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Believable Synthetic Characters with Social Identity

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Lisbon, October 15th 2012
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To my parents, my brother and my girlfriend

Resumo

Nos jogos de hoje em dia a podemos ver uma procura por personagens credíveis. Nós sabemos que criar personagens credíveis não é fácil, mas nós vamos aceitar o desafio e neste documento vamos criar um modelo conceptual de agentes baseado em identidade social. Este trabalho está incorporado no projecto INVITE onde os principais objectivos são "explorar o papel da identidade social em relações e dilemas sociais em desafios mistos"[1]. Tudo isto dito, neste trabalho estudámos como a identidade social desempenhava um papel nas relações entre agentes e Humanos [1]. Nós estudámos trabalho relacionado de psicologia e informática e neste documento vamos discutir todo esse trabalho para explicar o que nós pensamos ser a melhor solução possível no momento actual para o problema. Com todo o conhecimento adquirido ao ler trabalho de outros nós criámos e implementámos o modelo conceptual que propomos neste documento para resolver o nosso problema e dar características humanas a um computador.

[1] Player $\leftrightarrow$ Player, Agent $\leftrightarrow$ Agent, Player $\leftrightarrow$ Agent

Abstract

In today's games we can see a demand of "believable" AI players. We know that creating a believable synthetic player is not an easy job, but we accept that challenge and in this document we will create an agent[2] conceptual model based in social identity theory. This work was incorporated in the INVITE project. We have created a 3D game to prove the agent's model. The goal of the INVITE project is "explore the role of social identity in partnerships and social dilemmas in mixed motive tasks"[1]. That said, in this work we studied how social identity plays a role in the relations between real Human players and agents[3]. We studied related work from psychology and computer science and in this document we discuss all the work we have studied in order to explain what we think is the best possible solution (right now) for our problem. With all the knowledge learned from others' work we created and implemented a conceptual model to solve our problem and give a Human ability to a computer.

[2] Synthetic characters, i.e., computational systems that are life-like entities and that will allow the user to interact in a natural way like if they where interacting in a real world with real people. [2]

[3] Player $\leftrightarrow$ Player, Agent $\leftrightarrow$ Agent, Player $\leftrightarrow$ Agent

Palavras Chave
Keywords

Palavras Chave

Agentes
Inteligência Artificial
Personagens Sintéticas Credíveis
Identidade Social
Relações de Grupo (Relações Intergrupais)
Mudança Social

Keywords

Agents
Artificial Intelligence
Believable Synthetic Characters
Social Identity
Intergroup Relations
Social Change

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1

Introduction

Contents

When we play a game against synthetic characters we want them to act in a believable way. We want believable synthetic characters. By this we mean that even if the human player realizes that he or she is playing against a synthetic character, the synthetic character should take believable and coherent decisions during the game and should also recognise different social groups.

In this dissertation we will study how to create believable synthetic characters based on social identity. To achieve that believability we will study how social identity plays a role in intergroup relations. First we should say what it is and why will we use it in our approach. Social identity theory was originally developed and studied by Tajfel and Turner in the 1970s and 1980s, in order to explain intergroup behaviour [8][9]. Tajfel and his colleagues proved that social identity plays an important role in relationships between humans. It can influence our satisfaction and the way we collaborate with other people. Therefore, it has an important role in our everyday life. Social identity states that people do not have only one personal self but also a repertoire of social identities for each social group that he or she feels to belong. Each of these social identities is then going to influence the individual's thoughts, feelings and behaviours. Social identity is central to every aspect of social behaviour [10][11]. It anchors us in the social world by connecting us to other people, people whom we otherwise might have little reason to trust, to like, or even to know at all, and just like Tajfel has shown, it can even increase cooperative behaviour between people who are totally strangers [10][11].

1.1 Motivation

Taking as example the video games interaction, if we can make artificial intelligence players with social identity perception and social identity reactions, and we can give them the ability to maintain relations, we can increase a lot the believability of our synthetic characters. This is our biggest motivation to study this theme and implement a possible solution to this problem in the INVITE project. In the future somebody can pick this work as a first step and build better and more realistic games than we saw today, based on human interactions, where the immersion of the players will be much better (compared to current games).

1.2 Objectives

This work addresses the problem of how the social identity influences a intergroup relation.

Goals: With this work we will create believable synthetic players and integrate them in a 3D game called INVITE. In the end, we hope that human players feel that the synthetic characters with our social identity module are more believable than the same synthetic characters that do not have our social identity module. We will also explore the cooperation between our agents human players and how cooperation and satisfaction are related with each other.

Expected results: The work will produce:

1. a specification of our model.
2. an implementation for our model.
3. an integration of our implementation with:
   (a) ION framework. A framework to help us build our agents without dependencies of a graphic engine.
   (b) Unity 3D. It's our 3D graphic engine.
   (c) INVITE project. Invite is the project that leads this thesis. For more information about INVITE please check this url - http://project-invite.eu/
4. experimental evaluation with users.

1.3 Dissertation outline

The rest of the report is organized as follows. In section 2 we present all the background related with our work. In section 3 we will explain how we have implemented our game. Section 4 we describe the proposed model that we have implemented. In Section 5 we describe the user tests that we have done and in the following section we describe our agents results compared with the human results. In the final section we present our conclusions and the possible future work.

2

Related Work

Contents

In this section we will study work in the area of social identity and intergroup relations from psychology and computer science, in order to achieve enough knowledge to create believability synthetic characters. In the end of this section we will do a brief mapping between the documents studied and its content.

2.1 Social Identity Theory

We have talked a little bit about social identity theory in section 1 and we said what social identity is. Based on that, and knowing that a social group is a set of individuals who view themselves as members of the same social category, and because a person can belong to several social groups, it's easy to conclude that he or she will also have several social identities, besides their own "personal identity". The most salient of these many identities, for an individual, will vary according to the social context where he or she is [12][13][14][15][3][10]. By social context we mean where the person is and what is happening where the person is. It can involve time period, an event that is going on, social class or relations between social classes.

The social identity theory says that, when we are part of a group, we discover the good values and all the good things about the group we belong to, but we try to find negative aspects in the groups we do not belong to, sometimes only to enhance our own self-esteem [8][3]. People do not act only as individuals but also as group members, sharing the same perceptions, goals and identity, the social identity [12][16]. It confers a shared or collective representation of who one is and involves self-categorization(cognitive), self-esteem(evaluative), and commitment(psychological) components [3].

The accentuation of the perceived similarities between the self and other in-group members occurs for all properties correlated with the intergroup categorization such as the attitudes, beliefs, values, affective reactions, and behavioural norms [3]. Social identity can also influences the use of avatars in virtual communities [3]. We have to choose carefully the avatars to simulate the social identity in the real players (Human players).

Kai Wang and Chi-Feng Tai [3] have also proposed a model about how social identity in virtual communities. The research model incorporates social identity theory to investigate how social presence contributes to Sense of Virtual Community which further leads to the satisfaction with and continual participation of virtual communities. The research model they proposed is shown in Figure 2.1.

This model can be useful for our agents design, where we can module the agent with something similar but using identity-formation, self-categorization, emotions, social identification and group-distinctiveness.

In this section we introduced the concept of Social Identity Theory. This knowledge

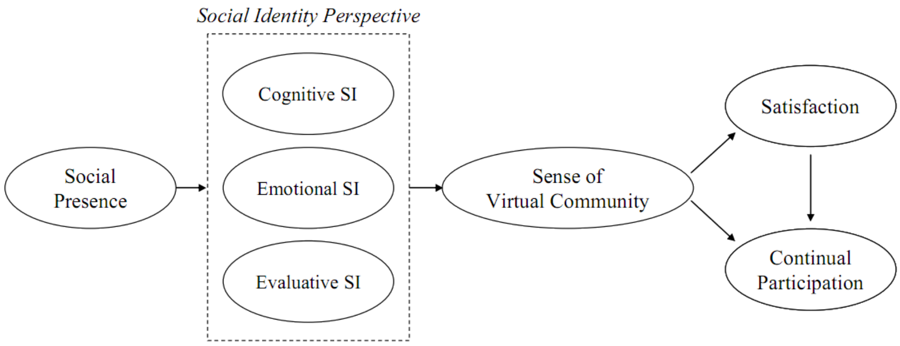


Figure 2.1: Research Model for SOVC [3].

will be the support for our research in the next sections.

2.2 Identity Formation

Tajfel and Turner observe that group members tend to discriminate people from out-groups, and they also observe that this discrimination can trigger a tendency to favour one's own group at the expense others [12]. Then Tajfel and Turner proposed three cognitive processes in deciding whether someone is part of the in-group or out-group.The three processes can be explained above with the order they are presented:

1. **Categorization** People establish a category to objects in order to understand and identify them [12]. With the same logic we categorize people in general, including ourselves, in order to understand the social environment we are in. We do this everyday because if we put people in categories we know what type of person he or she is. We try to do the same exercise in ourselves and observe in what categories we fits in, to really understand who we are, and what type of person we are.

2. **Social Identification** As we talked in the last point we categorize ourselves in groups, and this is what social identification is all about. Sometimes we adopt the attitudes (and identity) based on the groups we think we belong to. When our identification with a particular group is salient we start to talk, to act, and to do a lot of things like the group. Also we start to help the group members and start to cooperate with them. We feel attracted to the group and we adopt the conventions of the group. In-groups are groups we identify with, and out-groups are those we do not identify with.

3. **Social Comparison** Social comparison happens when we have categorized ourselves as part of a group and have identified with that group, then we tend to compare that group with other groups. If our self-esteem is to be maintained our group

needs to compare that group with other groups. This is critical to understanding the prejudice, because once two groups identify themselves as rivals they are forced to compete in order for the members to maintain their self-esteem. Competition and hostility between groups is thus not only a matter of competing for resources like jobs, but also the result of competing identities [12]. This will be a focal point in our game because we will have two groups and they will compete to be the first exiting the island. The two groups will be in competition from the beginning to the end of the game. The two groups will compete to be the winning group, and this will increase (or decrease) the group self-esteem during the game. Status is the outcome of intergroup comparison, it reflects a group's relative position on some evaluative dimensions [17].

This section summarized how someone considers that character x is part of the in-group or out-group. This will be important on our game implementation to "decide" if we consider character x as part of our group or not. This is also an good introduction to the next section, self-categorization.

2.3 Self-Categorization Theory

Self-categorization theory is a relatively new paradigm in social psychology. Self-Categorization Theory appeared when John Turner and his colleagues were studying the processes that can create social identity effects and as a result the self-categorization theory was developed. They also discovered that a person can be defined as an individual, which is called personal identity or as a member of a social group, which is called social identity. Self-Categorization theory also explains the variation in how people defines themselves in terms of individual or personal identity [18][12][4][19][20].

As the scope of the theory of self-categorization is group processes, it deals fundamentally with situations where a great number of individuals interact [20]. These situations typically generate complex collective phenomena, which are difficult to anticipate on the basis of the behaviour of individuals [4][20].

Experiment proved that people define themselves and behave differently in different situations. The same person may, for example, think and act typically as a business-man during working time (being serious, wearing a suit, etcetera.) but behave like a typical supporter during football matches (shouting, drinking, etcetera.). Self-categorization theory makes the hypothesis that one's identity is defined by the set of individuals with whom one identifies. Such a set is called a self-category, or in-group. Other social categories are built to identify other people of the context; they are called out-groups. Identity thus depends on the present social context of an individual [4].

The process of seeing oneself as a member of a group rather than an unique individual is known as self-categorization [19]. Or in other words, the theory defines how people define themselves at a group level but also at an individual level [18][12].

Social-Categorization (Self-Categorization) can be understood as the ordering of social environment in terms of social categories, that is of groupings of persons in a manner which is meaningful to the subject [10]. Social-Categorization (Self-Categorization) is a process of bringing together social objects or events in groups which are equivalent with regard to an individual's actions, intentions, attitudes and system of beliefs [10][19][20].

We as persons can have multiple social identities depending on the context or group. We can say that salience of an entity is a product of accessibility and fit [21]. Accessibility reflects a person's past experience, present expectations, and current motives, values [20]. Fit has two aspects a comparative and a normative [20]. A comparative fit is defined by the principle of meta-contrast, which states that a collection of stimuli is more likely to be categorized as an entity to the degree that the average differences perceived between those stimuli are less than the average differences perceived between them and the remaining stimuli that make up the frame of reference [20]. Normative fit refers to the content aspects of the match between category specifications and the instances being represented. For example, to categorize a group of people Catholics as opposed to Protestants, they must not only differ (in attitudes, actions, etcetera.) from Protestants more than from another (comparative fit), but must also do so in the right direction on specific content dimensions of comparison [20]. Their similarities and differences must be consistent with our normative beliefs and theories about the substantive social meaning of the social category [20]. Self-Categorization *always* reflects an interaction both between comparative and normative fit and between fit and accessibility (the latter, in turn, reflecting cognitive, affective, and motivational factors). For example, when we are discussing political issues, some behaviours like nationality may become more salient. Another example, if we want to look "affable" to a person we adopt a different behaviour. Sometimes and under certain circumstances, group belonging is psychological as well as demographic [19]. This is easily understood, imagine that a Portuguese citizen goes to another country and he or she found another Portuguese, then he or she tend to talk with him or her, even if the other characteristics of the person does not fit in him or her interests. In other words, we can talk to a person that in our natural environment with our friends we would never talk. That is a really simple, but powerful example of how nationality (salience) played a important role in this situation. If we are in a low-status group (inferior group), if we compare with another out-group (not he high-status out-group), the relevant inferiority should decrease in salience and self-esteem should recover [17]. In the same paper is said that the self-esteem was higher among blacks who made self-comparisons with other backs rather than whites. This is consistent with the fact that competition between subordinate groups is sometimes more intense than between subordinate and dominant groups [17].

That said, is easy to understand that an individual is always a member of multiple social groups [22]. Julian Kilker [22] refers to social identities in informatics project teams, but has many good examples that we can look in and adapt to our problem. One of the examples in the paper said that an individual can be part of the marketer group and at the same time he or she can be part part of the project team group [22]. Again we are facing the reality that we have multiple social identities, depending on the situation, the local, the environment and other factors.

In the study made by Julian Kilker [22] about informatics teams, he demonstrated that individuals defined themselves using social or technology ideals, and evaluated others based on these ideals. These identities influenced the design process of the identities. They have done this choose of evaluating the other colleagues in such way just because they were in a technology company, maybe if they were in other ambient they would choose other ideals to identify the colleagues and themselves.

Self-Categorization causes people to think of themselves less as unique individuals and more as relatively typical members of a group, and they act accordingly[19]. They see themselves as having the characteristics associated with group memberships, and they act as they believe group members should act, a process called **self-stereotyping**[19].

Because of that, self-categorization increases similarity within the group. Since every member of the group adopts the attributes characteristics of the group, everyone ends up having the same qualities. Adopting group characteristics like this is not intended only for public display. On the contrary, when tested in ways that prevent dissembling it is clear that group members actually see themselves as like the group. In a very real sense, the group has became part of the self [19] and the mere awareness of the presence of an out-group is sufficient to provoke intergroup competitive or discriminatory responses on the part of the in-group [17].

The idea of Salzarulo, 2006 is to group together similar individuals to form a social category (we separate different individuals into different categories) [4]. However, there is no absolute measure of how similar two individuals really are. Individuals can only be judged as similar relatively to other individuals in the context. A clear example is presented by Salzurulo, 2006. Imagine that we have two individuals speaking French, they will not feel very similar if they cross in Paris, whereas they will feel very close to each other if they cross in a small village of the Amazonian forest. In accordance with what is called the principle of meta-contrast, Self-Categorization theory predicts that a given set of individuals will be more likely to be perceived as a category if the mean difference between this set of individuals and all other individuals of the context is perceived as larger than the mean difference between the individuals within this set [4]. This is the principle of Salzarulo to implement a system of agents that will discribe better in section 2.10.

Although everyone belongs to groups, some groups are more central, important, and emotionally significant to some individuals than to others. The more central and important the group is to the self, the more an individual identifies with, or derives his or her identity from it [19]. We can easily understand this. Now let us imagine a really common example that most of us have pass through it. When we pass more and more time with one person, lets say a boyfriend or a girlfriend, typically we tend to have the same attitudes and in some cases we tend to have the same type of expressions (phrases) and sometimes we can share more than this two examples.

Highly identified members are more likely to chronically think about themselves in terms of group membership, to become socially categorized with weaker or fewer cues, and to display the consequences of categorization more strongly [19]. Self-categorization dictates emotions, especially for highly identified group members [19]. In the next section we will talk about emotions and how groups can dictate emotions. Emotions are used in many systems to create believable synthetic characters. We can take as example projects from INESC-ID, GAIPS[1] like LIREC, eCute and e-Circus [23].

As we will see in section 2.10 Salzarulo's used self-categorization to create his agents. He obtained good results and this is a good approach in same systems, systems where we are always meeting new people, new groups, but this is not what will happen in invite many times, it only happens when the game starts, but we will consider this theory in our implementation, because it is crucial that the agents in the begging of the game choose one group, and identify themselves with the group where they "think" they fits in.

2.4 Self-categorization dictates emotions

People can experience different emotions depending on whether they see themselves as unique individuals or members of a group, through processes of **self-categorization**. Furthermore, they experience different emotions when thinking about themselves as members of one group than when categorized as belonging to another group [19].

