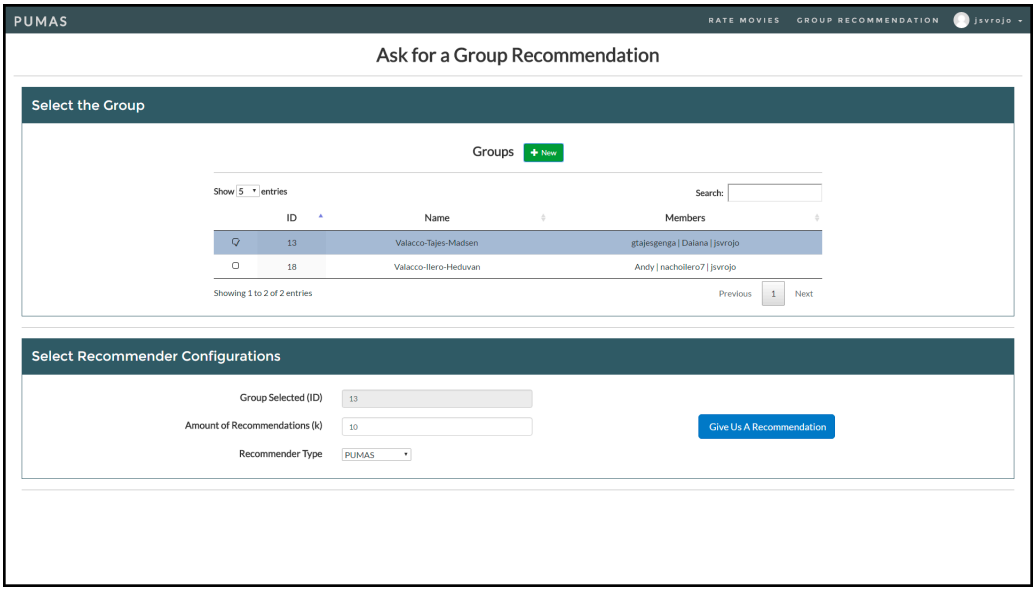

Figure 6: Group Recommendation view.

Step 4: Ask for a group recommendation

When all the parameters of the group recommendation process were defined (group, *k* and the recommendation approach), the active user only needs to click on the *"Give Us a Recommendation"* button and wait until the *Recommendation Results* view is showed by the application. The response time of the recommender system depends on the technique selected, the group size, the group member's preference models (for groups in which the users don't have enough preferences loaded in their profiles, the recommendations takes more time regardless the approach used), among other minor factors.

Additionally, as explained in (Villavicencio, et al., 2016), even though the recommendation process when using PUMAS approach can take a bit longer than when using the TRADGREC one, the quality of the recommendation tends to be better when using the former approach and also the recommendation time is in most of the cases within an acceptable time window (between 1 and 15 seconds).

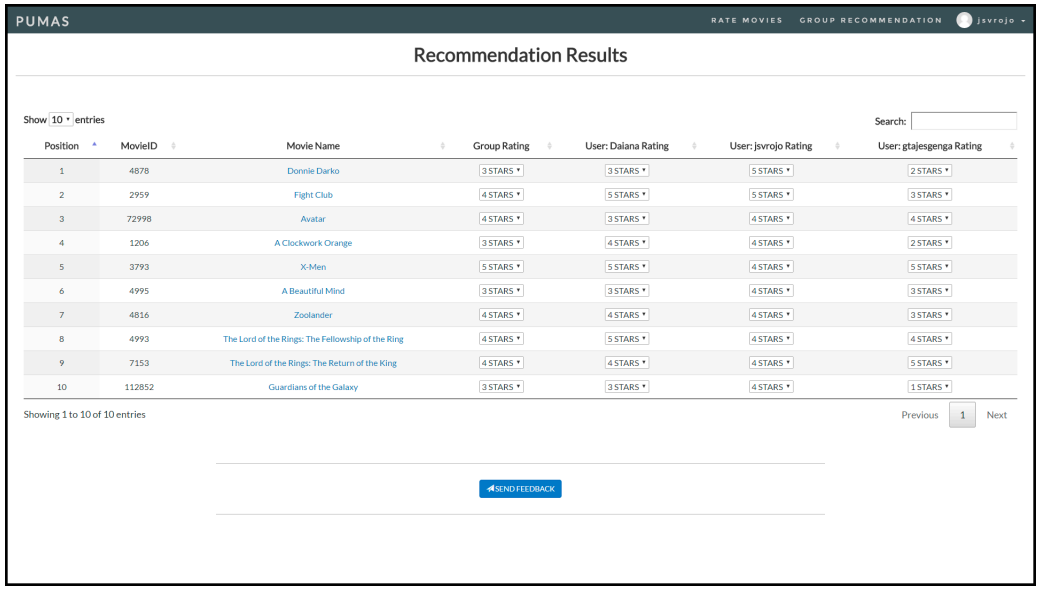

Figure 7: Recommendation Result and Feedback view.

Step 5: Get the recommendation and give feedback about it

After the recommendation is produced, the application presents to the user the list of recommendations in the "Recommendation Results" view (Figure 7). In the mentioned view the users receive also a form to place their feedback on the recommendations. This form was created only for evaluation purposes only, to assess the quality of the recommendation from the group members point of view, and to assess the estimation errors of both of the recommenders. This feedback mechanism allows us to compare the rating the recommender thought the user will give to a certain movie against the rating given by the user. When filling this form, the users must rate every one of the recommended movies both individually and as a group (in the latter case, the group members should discuss among each other about the group rating they would give to the movie). The ratings are, at the time given in terms of "stars"[3], and they depict the interest of the group member/group in the movie.

[3] This will be changed in the future as we do consider that stars cannot capture the real essence of the feedback.

4. Related works

The problem of generating recommendations to groups began to be investigated in the last decade (Cantador & Castells, 2012), and most of the proposed solutions for this problem share one trait: they seek to reuse the technology used for producing recommendations for individual users by using aggregation techniques. Where and when they use those techniques varies from one recommender system to another, but it is possible to classify all the systems in three main categories:

i. Those that merge individual recommendations. These systems generate individual recommendations for every one of the group members and then aggregate those recommendations using some technique so as to produce the group recommendation (Baltrunas, et al., 2010).

ii. Those that aggregate the individuals' profiles. These systems generate an artificial profile that contains the aggregated information of the profiles of the individuals that form part of the group. This way, the group is treated as any other user and, therefore, the recommendation techniques for individuals can be applied to produce group recommendations (Christensen & Schiaffino, 2014).

iii. Those that perform an aggregation of individuals' preferences (ratings). Similarly to what the systems of the second category do, these systems also attempt to create a virtual user that represents the group but the preferences of the users are aggregated instead of their profiles. The process to create the recommendations is the same: once the group user (virtual user) is created, it is added along with its preferences (computed using the aggregation technique) to a single user recommender, which treats the group user as any other user, and therefore can produce recommendations for him.

The aggregation technique to be used depends on the category in which the system falls. This is because not all the techniques are suitable to be applied to every type of data and every situation, for example, a technique that is useful for merging individual recommendations probably will not be useful for computing the aggregated rating of one item.

Multi-agent systems (MAS) have been applied in various domains. When it comes specifically to recommendation systems, some approaches have proposed multi-agent techniques to generate recommendations to both individual users and groups in different domains, like adaptive customization of websites (Morais, et al., 2012), e-commerce (Lee, 2004), games on mobile phones (Skocir, et al., 2012), semantic knowledge extraction (Lopes, et al., 2009), tourism (Bedi, et al., 2014), among others. One thing to notice is that most of those systems can produce recommendations targeted only to individual users.

In (Blanco-Fernandez, et al., 2004), the authors present AVATAR, a modular multi-agent architecture for a personalized recommender system on the TV shows domain, whose main novelty is the semantic reasoning about user preferences and historical logs, using an OWL ontology. The system presented in (Bedi, et al., 2014), MARST, uses a Reputation based Collaborative Filtering (RbCF) algorithm for generating relevant recommendations to a user. Finally, in (Marivate, et al., 2008) the authors present a Multi-Agent approach to the problem of recommending training courses to engineering professionals.

To the best of our knowledge, only a few works have targeted group recommendations with MAS. In (Bekkerman, et al., 2006) a group recommender system relying on the application of cooperative negotiation is presented. The authors propose a process in which agents, acting on behalf of group members, participate in a direct (alternating offers) or mediated (merging rankings) negotiation. This negotation produces group recommendations, based on individual recommendations and user preference models. The approach has only been tested with simulations involving two agents while we will test our approach on bigger groups of users. In (Garcia, et al., 2009) an agent-based negotiation schema that uses alternating offers is developed, in which agents negotiate the preferences of the whole group. The authors of (Sebastiá, et al., 2011) propose a system named *e-Tourism* that is able to produce recommendations for both individuals and groups, but the downside of this system is that for producing the latter it makes use of aggregation techniques. Finally, in (Garcia & Sebastia, 2014) the authors propose a MAS where user agents negotiate with the aim of building a group profile that satisfies the users' requirements. A mediator governs the negotiation in order to facilitate the agreements. Our work differs from the ones of Garcia in that they negotiate user preferences while we negotiate recommendations.

5. Conclusions

PUMAS-GR is a MAS approach for group recommendation based on negotiation techniques. Preliminary experiments with our prototype in the movies domain have shown promising results in terms of satisfaction of group members, when compared to traditional rank aggregation techniques. A limitation of our prototype is the high reliance on movie scores predicted by Duine as the main source of rankings for individual users. In addition, Duine sometimes presents performance problems when recommender system is used constantly by several users. However, our architecture is flexible to admit other scoring strategies or (single-user) recommender systems. Currently, we are in the process of substituting Duine by Mahout[4], in order to improve the performance of the prototype. Finally, we plan to evaluate our approach in other domains involving groups (e.g., tourism, software architecture decision making), and to compare it with other standard techniques for group recommendation.

6. Acknowledgements.

This work has been partially supported by projects ANPCyT-PICT2011-0366 and CONICET-PIP112-201101-00078 (Argentina), and also by “PUMAS” CONICET-CNRS bilateral cooperation project.

[4] http://mahout.apache.org/

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Energy-Aware Routing in Multiple Domains Software-Defined Networks

Adriana Fernández-Fernández[a], Cristina Cervelló-Pastor[b], and Leonardo Ochoa-Aday[c]

[a,b,c]Department of Network Engineering, Universitat Politècnica de Catalunya (UPC), Esteve Terradas 7, Castelldefels, 08860, Spain

[a,c]Student Member, IEEE

[b]Member, IEEE

adriana.fernandez@entel.upc.edu, cristina@entel.upc.edu, leonardo.ochoa@entel.upc.edu

KEYWORD

Distributed Routing Algorithm; Software-Defined Networks; In-band Control Traffic; Energy-Aware Routing; Traffic Engineering

ABSTRACT

The growing energy consumption of communication networks has attracted the attention of the networking researchers in the last decade. In this context, the new architecture of Software-Defined Networks (SDN) allows a flexible programmability, suitable for the power-consumption optimization problem. In this paper we address the issue of designing a novel distributed routing algorithm that optimizes the power consumption in large scale SDN with multiple domains. The solution proposed, called DEAR (Distributed Energy-Aware Routing), tackles the problem of minimizing the number of links that can be used to satisfy a given data traffic demand under performance constraints such as control traffic delay and link utilization. To this end, we present a complete formulation of the optimization problem that considers routing requirements for control and data plane communications. Simulation results confirm that the proposed solution enables the achievement of significant energy savings.

1. Introduction

The high energy consumption generated by network elements and the expansion of Internet, have brought power consumption of data networks to the forefront as a major optimization concern (Van Heddeghem et al., 2014). According to (Gelenbe and Caseau, 2015) in 2012, close to 4.7% of the world's electrical energy was consumed by ICT, releasing into the atmosphere roughly 1.7% of the total CO_2 emissions. Moreover, recent studies state that energy demand of ICT sector is growing faster than the overall one (Aebischer and Hilty, 2015).

Among the main ICT sectors, telecommunication networks account for more than a third part of the ICT total energy consumption (The Climate Group, 2008). As a result, the reduction of power consumption in Internet Service Provider (ISP) backbone networks is crucial to accomplish significant energy savings in this sector. For this problem, the emerging paradigm of Software-Defined Networks (SDN) can be seen as an attractive solution.

In SDN (Kreutz et al., 2015), control functions are decoupled from forwarding devices and are logically centralized in a new entity called controller. The controller has a global network view and can manage network tasks without the need of additional software in each of the switching elements. Meanwhile, the network devices only forward traffic according to the rules set by the controller. In this paper we address the problem of optimizing the power consumption in OpenFlow networks (McKeown et al., 2008).

The idea of saving energy by turning off unused networks elements such as line cards or port interfaces, was first considered by (Gupta and Singh, 2003). In (Zhang et al., 2010), the exact optimization problem of maximizing the total power saving under Maximum Link Utilization (MLU) and network delay constraints in traditional networks, is formulated.

The use of OpenFlow for this purpose has already been included in other research papers. The authors of (Wang et al., 2016) formulated an optimization problem for finding minimum-power network subsets in hybrid SDN. Giroire et al. (Giroire et al., 2014) proposed an energy-aware routing approach, taking into account the limited rule space of TCAM (Ternary Content Addressable Memory) in SDN devices. The authors of (Wang et al., 2014) provided two greedy algorithms for minimizing the power of integrated chassis and line-cards used. For this they considered an expanded network topology according to the connections between the forwarding devices. However, all these related works considered a centralized approach.

In practice, the logically centralized control in SDN could be implemented with multiple distributed physical controllers, which is the scenario considered in this work. The hypothesis of our research is that in these scenarios, an effective optimization of power consumption could be achieved with a distributed energy-aware routing algorithm. Different from previous works, we focus on optimizing energy consumption in multiple domains OpenFlow networks with in-band control traffic.

The rest of this paper is structured as follows. In Section 2 we explain the main considerations of our distributed approach together with the network model considered and the mathematical formulation of our optimization model. The simulation strategies and the obtained results are discussed in Section 3. Finally, in Section 4 we conclude our work and outline future research guidelines.

2. Distributed Energy-Aware Routing Algorithm

The Distributed Energy-Aware Routing (DEAR) approach consists in the use of traffic engineering in each domain to optimize the overall power consumption. The idea is to find the routes between network elements that minimize the number of active links used to satisfy a given data data traffic demand, subject to the capacity constraint.

In order to ensure compatibility with SDN using in-band control traffic (Sharma et al., 2013), in this proposal control paths between controllers and switches are also established. This means that control messages are exchanged using the same links that data traffic without the need of additional links. This is a more realistic scenario for large backbone networks, where dedicated links to transfer the control messages between controllers and forwarding devices are impractical and cost-inefficient. In addition, to avoid additional traffic load in the controllers, we establish that data plane communications cannot be routed through these devices.

We consider a multiple domains SDN architecture, where each domain has a centralized controller with a number of predefined switches associated to it. We assume that each controller has a total knowledge of its domain topology and a partial knowledge of the global network topology, i.e., it has identified border nodes that it shares with each other domain. Inter-domain data traffic demands are routed in each domain using these nodes.

2.1 Network Model

Each controller domain is represented by a directed graph $G = (V, E)$, where V and E denote the set of nodes and links, respectively. Each link $e \in E$ has associated its capacity, denoted by c_e. The set $B = \{ b_1, \dots, b_{|B|} \} \subset V$ contains the border nodes. D_{v} and D_{w} denote the set of intra-domain traffic flows for the data and control plane communications, respectively. D_{u} denote the set of inter-domain data traffic demands.

