Providing Social Scaffolding for Effective Agent Communities

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Abstract

This paper explores the general landscape of virtual communities and reflects upon their relevance to their agent community counterparts. It examines several disparate virtual communities in order to identify common threads and characteristics, which underpin social cohesion. In turn we introduce *social realism* and reflect on the extent to which, this can form the basis of a social scaffolding for the support of effective agent communities. Thereafter we introduce the concept of *agent chameleons* and consider how this might influence both agent and group behavior.

Introduction

This paper explores the issue of agent community dynamics. In particular it considers those factors that influence and engender a heightened sense of group cohesion. We draw upon work undertaken in several dimensions, whereby agent groups operate in very different and challenging domains.

Much work has addressed such issues as the underlying deductive models that underpin agent behavior, interaction and models of planning and collaboration. Most of this work has however paid scant regard to the actual process of team formation and building and the social factors that typically influence human teams.

In this paper we first examine the concept of the virtual community. Thereafter we consider three contrasting manifestations of such communities namely those of social robots, social avatars and social mobile users. In so doing we seek to identify commonalities and characteristics than contribute to group cohesion and function. In conclusion we introduce the concept of agent chameleons and explore their impact upon agent community dynamics and structure.

Virtual Communities

It was the evolving arena of Computer Support for Collaborative Work (CSCW), which necessitated the reconsideration of the definition of *community*. New technologies blur the traditional separation and distinction between the physical and the virtual and today the virtual community offers many similarities to that of its physical counterpart. Traditional communities have a strongly shared sense of belonging, as can virtual communities, to their participant members. Virtual communities must exist in the minds of their members through the medium of imagination if they are to exist at all (Rheingold 1993), yet the degree of imagination demanded is perhaps not that great. The Blue-C project for example (Staadt et al 2000), seeks to achieve even greater levels of user immersion supporting full immersion within a world through real time integration of human representations using large screens and cutting edge projection technologies. Three contrasting virtual communities are now considered.

Social Robotics

One virtual community that we have examined extensively is that of teams of robots that collectively work together in the solution of shared goals. We have introduced the term *social robot* and an associated Social Robotic Architecture[1] both of which have been described extensively in the literature [Duffy, Garcia et al 2000, Duffy, O'Hare et al 1999, O'Hare, Duffy et al 1999]. We borrow heavily from the Multi-Agent Systems (MAS) arena, considering such robotic entities as being *strong* agents. We ascribe mentalistic attitudes akinned to Belief Desire Intention (BDI) agents (Rao & Georgeff 1991) and incorporate this

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deliberative layer within a classical subsumption style robotic architecture. Such robots are thus equipped with a rich repertoire of sensory input with which they can sense their environment including odometry, bump sensors, sonor and an on board vision (Figure 1).

The world is highly dynamic and is cohabited by robots that are both mobile and autonomous and are profoundly social in that they can communicate using an Agent Communication Language (ACL) Teanga, which is based upon Speech Act Theory. Such interaction is supported across a wireless network. In addition to considering the robots themselves we have also considered certain software packages as agents. Particular robotic capabilities may be nomadic in nature and roam the network converging on those location(s) where they are most needed (Collier et al 2000).

Figure 1: Nomad Scout II with Vision System

Social Avatars

A second community that we consider is that of social avatars. One such community with which we have had first hand experience has been that of ECHOES. The main objective of the ECHOES project (Pasquarelli et al 1999, O'Hare et al 2000) was to build a distributed dynamic environment for educating and supporting technicians in the use and maintenance of complex industrial artifacts. To pursue this objective, Web Based Training, Virtual Reality and Multi-Agent Systems were integrated and synthesized into the ECHOES environment.

The ECHOES[1] system constitutes a specific instance of the broad class of system namely Collaborative Virtual Environments (CVEs). The ECHOES training environment remotely immerses the engineer or trainee into a familiar virtual environment and a virtual community where they

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[1] ECHOES (European Project Number MM1006) is partially funded by the Information Technologies, Telematics Application and Leonardo da Vinci programmes in the framework of Educational Multimedia Task Force.

can receive information and assistance, communicate and virtually meet with colleagues and collaboratively solve tasks. This environment is delivered via the internet through VRML where the user presence is depicted through an avatar which is moved through the space by way of the External Authoring Interface (EAI) dynamically updating the .wrl file.

