Intelligent Social Networks

Miguel Doctor
Departamento de Automática,
Universidad de Alcalá
mdoctor@aut.uah.es

Ángel Moreno
Departamento de Automática,
Universidad de Alcalá
angel@aut.uah.es

Pablo Muñoz
Departamento de Automática,
Universidad de Alcalá
pmunoz@aut.uah.es

Daniel Díaz
Departamento de Automática,
Universidad de Alcalá
ddiaz@aut.uah.es

María Dolores R-Moreno
Departamento de Automática,
Universidad de Alcalá
mdolores@aut.uah.es

ABSTRACT

Personal homepages, blogs or virtual communities have contributed to the birth of the Social Networks. The success of these platforms will continue to increase while they are able to offer tools and services to improve users' social relationships. The rapid evolution of social networks, the growing business opportunities and the possibility to apply new techniques to a relatively unexplored domain, have awakened strong interest among researchers. The potential benefits have generated the need to be the first one to achieve an enough level of autonomy to provide customized services for both users and product providers.

But the true revolution will arrive when social networks become "smart". To build these new intelligent systems we propose to use Artificial Intelligence techniques, more concretely *plan recognition*. In this paper we propose an architecture able to recognize the users intentions from partial observations of their actions. In addition, we present three scenarios where our system can be useful: Online commercial intentions, adaptive user interfaces and identity theft and extortion detection.

Keywords

Social Networks, Plan Recognition, Online-Commercial Intention, custom services, extortion detection

1. INTRODUCTION

Social networks have came to stay with us, and the success of these platforms will increase as much as they are able to answer user's needs, that is, the ability to facilitate and offer tools to improve their social relationships. The rapid evolution of social networks and the growing business opportunities around them have awakened the interest of many people. The potential benefits have generated the need to be the first to achieve a level of autonomy enough to provide customized and profitable services for both users and product providers. These future systems will require increasingly capable functionalities to achieve the goals they are designed for. Nowadays, these capabilities focus on product improvement, trying to evolve the existing techniques to get faster, more visually attractive, or more usable and accessible systems. But the true revolution will arrive with social networks becoming intelligent. Evolution should be driven to achieve intelligent environments offering adaptive behaviors depending on user's intentions.

Although a revolutionary method of intelligent communication with other persons, even machines, is in the scope of our sight, is the application of Artificial Intelligence (AI) techniques to solve current problems what is now focusing our attention. In traditional systems, commercial and security issues are covered by common techniques used in general purpose web platforms [13]. Often, these systems do not ensure the adequate use of the network (as we can see from time to time news about bulling and extortion cases related to them). The online commercial tendencies are less critical (in personal security terms) but more interesting for private companies that see social networks as a huge shop-window for their products [9]. Both issues are pointed out in this paper, where it is shown how AI tools can be very useful to improve the performance of such platforms in these and many other similar topics.

This paper presents how modern plan recognition techniques [22, 20] allow for the development of a complete (intelligent) suite of tools fully embeddable in current and future social network platforms. Plan recognition or activity recognition aims to recognize the actions and goals of one or more agents from a series of partially observations on the agents' actions and the environmental conditions. These techniques analyze a partial observed plan and generate a set of goals compatibles with these actions, thus we can know the intentions of the agent before it accomplishes them. In addition, bridges are built with others AI fields showing how those can be used to complement the plan recognizer suggested here to obtain even more intelligent and useful tools.

The structure of the paper is as follows. Section 2 provides an overview of social networks and the role they play in the society. Then, the plan recognition research area and its role inside AI techniques is described. Next comes a description of several plan recognition implementations and application areas where they have been successfully integrated. Section 4 shows simple examples that illustrate the behavior of the approach adopted and three scenarios are studied. Finally, some conclusions and future works are outlined.

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2. SOCIAL NETWORKS

Informally, we can define a social network as a group of individuals that pursue meeting other people for multiple motivations.