Imagine, for example, that we first ask people to think about themselves as unique individuals and to tell us how they feel at that moment (happy, angry, anxious, etcetera). If we then ask those same persons with the same questions but to first think about themselves as Portuguese citizens, and then as Students, and then as university students the

[1] "Grupo de Agentes Inteligentes e Personagens Sintéticas" in Portuguese, or "Intelligent Agents and Synthetic Characters Group" in English

opinions will vary depending of the group we choose to ask. Then three things stand out.

1. Although there is some overlap between responses, people report feeling quite different emotions as members of each group, and those emotions differ from the emotions they report to us when thinking about themselves as individuals [19]. For example, Portugal now is in crisis, and if we ask people how they feel as individuals, they could respond they feel happy about his or her girlfriend (or some other subject of his or her personal life), but they feel unhappy and sometimes angry about the country situation. We can be really proud of being IST[2] students but less proud as Portuguese citizens. Thus, **self-categorization**, by influencing which group membership is salient, dictates the emotions people report feeling [19].

2. People's responses as members of a group are shared with other group members. If we are thinking about Portuguese citizens we report feelings about the same amounts of sadness and anger, as other individuals thinking about themselves as Portuguese citizens [19]. Members of a group converge in their emotional responses, so individuals thinking about themselves as members of the same group share the same emotions far more than individuals thinking about themselves as unique individuals. People categorized as group members share emotions as well as attributes, attitudes and actions with the in-group members [19].

3. Individuals for whom the group is central and important experience, the emotions of their group are felt more intense to them. If the group feels proud, highly identified members feel greater pride than less identified members do. There is one exception to this rule. When shared emotions reflect badly on the group, such as when an in-group transgression elicits guilt, highly identified members are less likely to share such emotion, because the in-group is important and central to their selves, highly identified individuals are loath to accept the negative implications that such feeling imply [19].

"The evidence is unequivocal: **self-categorization** determines emotional reactions, and identification with the group by and large heightens its impact. Such findings do not rely on heavy-handed reminders of group membership or social pressure to get people to think like a group member." [19]

"When people are categorized as group members, however, they see the world not in terms of the implications of events and objects for them personally, but in terms of the implications for the in-group." [19]

[2] Instituto Superior Técnico de Lisboa

The authors of Intergroup Emotions and Intergroup Relations [19], assumed that intergroup emotions feel pretty much the same as individual emotions do. If other members of the in-group (but not the self) are insulted, for example, people feel anger on behalf of the group, and this anger involves physiological arousal. Just as being personally insulted makes people feel tense and upset, the same happens when one in-group is insulted. We can give again the example of being a college student (for example, IST student). If one of our colleagues is insulted about his lack of knowledge in a certain area that was taught at our college, even if we don't know him personally we feel identified with him and we will feel sad/angry about the depreciative comment. It seems that the comment is being directed to us because he is from our college.

Emotions is one area of investigation and many projects in GAIPS are build supporting agents' emotions [23].

2.5 Group Distinctiveness

Based on Joana Dimas, 2011 [12] citing Tajfel we can say that sometimes distinctions between groups can generate different behaviours to different groups and a tendency to favour one group and prejudice another group, because we felt more identity with one group than another.

Tajfel said that in order for the members of an in-group to be able to hate or dislike an out-group, or to discriminate against it, they just first have acquired a sense of belonging to a group which is clearly distinct from the one they hate, dislike or discriminate against [10].

As we having talked in this document people categorize themselves in groups. The mere act of categorizing themselves in a specific group is enough to lead them display in-group favouritism. The Tajfel experiments showed that individuals achieve positive self-esteem by positively differentiating their in-group from a comparison out-group on some valued dimension [12][10][16].

Tajfel and Turner identified three variables whose contribution to the emergence of in-group favouritism is really important. This three variables are really well summarized and identified in Joana Dimas paper [12], so we will quote the next three points from her paper:

- The extent to which individuals identify with an in-group to internalize that group membership as an aspect of their self-concept.

- The extent to which the prevailing context provides ground for comparison between groups.

- The perceived relevance of the comparison group, which itself will be shaped by the relative and absolute status of the in-group Individuals are likely to display favouritism when an in-group is central to their self-definition and a given comparison is meaningful or the outcome is contestable.

Sometimes an individual may wish for his own group to be more similar than it is to certain other groups; this is usually so when these groups are considered “superior” or “better” in some respects. However, the fact that an individual may wish for his group to be more like another in certain respects means that, **in these respects**, his own group is not adequately fulfilling its function of contributing to positively valued **social identity** [10].

Social comparisons between groups are focused on the establishment of distinctiveness between one’s own and other groups [10].

2.6 Cooperation

Social identity plays an important role in terms of Cooperation. According to this theory, the psychological process of social identification constitutes a basis for intra-group cooperation [8].

Kilker, 1999 [22] citing Hogg and Abrams, 1988 [13] is said that social identity theory is useful for examining how individuals in heterogeneous groups collaborate. Individuals are said to be part of a social group if they share a common definition of themselves as part of the group and exhibit consensus about the evaluation of their group and other groups.

We tend to see ourselves and others as one unique component of a big social unit rather than unique individuals. We can say that in-group members become part of “me and mine” and so we like them, usually much more than we like out-group members, and this is one of the basis for cooperation between in-group members.

We treat in-group members in the same way we would like to be treated and sometimes we confuse our self-interest with the group interest and we have no distinction between the two interests (individual/group interest) [12][24].

Individuals tend to accentuate similarities within their own groups but differences between groups, because of the challenging presence of competing ideals, stereotypes are more likely to be expressed by individuals in a heterogeneous group than in a homogeneous group [22].

As said Joana Dimas[12], De Cremer and Van Vugt [25], De Cremer and Brewer[26] “Group identity involves a transformation of goals from the personal to the collective level”.

Accordingly to this theory, the psychological process of social identification, constitutes a basis for intra-group cooperation [12].

Several studies have demonstrated that social identity has a positive effect in in-group cooperation, and a negative effect in out-group cooperation. By Ross and Brown [27] is demonstrated that negative out-group opinion results in greater in-group cooperation and larger in-group effects [12].

Stephen Reicher, Russel Spears and S. Alexander Haslam [22] have done a study in a technology college, where they observe two different social groups. They saw one major difference between technology oriented students and those less familiar with technology. In the paper they affirm that the students responded in polarized manner, and they were manipulated in that way by them (paper author's). Is also said in the paper that social identity represents a challenge to collaboration in two respects:

- People with polarized identities have difficulty synthesizing their perspectives.
- These polarized people, may hold different views on the process of collaboration itself.

In the same paper (Stephen Reicher, Russel Spears and S. Alexander Haslam) [22] they studied the importance of team identity in real life projects and they have verified that teams who trusted in themselves obtains better results than teams with low confidence, and that is because those teams don't cooperate with each others. Some successful teams are successful just because they have built a sense of confidence between each others. In this paper they also refer that social identities play a key role in collaboration but also in negotiating different resource to the project. It could be opposition (negotiating and cooperation) but a team with good cooperation can have a more flexible negotiating point between individuals in beneficial of the group, rather than personal opinions or personal interest. This is not difficult to imagine and explain, we sometimes have to be flexible in negotiation to reach a good final work/project(for example). This is good for the group and at least it is good for all the individuals involved in the work/project, because they will benefit of the good work made by the entire group, they will all have benefits from good work for the company.

Tajfel made an experiment between self and anonymous other, who was either in the in-group or out-group. As long as minimal conditions existed for in-group identification, the subjects were prepared to give relatively less to themselves when the award (money, or points) was to be divided between self and an anonymous of the in-group, as compared with dividing with an anonymous member of the out-group [17]. These results seem particularly important, since the category of "self", which is minimal, was set here against a truly minimal in-group category [17]. The minimal group affiliation affected the responses

[17].

2.7 Social Identity and Intergroup Relations

The aim on the first Tajfel's studies was to establish minimal conditions in which an individual will, in his behaviour, distinguish between an in-group and an out-group. In order to create such minimal conditions Tajfel and his colleagues attempted to eliminate from the experimental situations all the variables that normally lead to in-group favouritism or discrimination against the out-group. Some examples are face-to-face interaction; conflict of interests; any possibility of previous hostility; any utilitarian or instrumental link between the subjects' responses and their self-interest [10].

Tajfel then put the individuals in individual cubicles. Their task was to decide (on a number of payment metrics) how points, worth money, should be divided between two other subjects. The individuals knew what was their own group membership (underestimation or over-estimation of dots: or preference for one or the other painter), and the group membership of those between whom they dividing the money; but these individuals were designated by code numbers, and their identity was unknown. The results were very highly significant in the direction of awarding more money to members of the in-group [10].

Tajfel then made another experiment, but these time the individuals knew each other well before the experiments and results were even better than the results shown in the first attempt [10]. Then Tajfel elaborated two "simple and overlapping" explanations for this results. A "normative" and a "learning" one. In the first one the individuals saw the situation as one of "team competition" in which one should make one's own team win at whatever cost. The second, they engaged in in-group behaviour which had been reinforced on countless occasions in the past. While both these explanations are sensible Tajfel refer that they are quite uninteresting because they are not genuinely heuristic [10]. The problems of an individual's self-definition in a social context, can be restated in terms of the notion of social identity [10].

Several consequences regarding group membership follow upon this "recognition of identity in socially defined terms". They can be described as follows (quoted from Tajfel, 1974) [10]:

1. It can be assumed that an individual will tend to remain a member of a group and seek membership of new groups if these groups have some contribution to make to the positive aspects of his social identity; i.e. to those aspects of it from which he derives some satisfaction.

2. If a group does not satisfy this requirement, the individual will tend to leave it unless

    - a) leaving the group is impossible for some "objective" reasons
    - b) it conflicts with important values which are themselves a part of his acceptable social identity.

3. If leaving the group presents the difficulties just mentioned, then at least two solutions are possible:
    - to change one's interpretation of the attributes of the group so that its unwelcome features (e.g. low status) are either justified or made acceptable through a reinterpretation;
    - to accept the situation for what it is and engage in social action which would lead to desirable changes in the situation (of course, there may be various combinations of a) and b), such as, for example, when the negative attributes are justified and social action to remove them is undertaken at the same time).
4. No group lives alone - all groups in society live in the midst of other groups. In other words, the "positive aspects of social identity": in 1) above, and the reinterpretation of attributes and engagement in social action in 3) above, only acquire meaning in relation to, or in comparisons with, other groups.

We will have relations, so this section is crucial to understand the relations between players and/or agents. The players can also be unhappy with is group and want to change, but group change and satisfaction will be discussed in the next section.

2.8 Social Mobility and Social Change

Tajfel concluded that social identity is understood as an intervening causal mechanism in situations of social change - observed, anticipated, feared, desired, or prepared by the individuals involved; and the effects of these changes on their subsequent intergroup behaviour and attitudes. From this point of view, three categories of situations appeared crucial in Tajfel opinion. They are [10]:

- The badly defined or marginal social situation of a group, which presents the individuals involved with difficulties as regards defining their place in a social system;
- The groups socially defined and consensually accepted as "superior" at a point in time when this definition is threatened either by occurring or impending social change, or by a conflict of values inherent in the "superiority";
- The groups socially defined and consensually accepted as "inferior" at a point in time when (for whatever reasons):

1. members of a group have engaged in a shared *prise de conscience* of their inferior status.
2. they have become aware of the feasibility of working towards alternatives to the existing situation
3. or a combinations of the two first points (1 and 2), which may also imply (1) leading to (2), or (2) leading to (1).

We can distinguish between "secure" and "insecure" social identity. A completely secure social identity would imply a relationship between groups (one or more) in which a change in the texture of psychological distinctiveness between them is not conceivable [10]. When status relations are perceived as immutable, a part of the fixed order of things, then social identity is secure. It becomes insecure when the existing state of affairs begins to be questioned. An important corollary to this argument is that the dominant or high-status groups, too, can experience insecure social identity. Any threat to the distinctively superior position of a group implies a potential loss of positive comparisons, which must be guarded against. Like low-status groups, the high-status groups will react to insecure social identity by searching for enhanced group distinctiveness [17].

A completely secure social identity for a superior group is almost impossible to achieve , but that superiority has a psychological distinctiveness that ensures its unchallenged superiority that must be preserved [17][10]. This superiority can only be preserved if social conditions of distinctiveness are carefully perpetuated together with the signs and symbols of distinctive status without which the attitudes of complete consensus about superior distinctiveness are in danger of disintegration [10]. That said, we can conclude that a superior group can never stop working in the preservation of its distinctiveness. When the in-group is not threatened, high-status group members should not feel a need to defend their interests against out-groups by embracing social dominance beliefs [28]. For an "inferior" group to have a secure social identity would imply the existence of a total consensus about the nature and the future of their inferiority [10].

Tajfel introduces us to two type of groups, "superior groups" (High Status Groups) and "inferior groups" (Low Status Groups). He said that some times the aim of differentiation is to maintain or achieve superiority over an out-group on some dimensions [17]. Different hypotheses pertain to the two kinds of groups. In each individuals' life we act as members of a group and as a single individual. When we act in terms of ourselves rather than in terms of our group is what Tajfel refer to "social mobility" as contrasted with "social change".

"Social mobility" refers to situations in which it is relatively easy to move individually from one social group to another; so that, if a group does not contribute adequately to an individual's social identity, one of the more obvious solutions for him is to move away from his group to another group that suits him better [17][10][11].

"Social change" implies that the nature and structure of the relations between social groups in the society is characterized by marked stratification, making it impossible or very difficult for individuals, as individuals, to divest themselves of an unsatisfactory, underprivileged, or stigmatized group membership [17]. For this reasons "social change" refers to changes in the relationships between the groups as a whole, to expectations, fears and desires of such changes, to actions aiming at inducing or preventing them, or to intentions and plans to engage in these actions [10][17]. Tajfel gave us a good example of social change. He (Tajfel) said that in the last years research conducted that American blacks now seem to be rejecting (or have already rejected) their previously negative in-group evaluations and developing a positive ethnocentric group identity [17]. Tajfel argue that these new data are likely to be a genuine reflection of social change [17].

Tajfel said that insecure social comparisons arising within a group which is consensually defined as being of higher status (**superior group**) can be due to two sets of conditions:

1. The group's superior status is threatened (or perceived as threatened) by another group. In this case we have two possibilities. The individuals can leave the group if the threat becomes overwhelming or the individuals can stay in the group taking the precautions to preserve the superiority of their group.

2. The superior group status is related to a conflict of values, i.e. it is conceived by some as based on unfair advantages, various other forms of injustice, exploitation, illegitimate use of force, etcetera. In this case the individuals can leave the group if the conflicts are destroying the positive contribution to social identity that the group provides to the individuals (in this case there will be no discrimination against the out-group and no hostility against it), but in the other hand individuals can stay in the group if the conflicts of values exists, but in-group affiliation is sufficiently powerful to remain the determination, attitudes and behaviours.

The same happens in a lower status group (**inferior groups**). We have conditions to leave the group, and conditions to stay in the group:

- **Conditions to leave the group**. In these situations of social mobility, as defined earlier, here is enough social flexibility to enable an individual to move or hope to move from one group to another, there are no serious social sanctions from either of the groups for moving, and no serious conflict of values involved in moving [10][29].

- **Conditions to stay in the group**. This is really interesting from the point of view of intergroup attitudes and behaviour than the previous one. The major social conditions are: any form of caste system (whether determined by birth, race or other criteria), or any other social differentiation system which, for whatever reasons makes it difficult to move [10][29]. The two major psychological conditions are a strong conflict of values inherent in leaving one's group, or the fear of powerful social sanctions for so doing, or even a combination of both factors [10][29].

2.9 Summary - Social Identity and Psychology

In this section we will summarize what we think are the most valuable documents for our research from all the papers presented in this document until now.

As we described in section 2.1 the work done by Kai Wang and Chi-Feng Tai [3] is a really simple approach to our problem. They simple have done a model represented in Figure 2.1 that could be useful as a starting point for our model. This paper is a really good starting point to our work in computer science world.

The papers from Joana Dimas [8][12] and Tajfel [10] were a good starting point for our research. They have really good information that we definitely will use in our game!

In table 2.1 we will summarize some of the psychology documents we studied in the last sections and briefly describe which themes are studied in which document.

From table 2.1 we can see that many of the researches we have studied empathizes that self-categorization, satisfaction and cooperation are really important in our everyday actions and attitudes, so in order to build believable synthetic characters in the next section we will study papers from this three areas in particular in computer science.

2.10 Social Identity and Computer Science

We will start describing Salzarulo [4] paper in detail. In general he presented a model about self-categorization, polarization and some mathematical formulas to compute many of the agent decisions in the world. This is really important and we could just use some of his formulas in our work, because he had good results in his tests and some of the formulas are really simple to understand and they are not so expensive in terms of processor CPU cycles, which is really important in a real time game like INVITE.

