Vactor Elucidated:

An Observation of Speciation in Interactive Virtual Environment Technologies

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Authorization to Submit Thesis

This thesis of Jacob B. Cooper, submitted for the degree of Master of Science with a Major in Architecture and titled "Vactor Elucidated: An Observation of Speciation in Interactive Virtual Environment Technologies," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

Observing the technologies utilized by interactive virtual environments reveals a possible speciation resulting in a virtual entity described as a virtual actor, or vactor. The emerging technology culminating in the vactor is discussed and a definition of vactor is given through describing relationships between users, avatars, and agents through virtual environments. This definition of vactor is examined in relation to several research and academic projects which I have actively participated in to demonstrate how a vactor might influence similar interactions with virtual environments. A comparison is drawn between the definition of virtual representation and the theatrical actor which elucidates the potential relationships between vactors, users, and virtual environments. The potential of the emerging technology indicated by vactor, and the resulting virtualized persona has implications extending to virtual communities within virtual environments, as well as impacting the current zeitgeist of individual identity.

Acknowledgements

This paper would not have been possible without the work and dedication of several individuals who have been instrumental in my studies and in guiding me through the research process. I wish to express my sincerest gratitude to Brian Sumption, Professor Emeritus of the University of Idaho, Virtual Technology & Design department who served as my first graduate committee chair and helped me to discover vactor, and how it was connected to virtual communities and narratives. Also, to John Anderson who has worked diligently with me to refine how vactors might operate in virtual systems and who exposed my research to the current technological zeitgeist which frames the emergence of vactor. In addition, Brian Cleveley and Robert Caisley have been incredibly patient and overwhelmingly insightful in their observations of how vactors might be utilized and evolve. Additionally, I would like to thank Cheri Cole and the entire College of Graduate Studies office for all of their effort in making this thesis possible.

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Chapter 1: Introduction

In the bourgeoning expanse of interactive virtual environments (IVEs) the role of education, and tools for education within IVEs have been developed at a meager pace by comparison to other industries leveraging similar technologies. Meanwhile, computing industries have capitalized on IVE technologies through video games and cinema which have been spearheading much of the research and development making virtual worlds more accessible and affordable. This primordial soup of IVE technologies indicates the possibility for a system composed of human users, agents, and avatars which could greatly enhance IVE experiences, the vactor [fig. 1].

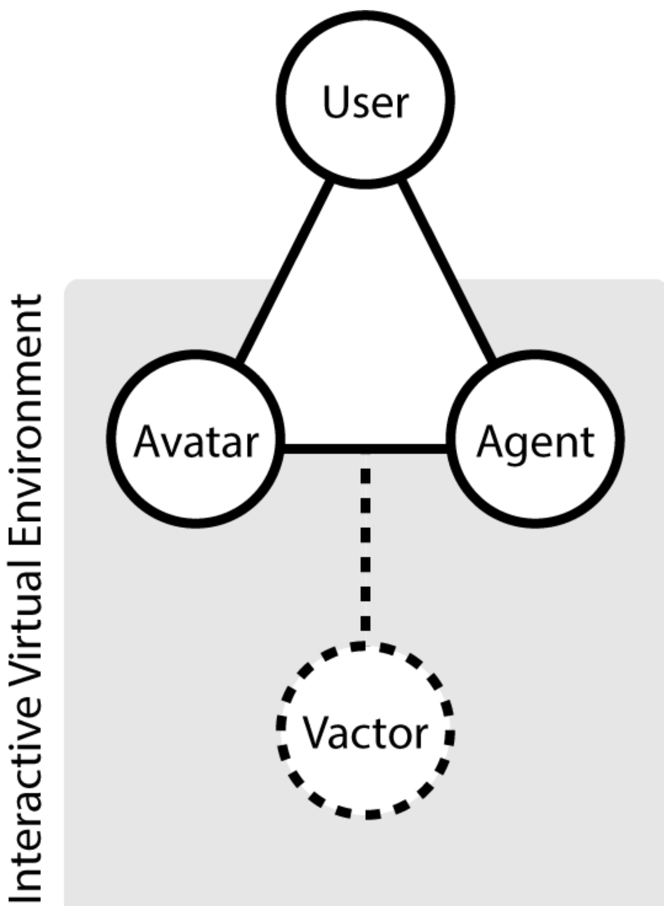

Figure 1. **UAA Vactor Speciation**

The emergence of the vactor is heralded in two ways. First, it follows the zeitgeist of technological evolution observed in the singularity research performed by Ray Kurzweil. His work in *The Age of Spiritual Machines* (1999) examines the rate at which technology is progressing. Kurzweil suggests that human experiences with technology are moving towards a more refined integration. As IVE technologies are developed and accessibility to these technologies increase, the prevalence of virtual environments and the quantity of humans inhabiting them will likewise grow. The rate of this growth has historically been exponential (Kurzweil, 2012).

The second herald of the emergence of vactor comes through the proliferation of virtual environments through the broad based mediums of social media and video games. Babajide Osatuyi suggests that, “Social media technologies including social networking sites, blogs, forums wikis and microblogging tools are becoming a reliable platform for sharing information…” (Osatuyi, 2013). His observations of social media led him to suggest that it is growing as an information dispersion source beyond the capacities of traditional media outlets such as television, newspaper, and radio. With United States internet usage estimated at 84% of the population (Pew Research Center, 2014), and 74% of online adults using social networking sites (Pew Research Center, 2014), the saturation of social media in modern culture is prolific. Add in that and estimated 67% of American households play video games (Entertainment Software Rating Board, 2015), and the impact IVE technologies has on the preponderance of Americans becomes clearer. This proliferation of IVE usage has led to an incredible boom in the development of IVE technologies, and sets the stage for human representation in these virtual environments to evolve.

The emergence of vactor through human IVE representation speciation is clarified by discussing how a new form of human representation might function in existing IVEs. Through work in projects involving IVE experiences such as the Virtual World Village, Virtual Vandal Playbook, and the Virtual Hamlet Ghost, myself and others have observed an evolution taking place in virtual worlds where our personas are being interpreted by different technologies in these virtual worlds. Human behaviors in these IVEs become quantifiable data through the recording of actions on objects within the IVEs.

Technologies including networked intelligence and behavior analysis [fig.2], along with increasing multiplatform integration across both hardware and software, provide the grounds upon which a new form of agency, in the form of a virtual entity can be developed. The emerging technology explored here is that of a combination of technology and methods which culminate in a virtual entity referred to in this study as a vactor. Vactors could enhance human experiences with IVEs through analysis and observation by means of a user-agent-avatar system (UAA) to generate a virtual persona. This virtual persona generated by a UAA provides the means by which contextual agent feedback can be provided to users in relation to their IVE experiences which would provide a personalized guide, vehicle, role model, and companion within IVEs.

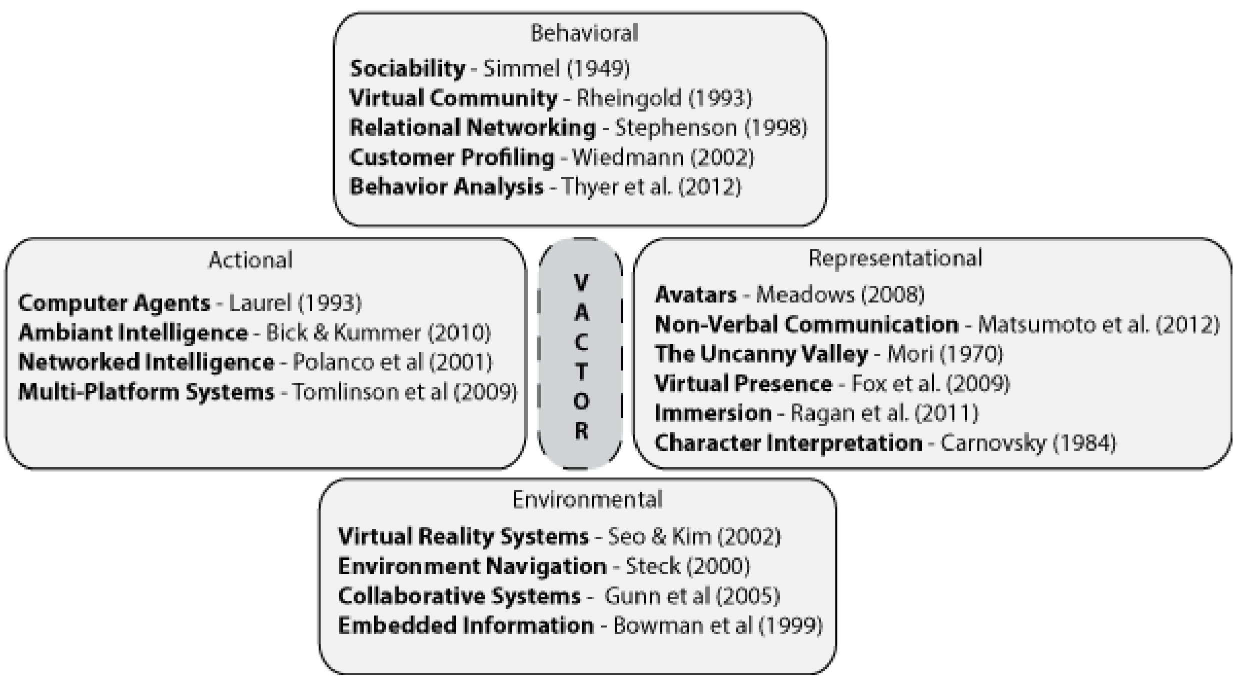

Figure 2. **Indicative Technologies**

In the context of this paper, an interactive virtual environment (IVE) includes

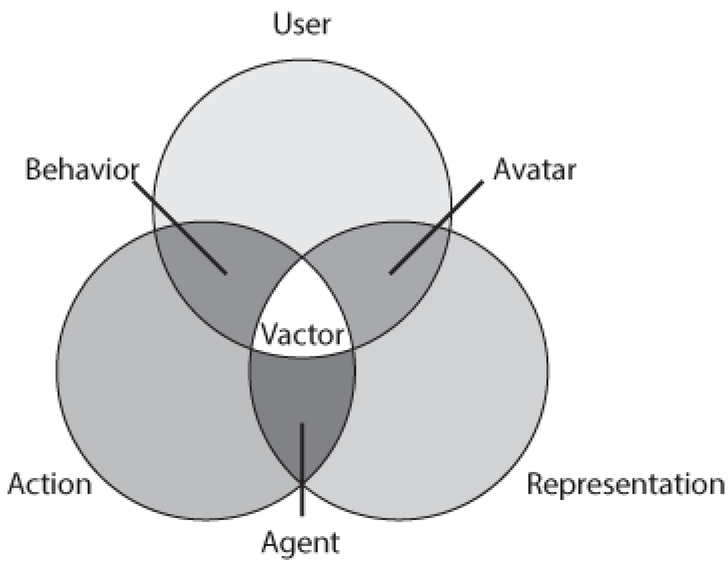

***Figure 3*. Characterization of Vactor Emergence**

immersive digital worlds that can be found in video games, social media, training simulations, and educational software. The distinction between a virtual environment and an IVE lies in the nature of the interaction between human users and these digital worlds. An example of a virtual environment which is largely not interactive would be narrative environments created in books or in movies. While it can be argued that these mediums do have a certain level of interactive elements, the worlds themselves are largely unaltered by the participating user (Murray, 1997). In this regard, interaction is being defined as affecting a world in a significant manner as to perceptibly alter the world's state, and in return to have a perceptible change enacted upon the agent of action. In regard to interaction between humans or between users and agents or avatars, the interaction is viewed using the common definition of reciprocation of action or influence.

