Simulation Integrated with Web 3.0 as Smart Support for Command and Control

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ABSTRACT

This paper propose some preliminary research on the potential of the Web 3.0 concept into military training; the authors present an overview of this technology considering the application framework and developed the requirements for getting benefits of combining Simulation and Web 3.0; a proposal about a scenario and model is presented as case study to verify and validate this approach.

INTRODUCTION

The Web 3.0, as semantic web, allows to support quick and effective identification of resources and condition by correlating the info and data; in fact usually no single database or network source contains all the critical information for complex problems. A critical question it is if this capability could be applied to the training process of military simulation; based on subject matter experts operating in this area the answer results clearly positive; in fact to create a semantic infrastructure could results in an important support to simulate and facilitate data mining; in fact by this approach it becomes possible to show relationship among resources and services and, through intelligent support algorithms, to underline specific result by creating effective opportunities able to associate different contents with resources on the dbase and web (foir this context obviously mostly intranet). This is especially true for the intelligence field where the right gathering, correlation and spreading of the right information is determinant in a asymmetrical full spectrum military environment. Semantic technologies allows users to easily build new web sites and application to manage their needs, presenting various threads in a composite picture. The semantic web service/application could serve also as application integration mechanism by using meta-data that are interpreted in the meaning, realizing a common and universal understanding. In fact the combination of this approach with Intelligent Agents driving Computer Generated Forces (IA-CGF) could support quick and effective creation of complex scenarios in asymmetric warfare conditions for training. The authors are developing these concepts for a demonstration devoted to training and to complete VV&A with further potential for test and analysis and decision support applications.

SEMANTIC WEB

The first step it is to consider the innovative concepts behind Web 3.0: Berners-Lee, et al (2001) wrote "a new form of web content that is meaningful to computers will unleash a revolution of new possibilities." This is the concept related to the Semantic Web.
Tim Berners-Lee (well known for inventing the World Wide Web), already presented this idea at the very first World Wide Web conference in 1994. The potentials of the Semantic Web are also strongly reaffirmed in Shadbolt et al. (2006): the authors revisit the Semantic Web idea stating that it will mainly rely on key insights, tools and techniques developed during the last 50 years of research in the field of Artificial Intelligence. Nowadays all the disciplines (life sciences, environmental sciences,

business, commerce and defence to cite a few) ask for data (potentially available on the web) integration coming from different sources and the need for intelligent information combination (according to user requirements) is constantly growing. On the actual web (syntactic web) the main difficulty lies in the interpretation of the text being searched that is not semantically annotated. In 2006, Tim Berners-Lee said that the Semantic Web has to be regarded as one of the main components of the Web 3.0 (Shannon, 2006). The main difference among Web 1.0, 2.0 and 3.0 is based on bandwidth availability that allows the use of more packages, functions and applications for unlimited time with heavy multimedia applications (video web), that were before less manageable. From this point of view Web 3.0 allows users to extend previous communication capabilities by integrating them with multimedia contents and automatic search.

In effect the Web 3.0 should include multiple aspects; among others the most important are the advanced use of artificial intelligence techniques, the organization of information in databases (for information access) and Web 3D (three dimensional environment). Web 3.0 should adopt a multiplatform technology that can be easily integrated with different Operative Systems, architectures, browsers and should use many libraries and framework applications. Therefore the first step is to improve data interoperability levels (data web), then the combination of data mining and intelligent agents should support the intelligent integration of available information (in Web 2.0 this step is carried out by the user according to multiple syntactic searches and data re-organization). Following this process Web 3.0 becomes a Service Oriented Architecture that can also include a 3D application to create a set of three dimensional environments as demonstrated in systems such as "Second Life". What is?

In this paper the authors explore the possibility and the potentials to use Web 3.0 (specifically the Semantic Web) for training processes in military simulation with particular attention to Command and Control System services. In this context the Semantic Web can strongly support the user's requirements and predict what the user means by his query and deliver more relevant researches and results. A framework that includes a Semantic Web provides a strong potential in describing data and applications. The authors propose using these concepts in a framework for supporting Intelligent Agents Computer Generated Forces in generating threats for complex urban scenarios.

The state of the art on the Semantic Web reveals a wide spectrum of research topics and results as well. Semantic Web is currently a very exciting topic for researchers in different areas: from distributed information systems to artificial intelligence. One of the most important features of Semantic Web (as well as the current syntactic Web) is related to information search. When users search for information they would like to see only relevant results. They do not like to retrieve data that are unrelated to their search string. The major problem is that in the current Web it is difficult to find good research results due to a non-semantically annotated interpretation. Algorithms that interpret the syntactic content in order to return good search results are necessary. These algorithms can decide whether or not to take user context and the search history of users into consideration.