For each $k \in D_{\mathrm{v}}$, let t_k denote its throughput and P_k be the set of paths that can be used to route this traffic. $P_c^k \subset P_k$ denote the set of paths that pass through the controller for each $k \in D_{\mathrm{v}}$. Let $P_e^k \subset P_k$ be the set of paths that use link $e \in E$ for each $k \in D_{\mathrm{v}}$. Similarly, it holds for D_{w} and D_{u} traffic flows.

2.2 Optimization Problem Formulation

The distributed proposal of our approach in multiple domains SDN, can be formulated as an Integer Linear Programming (ILP) model with two steps of optimization, using the following binary variables:

x_e: describes the state of a link $e \in E$.

$$x_e = \begin{cases} 1 & \text{if link } e \text{ is active,} \\ 0 & \text{otherwise.} \end{cases}$$

q_b^k: describes the selection of a border node b to route a traffic $k \in D_{\mathrm{u}}$.

$$q_b^k = \begin{cases} 1 & \text{if border node } b \text{ is selected to route inter-domain traffic } k, \\ 0 & \text{otherwise.} \end{cases}$$

$l_{b,p}^k$: describes the selection of a path $p \in P_k$ to route a traffic $k \in D_{\mathrm{u}}$ through border node b.

$$l_{b,p}^k = \begin{cases} 1 & \text{if path } p \text{ is selected to route inter-domain traffic } k \text{ through border node } b, \\ 0 & \text{otherwise.} \end{cases}$$

r_p^k: describes the selection of a path $p \in P_k$ to route a traffic $k \in D_{\mathrm{v}} \cup D_{\mathrm{w}}$.

$$r_p^k = \begin{cases} 1 & \text{if path } p \text{ is selected to route intra-domain traffic } k, \\ 0 & \text{otherwise.} \end{cases}$$

In the first step, each controller-instantiated agent individually computes the routing paths in its domain that minimize the number of links used. In this phase, performance constraints (e.g., control traffic delay and link utilization) could be included. Considering the notation of binary variables shown above, the optimization model of the first phase can be formulated as:

$$\text{minimize} \sum_{e \in E} x_e \tag{1}$$

subject to the following constraints:

$$\sum_{b \in B} q_b^k = 1 \qquad \forall k \in D_{\mathrm{u}} \tag{2}$$

$$\sum_{p \in P_k} l_{b,p}^k = q_b^k \qquad \forall k \in D_{\mathrm{u}}, \forall b \in B \tag{3}$$

$$\sum_{p \in P_k} r_p^k = 1 \qquad \forall k \in D_{\mathrm{v}} \cup D_{\mathrm{w}} \tag{4}$$

$$r_p^k = 0 \qquad \forall k \in D_{\mathrm{v}}, \forall p \in P_c^k \tag{5}$$

$$l_{b,p}^k = 0 \qquad \forall k \in D_{\mathrm{u}}, \forall b \in B, \forall p \in P_c^k \tag{6}$$

$$\sum_{k \in D_{\mathrm{u}}} \sum_{p \in P_e^k} \sum_{b \in B} l_{b,p}^k t_k + \sum_{k \in D_{\mathrm{v}} \cup D_{\mathrm{w}}} \sum_{p \in P_e^k} r_p^k t_k \leq c_e x_e \qquad \forall e \in E \tag{7}$$

The objective function (1) minimizes the number of active links. Equation (2) ensures that exactly one border node is selected for every inter-domain data traffic demand. Equation (3) ensures that exactly one path is used to route every inter-domain data traffic demand through the border node selected. Equations (4) ensure that exactly one path is used to route every intra-domain traffic flow for the data and control plane communications. Equations (5) and (6) ensure that paths passing through the controller can not be used to route data plane communications. Equation (7) ensures that the total traffic in each active link $e \in E$ is less than its capacity c_e.

After completing this computation, the distributed control plane agents in different SDN domains must exchange some performance metric (e.g. MLU in each domain) and the identifier of the selected border nodes to route each inter-domain data traffic demand (i.e $q_b^k \quad \forall k \in D_{\mathrm{u}}$). The first element of this shared information is intended to be used as comparison metric to define the domain with the best performance, which is also the one with the lowest probability to run out of capacity, while the second one allows a proper and coherent rerouting of inter-domain data traffic demands.

In the second step, the agent of the domain with the best performance (less MLU, for instance) recomputes its energy-aware routing paths using now, for each inter-domain data traffic demand, the border nodes preselected by its neighbor domains. The corresponding problem for the second step of optimization could be formulated using these received identifiers in (3) of the model above.

3. Preliminary Results

In this section we describe the evaluation of our distributed approach and analyze the results obtained. We used the linear programming solver Gurobi Optimizer (Gurobi Optimization) to assess the performance of the ILP model. All computations were carried out on a computer equipped with 3.30 GHz Intel Core i7 and 16 GB RAM.

We conducted our simulations using a real network topology, Abilene, and the subset of online available traffic matrices measured on September 5th 2004 (Zhang, Y., 2004). The energy savings were computed as the number of links in sleep mode over the total amount of network links.

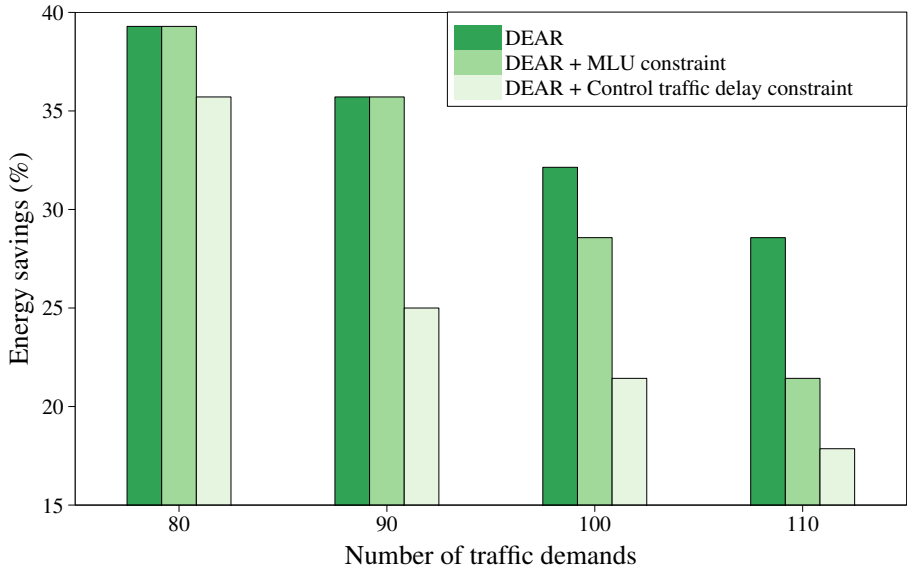

Figure 1: Percentage of shutdown links in the Abilene topology with two controllers.

The evaluation of DEAR in Abilene topology (11 nodes, 28 links) is shown in Figure 1 for the case of having two controller domains, against two other versions of the algorithm with additional constraints (that is MLU and Control Traffic Delay constraints). The controllers placement were obtained using the well known minimum k-median model (Heller et al., 2012).

Results show that DEAR could save until near to 40% of energy consumption when traffic is low. It is also shown, that more restrictive constraints will be paid with less energy saving. This behavior is expected given that, in order to meet the new performance requirements, a fewer number of alternate paths can be considered in the optimization. Therefore, it will be a trade-off to consider in accordance with the main objectives in each implementation.

In a second set of simulations, the analysis of using a modified Shortest Path Routing (Mod-SPR) is also included to get a sense of the values of energy savings achieved by our approach. Mod-SPR can be considered as a default shortest path routing algorithm for multiple domains SDN with in-band control traffic, where data plane communications cannot be routed through any controller. We use Mod-SPR as a fair comparison in the evaluation since there is no research considering energy saving with in-band control traffic in multiple domains SDN under routing behaviour presented in this proposal.

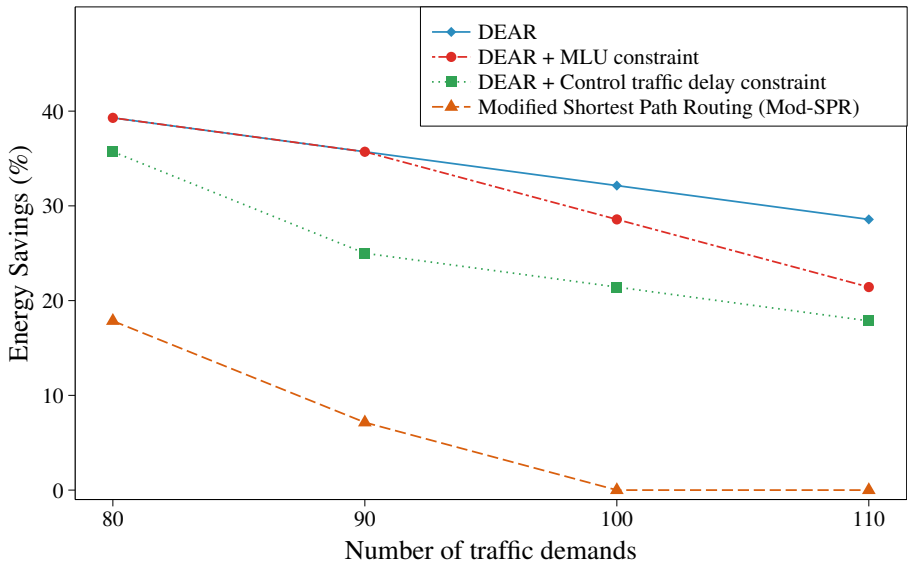

Figure 2: DEAR vs. Mod-SPR in Abilene topology with two controllers.

As shown in Figure 2 in all cases our distributed energy-aware routing approach outperforms the shortest path routing in terms of energy saving. In general DEAR achieves significant energy savings but bigger improvements over shortest path routing are reached when the traffic grows.

4. Conclusions

In this paper, we proposed a distributed energy-aware routing approach that optimizes the number of active links required to route the control and data plane communications in large-scale SDN with multiple domains. Such goal is achieved by an ILP model with two steps of optimization that integrates the routing requirements for data and control traffic in OpenFlow networks with in-band control traffic.

Using an agent-based approach, DEAR can be implemented as a software agent in each one of the distributed controllers in different SDN domains. In this way, an energy-aware control plane could be achieved, where the controllers determine the link interfaces that should be put into sleep mode. This proposal allows to attain optimal solutions for the power consumption problem in a multi-domain SDN. Based on experimental simulations using a real topology and traffic demands, we showed that our distributed energy-aware routing approach achieves energy savings of up to 40% and outperforms the shortest path routing with noticeable improvements.

Developing a heuristic algorithm to use this model in topologies with a bigger number of nodes in each domain, will be an important task as future work. We also plan to extend this work to take into account the use of restoration mechanisms in order to improve the fault tolerance capacity of our approach.

Acknowledgments

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Educational Resources Recommendation System for a Heterogeneous Student Group

Paula Rodríguez[a], Mauricio Giraldo[a], Valentina Tabares[b], Néstor Duque[b] and Demetrio Ovalle[a]

{parodriguezma,maugiraldooca,vtabaresm,ndduqueme,dovalle}@unal.edu.co

[a] Universidad Nacional de Colombia Sede Medellín (Colombia)

[b] Universidad Nacional de Colombia Sede Manizales (Colombia)

KEYWORD

Educational resources; Metadata; Multi-agent systems; Recommendation systems; Student group; User profile

ABSTRACT

In a face-class, where the student group is heterogeneous, it is necessary to select the most appropriate educational resources that support learning for all. In this sense, multi-agent system (MAS) can be used to simulate the features of the students in the group, including their learning style, in order to help the professor find the best resources for your class. In this paper, we present MAS to educational resources recommendation for group students, simulating their profiles and selecting resources that best fit. Obtained promising results show that proposed MAS is able to delivered educational resources for a student group.

1. Introduction

In the traditional education classroom, the teacher is facing a heterogeneous group of students. This group there are students with different features, preferences and ways of learning (Kaššák, et al., 2015). UNESCO in 2011 defined educational resource how any type of resource (including curricula, course materials, textbooks, video, multimedia applications, streaming audio, and other material that is designed for use in the teaching and learning process) that are available for use by teachers and students, without the need for any payment for rights or licenses for use.

Likewise, a Recommendation Systems (RS) is defined as a piece of software that facilitates users to discern more relevant and interesting learning information (Sikka, et al., 2012). RS are a tool aims at providing users with useful information results searched and recovered according to their needs, making predictions about matching them to their preferences and delivering those items that could be closer than expected (Mizhquero & Barrera, 2009). In the case of educational resources, the system should be able to recommend resources adapted to one or more user's profile characteristics using metadata (Li, 2010).

Students and teachers need a starting place for thinking about, and understanding, how they learn. In addition, a learning style is a description of a process, or of preferences. Any inventory that encourages a

learner to think about the way that he or she learns is a useful step towards understanding and hence improving, learning (Fleming & Baume, 2006).
Besides, it is necessary that students "learn to learn" and teachers should recognize the individual differences of their students to customize their education. It is important highlights that teaching styles do not influence the learning styles of the students (Alonso, et al., 1997).
Similarly, teachers should give classes using teaching strategies that strengthen learning styles. That is teach the classes first with a style after another so that all students feel cared for according to their preferences in the way they learn (Othman & Amiruddin, 2010)

Currently, the group recommender systems have been extended and are increasingly popular. Some works make recommendations using hybrid approach combining content-based and collaborative strategies. It is used in cases where groups are heterogeneous and can only recommend a small amount of items in a given period (Kaššák et al., 2015)(Elahi, et al., 2014).
This type of recommendation is mainly applied in various contexts where people gather to perform a specific activity. These contexts are associated with the use of multimedia such as movies, TV content, music selections resources and educational resources (Boratto & Carta, 2010). Also, consider learning styles in the classroom to deliver tailored materials is increasing.
An alternative to the selection of the most suitable educational resources for each learning style is a mapping between metadata and every learning style. Several proposals have been made in this regard, using different models of learning styles and metadata standards (Duque, et al., 2015)(Peña, et al., 2002)(Rodriguez, et al., 2013).

Multi-agent Systems (MAS) -being emergent computing approaches- are widely spread in several e-learning areas providing solutions for complex and restrictive systems. In contrast with conventional computing approaches, MAS has special features such as customization, intelligence, accessibility, safety, task distribution, decision making, among others (Ahmad & Bokhari, 2012).

In this paper, we propose an educational resources recommender system for a heterogeneous student group, taking account the learning style of each student of the group. The aim is delivering, for the teacher, educational resources to supporting the face class.
Experiments are done using *Federación de Repositorios de Objetos de Aprendizaje Colombia* - FROAC (available at: http:/froac.manizales.unal.edu.co/froac/). For quantifying the retrieval quality, a precision metric is used.

The rest of the paper is organized as follows: Section 2 describes the proposed model the recommender for heterogeneous group student and the proposed MAS. Section 3 explains the model validation and the results of the proposed model, through a case study. Finally, the main conclusions and future research directions are shown in Section 4.

2. Proposed Model

This work proposes a multi-agent system for adaptive educational resources recommendation for a student group heterogeneous. The search resources are recommended according to learning style of each student. The learning style are built according to VARK model proposed by Fleming and Baume (Fleming & Baume, 2006). This model is an instrument to determine the preference of students to process information from the sensory point of view. This model is considered that people receive the information through the senses and the brain selects some of that information and ignores the rest. The model takes the name VARK by the acronym of sensory modalities identified.

The students answer the test to kwon the learning style own, this is the main input of the recommender system. Fleming and Mills suggested four modalities that seemed to reflect the experiences of the students and teachers (Visual, Aural, Read/write, and Kinesthetic). This is sensory modalities that are used for learning information (Fleming & Baume, 2006).