Vactors are the emerging virtual entities [fig.3] characterized by close relationship and action on the behalf of users within IVEs. The notion of user here defines the acting participant in an IVE and is used in regard to an individual human. The term vactor, from virtual-actor, informs the nature of the entity by speaking both of its virtual existence and of the entities role concerning action. Action is defined in this context as the effect of behavior on an individual or object. This is further described through Aristotle's definition of an actor as an agent who takes on and interprets action (Poetics, 1450a, 1-5, 22-25). Through merging the concept of an actor with existence in a virtual environment, the resulting virtual entity becomes an empowered form of the original actor, gaining capabilities beyond that of the classical notion of actor as profession. These capabilities imparted through virtualization include amplifications of existing traits like the dynamic representation of someone or something other than the self of the actor. A virtual actor can change their entire form beyond makeup, voice augmentation and costume. This kind of virtual entity leverages a UAA system [fig. 01] to guide, observe, and work on the behalf of human users in IVEs; they assimilate the actions of the users to become entitative virtual personas which manifest ambient intelligence. The virtualized persona generated by the UAA functions to give the vactor insight into the guidance of a user toward specific goals by providing a behavioral action analysis capable of predicting general behavioral tendencies and establishing an effective user's individual needs. It is important to understand that vactors are indicated here as an emerging technology and do not exist currently in the fullness of this definition, rather there are examples of agents and virtual entities which embody portions of this definition of vactor and act as evidence for the existence of these entities through current technology.

Coupled with an open world educational IVE such as the Virtual World Village project, vactors would have the ability to leverage STEM learning goals through the guidance of a student in an IVE both directly as a guide, and indirectly by providing information relevant to student goals and interests. A vactor operating in an open world IVE can network with other vactors to crowdsource goal solutions and facilitate cooperative activities between students. The vactor could also act as a role model by demonstrating how a student can achieve different professions or perform various tasks tailored to a student's interests and experiences to provoke curiosity and exploration.

In addition to STEM learning, within the directed sports educational IVE project Virtual Vandal Playbook, vactors could be used to act as personal trainers for a player's brain, guiding the student through drills and simulations targeting reaction times and pattern recognition. Through the virtualization of player profiles, targeted warm-ups, exercises, and drills can be scheduled and facilitated. The data from those simulations can then be analyzed to generate useful feedback to a coach or trainer. As virtualized personas, vactors can also be utilized to render more accurate simulations by providing personalization to training agents allowing team building exercises to be performed remotely.

This research is intended to elucidate how vactors could function as an answer to the issues incumbent in current educational methods, specifically in the US. The process by which vactors are examined will be first to establish a definition for what a vactor might be. Relevant research and technologies are then provided which point to the establishment of an entitative virtual persona that displays ambient intelligence. Then an examination of how the vactor might function in a couple of key example IVEs demonstrates how education could be enhanced through vactor interaction. In broadening the utility and understanding of what a vactor could be, comparisons between the defined vactor and the theatrical actor are discussed. Together these examples will address issues of scope and functionality both at local direct interactive levels as well as at a larger community scale.

Chapter 2: Literature Review

In order to frame the definition of vactor appropriately, a literature review of current research which points to the emergence of vactors needs to be examined in relation to IVEs. Existing interactive virtual environments involving agents and avatars are explored to establish the context within which vactors might emerge as an experience enhancement tool. Other agents and ambient intelligences used in IVEs should be recognized as an impromptu taxonomy of virtual entities which will be used not only to gauge scope for this study and to add contrast which will differentiate vactor from similar virtual entities. Technologies which grow networking and multi user collaboration are explored with a perspective toward the future of these technologies. Projected from this perspective, the technologies surrounding human computer interfaces (HCIs) and the development of neural networks emulating human thought patterns begin to form a framework by which interactive experiences in virtual environments can be enhanced. This chapter will examine three areas of research: IVE education, network & profiling, and virtual theater.

The scope of the discussion concerning vactor is narrowed by examining vactor as an emerging technology from a composite of other existing technologies. This progression of technology is both illustrated and predicted by Ray Kurzweil in his book *The Age of Spiritual Machines* (1999). In his book he describes how technology is rapidly changing by examining how computers and networks have evolved to their present form. Kurzweil relates the history of computers to the growth rate of computational power to extrapolate a future where computers will have the capacity to operate beyond the capabilities of the human mind. In Kurzweil's book *How to Create a Mind* (2012), he breaks down the human mind, specifically the neo-cortex into modes of thought and examines how they can be replicated in computer processing. These relationships between computing and human mental capacity suggest that as technology advances, the relationship between computing technologies and human interfaces will become imperceptible (Kurzweil, 2012). This narrowing of the barrier between computers and humans includes interactions with IVEs. As human computer interactions are refined, the nature of user interactions with IVEs will become more accessible. Using this model, computers will be able to anticipate user needs and work in tailor made capacities suited to a closer relationship with humans.

Section 2.1 IVE Education

Research and technology have both pushed toward greater computing power and communication utilizing agents and avatars in IVEs. There are several developing websites exploring different aspects of the implementation of education through agents and avatars within IVEs in a variety of classroom settings. MinecraftEdu at *MinecraftEdu.com*(2015) adapts the popular voxel based creation-survival video game *Minecraft* (2009) to a wide variety of classroom setups and provide adaptable curriculum in a manner that is accessible and user friendly for teachers of K-12 students to implement. Their customized version of the game provides a multi-user IVE within which teachers can apply pre-packaged or customized environments and lesson plans in the classroom or as an after-school activity. Within the IVE, teachers can use the game mechanics to demonstrate subjects including STEM education, social studies, architecture, and even art. The online community of teachers provides a forum where teachers can share their customized worlds with each-other, expanding the lessons available to students and applying creative approaches to setting up peer-reviewed curriculum. Illustrating the popularity of this project, Northern Ireland is deploying MinecraftEdu's software in up to 240 sites across the country and plans on providing access to the tool to up to fifty thousand students ("Minecraft launches in NI", 2015). The social aspects presented in some of the MinecraftEdu lesson plans are of particular relevance in that they focus on how people communicate and cooperate online through avatars to problem solve and how their representations can work within IVEs to communicate non-verbally with other participants by interacting with the virtual environment (MinecraftEdu, 2015).

Arizona State University hosts the Mary Lou Fulton Teachers College which has developed a center exploring video games and how they can be applied in the classroom. The Center for Games & Impact (2015) provides teachers and parents with access to games and lesson plans for games providing IVEs which students can work within. From role-playing games exploring history or medicine to games designed to build other games, the list and curriculums provided by the center are extensive and include many main stream titles such as *World of Warcraft* (2009), and *Minecraft* (2009). Each of the games listed on the website are provided a lesson plan which can be carried out in the classroom or as an after school activity and teach topics like resource management, effective collaboration, and design thinking. The center has developed a methodology for building, researching, and implementing these IVEs and other products and services that they have titled Impact Based Research (IBR). They describe IBR as "… an agile research approach that aligns stakeholders around impact outcomes accomplished through clearly articulated theories of change that are continually optimized through sustained real-world implementations and shared best practices across a committed community of practice" ("Impact-Based Research", 2015). The implications of methods like IBR indicate that research is moving towards a greater exploration of the applications of IVE technologies in direct relationship to societal needs like education.

Section 2.2 Network & Profiling

This section outlines how different IVEs and other software leverage networks and profiling to offer user tailored experiences. In reference to networks concerning IVEs, network can mean a community of users or agents which communicate within a common scope. Dr. Karen Stephenson (1998) defined networks as "a structured pattern of relationships typified by reciprocal patterns of communication and exchange". While her definition of network was concerning human and corporate networks, it can also apply to virtual networks. The reciprocity of nodes within a network expand the information each node has access to and allows the community to dynamically adapt either for or against change (Stephenson, 1998). This brings about research in adaptive virtual networks, which is an adaptive network methodology which allows data sharing networks to tailor the quantity of information shared across nodes based on individual node need and according to some studies may be the future of computer networking (Anderson et al., 2005; Turner & Taylor, 2005; Feamster, Gao & Redford, 2007). These researches point to an even greater understanding of how information is shared both between humans and between computer systems. From this growth of knowledge comes the opportunity to capitalize on community based knowledge sharing through leveraging interactivity in virtual environments. In communities such as those found in the video game *World of Warcraft* (2004), knowledge sharing is an integral part of problem solving and individual progression. Users form virtual communities which in some games might be referred to as guilds, corporations, or alliances, but all share the characteristics of users with similar goals or personalities sharing information and resources to progress (Yee, 2015).

Device networking such as demonstrated by the technology announced by Apple on January 9, 2007, with the launch of Apple TV at its annual Macworld conference, suggests that the future of computing will move toward more integrated networks posing the possibility of user preferences being carried over across multiple platforms as well as IVEs. The Apple TV's next deployment proposes to be a device which links broadcast television with a home network of devices including desktop computers, mobile phones, and pocket media-players and in future iterations may even include the Apple corporations Siri computer agent (Kline, 2015). In this proposed combination, the possibility for personalization through an agent with access to multiple platforms containing user information poses interesting questions of security, privacy, and expansion not inherent in the scope of this study. What is important to note concerning this vector of technology development is how devices are being connected together, which inherently connects multiple IVEs as well.

Marketing has had a dramatic effect on research and development in the field of customer profiling since the 1990s and this is no less true for the effects of e-commerce in the development of methods for gathering user specific information. “When users move through the Internet, their every step through the virtual pathways can be followed and can be recorded in detail and combined with timing data” (Wiedmann, 2001). Through the development of techniques for gathering information on the actions of users in virtual space, methods for the personalization of internet applications and IVEs can be form fitted to the behavior patterns of users in those spaces. Research has demonstrated increased interaction rates between personalized interfaces and users (Brokke & Postma, 2001). This suggests that by providing interactions relevant to the interests of an individual user, that user’s experience with that IVE could be enhanced.