More formally, we can see a social network [25] as a (graph) structure that is made up by individuals that "act" and are connected by one or more specific types of relationships such as friendship, business, beliefs or politics. Social network theory is the science interested in studying the many ways in which such individuals interrelate and communicate via the different social networking (real and online) platforms.

The most important features of social networking are ubiquitous connection and profile personalization. The former enables users to create one or more personal homepages, and easily add personal information and preferences such as location or hobbies and share them. The latter refers to the ability of adding friends or acquaintances in the user's personal profile.

2.1 Web Patterns and Social Ecosystems

We have already found simpler forms of social organizations on the Web (or Web communities) before the eruption of social networks. A web community can be simply seen as a collection of web pages that deal with a common topic, presumably created by people with common interests.

There is a natural ontology that sociological scientists use to understand and contextualize all those forms of social patterns: *social ecosystems*. They can be referred as the agglutination and interaction of different web communities (such as social networks or blogs). It is broadly accepted that current and prevailing social ecosystem are mainly shaped and populated by the social networks, or more concretely, by a synergy between classical blogs with social networks. Social ecosystems are dynamic, open and inclusive of both public and private organizations, and remain independent of geography and language.

In this context, we can make a classification [23] of the different flavors of web communities that may form a social ecosystem attending to the following patterns:

- Horizontal social patterns: they typically represent public places where participants have an equal status (i.e. friendship).

- Vertical social patterns: they are commonly focused on common interests (i.e. common hobbies).

2.2 Types of Social Networks

In order to understand what types of social networks exist on the Web, it is important to look at all facets of how people interact online with each other. The term "social networking" is generally related to the largest and most popular "general use" social networks present on the Web today. We can break down the existing social networks into the following major categories.

- *General purpose or friend-based*: General social networks do not focus on a particular topic.

- *Informational*: The objetive of these networks is to offer answers to daily challenges.

- *Professional*: Professional social networks are used to find new oportunities within your career or industry.

- *Educational*: Educational networks are platforms to enhance the student's experience.

- *Hobbies*: These networks are a meeting point to people with the same likes.

- *Academic*: Social networks are an obvious benefit for academic researchers offering an update source of knowledge.

- *News*: Another popular type of social network is the one related to the publishing of "community content".

2.3 Applications

Many research works consider the Web in terms of *social network theory* (i.e. links or relations between sites) or fractals (i.e. as a compound of sub-graphs organized through natural hierarchies) to better understand and predict its evolution, by using methods and tools of *social network analysis*. Studying the web as a network reveals the sociology of its content creation, and helps to discover new and more effective algorithms for information retrieval (i.e. in Web search) [17].

One of the defining elements of social network theory that differentiates it from other sociological sciences is the importance it gives to the relationships between the nodes, as opposed to the attributes of the nodes themselves. While this is useful to explain many social phenomena, it is also criticized for, apparently, making the individual less able to shape their own destiny, "putting the emphasis on a person's place in the network as opposed to their own attributes". However, this particular idea could be turned and exploited to, for instance, reinforce our future professional success since the building of the network of contacts depends, to a great extent, on ourselves. Social network analysis has demonstrated that communication patterns surrounding us eventually determine our opportunities, social influence, wealth and the way we learn and interrelate.

Social networks are excellent platforms to apply AI techniques. As social networks are growing bigger and more influential, and more people use them to share more information, finding what people prefer to read inside of them will became soon not trivial at all. AI techniques could be really helpful in organizing such information and bringing the most relevant pieces to users in a completely personalized way.

Next section presents different AI techniques, which may facilitate us the creation and infusion of autonomous services within the social networks, with the aim of supporting and helping users in this context.

3. AI TECHNIQUES

In the last two decades the advances in computer science have been translated into tools and techniques to automate processes that until then where performed and supervised by humans. Without any doubt, Artificial Intelligence (AI) is one of the computer science areas with more expectation created in the last years. AI is a scientific discipline which tries to operationalise human intellectual and cognitive capabilities in order to make them available through information processing systems. Within AI, one of the problem solving techniques that has gained some relevance are: planning and scheduling.