The ECHOES virtual environment is based upon the familiar physical metaphor and trainees can wander a spatial environment namely the ECHOES training environment comprised of rooms each yielding a cohesive set of functions which support particular user tasks. At a functional level the following rooms are provided; meeting room, library, training room, simulation room, first aid room and control room. Various interaction modalities are supported. Users can communicate by email, navigate the virtual world, retrieve and view technical manuals in the library, participate in a virtual meeting, engage trouble shooting assistance in the first aid room, undertake courseware modules in the training room, either in a classroom context or in trainee moderated individual training booths.

A complimentary system ENTER (Environment that Totally Envelopes the useR) environment addresses a contrasting arena that of electronic commerce (Guinan et al 2000). The virtual environment depicts a retail park with users able to wander both along shopping malls and enter selected retail outlets. In this environment crucial shopping behavior data can be accrued. This can in turn be utilized in the management of the user experience.

Figure 2 depicts an example component of the ECHOES world. In both the ECHOES and ENTER worlds users are immersed within the environment and cohabit it with other users. In this sense ECHOES and ENTER are no different from other CVE's.
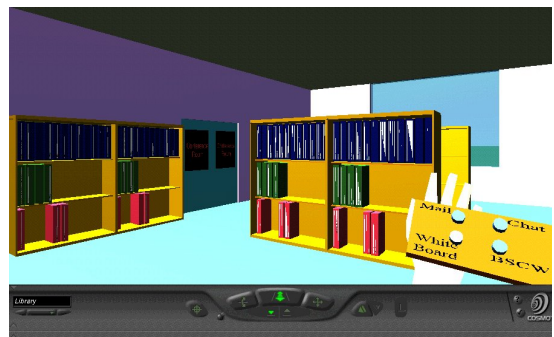

Figure 2: ECHOES Library

One of the key thrusts of the ENTER research however which differentiates it from other CVEs was its ability to

dynamically reconfigure the world within which the user is situated. Experience has shown that relatively crude and blunt user profiles can result in considerable personalization capacity. While personalization within 2-dimensional web situations is not uncommon the ability to dynamically rebuild a 3-dimensional world to the individual needs of the user is highly innovative.

Of late much work has addressed the issue of realism or more accurately, perceived realism in Collaborative Virtual Environments. Initially researchers were concerned by visual realism of avatars (Aubel, & Thalman 2000, Kalra, et al, 1998), subsequently there was the dawning realization that whilst this was an important factor it was nevertheless subservient to behavioral realism (Blumberg, & Galyean 1995, Perlin & Goldberg, 1996). Behavioral realism involves a characters ability to convey their inner feelings. This work in contrast advocates a *social realism* whereby a distinct and believable sense of community is engendered amongst the participants.

Social Mobile Users

Mobile and wearable computing provides yet another virtual community worthy of investigation. The Where Are You (WAY) system (O'Hare et al 2002, Lowen et al 2002), is one such system that enables mobile users to form linkages as they go about their activities. It delivers a simple, yet effective application for assisting mobile users in the performance of a variety of routine tasks. The WAY system supports the mobile citizen in the location, tracking and rendezvousing with a variety of moving entities. The WAY system provides such support by deploying a rich collection of appropriate technologies including mobile agent based technologies, Geographic Information Systems

Figure 3: The WAY User Interface

(GIS) and context aware mobile computing.

System functionality is delivered through a collection of mobile lightweight intentional agents, which take cognizance of the memory and processing restriction of Personal Digital Assistants (PDAs).

The Where Are You (*WAY*) system, constitutes a simple, yet effective application for assisting mobile users in the performance of routine tasks such as tracking and rendezvousing with a variety of moving entities.

The operation of the WAY system involves the acceptance of connections from fellow users and in a bi-directional sense posts location and orientation updates. These are subsequently depicted on a map-based interface (Figure 3). The WAY system embraces an agent-oriented design supporting weak migration of strong BDI agents across a wireless network. Agent migration can be prompted in a variety of situations including the need for resource access, low battery life on the device on which it is currently resident or indeed in the interests of load balancing.