New approaches and techniques were developed in the last few years to better search results. For instance, Hsua and Wub (2006) introduced a new approach that determines the relevance of a Web page in its context, based on the relevancy context graph. These graphs estimate the distance and the relevancy degree between the retrieved document and the given topic. By calculating the word distributions of the general and topic-specific feature words, the method is expected to preserve the property of the relevancy context graph and reflect it on the word distributions. In contrast, Godoy and Amandi (2006) developed a document clustering algorithm, named WebDCC (Web Document Conceptual Clustering) in order to acquire user profiles, taking in consideration their search history that is properly clustered.

Another difficulty of current Web is represented by the integration of the various data sources in order to produce good search results. In fact information space is scattered over several sources that have different and non-standard structures, schemas and meta-data. The concept of community helps to overcome this limit. In fact, when one queries for a specific topic, the search can focus on the data provided by an existing community around that topic, excluding unrelated ones. Benatallah et al. (2006) underlined the problem of querying heterogeneously structured data and proposed a flexible and user-centric query matching algorithm. It exploits both community descriptions and peer relationships to find e-catalogs that best match a user query.

Another relevant aspect in Semantic Web is people trust. Consider for instance people authentication and reputation problems, users' privacy, confidential information management, etc. Artz and Gil (2007-a, 2007-b) studied trust feelings in content on the Semantic Web, identifying and analysing just what factors people use to decide what content they will trust and why. In this case simulation was very useful in order to study alternative models of content trust. Concerning people trust and specifically users' privacy during e-commerce activities, Jutla et al. (2006) propose a privacy management architecture, consisting of client-side and web-side architectural data components and services which inform the user of online privacy and trust within e-commerce tasks. Client-side ontology and data structures for representing user contexts are introduced. In the context of the Semantic Web, social networks are crucial to realize a web of trust, which enables the estimation of information credibility and trustworthiness. Matsuo et al. (2007) described a social network extraction system called POLYPHONET, that extracts relations of persons, detects groups of persons, and obtains keywords for a person by using several advanced techniques. Finally, social relations are classified in order to obtain and use person-to-word relations. A particular characteristic of Semantic Web is related to the extension of Web Services by representing explicit meanings. One aspect of the formal definition of Semantic Web Services is the description of the data that are processed by Semantic Web Services. The Web Service Modelling Framework, WSMF, (Fensel and Bussler, 2002) proposes a formal representation of Web Services, that allows access machine executable semantics. Note that usually different applications domains have different conceptualizations of their specific data sets. For instance, the health care industry where numerous providers use different standards to describe their application data. In particular Dogac et al. (2006) defined formal representations of healthcare data in order to develop Semantic Web Services.

Another important element of Semantic Web Service definition is the composition of Web Services. In fact an appropriate composition of different Web Service can produce the desired result for a client. Rao et al. (2006) studied an automatic Web Services composition, based on Linear Logic and theorem proving. In addition, it is necessary to specify how Semantic Web Services are executed; in particular a life cycle determines the order of Semantic Web Services use. When a request comes from a client, an appropriate set of Web Services have to be invoked in order to satisfy the client's requirements. Different researchers have studied a Web Services discovery approach. For instance, Bianchini et al. (2006) introduces a discovery approach based on a three-layer ontology, each layer describing Web Services more specifically in the form of an abstraction hierarchy.

MILITARY APPLICATIONS

The complexity of military applications comes from the necessity of integrating more options in just one complex application. In the case of a generic Command and Control (C2) system, such applications must guarantee:

- the visualization of a referenced and accurate cartography that usually includes a series of military data (in general units, means, tools, capability or references identifications)
- the possibility of sending standard messages
- the management of databases containing operative and logistics data (in a classified environment as well)
- the possibility of operations planning by scenarios/situations investigation and by correlating collected information in order to implement the received orders and transform them into possible actions/reactions.

The C2 system can be eventually completed with the integration/interoperability with other data/systems; however the system often is not able to provide a mid-level military decision maker with a complete general or particular framework, fundamental for a proper application of the decisional process and for a quick and coherent decision. This is mostly due to the implementation of partial architectures in the C2 Systems design because they only take into consideration a specialized referenced environment (ground, sea, air, cyberspace) and they do not consider other realities (by their inherent construction). Such situations can happen due to developer's choice, opportunity or blindness.

