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ICWorld: An MMOG-Based Approach to Analysis

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Wicked Intelligence Problems and Analysis Shortcomings

Intelligence analysts routinely work with "wicked" problems—critical, time-sensitive problems where analytical errors can lead to catastrophic consequences for the nation's security. In the analyst's world, important decisions are often made quickly, and are made based on consuming, understanding, and piecing together enormous volumes of data. The data is not only voluminous, but often fragmented, subjective, inaccurate and fluid.

These "wicked" problems form the crux of the shortcomings that have been identified and assessed in reviews of the Intelligence Community's current analysis process. According to the literature and analyst interviews conducted during Forterra Systems[1] research, the current analysis process does not:

- Support a knowledge-focused approach that is focused less on creating a final product, and more on seeking information, developing theories, testing hypotheses, and collaborating—while learning and developing expertise along the way (Brown and Rudman 1996; Cooper 2005; Heuer 1999; Russell; Silberman and Robb 2005);
- Emphasize procedures that expose and elaborate alternative points of view—devil's advocate, analytic debates, competitive analysis and elicitation of outside expertise (Cooper 2005; Heuer 1999; Russell; Silberman and Robb 2005);
- Provide tools and techniques to structure information, challenge assumptions, and explore alternative interpretations, to encourage

1 Forterra Systems provides private, virtual world technology for corporate, healthcare, government, education, and entertainment. http://www.forterrainc.com/

higher levels of critical thinking (Cooper 2005; Heuer 1999; Silberman and Robb 2005);

- Provide a formal process for collaborating between analysts, managers, customers, and experts across the IC (Brown and Rudman 1996; Cooper 2005; Kean et al. 2003; Interviews 2006);
- Provide a formal process for collaborating with experts within academia and the business community (Brown and Rudman 1996; Cooper 2005; Russell);
- Enable efficient coordination and approval of final intelligence products—specifically for proof, validation, review, and lessons learned (Cooper 2005; Russell; Interviews 2006); and
- Encourage products that clearly delineate analytical assumptions and chains of inference, and specify the degree and source of uncertainty involved in the conclusions (Heuer 1999; Silberman and Robb 2005).

The Computer Gaming Industry

Computer gaming is becoming the largest segment in commercial entertainment, with an estimated $30B in revenue and a 20% annual growth rate in the US alone (Delaney 2003), surpassing revenues at the Hollywood box office (Snider 2002). One of the fastest growing segments in the gaming market is massive, multi-player on-line gaming (MMOG) where many participants are electronically connected to interact in the same virtual environment. DFC Intelligence (2006) estimates that the MMOG market will grow by 150% between 2006 and 2011. This growth has been spurred by the huge success of MMOGs such as World of Warcraft, which is on its way to becoming a billion-dollar per year game. MMOG growth is also evident with the new consoles. Microsoft now requires that every new title developed for the XBOX 360 support the multiplayer XBOX Live service. The message is clear—computer gaming is becoming the largest segment in commercial entertainment and MMOGs will comprise an ever increasing segment of the market.

Applying Gaming Technologies to Intelligence Analysis

Why does MMOG technology matter to the IC? Fundamentally, there are two reasons. The first is technological: stripping away the gamelike content, MMOGs are dynamic systems that represent a physical world, where

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users are presented with (virtual) life-and-death challenges that can only be overcome through planning, collaboration and communication. The second is cultural: the emerging generation of analysts is part of what is sometimes called the "Digital Natives" (Prensky 2001) and is fluent with interactive media. MMOGs enable faster visualization, data manipulation, collaboration and analysis than traditional text and imagery.

ICWorld is an MMOG approach to intelligence analysis that fuses ideas from experts in the fields of gaming and data visualization, with knowledge of current and future intelligence analysis processes and tools. The concept has evolved over the last year as a result of evaluations by all-source analysts from around the IC. When fully developed, the Forterra team believes that ICWorld will fundamentally address major shortcomings of intelligence analysis, and dramatically improve the effectiveness of intelligence products.