The test alerts people to the variety of different approaches to learning. It supports those who have been having difficulties with their learning and has particular applications in business, relationship, sport, training and education.

In order to select the most suitable educational resources for each learning style is performed a mapping between metadata and every learning style. Similar to the proposal in (Duque et al., 2015), this paper presents a mapping between the scores in the VARK test for each simulated student and the metadata "Educational Resource Type" included in the LOM metadata standard.

Table 1 shows the mapping performed, where indicated with "1" if the Resource Type is relevant or not for each learning style. For example, if the Educational Resource Type of a LO is "Diagram", this will be convenient for a student with a 'Visual' learning style.

	V	A	R	K
Exercise				1
Simulation	1			1
Questionnaire				
Diagram	1			
Figure	1			
Graph	1			
Slide		1	1	
Table	1			
Narrative text		1	1	
Exam			1	1
Experiment				1
Problem statement			1	1
Self assessment	1			1
Lecture		1	1	

Table 1: LOM metadata vs. VARK learning styles.

Likewise, the agents of MAS can assume different roles within the system and can be created following a template. Each student is represented through an agent and it behaves autonomously, this ensure that the realized evaluation to each resource is independent. Once created the agents that representing students with their respective profiles, the evaluation process of educational resources begins.

The proposed model assisting teacher in the selecting educational resources for students group, because the system simulates the resource evaluation depending on their characteristics. After the evaluation, the scores assigned to educational resource for each simulated student are aggregated, and the educational resource with more points are best suited to the group average. This ensures greater efficiency and effectiveness against individual recommendation.

Figure 1 presents the architecture of the MAS proposed. Then explains the behavior and communication of each agents in this work.

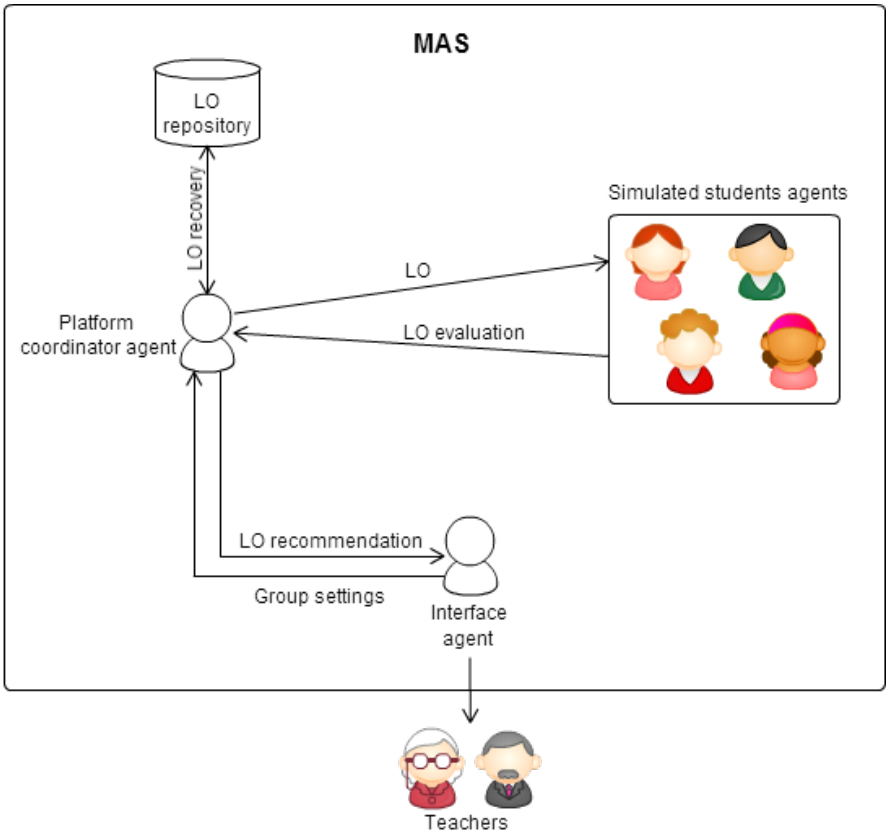

Figure 1: Proposed architecture.

Interface agent: It is responsible for presenting two interfaces to the teachers. A first interface allows entry the characteristics of a group. The data can be entered to the platform using a plain text that contains the id of the students and the results of the scores for each learning style. In addition to the above, the teacher can enter keywords related to the central theme of the course and with these perform the initial search of the LO in the repository. Other data that help to refine the amount of resources to be evaluated are: the education level to which is this course, learning time than is available for the course and the age range of students.

Coordinator agent: responsible for creating agents that simulate each of the members of the student group, which are created with the profile of learning according to the VARK model, admitted by the teacher together with the configuration data of the group. This agent also makes consulting LO in the repository and sends these to each of the simulated students so that they make their respective evaluation. Finally received the assessments made during the simulation and totals the results for the overall rating for each LO and recommend the LO with the higher qualifications

Generic student agent: This generic agent is the basis for creating the simulation of each student. Each simulation must be different, receiving the configuration data of individually profile, where the complete classification of each learning style is present being as the profile contains not only data of the predominant style, but also takes the calcification obtained in the other styles available in the model. This allows a weighted score of each LO. Once completion the LO classification, these come back to the Coordinator agent who totalizes the obtained data.

3. Case Study

This section is divided in two parts, the first one show the description about implementation process, and the second is showing the validation and tests on the system.

3.1 Implementation

To validate the model proposed we make two different experiments apply to case study. We use the educational resources stored in *Federación de Repositorios de Objetos de Aprendizaje Colombia* - FROAC (available at: http:/froac.manizales.unal.edu.co/froac/), in the aim to delivered metadata resources to initialized process.

The JADE (Java Agent Development Environment) framework was used to perform the prototype implementation, that offers a suite of resources to supply the development and implementation of MAS. For this work, we have chosen JADE-LEAP (http://jade.tilab.com/), a FIPA-compliant agent platform that follows agent international communication standards.

Figure 2 shows the configuration interface for the group, where the specifics of each student and the general characteristics of the group are entered.

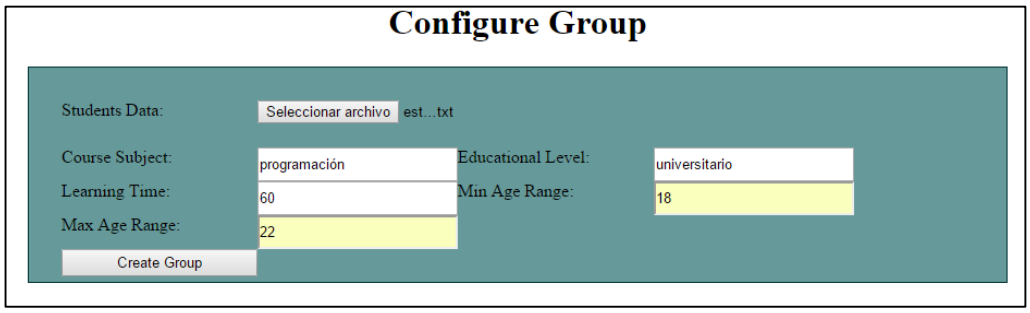

Figure 2: Configure Group Interface.

Following, we describe each one of the fields:

First, in Student data field is selected and loaded a plain text file where the first column represents a serial of the student, the second column corresponds to the score obtained for the student in the visual component of VARK test, in the next column the score for aural component, then the reader/writer component and finally in the fifth column value of kinesthetic component.

Second, Course Subject corresponds to the name of course.

Third, Educational Level is concern to the degree which it is addressed, such as primary, secondary, university degree, graduate.

Next, Learning Time corresponds to the maximum time spent for this specific class, the recovered set of LO should not exceed that time; this field is given in minutes.

Finally, as fifth and sixth maximum and minimum of age range correspond to the age limits of the group of students.

Figure 3 shows the interface to display LOs that are recommended to the teacher. When is presented the set of LO that accomplish the criteria established in the recommendation system configuration.

Figure 3: Results Interface.

3.2 Validation

The aim the first experiment is to validate the discriminating among different groups. If two groups have the different predominant learning style, presumably the recommender result are different for these groups, although the search string are equals.

For this experiment, we have two student groups, in the figure 4 show learning style for each student in these groups.

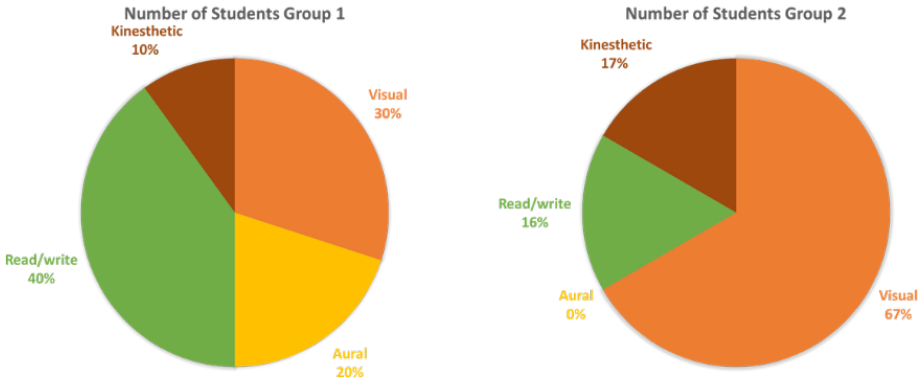

Figure 4: Distribution of groups in learning styles in experiment 1.

Students group 1, the learning style predominant is Reader/Write; this means that the preference for learning are the narrative text, slide, exam, problem statement, and lecture.

Students group 2, the learning style predominant is Visual; this means that the preference for learning are simulation, diagram, figure, graph, table, and self-assessment.

In the experiment, the results are different in both cases; the searching string is "*programación*". The table 2 show the educational type resources result.

Group 1	**Group 2**
Text	Simulation
Lecture	Graph
Lecture	

Table 2: Educational type results for each group.

With this experiment concludes that the proposed recommendation system discriminates and delivers different results for each group of students, according to the learning style of the majority.

The second experiment want to measure the level of satisfaction of the recommendation. Formula 1 is the metric of precision that is commonly used to measure the quality of information retrieval. The relevance is understood as the importance of LO delivered for carrying out a learning process. For that students of Computer/ Management Information Systems, Universidad Nacional de Colombia, Manizales, belonging to the research group on adapted and intelligent environment -GAIA, were selected to rank the relevance of the recommendation outcomes.

$$Precision = \frac{Relevant\ LOs}{Relevant\ LOs + Retrieved\ LOs} \quad (1)$$

A precision metric was applied for performing the LO relevance evaluation. The table 3 and 4 show the results for precision metric for each group.

Group	Relevant LO	Recommended LO	Precision
Group 1	4	5	0,8
Group 2	2	3	0,67
Average	**3**	**4**	**0,75**

Table 3: Precision metric results with recommender.

Group	Relevant LO	Recommended LO	Precision
Group 1	1	7	0,14
Group 2	1	3	0,33
Average	**1**	**5**	**0,2**

Table 4: Precision metric results without recommender.

On average, recommendation system recovered around four LO for each student group and on average, three were relevant, therefore the result of precision was 0.75 on average for this experiment. If delivered to the student group random LO about theme (without recommender), the number of results are five LO, on average only 1 which is relevant LO, then precision is 0.2., and can be concluded that recommendations adapted to the student groups are delivered supports the teaching process on the face classroom.

4. Conclusions and future work

This paper proposes a model for recommendation of educational resources for a student group, which is based on the MAS paradigm using repository federations. Such a model takes advantage of simulating.

This proposal can support the teacher in the difficult task of selecting educational resources for use in the teaching of large groups of students. The suggestions are based on the characteristics of the students and how they learn best.

The results of the case study show that there is differentiation between the recommended educational resources for each group of students, who are relevant and can support the learning process.

Experiments are carried out over *Federación de Repositorios de Objetos de Aprendizaje Colombia* - FROAC (htp:/froac.manizales.unal.edu.co/froac/). Our model not only slightly improves the precision rate but optimizes the amount and quality of delivered LOs.

As a future work, we are aiming at exploring and incorporating more student characteristic and other recommendation techniques. Also, expand the validation of the system. As well, the model performance is to be improved from an adequate agent behavior configuration.

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Accelerometer vs. Electromyogram in Activity Recognition

Heli Koskimäki and Pekka Siirtola
Biomimetics and Intelligent Systems Group
University of Oulu, PO Box 4500, 90014 Oulu, Finland
heli.koskimaki@ee.oulu.fi, pekka.siirtola@ee.oulu.fi

KEYWORD

Activity recognition; Wearable sensor; Acceleration; Electromyogram; Unseen activities

ABSTRACT

In this study, information from wearable sensors is used to recognize human activities. Commonly the approaches are based on accelerometer data while in this study the potential of electromyogram (EMG) signals in activity recognition is studied. The electromyogram data is used in two different scenarios: 1) recognition of completely new activities in real life and 2) to recognize the individual activities. In this study, it was shown that in gym settings electromyogram signals clearly outperforms the accelerometer data in recognition of completely new sets of gym movements from streaming data even though the sensors would not be positioned directly to the muscles trained. Nevertheless, in recognition of individual activities the EMG itself does not provide enough information to recognize activities accurately.

1. Introduction

The wearable sensor market is currently one of the most rapidly growing area in consumer electronics. The global market for wearables is estimated to reach $34 billion by 2020 (CCS Insight, 2016) and to almost $70 billion by 2025 (Weinswig, 2016). In research perspective, this has enabled that mobile sensors based recognition (activities, gestures, symptoms, diagnosis) to become one of the fastest developing areas of machine learning. The remarkable progress in the actual sensor development including improved memory and battery properties has making possible to measure human physiology 24/7, and more importantly with such accurate readings that has previously been possible only in laboratory settings.

The overall wearable sensors based human activity recognition process includes a data set collected from the activities wanted to be recognized, preprocessing, segmentation, feature extraction and selection, and classification (Bulling et al., 2014). By now the activity recognition approached include for example, daily activity recognition (Banos et al., 2012; Zhang and Sawchuk, 2013) and it has been used in various sport sector applications (Chang et al., 2007; Siirtola et al., 2011). It has also been utilized for manufacturing industry purposes like in monitoring of assembly tasks (Stiefmeier et al., 2008; Koskimäki et al., 2009).

One of the problems of activity recognition is that to recognize n activities, training data must be collected from at least n-1 activities (Siirtola, 2015). The remaining activity could be recognized based on the assumption that if the performed activity was not recognized as one of the n-1 from which training data was collected, it

must be the one from which training data was not available. Nevertheless, in practice the streaming data consists also plenty of data not interesting from application specific point of view, and that cannot be collected inclusively. This so called as null-data or "other activities" makes the decision if there actually is a novel activity or should it be considered to belong null-class a challenging task.

Thus in this article the problem studied for unseen activities is that how to recognize them as activities instead of belonging to the null-class. Moreover, in this study, a new sensor is introduced to be used to solve the problem in gym setting. The gym activity recognition makes a quite unique problem into the activity recognition area while the gym exercises mostly consists of repetitive movements. How to recognize different gym activities based on acceleration sensors have been studied, for example, in (Chang et al., 2007; Muehlbauer et al., 2011; Morris et al., 2014). In (Chang et al., 2007) there were no null-data collected thus making the research simpler but in (Muehlbauer et al., 2011; Morris et al., 2014) both a segmentation approach was used as a solution to decide beforehand if gym activity is performed against the null-data. Nevertheless, in both cases the segmentation is optimized based on the existing activities (the leave-one out approach is used as person independent approach) and there are no information of the generalization of the segmentation to novel gym sets. Moreover, the few studies considering the unseen activities are also completely different to ours. In (Cheng et al., 2013), for example, they are concentrating to recognize the actual gym exercises based on semantic attributes (e.g. dumbbell curl consist of arm down and arm curl actions) and there are no null-data in the study.