AI Planning systems select an order set of activities in order to achieve one or more goals and satisfy a set of domain constraints. For most part, planning research has focused on finding a feasible chain of actions that accomplishes one or more goals. Examples of planning domains can be real time robot planning, travel planning, planning for information gathering and Database Queries, satellite planning operations and financial planning, among others. AI Scheduling is in charge of assigning resources and time for activities, obeying the temporal restrictions of activities and the capacity limitations of shared resources. Examples of scheduling domains include classical job-shop, manufacturing and transportation scheduling.

3.1 Introduction to plan recognition

Plan recognition (or activity recognition) is the inverse operation of AI Planning [8]. It aims to recognize the actions and goals of one or more agents from a series of partially observations on the agents' actions and the environmental conditions. This kind of reasoning is sometimes called "abduction", and the conclusions "explanations". This technique analyzes a partial observed plan and generates a set of goals compatibles with these actions, thus we can know the intentions of the agent before it accomplishes them. We can distinguish the following elements in a plan recognition process.

- Actions: are atomic operations performed by the agents which could produce effects on the environment and to change the domain status.
- Goals: are a set of environment conditions that one (or more) agents desire to achieve. Agents direct their actions to satisfy these conditions.
- Plans: are sequences of actions the agents perform to accomplish their goals from an initial environment state.

Some approaches [3] consider actions as events driven by users through the user interface, while tasks are slices of work that agents perform in the environment composing an execution plan. Each task can be obtained as a result of the execution of one action or sequence of actions.

A plan recognition system requires, at least, two agents involved, that is:

- An actor executing actions.
- An observer capable to infer the goals pursued by the actor analyzing his actions.

The relationship between an actor and an observer determines the kind of the plan recognition problem tackled by the system [24]. If the observer uses the information about actor's goals inferred to help him to achieve his objectives, the system is cooperative or intended. If the observer's goal is to avoid the accomplishment of actor's goals, then it's a competitive or obstructed system. And, at the end, a keyhole plan recognition system is one where actor's task doesn't need take account the observer, therefore the domain of the actor doesn't suffer changes from observer's actions. However, in this paper we don't discuss which approach is better to apply in the social networks context.

3.2 Plan recognition systems

Perhaps the most well-known of the early plan recognition systems are those of Robert Wilensky [26] and James Allen [2]. Wilensky's system was developed for story understanding, and the inference path served as an explanation for the occurrence of an action $A1$ in the story. Wilensky's system selected the shortest inference path connecting an observed action to an expected goal, without considering the current focus of attention in the story. Allen's system assumed that an agent had one of a small number of top-level goals which could be deduced from a single utterance. Another researchers propose plan recognition systems using hierarchical model of plans [16]. These systems have many limitations related to the needs for input the plans library that the systems were able to recognize.

Other approaches has extended it introducing an AND/OR graph as the plan library [18]. However, such algorithms suffer the problem of acquisition and hand-coding of a large plan library. In order to reduce the manual library plan generation and face more realistic scenarios, some authors have attempted to use machine learning techniques [5], pattern recognition using Bayesian inference [1], probabilistic reasoning, and partially observable Markov decision process (POMDP). However, other formalisms have been proposed for dealing with the uncertainty inherent in plan inference, most notably formal argumentation models and approaches based on probabilistic reasoning. Several researchers have captured plan recognition in a formal model of argumentation or abduction. Charniak and Goldman [6] constructed the first Bayesian plan inference system.

Some recent approaches have used techniques from classical planning into planning recognition [22, 20]. But classical planning assumes that actions are known and deterministic, and the world is always perfectly known. The only changes allowed to occur in the environment are due to the actions the agent decides to execute. Unfortunately, agents acting in the real world usually face a highly dynamic and partially observable environment. Consequently, their beliefs about the current state of the world are limited, uncertain or simply incorrect.

3.3 Research fields in plan recognition

Since the 1980s, this research field has captured the attention of several computer science communities due to its strength in providing personalized support for many different applications and its conection to many different fields of study such as medicine, human-computer interaction or sociology. Despite the importance and ubiquity of plan recognition techniques there has not been a great deal of computational research on this problem.