The base for Salzarulo work was that we have to try to resemble as much as possible what we think is prototypical of the group in order to identify somebody (agent) with that group. He also know that people are context-dependent and then we will to built his prototypes in the same way (context-dependent) [4]. Salzarulo also emphasise that some people are polarized. He defines group polarization in a really simple way saying:

Paper	Summary
António Soares[2]	Relationship Models and Filters.
Joana Dimas [8][12]	Two papers with valuable information about social identity describing: Social identity theory, self-categorization theory, identity formation, group distinctiveness and cooperation.
Julian Kilker[22]	A paper about conflict on collaborative design teams, and how social identity plays a role in collaboration.
Henri Tajfel[10]	Social identity and intergroup behaviour, conflicts in in-group and out-group, satisfaction with the group.
Dianne Mackie, Eliot Smith and Devin Ray[19]	Emotions and intergroup relations. Social identity and self-categorization. Self-categorization dictates emotions. Consequences of intergroup emotions. Explain why intergroup emotions are important.
Kai Wang and Chi-Feng Tai[3]	Social identity, social presence, sense of virtual community, participation e satisfaction are studied in this paper.
Christina Margaret Baird[29]	social identity theory and intergroup relations in gender dominated occupations. For example Man vs Women.
Stephen Reicher, Russell Spears and S. Alexander haslam[9]	A document about social identity explained in detail with examples.

Table 2.1: Summary from psychology papers

"Group polarization is usually defined as the tendency of the average response of group members on some dimension to become more extreme towards the initially preferred pole after group discussion than the average of their initial individual responses" [4]. Hence, in the frame of this theory, polarization is an intra-group process. The presence of extremists is not necessary to induce group polarization. To the contrary, mere exposure to a central tendency is sufficient. Moreover, extremists can even lead to depolarization if they are categorized as out-group [4].

Salzarulo also express the "attractive force" between similar opinions, but do not take into account any "repulsive force" between different social groups, which should exist according to Self-Categorization Theory. As a result, these models are unable to predict situations where the final opinions are more extreme than the most extreme initial opinion. In the bounded confidence model, each agent i has a confidence level or uncertainty u_i, and considers the set Ii of agents whose opinion does not differ by more than u_i from his own. Agents take into account opinions in an interval $[-u_i; +u_i]$ around their own opinion. By introducing asymmetric confidence intervals, agents can be made more “opened” to extreme opinions and convergence to extremism or polarization is observable. By Introducing “extremists” as agents with an extreme opinion and with a low uncertainty allows for large extreme clusters to emerge (single extreme convergence or bi-polarization), even with a small initial proportion of extremists. As showed by experiments, the extremists are more self-confident, this should be take into account in our game[3].

By Salzarulo model supposing that an agent know the opinions of n inviduals to some topic. We will call $x_i \in [0; 1]$ to the initial opinion of individual i regarding this topic. He defined $X = \sum_{i=1}^{n} x_i$ as the context, that is the set of opinions of all individuals. The X value can vary from individual to individual. At this step Salzarulo needs a function of distance between X and the opinion of agent x_i. To compute that distance of opinions between agents Salzarulo uses the function number (2.1). He has also to ensure that $\mu(x, x) = 1$ and $\lim_{|x-x_i|\to\infty} \mu(x, x_i) = 0$ and $|x - x_i|$ is a decreasing function.

$$\mu(x, x_i) = \exp(-\frac{(x - x_i)^2}{\omega^2}) \tag{2.1}$$

In function number (2.1) $\omega \in]0; 1]$ is a parameter of the model which can be interpreted as a typical group width, in the opinion space, in other words means how are the diversity of opinions in one group. With this function agents do not know that they are group members, and they don't know, for now about other group memberships.

Salzarulo then used the intra-category distance, that is the distance between opinion x and the opinions of other in-group members. He describe intra-category distance by formula number (2.2).

$$d_{intra}(x, X) = \frac{\sum_{i=1}^{n} \mu(x, x_i)(x - x_i)^2}{\sum_{i=1}^{n} \mu(x, x_i)} \tag{2.2}$$

Salzarulo also used the inter-group distance, that is the distance between opinion x and the opinion of all out-group members. He described as follows in formula number (2.3).

$$d_{inter}(x, X) = \frac{\sum_{i=1}^{n}(1 - \mu(x, x_i))(x - x_i)^2}{\sum_{i=1}^{n}(1 - \mu(x, x_i))} \tag{2.3}$$

A measure of how opinion x is prototypical of some social group is given by how large its inter-category distance is, compared to its intra-category distance. This measure is showed in function number (2.4) and variable a means out-group aversion.

[3] INVITE

$$P(x, X) = a * d_{inter}(x, X) - (1 - a) * d_{intra}(x, X), a \in [0; 1] \quad (2.4)$$

- If $a = 0$, the maxima of P are located in the centre of the groups (in areas with a high density of opinions).
- If $a > 0$, means that each maximum of P will be close to one group centre, but slightly repulsed by every out-group.
- If $a \in [0.5; 1]$, P gets higher as x goes away from any group.

A local maximum of P represents an opinion that will be recognized as prototypical by people having a similar opinion. The main purpose of the bounded confidence model was to predict the categorization that would occur within a given context. With this model the agents adopt the opinion of the agent who has the most prototypical opinion for the in-group. We can in resume say that the whole updating rule for agent i having opinion x_i is:

1. given X as the set of opinions agent i perceives in his neighbourhood, compute P(x, X) [4].
2. find the position x^* of the local maximum of P which is the closest to x_i (this is the prototypical opinion for i) [4].
3. find in i's neighbourhood which agent has the opinion which is the closest to x^*. This agent has the most prototypical opinion of i's category [4].
4. adopt the opinion of the most prototypical neighbour [4].

With this we can ensure that no opinion is created during interaction, but like Salzarulo have done we have to run this update process for the first simulations to ensure that if we iterate the process all opinions stay in the initial $[0; 1]$ interval in order to reach a steady state. [4].

Salzarulo also proposed a multidimensional model to simulate the fact that an invidual can have more then one simultaneously opinion, but that is not the proposal of his paper. We can represent his model by function number (2.5) in equations (2.1), (2.2) and (2.3).

$$(x - x_i)^2 = ||x - x_i||^2 = \sum_{\alpha=1}^{D} (x_\alpha - x_{i\alpha})^2 \quad (2.5)$$

In function number (2.5) the D means the number of different topics, and $x, x_i \in [0; 1]^D$.This would allow to study the simultaneous dynamics of several opinions per individual.

To show how to agents interact through this model, lets consider their opinion x_1 and x_2. In Figure 2.2 the new opinion of agent 1, then will get more extreme after interaction with agent 2. This is an important feature of this model, that distinguishes it in particular from the other models. This model also includes a repulsive force between two opposing opinions, allowing opinions that are more extreme than the existing ones to emerge during interaction.

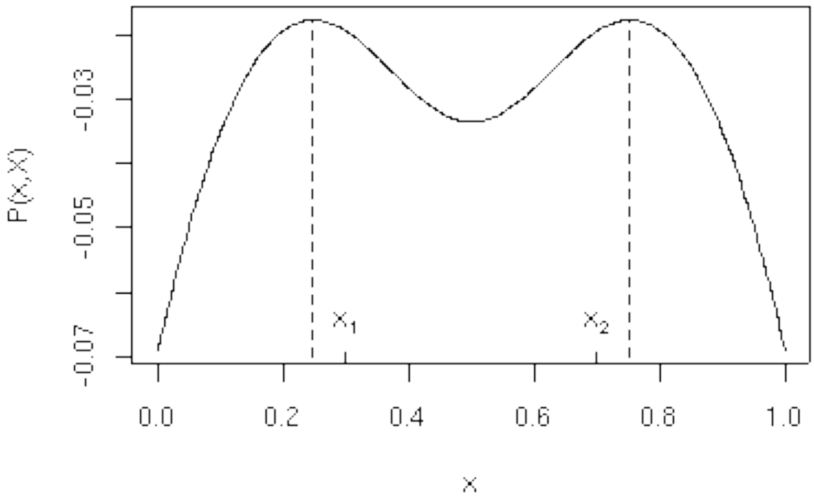


Figure 2.2: Prototypicality curve $P(x, X)$ for the context. $X = (x_1 = x_2 = 0.7$. $a = 0.08$, $w = 0.36$ [4].

In Figure 2.3 the prototypicality curve has a single maximum located halfway between x_1 and x_2 for the same values of both parameters a and ω.Here the opinion of agent 1 will be closer to that of agent 2 than it was before, and the process will eventually lead to consensus.

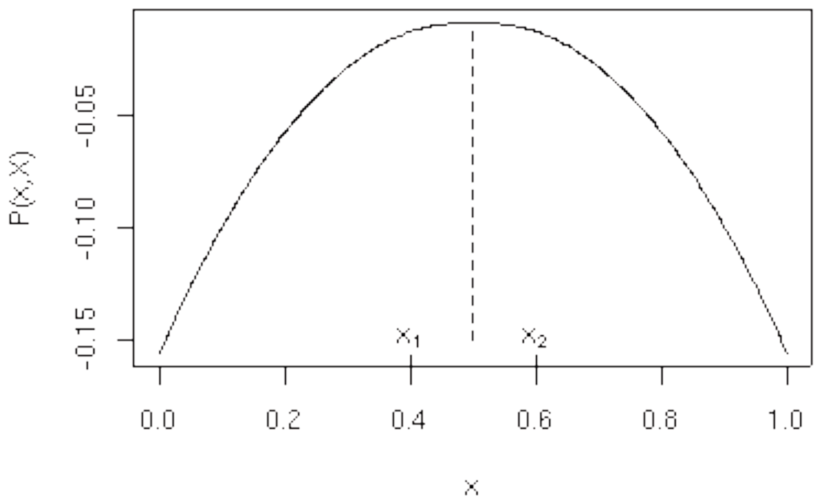


Figure 2.3: Prototypicality curve $P(x, X)$ for the context. $X = (x_1 = 0.4, x_2 = 0.6$. $a = 0.08$, $w = 0.36$ [4].

In order to see what happens we measure the value of the value of the first derivate of P at x_1 as a function of P, which is the relative position of x_1 and x_2, $(x_1 - x_2)$. This can be seen in Figure 2.4. When $x_1 = x_2$, both agents has the same opinion (and that opinion is also the prototypical one and has no forces on it). This graphic shows that when the opinions are really different the agents tend to be repulsive to each other.

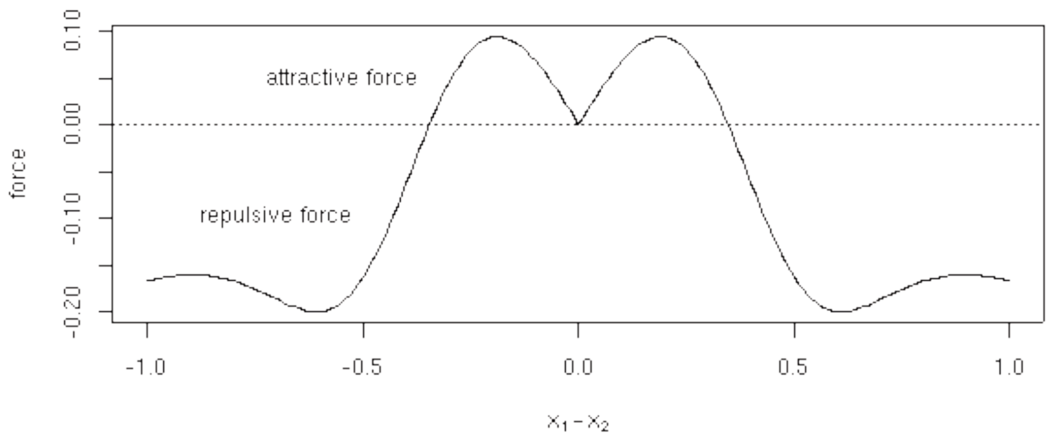


Figure 2.4: Force attracting or repulsing agents one's opinion as a function of his relative position with agent 2, $(x_1 - x_2)$. The intensity of the force is given by $\frac{\partial P}{\partial x}(x_1)$.

In Salzarulo studies he used a population of 100 agents [4]. At each time step, an agent was randomly chosen and updated applying the self-categorization rule given above. Agents were fully connected, which means that every agent exactly knows the opinion of any other agent in the population. Opinions are initially uniformly distributed between 0 and 1 in the population [4]. As a result, this model by Salzarulo generates consensus, bi-polarization or multiple clusters depending on the values of both parameters a and ω [4]. This same model (Meta-Contrast Model) was developed to reproduce the categorization phenomenon and to identify prototypes associated with each category [4].

The next paper we will study about computer science and social identity is a paper that identifies user's roles and social relationships as the most prominent forms of social identity by reviewing the social science discourses (e.g.psychology, sociology) and philosophy. In this paper, semantic technologies play the vital role for formal representation of relationships and access authorization policies [5]. The formal representation provides the machine understandability and manipulability. Mohammad and Noll used Web Ontology Language (OWL[30]) for formalization of relationships and surrounding social contexts, and Semantic Web Rule Language (SWRL) and Semantic Query-Enhanced Web Rule Language (SQWRL[4]) for specification of authorization policies. The execution

[4]Semantic Query-Enhanced Web Rule Language (SQWRL), http://protege.cim3.net/cgi-bin/wiki.pl?SQWRL [31]

of policies results the access authorization decisions [5].

They have proposed that identity should be visualized more of an onion like shown in Figure 2.5, where individual's unique characteristics across any context sit in the middle, and the possession based, social and context dependent identities surrounds them [5].

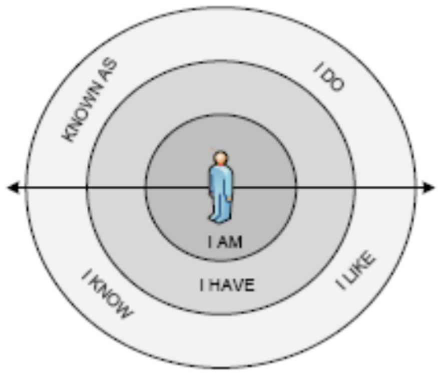


Figure 2.5: User identities are visualized more of an onion [5].

This paper echoes the notion of social identity through individual's relationship with a group or with other known individuals. To draw a scenario this paper considers an online community space where there exists two communities: Cycling and Rowing, each containing community and public resources (e.g. videos and photos) [5]. Alice, Bob, Katherin and Stefan are members of Cycling community, while Bill and Josef are members of Rowing community. Alice, Bob, Stefan and Bill are friends of each other [5]. Bob shares some of his private contents (e.g. videos and photos) in the community platform [5]. Among his friends, Bob trusts Stefan and Bill more than Alice [5]. The relationship to the community (membership) and the relationship among individuals are considered as identities here [5].

In this research, integration of social identities in access control requires the machine interpretable representation of identities. In this regard, they used OWL to represent them. The sample codes are shown in RDF/XML (OWL syntax) representing a community scenario described in the last paragraph.

The Code:

```
<Community rdf:ID=”Cycling”>
<hasMember rdf:resource=”#Alice”/>
................
<hasCommunityResource rdf:resource=”#PartySummer09”/>
</Community>

<owl:Class rdf:ID=”Member”/>
```

<Member rdf:ID="Bob">
<belongTo rdf:resource="#Cycling"/>
<hasFriend rdf:resource="#Alice"/>
<hasPrivateResource rdf:resource="#KillBill"/>
</Member>

One of the main goals of this paper as said in the conclusions is that it "describes the identity from social perspectives and shows how social identity theory can provide secure service access in digital world"[5]. Another main goal is that this paper "focuses on the formal representation of social aspects of identity and presents an access authorization mechanism based on these formal semantics" [5], which could be really important in the way we will build our entities.

The next paper we will focus is a paper from Roman Neruda[32]. In this paper, Roman focus is attention on the cooperation of agents. The main goal of his approach is to allow to create new agent classes consisting of several cooperating agents. He introduced cooperation in a distributed system, where one node is an agent. Agents can cooperate with each other in order to distribute the load. In his system an agent should be able to cooperate, and his architecture consists in four layers. The monitors layer, the evaluators modelling layer, the layer for decision support, and the behaviour generation layer. All his layers are influenced by global preferences. His agents are capable of understand if another node (agent) needs some help in heavy loading tasks. His agents have many states to communicate between each others, like normal state, load, etcetera. This is a simple way of communication that we can use in our game (INVITE) to communicate between our agents with states and have a fully connected network between agents like Roman has. He also introduced a BDI model, which encapsulates all his logic, but the main advantage his that this BDI model also improved his performance in about 10%.

Now we will introduce a paper from Zhen Liu and Yu-Sheng Lu with "a motivation model for virtual characters" [6]. Motivation is an important psychology characteristic for a virtual character. They define motivation in a five layer hierarchy, starting from the bottom we have, Physiological (food, water), Safety (money), Love (acceptance), Esteem (respect) and Self-Actualization. In order to create believable virtual characters the characters should include emotions, personality and motivation. They also said that motivation can drive behaviour and emotion. They consider that every virtual character should be an autonomous agent with built-in structure:

1. Body data: including 3D geometry and motion captures.

2. Sensors

3. Perceptrons: A perceptron is different from a sensor, it can filtrate and get the high-level cognitive information from sensors. A perceptron can be equipped with attention mechanism to increase the efficiency.

4. Soul: it can control the autonomy of virtual character. Like Roman Neruda, also Zhen Liu and YU-Sheng LU also proposed something similar to a BDI implementation.

5. Actuators

Basically the model they proposed is summarized in figure 2.6.