On the other hand, electromyogram (EMG) is used to measures muscles to see the power needed to perform certain gym exercises (Holviala et al., 2012). Nevertheless, to be able to do that EMG device has to be positioned directly on the muscle to be measured. Thus although it could sound trivial to use EMG to recognize the actual gym exercises from the other activities the approach where sensors are not positioned to the actual trained muscle or changed between the exercises makes the study novel. While the EMG-sensors are attached in the forearm of the user in this study the movement of individual fingers also effect to the tension of the forearm muscles making the approach more challenging.

As an extension to the authors' previous article (Koskimäki and Siirtola, 2016), in this article also the possibility to use the EMG signals to the user-independent (UI) activity recognition is studied. In this approach the null data is discarded and the basic leave-one-person-out cross-validation is used using acceleration information, using EMG information, and using combination of both.

This article is organized as follows: Section 2 introduces the sensors used as well as the data collection procedure. The methods related to the activity recognition process including feature extraction, feature selection, classification and leave-one-out cross-validation are described in Section 3. The results for both scenarios 1) unseen activities and 2) UI activity recognition are covered out in Sections 4 and the discussion of the findings is carried on in 5. The whole study is concluded in Section 6.

2. Sensors and Data Collection

The data were collected using a Myo Armband (Myo, 2016). Myo includes 8 EMG sensors and a nine-axis IMU containing three-axis gyroscope, three-axis accelerometer, three-axis magnetometer (Figure 1). It is developed for gesture recognition purposes and thus meant to be worn in a forearm of the user. In our study, the Myo was

Figure 1: Myo Armband.

Muscle group	Exercises
Triceps	Close-Grip Barbell Bench Press, Bar Skullcrusher, Triceps Pushdown, Bench Dip / Dip, Overhead Triceps Extension, Tricep Dumbbell Kickback
Biceps	Spider Curl, Dumbbell Alternate Bicep Curl, Incline Hammer Curl, Concentration Curl, Cable Curl, Hammer Curl
Shoulders	Upright Barbell Row, Side Lateral Raise, Front Dumbbell Raise, Seated Dumbbell Shoulder Press, Car Drivers, Lying Rear Delt Raise
Chest	Bench Press, Incline Dumbbell Flyes, Incline Dumbbell Press, Dumbbell Flyes, Pushups, Leverage Chest Press
Back / lats	Seated Cable Rows, One-Arm Dumbbell Row, Wide-Grip Pulldown Behind The Neck, Bent Over Barbell Row, Reverse Grip Bent-Over Row, Wide-Grip Front Pulldown

Table 1: Gym exercises, more details can be found from (Koskimäki and Siirtola, 2014).

located at the right forearm positioned so that the IMU was on the top of the forearm while the EMG sensors located evenly distributed around the arm. In this study the frequency of 50 Hz were used in data collection. The recognition was done based on EMG and accelerometer data, and therefore, gyroscope and magnetometer data were not used.

The actual data were collected from 10 persons and from 30 different gym exercises, each of them consisting a set of ten repetitions. The exercises were mostly done using free weights, and for every upper body muscle group, data from six different exercises were collected (Table 1). While the data set was gathered as a continuous signal, the data set constituted also data between every exercise set in which the subject moved around at the gym, changed weights, stretched or just stayed still (null-data). Altogether, there were more than 11 hours of data of which 77 percent was considered as null-data.

The difference between EMG and acceleration signals are shown in Figures 2 and 3. In both cases the same

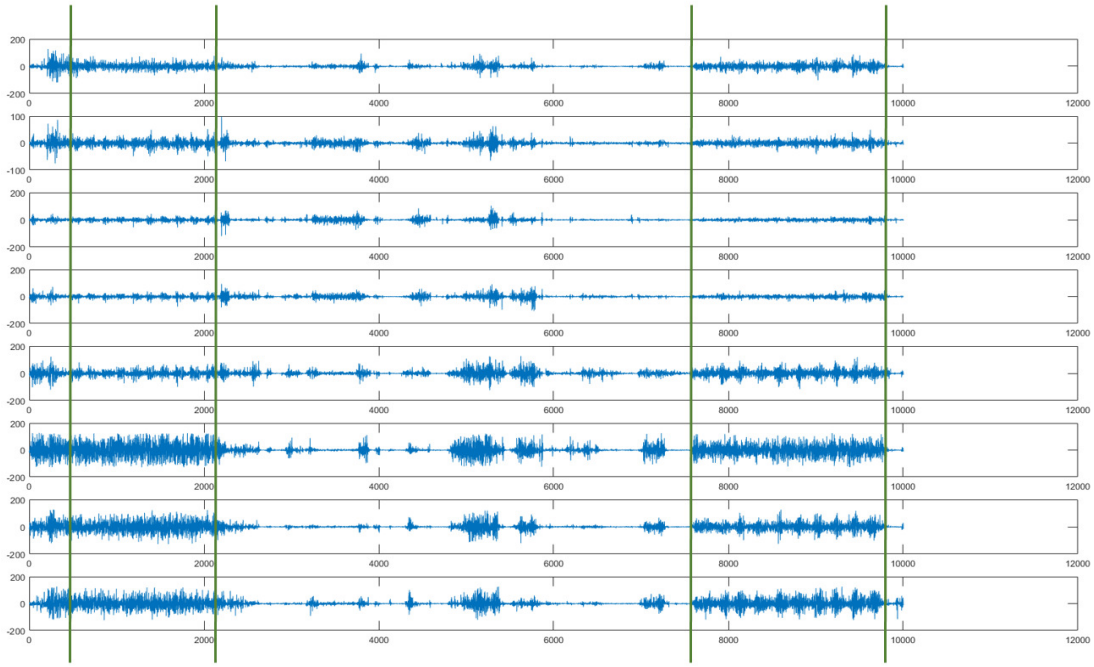

Figure 2: 8 channels of EMG signals corresponding to two different gym exercises (separated between vertical lines) and null-data between the exercises.

time interval is shown including data from two different gym exercises and null-data between the exercises. It can be noted that during exercises there is periodical movement in each of the three acceleration channels. However, in the case EMG periods are not visible in all of the channels, and also in these channels they are more difficult to see than in the case of accelerometer data. In addition, when signal from two different activities are compared, it can be seen that with accelerometer data signals are different while with EMG there are much less differences. When null-data interval is studied, it can be seen that accelerometer signals contain a lot more non-periodical movement than EMG signals. Therefore, it would seem that periodical exercises are easier to detect from accelerometer data than from EMG while EGM seems to be more suitable in recognizing null-data.

3. Methods

The EMG signals were pre-processed with two different ways: 1) all the eight EMG signals were summed up as a single signal, or 2) different channels were summed with the values of adjacent EMG signals (the EMG signal 1 consisted of sum of signals 8, 1 and 2; and signal 2 of signals 1, 2 and 3, etc.). For acceleration signals, no

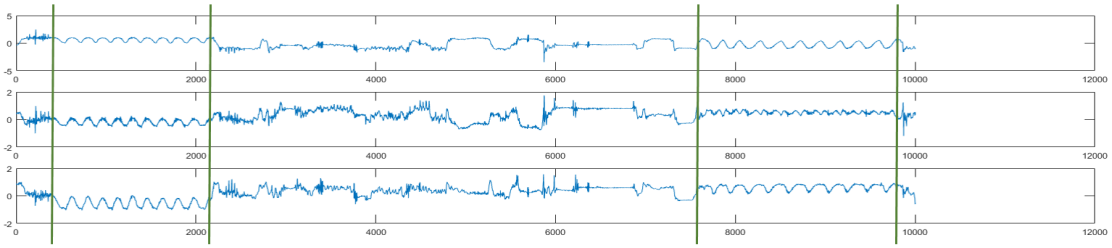

Figure 3: 3 acceleration signals (x,y,z) corresponding to two different gym exercises (separated between vertical lines) and null-data between the exercises.

Data set	Feature type	Features
Acc	Statistical features	std, mean, min, max, median, percentiles (5, 10, 25, 75, 90, 95), zero and mean crossing
	Frequency domain	FFT sums (1:2, 1:5, 6:10, 10:15), squared sum using all channels
	Haar wavelets	sums of wavelet decompositions using different bookkeeping vectors
	correlation	autocorrelation and cross-correlation
EMG	Statistical features	std, mean, min, max, median, percentiles (5, 10, 25, 75, 90, 95)
	Sums	sums of data value over 25, 50, 100, 150 and 200
EMG sum	Statistical features	std, mean, min, max, median, percentiles (5, 10, 25, 75, 90, 95), zero and mean crossings
	correlation	autocorrelation

Table 2: Features calculated from acceleration data, EMG signals (channels summed with adjacent channels (EMG), or channels summed altogether (EMG sum)).

pre-processing was done.

After the pre-processing the continuously measures signals were divided into segments using the sliding window method, where window length of two seconds with a slide of 0.5 seconds between two sequential windows was used. For every of the windows, features were calculated including statistical values for all the signals and for acceleration also frequency domain and correlation features were calculated (Table 2). The amount of features for acceleration signals were 219, for 8 channels of EMG 128 and for summed EMG channel 19.

In this article, the best features to recognize unseen activities were chosen using sequential forward selection (SFS) and minimum Redundancy Maximum Relevance Feature Selection (mRMR). With SFS the best features

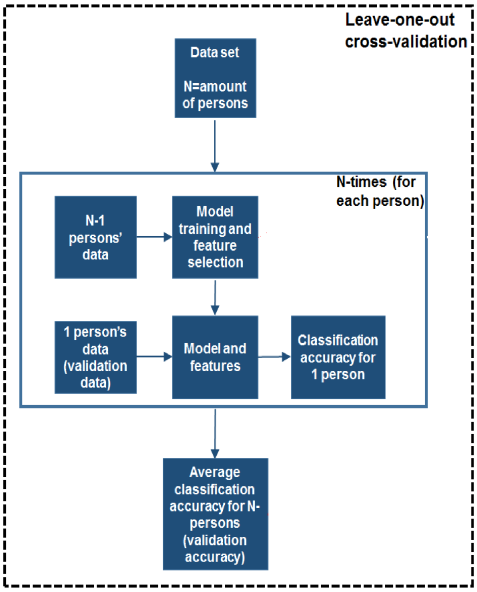

Figure 4: Leave-one-out cross-validation.

were selected one at a time using the classification accuracy of the model in question as a selection criteria (Devijver and Kittler, 1982). However, the selection was not stopped at local minimum but it was allowed to choose until "the best features" included all the features. On the other hand, with mRMR the feature selection was done model independently by selecting features having the highest correlation to the classification variable but locating far from each other (Peng et al., 2005). With mRMR the amount of features was decided before hand as signal-wise based on a preliminary test with all the data. The recognition of individual activities was done using all the features, and therefore, feature selection was not used.

The classifiers used in this study were the parametric linear discriminant analysis (LDA), quadratic discriminant analysis (QDA). The LDA and QDA model the class-conditional densities parametrically as multivariate normals (Duda et al., 2012). In practice, QDA separates classes using nonlinear decision boundaries while LDA uses linear decision boundaries. Both of the methods are fast to train, easy to implement and the memory requirements are small thus making them well-liked in practical applications and devices. Moreover, it has been shown in practical activity recognition applications the simplest methods can outperform the more sophisticated methods (Koskimäki, 2015).

To compare the results leave-one-person-out cross-validation was used (Figure 4). The idea is to divide the data set into as many data sets that there are persons in the data. With every iteration one person's data is used as validation data while the data from the N-1 person are used in the model training. The person-wise accuracies achieved during these N iteration are then used to to calculate the average user-independent classification rate.

Figure 5: Two scenario examples for case of data from three persons. The training data includes data from the persons as well as gym activities not used for testing. In the study all the combinations are went through.

4. Results

4.1 Recognition of unseen activities

The model generalization to new exercises were studied by selecting suitable subsets of activities into training and testing under leave-one-person-out cross-validation schema. In addition to that, to study the recognition of unseen activities also data from certain exercises were deleted simultaneously. Nevertheless, instead of the traditional version where a single activity is deleted at a time the deletion in this article is done muscle-group specifically in four scenarios.

In practice this means that for every person at a time, in scenario 1, every set of exercises (6 exercises) at a time and the null-data were used as testing data while the other 4 sets of exercises (24 exercises) and the null-data from the remaining 9 persons were used for training (see Figure 5). In scenario 2, the same procedure was done by using two sets (12 exercises) for testing and three sets (18 exercises) for training, in scenario 3 using three sets (18 exercises) for testing and two (12 exercises) for training and in scenario 4 using four sets (24 exercises) for testing and one (6 exercises) for training. Thus the classification becomes more and more difficult between

Feature selection	Classifier	Scenario	Signal				
			ACC	EMG	EMG sum	ACC+EMG	ACC+EMG sum
mRMR	LDA	1	77.7	85.2	82.7	83.2	**84.2**
		2	74.8	81.1	82.3	81.8	82.6
		3	69.9	76.2	81.9	76.3	77.8
		4	62.2	70.4	81.3	70.3	71.6
	QDA	1	68.6	77.0	84.0	81.4	83.4
		2	66.5	77.2	**84.0**	80.8	81.3
		3	64.0	78.5	**83.8**	75.2	76.6
		4	59.7	77.5	**83.2**	70.1	65.2
SFS	LDA	1	85.2	88.2	83.0	89.9	88.1
		2	83.1	88.2	83.1	89.5	87.7
		3	82.3	88.0	83.1	**88.6**	87.0
		4	79.3	87.7	83.0	**88.2**	85.7
	QDA	1	84.7	87.8	85.3	**90.1**	89.8
		2	83.9	87.8	85.2	**89.6**	89.1
		3	83.9	87.8	85.1	88.5	87.5
		4	77.5	87.5	84.7	87.8	86.5

Table 3: Average recognition rates using mRMR and SFS feature selection methods with both LDA and QDA classifiers using acceleration data, EMG signals (channels summed with adjacent channels (EMG), or channels summed altogether (EMG sum)), or a combination of the signals.

scenarios. In every scenario, all the combinations are gone through and the results are shown as an average of every person and of those combinations (6, 10, 10 and 6 combinations, respectively). Moreover, the average is shown as an average of class-wise averages preventing the massive amount of null-data to skew the results.

The results in Table 3 clearly show that the accuracies achieved with mRMR feature selection method are remarkably different from the SFS results. The only accuracy staying over 80 percent through the four scenarios is the accuracy achieved when using features calculated from the summed EMG-signal. Naturally, the reason for that is that there were not so many features to be selected (19 original features). Nevertheless, when using the summed EMG-signal and QDA, over 83 percent accuracies were achieved even when only movements targeted to single muscle groups were used as training data (scenario 4) which is over 20 percentage units higher than the accuracy achieved using acceleration signal (62.2%).

On the other hand, when considering the results achieved with SFS feature selection a more higher accuracies overall can be seen. The first obvious remark also with this case is that EMG signals contained more generalizable information than the acceleration signals. From the scenario 1 to scenario 4 only 0.6 percentage units drop was shown while within the acceleration signals a drop of 6 percentage units is seen between the scenarios, in addition to the 3 percentage units lower accuracy already in the first scenario (LDA). Moreover, by combining the acceleration information with EMG-information, it can be seen that no remarkable improvement in overall accuracies is achieved at least in the scenarios 3 and 4.