The research areas where plan recognition techniques have been applied getting interesting results are, for instance, *military simulations and defenses issues.* These fields have quickly evolved using different approaches such as incorporating learning machines with intelligent agents in the development of mental models of others agents. An example of this approach is a system capable to recognize executing plans of the combat aircrafts [4], providing the capability to customize the behavior of the aircraft in function of the actions taken by the opponent, trying to anticipate their movements thanks to this behavior recognition system. The intrusion detection process is a field wherein progress in plan recognition techniques have been well received [7]. The ability to identify hostile agents by their behavior is a powerful tool. This is possible because we don't search the actor responsible of the attack, but rather the actions composing the attack. Another insterest application field is the prevention and early identification of terrorist activities analyzing suspicious tasks and making hypotheses from other sources of information [12].

A different direction taken by plan recognition research is the development of intelligent user interfaces. The approaches in this topic is very diverse. Some researchers try to predict the user preferences using quantitative approaches to create the possible plans and plan recognition techniques to identify them [5] but the current trend is focused on identifying the user's behavior when he interacts with the system. Furthermore this capability to model users has attracted the interest of many commercial sectors producing significant results in domains suchs as prediction of costumer's commercial intentions [11], students modeling and human-computer interaction [24].

In general, plan recognition techniques have been applied in many diferent areas with diverse goals, getting good results. So what should we do? The answer is simple: we need to design architectures that allow us to implement intelligent features based on plan recognition techniques. This new point will automatically provide new functionalities, new security systems and customizable interfaces according to user's preferences and profiles .

4. INTELLIGENT SOCIAL NETWORKS

Nowadays, the importance of social networks is undeniable. The competition between different platforms such as Facebook, Twitter, Tuenti, etc) requires a big effort to guarantee efficiency, security and innovative ways to improve the social connections. The social networks platforms are systems as integrated in the society as mobile phones or email, and it is not wrong to start to assume they can become the main comunication channel in a few years (especially among younger users). Then, the next is, what aspects are key to determine the success or failed of one of these platforms? First we think a system is successful when it increases the number of users in its first years. When the growing number of people is estabilished, the platform should provide services that allow the users to find help for solving common problems they can encounter. There are many metrics to set the success of the network solution. One of them is the MetCalfe law [19]. It says that the value of a telecommunications network is proportional to the square of the number of connected users in the system so the social networks must progress to make the user's life easier with the aim of becoming more essential in their day to day routine.

The integration of AI techniques to solve current problems is a help to achieve intelligent environments offering adaptive behaviors depending on the user's intentions. In order to identify the required steps to contribute in the evolution of these systems, we list the current challenges that we propose to face using AI techniques:

- Customize and provide commercial solutions based on behavioral targeting.
- To creat a custom user interface to improve the user experience.
- To improve and design new systems to avoid identity fraud actions and extortions, especially among non-adults members.

4.1 Plan Recognizer and Social Networks

A plan recognition approach we consider appropriated to work as an engine of an intelligent social network is the GoalGraph architecture [10], but modified to fit the context requirements. GoalGraph is one of the few systems that integrate modern plan synthesis method, like GraphPlan [14], into plan recognition approaches. The systems based on this architecture provide the following advantages:

- These systems are faster recognizing agent's goals than others systems based on plan libraries.
- A plan recognition system based in GraphPlan doesn't need a hand-coding plan library to predict the agent's goal, so it saves work compared to others systems.
- The dynamically built graph provides agent's candidate goals, so the plans that it can recognize are not limited. This problem occurs with plan library systems (i.e. hierarchical systems) where introducing new plans in the recognizer is a very cost process.
- This system is domain independent so it can be used in many applications.

However there are also some disadvantages. They require a fully observable domain and all the actor's actions relevant to get the set of goals, but it does not affect the domain under considerations for two main reasons. Firstly, the costumer actions can be completely monitored in a social network platform. Furthermore the constrain about the fully relevance of the actor's actions is covered through the implementation of a "Task extractor from user actions" interface placed between the monitored user interface and the plan recognizer module. So for us, the social networks domain is ideal to implement a GoalGraph based on plan recognition system.