ICWorld Concept

ICWorld is a system, based on MMOG technology, which enables analysts to identify and connect the information and people relevant to their interests; develop and test hypotheses; think critically by challenging assumptions and exploring alternative viewpoints; and participate, communicate, and collaborate with colleagues along the way.

The ICWorld concept relies on 5 main components and the collaboration that occurs in each:

1. Virtual Environment

2. Hypothesis Management System

3. Analysis Management System

4. ICWorld Knowledgebase

5. Expert Finder

Virtual Environment

The virtual environment is the hub of ICWorld, and for the purposes of this research, is based on Forterra's MMOG platform, OLIVE (On-Line Interactive Virtual Environment). It is a geospatially-accurate, persistent, 3D virtual world where users, as avatars, can move about and interact

with the things around them (such as buildings, cars, streets, and other avatars) to find, view, filter, prioritize, and semantically process information about the people, places, and events relevant to their analyses.

ICWorld users interact with the virtual environment through their avatars. ICWorld's avatars are unique because they are unusually lifelike—their appearance can be customized to closely resemble their real-world counterparts; they move through the virtual environment with realistic animations; and they have scripted behavior to control their emotions, gestures, movement and animations in individual and culturally-specific ways. Avatar (User) identities are managed via profiles. Users can create personal profiles for their avatar that can be shared and accessed by other people in-world. Each user maintains control over their identity and can selectively control their personal data, its use, and its distribution.

Communication in the virtual environment occurs through a variety of means. Integrated, spatially-accurate voice over IP (VOIP) allows avatars to talk to each other directly for the most realistic and natural communication. Integrated text chat enables natural communication to low-bandwidth users. Broadcast messaging allows communication with everyone in the virtual world, regardless of their location or state, and radio communication "channelizes" discussions between people in-world.

The virtual environment operates in three spaces—Geospatial, Temporal, and Textual—that enable analysts to view data at different levels of abstraction, and perform knowledge discovery by sorting through large amounts of data in meaningful contexts. The *Geospatial space* enables whole-earth navigation and free-form discovery of information through zoom-able 3D geospatial views at varying degrees of resolution, from "whole earth" down to specific room interiors (Figure 1). At the "whole earth" view, analysts get a global view of information about subjects of interest. As they explore this data, ICWorld automatically builds virtual, geospatial node-link diagrams of these entities using satellite imagery, maps, and other geospatial data as a backdrop. At an on-the-ground view, analysts are immersed in 3D representations of their surroundings—standing on a street corner, outside a train station, or inside a building, for example—to get a closer look at their environs and even test theories and hypotheses about their data by creating and role-playing scenarios.

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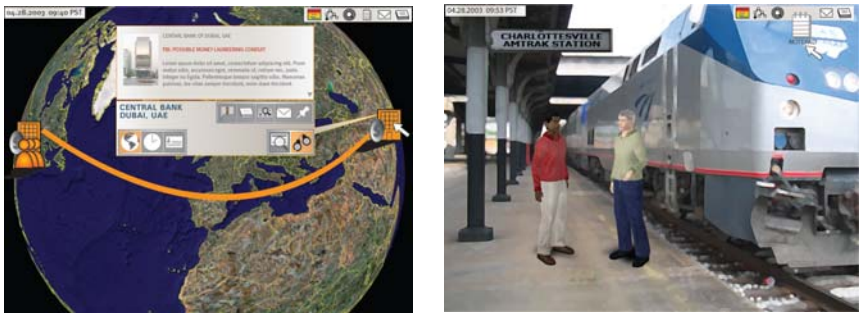

Figure 1: Geospatial Space: "Whole earth" and on-the-ground views.

Temporal space integrates a timeline with various 3D visualizations so that analysts can view the history and timing of events, without the clutter that often occurs when large amounts of data are plotted in two dimensions. 3D visualization allows the analyst to visualize data from any angle, making overlapping events and clusters of activity more obvious. *Textual space* provides the ability to access, view, and manipulate 2D text documents within the 3D environment, maintaining context between documents and the 3D world.