Section 2.3 Virtual Theater

In her book *Computers as Theatre* (1991), Brenda Laurel describes how the development of the computer presents the possibility for a new dramatic medium, or at least a new forum by which drama can be viewed and expressed. From her work, the similarities between actors and computer agents are compared and contrasted to reveal an underlying theme by way of the interpretation of action (Laurel, 1991). In addition, Laurel suggests that interaction is central to human computer interfacing and that the similarities between stage performance and software representation provide incredible perspective on how interface design can be approached, placing the user as the central element in the design. Laurel takes special care to address how human perspective is within a set sensory framework, which through VR experiences IVEs can elicit emotions from users by applying immediacy and immersion in a first person perspective. Janet Murray takes the evocation of user emotion a step further in human-computer interactions by illustrating the potential for the composite multi-media platform embodied by the computer to form new narrative delivery systems in her book *Hamlet on the Holodeck* (1997). Murray connects the procedural nature of computation to the behavior of users in IVEs by suggesting that the most important element of the representation power behind IVEs is found in the “ability to capture [user] experience as systems of interrelated actions” (Murray, 1997). In this manner, by placing user initiated action influencing objects, agents, or other users within an IVE into a network of related actions and observing them from an analytical perspective might produce a means by which user experience in IVEs could be quantified. Returning to the analogy of theater, Murray places the user experience as a dynamic element in an otherwise scripted narrative within many existing IVEs, but suggests that the narrative could through procedural representation become dynamic in virtual environments and interact reciprocally with an inhabiting user (Murray, 1997).

Chapter 3: Vactor Elucidated

Vactor in the perspective of this research is defined as a combination of agent and avatar forming an entitative virtual persona which harnesses ambient intelligence to act as guide, transportation, and assistant for human users within interactive virtual environments. This research presents the emergence of vactor as an evolutionary speciation of the relationship between humans, agents, and avatars in IVEs. Through close examination of these components as well as the relationships between them, the emergence of the vactor takes form. The user component of these relationships lends purpose to a vactor by establishing the audience and providing inspiration which is interpreted into a virtualized persona. Avatars and agents both serve as tools by which users can experience IVEs and form the technological basis by which vactors can exist. Together, the three components indicate the possible speciation elucidating vactor. This study begins its examination of vactor by examining user, agent and avatar individually. Then, the pairing of user-agent, user-avatar and finally agent-avatar are examined to describe how each node works with another. Finally, the relationship between all three are examined and related to the emergence of vactor.

3.1 - User/Audience

The audience and defining element of a vactor is human users, rather than artificial intelligence, interactive environments or virtual agents. Users define the purpose of a vactor and provide information by way of observable behavior which this study will refer to as inspiration upon which a vactor bases the virtualized persona. User can be defined as any person who wishes to experience and interact with a virtual environment be it social media, video games, graphic design, educational simulation, or theatrical augmentation. The association between users and vactors can be thought of as a dynamic relationship, where each in turn acts as audience and performer, but having an audience-as-active-participant can present an issue by adding noise to the user's experience in the IVE as the audience becomes the actors and 'passive' observation becomes inaccessible (Laurel, 1993). This issue is addressed by looking at the human-agent and human-avatar relationships where the audience and performer roles are examined. It is important in the context of this research to examine the user as audience in the context of the relationship between both user and avatar as well as user and agent. In this light, user acts as both a source and a destination for action and information. Interface is both the barrier and conduit by which users can interact with IVEs, but without some means by which human desires can be enacted in an IVE, influence and immersion become inaccessible. Therefore interface performs a crucial role in understanding the relationship between humans and IVEs and is inherent in both agents and avatars as part of their purpose.

3.2 - Agent

In the Aristotelean approach to drama, agents are entities who take action (Aristotle, n.d./2000). This can refer to individuals or collective entities which make up an agent and who are capable of initiating action. There are several different models into which the term agent can fall. In this study the software agent defined as "referring to a component of software and/or hardware which is capable of acting exactingly in order to accomplish tasks on behalf of its user" (Nwana, 1996) is the principal definition of agent examined. Action being the means to accomplish tasks becomes the focus by which the interplay between users and agents can be understood. Nwana proposes a non-definitive typology of agents where 4 categories are established: interface agents, collaborative learning agents, collaborative agents, and smart agents. Each of these agent categories can be conceived of as interfaces between the goals of users and actions within a virtual environment; the goal could be the retrieval of information or the performance of tasks such as setting up schedules, reserving hotel rooms, or outlining meeting topics (Norman, 1994). The agents employed for these tasks can accomplish the tasks independently, but the impetus action most often is hierarchically dependent requiring an initiating directive which contrasts agents to users as a user originates the action. Dependence in relation to a user does not break the Aristotelean view of agency, but rather expands it to include a causal source of the action and defines the action taken by the agent as an interpretation. This casts the agent as a filter for action, narrowing the scope implied by the action to the capabilities of the agents. Expanding the capabilities of an agent finds the most efficiently through software programming, however there are other methods by which an agents capabilities can be broadened (Smith, Cypher, Spohrer, 1994).

Agents can direct other agents just as though they were dominos stood up in a row, but ultimately an exterior entity must initiate the system of agents by providing directive by way of action, like knocking over the first domino in the series. Once initiated, an agent or agents can work independently, participating actively toward whatever goal it was purposed as an entity taking action when provided with the necessary resources (Smith, Cypher, Spohrer, 1994). The initiating action does not need to be direct, which is to say that the user does not have to explicitly engage an agent for the agent to take action itself. Instead, software agents are intended to have a relationship with the user by which the agent could anticipate a need based on a knowledge of the individual user (Shneiderman & Maes, 1997).

3.3 - Avatar

The term ‘avatar’ originates from the Sanskrit combination of ‘ava’ meaning ‘down/descent’, and ‘tar’ meaning ‘to cross’. The first real usage of the term to refer to a human representation in virtual space could be traced back to the video game *Ultima IV: Quest of the* Avatar (1985), whereby avatar is used as an honorific title which users achieve through conquering the game (Barbas, 2013). The term was later taken up by the online role-playing game *Habitat* (1986) where the term was used both in the program and by the developers to describe the animated figures which represented the users (Morningstar, Farmer, 2008). Avatar in this study is a digital representation and form of interface by which a user gains presence in an IVE and acts as a simulacrum in interactions with other users and virtual communities (Rheingold, 1991; Mason, 1999). In the myriad of different IVEs available to users today, the different forms the avatar takes are diverse. In social media, a Facebook page or Twitter handle can be considered avatars as they are diminished representations of individuals. In the life simulation *Second Life* (2003), avatars are highly customizable and capable of a large range of expression to allow users greater control over the development of their identity through the personalization of character traits and appearance. In video games like *World of Warcraft* (2004) there is a limited amount of customization that can be given to allow a user to build their identity in that IVE. An example of this customization would be that roughly half of the female player representations in the game were male users who had created 'gender-bent' characters (Yee, 2005). In *League of Legends* (2009) users are represented in an avatar hybrid of an abstract handle known as a 'Summoner' and the static character they choose before a match. A tangible example of avatar would be an automobile, which a user comes to identify with when operating in the virtual environment of traffic. Avatar functions as a vehicle and as a source of feedback from actions made in an IVE to the user.

3.4 User-Agent

The relationship between a user and an agent centers on action and describes how users find information and work discretely within IVEs. Users provide tasks for agents such as information retrieval, and depending on the type of agent the task is accomplished according to the resources available to that agent. This relationship provides information both ways as the agent reciprocates action by feeding the result of its interpretation of the goal set by the user back to the user. An example of this relationship would be the taste profile system *Netflix.com* (2015) uses to suggest movies to users based on what they have watched and rated. Their streaming system initializes the relationship with a new user by asking the user to rate some of the movies and television shows the user has watched and based on their selections develops a taste profile for the user to offer media with related elements to the media the user has indicated they enjoyed. In a very similar manner, *Amazon.com* (2015) suggests relevant products to users based on their browsing entries and past purchases made. These types of user-agent relationships suggest information and media to the user based on what the user has defined and on what the agent has observed.

3.5 User-Avatar

Within the relationship between users and avatar the development of a character through translated identity and immersion drives the user's experience within an IVE. The distinguishing attribute that avatars have as opposed to other interfaces is that users can personally relate with an avatar. Commenting on identity in an interactive virtual environment known as a multi-user dungeon (MUD), Howard Rheingold observed:

> Identity is the first thing you create in a MUD. You have to decide the name of your alternate identity--what MUDders call your character. And you have to describe who this character is, for the benefit of the other people who inhabit the same MUD. By creating your identity, you help create a world. Your character's role and the roles of the others who play with you are part of the architecture of belief that upholds for everybody in the MUD the illusion of being a wizard in a castle or a navigator aboard a starship: the roles give people new stages on which to exercise new identities, and their new identities affirm the reality of the scenario. (Rheingold, 2000).

While Rheingold uses identity and character interchangeably, this study examines the two terms as separate from one another. Identity in the discussion of avatar refers here to the traits and unique patterns a user manifests in an avatar through use, whereas character is the combination of traits and characteristics established by the user.

When a user acts through an avatar the user is projecting a portion of themselves upon the avatar by way of autobiographic actions, which are actions that denote aspects of a user's identity. The degree to which a user identifies with an avatar is largely dependent upon the user's immersion in the IVE which the avatar inhabits. Immersion functions for a user as a sense of place and presence within the environment and a sense of engagement with the events surrounding the avatar (Loomis, Blascovich, & Beall, 1999).