Scaffolding for Social Teams

While the three virtual communities we have considered are very different, there nonetheless exists a rich vein of commonality. We wish to extract those factors that contribute to the reinforcement of the sense of community. We have identified four key facets, which collectively contribute the necessary social scaffolding for effective agent communities (figure 4), these are cooperation & collaboration, awareness, presence and embodiment. We will now consider each in turn.
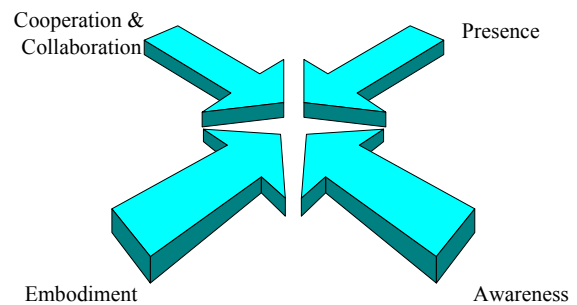

Figure 4: The Key Components of Social Realism

Cooperation and Collaboration

One of the cornerstones of effective social teams is their willingness to cooperate and collaborate to provide mutual assistance. Cooperation obliges individuals to develop mutual dependence, which in turn fosters organic solidarity (Durheim 1933). This process seems equally prevalent in both real and virtual communities. Consequently this will

impact upon existing rules of cooperation and competition. Since collaboration relies on people sharing information, the sharing of resources between several users is therefore pivotal.

Awareness

In order to allow sharing, an important prerequisite is that of an awareness of self and others. An underlying correlation exists between focused collaboration and the level of awareness.

Awareness is generally defined as an understanding of the activity of others, which provides a context for individual activity (Dourish and Bellotti 1992).

Gutwin and Greenberg (1999) identified the basic characteristics of awareness, which distinguish it from other kinds of knowing. Thus, awareness involves knowledge about the spatio-temporal state of a given environment, which must be maintained in order to reflect the dynamics and continuous changes of that environment. This knowledge is available through people interacting with the system and is not a goal in and of itself, but rather emerges as a bi-product of achieving the main goals of the activity. Benford et al. (1993) have built a spatial model of interaction in virtual environments based on properties of space (e.g. aura and nimbus), as the base for mediating interaction.

In some particular situations, where the system complexity surpasses our cognitive abilities, awareness is called situation awareness (Gilson 1995). Since situational awareness is a multidimensional concept, involving both status and spatio-temporal issues, different authors have identified spatial awareness as being an important component, encompassed by situational awareness (Endsley 1988). In his theory of situational awareness, Endsley proposed a three-stage definition, based on perception of relevant elements of the environment, comprehension of those elements and prediction of the states of those elements in the near future (Endsley 1995).

Awareness of others can be facilitated through embodiment where it is viewed as a technologically extended body (Biocca 1997).

Embodiment

Arguably the most important concept in engendering a sense of identity and consequently that of community within virtual reality systems is that of embodiment. The commissioning of avatars as a vehicle for embodiment raises interesting philosophical issues. Thus the avatar can be considered as being an interface through which the individual can exercise direct control, and through which it can influence the environment. Avatars have become increasingly photo-realistic offering greater personalization of the form and nature of the avatar coupled with heightened realism in terms of animation and character development. Benford stressed the dual role such avatars play in delivering both a sense of presence to the individual and to others (Benford et al 1995). The avatar can sometimes even take on an existence that is considered beyond that of its mere user. It is however, clearly inseparable from that of its host, the human user. Little (Little 1999) emphases the idea of the avatar as an "imaged prosthesis of its referent - the user, and so is fundamentally related to linguistic signs and representational icons".

An interesting issue is the level to which users identify with the avatar, with all the psychological associations on body schema or body image (Biocca 1997). As Jackson highlighted (Jackson & Lalioti 2000), users are beings with diverse identities, and the embodiment plays a vital role in understanding them. The embodiment is more than just material body, but it also carries a gendered, social, political and economic identity. One of the most common psychological effects of embodiment is the rendering of a sense of presence (Biocca 1997). Nowak and Biocca (1999) stressed the importance of body in achieving a sense of place, space and of another person's presence.

Presence

According to Biocca (1997) the sense of being there, in the physical environment consists of "a basic state of consciousness in which the user attributes the source of the sensation to the physical environment". Durlach and Slater (2000), regard presence as the sense of being with someone or the general sense of togetherness.

Togetherness, co-presence and social presence are all socially derived concepts, grounded on presence. Co-presence is a notion, which enlarges the borders of presence, involving in addition the feeling that one is in the same spatio-temporal virtual environment with other users and where interaction is also possible. An important feature of co-presence consists of mental connection, which enable individuals to be aware not only one of the other, but also all of the common activity which takes place in the virtual space (Nowak & Biocca 1999). In a multi-user context, the individual can achieve a sense of social presence, namely the degree to which a user feels access to the intelligence, intentions, and sensory impressions of cohabitants. As IJsselsteijn et al. (2000) noticed, although the terminology used by various authors tends to vary, the term `co-presence' has been suggested to refer to the mix of social and physical presence, i.e. a sense of "being there together".