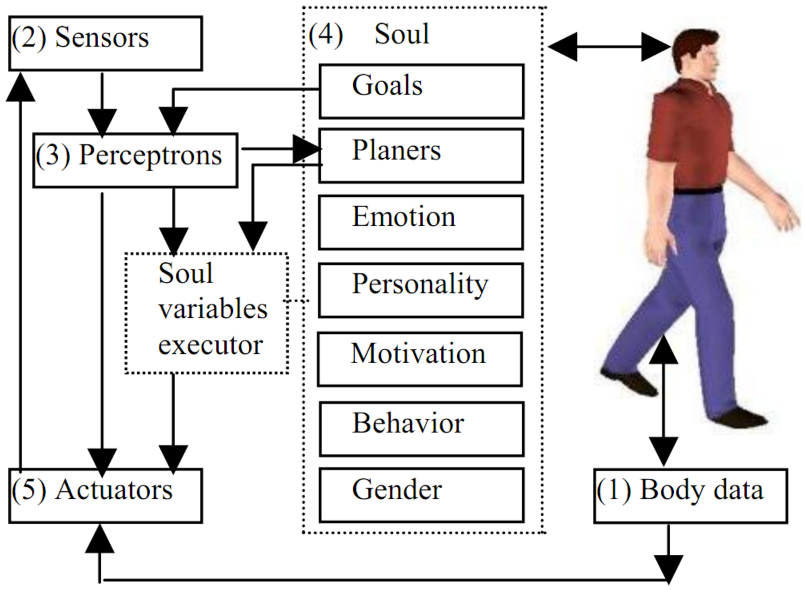


Figure 2.6: A virtual character's component[6].

In summary this model from Zhen Liu and Yu-Sheng Lu integrates personality, motivation, emotion, behaviour, and stimuli together. This model can be useful in our character creation/modelling process, but they said in their conclusions that modelling motivation of virtual characters is a very difficult task. This paper are focused in the motivation, but also gives us another useful knowledge in what we are interested in (how to create believable synthetic characters).

2.11 Summary - Social Identity and Computer Science

Besides Mohammad and Noll [5] paper is not exactly what we are looking for, we can take a lesson from it. They have used social identity theory to build one access control with success from their experiments

The paper from Salzarulo [4] has good results. He has equations to every aspect that we will need and we will use his knowledge, because it is a proved work with good results.

Roman has an approach with agents applied to distributed systems, but some of his theories we can apply to our cooperation module.

Zhen Liu and Yu-Sheng Lu have created a believable synthetic character with a different approach than what we will do, but we can learn a lot from their experiences and take good advices from them.

All our conclusions about the related work in computer science is summarized in table 2.2.

Paper	Summary	Relation with psychology themes
Salzarulo[4]	The main focus of Salzarulo is in self-categorization. Salzarulo said that he achieved good results in his work comparing to another related work.	Self-Categorization.
Mohammad[5]	Mohammad is focused in social aspects of identity, types of identity and role of the identity. He used this theories in a access control system.	Social Identity Theory.
Roman Neruda[32]	In this paper Roman Neruda focused his attention in a creation of agents to control a distributed system. All the agents in the system should cooperate and communicate (change messages with his states) between each others.	Cooperation, “inter-group relations”.
Zhen Liu and Yu-Sheng Lu[6]	In summary this model from Zhen Liu and Yu-Sheng Lu integrates personality, motivation, emotion, behaviour, and stimuli together.	Emotions.

Table 2.2: Summary from computer-science papers

3

Implementation - INVITE Game

Contents

In this chapter we present the demonstrator application, which we implemented in order to integrate and evaluate our agents. These demonstrator application is a game and is part of the INVITE Project (http://project-invite.eu/).

Before explain the implementation and the tools we used, first we need to clarify what type of game we will implement.

3.1 The Game

In this section we will describe the game and the objectives of it. The scenario of the game is an Island with a volcano that will erupt in a certain amount of days. The game is played by two to five teams with two to five members in each team.

The main objective of the game is to have the highest score at the end, but to complete the game we need to escape from the island. To escape from the Island every team should build a raft with wood. Every team member have an fixed amount of time to spend in everyday and he/she can decide to gather wood or gold. That resources (gold and wood) are placed in the Island.

To obtain points for the final score and win the game individually our team should build the raft, but we also need to have more gold than everybody else. The wood at the end of the game is divided in an egalitarian rule by every team member, but the gold that one player have gathered is only for its score.

Now we will give an example of a single game. When the game starts every player is spawned in his/her team camp site. Then the user should go to the resource site where he can use his/her available hours to obtain wood or gold. If he/she choose the wood, that wood is to share with his/her team in order to build a raft to escape from the island. If the player chooses gold, that gold is for his/her personal benefit.

The game has a lot of parametrizable values, for example, hours in a day, how much wood/gold is earned by one hour of ”work and so on. After the mini game is played the player should return to his/her team camp. When all players are in their team camps the day advances and the players have again available hours to spend in gathering resources. The user interaction is only with the mouse. This game is a point-and-click game.

3.1.1 Game Parametrization

In our game we have some configurable parameters. In this section we will present all the parameters that we can configure. This configurations are in a file called “invite.xml”. In this file we can configure:

- PlayerConfiguration, is where we set up the name of all players in the game and the number of players.

- TeamConfiguration, is where we configure a team. A team have some PlayerConfigurations (that are players) and a name.
- PlayerTimePerDay, This is the number of hours that one player has to spend in a single day.
- WoodPerTimeUnit, The player can achieve X units of wood, for each hour.
- GoldPerTimeUnit, The player can achieve X units of gold, for each hour.
- WoodRequiredForRaftCompletion is the number of wood units required to build the raft.
- NumberDaysUntilEruption is the umber of days before the volcano explodes the whole island.
- DistributionRule, this is the distribution rule. When a team ends a raft, the amount of wood will be divided equally by all team elements. Imagine a team of 3 elements: when the team ends the raft, all the three players in their final score will have 85 units of wood.
- GoldPerWood is where we can configure how much one unit of wood represents in gold units. The first team finishing the game can have a higher value. All of this is configurable here.

In the game we can also have a lot of other parametrizations like our own Logger and our own agents adding just a simple “dll” to the Agents folder.

3.2 Technologies and Tools

As we stated in the last section we implemented a game to test our agents, so we used a game development tool. We have many options, but for several reasons, including simplicity, good online support and a good community helping a lot with some details, we have chosen Unity3D[1].

We will try from now on to explain our implementation in a Top-Down approach (from a simple and abstract view to a detailed view). The simplest way to look at our system is by having Unity3D running only for graphics and game logic, and our agents will be running in a sandbox abstracted from the Unity3D code. To communicate between our agents and Unity3D we will use ION Framework with all the benefits we will explain in the next section. We can take a look at our simple architecture in figure 3.1.

[1] “Unity is the development environment that gets out of your way, allowing you to focus on simply creating your game. Developing for web, mobile, or console? Unity is the tool for the job” [33]

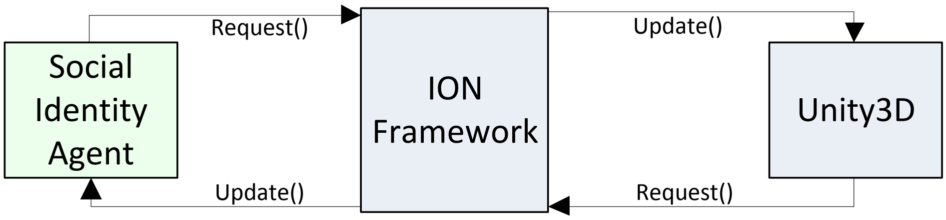


Figure 3.1: Our Agents and Unity3D communicating via ION Framework.

In the next section (3.3) we will take a closer look to ION Framework and all its benefits.

3.3 ION Framework

Now that we have chose the technology for the graphics, we have to take care of the development of the agents. Agents cannot be decoupled from their environment. To help us connecting Unity3D with our agents[2] we will use a framework developed at INESC-ID, GAIPS named ION Framework [7]. ION Framework is a framework for simulating virtual environments which separates the simulation environment from the realization engine[3]. In doing so, it facilitates the integration and reuse of the several components of the system.

As said in ION Framework paper, a virtual agent is by definition an entity that senses, reasons and acts within an environment [7]. Using ION Framework we can take advantage of many work done and tested by PhD students. With ION we can have a coherent access to information because all the modifications are made at the same time and because of that last point we can also have a mediation of conflicts and only commit that changes after applying some rule defined by us. With ION we can subscribe a particular bit of information which will be delivered later. They[4] use the observer pattern [34] to provide an event-driven paradigm. Similarly to what happens with Requests, Events are not processed immediately. Likewise, their handling is performed by Event handlers at a specific phase of the update cycle, the Process Events Phase. At that time all interventionists registered to get a particular Event are notified if that Event happened. In Figure 3.2 is shown the simulation update cycle with both phases.

While Requests are the desired changes to the simulation state, Events are the infor-

[2]Written in C#. A Microsoft Object Oriented Programming Language
[3]Unity 3D
[4]ION Framework team

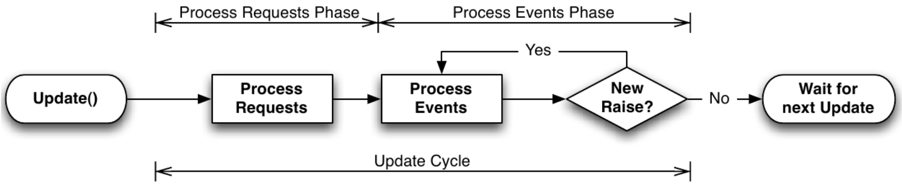


Figure 3.2: Update Cycle. Image from ION Framework paper [7].

mation of which changes effectively took place.

The ION Framework allows dynamic configuration changes and it is possible to completely change the simulation state behaviour in runtime. We can add or remove Elements to the simulation, but also change how these Elements inherently behave by modifying their Request Handlers.

Unfortunately ION Framework is not ready to work in a LAN(Local Area Network) with a server and multiple clients connected to the server. For this reason we invested a lot of time in “ION Framework Remoting”. “ION Framework Remoting” which is a normal ION Framework but distributed to many computers. In the next section we explain how we achieved this goal.

3.4 ION Framework Remoting

As we said in the last section we invested a lot of our time to transform ION Framework from a single-computer framework to a multi-computer framework. To achieve this we used Microsoft Remoting, a framework to access objects from another computer, or as said in Microsoft web site “One of the main objectives of any remoting framework is to provide the necessary infrastructure that hides the complexities of calling methods on remote objects and returning results. Any object outside the application domain of the caller should be considered remote, even if the objects are executing on the same machine...”[35].

One of our biggest problems was that “not all objects can be serialized”. Another of our biggest problems was how to throw events from the server to the client, because C# Remoting has numerous limitations. Those limitations were the reason why Microsoft created Windows Communication Foundation (WCF). We tested WCF but we have not used WCF, because Unity 3D does not really uses Microsoft C# but instead an open-source implementation called Mono, and Mono has some limitations with WCF that are not yet solved, but will be in a near future, so probably then we could migrate all of our work to use the new technology (WCF).

Throwing events from the server to the clients was our biggest problem, which we solved with a really simple solution: Remoting. We just put at the same time every client being also a server, but in another port, and when the real server needs to throw an event to the client, the server just calls the client in that server port.

When a client wants to be informed about a change in the server, that client should register his intention in the server giving it a function to be called, and when that action happens in the server, the server should call all the registered clients in that event/action. This works like a simple publisher-subscriber system, which is not possible in a standard C# Remoting application, without all the clients being at the same time “false” servers.

3.5 ION Framework in Unity3D

The ION Framework is integrated in Unity3D by adding the ION Framework’s DLLs or source files (in C#) directly into Unity3D’s application assets. Further, this integration is supported by script Components (in C#) whose purposes are to define the Entities, Properties and Actions and maintain a link with those elements in the ION simulation.

Therefore, we can design the simulation’s environment by attaching these Components to Game Objects. In the next section we describe some of the most important concepts (from ION) that we have used in INVITE.

3.5.1 ION Framework concepts and abstraction

In this section we will try to be as simple as possible.

ION Framework has lots of concepts, but the most important ones for our game are those related with *Locales*, and *Effectors*. In ION Framework a *Locale* is a physical space, ION has a default place called ‘*World*. In INVITE we have created more *Locales*. We created inside the *World* a Locale called *Island*, and inside the Island we have created *CampSite* Locales (one for each team) and *ResourceSite* Locales, here again, one for each team.

ION Framework has another important concept, *Effector*. In INVITE every action we do is an *Effector*. We have *MultipleStepEffector* and *SingleStepEffector*. A *MultipleStepEffector* is something that persists in the time, like walking from site “A” to site “B”, it takes some seconds. For walking we have an Effector called *Mover* and it receives an ION *Action* called MoveTo. We have also other *MultiStepEffector* called *MiniGamePlayer*, this is used by our agents, to play a MiniGame with a given delay. That *MiniGamePlayer* calls other two *SingleStepEffector* called *GoldMiner* and *WoodCutter* and both receive actions with the values of gold/wood.

We have also much more *Actions* and *Effectors*, and for more details you should read the INVITE Project page [1].

Just as a quick demonstration of concepts in the next section we present our Time Logger Framework that was easily integrated with our game because we used a lot of abstractions.

3.6 Time Logger Framework

A counter is started when the player stops and when the player starts to move. Those values are recorded in a file. This is really useful because we can make our agents repeat the exact amount of time spent by Human people in different occasions. For more details the framework is presented in figure 3.3.

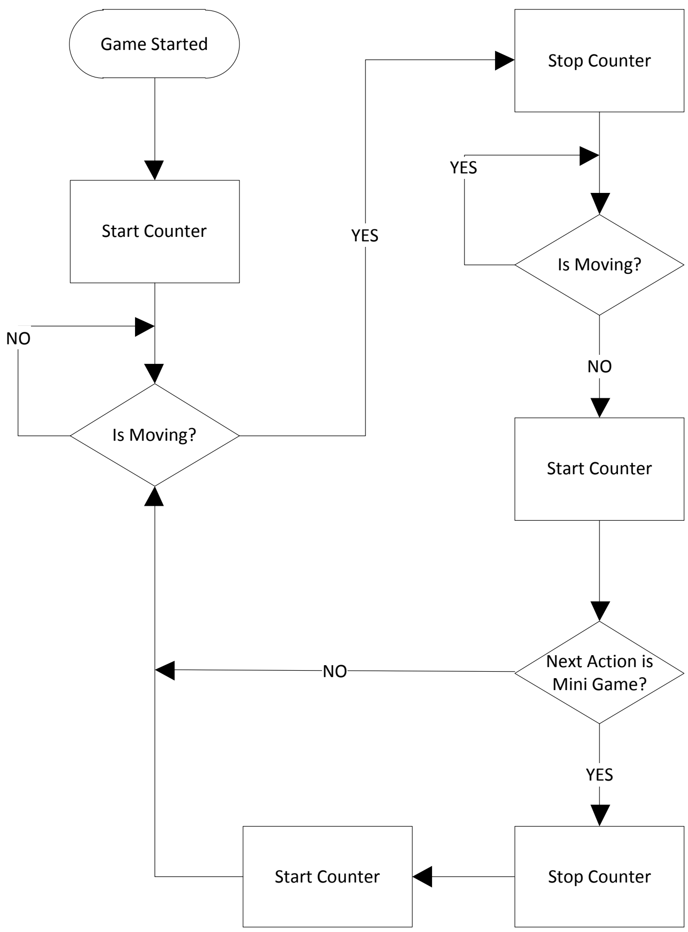


Figure 3.3: A flow chat of our Time Logger Framework

3.7 Testing framework

To make our task of testing easier we created what we called the FileReaderAgent. This is basically a simple framework that gives us the possibility to repeat the tests. We create a file ".txt" with the name of the player for example "Bruno.txt" and then the agent with that name will read the file and make its actions based on this. The actions we have in this ".txt" are actions that the human players have done (or could actions that we wrote on the txt). Then we put our agents and observe the results. We should say that our framework just for an integrity of results will use the first value (first day) from the txt and not the value calculated by the agent. With that we can easily monitor our agent after the first round. We can also turn that feature off, but in this thesis we will stay with that feature turned on. So in the final results of this thesis in the first day our agents will have the same result as the human players. With that will be easier to understand our agents behaviour.

We did all our tests (even if it is not important) in a machine with the following specifications:

- Pentium 4 2.8Ghz
- 768MB of ram
- On-Board Graphics Nvidia 6200 Series
- Windows 7 32bits.
- 40GB Hard-Drive 5400RPM.

With this specifications we can show how well optimized is our game, it runs at about fifteen Frames Per Second in a ten years old computer.

3.8 Summary

In this chapter we present our architecture for the INVITE Game. We used a lot of technology that helped us to achieve our final result, like Unity3D and ION Framework. We also created to frameworks for testing purposes, the Time Logger Framework and the FileReaderAgent to help us repeat the results in different games. In the next chapter we present you the model we will use to program our agents. We also give you some implementation details about our agents.

4

Social Model and Agent Implementation

Contents

In the previous chapter we explain our game. In this chapter describe the model we have implemented to overcome the problem our work tries to solve:

"How can autonomous agents be believable with a sense of social identity?"

Each element in the model will be described and representative examples will also be given to illustrate their mechanism.

4.1 Agent Model

As many agents based models our model has sensors and effectors as described in figure 4.1.