4.2 A preliminary architecture for Social Networks

In this section we explain our desing to extract and use information from the user's network and from the world wide web search to recognize the user intention and generate useful information for users in different contexts. Figure 1 shows the different elements of our architecture. Each element is next explained.

- Action Analyzer: is responsible for parsing the generated actions within the social network platform. This module is very important because it allows us to apply modern plan synthesis techniques like Graphplan. It receives a set of actions performed by the user in the social network using the API. Then, it determines which actions can be joined to product tasks discarding those actions without significance for the domain. This process is supported by an external analysis system and data collection module based on other AI techniques related to the study of behaviors such as clustering [21] or datamining [15]. The output of this module is a set of compatible tasks with the requirements mentioned before such as fully observable domain or relevant actor's tasks.

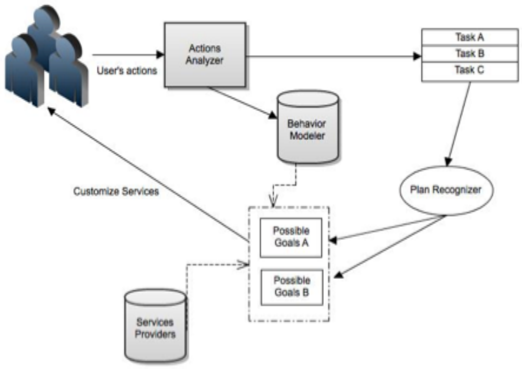

Figure 1: The different elements of the proposed architecture

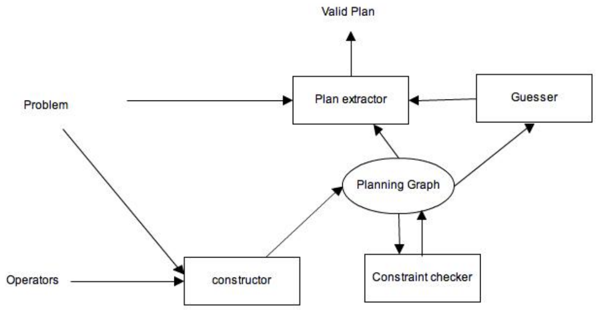

Figure 2: An schema of the plan recognizer module

- Plan Recognizer: is the heart of the architecture. The inputs are the user's tasks to process. The proposed plan recognizer builds a graph to generate possible user's goals under a domain with constrains. Thus, it determines what sets of goals are compatible with the user's tasks and send them to the next state. In figure 2, we show the schema proposed for this module using a blocks diagram. This architecture is taken from [22]. Given the initial state and the possible actions we can perform in our domain, the *Constructor* generates a partial planning-graph. Then, the *Planning Graph* receives the observed actions that are verified by the *Constraint Checker*. When the observed sequences doesn't have new actions to incorporate into the graph, the *Plan Extractor* returns a valid plan. If the *Plan Extractor* is not able to generate a valid plan from the set of goals (or vice versa) the *Guesser* will try to complete the structure with new likely actions. To more information see [22].

- Behavior Modeler: is the module that ensures the compatibilty between the detected user's actions and the personal information contained in the social network. The information generated from this module is useful for determining the relevant user's actions and selecting the most likely plan among all possibles. We can distinguish three sources of information:

  – The information from the user's public profile, which can help to extract possible actions (climb, go to cinema, read, etc.) and some particular tastes (pop music, spanish food, etc.). Also, it may be interesting in some cases to know the location of the user (where he lives or his position when he uses a mobile device).

  – Previous user's behaviors for similar situations. A semantic recognition system can be used to extract more information from the comments, chats and others social network platform tools.

  – The World Wide Web provides updated and extra information about events, new films or particular activities for example.

  Figure 3 shows how the behavior modeler feeds the plan recognition system to help it to find the most suitable plan. We distinguish two sources of information: Social information (e.g. user preferences and local information) and World Wide Web information.