Lombard and Ditton's (1997) grouped presence conceptualizations in two dimensions, namely physical and social presence. The physical presence is concerned with the sense of being physically located somewhere, while the social dimension underlies the feeling of being together

with someone. One of the distinctive features of social presence consists of the awareness of another presence and the possibility of communicating and interacting with them.

Toward Agent Chameleons

Based upon these four primary ingredients, which we believe to underpin the concept of community. These parameters ought in some sense to influence and motivate agent community dynamics, group cohesion, social norms and protocols. Social realism is of paramount importance in achieving effective self regulating community behavior. Given the evolving nature of such communities we believe subsequent generations of agents will necessarily have to manage and preserve their very existence. Macro economies will emerge within which agents will compete for customers or consumers of their services.

It is our conjecture that the concept of the *agent chameleon* will emerge. Indeed the Agent Chameleons project[1] is currently investigating these very issues (O'Hare & Duffy 2002).

The objectives of Agent Chameleons are as follows:

1) To investigate the choice and selection of embodiment forms;
2) To develop a mechanism whereby agent chameleons can migrate;
3) To investigate processes that support the mutation and evolution of agent forms;
4) To re-examine the concept of community and offer a redefinition based upon Collaborative Immersive Virtual Environments (O'Hare, Sas & Byrne 2001).

Agent Chameleons must have a sense of presence (Breazeal, 2000, Sas & O'Hare 2001) and thus be embodied within a given world. Indeed the form of an entity inextricably dictates or constrains its behavior and capabilities within a particular environment. The optimum form is very much dependent upon its world (O'Hare & Duffy 2002, O'Hare 2000, O'Hare 2001). Judicious selection of appropriate forms or persona ought to empower the entity.

The agent chameleons project strives to dismantle traditional world boundaries. Such agents will be mobile and ubiquitous in nature moving from one device or location to another moving from one world to another. We strive for a seamless migration from the physical to the virtual and the virtual to the physical. Synonymous with this migration is the obligation or possibility for *agent*

metamorphosis whereby the entity changes representation such that its form is appropriate to the new *context.* The context is viewed as a tuple of task or activity and the new environment.

The form of an entity inextricably dictates or constrains its behavior and capabilities. The form is very much dependent upon its world. Appropriate forms or persona ought to empower the entity. Thus the agent form may be embodied in a virtual character within a Collaborative Virtual Environment but upon migration to the physical world may appear as an animated image on a computationally restricted PDA.

The agent is thus considered as an autonomous, mobile and social entity in the classic multi-agent systems sense. Above and beyond this it is considered an agent chameleon. The agent has at any given instance a persona and associated with a given persona are a given set of capabilities. The migration and mutation of agents may thus be invoked in one of two manners, firstly by the agent itself through proactive mutation/migration or secondly, as a result of environmental events, reactive mutation/migration. Both proactive and reactive responses are determined by input parameters, which originate internally and externally to the agent. The former comprise the personality attitudes (e.g. aggression, friendliness, moodiness) and mentalistic attitudes (e.g. Beliefs, Desires, Intentions (BDI)) while the latter are situational or environmental. Clearly such mutation will also influence and be influenced by, social dynamics within the agent group.

In parallel to the fusion of the physical and virtual spaces we also examine the fusing of the social space where characters may be virtual or real. Thus, a redefinition of the traditional community concept is necessitated (O'Hare, Sas & Byrne 2001), whereby new forms of *social inclusion* and *social norms* are accommodated.

We have already witnessed how agents undertake differing *roles* in differing social *contexts*. So the agent chameleon will be able to mutate not only its role, but, their whole persona.

Conclusions

Within this paper we have explorde the concept of virtual community and examined those factors that contribute to a heightened sense of belonging to such communities. We introduce the concept of agent chameleons and consider how the capability of metamorphosis influences or facilitates agent community interaction.

We reflect on the blurring of the traditional information space boundaries, in particular the 4th dimension where the virtual is fused with the physical in an indistinguishable

manner. Further to this we examine the decision making process that underpins the change of agent form and the potential for such processes as *agent cloning* and *agent evolution* where in a Darwinian sense through *socially situated learning* (Breazeal, 2000) the agents may learn from their experience and evolve in the light of this. We postulate that the next form of evolution that must be addressed is the evolution of autonomous software entities.

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