Data set	Acceleration	EMG	Acceleration and EMG
All the data	55.8	12.4	58.7
Every second exercise	72.0	21.5	75.9
Every sixth exercise	86.1	41.0	85.9

Table 4: Recognition rates when using all the exercise data (30 classes), using every second exercise data (15 classes) and when using only one exercise per muscle group (5 classes).

4.2 Recognition of the individual activities

To test the information comprised by acceleration and electromyogram signals the null data was removed manually from the data set. Due to the high variety of gym exercises used in data collection (the recognition is in most studies based only on nine or ten exercises) three different sets of the whole data set was used. In the first case, all the data was used including data from 30 exercises of which some were highly overlapping (e.g. Spider Curl vs. Concentration Curl). In the second case the amount of activities were dropped to half deleting every second activity (15 classes, 3 activities per muscle group). The third case is the simplest one, including only one activity per muscle group and altogether 5 classes.

From the results presented in Table 4 can be seen that the recognition rate, 55.8% using only accelerometer and 58.7% using combination of accelerometer and EMG, is really low when all 30 are recognized. The detection accuracy is especially low when the recognition is based only on EMG data (12.4%). Therefore, the collected data set does not include enough information to detect all 30 exercises reliable. Reducing the number of classes to 15 improves the recognition accuracy, 72.0% using only accelerometer and 75.9% using combination of accelerometer and EMG, but still the rates are quite low. Again, it can be seen that individual activities cannot be detected using only EMG (21.5%). After reducing the number of classes to 5, the recognition rates are already pretty good (86.1% using only accelerometer and 85.9% using combination of accelerometer and EMG), except if only EMG data is used (41.0%). What is noticeable is that based on the results of Table 4, it can be noted that when individual activities are recognized, EMG data does not provide any added value to the accelerometer data as the combination of EMG and accelerometer data does not improve the detection rates significantly compared to using accelerometer only.

5. Discussion

When the aim was to recognize unseen activities, the results showed that the EMG signals contained more generalizable information than the acceleration signals. While the acceleration signals still coped the problem when there can be assumed to be at some level similar information in the training set, the more novel the new activity is the more difficult it is classified using the acceleration. This is quite surprising while the gym exercises contained sequential movements (repetitions) which are in acceleration signal based studies considered to separate the activity from the null-data. Nevertheless, as stated before, in previous studies the optimization of segmentation is based on the known activities which can affect to the results.

From the feature selection point of view an interesting remark was that the mRMR feature selection itself had

a notable negative effect on the generalization results. This can be explained that with the SFS the features were selected based on results achieved for the testing data, in practice, telling the feature selection method that we do not want to optimize the training data classification but the testing data classification. For mRMR no information of the actual problem was introduced. Nevertheless, it has been already show that the recognition rates are biased in SFS while the same data is used for selecting the features and validating the features (Koskimäki, 2015). Thus by using SFS the unseen activities are not unseen but already used in model optimization. Although the difference between the accuracy of EMG and acceleration signals with SFS is so apparent that it cannot be caused by this bias, the more reliable overall results are those achieved with mRMR which clearly favored EMG-data.

EMG-data was useful when unseen activities were recognized. However, when the task was to recognize individual activities, the situation was different. In this case, the combination of EMG and accelerometer did not provide any added value compared to using only accelerometer. In addition, when only EMG data was used in the recognition process, the recognition accuracy was really low. The reason for this this can be seen from Figure 2, EMG signals are not different in different exercises. In addition, movement caused by exercise is visible only in some signal channels, not in all. Therefore, when the aim is to recognize individual activities, the recognition should not be based on EMG data, instead accelerometers are advised to be used.

In this study, all the activities were targeted to upper body muscles which still leaves the question "how the results generalize in the cases of lower body muscles workouts" open. For example, there are lower body muscles targeted gym equipments where hands are positioned into stationary handles causing the acceleration to fall behind. Nevertheless, interesting would be seen, if the adherence of the handles would be enough to EMG-signals to contain the information of exercise time. Also interesting would be to know if lactic acids effect to the EMG signals.

6. Conclusions

In this article, the generalization of acceleration signals information was compared with EMG signals in novel events at gym activity recognition. It was shown that when the aim is to recognize unseen activities even non-optimally positioned EMG-sensor will outperform the accelerometer information; the most dissimilar new activities can be extracted from null-data with 10 to 20 percentage unit higher accuracy by using EMG signal. Naturally, more accurate results could be achieved by using optimally located EMG sensor but this was considered non-practical in real world usage while the end-user cannot be obligated to change the sensor location between every gym set. However, the situation is totally different when the aim is to recognize individual activities. In this case, accelerometer-sensor outperforms EMG-signal. In fact, even the combination of EMG and accelerometer does not provide any added value compared to using only accelerometer.

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From VoiceXML to multimodal mobile Apps: development of practical conversational interfaces

David Griol and José Manuel Molina
Computer Science Department, Carlos III University of Madrid, Avda. de la Universidad, 30. Leganés (Spain), 28911
{david.griol, josemanuel.molina}@uc3m.es

KEYWORD

Conversational interfaces; VoiceXML; Mobile devices; Android

ABSTRACT

Speech Technologies and Language Processing have made possible the development of a number of new applications which are based on conversational interfaces. In this paper, we describe two approaches to bridge the gap between the academic and industrial perspectives in order to develop conversational interfaces using an academic paradigm for dialog management while employing the industrial standards. The advances in these technologies have made possible to extend the initial applications of conversational interfaces from only spoken interaction (for instance, by means of VoiceXML-based systems) to multimodal services by means of mobile devices (for instance, using the facilities provided by the Android OS). Our proposal has been evaluated with the successful development of different spoken and multimodal conversational interfaces.

1. Introduction

Recent advances in conversational interfaces has been propelled by the convergence of three enabling technologies. First, the Web emerged as a universal communications channel. Web-based conversational interfaces are scalable enterprise systems that leverage the Internet to simultaneously deliver dialog services to large populations of users. Second, the development of mobile technologies and intelligent devices, such as smartphones and tablets, have made it possible to deploy a large number of sensors and to integrate them into conversational interfaces that provide multimodal interaction capabilities (i.e., use of different modalities for the input and/or output of the system) and allow their access in almost every place and at any time. Third, computational linguistics, the field of artificial intelligence that focuses on natural language software, has significantly increased speech recognition, natural language understanding and speech synthesis capabilities (McTear et al., 2016).

These advances have extended the initial application domains of conversational interfaces to complex information retrieval and question answering applications (Metze et al., 2014), e-commerce systems (Tsai, 2005), surveys applications (Stent et al., 2006), in-car systems (Hofmann et al., 2014), remote control of devices and robots in smart environments (Minker et al., 2010), e-learning and tutoring systems (Kopp et al., 2012), communication within vehicles (Misu et al., 2015), Ambient Assisted Living systems (Bickmore et al., 2010), recommendation systems (Reschke et al., 2013), or virtual companions (Horchak et al., 2014).

In this paper, we describe two approaches to bridge the gap between the academic and industrial perspectives in order to develop conversational interfaces using an academic paradigm for dialog management while employing the industrial standards. Our first approach to integrate statistical methodologies in industry applications combines the flexibility of statistical dialog management with the facilities that the VoiceXML language offers (Rouillard, 2007; González-Ferreras et al., 2006), thus introducing statistical methodologies for the development of commercial (and not strictly academic) conversational interfaces. Our technique employs a statistical model based on neural networks that takes into account the history of the dialog up to the current dialog state in order to

predict the next system response (Griol et al., 2008). To learn the dialog model we propose the use of dialog simulation techniques. Our approach for acquiring a dialog corpus is based on the interaction of a user simulator and a dialog manager simulator (Griol et al., 2013). In addition, the system prompts and the grammars for ASR are implemented in VoiceXML compliant formats, for example, JSGF[1] or SRGS[2].

Multimodal conversational systems offer the user combinations of input and output modalities for interacting with mobile devices, taking advantage of the naturalness of speech (Pieraccini, 2012). Different vendors offer APIs for the development of applications that use speech as a possible input and output modality, but developers have to design ad-hoc solutions to implement the interaction management. Speech access is then a solution to the shrinking size of mobile devices (both keyboards to provide information and displays to see the results). Besides, speech interfaces facilitate the access to multiagent systems (Corchado et al., 2008), especially in environments where this access is not possible using traditional input interfaces (e.g., keyboard and mouse). It also facilitates information access for people with visual or motor disabilities.

Our second approach is focused on the development of multimodal conversational agents for mobile devices operating with the Android OS (McTear and Callejas, 2013). Our proposal integrates the Google Speech API to include the speech recognition functionality in a multimodal conversational agent. The development of multimodal systems involves user inputs through two or more combined modes, which usually complement spoken interaction by also adding the possibility of textual and tactile inputs provided using physical or virtual keyboards and the screen. In our contribution, we also model the context of the interaction as an additional valuable information source to be considered in the fusion process. We propose the acquisition of external context by means of the use of sensors currently supported by Android devices. The Android sensor framework (*android.hardware* package) allows to access these sensors and acquire raw sensor data.

The remainder of the paper is organized as follows. Section 2 describes the main modules of a conversational interface, the main approaches to develop them, and the main challenges that different experts have envisioned as future research guidelines. Section 3 describes our first approach to develop conversational interfaces using the VoiceXML language. A practical example of our proposal to implement interactive voice portals that provide municipal information is described. Section 4 describes our proposal focused on the development of multimodal conversational interfaces for mobile devices operating with the Android OS. We describe a practical App that facilitates the interaction by means of speech or using the screen and virtual keyboard. The services that are provided by the App include accessing the latest local and international news, the weather forecast for the coming days for the current place, the results of different lottery contests and events, the movie listings and upcoming movies. Finally, in Section 5 we present the conclusions and outline guidelines for future work.

2. Related work

A conversational agent is a software that accepts natural language as an input and produces natural language as an output engaging in a conversation with the user (McTear et al., 2016; Pieraccini, 2012). To successfully manage the interaction with the users, conversational agents usually carry out five main tasks: automatic speech recognition (ASR), natural language understanding (NLU), dialog management (DM), natural language generation (NLG) and text-to-speech synthesis (TTS).

Speech recognition (Rabiner and Juang, 1993; Baker et al., 2009) is the process of obtaining the text string corresponding to an acoustic input . It is a very complex task as there is much variability in the input characteristics, which can differ depending on the linguistics of the utterance, the speaker, the interaction context and the transmission channel. Linguistic variability involves differences in phonetic, syntactic and semantic components

[1] https://www.w3.org/TR/jsgf/
[2] https://www.w3.org/TR/speech-grammar/

that affect the voice signal. Inter-speaker variability refers to the big difference between speakers regarding their speaking style, voice, age, sex or nationality.

Once the conversational agent has recognized what the user uttered, it is necessary to understand what he said. Natural language processing is the process of obtaining the semantic of a text string (Minker, 1998; Baker et al., 2009). It generally involves morphological, lexical, syntactical, semantic, discourse and pragmatical knowledge. Lexical and morphological knowledge allow dividing the words in their constituents distinguishing lexemes and morphemes. Syntactic analysis yields a hierarchical structure of the sentences, while semantic analysis extracts the meaning of a complex syntactic structure from the meaning of its constituents. In the pragmatic and discourse processing stage, the sentences are interpreted in the context of the whole dialog.

There is not a universally agreed upon definition of the tasks that a dialog manager has to carry. Traum and Larsson (Traum and Larsson, 2003) state that dialog managing involves four main tasks: i) updating the dialog context, ii) providing a context for interpretations, iii) coordinating other modules and iv) deciding the information to convey and when to do it. Thus, the dialog manager has to deal with different sources of information such as the NLU results, database queries results, application domain knowledge, knowledge about the users and the previous dialog history (Griol et al., 2014; Bohus and Rudnicky, 2003).

Natural language generation is the process of obtaining texts in natural language from a non-linguistic representation. The simplest approach consists in using predefined text messages (e.g. error messages and warnings). Finally, a text-to-speech synthesizer is used to generate the voice signal that will be transmitted to the user.

Human beings have always been interested in being able to communicate with artificial companions. In fact, one of the main challenges of AI since his early days has been to achieve the man-machine communication through natural language. At the beginning of the XX century J.Q. Stewart built a machine that could generate vocalic sounds electrically; and during the 30s, the first electric systems covering all sounds were built. The first one was the VOCODER, an speech analyzer and synthesizer developed in Bell Laboratories that could be operated by a keyboard. At the same time appeared the first systems with very basic natural language processing capabilities for machine translation applications.

During the 40s, the first computers were developed and some prominent scientists like Alan Turing pointed out their potential for applications demanding "intelligence". This was the starting point that fostered the research initiatives that in the 60s yielded the first conversational agents. For example Weizenbaum's ELIZA (Weizenbaum, 1966), which was based on keyword spotting and predefined templates.

Benefiting from the incessant improvements in the areas of speech recognition, natural language processing and speech synthesis, the first research initiatives related to spoken dialog systems appeared in the 80s. To some extent the origin of this research area is linked to two seminal projects: the DARPA Spoken Language Systems in the USA (DARPA, 1992) and the Esprit SUNDIAL in Europe (Peckham, 1993).

Among the most important research projects in the 90s with multi-domain capabilities, stands out the DARPA Communicator. This government-funded project aimed at the development of cutting-the-edge speech technologies, which could employ as an input not only speech but also other modalities. Currently experts have proposed higher level objectives to develop dialog systems, such as providing the system with advanced reasoning, problem solving capabilities, adaptiveness, proactiveness, affective intelligence, multimodality and multilinguality (Dybkjaer and Minker, 2008). As can be observed, these new objectives are referred to the agent as a whole.

Throughout the last years, some experts have dared to envision what the future research guidelines in the application of multimodal conversational interfaces would be. These objectives have gradually changed towards ever more complex goals, such as providing the system with advanced reasoning, problem solving capabilities, adaptiveness, proactiveness, affective intelligence, and multilinguality. All these concepts are not mutually

exclusive, as for example the system's intelligence can also be involved in the degree to which it can adapt to new situations, and this adaptiveness can result in better portability for use in different environments.

Proactiveness is necessary for computers to stop being considered a tool and becoming real conversational partners. Proactive systems have the capability of engaging in a conversation with the user even when he has not explicitly requested the system's intervention. This is a key aspect in the development of ubiquitous computing architectures in which the system is embedded in the user's environment, and thus the user is not aware that he is interacting with a computer, but rather he perceives he is interacting with the environment. To achieve this goal, it is necessary to provide the systems with problem-solving capabilities and context-awareness.

Adaptivity may also refer to other aspects in speech applications. There are different levels in which the system can adapt to the user. The simplest one is through personal profiles in which the users have static choices to customize the interaction. Systems can also adapt to the users' environment, for example ambient intelligence applications such as the ubiquitous proactive systems described. A more sophisticated approach is to adapt to the user's knowledge and expertise. This is especially important in educative systems to adapt the system taking into account the specific evolution of each of the students, the previous uses of the system, and the errors that they have made during the previous interactions.

There is also an increasing interest in the development of multimodal conversational systems that dynamically adapt their conversational behaviors to the users' affective state. The empathetic educative agent can thus indeed contribute to a more positive perception of the interaction.

Portability is currently addressed from very different perspectives, the three main ones being domain, language and technological independence. Ideally, systems should be able to work over different educative application domains, or at least be easily adaptable between them. Current studies on domain independence center on how to merge lexical, syntactic and semantic structures from different contexts and how to develop dialog managers that deal with different domains.

Finally, technological independence deals with the possibility of using multimodal systems with different hardware configurations. Computer processing power will continue to increase, with lower costs for both processor and memory components. The systems that support even the most sophisticated multimodal applications will move from centralized architectures to distributed configurations and thus must be able to work with different underlying technologies.