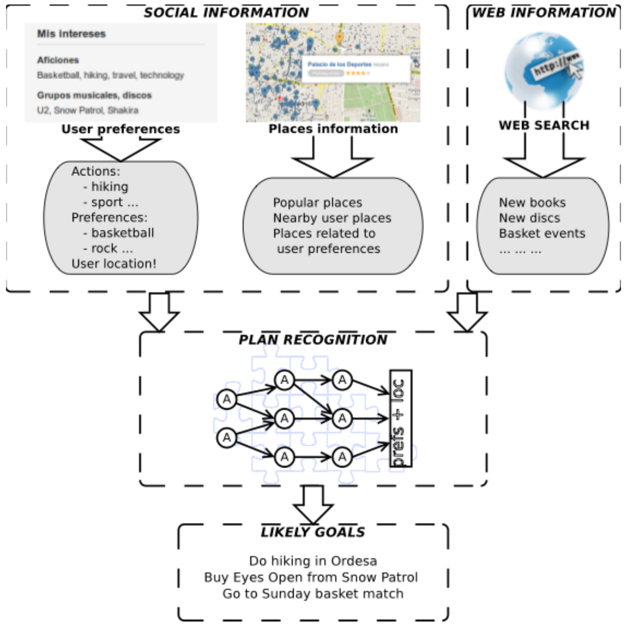

Figure 3: An example of the behavior modeler

- Services Providers: is an external module where the tool can search real products and services to offer to the users. This repository contains a variety of services as a function of the customized reponse we would like to implement in the system. In the next sections we discuss some examples of the services we can provide to show the real possibilities of our system.

These new services should help to social networks members to easily perform their daily tasks while the platforms become safer and more efficient. Working in this direction we propose to apply the described plan recognition approach over three scenarios.

4.2.1 First Scenario: Online Commercial Intentions

Nowadays the social networks are underused in commercial issues. The traditional advertising methods, as service announcements or spots, do not use the flexibility and the power that these systems could offer using customized services.

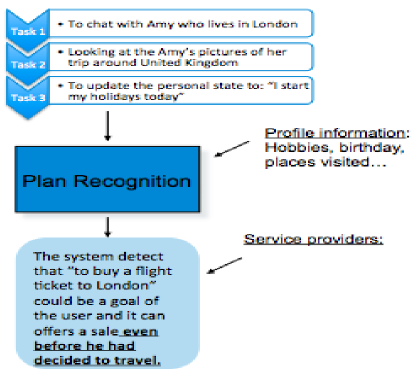

Figure 4: An example of online Commercial Intentions scenario

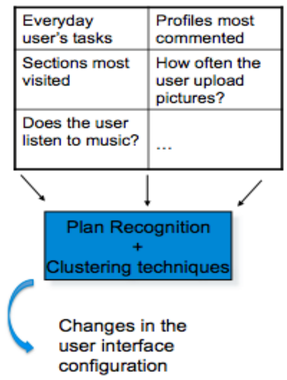

Figure 5: An example of adaptive interfaces scenario

This problem is not new and other systems like Google or Amazon have solved it using a lexical recognizer and historic sales records to offer products to the costumers. We consider them, very simplistic techniques because the same words can mean different things in many contexts and Amazon's system made the assumption that all customers have similar needs. These systems have the following problems: excessive and uninteresting announcements, inadequate products offered (for example an e-book and adults novels to a younger costumer that wants to buy an e-book) and undeliverable products in the user area. We propose to cover the problem building a customized process for each client and offering products only for people that we detect are interested in them. To achieve this goal we will use the user's actions made in the virtual environment and all the information available in the social networks (relationships, local information, age, hobbies, friend's information, birthdays…), then we use the social network like a bridge between users and companies that offer the products that the users are interesting in but without sharing personal information. The platform is not a simple storefront and we would like to convert it into a personal shopping assistant offering just the adequate products for the clients features (age, tastes, intentions).