The developed persona known here as avatar acts as the user's simulacrum in interactions with other users within a multi-user IVE. Avatars are at their core, constructed social identities acting as the representation of users to other users in IVEs (Meadows, 2008). This constructed identity is composed of characteristics and traits imparted by a user into the IVE in the development of the avatar [fig. 4]. Constructing an avatar involves two forms of identity infusion, passive trait infusion and active characteristic infusion. The characteristics actively infused into the avatar could be aesthetic, such as an

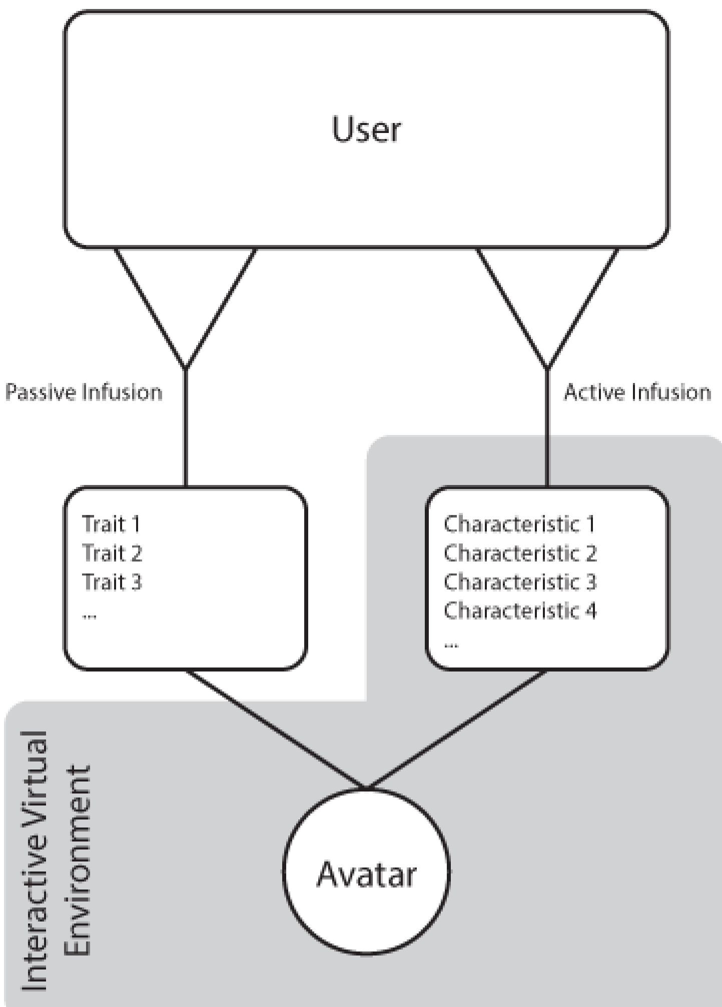

Figure 4. **User Avatar Construction**

image, three dimensional model, or screen name. They could also include narrative elements by way of constructed biographical information or IVE specific archetypical information such as a fictitious role or race. Characteristics selected by a user form the representative portion of the constructed identity of the user in an IVE. This constructed identity can act as a façade against which anonymity can be leveraged to expose a more genuine self through the passive infusion of inherent traits to other users. The addition of passive traits such as user speech pattern or manifest sexuality to the characteristics actively selected by a user adds authenticity and individuality to the avatar representation. The avatar is also defined by the actions manifest by the user. These actions can be both reflections of the active characteristics, and manifestations of behavior while the avatar is being utilized. Traits associated with the user's behavior are passively infused into the created identity of the avatar, in some cases without the user even being aware of it. Examples of this could be a user's speech pattern, or the selection of clothing indicative or personal taste. The identity created from the infused characteristics combined with the passive infusion of action based traits in the IVE are diminished representations of the user. The diminishment of the user is in terms of capability to intuitively communicate and interact within an IVE (Manninen, 2003).

The identity formed by the user-avatar relationship contains qualitative and quantitative traits which can be observed and stored. Qualitative traits include the preference, demeanor, motivation and engagement of a user within an IVE. These are products of built and manifest identity. Quantitative values observable in the identity of an avatar include contextual information as well as the effects of decisions made by the user in the IVE. The contextual information includes the choice of IVE and time spent in the IVE. The effects of action within an IVE produce observational and heuristic quantitative effects like movement, discourse, and progression which can be saved in relation to the user. In constructing an avatar and acting within an IVE, a user adopts autobiographical authorship in a similar fashion to which a late adolescent or young adult might frame their personal history as a narrative identity, beginning in autobiographical memory and including dreams, goals, and aspirations for the future to form a cohesive sense of self (McAdams,2013). It is important to note that the data collected in this manner is relative to the avatar and the observable behavior of a user within an IVE; this means that it does not necessitate personal information concerning the user (e.g. name, address, gender, race, etc.) which keeps the relative anonymity of the user intact. This is crucial concept in the continued exploration of these emerging technologies due to public concerns regarding security in IVEs and the building of trust between humans and computer systems (Norman, 1994).

3.6 Agent-Avatar

Connecting avatar and agent within an IVE provides several opportunities to capitalize on user constructed identity and inherent behavioral profile manifest through interaction to provide agent services targeted to user needs without overt direction. The avatar acts as a glove in a crude sense, through which a user can experience an IVE and while doing so an observing agent can retain the decisions made as a persona imprint, which would be a crude interpretation of character and identity. It is the observation of action oriented decisions through the avatar which provides the agent with the information necessary to employ the actions at its disposal to guide and assist the user with relevant information and direction within an IVE. Like the example of Netflix presented earlier, information pertaining to a user's identity through behavior can be gathered both actively and passively. Active gathering would involve direct interaction between the avatar and the agent whereby the agent parses established static information including the selected characteristics imbedded within the avatar which the agent can use as a foundation. This origin framework is generated in a manner similar to the initialization process in Netflix where the user is asked to identify and rate media they have already experienced. This also applies to the decisions and behaviors infused by a user into the avatar. Active data gathering on the part of the agent could also involve queries directly to an outside source concerning the intent of the avatar. Passive gathering of information on the part of the agent would involve observation of the communications and behavior of a user in an IVE, similar to the information gathered by Netflix as a user interacts with the website.

3.7 User-Agent-Avatar

User-Agent-Avatar (UAA) describes a system by which user presence in an IVE can be utilized to enhance the user experience. Within this system we find qualitative and quantitative information provided by the relationship between users and avatars within an IVE which can be actively and passively gathered by an agent to enhance the user's experience within an IVE.

The UAA system provides agent feedback based on three types of information: state data, identity data, and situational data [fig. 5]. These data sets are stored by the agent in relationship to the individual user and are processed through a pattern recognition set which filters the data into quantitative behavioral archetypes. These behavioral archetypes

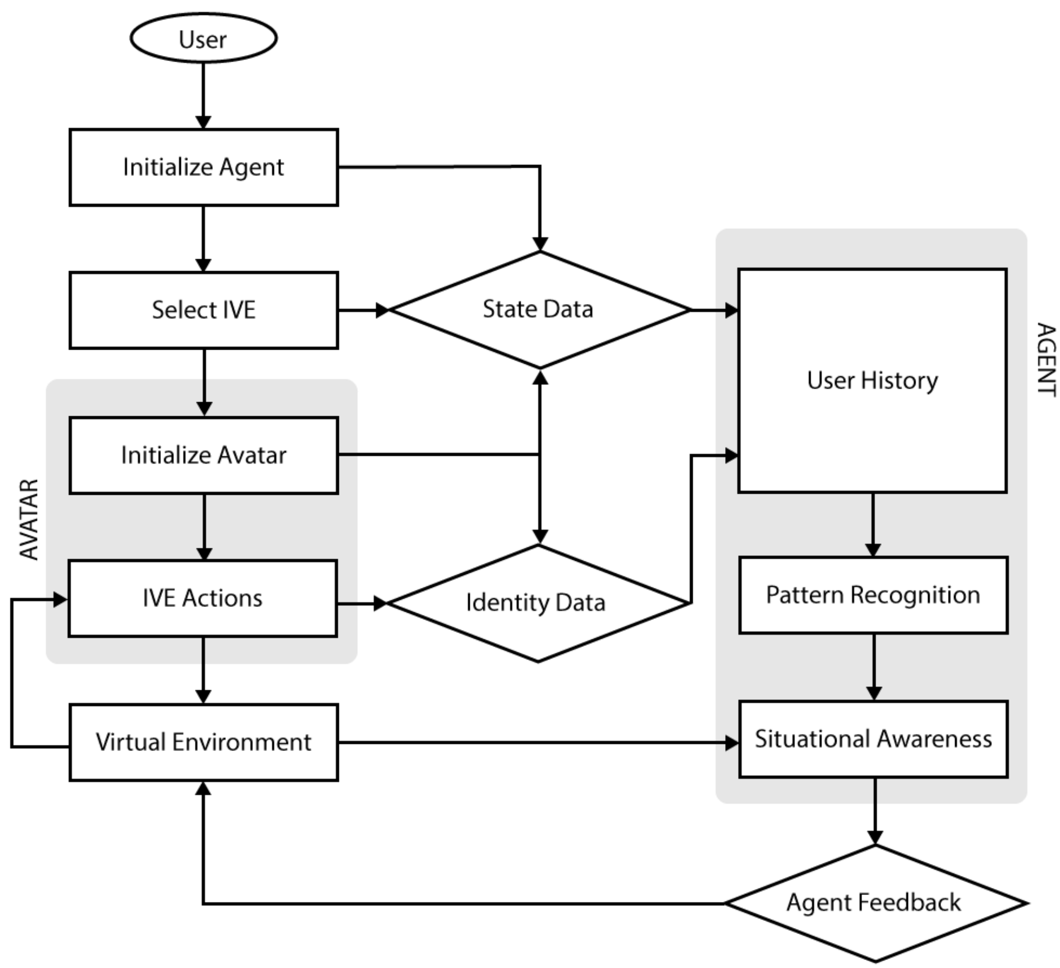

Figure 5. **UAA System**

function as a profile and can inform the agent of the user's preferences, tendencies, and desires and are used in conjunction with a virtual environment situational awareness tracking to generate feedback to the user. The agent feedback can take the form of any agent related function (e.g. situational guidance, IVE manipulation, social networking, information retrieval, etc.) (Nwana, 1996).

The system starts with a user initializing an agent, which describes what kind of information the user would like to be encoded and what types of feedback the user intends to receive. This agent initialization process is not necessary for every interaction, but it should be performed the first time a user encounters the system as it will establish the grounds upon which the user and system will relate to one another. In this sense it is not unlike a computer operating system where a user might change settings from time to time so that their experience is more comfortable and accessible, but the settings go largely unaltered or at least altered infrequently as the system works in the background. These settings are a form of quantitative state data which is stored by the agent locally, on a networked database, or even on a cloud system.

Following agent initialization the user proceeds to select an IVE, not unlike selecting an application in an operating system. The IVE is not contained within the UAA, but rather the UAA interacts and observes the IVE as a separate software process. The selection of IVE is also a form of state data handled by the agent which informs user preference through frequency and duration of interaction.

Once an IVE has been selected, the user then selects, modifies, or creates their representation within that IVE. These options generate both state data and identity data which are added by the agent to the user history. The qualitative identity data generated here is generated primarily through the creation and modification processes where behavioral cues in terms of both direct and indirect action are extrapolated from the editing process. The process of creation or modification of the representation by the user generates the user's avatar, which is specific to the IVE in which it has been created.

With an avatar selected, the user sets about pursuing their personal goals within the IVE. As the user takes action, those decisions and behaviors effect the virtual environment and generate qualifiable identity data which are both handled by the agent. The behavioral cues and decisions made by the user through the avatar in the IVE are recorded in the user history. The effects of the user's actions on the virtual environment with which the user is interacting are taken into consideration by the agent as a component of the generation of agent feedback.