3. VoiceXML-based conversational systems: Interactive voice portals to provide municipal information

In this section we describe a voice portal that integrates different technologies such as the VoiceXML standard, databases, web and speech servers, and several programming languages (SQL, PHP, HTML), which make it more dynamic and flexible and increase its quality, efficiency, and adaptation to the users' specific preferences and needs. The functionalities of the system are to consult information about the City Council (Government Team, Councils, etc.) and the city (history, geographic and demographic data, access to the city, yellow pages, movie show times, news, events, weather, etc.), carry out several steps and procedures (check lists and personal files, book municipal facilities or make an appointment), complete surveys, access the citizen's mailbox to leave messages for suggestions and complaints, and be transferred to the City Council to be attended by a teleoperator.

The *Home module* implements the first dialog that is provided to the user. The options that the system provides to users are divided into five modules that takes into account the type of interaction and data that is facilitated: information, procedures and formalities, surveys, mailbox of the citizen, and human operator. Therefore, this module facilitates the access to the rest of functionalities provided by the portal.

The *Information module* provides specific information about the city. This information has been divided into six categories and classified so that users can easily access each functionality provided by this module:

- *City Council*: This module provides specific information related to the local government, local governing entities, teams and areas.
- *City*: By means of this module it is possible to access information related to the city (history, access, and yellow pages with bars, cafes, restaurants, shops, hostels, hotels and entertainment guides for cinemas and theaters).
- *Thematic Areas*: This module integrates the rest of information that users can consult by means of the voice portal. This information has been divided into 15 areas, which respectively provide general information, competences and contact details. Additional functionalities can be perfectly incorporated by simply adding more static information in the corresponding database of the application.
- *News*: This section provides current news of the municipality, including the date, title and corresponding description of each one of them.
- *Events*: This section reproduces the list of events of the municipality, providing its specific area, title, date, location, and detailed description.
- *Weather information*: Users can get the current weather information from the municipality and a forecast for the next two days.

The *Procedures and Formalities* module provides information about procedures and steps, such as verifying the correct incorporation into specific lists, checking the status of dossiers and documents, booking a municipal facility, or making an appointment related to a specific municipal service. The *Surveys* module allows the City Council to easily and quickly know citizens' opinion about specific issues and queries. Surveys in the application have been designed to be completely anonymous, so the voice portal does not require the users' identification. Once users have finished answering a survey, they are given the options to listen to the answers they have provided. An example of a dialog for a user asking about a specific procedure is shown below (dialog translation from Spanish to English).

```
S: Here you can access and complete procedures and formalities.
   To verify whether you are included in a list or not, say list or press 1. To check the
   status of your dossier, say dossier or press 2. To make a reservation of a sport
   facility, say reservation or press 3. If you want to schedule an appointment, say
   appointment or press 4.
U: Dossier.
S: Please tell us your ID saying or dialing the 8 digits one by one.
U: 47452060.
S: You have‘provided 47452060. The status of your dossier is as follows: Your certificate
   of registration has been
   requested.
S: What do you want to do now?
   To return to the main menu of the voice portal, say main or press 1. To access or
   complete other procedures, say procedures or press 2. If you want to exit the application,
   say exit or press 3.
U: Exit.
S: You have chosen to exit the application. Thanks for using our voice portal. See you soon!
```

The *Citizen's mailbox* implements the functionality of recording a user' speech message and store it for further processing. Thus, citizens can provide their requests, complaints, claims or comments at anytime and anywhere. The Citizen's mailbox is then managed by a specific Office of the City Hall. In addition, if users

provide their contact information (telephone, mobile phone or email), this Office would contact them to provide a personalized response to their request. Finally, the *Teleoperator* module transfers the user's call to a human operator.

3.1 Architecture of the application

The voice portal has been developed following the client-server paradigm with the architecture described in Figure 1.

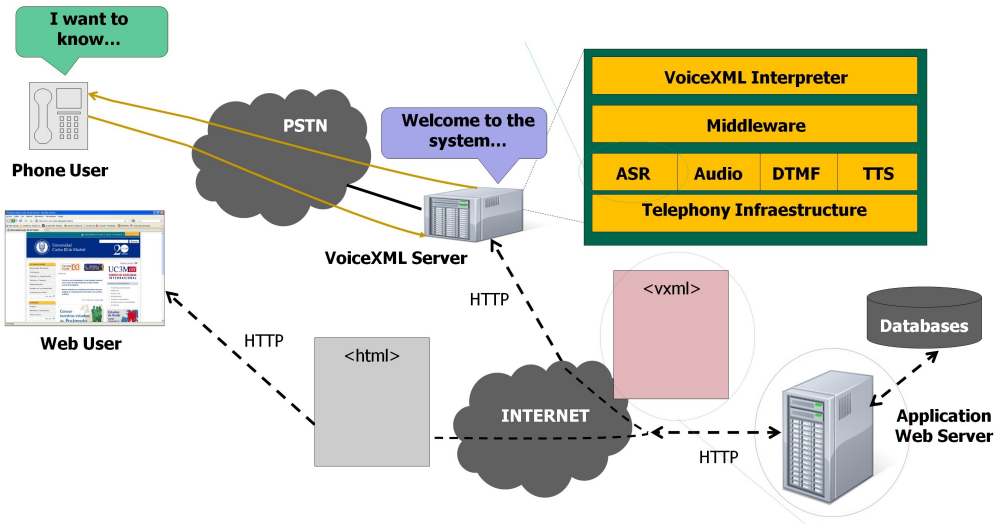

Figure 1: Architecture designed to develop interactive voice portals.

The architecture is based on two main components: an IVR (Interactive Voice Response) server and a set of web servers. The IVR provides users with pages following the VoiceXML standard[3], the ASR and TTS interfaces, and VoIP and telephony technologies. Different web servers connected to the IVR via Internet provide dialog management facilities, grammars and system prompts, and the access to the information and different web services.

Regarding the VoiceXML server, it receives the users' calls and interprets the documents to provide the required services. The interpreter, in our case the Voxeo Evolution platform[4], also requests the required resources for the application, defines the logic of the services and stores users' session state to interact accordingly. To carry out these actions, the VoiceXML interpreter includes different systems to deal with users' calls, manage the communication with the servers and access the required resources, play audio files, convert text to speech, collect user data, perform voice recording, and manage sessions and events.

There are currently many VoiceXML language interpreters. One of the most important ones, given the number of functionalities provided, is Voxeo Evolution[5]. Voxeo allows creating VoiceXML applications and access them by means of a local phone number and/or a Skype number. Voxeo also allows to track calls in real time, as well as automatically create log files. These files are very useful for debugging and optimizing the

[3]http://www.w3.org/TR/voicexml21/
[4]http://evolution.voxeo.com/
[5]http://evolution.voxeo.com/

application. In addition, the Voxeo platform provides a fast and efficient support system, which includes forums, support tickets and very complete documentation. Finally, Voxeo also provides the VoiceXML interpreter and the ASR and TTS components required for the voice portal. Our system uses the Prophecy 9 Multi-Language VXML implementation, which has allowed to develop the application for its use in Spanish.

Regarding the Web servers, PHP and VXML files are used to implement each service provided by the voice portal, in addition to access MySQL databases containing the specific information. The different functionalities and corresponding files allow users to complete more than one action in each call.

3.2 Providing a personalized service

The information provided by the voice portal can be classified into static and dynamic information. Static information has been collected from web pages, stored and classified in the databases of the application. Each time users request this information, the system accesses the database and returns this information encapsulated into a VoiceXML file. Examples of this type of information include the history of the city, access information, or contact information of hotels and main offices in the city. Dynamic information includes local news and events, weather information, surveys, and entertainment guides for cinemas and theaters. This information is automatically updated in the application by means of a PHP-based procedure that access the required web pages, carries out a syntax processing of this information, and stores the updated information the database. Each time the user requires this type of information, the system only has to access the database and return it.

All the application dialogs use voice grammars and DTMF, which means that users can access menus by speech or using the phone keys, making the application more accessible. Grammars are encoded following the XML standard format defined by the W3C and, therefore, supported by any VoiceXML platform. In addition, this format allows greater flexibility in terms of grammar structure and debugging. Static grammars deal with information that does not vary over time, including a small number of options to choose from. These grammars are coded in the same file where they are used. Dynamic grammars include information that varies with time and often deal with large amounts of data. These grammars are automatically created using PHP files to manage their contents (creation, obtain contents, modify and update information).

One of the main aspects in the development of the voice portal is the introduction of different functionalities that allow the adaptation of the system taking into account the current state of the dialog as long as the characteristics of each user. On the one hand, we captured the different VoiceXML events considering different messages for the main events: *noinput* (the user does not answer in a certain time interval or it was not sensed by the recognizer), *nomatch* (the input did not match the recognition grammar or was misrecognized) and *help* (the user explicitly asks for help).

Additionally, VoiceXML provides the *property* element to establish the value of a property that affects the behavior of the platform. These properties may be defined for the whole application, for the document, or for a certain element in a form or menu. For the implementation of the voice portal we have tuned the following properties: *Confidencelevel*, *Sensitivity*, *Documentfetchhint* y *Grammarfetchhint*. The property *Confidencelevel* allows to adjust the accuracy of recognition in order to be accepted. The *Sensitivity* allows to adjust the sensitivity of the recognizer. The properties *Documentfetchhint* and *Grammarfetchhint* allow to adjust the usage of the cache to make searches either safer or faster. In our voice portal all these properties are adjusted dynamically depending on the analysis of the generated events and the history of the dialog.

On the other hand, the voice portal adapts to specific characteristics of the users. It can be used in different languages (Spanish, English, French, German and Italian), as the speech recognition is tuned using the property *xml:lang* and the prompts have been stored in the different languages using different encodings in the database. Also the voice portal stores the telephone numbers from which the users access the system in order to compute which are the most frequent queries and predict the user preferences which can be directly accessed by the user in the next calls in order to safe time and provide a better user experience.

4. Multimodal conversational interfaces for Android mobile devices

Our second proposal is focused on the development of multimodal conversational agents for mobile devices operating with the Android OS (McTear and Callejas, 2013). The Google Speech API is integrated to include the speech recognition functionality in a multimodal conversational agent. The development of multimodal systems involves user inputs through two or more combined modes, which usually complement spoken interaction by also adding the possibility of textual and tactile inputs provided using physical or virtual keyboards and the screen. In our contribution, we also model the context of the interaction as an additional valuable information source to be considered in the fusion process. We propose the acquisition of external context by means of the use of sensors currently supported by Android devices. The Android sensor framework (*android.hardware* package) allows to access these sensors and acquire raw sensor data.

Using the Google Speech API (package *android.speech*), speech recognition can be carried out by means on a *RecognizerIntent*, or by creating an instance of *SpeechRecognizer*. The former starts the intent and process its results to complete the recognition, providing feedback to the user to inform that the ASR is ready or there were errors during the recognition process. The latter provides developers with different notifications of recognition related events, thus allowing a more fine-grained processing of the speech recognition process. In both cases, the results are presented in the form of an N-best list with confidence scores.

The dialog manager of the system is based on a statistical methodology (Griol et al., 2014). The visual structure of the user interface (UI) is defined by means of layouts, which are defined by declaring UI elements in XML or instantiating layouts elements at runtime. Finally, we propose the use of the Google TTS API to include the text-to-speech functionality. The *android.speech.tts* package includes the classes and interfaces required to integrate text-to-speech synthesis in an Android application.

The text-to-speech functionality has been available on Android devices since Android 1.6 (API Level 4). To listen a sample of the included TTS speech synthesizer, once located in the settings menu of the device, the option Settings of Speech Synthesis must be selected in the menu Speech Input and Output. This menu allows selecting the TTS engine, language, and speed used to read a text (from very low to very fast). The *android.speech.tts* package includes the classes and interfaces required to integrate text-to-speech synthesis in an Android application. They allow the initialization of the TTS engine, a callback to return speech data synthesized by a TTS engine, and control the events related to completing and starting the synthesis of an utterance, among other functionalities.

4.1 A multimodal entertainment App

We have developed a practical multimodal entertainment App for Android-based mobile devices. Users can interact with the developed application by means of their speech or using the screen and virtual keyboard. The App allows to access the latest local and international news, the weather forecast for the coming days and current place, the results of different lottery contests and events, and the movie listings and upcoming movies. The information is provided in Spanish. Users can also personalize the information that is provided by the App by means of specifying their preferences when accessing the different services.

In order to provide the functionalities described, the system engages in a dialog with the user to retrieve different pieces of information that are complemented with the context-awareness capabilities of the system. This way, the system response is adapted taking into account the specific preferences and suggestions selected by the users, as well as to the context in which the interaction takes place. The statistical models for the user's intention recognizer and dialog management modules were learned using a corpus acquired by means of an automatic dialog generation technique previously developed (Griol et al., 2011).

Figure 2 shows the main screen of the application, the screen that users can employ in order to personalize the services provided by the App, and an example of the information provided for a specific movie.

Figure 2: Set of functionalities provided by the developed App (main screen, personalized user profiles, and movies listing).

Figure 3 shows different examples corresponding to the access of the latest news, the results of a specific lottery contest for a given day, and the weather forecast corresponding to the date provided by the user.

Figure 3: Set of functionalities provided by the developed App (latest news, lottery contests, and weather forecast).

The developed multimodal App also uses Google Maps, Google Directions and Google Places. Google Maps Android API makes it possible to show an interactive map in response to a certain query. It is possible to add

markers or zoom to a particular area, also to include images such as icons, highlighted areas and routes. Google Directions is a service that computes routes to reach a certain spot walking, on public transport or bicycle, and it is possible to specify the origin and destination as well as certain intermediate spots. Google Places shows detailed information about sites corresponding to number of categories currently including 80 million commerces and other interesting sites. Each of them include information verified by the owners and moderated contributors. The application also employs the *android.speech* libraries described in the previous section.

5. Conclusions

In this paper, we propose two techniques for developing conversational agents using well-known standards and operative systems like VoiceXML or Android, and also including a statistical dialog manager automatically learned from a dialog corpus. The main objective of our work is to reduce the gap between academic and industry perspectives and take the best of both methodologies. On the one hand, the effort that is required for the definition of optimal dialog strategies is reduced. On the other, VoiceXML and Android-based implementations makes it possible to benefit from the advantages of using the different devices and platforms that are already available to simplify the development of conversational agents. The paper also describes two systems developed using the described techniques and respectively providing spoken or multimodal access to users' adapted information.

We have described a practical application of the combination of conversational agents and hand-held Android mobile devices to develop context-aware multimodal applications. The developed Android conversational agent uses geographical context and user profiles to provide adapted entertainment information and services to its users. To develop this system we have defined the complete requirements for the task and developed the different modules, and the necessary information sources to be incorporated in the user profiles.

We are currently undergoing the next phases in the deployment of the application. We want to include additional functionalities to facilitate the location of points of interest related to the provided user preferences, and to also consider additional information sources related to the users' emotional state and personality for a more detailed adaptation of the services that are provided. With the results of these activities, we will optimize the system, and make it available in Google Play.