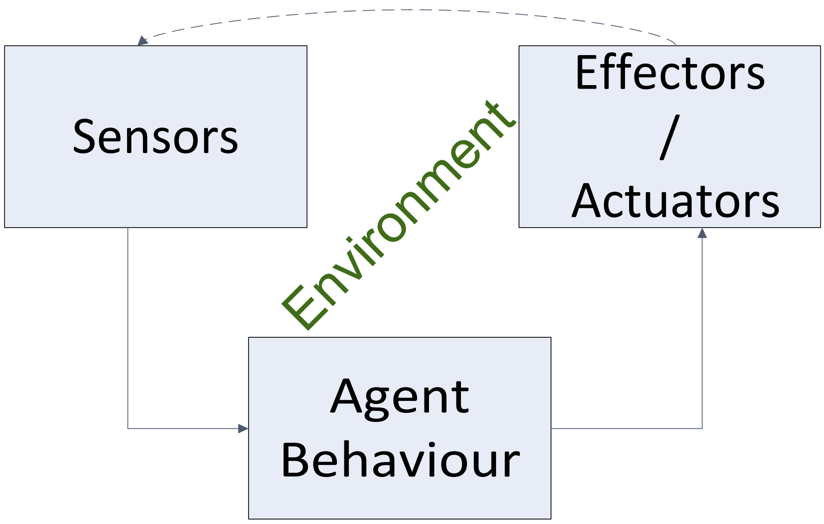


Figure 4.1: Sensors and Effectors

The sensors feel the world modifications and the actuators/effectors make changes in the world. Every single action that the agent does with its effectors will be felt in his sensors. That is also a simple way to check if the agent modifications have some effect in the world where the agent is.

At this point we have sensors and actuators, but we need something to process the inputs, felt by the sensors, and make a decision in what action should be done by the effectors. For now we will explain our model in a very simple way and we will explain how each sub-module relates to each other and what each module specifically does.

Our model is presented in figure 4.2.

As promised, in the next sections we will explain each module and how they relate to each other.

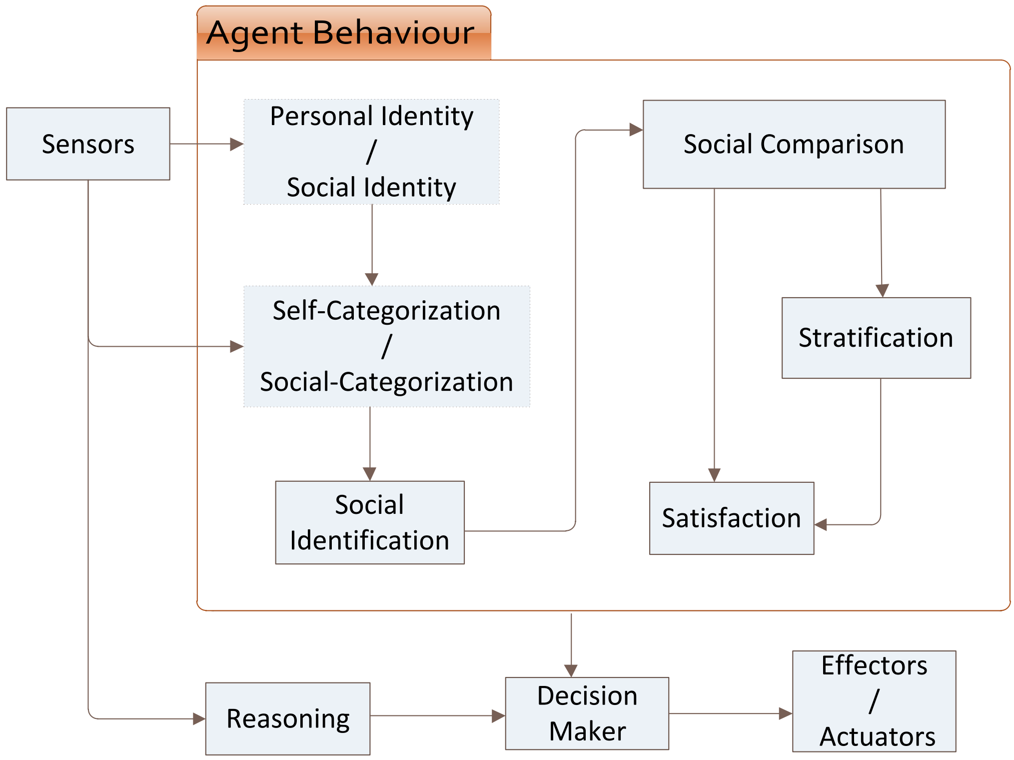


Figure 4.2: Our Agent Model Proposal

4.1.1 Personal Identity / Social Identity

As persons we can have multiple social identities depending on the context or group. We can say that salience of an entity is a product of accessibility and fit [21]. We studied this in section 2.3 where we explained what salience, fit and accessibility are with some examples.

After this brief introduction we should say that this module are not part of this thesis work. We just use parameters to simulate this module. That parameter has a range from zero to two, $[0, 2]$. If we used the value zero our agent only play gold, but if we chose 2 it only plays wood. This parameter acts like a multiplier in our solution, after all the other modules calculates his values we multiply this parameter with the other parameters result and then we obtain our agent output, before the reasoning module, but we will talk about our reasoning module later in this chapter. Just to clarify, if we want to play with our agent in "neutral" mode we should use the value one (1) for this parameter.

4.1.2 Self-Categorization

As we studied in our related work Self-Categorization causes people to think of them-selves less as unique individuals and more as relatively typical members of a group, and they act accordingly[19]. They see themselves as having the characteristics associated with group memberships, and they act as they believe group members should act [19].

We categorize people in general, including ourselves, in order to understand the social environment we are in. We do this everyday because if we put people in categories we know what type of person he or she is. We try to do the same exercise in ourselves and observe in what categories we fit in, to really understand ourselves, and what type of person we are. This as the last module is part of building a personality and is not part of this thesis. This thesis only uses existing personalities and play games based on that personalities. The creation of groups is defined by the person that creates the experience (the XML file).

4.1.3 Social Identification

This is where our thesis really starts, we have an entity of a person formed, so our agents can use it and play a complete game. The first module of our chain of modules is Social Identification.

As we stated in section 4.1.2 we categorize ourselves in groups, and this is what social identification is all about. Sometimes we adopt attitudes (and identity) based on the groups we think we belong to. When our identification with a particular group is salient we start to talk, to act, and to do a lot of things like the group [17].

In our implementation to the INVITE Framework we take basic approach to this issue. As we studied, social identification is where we identifies (or not) with our group. In this particular game the most evident aspects of comparison are the wood and the gold. Because we don't have access to our team mates gold we should compare our wood with the average of wood gathered by our team mates.

So, based on the last paragraph our agent in this module look at his contribution to the team wood and sees how much wood (in average by player) the rest of the team have gathered. Obviously if this module is just that, when we put more than one agent playing against each other in the end they are all playing the same amount of wood and that is the basis of social identity. But in this particular scenario (our game) we don't want that, and that's why we also has our reasoning module. To solve that issue we gave different percentages depending in how much days have passed.

Just to clarify, let's imagine that we are at the end of the second day, we are in a team of three players and our team have a total of 30 units of wood. For this example our team have gathered 15 units of wood in the first day and 15 in the second day. Let's imagine that we played in the first day 7 units of wood and in the second day we have played 1 unit of wood, for example. In this scenario most of us will decide what to play in the third day looking at the day number two with a higher importance, and probably we will play more wood than in the second day. To do that type of human behaviour in this module our agent does the following solution. Our agent does $7+1=8$ which is the amount of collaboration that we have in the team. Our agent does another math it see that to be in the average he should have played $(15+15)/2=15$. That our agents sees that in the last round he has played just 1 unit of gold and is team mates have an average of 7.5, $(15-1)/2=7$. Then our agent converts everything for percentage ($results/hoursintheday$) and multiplies by x the percentage of the last day and by y the percentage of the all time. That result of that math will be a result between zero and one, which will be multiplied by the total of hours in a day and passed to the next module. The output of our modules are always the value of wood they will play if "they are alone" in the conceptual module, without any other modules. In our initial user tests we have calculated that the value of x is 0.7 and the value of y is 0.3. Obviously that this values could change with different sets of users.

4.1.4 Social Comparison, Stratification and Satisfaction (Self-Esteem)

Social comparison happens when we have categorized ourselves as part of a group and have identified with that group, then we tend to compare that group with other groups. If our self-esteem is to be maintained our group need to compare itself with other groups. This is critical to understand the prejudice, because once two groups identify themselves as rivals they are forced to compete in order for the members to maintain their self-esteem. Competition and hostility between groups is thus not only a matter of competing for resources like jobs, but also the result of competing identities [12].

Let's start by the easiest module to understand, the Stratification module. In this module our agent just take into account all teams "raft completion" and calculates by how much our team is in the lead or behind. This value will be the simplest to calculate. Imagine that our team has an advantage of 25 units of wood and the the amount of wood necessary to complete the raft is 255 for example, this module will produce an output of $25/255 = 0,098$. This value will be used later to calculate the difference to the other teams and if we are losing by an higher difference our agents will tend to play more and more wood. If our team is winning and the advantage is huge our agents will tend to play less and less wood. Obviously if an agent or player play less wood he/she will play more gold. Just to clarify, if we are losing the game by 25 units of wood the result will be $-25/255 = -0,098$. In this module we don't take into account the amount of wood needed to complete the raft, that factor will be calculated in our agent's Social Comparison module and also in the Reasoning Module.

Our Social Comparison module has almost the same maths of our agent's social identification module, but this time our agent compare his/her team with the other teams. Our agent's Social Comparison module only sees if his/her team is in the leading. If it is leading the game the math will be $value = (0.5 - advantage) * cooperationVariable$, if the agent's team is in the second position (of lower) the math will be $value = (1.2 + advantage) * cooperationVariable$. The advantage variable is what we have calculated in the stratification Module and cooperationVariable is what we have defined as our parameters (from Joana work).

Our Satisfaction module will only gather the values calculated in our social comparison module (that uses the Stratification module) and our Social Identification module and multiply that factors (percentages from 0 to 100%) by the amount of hours in a day and obtain the value to be played by our agent, but this could not be the final output of our agent, because the Reasoning module can change the values.

4.1.5 Reasoning

This module as stated in the previous sections has his opportunity to take into action only after all the other modules have done its work. This module has a complicated task, but we will try to explain it in a simple way. This module take into account the values calculated in the stratification module (not the final value in percentage, but the real values, for example, 175 units of wood "vs" 200 units of wood). This module will see if our team can end the game in this day, and if it's possible this module will calculate if it is possible to end the day with just one "player" and if its the case, this module will pass an information to the decision maker to ignore all the other information and use the Reasoning information.

4.1.6 Decision Maker

Taking in count all the previous modules the agent will decide what is his next decision choosing between the best possible solution (Reasoning) and the agent behaviour decision, depending on his social feelings. The Decision Maker module will be like a police officer controlling the traffic in a road. In other words, the decision maker will choose between the agent behaviour or reasoning. As a summary we can say that our decision maker will only choose reasoning when our reasoning module passes the information that our team can end the game in this day. But again, the cooperation variable that we have described some sections before, has an important role, because the result given by the Reasoning module will be multiplied by that factor and the result of the other modules will be multiplied by $1 - cooperationVariable$.

4.2 Summary

Our agent is an extension of ION Framework, more accurately from IPlayer presented in INVITE Framework. We have implemented our agent on our related work. We have two points that we want to explain. The first one is the cooperation parameter and the second one is how our social comparison module works in more detail.

For the cooperation parameter it is only a parameter between 0 and 2 that will make the agent be more or less cooperative with his/her team mates. When all the calculations are done we multiply the value obtained by the cooperation parameter, if the parameter is 0, the agent will always play 0 wood and 12 gold. If the parameter is 1 then the output is the "neutral" values. If we put the parameter to 2, that doesn't mean that the agent will play always 12 wood and 0 gold. That is not true!

The person who is controlling the agents can always increase/decrease this value. Let's now talk about some values to have a clear idea what this parameter does.

We hope that what the cooperation parameter does is now clear. The second point that we want to explain is the social comparison module. Just to simplify the explanation we calculate in what position our team is, and if we are in the lead we tend to be happier with our team but at the same time something tells us to play more gold than wood. To overcame this, in the social comparison module we included a parameter that varies with our leading distance to the second team. If our distance is huge we will tend to play more and more gold, but if the difference is smaller or we are losing the game we tend to play more and more wood. Obviously this will be balanced with the cooperation parameter and hopefully we can have the same behaviour with our agents as the players that we observed.

5

User Tests

Contents

Before we can test our agents we need to retrieve some information from a small group of users. For this purpose we used our TimeLogger framework to look and record the users actions. This implementation is explained in section 3.6. In addiction to the TimeLogger we are also recording the mini game values. In section 5.3 we show and explain our results and how we will use them.

5.1 Time for some tasks

In order to create believable synthetic character we also need to give them other Human characteristics, like the time to do a specific task. To achieve this requirement we have done some tests with users to retrieve that information. The results presented in the next tables were given to our agents in order to increase their believability. In table 5.1 we show the time that one person takes before the game starts and his/her first move. We observed that behaviour 70 times. In table 5.2 we can see how much time one person waste before play the mini-game, it's the time that one person take to think and play the game. For this table we recorded 389 actions, which means, 389 mini-games played. In the third table (number 5.3) we can observe how much time a person takes to start moving after some other action. For example after a mini game was played the person takes some time. We have registered 717 of this actions.

Average	8,51 seconds
Standard deviation	5,28 seconds
Variance	25,78 seconds
Max	27,34 seconds
Min	2,13 seconds
Sample Size	70 Actions

Figure 5.1: Time before the first action

This results will be really useful for our final agent, because all those small details can be a huge boost to increase the agent's believability. We could only focus our attention on the agents actions, but we think that these small details make all the difference in the "final product". Even if our agents do Human actions, if it takes them less than a second (for example) to do everything, it won't be that believable for the Human players. Our main focus in this thesis is how to create believable synthetic characters, so in our opinion, we must give the needed attention to details, even if they are small.

Observing all the data we see that the average time for every action is almost the same, but the standard deviations are really different. In "time to decide where to go"

Average	7,73 seconds
Standard deviation	4,04 seconds
Variance	16,29 seconds
Max	36,14 seconds
Min	1,95 seconds
Sample Size	389 Actions

Figure 5.2: Time to think before a Mini-Game

Average	7,51 seconds
Standard deviation	7,57 seconds
Variance	57,28 seconds
Max	58,77 seconds
Min	0,79 seconds
Sample Size	717 Actions

Figure 5.3: Time to decide where to go

is where we observed the biggest deviations from the average result, and that could be an interface error in our game, because the users have to use the mouse's right button which is not really a standard in the video game industry, so we should change it and make another set of tests in the future, and hope for better results in that particular area.

5.2 Complete Scenario for Tests

Now that we have described all the aspects of the game, the agents' architecture, the application and the system that integrates these two aspects, we can present an example of a complete scenario of the working system. In this section, we begin by introducing the illustrative scenarios. We have four different scenarios to have a larger set of information for our tests, but we won't present the fourth set in this thesis. In the three scenarios we have a lot in common between them. In the next section we will present a scenario that is the base for the other three scenarios. Attention, this "standard scenario" is just to help us explain the other three, this is an abstract scenario, not a concrete scenario.

5.2.1 Standard Scenario Description

In the game we can have a lot of configurable parameters as we have explained, but most of them were the same between our different two tests. The Following parameters were the same between all the two scenarios.

- PlayerTimePerDay = 12; This is the number of hours that one player has to spend in a single day.
- WoodPerTimeUnit = 4; The player can achieve 4 units of wood, for each hour.
- GoldPerTimeUnit = 2; The player can achieve 2 units of gold, for each hour.
- WoodRequiredForRaftCompletion = 255; Number of wood units required to build the raft.
- NumberDaysUntilEruption = 8; Number of days before the volcano explodes the whole island.
- DistributionRule = Egalitarian; This is the distribution rule. When a team ends a raft, the amount of wood will be divided equally by all team elements. Imagine a team of three elements: when the team ends the raft, all the three players in their final score will have 85 units of wood.
- NumberOfPlayersByTeam is two (2).
- NumberOfTeams is two (2).

In the next section we will only explain what is different from the standard scenario. This standard values were obtained after a series of user tests.

5.2.2 First Scenario Description

In this scenario the users just have the result of the other team in the end of the game. For the winning team the value of the raft will be multiplied by five (5). All players are Human Players. The amount of wood to complete the raft is two hundred and twenty five (225). With this kind of scenario we want to see how Humans react with what we called social identification, in other words, we want to measure how the players react to the fact of only knowing that they have x days for the end of the game and his/her team mates are playing y units of wood. In this scenario the players don't have anything to measure their social comparison, and stratification. This scenario is really useful, because the players are just using social identification. Again, we should refer that the only feedback that the players had during the game was his/her team mate wood. They obviously know after one game ends, their score and the other team score, so that worked as a priming message for the next game.

5.2.3 Second Scenario Description

In this scenario the users will have the results of the other teams after each round. For the winning team the value of the raft will be multiplied by two (2). All players are Human Players. The amount of wood to complete the raft is two hundred and fifty five (255). The players have social identification between each team mates and social comparison between different teams.

5.3 User Results

In the next sections we will show all the results that we achieved with user tests. In the next chapter we will put our agents in the place of a person and see what does our agent. This section is really important, because we used this results to test our agents.

In the next charts we have the first and second scenario results. In the left side of each image we have Team 1 and in the right side we have Team 2. The labels represented in the charts are the following:

- Wood All is the total (accumulation) wood that the corresponding team has in the previous day. The value in the third day is actually the value that the team achieved in day one plus day two.
- Wood Rd. is the total wood that the team achieved in the previous day (only in the previous day, this is not the accumulation of all days).