Between the recording of user derived data and situational awareness filtering, the agent is analyzing the user history by filtering it through a database of pattern recognition possibly similar to the algorithm proposed by Wang, Deshpande and Shneiderman (2012) which allows the agent to construct a virtual model of the user and apply appropriate situationally aware feedback to the user which could be through the IVE interface, by enacting modifications to the virtual environment, or even by direct interface with the user. The agent feedback could also include reaching out across a network to find resources or information relevant to the user in the current situation. This presents opportunities for leveraging the user history to a network of similar systems by which the UAA can cooperatively problem solve and pool data to develop and refine behavioral pattern recognition and situational awareness libraries. The parsing of this information to create recognizable pattern structures appears to only exist in component parts, where a system like the one used by Netflix.com to analyze viewer habits only accurately applies to the mediums of television and movie viewership, but could be paired with other pattern analysis systems to composite a more complete picture of the tendencies and interests of a particular user.

3.8 Vactor Emergence

Through a system like the UAA, networking technologies can be used to bring the virtualized persona information to multiple platforms. Networked platforms such as mobile devices like laptops, smartphones, and tablets help to define the accessibility of an entity like the vactor which can be used across multiple devices. Behavior patterns from accessing dating sites to working on homework could become available to vactors functioning at an operating system level and provide users with feedback at multiple points of contact throughout the day. In this sense, the vactor is similar to the JARVIS system portrayed in Marvel's *Iron Man* movies and comics. The vactor could act as an extension of the social intent of an individual, a personal assistant which could be available through any internet access point to work with and on the behalf of a user. Acting as a composite of passive and active behavior, the virtual persona of a user composed by a vactor could reflect a similar joining of technologies to the observable integration of social networking like Facebook or Windows Outlook as they are now used to access various websites and services such as Skype, Hulu.com or Spotify.com, providing a unified portal through which a single profile for user behavior can be constructed. This cloud profiling is already available across multiple platforms from television sets to mobile phones, and according to Ray Kurzweil's zeitgeist of technological evolution this unification and proliferation of virtual personas will only continue to grow (2013).

It is at the point of the networked integration of UAA systems that the implication for the speciation of vactor is elucidated. In networking multiple UAA systems together, a virtually interpreted persona derived from a user can be constructed [fig. 6]. This virtual persona, this collective of IVE related profiles is what makes up the virtual actor. Vactor

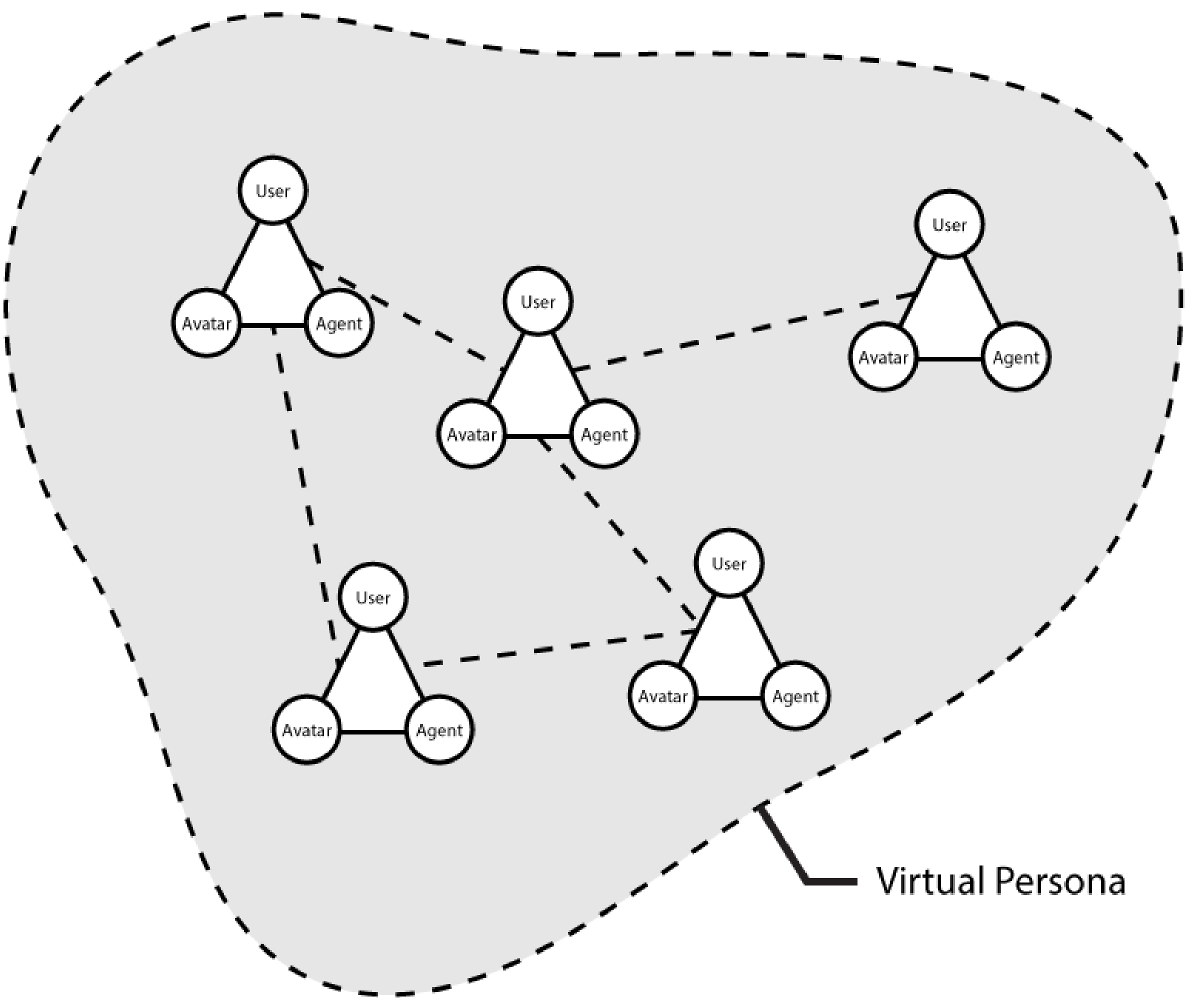

Figure 6. **UAA Network as Virtual Persona**

therefore is composed of a collection of interpreted behaviors by way of the observable identity of a user combined with broad spectrum pattern recognition and the predefined traits which make up the avatar character now becomes its own entity through networked ambient intelligence. While the vactor could be made up of a single instance of a UAA system as in Figure 1, the implications of networking multiple devices and platforms (e.g. smart phones, game consoles, personal computers, etc.) is that the more UAA systems there are involved in the virtualized persona, the more accurate the agent feedback can be to the user and the vactor becomes more defined as an interpretation of that user. This is demonstrated by the compound effect of hidden (processing) layers in neural net artificial intelligence, where more layers and more nodes per layer equate to the handling of more complex data (Polanco, 2001). As a virtual entity, vactors are dependent upon virtual mediums to interact with and on the behalf of the users of the IVEs with which they are associated. In order to examine how vactors might work in the context of current technologies, the definition of vactor needs to be paired down to fully explore how the specific definition presented in this study differentiates this virtual entity from other IVE entities and agents.

The vactor at the networked level operates as a persistent ambient intelligence across multiple software platforms. In this capacity it can serve as an ambient intelligent conduit, connecting IVE information and interactions to users. Ambient intelligence (AmI) describes a networking of devices and mediums which gather information and analyze it to derive and enable dynamic independent actions (Bick & Kummer, 2010). The similarities between AmI and ubiquitous intelligence lead to an important distinction between the general understanding of AmI and the use of the term in the context of vactor. Vactors have the capacity to operate as intelligent agents from multiple platforms with a high degree of interactivity with the virtual environment and as such the definition of ambient intelligence in the context of this examination of vactor is extended beyond the single environment to include virtual environment connections across multiple computing platforms. This expanded definition helps to encompass the vactor acting as an ambient intelligence across multiple sources of interaction both with IVEs and with users to provide directed user specific feedback.

A vactor interacts with users through the UAA systems, operating to enhance user experiences in IVEs. The vactor inferred by the networked UAA is made up of two distinct components: at least one local UAA system accessible by a user and a user history database containing information on a specific user, which used together compose the ambient intelligence described in relation to vactor. The agent component of a UAA within a vactor drives the ambient intelligence actions through dynamic decisions based on analyzed information gathered from the user through the avatar component of the UAA.

Virtual persistence brings an incredible functionality to a vactor as it enables a capitalization on the virtual persona incumbent within a vactor to provide feedback based on user decision making in IVEs over time. Persistence across multiple platforms allows the vactor to provide the agent feedback to users on demand, wherever and whenever a user would be interested in that service. Further, persistence means that the development of the ambient intelligence that vactor embodies has more possibilities of access to user behavior, which is used to help the vactor provide services through agent feedback to enhance user experiences across multiple IVEs.

The agent feedback in relation to vactor can be purposed to some of the adaptive benefits of IVE interaction including: users understanding their identity as both an agent and object within a community of other agent-objects; the placement of a user in the perspective of another individual for trans-identity, alternate perspective experiences; and intentional instruction and learning (Murray, 2006; Tomasello, 2000). Through identity and situational analysis, a vactor could enhance a user's experience as well and enrich the user individually through directed agent feedback in interactive virtual environments in applying these adaptive benefits.

3.9 Vactor as Theatre

The definition of a vactor benefits greatly by being compared and contrasted with the term and notion of actor. The relationship between vactors and users can be compared on three levels in theatrical terms: audience-actor, actor-script, and actor-director. Examining vactor in these three analogies helps to elucidate how a vactor could enhance the experience of a user in an IVE. The comparisons also provide insight into interpretive active and passive feedback.

In the classical medium of theatre, actors are conduits for and interpreters of action; actors become avatars of a narrative on a stage before an audience. In addition, actors function as agents, performing on the behalf of a director or vision of a narrative. Even improvisational actors work out of a set of rules which guides their performances. The actor embodies both the avatar and the agent; an actor utilizes independent action to form an intimate connection with an audience while transporting them through a narrative. Vactors are not actors, but in terms of professions vactors behave and are most similar to actors. As a virtual entity, the vactor first and foremost interprets action into a virtual environment.