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Review of the Main Security Problems with Multi-Agent Systems used in E-commerce Applications

Alfonso González Briones[a], Pablo Chamoso [b] and Alberto López Barriuso [a]

[a] University of Salamanca, BISITE Research Group, Edificio I+D+I, 37007 Salamanca, Spain

[b] Catholic University of Daegu, Faculty of Information Technology, Daegu, South Korea

alfonsogb@usal.es

KEYWORD

Security problems; Multi-agent systems; E-commerce applications

ABSTRACT

The ability to connect to the Internet from a wide variety of devices such as smart phones, IoT devices and desktops at anytime and anywhere, produces a large number of e-commerce transactions, such as purchases of clothes, ticket entrances for performances, or banking operations. The increasing number of these transactions has also created an increase in the number of threats and attacks by third parties to access user data banks. It is important to control the access procedure to user data so that the number of threats does not continue to grow. To do so, it is necessary to prevent unauthorized access, theft and fraud in electronic commerce, which is required to ensure the safety of these transactions. Many e-commerce platforms are developed through multi-agent-systems because they include certain advantages to control the product, resource management, task distribution, etc. However, there are a number of threats that can jeopardize the safety of the agents that make up the system. These issues must be taken into account in the development of these multi-agent systems. However, existing methods of development do not cover in depth the issue of security. It is necessary to present and classify the potential security flaws of multi-agent systems. Therefore, the present research presents a review of the main vulnerabilities that occur in multi-agent systems responsible for managing e-commerce applications, as well as the proposed solutions to the major security problems on these platform systems. The main conclusions provided by this research is the need to optimize security measures and enhance the different security solutions applied in e-commerce applications in order to prevent identity theft, access to private data, access control, etc. It is therefore essential to continue to develop the security methods employed in applications such as e-commerce as different types of attacks and threats continue to evolve.

1. Introduction

E-commerce is an economy of buying and selling products or services over the Internet by using electronic technologies such as the Internet and / or other computer networks. The number of e-commerce transactions has grown dramatically since its inception due to the use of Internet. Electronic commerce does not only focus on the buying and selling of goods or services between customers and companies; there is a considerably high percentage of sales from virtual items such as access to virtual "premium" content websites. The advantages provided by the technology used make it possible to access these applications

from anywhere and have the same products and services, thus eliminating the barriers of time and location. This provides a global scope allowing the sale and purchase of goods and services from anywhere, while at the same time allowing the manufacturer and the seller to reduce the advertising costs required to reach a large number of customers. However, there has also been an increase in the existence of threats and attempts to exploite security flaws (Bouch, 2011).

There are different safety aspects related to e-commerce applications that should be considered. Thus, we can define a series of objectives that e-commerce platform must meet in order to be considered safe, such as:

- **Confidentiality (Lokhande, 2013)**¡Error! No se encuentra el origen de la referencia.: protection of stored data from unauthorized users.
- **Identification and authentication (Lokhande, 2013):** identification refers to users who reveal their identity in order to access the system. Authentication refers to a response that users provide to prove their identity (usually a password or digital certificate).
- **Access control (Lokhande, 2013)**: determines the level of access to a user or group of users.
- **Non-repudiation (Lokhande, 2013)**: guarantee that users cannot deny being responsible for any action they have taken.
- **Data Integrity (Lokhande, 2013)**¡Error! No se encuentra el origen de la referencia.: refers to the completeness and accuracy of the data stored.

However, there are different intrinsic vulnerabilities to any electronic commerce simply due to being exposed to the general public via internet access. These vulnerabilities can be classified into three categories:

- **Denial of service**: attacks that are made with the purpose of rendering the site or resource unavailable to users who try to retrieve or access the site, whether temporarily or indefinitely. In the case of electronic commerce, such an attack would stop the transaction, resulting in customer loss during the period of time they are trying to access the resource-dependent services. Such attacks are more effective the greater the volume, so it is common practice to carry out these attacks in a distributed manner by different attackers or by a single attacker from multiple locations simultaneously, which is known as DDoS (Distributed Denial of Service).
- **Unauthorized access:** represents illegal access to systems, applications or data, generally taking advantage of any existing security vulnerability in the system. These accesses are quite dangerous since they can modify data, personal information, etc. that cannot be recovered. A common practice to carry out such attacks is the use of sniffers in public networks, keyloggers, or SQL injection.
- **Fraud and theft:** theft of data can be achieved through unauthorized access, but if such data are used to commit malicious actions, it is considered an act of fraud.

The main attacks that tend to focus most on e-commerce are web-based and include:

- **Fraudulent e-mail (Niranjanamurthy et Cluster, 2013):** Given the widespread acceptance and use of email as a communication medium, this type of attack is often used. It involves making the recipient believe the content is original, when in fact the e-mail contains links or attachments that include some type of malware. This is considered a type of social engineering.
- **Man in the middle attack:** an attack in which the attacker becomes involved in the communication between the server and the client, unknown to the customer, and is able to modify, delete, insert or otherwise modify at will any request the client makes to the server.
- **Malware:** Most attacks on e-commerce portals contain malicious software that is used to obtain information in an unauthorized manner, monitor user actions, etc. Such malicious software can be broken down and classified as: a virus, Trojans, adware, worms and back door. See the distribution shown in Figure 1.

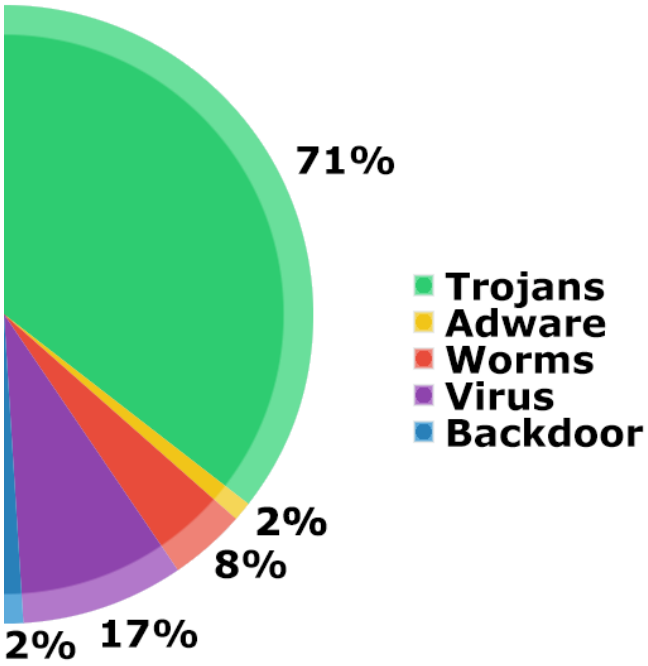

Figure 1: Percentage of use of different types of malware.

- **SQL injection:** the insertion by the attacker of a malicious SQL code that acts directly on the data to gain unauthorized access to the page, or to modify database information.
- **Pharming:** These attacks focus on DNS systems, interfering with search requests and redirecting the user to a site with a similar appearance but fraudulent content.
- **Snooping:** The concept of snooping responds to a series of techniques applied to ensure the safety of an existing DHCP infrastructure. The most common attacks apply to port scans, which are user ports that have been opened, which provides the attacker with unauthorized access to the user's computer. In this case, the attacker can gain valuable information like passwords or sessions (cookies).
- **Cross site scripting:** also known as XSS, allows attackers to inject malicious code or scripts on legitimate websites that request password verification, to redirect users to malicious sites, etc.
- **Cryptographic Attacks:** These attacks are very common and focus on guessing the password of a user (the victim in this case) by employing a tool that, for example, uses dictionaries or brute force methodologies (trying all possible combinations).

It is therefore imperative for electronic commerce systems based on multi-agent systems to be modelled and prepared to withstand these attacks. Therefore, the present study presents a multi-agent platform with agents that are responsible for identifying and responding to such attacks before they are carried out, thus avoiding the theft of information.

The remainder of the article is organized as follows: the second section presents security solutions proposed by multi-agent architectures; section 3 provides the conclusions obtained and discusses the progress in the safety of these architectures.

2. Security in multi-agent architectures used in e-commerce applications

This paper presents the security measures that should be taken in developing an e-commerce application and a multi-agent system that aims to facilitate logistics, supply, storage and transport of the electronic market application architecture. This point focuses on blocking the main security threats cited in the state of art.

2.1. Security in E-Commerce

The above security requirements in electronic commerce must be associated with methods to properly protect the systems that house them, protecting the information generated during an e-commerce transaction. These techniques focus on the transmission of data on the Internet, payment transactions and storage methods of such information.

2.1.1. SSL Security in Information Transmission

The transmission of private and confidential information over the Internet requires security techniques that encrypt data ensuring that e-commerce applications maintain data protection. One of the most widespread protocols in communicating information is SSL "Secure Sockets Layer". The SSL protocol is designed to allow data communication to be secure, whether sending or receiving the data, using an encryption key to prevent decoding by unauthorized persons. SSL incorporates features that make it possible to validate the integrity of the data transmitted. E-commerce applications show the use of this protocol in their web portals by adding the letter s to the URL, making the URL https:// instead of htpp:// . Additionally, the browser incorporates an indicative symbol, such as a key, a padlock and trusted icons. One of the errors that users often make is to rely on these applications sole for their use of HTTPS in the login process, even though all subsequent communication can be in plain text, still readable by the various "sniffers" network.

Therefore, all e-commerce applications must implement this protocol, requiring a certificate authority to issue the key and digital certificate. This way the virtual entities that offer the purchase of products or services online can require the real identification of customers and consumers. If such a certificate is not recognized by a certification authority, the previous layer to the application, which is the web browser itself, displays an alert to the user to confirm whether the user trusts the e-commerce application in cases where information must be sent.

2.1.2. Payment Security

The vast majority of e-commerce fraud is due to the fact that the seller does not authenticate clients in a way that is completely secure, through certificates, and then struggles to validate payment and ensure non-repudiation.

Making an online payment via credit card does not mean that the user is the actual owner of the bank card, resulting in identity theft. Attempts to avoid this include introducing additional security in payment gateways, which may include sending a code sent to the mobile terminal employed by the user during the registration process on the platform. This has also given rise to the use of payment intermediary entities such as Paypal, Amazon Payments, Google Wallet or Apple Pay. These entities produce a layer of

abstraction by which the buyer does not know the details of the seller and vice versa, allowing the seller to charge payment while the intermediary is in charge of the transaction.

2.1.3. Data Security Storage

One aspect to consider is the security of the server that stores all the information related to users, products, etc. It is important for the stored information to be encrypted. In the multi-agent systems that manage e-commerce applications there are agents that perform data encryption and decryption tasks. Strong passwords are needed to protect the access and control of the databases that store information, and they must be generated randomly through the alternating use of alphanumeric characters. This prevents the use of brute force methods to obtain the password. It is essential for the number of characters to be greater than 8 with no repeated characters. If the server is a contracted service, the hosting server should have the highest security measures available (firewall, intrusion detection systems, detection system malicious code).

For the identification process, the use of encryption mechanisms, usually based on SSL protocol is mandatory in order to avoid the data used for identification from being intercepted when transmitted through the internet.

2.2. Security in the development of multi-agent systems

One of the main problems encountered by developers of e-commerce applications in multi-agent systems is that they often do not have enough information security software. The security level of the system is separated primarily into the design and the implementation of design features (Mouratidis et al., 2003) (Viega et al., 2001). Factors to consider in this process include taking steps to ensure the confidentiality, integrity and availability of information within the system, which leads to the construction of a secure multi-agent system during the development phase (Stallings, 2008).

The main threats that occur in multi-agent systems are identified in the following research (Wong et al., 2000) (Cremonini et al., 1999) (Borselius et al. 2002) (Bijani et Robertson, 2014). These problems occur in the stages of authenticating and authorizing agents, according to Cremonini et al., 1999. Other problems that arise are related to the protection of agents by their hosts and vice versa, as described by Borselius et Alabama, 2002. Some very important problems to consider are those involving the verification of the information collected from the Internet by agents, unauthorized access to agents, unsecure communications among agents, attacks on the communication between agents, or attacks on the communication between agents and humans in conducting transactions produced by others (Jung et al. 2012).

There is no application that is 100% secure, but it is important to detect and prevent the vast majority of attacks from occurring in these systems. In the development of a robust multi-agent system it is imperative to take these assumptions and recovery mechanisms into account after an attack.

The proposed solutions, both at the host or agent level, are shown below. Creating two levels of security ensures that upon accessing the second level, there will be a new barrier.

Level	Requirements	Proposed solution
System	Protect the host system.	Create an agent that controls all communications and communication flows, and disrupts the
	Protect the agents that make up the system.	

	Isolate the main system in case of danger	communication processes if a vulnerability is detected, thus keeping agents out of danger. This agent must have an optimal security design, since an attack on this agent would open access to the agent level; therefore, it must also have security at the agent level, which requires us to implement a new barrier. This agent will send alerts to other agents to inform the team of developers of a breach in the security level of the system.
	Provide secure communications.	
	Provide security operations performed by users	
	Communicate access to the agent level	
Agent	Identify sources of threats and danger	Introduce an identification code composed of a unique identifier. This code is included at the beginning of the headers in the communication processes between agents, or with the user.
	Prevent unauthorized access	
	Provide secure communications.	

Table 1: Solutions proposed security level multi-agent applications .

3. Conclusions

The main conclusions obtained by performing this work are in the form of a compilation of the main vulnerabilities and security measures in e-commerce applications, and the multi-agents that provide support in managing e-commerce applications systems. We have focused on addressing all of the possible sources of danger that these applications can have.

The collected vulnerabilities are especially focused on the theft of information through communication processes, payment processing and access to storage servers.

The modelling of a multi-agent system must provide efficient solutions that ensure compliance with security requirements without hindering the functionality of the application. These security measures offer greater security and protection. For the multi-agent system to provide a secure electronic commerce transaction, systems must meet Internet security requirements (confidentiality, authentication, integrity and non-repudiation). Any commercial transaction performed on the internet involves a certain risk, not only when providing personal and banking data for online purchases, but when authorizing online payments.

To meet the safety requirements mentioned e-commerce platforms must have mechanisms to protect information systems involved in online shopping processes. These mechanisms include two aspects, one intended for data transmission via the internet (SSL security) and the other oriented to data storage (Data Security).

4. Discussion

The main points of discussion for this work focus on providing security measures to ensure the security of user data in these applications. It is important to develop the security measures employed, as well as develop new measures.

However, as the development of security solutions continues to advance, experts in detecting security failures are also progressing in creating new system failures in order to access information.

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The Algorithm of the Snail: An Example to Grasp the Window of Opportunity to Boost Big Data

Jean Louis Monino[a] and Soraya Sedkaoui [b]

[a] Department of Economics, TRIS Laboratory, University of Montpellier France

[b]Department of Economics, University of Khemis Miliana Algeria/ TRIS Laboratory

monino@wanadoo.fr, soraya.sedkaoui@gmail.com

KEYWORD

Algorithm of the snail; Localization; Big data; Real time analysis

ABSTRACT

This work explores a new application which can effectively meet different localization accuracy requirements of most data location services studying the interactions between customers and suppliers. It helps to have the status or position of what is sought with respect to an address that summarizes thus a reference point which is the point of research. This proposal explains what snail algorithm is and how we can benefit from using it for the localization of information for business applications especially in the field of analytics. A business application using our algorithm has been developed by the Autour.com company (located in the department of Herault, Montpellier city) to illustrate its feasibility and availability. The results show that our algorithm can improve the localization accuracy.

1. Introduction

The age of big data is now coming. But the traditional data analytics may not be able to handle such large quantities of data. Therefore, there is a need to be able to recognize the appropriate analytics technique to use for the data and business problem. However, these companies are interested in applications that enable a range of data (coordinates) relative to a reference point, for example, the situation of a manufacturer to offer a good or a service in relation to applicant of this type of good or service. The challenge identified is to organize the flow of data from their sources, process them and make them available to different users, but as applicant information is needed still more. To locate the closest ads you need a fast and efficient way which allows for the status or position of what is sought with respect to an address that sums up to a reference point which is the point of research. So it is more than necessary to plan and implement modern applications with sufficient details and observations covering the points between.