Just as a brief note the Figure 5.4 represents the labels of the x and y in the next charts. Just another brief note, in the following graphics we will not show the gold of each player because the charts weren't legible that way, but the maths are simple, the player with more wood, has less gold, and vice-versa.

5.3.1 First Scenario Results

After analysing the first group of tests, we have analysed that the players have tried to play more wood than the average wood by the other team in the last game. We can see an increasing value of wood by round in the games, so they used the social comparison, even if they don't know the other team result during the game. The last games have a considerable less number of rounds which means that the players have played more wood than in the first couple of games.

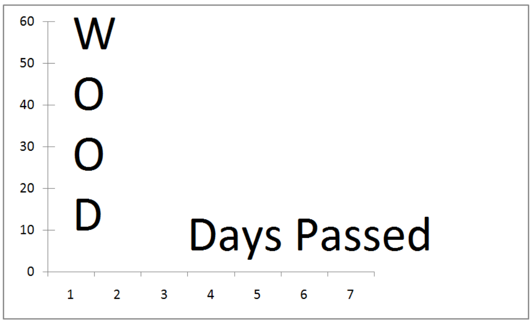
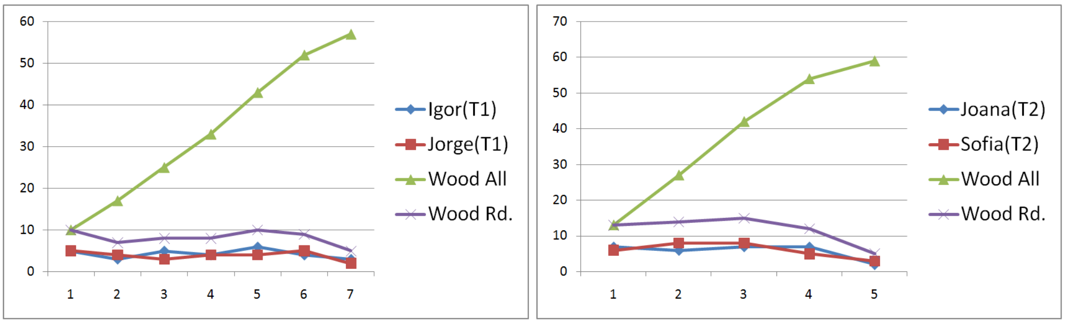


Figure 5.4: Label of the following graphics.



Igor(T1)	5	3	5	4	6	4	3	
Jorge(T1)	5	4	3	4	4	5	2	
Wood All	10	17	25	33	43	52	57	
Wood Rd.	10	7	8	8	10	9	5	57
W. Average	5	3,5	4	4	5	4,5	2,5	4,1

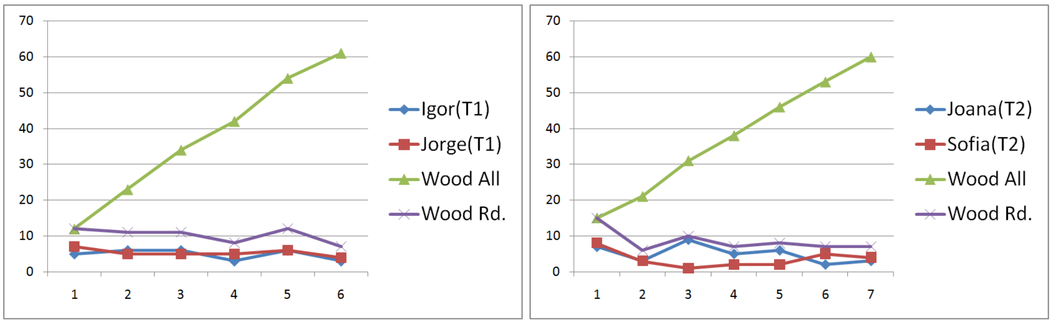
Joana(T2)	7	6	7	7	2	
Sofia(T2)	6	8	8	5	3	
Wood All	13	27	42	54	59	
Wood Rd.	13	14	15	12	5	59
W. Average	6,5	7	7,5	6	2,5	5,9

Figure 5.5: First Game, First Group of Tests.

We can also see that the players have played based on the last round of their partners. With the last sentence we want to focus that if in the last round my team mate has played more wood than me, in the next round I will play more wood and obviously he will decrease his amount of wood played. This is proved by the graphics where the lines are always crossing. We can see that the players are also taking into account the average value of wood played by the other team in the last round, and in many cases they have that in mind. Even if they were playing with social comparison from the last round the social identity is stronger, so we can also consider it like a “unit test” for our social identification module.

We can also see that some players are focused in the priming message and tried to win the game even if their team mates were not cooperating. In these cases they used social comparison, or they are really cooperative persons, which is also possible. A good example of our last sentence is the chart 5.7, where Igor has tried to compensate Jorge’s desire to win at any cost.

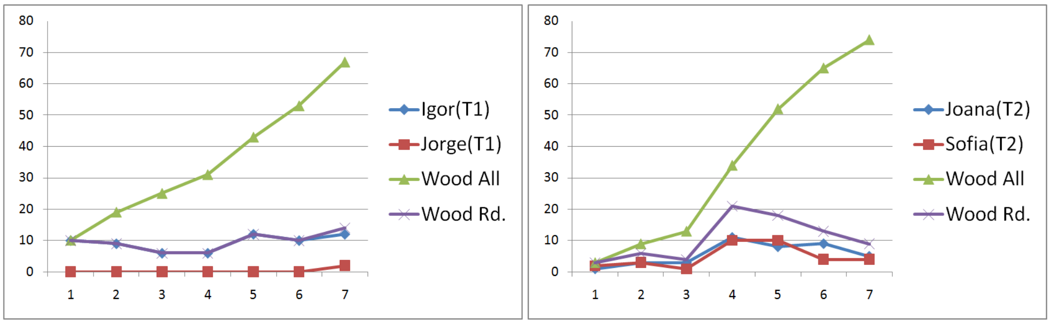
In the next chapter corresponding to this tests we will try to simulate the behaviour observed here. We observed three types of behaviours, first the “crossing one” that we



Igor(T1)	5	6	6	3	6	3	
Jorge(T1)	7	5	5	5	6	4	
Wood All	12	23	34	42	54	61	
Wood Rd.	12	11	11	8	12	7	61
W. Average	6	5,5	5,5	4	6	3,5	5,1

Joana(T2)	7	3	9	5	6	2	3	
Sofia(T2)	8	3	1	2	2	5	4	
Wood All	15	21	31	38	46	53	60	
Wood Rd.	15	6	10	7	8	7	7	60
W. Average	7,5	3	5	3,5	4	3,5	3,5	4,3

Figure 5.6: Second Game, First Group of Tests.



Igor(T1)	10	9	6	6	12	10	12	
Jorge(T1)	0	0	0	0	0	0	2	
Wood All	10	19	25	31	43	53	67	
Wood Rd.	10	9	6	6	12	10	14	67
W. Average	5	4,5	3	3	6	5	7	4,8

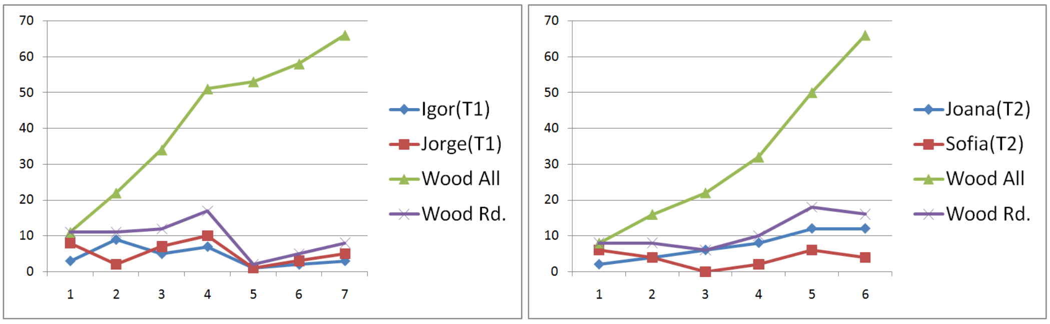
Joana(T2)	1	3	3	11	8	9	5	
Sofia(T2)	2	3	1	10	10	4	4	
Wood All	3	9	13	34	52	65	74	
Wood Rd.	3	6	4	21	18	13	9	74
W. Average	1,5	3	2	11	9	6,5	4,5	5,3

Figure 5.7: Third Game, First Group of Tests.

can see for example in figure 5.5. The second one is the really cooperative player like Igor in 5.7 and the third one could be an attitude like Jorge in the same game, a player with the desire to risk everything, he can win everything or lose everything.

5.3.2 Second Scenario Results

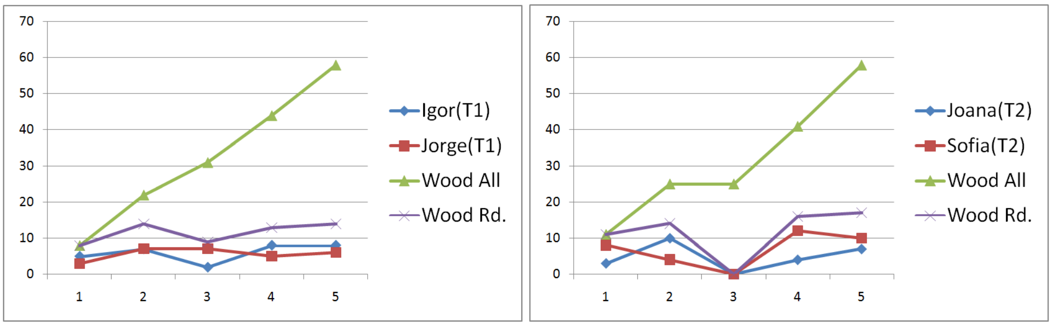
In this group of tests the players had access to the information of the other team wood in every round.see by observing all charts, the lines are crossing almost in every round (players and teams). The players tend to play more and more wood when their team is losing the game (the team has less wood than the opponent team). This is not because they are really happy with his/her team, but because his social comparison says that his/her team is losing the game. The team tends to play less and less wood when they are winning (same reason as before). When a team is leading, its players tend to play



Igor(T1)	3	9	5	7	1	2	3	
Jorge(T1)	8	2	7	10	1	3	5	
Wood All	11	22	34	51	53	58	66	
Wood Rd.	11	11	12	17	2	5	8	66
W. Average	5,5	5,5	6	8,5	1	2,5	4	4,7

Joana(T2)	2	4	6	8	12	12	
Sofia(T2)	6	4	0	2	6	4	
Wood All	8	16	22	32	50	66	
Wood Rd.	8	8	6	10	18	16	66
W. Average	4	4	3	5	9	8	5,5

Figure 5.8: Fourth Game, First Group of Tests.



Igor(T1)	5	7	2	8	8	
Jorge(T1)	3	7	7	5	6	
Wood All	8	22	31	44	58	
Wood Rd.	8	14	9	13	14	58
W. Average	4	7	4,5	6,5	7	5,8

Joana(T2)	3	10	0	4	7	
Sofia(T2)	8	4	0	12	10	
Wood All	11	25	25	41	58	
Wood Rd.	11	14	0	16	17	58
W. Average	5,5	7	0	8	8,5	5,8

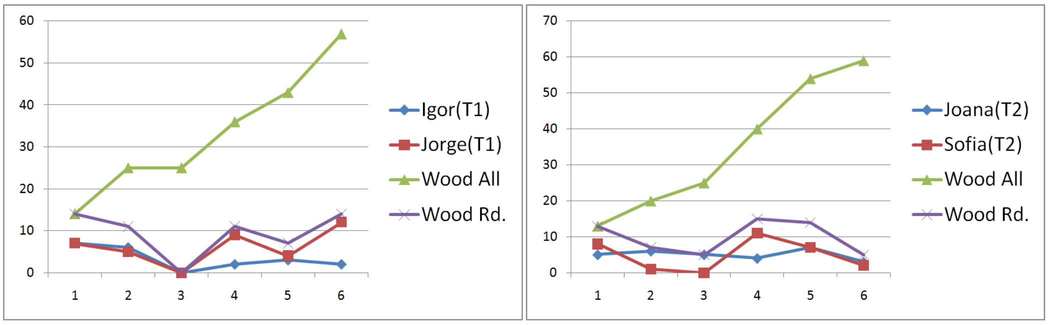
Figure 5.9: Fifth Game, First Group of Tests.

less and less wood, and that is quite logic if we thing about it.

Inside every team the players are always trying to compensate their team mate. The teams are crossing wood lines and the players in each team have an interesting behaviour. In team 1 Pedro is not cooperating, but Joao tries to compensate the Pedro's behaviour. In Team 2 the players are always crossing his wood lines. In this game we have also to say that we won't be able to simulate the last two rounds of team 2, because it is a particularity of this specific game and our agents doesn't cover every specific cases at the moment, maybe in a near future we can improve the agents to do so.

5.4 Summary

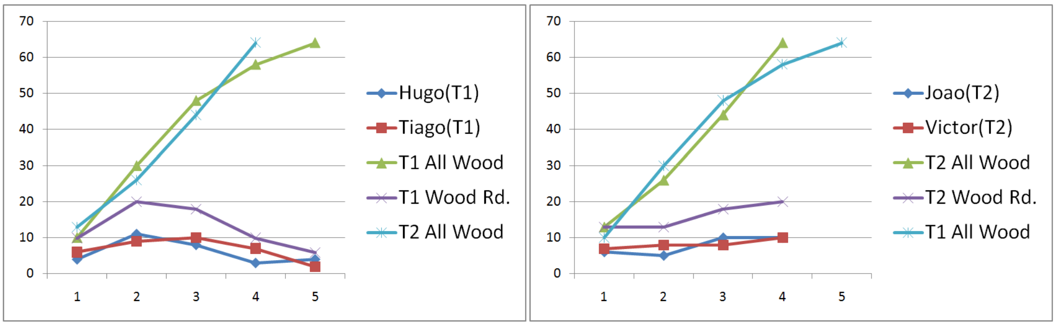
In this chapter we have presented the two main scenarios. These are the scenarios that we will use to test our agents in the next chapter. We are really interested in tests



Igor(T1)	7	6	0	2	3	2	
Jorge(T1)	7	5	0	9	4	12	
Wood All	14	25	25	36	43	57	
Wood Rd.	14	11	0	11	7	14	57
W. Average	7	5,5	0	5,5	3,5	7	4,8

Joana(T2)	5	6	5	4	7	3	
Sofia(T2)	8	1	0	11	7	2	
Wood All	13	20	25	40	54	59	
Wood Rd.	13	7	5	15	14	5	59
W. Average	6,5	3,5	2,5	7,5	7	2,5	4,9

Figure 5.10: Sixth Game, First Group of Tests.

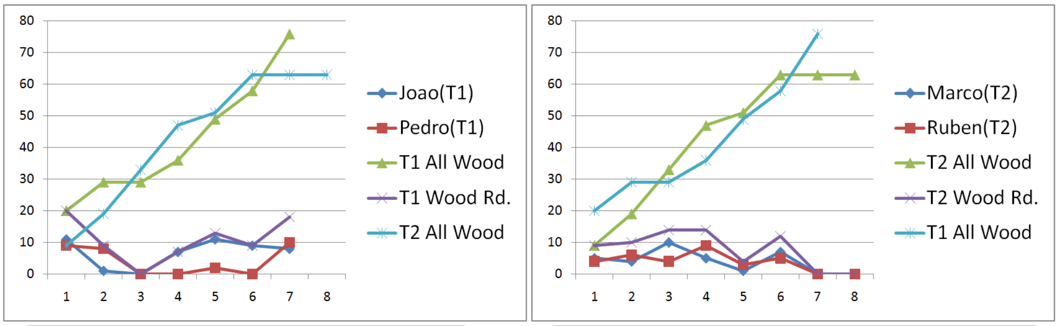


Hugo(T1)	4	11	8	3	4
Tiago(T1)	6	9	10	7	2
T1 All Wood	10	30	48	58	64
T1 Wood Rd.	10	20	18	10	6

Joao(T2)	6	5	10	10
Victor(T2)	7	8	8	10
T2 All Wood	13	26	44	64
T2 Wood Rd.	13	13	18	20

Figure 5.11: First Game, Second Group of Tests.

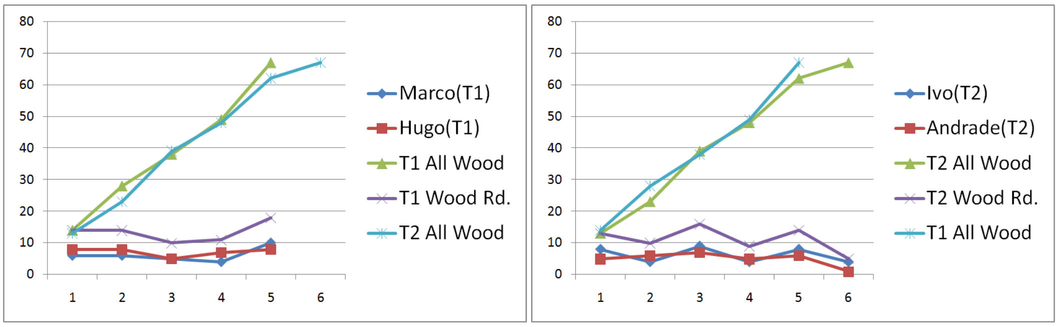
where we see crossing lines (crossing lines between team mates and teams).