The advantage of the social networks is that all the users have already set their personal information which allow us to offer personalized services inside the legal frame. Figure 4 shows a simple example of the possibilities of our approach in this topic. On the one hand the Plan Recognition module receives a sequence of tasks performed by the user. On the other hand, it receives the personal information about him (birthday, tastes, visited places …). After that, the Recognizer searches compatible services with the posible user's goals. And when found, the system offers them to the user.

4.2.2 Second Scenario: Adaptive Interfaces

Each customer uses the social networks to accomplish different tasks. Some of them are looking for new friends, others to plan activities with colleagues, or to show what they did the last holidays uploading their pictures. But why is the appearance of the system the same for all the users?

This is another topic where a better knowledge of the user, and his routines, could help to provide a customized service. The solution based on our approach detects the user's actions and it allows us to dynamically change the user interface making more visible and accessible the sections that the system predicts the user want to use.

We do not talk about new skins or a simple option to change the colors. Our approach pursues to make easier the use of the platform anticipating the desires of the current user. Figure 5 shows what information our system analyzes to propose a new customized user interface. The information about the user's behavior into the social network (everyday user's tasks, sections most visited, profiles most commented…) is also analyzed with plan recognition and clustering techniques.

4.2.3 Third Scenario: Identity Theft and Extortion Detection

The security is currently one of the most controversial issues in the social systems and the main handicap which prevents the access of some sceptical sectors to the social network platforms. In order to enhance the safety of these systems, we're going to develop an innocuous security system without privacy intromission (we do not want to transform these platforms in a police state platforms), but we would like to unlink the social networks from future cases of bulling or extortion happened around current platforms in the whole world.

We want to avoid the reject of parents, sociologists and politicians in the increase number of members on the network, independently of the age, condition or others safety matters. We propose to resolve the problem using AI techniques to model behaviors. Once the system had a pattern of conduct, we can detect possible anomalies analyzing the current user's actions. To achieve this goal we can develop a framework based on plan recognition techniques to identify suspicious profiles whose behaviors had the same goals that the aggressors and victims profiles modeled within the domain. Furthermore we can use dynamic techniques able to modify theses profiles to try to detect the futures cyber bulling's techniques in the social networks. Figure 6 shows how our system detects a suspicious behavior. We distinguish three main blocks in the figure. The suspicious tasks analyzed by the recognizer, the information about the suspect and their contacts, and the intelligent module.

5. CONCLUSIONS

In this paper we have presented an architecture based on AI Plan Recognition techniques for implementing secu-

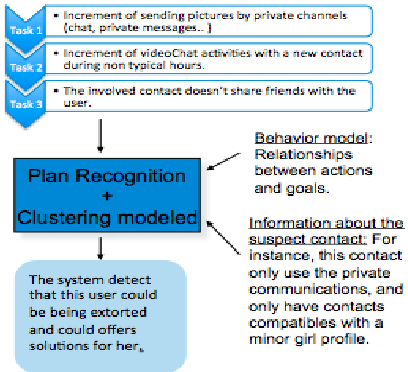

Figure 6: An example of extortion detection scenario

rity and adaptive innovative features for social networks. A user's behavior can be detected through his actions along the social network, which causes multiple system reactions depending on the goal predicted for that user. These reactions influence other subsystems, some of them also making use of AI disciplines. In particular, we have considered three real (but simplified) scenarios, related with different challenges a social network platform should afford in order to succeed in the *not so far* future: commercial issues, adaptive interfaces and security-privacy active techniques.

The work presented here can be extended by using other AI techniques in order to optimize the scenarios generated and the plans identified under some source of knowledge such as clustering, data mining, and statistical methods o markov-based approaches. Moreover, we propose to broaden the research work towards ways to increase the level of autonomy of these systems in order to make daily tasks easier for users, who will become more and more dependant of these tools in their interaction with social networks. Finally, there are also interesting areas of future research related to technical matters, comparing, for instance, the temporal and spatial requirements of our Graphplan-based approach with other modern planning algorithms applied to plan recognition problems.

6. ACKNOWLEDGMENTS

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