Indeed, it is a fact that database or network resources cannot contain all the needed information. The most recent tenets on information spreading/sharing such as those foreseen by NCW/NEC (Network Centric Warfare/ Network Enabled Capability) intend to mitigate this shortfall by applying circular methodologies for information spreading and sharing so that data can be managed and used (effectively and efficiently) by a large number of users. The possibility of modeling and simulating these different approaches for information spreading and sharing could make possible a more complete and detailed analysis of any possible scenario.

From this point of view Web 3.0 techniques represent an enormous potential, especially if we imagine its application in a functional modern C2 System, oriented to NCW/NEC techniques. The semantic techniques are used to multiply database queries in different functional areas and environments and to simplify data research by using IA (Intelligent Agents) and information correlation. Data mining can be used for simulating and showing resources and services relationships or for supporting the representation of specific actors on training simulators (using IA). In addition, by using ad-hoc algorithms, it is possible to create great opportunities by associating various resource contents of different realities via intranet and to represent dynamic and complete JCOP (Joint Common Operating Picture), that can be used to populate Constructive Simulator databases and reproduce real world scenarios. The resulting output may help to quickly predict possible actions/reactions or make hypotheses in the intelligence domain and in static and asymmetric environments, and lead to understanding the great importance of correct information reading, representation, and spreading in full spectrum environments. For example, analysis applied to an urban 3D environment in order to predict possible shooting directions used by a sniper or positions which can be used to trigger IEDs (improvised explosive device) or launch ambushes. Semantic capabilities could be used to manage local information from a commander on the ground in order to create its own order of battle, collect information, and to send needed information to his subordinates to reproduce a graphic planning or to search information on internet by using assisted Web 3.0 research benefits. Web 3.0 technology could be used as mechanism to integrate data and metadata of different systems.

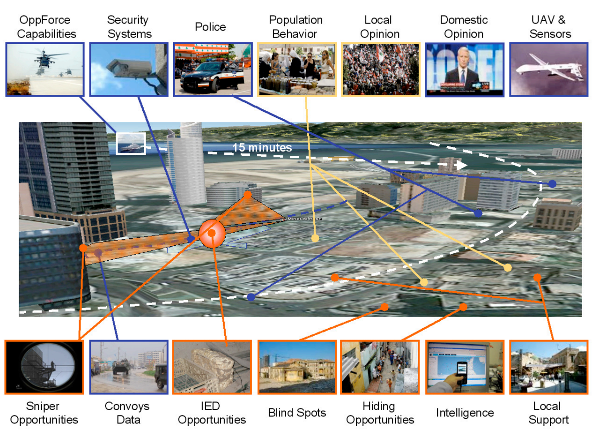

Figure 1- Queries to be elaborated by Intelligent Agents

MILITARY REQUIREMENTS WEB 3.0

As already mentioned, in the last years the development, deployment and interest for networked information systems for military applications are really increased. Referring to a multiple platform standard architecture, it is possible to observe new generations of client systems that integrate advanced communication paradigms and functionality; for instance information repository could be queried from clients with mechanism related to events and correlated in new high level events as complex information ontology and information management architecture and comprehensive security model.

Web 3.0 and related semantic web services have also received key elements from new software technology (CORBA, J2EE, C# and .NET), realizing new interfaces in a wide variety of technologies as hardware, components, internal components for operating systems, servers, etc. The possibility to map military architectures as GIG (Global Information Grid) or NCW/NEC (Network Centric Warfare/ Network Enabled Capability) with semantic web services is a real matter. In a hasty overview we can imagine a relative overlap between a general SOA (Service-Oriented Architecture) and GIG architectures as both normally use XML (eXtensible Markup Language) information representation and notification capabilities. Furthermore, some concerns should be identified in the web architecture weakness in terms of lack of support for real-time high availability delivering mechanisms or information services. To be more restrictive in the military environment there are other practical considerations such as the feasibility of scaling concept, size of development, level of communications and disruption that could be part of a military requirement.

A general GIG architecture should be planned as a “rapid targeting” or “rapid response”, as an application that has to collect information and collect data from different sources. It makes clear the necessity of a meta-data repository to identify classes of servers and types of information that are available for querying as well as the subset of information that should be relevant to a generalized engagement/plan/decision. Keeping in mind that, in this case, the information sources are military computing applications or information systems, it is necessary also to identify military capabilities to be applied in standard formats. Standard formats are the key policies to the proposed approach because they allow the systems to be extended to new applications, new clients, new security policies and new systems.