The audience-actor relationship presents an analogy by which the interpretation of action and the notion of human identity are better understood. Using Aristotle's framework of agent in the dramatic context to refer to an actor, the relationship between communicating identity as an interpretive process becomes clearer (Laurel, 1993). In this framework, an actor becomes the embodiment of the action of a drama. The actor interprets the action by way of an artificially constructed identity called character [fig. 7]. The character, as the interpretation of action, is the summation of the actor's traits, thought, active cognition, and pattern recognition (Aristotle, n.d./2000). Putting a user in a multi-user IVE through an avatar is like putting an actor on a stage, whereby the user can be deliberate in their actions so that the audience, composed of other users, interprets their identity

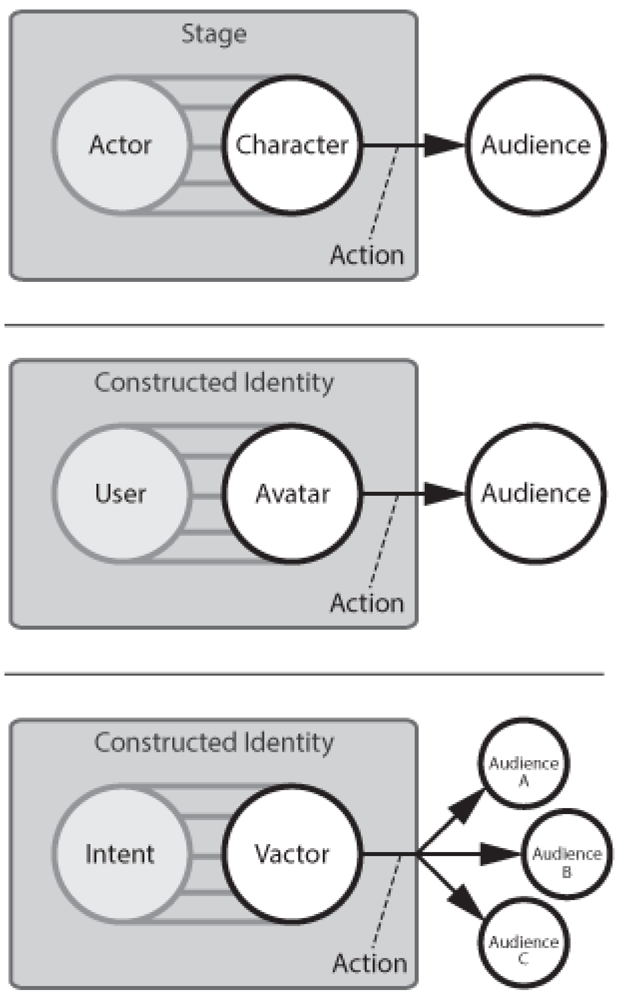

Figure 7. **Character, Avatar, and Vactor Interpretations**

in an intentional manner. The vactor, by comparison to an avatar, could present a more accurate interpretation of a user's intent by leveraging the virtual persona created from the user's behavior against observable behavior in the audience's reactions to present the user's constructed identity in a more believable fashion. The vactor could augment verbal and nonverbal aspects of language and appearance to better suit an audience's expectation of behavior so that the user's constructed identity conveys the intended character. This would be like a physical actor having a microphone which automatically adjusts their speech into an appropriate accent, or like a costume which morphs into colors and shapes that cause an audience to react in an intended manner. In addition, should the audience be made up of users who are also using virtual personas constructed by vactors, the believability of the constructed identity could be further increased by through alterations made to the individual audience members' perceptions of the constructed identity.

In forming a virtual narrative identity by which a user can be known, an interpretation of self occurs where the character framework of traits presented in the IVE is merged with the persona a user wishes to adopt, not unlike an actor using their life experiences to interpret a character presented in a script (Donnellan, 2002). This leads to the second theatrical comparison, actor-script. The script embodies the action of a narrative, which works as an analogy for a user as the source of action for a vactor. The vactor in this analogy take the role of the actor, with the user adopting the role of the script. As the vactor observes and imitates the user, it is interpreting the user into a representational character. The vactor is no more the user than the actor is the character, but rather the vactor might appear like the user in the sense that it stores and recognizes user behaviors.

The comparison between actor-director come into play as the interpretation of action is brought into the scope of an IVE. In theater, it is the vision of the director guides the actors' interpretation of their characters and orchestrates them in concert with one another. Relating this to vactor, the role of the director is taken on by the user history which contains data concerning not only the user's direct behavior, but also the user's history with one or multiple IVEs. The vactor can be cast individually or as a group of actors in this analogy as their interpretation of the behaviors of the user forming a virtual persona is guided by within an IVE context.

Chapter 4: Agent Guided STEM Education in IVEs

Chapters 4 and 5 examine how vactors could enhance the educational experience in two different interactive virtual environments (IVEs), the Virtual World Village (VWV) and Virtual Vandal Playbook which address STEM education and sports training respectively to demonstrate how vactors might perform in these applications and by doing so, help to define what form the emerging technology might take.

Something that has been lacking until recently between entertainment and education is a bridge which can apply the confluence of technologies surrounding the development of avatars and agents in IVEs to provide both an increase in the efficacy of education within IVEs and a stronger relationship between audience and environment. Schools in the United States struggle to keep up with the academic success of other nations and more specifically STEM disciplines where it is widely acknowledged that too many US students are unprepared in math and science and that the nation's STEM workforce are not finding sufficient human resources to meet their needs(Education, 2014). Vactors may provide the ability to leverage the technologies developed in the thriving IVE industries to enhance education in STEM disciplines as well as providing a tool to assist teachers in addressing a broad spectrum of education ranging from fine arts to sports. A virtual actor could enhance immersive educational experiences in IVEs by bridging observed user interactions with individual learning goals and providing a personalized guide, vehicle, and role model within the IVE. Coupled with an open world educational IVE such as the Virtual World Village project (Anderson & Cooper, 2014), vactors would have the ability to leverage

STEM learning goals through the guidance of a student through the IVE both directly and indirectly with way-finding navigational elements and dialogue based suggestions.

The Virtual World Village project operated from a Micron STEM Education Research Initiative grant to formulate a possible solution to elementary STEM awareness and education for 7th to 10th grade females in secondary school (Anderson & Cooper, 2014). Here is a description of the VWV project from the 2014 STEM Conference program:

> The intent of the Virtual World Village (VWV) is to elevate the utility of virtual educational environments so that they better target females' educational interests in sustainability, enhance overall STEM awareness, and provide contextual experiences for a variety of possible STEM career paths. The VWV provides a learning platform that will allow students, parents, and teachers the ability to engage in STEM related exercises while they solve authentic problems. The viability of the village is dependent on the ability of the students to study, develop, and implement solutions to problems they are presented with. The VWV provides students with engaging, interactive activities that contextualize STEM concepts and connect them to other STEM domains. There is a multitude of potential scenarios—they could for example, take the role of a villager faced with a water shortage, a tsunami victim faced with water contamination, or an engineer tasked with designing a wind farm to provide power to the village. The VWV fosters peer interaction as students collaborate to develop models and critique potentially viable solutions to real world problems. One intended outcome is that as students interact within the VWV they collect and interpret information to manage real-world problems which increases the students'

interests in STEM fields as they see their efforts making a difference in a sustainable future. This is corroborated by others who found that interactive technologies are capable of presenting authentic, experimental approaches to STEM problem solving, and have potential to excite all students, especially minority and female students. (Anderson & Cooper, 2014).

The potential this system provides for a conceptual application of the vactor in an educational IVE merits exploration into how a vactor might be integrated into an IVE like the VWV. Three areas of influence stand out for the application of vactors here:

- Personalization: Assistance in personalizing both content and subject matter to an individual student could be obtained.
- Guidance: The provision of direction and guidance could be communicated to a student relative to a student's interests and learning objective within the IVE.
- Collaboration: Compatibility and user diversity could be assessed and user peers could be suggested for collaborative problem solving activities.

Through assessing these three areas of influence by which a vactor can enhance a student's experience within an educational IVE, a greater understanding of what a vactor could be and how they might work emerges. While not an exhaustive list, the areas examined here imply the nature and direction the technologies surrounding and implying vactor are headed.

4.1 Personalization

The ability for a vactor to store, recognize, and relate patterns of user behavior in IVEs lends itself to user profiling and through that, to IVE personalization. In this sense, a vactor could serve as a sort of virtual personal assistant by placing interface elements, information resources, social communiques, and current objectives in an arranged order based upon the user's personal interests and indicated preferences. Products like the proposed Apple TV which can network multiple home devices together with a virtual agent allow for the potential of gathering behavior data and applying it across multiple platforms. This is a function which could be facilitated by a vactor as a system composed of multiple UAA interfaces imbedded in various IVE software. Students in IVEs such as the VWV utilizing vactors could find that the avatars, music, and graphical user interface elements used by the IVE software could be swapped out by a vactor to elements which might be more appealing and thus more immersive to a student. Learning objectives set by parents and teachers could be tailored by a vactor to a student's age-group, disposition, achievement, and inclination. This learning information could continue with a student outside of school and be applied as the student studies and plays at home.

4.2 Guidance

Generally speaking, within a given IVE there are multiple avenues by which a user could navigate to get to a desired destination. Vactors at the situational awareness level could leverage a preset knowledge of the layout of an IVE, or acquire a knowledge of an IVE through observation and networked information sharing to provide users with useful guidance through interfaces and virtual environments. This agent feedback could come in graphical form with arrows or highlights suggesting interesting routes or areas of possible interest encouraging exploration while also keeping a student on track towards their established learning objectives. The feedback could also take the form of natural language dialogue which could be displayed as text or delivered as audio to the user. Some examples of agents providing guidance through interactive virtual environments exist as references to how vactors might deliver feedback by way of natural language (Hofs, Theune, & Akker, 2009; Roque et al., 2009). In the scenario provided by the VWV project, the vactor might highlight an intractable non-player character (NPC) who possess dialogue pertaining to a task at hand. The vactor might even suggest different avenues a student could explore in terms of building their avatar, or might facilitate guidance from an external source like a teacher or parent to tackle a particularly relevant problem such as a student-peer behavior like sharing resources.

4.3 Collaboration

A feature of having a network of agents is the ability for the agents to share information. This could result in the ability for a vactor to recognize potential peers for a user as being compatible partners with whom the user could work to problem solve a particular learning objective or even simply to play with. While there is little agreement on what might constitute compatible in terms of student peer relations (Furman, 1985), a benefit of the vactor's relationship with the user is that information on what online personality traits the user gravitates toward by spending time around may prove to be clues in the development of a system by which users can be provided options to socially network with other users with whom positive and productive cooperation toward specific goals could be encouraged.

From studies done on sociability (Simmel, 1949; Oldenburg, 1989), and especially from the research done on sociability in virtual worlds (Brown, 2005; Rheingold, 1993; Steinkuehler; 2005), the patterns by which users positively and productively interact within IVEs have begun to take form and may soon distill methods by which users can be encouraged to form both heterogeneous and homogeneous social networks (Ducheneaut, Moore, & Nickell, 2007). The selection of parameters available to vactors in finding user peers correlate to the amount of information available on a user and to the quantity of information made available for other vactor systems to locate and reference, which over time could be utilized in helping students find tutors with whom they can learn, or teachers who hold a particularly valuable piece of information or learning method benefiting the student. A vactor could also act in the manner of a recess supervisor in terms of user interaction, who with training can providing support for positive social interactions and encouraging movement away from destructive or aggressive behaviors within an IVE (Pellegrini, 2008).