Figure 2: Temporal and Textual Spaces

Within all three spaces, information is presented and explored through a summary card, a self-organizing, intelligent user interface with a "one-click look" into the data available for a particular person, place, or thing. The summary card semantically filters and sorts information based on user models to help analysts deal with the overwhelming volume of available data. As an example, Figure 3 shows a summary card for a fictional

person named Faysal Goba, which reveals his social and financial networks, financial transactions, recent communications, and records of terrorist and other criminal activity.

Figure 3: ICWorld Summary Card.

There are limitless ways to collaborate and share data within the virtual environment. Ad-hoc collaboration and data sharing occurs inherently during data exploration when analysts visualize and update information in the ICWorld Knowledgebase. It occurs when analysts meet in-world at the ground level to role-play a scenario or when they meet with colleagues to exchange ideas or look strategically at 3D data visualizations. Formal collaboration and data sharing occurs inside virtual meeting rooms (VMR), 3D spaces that look like a real-world meeting space, where users can meet others—analysts, experts, or management—to discuss topics of interest, present data, hypothesize, work common analytical problems, or even present finished intelligence (Figure 4).

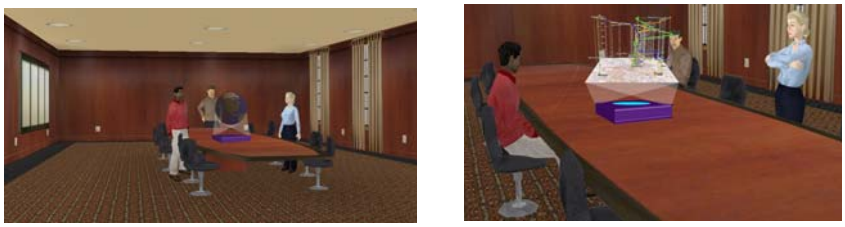

Figure 4: Data being represented and shared in a VMR.

Within the virtual environment, data exploration culminates when the analyst makes an important discovery or connection. When this occurs, a snapshot of that discovery is "flagged" and sent to another ICWorld component, the Hypothesis Management System, to be organized and incorporated into a new or existing hypothesis and to be shared with others, if desired, for further consideration.

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Hypothesis Management System (HMS)

The Hypothesis Management System (HMS) is a 3D environment critical to supporting an analyst's ability to create and explain finished intelligence. Within the HMS, analysts can organize their data into structured arguments to create, explore and test multiple hypotheses simultaneously. They can also collaborate with colleagues and experts to help organize their data, structure or refine their arguments, or offer alternative viewpoints.

The HMS uses node-link, geospatial and temporal representations to structure arguments. Data that are flagged to the HMS from the virtual environment appear in the HMS as pre-constructed networks. Network links are automatically formed between entities when their relationships are established by source reports. Analysts can then remove, modify, or insert their own relationship links at varying levels of confidence; drag in additional reports to further modify the existing network; or store portions of the network they believe are relevant to their hypothesis. Networks are organized via a free-flow model where nodes are hand-grouped and ordered, or using a simple physics-based model where the strength of the connection between entities establishes a matrix of attractive forces. The geospatial and temporal views function as additional methods for reorganizing the network, by applying geo-space and time constraints on the view to establish correlations that might not otherwise be connected. Once a coarse hypothesis is formed, the HMS provides templates to help the analyst more rigorously construct a hypothesis regarding the means, location, and timing of activities or events. The templates are a collection of entity-relationship models that describe, in general terms, what is needed to execute different activities such as types of terrorist attacks. The HMS automatically compares the existing node-link views with the available templates and suggests an ontological template that might best describe the scenario. Then, using Bayesian methods, the models compute the likelihood that the given network will fit a known activity, highlight what portions of the scenario remain unknown, and determine what connections would increase a user's confidence in his or her hypothesis.

In the future, the HMS will integrate with various cognitive aids to assist the analyst with "automated discovery" of information or hypotheses that are not intuitively clear, or help the analyst overcome mental blocks to develop better hypotheses. The HMS will also send alerts to users when enough information has been connected within a hypothesis to depict a potential threat.

Once a hypothesis has been created in the HMS, it can be tested through simulation and/or role-playing within the virtual environment, to help the analyst determine potential courses of action. Scenarios can be generated manually, or in the future automatically, by the system using models integrated from external sources. Scenarios can be created to take place in the past, current real-world time or in the future, and can use human-controlled avatars, semi-autonomous forces (SAF), or a combination of both.