Joao(T1)	11	1	0	7	11	9	8
Pedro(T1)	9	8	0	0	2	0	10
T1 All Wood	20	29	29	36	49	58	76
T1 Wood Rd.	20	9	0	7	13	9	18

Marco(T2)	5	4	10	5	1	7	0	0
Ruben(T2)	4	6	4	9	3	5	0	0
T2 All Wood	9	19	33	47	51	63	63	63
T2 Wood Rd.	9	10	14	14	4	12	0	0

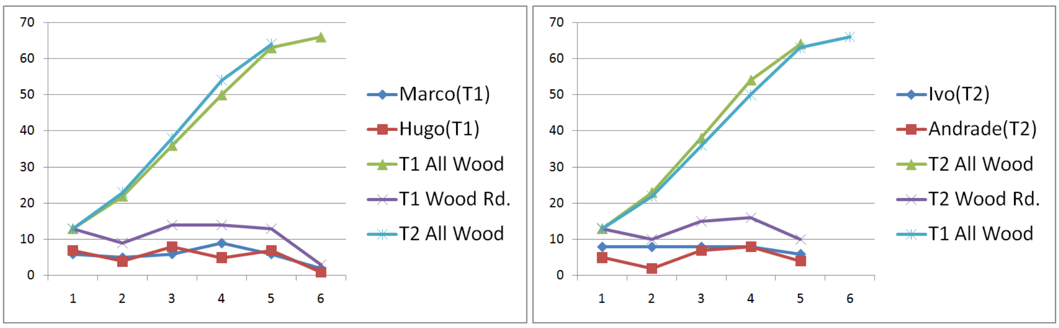
Figure 5.12: Second Game, Second Group of Tests.



Marco(T1)	6	6	5	4	10
Hugo(T1)	8	8	5	7	8
T1 All Wood	14	28	38	49	67
T1 Wood Rd.	14	14	10	11	18

Ivo(T2)	8	4	9	4	8	4
Andrade(T2)	5	6	7	5	6	1
T2 All Wood	13	23	39	48	62	67
T2 Wood Rd.	13	10	16	9	14	5

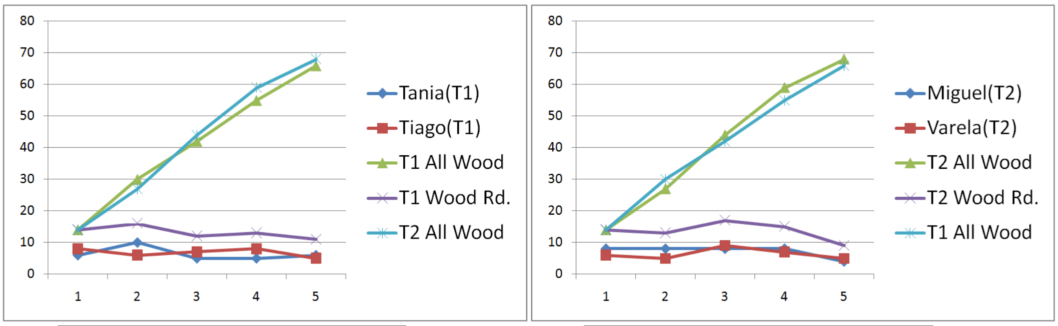
Figure 5.13: Third Game, Second Group of Tests.



Marco(T1)	6	5	6	9	6	2
Hugo(T1)	7	4	8	5	7	1
T1 All Wood	13	22	36	50	63	66
T1 Wood Rd.	13	9	14	14	13	3

Ivo(T2)	8	8	8	8	6
Andrade(T2)	5	2	7	8	4
T2 All Wood	13	23	38	54	64
T2 Wood Rd.	13	10	15	16	10

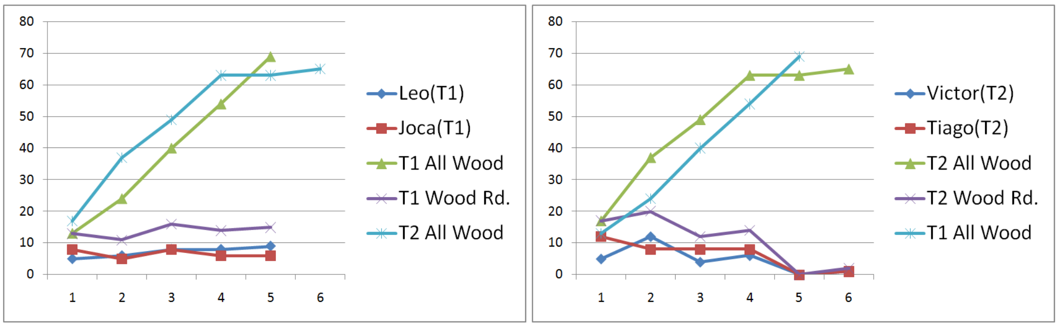
Figure 5.14: Fourth Game, Second Group of Tests.



Tania(T1)	6	10	5	5	6
Tiago(T1)	8	6	7	8	5
T1 All Wood	14	30	42	55	66
T1 Wood Rd.	14	16	12	13	11

Miguel(T2)	8	8	8	8	4
Varela(T2)	6	5	9	7	5
T2 All Wood	14	27	44	59	68
T2 Wood Rd.	14	13	17	15	9

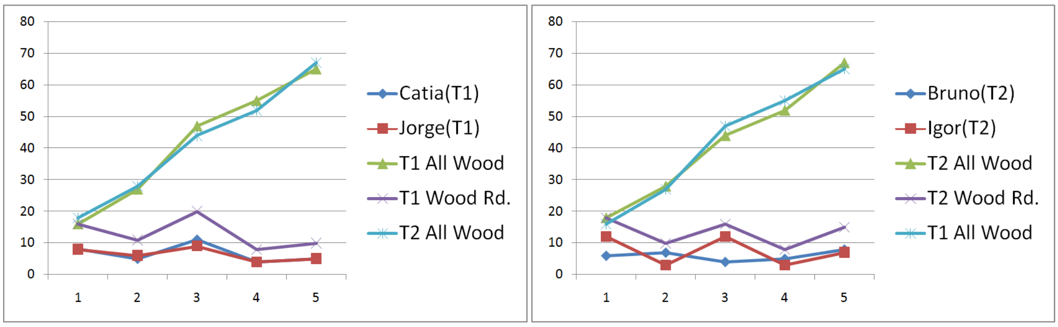
Figure 5.15: Fifth Game, Second Group of Tests.



Leo(T1)	5	6	8	8	9
Joca(T1)	8	5	8	6	6
T1 All Wood	13	24	40	54	69
T1 Wood Rd.	13	11	16	14	15

Victor(T2)	5	12	4	6	0	1
Tiago(T2)	12	8	8	8	0	1
T2 All Wood	17	37	49	63	63	65
T2 Wood Rd.	17	20	12	14	0	2

Figure 5.16: Sixth Game, Second Group of Tests.



Catia(T1)	8	5	11	4	5
Jorge(T1)	8	6	9	4	5
T1 All Wood	16	27	47	55	65
T1 Wood Rd.	16	11	20	8	10

Bruno(T2)	6	7	4	5	8
Igor(T2)	12	3	12	3	7
T2 All Wood	18	28	44	52	67
T2 Wood Rd.	18	10	16	8	15

Figure 5.17: Seventh Game, Second Group of Tests.

6

Results

Contents

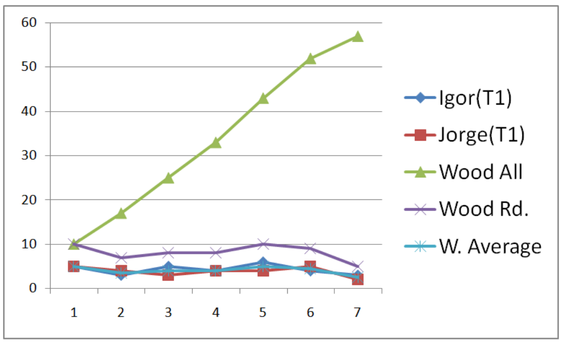
6.1 Evaluation Plan and Results

Our evaluation plan uses the same scenarios described in the last chapter in section 5.2. We will use a game that was played by humans in the first scenario and a game played in the second scenario. As we stated in the last chapter the third and fourth scenario of tests was only to gather information and not to test our agents. In the next section we will introduce again the games that we thought are more important and reflects the majority of behaviours. We will present a figure by each player that our agent want to represent (4 figures by each game). In the same figure and to save space and increase the legibility of the document we will represent the parameter cooperation in 3 different values by each player. The values are:

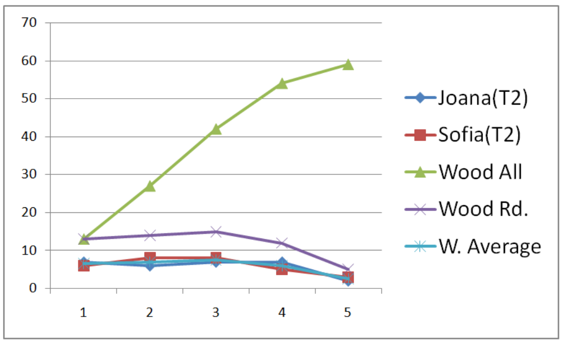
- 0.7, less cooperative agent
- 1, our agents normal behaviour
- 1.3, more cooperative agent

6.1.1 Results - Scenario 1

In this scenario as we stated in the last chapter we will try to simulate the player behaviour. We will give three different values of cooperation and see which one fits best to each player. We should say that in this test the agents doesn't know anything about the other team's wood. The following images represents a set of tests with the same persons in the same teams. The only feedback that the players and agents had during the game was his/her team mate wood. They obviously know after one game ends, their score and the other team score, so that worked as a priming message.

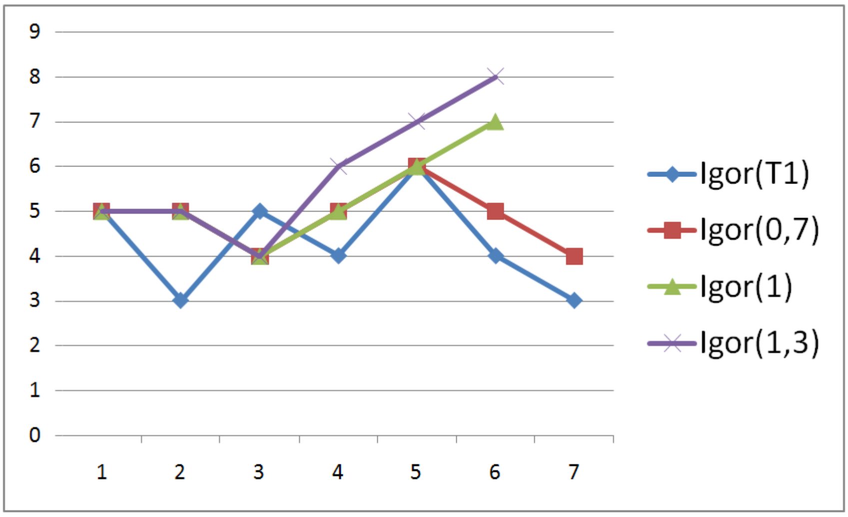


Igor(T1)	5	3	5	4	6	4	3	
Jorge(T1)	5	4	3	4	4	5	2	
Wood All	10	17	25	33	43	52	57	
Wood Rd.	10	7	8	8	10	9	5	57
W. Average	5	3,5	4	4	5	4,5	2,5	4,1



Joana(T2)	7	6	7	7	2	
Sofia(T2)	6	8	8	5	3	
Wood All	13	27	42	54	59	
Wood Rd.	13	14	15	12	5	59
W. Average	6,5	7	7,5	6	2,5	5,9

Figure 6.1: The game we will try to simulate



Igor(T1)	5	3	5	4	6	4	3
Igor(0,7)	5	5	4	5	6	5	4
Igor(1)	5	5	4	5	6	7	
Igor(1,3)	5	5	4	6	7	8	

Figure 6.2: Igor with three possible values of cooperation

After analysing all the three values in the graphics we can see that our agents have really nice results. We should refer that our best results are obtained with our value of cooperation in 0,7.

In Igor all the three approaches have good results but we can see that the Igor(0,7) has the closer line to Igor(T1), so this one is the one that best represents Igor behaviour.

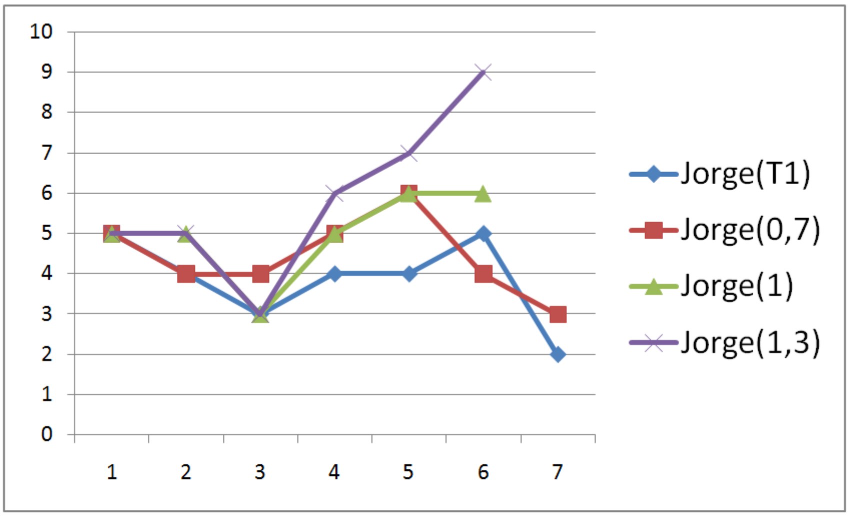
For example with our agent results for Jorge we should prefer the Jorge(1) rather than Jorge(0.7). Even if Jorge(0.7) has closer results to the Jorge(real player) the curve is more precise in Jorge(1) and Jorge(1.3), even with higher values in module.

For Joana we should choose Joana(1) because she has the most similar line to Joana(T2). It is almost the same explanation we gave to choose Jorge(1) and Jorge(1,3) instead of Jorge(0,7).

With the same logic in Sofia (T2) we should choose Sofia(0,7) because she has a line almost identical to Sofia(T2), in values and also in the line (ups and downs).

6.1.2 Results - Scenario 2

After analysing the second scenario results, with the three values, we concluded that we have a pretty nice model, at least for the type of tests we did. As we said in the last chapter we could not simulate the last two days of Marco and Ruben when they played 0, 0, even if we decrease the cooperative value, because our module doesn't cover that



Jorge(T1)	5	4	3	4	4	5	2
Jorge(0,7)	5	4	4	5	6	4	3
Jorge(1)	5	5	3	5	6	6	
Jorge(1,3)	5	5	3	6	7	9	

Figure 6.3: Jorge with three possible values of cooperation

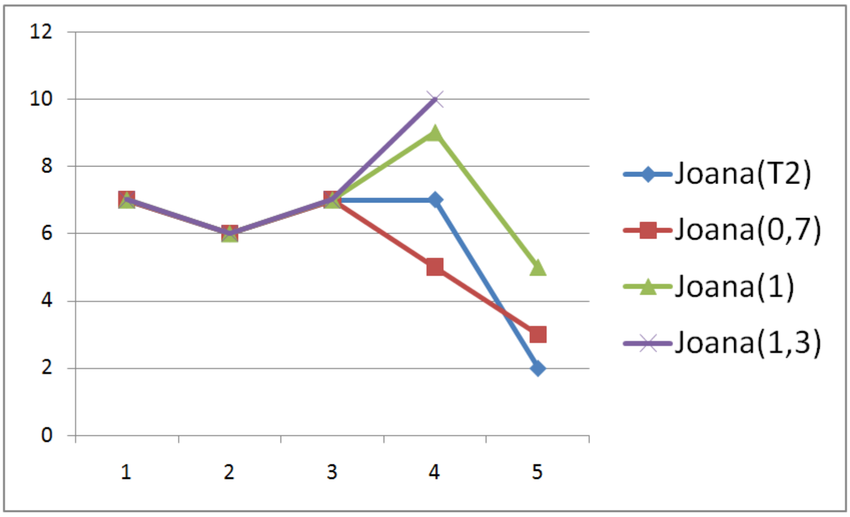
type of actions. In the next few paragraphs we will study this results in detail and explain why we should choose a "line" instead of another one.

For the first agent (Joao) until the fifth day all the lines are decreasing and increasing values, like Joao did in the real world, but after the fifth day the closest agent is Joao(1,3). Joao(1,3) is the highest cooperative agent in this test, so we can say that, based in our model, Joao is a cooperative person.

Now we will analyse Pedro's behaviour during its game and our agents. We can see that all of our agents have values of a really nice behaviour compared to Pedro(T1), but the closer line to Pedro is Pedro(0,7). Maybe if we decrease the cooperation variable a little bit we can be even closer to Pedro(T1), but with a closer cooperation variable the second day will have a lower result that it is right now with Pedro(0,7).

In our opinion the Marco(1,3) was quite impressive. It was incredibly closer to Marco(T2) results. The Line of Marco(T2), Marco(1) and Marco(1,3) are quite similar where they increase and decrease values, but Marco(1,3) has almost the same values of Marco(T2), the only "big" difference is in day 2 where Marco(T2) played 4 and Marco(1,3) played 6, but in the other values the difference between Marco(T2) and Marco(1,3) was never bigger than one unit, which is quite impressive.