This work explores a new application which can effectively meet different localization accuracy requirements of most data location services studying the interactions between customers and suppliers. It helps to have the status or position of what is sought with respect to an address that summarizes thus a reference point which is the point of research. This proposal explains what snail algorithm is and how we can benefit from using it for the localization of information for business applications especially in the

field of analytics. To show the importance of this algorithm we will use the department of Herault (Montpellier-France), although specifically, through the company "Autour.com" that handles every day huge files of its customers. The application of our algorithm by this company shows that people living next door (applicants and suppliers) can be put into connection; is a kind of creation of a district social networking. The remainder of this paper is organized as follows. The authors in section 2 discuss an integrative literature review on the localization algorithms. Our algorithm is explained in section 3. Finally, section 4 concludes this paper.

2. Literature Review

For several years, localization issues become more and more a challenging subject to our dynamic era. For this, a wide range of studies was per-formed to characterize the performance of these systems in different environments. Going from presentation of research capabilities of an interest point to the positioning of the user and its true location on the map. That presents an overview of tools and documentation to better understand the city either in whole, or in its environment through its districts.

Before starting the description of this algorithm, it's necessary to identify the context in which the idea arose. Therefore may be mentioned three essential issues (points)

- The first is the arrival of so-called Petabyte age or "Big data" characterized by the 3Vs: Volume, Variety and Velocity and its challenge that lies in the way of how analysis and combine this amount of data to extract value. The area of big data has compelled the community to pay serious attention to development of algorithms and applications for intelligent data analysis.
- The second issue is related to Fibonacci numbers. Fibonacci applied his sequence to a problem involving the breeding of rabbits, and he mapped out the family tree of a group of rabbits that initially started with only two members.

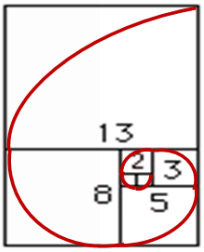


Figure 1: Fibonacci spiral.

For us the most important of these, is the Fibonacci spiral which drawn starting the corner of the first rectangle, all the way to the corner of the rectangle of the side.

• The last point on which the idea of the algorithm is based can be bounded to the shell of the snail. So, it's not about its speed but rather the form, because of this it's called "algorithm of the snail".

The benefits of grid mapping are well known as the readability of the gridded map enables detailed analysis of intra-urban dynamics. If these benefits are common to all types of grid, two families can be distinguished: the grid resulting from a breakdown of data collected in any zoning (zonal data transfer) and the one resulting from the automatic addressing (transfer point data). The interpretation of aerial pho-

tographs from 1986, based on a grid of 125 m side, allowed Dayre and Mazurek (1988) to analyze the land use on the urban district Montpellier. This method offers many possibilities for automated processing of data, especially regarding the dynamics of built areas.

As part of a mapping grid, Lajoie and Langlois (1998) studied the disintegration of zonal variables, returning on the assumption of the spatial distribution of populations. The aim is to approach differentiated rules disaggregation variables by merging morphological nature of information plans, topological and environmental. Modeling of Antoni (2001) appears as an interesting tool to better understand urban sprawl and to simulate various useful development scenarios for development. The methodological approach presented by the author combines three steps. Each step corresponds to a model:

- The first quantifies the spreading,
- The second locates it
- The third differentiates it.

The three stages are associated with a spatiotemporal database that uses the grid to store all the necessary information in a single GIS layer.

In recent years, many researchers have proposed solutions to the positioning system implementation based on different technologies, such as systems based on GPS (Zhou, and Shi, 2008), the ultrasonic sensor (Addlesee et al, 2001), video cameras (Hoey et al,2006) and the systems based on radio frequency identification. These different approaches and technologies offer different ways to address the problem of locating and monitoring in real time. Localization is a broad and active research area, and a diverse set of solutions have been proposed. Significant research has been done using location data of mobile users. Some were fundamental research such as Song et al.'s (2010) work on identifying patterns of human mobility. Some focused on building new services that may have great public or business potentials (Zhang et al, 2010), such as modeling city living neighborhood (Cranshaw et al, 2012) and recommending friends and locations (Zheng et al, 2011).

Our work also benefited from excellent works analyzing and making use of INSEE on the signs of the Toulouse Diversity (2008), but this study do not focus on the usual zoning (town, district) but on a continuous territorial coverage formed tiles. For us the interesting applications are those that contain devices allowing the user to enjoy all the benefits of positioning and location services. Recently, the realization of a location model involves:

- The availability of an infrastructure containing all the data needed to ac-quire the necessary information.
- Determining a reference against the position to locate.
- The treatment of acquired data and extracting the necessary information to determine position.

Our algorithm is inspired by related work in geo-localization and big data analytics. It offers solutions that can be deployed to large population and used for mobile proximity marketing or social networking services or why not in the field of health. The details of this method are discussed in the previous sections.

3. Presentation of "the snail's algorithm"

3.1. Description

In this section we will present our localization algorithm, which consists of three phases:

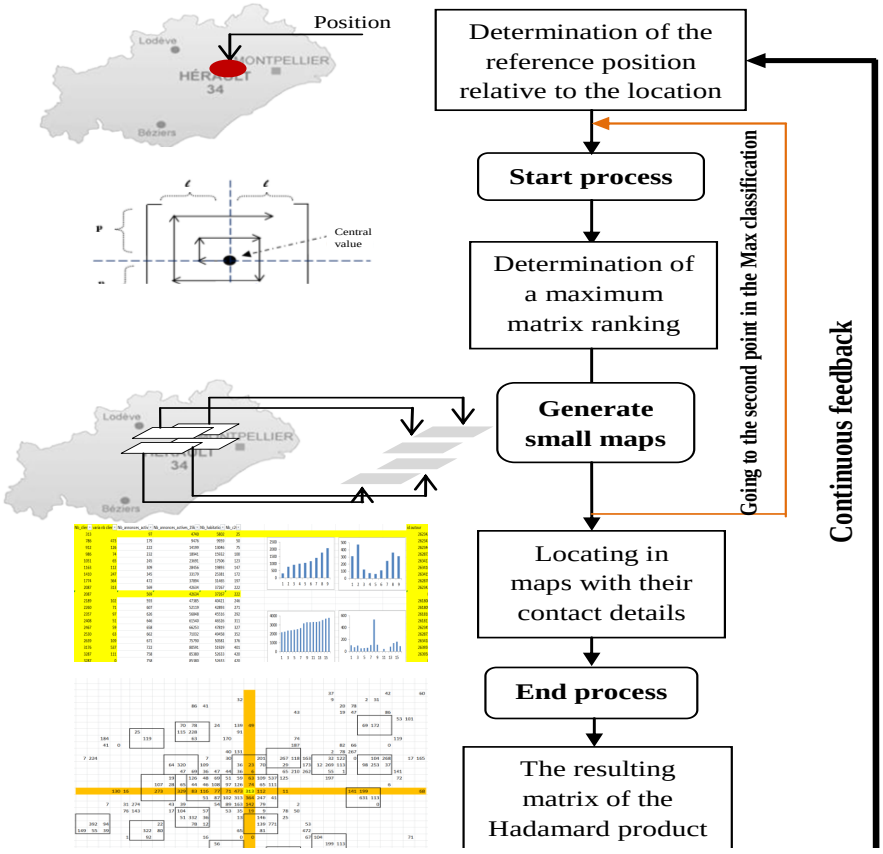


Figure 2: Snail algorithm process.

We are interested to the presentation of a point defined by a position on a plan or map that could be helpful to the user. And the most effective way for a retail designer map is to define the geographic coordinates in the coordinate system (X,Y). It should be noted that the situation of a point is expressed as coordinates in a reference geo-localization system in terms of territorial coverage and the quality of resulting data.

3.2. Data processing

First we must cut out the Local Area Map 3 km away into square (piece).

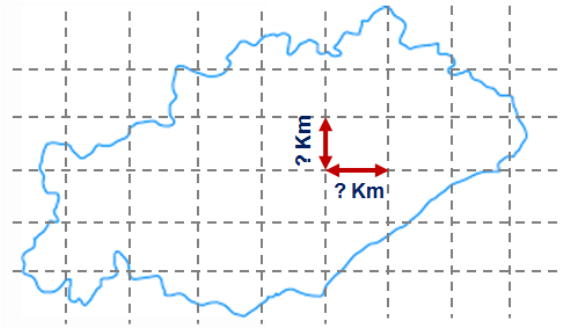


Figure 3: Cutting out the map of Herault.

Then, to start searching it must first define the position. We start from the point which is the central value of the indicated positions, around which rotates on a radius of 3 km range.

The first step is to determine a ranking of maximum matrix, it is not necessary that the starting point or the central value is a Max card, and then determine a point (x: for example) than 1000 people, in a square of 200 m on both sides, which makes a first square matrix, and each time there is a superimposed array. All that to find the median matrix " M2p +1.2 p +1".

In which the target region (map Herault department) is split into small grids. On a central point (max) removing the map is going to have a “mille feuille” on geo-location we will find small maps localized that bring together applicants and suppliers.

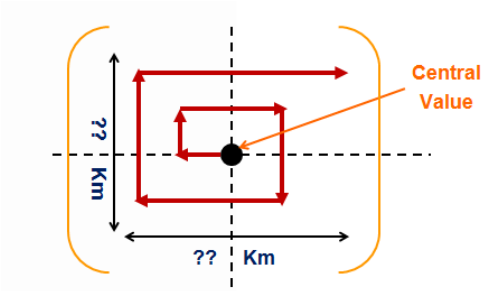


Figure 4: Graphic presentation of the snail algorithm.

Then, the same operation each time passing the second point in the ranking of Maxs, but there will be some cases where the second matrix in the ranking of maximum points will be included in the first round. It should be noted that used the Hadamard matrix product, which represents a binary operation for two matrices of the same dimensions, combines another matrix of the same size where each coefficient is the term by term product of the two matrices. Just like the addition, the Hadamard product is defined only for the matrices of the same dimensions, and the product of two matrices A and B is defined by:

$$A*B = [a_{i,j}*b_{i,j}] = \begin{pmatrix} a_{1,1}*b_{1,1} & a_{1.2}*b_{1,2} & \ldots\ldots\ldots & a_{1,j}*b_{1,j} \\ a_{2,1}*b_{2,1} & a_{2.2}*b_{2,2} & \ldots\ldots\ldots & a_{2,j}*b_{2,j} \\ \cdot & \cdot & \ldots\ldots\ldots & \cdot \\ \cdot & \cdot & \ldots\ldots\ldots & \cdot \\ \cdot & \cdot & \ldots\ldots\ldots & \cdot \\ a_{i,1}*b_{i,1} & a_{i.2}*b_{i,2} & \ldots\ldots\ldots & a_{i,j}*b_{i,j} \end{pmatrix}$$

3.3. Data processing

The previous phase will generate little maps that facilitate the research. So, instead of working on full maps we can have small maps. These small cards will be identified quickly with their contact information. But every time we finish analyzing a sub card the algorithm is spirit to pit the matrix (we replace by zero). The resulting matrix of the Hadamard product between two same-sized matrices contains the result of a multiplication element by element. The navigation data are determined by setting a plane tangent to a fixed point on the map of Herault. This method is a technique for mapping a set of points in a multidimensional space, using a matrix of distances calculated in the departure space. Items placed on the borders of central calculate their coordinates iteratively until it converges to the Max of Maxs, and in this state there is performed the rotation around this point to calculate the product. That is to say, one seeks the Max throne the matrix "A" and removes the matrix "B".

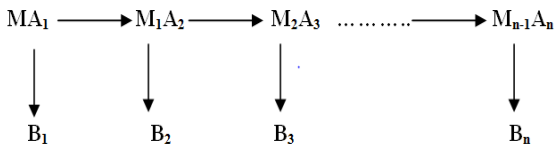


Figure 5: Transition from the first to the last matrix.

Such as:

A1 is the first matrix with enthroned extraction B1, An is the first matrix with enthroned extraction Bn. Note that "An" that represents the last enthroned matrix is a zero matrix because it always replaces the zero value as follows:

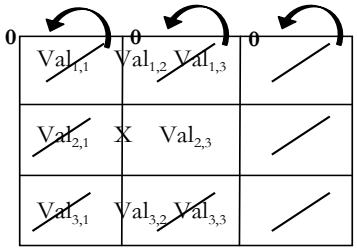


Figure 6: the last matrix form.

The great quest data is primarily aimed at understanding what customers' need, what works, what could be improved. Concretely it is to quickly collect raw data, explore and analyze, translate data into actionable information, and therefore globally to reduce the time between the discovery of relevant facts, the characterization of business opportunity and the outbreak of shares. The use of this algorithm reduces the information and develops a methodology based on the interaction data from several sources to provide reliable positioning and determining a navigation method. The Big data is becoming a tool to help companies explore new territories (Monino et al, 2014). For these gold mines can reveal intrinsic value which was not necessarily expected to start the analysis.

This algorithm was applied by the company "Autour.com" (see appendix). Know and meet their neighbors, helping each other, exchanging objects or services or to make some money by renting or selling property is what Autour.com offers to its members through use of algorithm.

But it is also an opportunity to promote a different type of consumption, sustainable and for social cohesion, focusing on rental, lending or exchange of goods or services. Autour.com today has over 15,000 profiles mainly in Montpellier but also throughout France as the national network is now

With using and application of the algorithm autour.com try to help their client to:

- Know and meet they neighbors
- Exchanging objects or services etc

In general this enterprise aims to mixing ads or mails for individuals, local shops, public institution and associations to better know the resources of their neighborhood (environment) the aim is to create a local social network to make a person who leaves next in contact

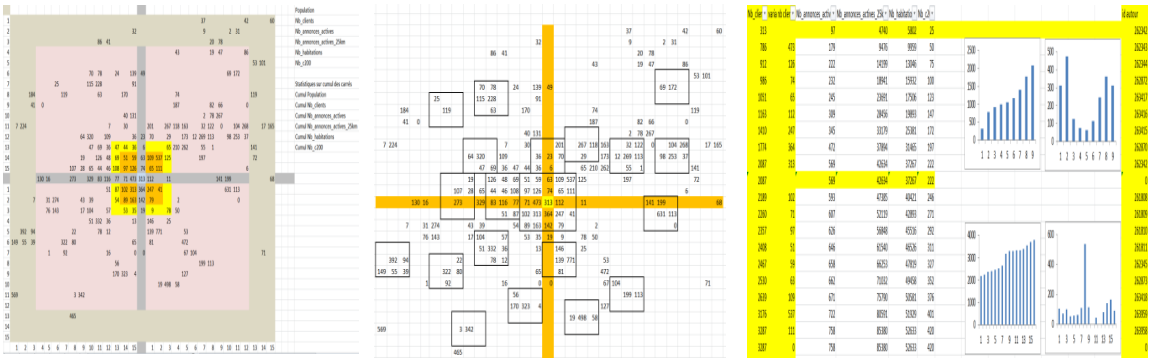
4. Conclusion

The algorithm just presented is only one example enabling companies to monetize their data. In this paper, we open a new application area for people living in the same area or district. This research provides a possible solution to the growing quantity of data. This work has immediate business implications with autour.com. The results of the application of our algorithm with this company show that our algorithm has a better performance, but it needs to be developed, with integration of many other operations.

This algorithm is a means that enables the company to better monetize Big data is a matter of understanding the model it wants to follow to define its way into the big data. For that currently have data on its customers or in the market is a competitive advantage. Finally, we wish that we can develop our algorithm and extend its advantages, in the field of health for example, recently we had a contact with a startup company in Morocco in order to develop this method in the field of health. This small company wants to create "moving parts" for kidney dialysis, with the integration of all necessary the tools and techniques in semi-trailers and go to the patient.

5. Appendices

Sample Application with “Autour.com”



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