Analysis Management System (AMS)

The Analysis Management System (AMS) captures and records all of the analysts' actions within ICWorld—for example, who was working on what, what data they were looking at, who they collaborated with and what was said. Its interactive user interface allows the analyst to visually review and recall past and present analysis sessions, analyze their own process, and share it with others. Within the interface, analyses are depicted as a series of beaded chains placed along a timeline, where each chain represents an analysis effort, and the individual beads comprising the chain represent important moments within the analysis (Figure 5).

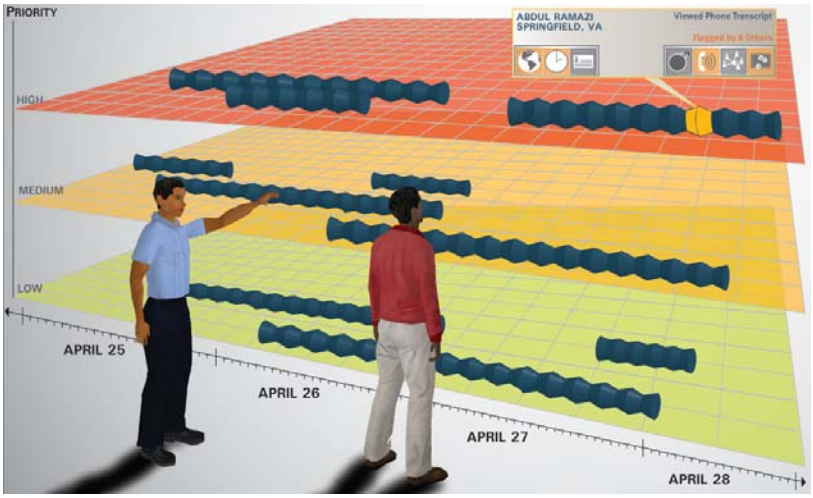

Figure 5: Analysis Management System (AMS).

The timeline indicates the dates and duration of an analysis, and priority planes (high, moderate, and low) show the priority of that analysis. Analysts can interact with individual beads to reveal a summary card about that particular moment in time, and can then step back into that visual-

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ization to review their work, branch their analysis, share that in-world experience with a colleague, mentor others, gain further insight, or solicit alternative viewpoints. Overall, the AMS and its interface helps analysts be more agile, by providing them the ability to quickly and easily switch from one thread or topic of analysis to another. It helps them be more thorough by tracking accountability and the logic behind their assumptions and hypotheses, and gives them a way to share their process and logic with others.

ICWorld Knowledgebase

The Knowledgebase is ICWorld's information backbone. It is a collection of static and dynamic open source and intelligence data in a variety of formats (text, photos, graphics, video, and web links). The Knowledgebase is configurable to include any data that is on the network where ICWorld is deployed, and is flexible enough to integrate with standard knowledge representation systems. The knowledgebase will include static information from encyclopedia-based public internet sites, the CIA World Fact Book, and various agencies' address books; and dynamic information from sources such as Reuters (or other news agencies), www.wikipedia.org, the IC's existing Intellipedia, and its internal messaging systems.

Data within the Knowledgebase will be pre-processed using entity extraction and profile-based filtering to identify and highlight entities of interest to an individual analyst (people, places, organizations). The pre-processing will be done through a combination of existing commercial entity extraction tools, and the results of ongoing research within the DTO's CASE program.

Expert Finder

The Expert Finder provides the ability for an analyst to search for, contact, and collaborate with experts within the intelligence community. In its most basic form, the expert finder will be made up of a combination of avatar/user profiles and a compilation of agency's address books. In a more advanced form, it will automatically create and maintain expertise profiles for avatars based on their activities in-world—their chat and voice conversations, their information-gathering and searches, and their hypothesis testing. This information will be stored as part of an avatar's profile, and will be integrated into ICWorld using an existing commercial tool or the results of ongoing research.