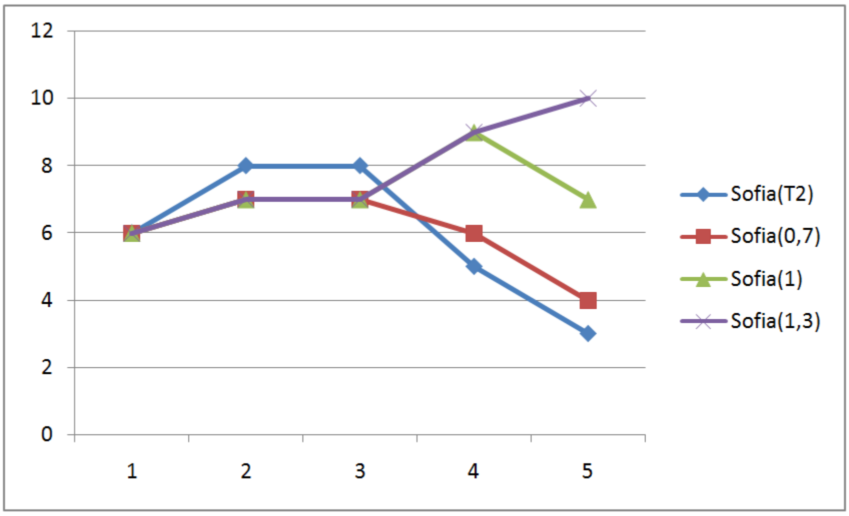
In Ruben agents we cannot simulate as accurately as we did with Marco, but we have not a bad set of results for an agent without particular cases in the code. To be honest the only really bad value that we have in Ruben is day four (4). So lets split this graphic



Joana(T2)	7	6	7	7	2
Joana(0,7)	7	6	7	5	3
Joana(1)	7	6	7	9	5
Joana(1,3)	7	6	7	10	

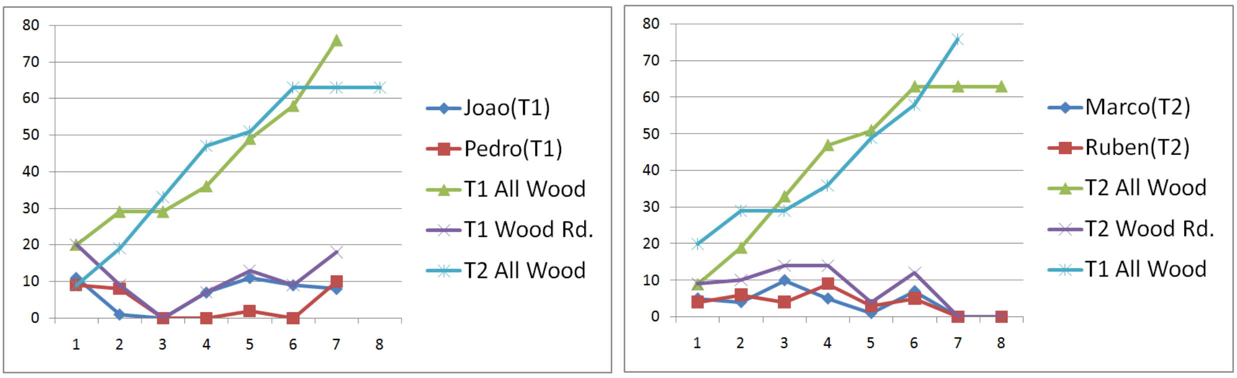
Figure 6.4: Joana with three possible values of cooperation

and analyse it separately before and after day 4. Before day 4 we that Ruben(1,3) even if the values are very high the curve is the same as Ruben(T2). It increases between day one to day two, decreases from day two to the day three. In day four(4) our agents failed miserably, because all of them decreased their values and Ruben increased his values. After studying Ruben action we concluded that this is a particular decision that he made with logic, but he did it one day after he should have done it. After analysing the graphs we see that our agents played in the right place (where team 2 has little advantage against team 1) and when the advantage increased (day 4) our agents reduced their cooperation, but Ruben increased his collaboration in this exact moment. If we have added a particular rule to our code we would pass this test, but our goal is to have a generic agent that performs quite well with all human beings and not a particular agent that simulates a human with an efficiency of 100%, but does everything wrong with other humans, that is why we do not want to have particular rules in our model. After day four (4) we can see that our agents and Ruben (T2) take the same type of decisions and it is quite interesting that in this particular situation our Ruben(1,3) would lose the game by just one unit of gold to his team mate. Ruben(1) and Ruben(0,7) would lose the game individually, but his team will also lose the game against team 1.



Sofia(T2)	6	8	8	5	3
Sofia(0,7)	6	7	7	6	4
Sofia(1)	6	7	7	9	7
Sofia(1,3)	6	7	7	9	10

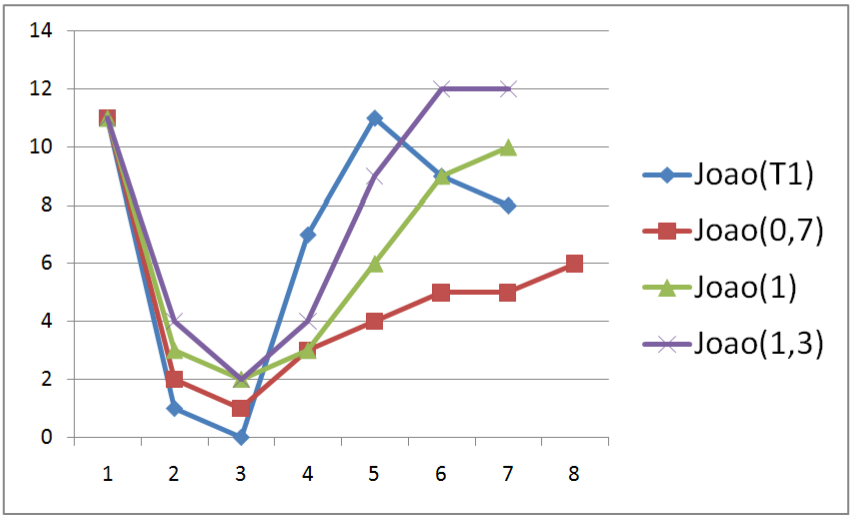
Figure 6.5: Sofia with three possible values of cooperation



Joao(T1)	11	1	0	7	11	9	8
Pedro(T1)	9	8	0	0	2	0	10
T1 All Wood	20	29	29	36	49	58	76
T1 Wood Rd.	20	9	0	7	13	9	18

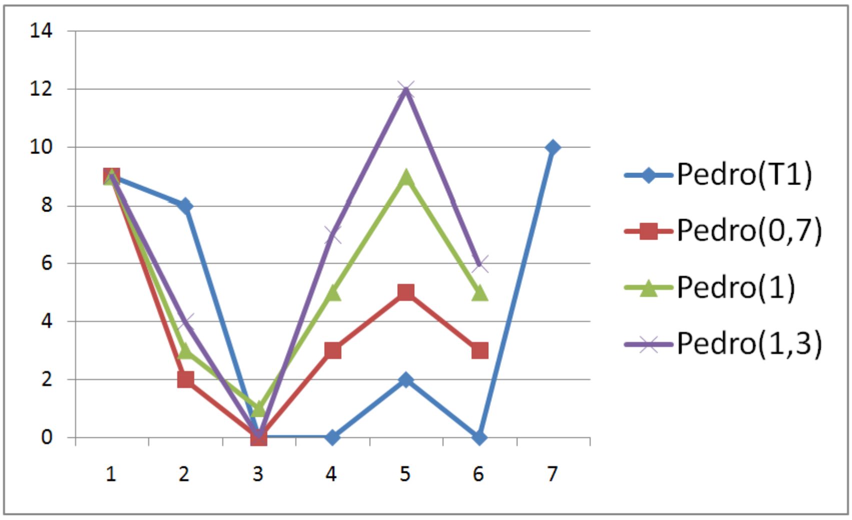
Marco(T2)	5	4	10	5	1	7	0	0
Ruben(T2)	4	6	4	9	3	5	0	0
T2 All Wood	9	19	33	47	51	63	63	63
T2 Wood Rd.	9	10	14	14	4	12	0	0

Figure 6.6: The game we will try to simulate



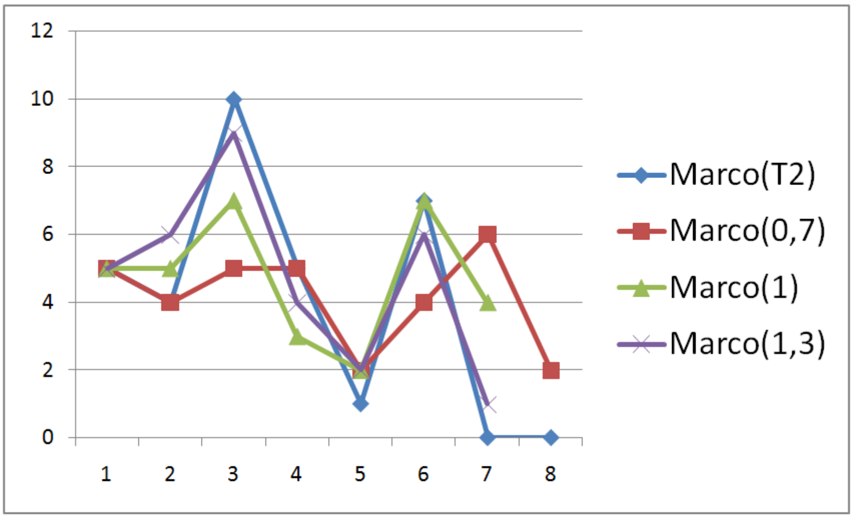
Joao(T1)	11	1	0	7	11	9	8	
Joao(0,7)	11	2	1	3	4	5	5	6
Joao(1)	11	3	2	3	6	9	10	
Joao(1,3)	11	4	2	4	9	12	12	

Figure 6.7: Joao with three possible values of cooperation



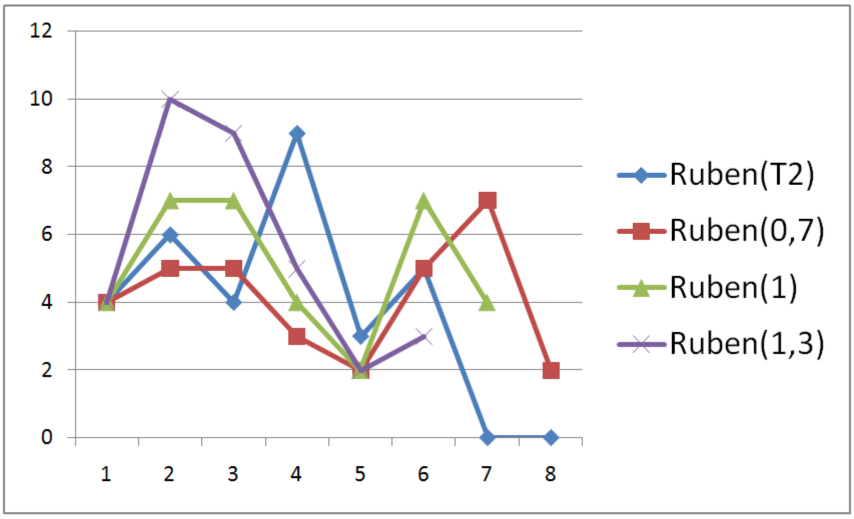
Pedro(T1)	9	8	0	0	2	0	10
Pedro(0,7)	9	2	0	3	5	3	
Pedro(1)	9	3	1	5	9	5	
Pedro(1,3)	9	4	0	7	12	6	

Figure 6.8: Pedro with three possible values of cooperation



Marco(T2)	5	4	10	5	1	7	0	0
Marco(0,7)	5	4	5	5	2	4	6	2
Marco(1)	5	5	7	3	2	7	4	
Marco(1,3)	5	6	9	4	2	6	1	

Figure 6.9: Marco with three possible values of cooperation



Ruben(T2)	4	6	4	9	3	5	0	0
Ruben(0,7)	4	5	5	3	2	5	7	2
Ruben(1)	4	7	7	4	2	7	4	
Ruben(1,3)	4	10	9	5	2	3		

Figure 6.10: Ruben with three possible values of cooperation

7

Conclusions

Contents

In this thesis we achieved our main goal, create a believable synthetic character to play our game. That was not an easy journey.

We started with problems in our game, and all of our frameworks. The first problem we faced was the problem that many of us have never worked with the evolved technologies, for example, Unity3D and ION Framework.

As we stated in our game implementation chapter, we had a huge problem that could stop our progress right at the beginning. ION framework was designed and programmed to only work in one machine without any network requirements from the beginning of its development. After much work we have made progresses and launched the ION framework Remoting. That solution was ready in mid March, working one a Local Area Network, but we lost much of our time preparing the existing technology to support our new requirements for this work, the INVITE Project.

We have back the attention to our agents, in mid April/May, but we have lost almost 3 and a half months with the ION Framework problem and the game implementation. We started to design the first drafts in paper at that time and imagining what the agents should do when programmed.

We have started with a very complicated situation, with a lot of useless code in our agents. Our first prototype had close to 900 lines of code, but we end with less than 200 lines of code for the agents, which was an giant effort from our part. We have focused our energy and our attention in a really concrete case scenarios like the scenarios we have described in this thesis, even thought our agents work in almost every scenario.

At the end we concluded that they are almost perfect for the type of tests that we have imagined, but they have some failures that could be considered in a future work. For example, if we put many of our agents playing again each others without any Human player after some days (40/50 days) they tend to start playing all the same values (if they have the same input parameter). That could be considered a problem by some people, but in our opinion it is not a big problem, because a normal game rarely has more than 10 days (in average), so we won't see any problem in that range of days.

We know that we have some faults in our agents that we will be describe in the future work section, but it is important to say that this is an area with an enormous effort from the industry and universities to understand the human behaviour and try to put that behaviour into "computers". We think that we have achieved all of that in about a year, which is an impressive result for us. We are very proud of ourselves. We started a really complicated job with our related work and ended this thesis with all the tests that we have made that proved our model.

7.1 Future work

In a future work we can improve a lot our agents, in many different ways, but one of the most important areas to improve is add an emotional module like the figure 7.1 represents.

For that we could use Fatima a framework developed at GAIPS - Inesc - ID. In gaips some people have done the integration between ION and Fatima, so in a near future we could have our model with emotions from Fatima. That will be a great challenge, but we know that the results will overcome all the effort needed to build such a solution.

In a near future we can also prevent another scenarios in our module, because not all the games are as we described, some people have completely different strategies that we have not take into account, and that type of new scenarios will make our model even better. We hope that this work is the first step for many more works in the area in the upcoming years.

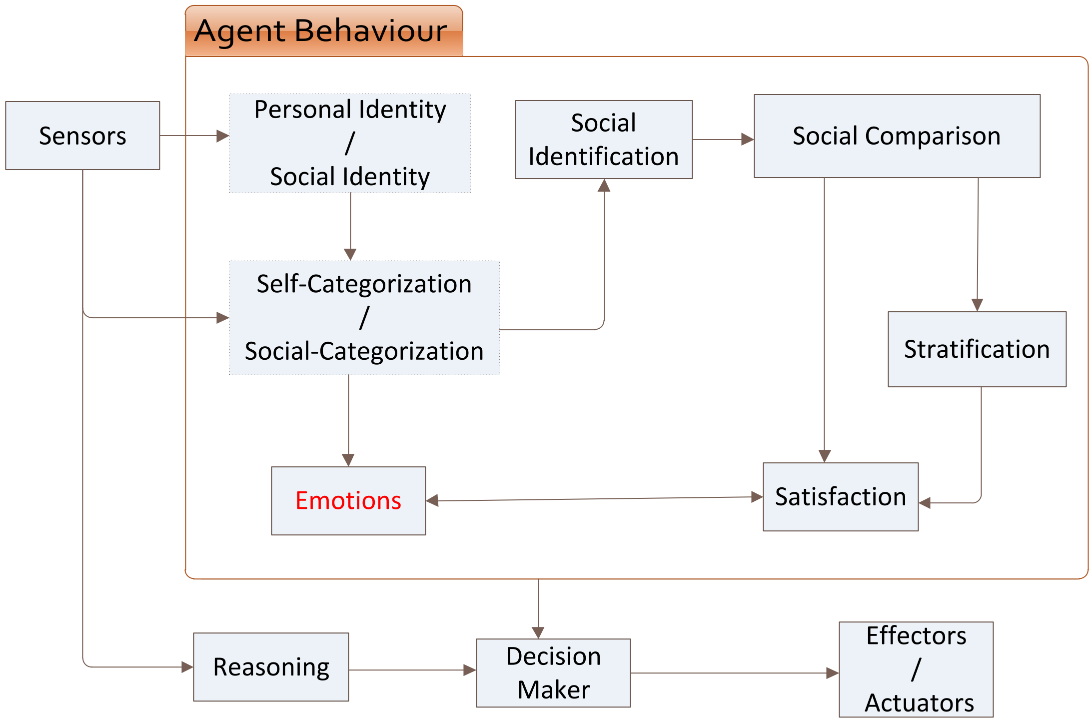


Figure 7.1: Our Agent Model Proposal

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