Chapter 5: IVE Training and Potential Factoring in VVP

Contrasting the example of secondary school education is done here by comparison to American football player training through the Virtual Vandal Playbook (VVP) project at the University of Idaho (2011). The VVP project undertook a problem observed in the communication of plays between Vandal coaches and players. Translating the plays from a two dimensional representation by way of the paper bound playbook to the three dimensional practice and game fields proved to be difficult, resulting in both player errors and injuries. VVP addressed this issue by bridging the gap between the playbook and the field through the use of interactive virtual environments. The virtualization of the football field enabled the players to run through formations and plays without risk of injury, and free from the time constraints placed on coaches by the NCAA. In addition, the team and position specific drills run by coaches were incorporated to offer a low risk means by which players could improve their skills and reaction times. Player profiles generated by data gathered in the system provided analytics by which coaches could evaluate the reaction times, reaction accuracy, and time practicing of individual players as well as player groups and of the team as a whole.

Drills could be run by individual players or by groups of players in a multi-user environment with the intention of fostering a heightened degree of trust and anticipation between players. Another marked benefit to running virtual simulations and drills was the capacity for practiced repetition which builds quick and accurate player reactions (Felfoldy, 1974). The repetition of simulations and drills could be leveraged in varying degrees of difficulty and speed, creating an opportunity for players to make decisions at two or even three times the speed of a normal football play. This allowed players to effectively slow the game down, which is a common adage among football players meaning to gain a better understanding of the game through an expanded ability to recognize patterns in offense and defense movements.

In placing a vactor into the VVP system, the potential for the training of players globally across multiple platforms becomes a possibility. A vactor operating within the context of a training simulation such as VVP could be placed in the role of a personal trainer, working with individual players on training regiments established by a coach to impart techniques and strategies pertinent both during general practice and in preparation for game day. Through observing the actions of a player within the VVP virtual environment, the vactor could also provide feedback as to how a player interacts with the system, which would be valuable to both the coach and the development team responsible for improving the VVP system. In using vactors working within VVP as an analogy illustrating possible capabilities of a vactor, three areas stand out:

- Vactor as Personal Trainer
- Vactor as Feedback Provider
- Vactor as Mental Analyst

Examining these three areas through the definition of a vactor reveals how future IVEs could shape human-computer interactions. While each of these areas pose interesting applications of vactor in the scope of the VVP project, they also elucidate applications beyond education and training, with implications in fields like marketing, mental and physical therapy, and architecture.

5.1 Vactor as Personal Trainer

In college and professional football, there are physical fitness trainers who work with players to keep the athletes at peak physical condition. There are not currently any mental fitness trainers adopted in by the major football communities, but pundits for these communities already acknowledge the relevance of mental fitness through the recently flourishing term 'intangibles' (Conley, 2008; Weathersby, 2013). Intangibles is used to describe traits such as a player's ability to learn, reliability in pressure, consistency over time, professional demeanor, and social chemistry. These traits were largely thought to be inaccessible to quantification, however they are observable through individual and interpersonal action which makes them accessible to an observing agent that knows what to look for. In this manner, a vactor could act as a personal trainer through the VVP to cultivate desirable 'intangible' traits in players through observation and guidance. For example, if a player is having difficulty learning a new play, the vactor working with that player could suggest an alternate learning method based on methods which have worked for that user in the past. If there were little or no history between the vactor and the user, the vactor could suggest different approaches based upon a known learning methodology database provided by VVP or established publicly online. If a different tact or unrecognized learning method appears to work for a user, the vactor could catalogue that method in a public online database for other vactors to reference within similar IVEs.

The previous chapter cited the education scenario played out in the Virtual World Village (Anderson & Cooper, 2014) wherein vactors were explored as virtual guides. In the context of the VVP system, a vactor could work on behalf of the student or player to interpret the coaches desires for that player and the team as a whole to guide the player to scenarios and drills within the system which will accurately address the externally established objectives. In addition, the vactor could also include goals set by the individual user, allowing for a mixture of personally and institutionally guided training.

5.2 Vactor as Feedback Provider

The feedback coaches currently get from players in terms of how much time the players studied the playbooks and film reels provided to them is measured both from personal reports and by how well the players perform on the practice field and in the game. VVP provided a system by which player performance could be tracked and stored as data while the player was studying the material the coaches provided, and later delivered to the coach in both directly and in the form of an analytical report. Vactors have the potential to further the feedback gathered by providing information in the context of the user/player's history which could begin to demonstrate how the intangible traits of a player could be made manifest. Through enabling a vactor across multiple platforms, a user's behavior in IVEs could help coaches determine how best to provide information to those players. It could even assist a coach in determining what situations a player performs best in by not only observing the training taking place in an IVE like the virtual vandal playbook, but also across other IVEs which introduce similar patterns and situations as those found on the football field. Factors such as a player’s ability to focus through visual and auditory noise, work under time pressure, and communicate with teammates could be used to guide the players and inform the coaches. This does give rise to issues in terms of player privacy and the confidentiality of behavior, which are currently the focus of several IVE studies (Nichols, Ryan, & Ryan, 2000; Keshtkar, Ghoreyshi, & Tootaghaj, 2013).

5.3 Vactor as Mental Analyst

The topic of intangibles in relation to football players is especially intriguing when compared to the studies on Sociability that were started back in 1949 by Georg Simmel. Aspects of sociability, namely how two individuals positively interact and work together has dramatic influence on a collective activity made up of a network of individuals (Morgeson, Reider, & Campion, 2005). Akhtar et al. suggests that there are identifiable traits by which a worker’s engagement can be quantitatively evaluated. A vactor could utilize trait sets to evaluate how engaged a player is in team goals and training which could then suggest how training routines in a virtual environment such as that provided by VVP. Other information which a vactor could make use of would be the reaction time information gathered in the VVP simulations. From this information, a vactor could encourage the player to try different types of IVEs like skill based videos which could help to elevate the player’s cognitive reaction times and pattern recognition with similar methodologies to those used virtual assessments like the Virtual Environment Performance Assessment Battery (Lampton et al, 1995).

Chapter 6: Emerging Theatrical Technologies

The relationship between vactor and theater tie directly to the root of the actor and as such, encompasses much of the history of actors in theater as viable analogy for the action expected from a vactor. Theater elucidates the operation of the vactor in the third person regarding the user, in a similar way to the relationship between the audience and the actor in a traditional theatrical forum. By examining some of the current uses of technology incorporating elements of IVEs, and IVEs that incorporate elements of theater, the relationship between the agents inside of these IVEs and the users becomes analogous the expected relationships formed with vactors. Framing these current technologies in a context of the evolution of technology in theater provides a perspective by which the integration of virtual environments could be understood as a natural progression from physical the environments found in classical theater. This forms two distinct areas which illuminate the relationship between vactors and users through the theatrical metaphor: discrete environmental agency, and actor character interpretation.

These two areas provide the analogy framework between vactor and theater which is leveraged to clarify how vactors could operate with and on behalf of users as well as in independent operation. Through the works of Brenda Laurel (1992), Janet Murray (1997), and Mark Meadows (2003) who have established comparisons between theatrical elements and virtual environments. Observations comparing human interaction with computer agents and the audience's interaction with the stage provided by Laurel describe the direct and indirect relationships with virtual environments formed through IVE immersion. Bridging the technological gaps between current virtual environments and fully immersive holographic interactive environments as examined by Murray might still take some serious research and development, but the recognition of agency systems like the vactor could be a step towards that bridge. The narrative forms described by Meadows gives a structure and context to better understand the actions observed in current IVEs, and also provide backing to the dramatic framework by which virtual interaction can be compared to the interactions found in theater.

6.1 Discrete Environmental Agency

Technologies and theater have had a long and interesting relationship. From the earliest forms of communal narrative taking place over a campfire to invention of the written word, the method by which humans shared information took the form of oral traditions and theatrical representations of action (Zarrilli et al., 2013). The written word had a dramatic impact on how information was shared within and between communities as it presented the ability not only to preserve a narrative, but also to manipulate the chronology of events in such a way as to expand the mind. The technology of reading and writing “rearranged the very organization of our brains, which in turn expanded the ways we were able to think” (Wolf, 2008). The printed word, or in the case of the first humans the printed pictograph, offered a new medium to channel the narratives which until now had been conveyed only orally or symbolically through ritual and non-verbal communication methods (Zarrilli et al., 2013).

Greek and later Roman theaters saw the introduction of mechanisms such as cranes and moving painted scenery which enabled visual transformations of the environment around the actors, creating a second on stage agent in the form of the environment which worked in conjunction with the human actors to convey a narrative (Leacroft & Leacroft, 1984). Aspects in the history of theater such as the perspective developed by Filippo Brunelleshi, the published work of Sicola Sabbattini on the construction of theatrical scenes and machines, and the first major English scene designer Ingo Jones who brought perspective from Italy to England and had framed his scenery with the proscenium arch, had profound impacts on the evolution of the environment as a narrative agent (Brockett, 1977; Macgowan & Melnitz, 1955).

The implications of the pursuit of technology to enhance theatrical drama could result in a growing expectation by audiences and designers alike to develop further relationships between virtual environments and the tangible ones used in modern theater. Some commenters on the future of technology suggest that the future of built sets could be diminishing if not being phased out completely by projection technologies bringing virtual sets and projected images to life on stage (Nadel, 2014). This proliferation of virtual technologies being used in theater presents an opportunity to explore vactor from a different perspective, in the role of the virtual environment.

Modern theater benefits from computer technologies both in the design and execution of plays. In design, 3D modeling software such as Blender and Autodesk's 3D Studio Max are used in conjunction with painting programs such a Gimp and Adobe Photoshop to produce simulated sets which can be engineered and built in physical form, or in the case of IVE theaters, are deployed directly to the virtual environment. In the execution of plays, computer software and hardware such as the ETC Lighting Emphasis lighting system incorporate the power of computer processing with modern stage lighting to reliably execute plays and offer solutions such as rapid design prototyping of light plots for use in theaters. Brenda Laurel's work in examining the similarities between computer and theatrical design have rendered valuable insights into human-computer interfaces (Laurel, 1992). From her research, the analogy of using the theatrical proscenium as the canvas upon which humans view virtual environments has helped to frame the relationship between users and computer software. Laurel described the graphical interfaces providing the visual environments of computers by saying that they:

> ... Represent part of what is in the 'common ground' of interaction through the appearance and behavior of objects on the screen. Some of what goes on in the representation is exclusively attributable to either the person or the computer, and some of what happens is a fortuitous artifact of a collaboration in which the traits, goals, and behaviors of both are inseparably intertwined. (Laurel, 1992).