Hardware, Network, and Interoperability

ICWorld operates on commodity Linux servers and mid-range Windows PC clients, and will be flexible enough to allow users to view ICWorld using their choice of a single-screen or multiple-screen display. ICWorld uses a service-oriented client/server architecture that exposes services and object states using industry-standard HTTP and XML protocols for easy interoperability with other systems. The client/server architecture ensures scalability by simplifying the operation and management of arbitrarily large virtual environments and unlimited numbers of users without sharding. Its distributed operation over a LAN, WAN, or Internet allows users to access the virtual world from anywhere with a network connection. Full functionality is available to users with high-speed internet, and users with limited bandwidth can still access ICWorld, but with limited functionality, such as absence of voice controls.

Since classification is currently dictated by the network structure in the IC and its associated access, ICWorld will mirror the current IC network configuration. There will be multiple versions of ICWorld—one version for each available network within participating agencies (Unclassified ICWorld, Secret ICWorld, and Top Secret ICWorld). The data available on the different versions of ICWorld will mirror the data allowed through that particular network. Within a specific version, ICWorld will include functionality to control access to information (data, avatar profiles, etc.) based on user-defined access control lists (ACLs). This will be important in those agencies where analysts are compartmented within the organization and require special clearances to access specific information not available to everyone else. Ultimately, if the IC migrates to a single access-controlled network, ICWorld will incorporate larger-scale functionality to handle system-wide access permissions to protect classified data and users.

ICWorld is interoperable with existing legacy systems and technologies. In the near-term, it will use Distributed Interactive Simulation (DIS) and High Level Architecture (HLA), and will interface with SCORM-compliant learning management systems. It will be capable of converting legacy OpenFlight databases, and will contain open application programmer's interfaces to directly integrate a variety of artificial intelligence packages to support computer-controlled characters. ICWorld will be capable of ingesting real-time data feeds, allowing the virtual world and its characters to respond accordingly, and will be able to output real-time data so it can be made available to external systems.

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Conclusions

ICWorld's immersive and collaborative 3D virtual world has the potential to strengthen analysis by addressing several of the identified analysis shortcomings. The system's core objective to connect people-to-people and people-to-data focuses the analysis process on knowledge and learning, rather than just on creating a product. ICWorld's summary cards and visualization spaces combat the data overload problem by providing information in a well-organized, filtered format. The Hypothesis Management System helps analysts organize their otherwise disparate information into logical, organized hypotheses, which can then be tested within the virtual world—an opportunity that doesn't exist today. The Analysis Management System helps analysts thoroughly and effectively communicate their results—their hypotheses, sources, and logic, and the assumptions behind their decisions. Perhaps most importantly, ICWorld provides a new way to promote collaboration and critical thinking that is not existent in other solutions. Through ICWorld, analysts have an infinite opportunity to share information with colleagues and gather alternative viewpoints, all within the context of the problem they are trying to solve.

The high-level ICWorld concept will continue to be developed and refined as feedback is collected from additional analyst evaluation sessions, and significant thought and research will continue as the finer details are conceptualized. Once the concept has been solidified, working prototypes of various parts of ICWorld should be built and presented to analysts for feedback.

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About the Authors

Kimberly Gill has spent her career serving the U.S. intelligence community. Prior to joining Forterra Systems' National Security Division in 2006, Ms. Gill was involved with investment deals, technology transfer, and prototyping at the CIA's venture capital fund, In-Q-Tel; managed geospatial programs at the CIA; and was a geospatial analyst at NGA.

Dr. David Rolston, CEO of Forterra Systems Inc., has over 35 years of experience in the high technology industry. His experience includes extensive involvement in simulation and training, graphics applications, imagery, gaming, artificial intelligence, entertainment, and early versions of the Internet. Prior to joining Forterra, Dr. Rolston held senior positions at ATI, Multigen-Paradigm, and Silicon Graphics.

Wyatt Wong has over eight years experience in design, engineering, and support of mission critical systems in areas of finance, networking, and database infrastructures. Mr. Wong has served on engineering and services teams at numerous commercial entities including IBM, Citi Corp, Scotia Capital Markets, and Embarcadero Technologies. Currently, Mr. Wong is a product designer at Forterra, focusing on UI and HCI design and engineering.

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