In military systems, at the beginning the applications download initial data for maps, GPS, current tactical data, situation report, status report, etc., and only when a new event occur or the refresh replication mechanism is set, the data source "publishes" the new summary, normally in a data form suitable for a rapid transmission on the network. Large data object (as a high resolution picture) could be downloaded separately only if needed. In this case an important requirement is represented by the security policies: data should be filtered and enforced based on the quality of mission. The same should happen regarding non-classified information that has to be introduced and downloaded in a specific operational map quadrant where a considerable number of classified information/data are present or, vice-versa, introduce only classified/unclassified data using a filtered bandwidth to avoid the unwanted information. In this case, the repository should collect all events and store them persistently in different DBs until they expire. During the validity period any applications might use rapidly and query the context also to associate the events to another map quadrant.

Additional "operational" capability/properties for this platform should be the ability to function robustly in a hostile environment: capability to re-configure the platform due to disruptions and provide the users with high performances in every network configuration (increase in number of clients, rates of clients, system failures, loading components, etc.).

Web 3.0 and C2 systems integration: critical issues

A more detailed list and description of the main problems in applying web 3.0 technologies in a C2 military system are reported as follows:

- Messages size: large sizes of data are destined to fail because of the problem with the bandwidth availability. In a traditional network with large bandwidth this is not a performance factor, whilst in a mobile tactical network among soldiers (as individuals) or low level command where the shared transmission capability is a decisive factor, it turns out to be the choke point of efficiency. Reduce the size and optimize the content of information becomes vital for this network as the standard Web System (WS) allows for negotiating a non-standard protocol to represent messages and would force the rules.
- Security enforcement: the servers, that embed security mechanism, do not guarantee the client about the enforcement of the message. The only guarantee is to implement an encryption policy or to send the document to a server that can respond to the client's expectations.
- Time critical events/message: in a military environment a lot of events/messages are important in a specific period of time; after this period their usefulness expires and they can be archived, disposed, erased. But in a particular situation (i.e. artillery coordinates) could be reused or turn into obsolete in less time than expected, hence the communication architecture must be able to deliver the right message at the right time, archive all valuable or history data, upload or expire other data.
- Quality of service: properties as security, robustness, performance, automatic configuration and other military specification must underlined as they are normally included in a GIG system. Scalability and performance are moreover important for the WS system.
- Reliable messaging: messages are normally a basic pillar for a military GIG system. A good WS must be include a notification application that can define a content-based publish-subscribe system and be compliant with the standard communication system properties.
- Scalability: the scalability needs have the same weight of time critical events delivering or architectural capabilities to favorite the decisional processes. Scalability becomes enormously important when we take into consideration the situation when nodes crash, messages are lost and, dynamic configuration problems present themselves, as in a neural network fundamental to maintaining the connection with the final scope.

INTEGRATION IA-CGF AND WEB 3.0

The authors are investigating the development of a framework, based on Web 3.0 technologies, that will be interrogated by IA-CGF units (Intelligent Agents Computer Generated Forces). The framework must provide the user with the evaluation of the best opportunities to set up asymmetric threats (i.e. ambushes, IED, snipers, etc.) in order to create an asymmetric scenario focused on effectiveness of the actions (including the impact of people behavior, human modifiers and network-related issues within a 3D environment). Figure 2 shows (in a possible architecture) how the IA-CGF interact with the Web 3.0 technologies as well as with multiple information sources.