Vactor as virtual environment poses some interesting notions on how ambient intelligence plays a role in the definition of vactor, and in the means by which a vactor works with the user. Examining vactor by way of an abstract environment casts the vactor in a passive relationship with the user, acting more in terms of voyeur than as a present entity. What is most intriguing is the relationship this generates between the vactor and an IVE, whereby the vactor is not definitively the environment, but rather adopts an aspect of it to use for interaction with the user. For instance, along the theme of ghosts, a vactor could "haunt" a virtual house, drawing the user's attention to objects or areas where the vactor might anticipate the user's interest. Doors and windows would open or close to steer the user through the IVE toward other users with whom the vactor might suggest interaction based upon the user's manifest personality.

6.2 Actor Character Interpretation

In relating vactors to theater, an example which demonstrates the use of an IVE in theater will elucidate the relationships between vactors, actors, and audiences. The example selected for this study was a joint production effort between the University of Idaho's Virtual Technology and Design (VTD) department and the Spokane Community College's (SCC) Theater/Performing Arts department (Rogers, 2012). In the project, the VTD students were tasked with providing a virtual avatar to be projected onstage in the SCC Theater's production of Shakespeare's Hamlet. In the production the Hamlet's father, played by Geoffrey Lang, dies and returns as a ghost. The ghost effect was to be the projected virtual avatar representation which was built to look like an ethereal version of Lang in costume, and was capable of vanishing and reappearing on stage. The image was projected through theatrical haze onto the scenery, which gave both dimension and translucency to the projection. Movement for the animation was captured from Lang through both an Xbox 360 Kinect, and the Optitrack motion capture system present at the University of Idaho. The animations were then filtered and adjusted for use in the virtual environment which hosted the virtual actor. The representation was not innately interactive, but rather was set to segments of dialogue and motion to allow control of the pace from the theater's technical booth and to simulate timely dialogue between the representation and the actors on stage.

The entire process used in the VTD-SCC project hinted further at the emerging relationship between technology and dramatic virtual narratives pointed to by Janet Murray in her book *Hamlet on the Holodeck* (1997). Taking a human form, capturing it's motion, and simulating interactions between the representation and other humans in dramatic form was certainly along the lines of Murray's fundamental dream of seeing interactive drama narratives come to life through interactive virtual environments. In terms of the evolution of theatrical technologies, the vactor could provide understanding in how people could interpret other people. It would be interesting to examine the effects of compositing the virtual personas generated by vactors to see what the results could render in terms of interactions with humans within IVEs. The phenomena of individuals pretending to be other individuals such as men pretending to be women in multi-user IVEs like the *World of Warcraft* is not uncommon (Yee, 2003). Vactors could provide insights into how actors could better represent characters by modeling the characters based upon their actions within a script. A vactor could be given a complete profile of Hamlet's father, and then use that in conjunction with a virtual persona based upon the actor from the VTD/SCC project to provide him with suggestions in how he portrays the character.

Chapter 7: Conclusions

In observing the emergence of the vactor through the circumstances [fig 1] and technologies [fig 2] which make user action manifest within interactive virtual environments, the opportunities to enhance IVE experiences across multiple platforms by leveraging a virtualized persona based upon the individual user become possible. As technologies related to IVE experiences continue to develop, more opportunities for experience enhancement will emerge.

7.1 Implications

The implications of multi-agent systems like the vactor in terms of user experiences within IVEs should see an expansion of the definitions of human identity as virtual personas continue to be defined in greater resolution and are merged together across multiple devices and platforms. Having a centralized virtual reflection of a user's actions opens opportunities both in research and in marketing, as behavior patterns are recognized and are able to be analyzed. The definitions of jobs like personal assistant or personal trainer could be altered to include virtualized systems which get to know a user over time and work with them to achieve a goal. Matchmaking systems could become significantly more efficient in establishing both work related and personal connections.

The impact of a system which incorporates user behaviors and represents an individual in an IVE could influence how virtual communities are formed and operate. Entities such as vactors could channel a virtual persona of a group of individuals at a small group level all the way up through representing an entire corporate network [fig. 8].

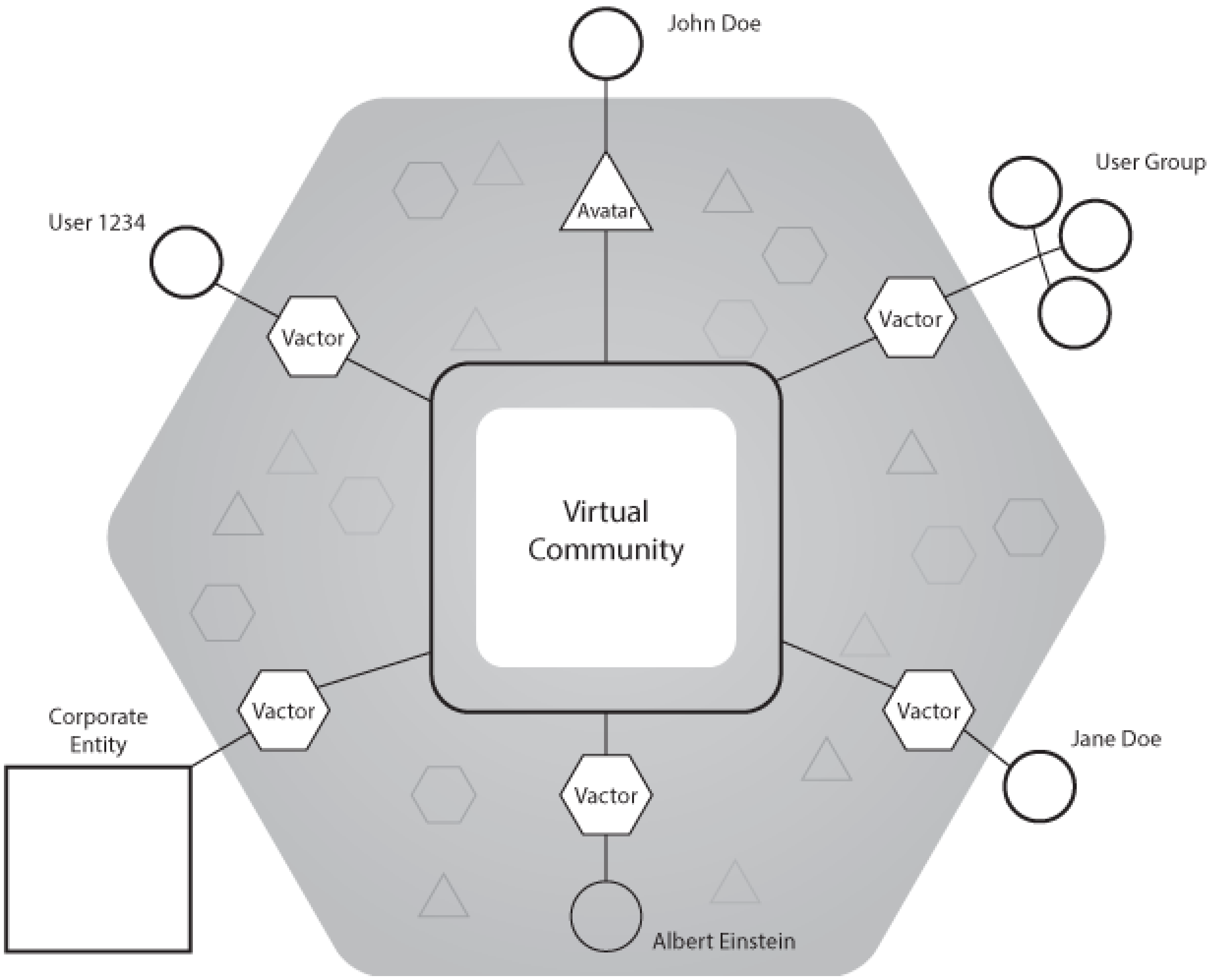

Figure 8. **Vactors as Virtual Community Mediums**

There is also the possibility for a vactor to represent a fictitious or deceased individual within an IVE virtual community if provided with enough behavioral information about that individual. In the figure, Albert Einstein represents an individual existing entirely within the virtual space of the IVE, but is also represented in the virtual community by a vactor.

7.2 Critiques

Critiques of the technologies which are used in this study to indicate the emergence of the vactor are broken into two categories which will each be addressed briefly. These critiques are presented to acknowledge the limitations of current technology, but do not inherently confine the possibilities future technological achievements could make on the development and functions of emerging vactors. The first category is that of privacy and security, where the issues brought up by cloud computing security are heavily debated, and the projections made of possible security breaches indicate a false sense of security is held by users of cloud based systems (Teneyuca, 2011). Additionally, concerns about the privacy of information related to the collection of behavioral data by an agent based system such as the vactor would need verifiable scrutiny in order to assure confidentiality (Serrato, 2012). This extends also to the ethical and moral implications of networking and virtualizing the representation of an individual. Through the addition of agency, concerns about the integrity of personal identity through networks and the release of personal information through automated systems become critical dialogues which will ultimately shape the form these emerging technologies assume. In the second category of critiques, accurate behavior prediction is addressed as unlikely and even impossible by some critics using neural networks or even through standard statistical analysis (Buyse & Piedbois, 1997). In this same vein, critiques of the predictions made by Ray Kurzweil concerning the tipping point of machine intelligence surpassing human capabilities challenge the notion of the singularity (Allen, 2011). The debate as to the linier or exponential development rate of technologies does not invalidate speculation on the emergence of vactor like systems, but rather speaks to the abstract timeframe within which the vactor speciation might occur.

7.3 Further Research

There are several topics upon which this research can be built which will allow further exploration into the emergence of vactor like systems. One such topic would include studies into what kind of artificial intelligence would need to be developed to parse through a behavioral data library and connect with a databank of communal patterns to recognize virtual persona elements which can be used to build resolution into the artificial representation of the vactor's related user. Another area which would require expansion would be connecting the conditional traits by which socialization occurs to form an algorithm by which productive relationships between users can be suggested. The topic of presence within IVEs can also be examined to explore how virtualized personas embodied by entities like vactors effects a user's approachability, sense of place, and sense of control. Additionally, antagonistic or negative behaviors would need to be analyzed so that constructive methods of redirecting users toward positive behaviors could be developed and distributed among vactors. Network architectures linking these systems would be required to allow vactors to operate across multiple platforms and IVEs. These network architectures could use cloud technologies or client based peer to peer systems, but the impact of virtual personas on virtual communities is directly related to the ability for vactor like systems to share information and connect to each other efficiently.

The implications of vactors generating virtual personas might not point directly to Kurzweil's singularity zeitgeist, but they most certainly offer fodder for continued research and discussion in that direction. In particular, the impact virtual personas could have towards downloading human consciousness through machines into IVEs may warrant further exploration, especially in the fields of human computer interfacing and neuroscience, as these vactor like technologies emerge.

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