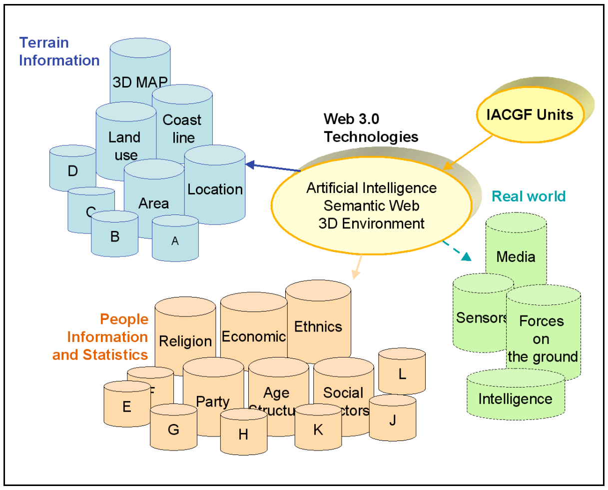

Figure 2: Intelligent Agents Navigating in Web 3.0

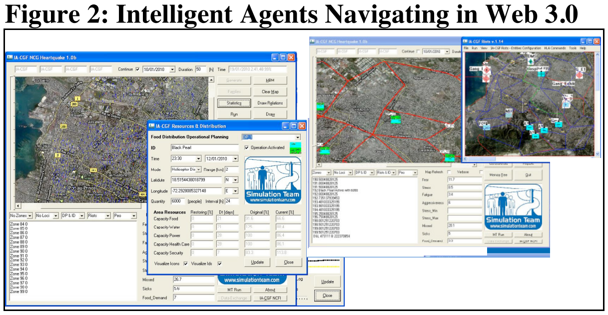

Figure 3: IA-CGF operating over complex urban scenarios

Figure 3 shows an example of a system (developed by the Simulation Team of the University of Genoa) implementing IA-CGF operating over complex urban scenarios.

Consider the case of an attack with snipers, the Web 3.0 technologies make possible an automatic identification of such an attack on the basis of a multiple factors investigation carried out over the social-terrain database by using the semantic queries. In this case, the following elements must be considered and included:

- OppForce Capabilities
- Security Systems
- Police
- Population Behavior
- Local Opinion
- Domestic Opinion
- UAV & Sensor
- Convoys Data
- Hiding Opportunities
- Intelligence
- Blind Spots
- Local Support
- Sniper Opportunities
- IED Opportunities

Noticeable fact is that IA-CGF are Computer Generated Forces managed by Intelligent Agents based on human behavior models (fear, aggressiveness, fatigue, stress, etc.). The IA-CGF Units are able to operate autonomously based on applicative sources of intelligence and human behaviors. In fact the IA-CGF units operate by collecting information from different sources based on Web 3.0 technologies (in particular Semantic techniques) and apply Artificial Intelligence algorithms in order to identify composite elements (i.e. synergy between a blind spot shooting and an hiding opportunity). In particular, IA-CGFs are expected to acquire multiple information from specific databases in a semantic way and then to use it to support decision making.

The present research is aimed to develop a demonstrator able to create scenarios that can be generated automatically by integrating IA-CGF and Web 3.0 technologies in reference to threats such as IED (Improvised Explosive Devices) allocation for a terrorist attack. The authors' goal is to provide IA-CGF units with all necessary information in order to establish the optimal IEDs position. A further step of integration could be to visualize all units in a distributed (web or GIG or other networks) 3D environment created by extracting information about the territory of interest from the users in order to provide such support not only in creating scenarios for training, but even for supporting users in AAR (After Action Review).

A wide range of information is requested to allocate IEDs, for instance:

- Territory Information: 3D Map, location, geographic coordinates, area, land boundaries, Coastline, maritime claims, climate, terrain, elevation extremes, land use, etc.
- People Information and statistics about the area: Population, Age Structure, Social, Ethnic, Religious, Economic and Political features, etc-
- Transportation: airports, heliports, pipelines, railways, roadways, waterways, ports and terminals, etc.
- Information from the real world: media and news, direct information from the field, sources of intelligence.

This gives an idea of the potential of this approach in terms of training; in addition it is evident that such architecture could be very effective in operative analysis and decision support on operational planning by integrating these technologies with real world data.

In addition, during the development of the proposed demonstrator for training, it will be possible to proceed extensively with VV&A (Verification, Validation and Accreditation). Once the demonstrator is successfully completed, it could be interesting, as a follow up, to consider adapting this approach to support decision making with integration even with real world data. Just one among possible further developments of this solution could be a decision support system and test and analysis tool based on these concepts.

CONCLUSIONS

Semantic Web and in general Web 3.0 is very challenging in improving search results and in integrating all data in a semantic way by using new techniques and approaches such as ontology of specific topics and domains. Taking into consideration sector complexity and data sensibility, Web 3.0 provides many opportunities for military training and for decisions making. In particular, the semantic techniques can be used for multiple database queries in different functional areas and environments, to simplify data research by using IA and information correlation, to improve data mining in order to simulate and show resources and services relations or to help the representation of specific actors on training simulators by using IA. The research in integrating IA-CGF with Web 3.0 for demonstrating the possibility to create automatically realistic threats for supporting training it is a very interesting opportunity; in this context it resulted critical the proper connection among military users and simulation experts for defining properly the development boundaries for being able to create a realistic and useful demonstrator with reasonable resources.

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