THE EDGE DECISION SUPPORT FRAMEWORK
"Emergency Management Training and Support to Operation"

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ABSTRACT
Organizations need agile Command, Control and Coordination frameworks that support a rising real-time flow of information and visualization with embedded training features. Decision makers and their teams are increasingly likely to be geographically distributed and composed of members of different organizations. One inherent problem is the limitation on sharing and visualizing time-critical information due to current informational boundaries.
The authors' research focuses on the design of an Edge Decision Support Framework (EDSF) and a Common Synthetic Environment Service (CSES) that provides shared awareness to a distributed group of users who operate as a team in a "synthetic" Command Center. It focuses on the concept, design and development of an integrated platform that can be used for training through operations and is suited to supporting Civil-Military Cooperation through its mechanisms for crowdsourced situational awareness and Command and Control supporting remote collaboration.
This paper addresses various issues including security, bandwidth and network reliability challenges and illustrates the potential for an approach that enables civilian and defense services to be trained to cooperate through web and mobile applications via interoperable information exchange models.

Keywords: Training, Decision Support Systems, Crowdsourcing, Emergency management.

1. INTRODUCTION
The impact of social media's role in the "Arab Spring", and the recent "Kony" campaign, is being felt globally, affecting developed and developing nations in a variety of ways. While these social media-driven movements demonstrate the potential for rapid mass politicization and mobilization of communities facilitated by social media communication without traditional political organizational structures, there is no certainty of the applicability of any "direct lessons" to other contexts (Stepanova K. 2011). Though the focus of this paper is on the possibility to build more agile and collaborative organizational systems with these technologies, the authors note that harnessing these technologies within organizations and government is likely to cause significant transformation over the longer term.

The concept of crowdsourcing is recent, but researchers have already looked at its application within decision support systems. Social networking technology used within organizations, known as "Social Enterprise" systems, has demonstrated mass collaboration can be used successfully internally and in external communication to generate new ideas, facilitate workflows and develop new processes, build cross-functional teams and better addresses the needs and desires of customers (Self R. L., 2010). Investigation is now required to determine the impact crowdsourced intelligence (and its analysis) will have on command and control (C2) organizations to support decision making processes.

The authors believe that ubiquitous mobile phone coverage, access to wireless Internet and intuitive communication software, available on mobile devices and desktop PCs, makes a simple but deceptive idea seem possible: that large groups of people can be smarter than an elite few. There is an underlying assumption within many crowdsourced intelligence projects that crowds can be "smarter" than traditional analysts at solving problems, fostering innovation, coming to wise decisions, and even predicting the future (Surowiecki 2004).

Crowdsourced information's potential to support faster decision making has led the authors to define a framework called the Edge Decision Support Framework (EDSF) that aims to enable safer decision making processes in a crowdsourced environment.

The initial prime use case for EDSF supporting decision making is an emergency and incident management scenario. The authors make several assumptions about the initial use case environment:

- The crowd is a filtered crowd consisting only of members of the inter-services organizations involved in a cooperative civil-military (CIMIC) cooperation scenario.
- Information can be verified by multiple independent sources.
- The "elite few" are members of cross-functional teams, and decision makers, who

are remotely connected via a reliable network connection.

- Decision-makers use innovative collaboration methods such as using a mix of synchronized web applications and virtual world technology that visualize a common understanding of the common operating picture including verified live data coming from the crowd and data collection systems such as geo-data and UAV video feeds.

This paper presents the description of the state of the art where: Social Decision Support Systems are defined based on the use of social networking technology within a crowd; and Edge Command and Control systems are defined by the NATO maturity model methodology.

This paper then investigates how social network technology and crowdsourced information can be used to expand the concept of a Social Decision Support system. A potential CIMIC environment scenario is outlined, then the authors propose the model, architecture and main components of a Decision Support Framework defined by an Edge C2 maturity model: the "Edge Decision Support Framework" (EDSF) presents an innovative solution integrating web and virtual worlds technology for distributed decision makers with a mobile application designed to enable a crowd of participants to provide decision makers with real time information and imagery from anywhere they have access to the crowd.

2. SOCIAL NETWORKS, DECISION SUPPORT & COMMAND AND CONTROL SYSTEMS

The history of Decision Support Systems (DSS) goes back to 1945 (Power, 2002). They can be classified based on their decision process emphasis (Power, 2007). The main classic types are:

- Model driven
- Data driven
- Document driven
- Knowledge driven
- Communications driven

A recent interesting model of classification of a DSS, looking at its maturity level, can be achieved through the NATO NEC Command and Control Maturity Model (N2C2M2). If we think of a C2 system as a decision support tool it is possible to imagine how a disparate set of independent entities (yet inter-dependent) that form an independent "collective" (a "community of practice") can focus and agree on decisions using this tool jointly in a remote and distributed environment. In this case the C2 environment can serve a collective-supported decision making function. This function has to be based on variations in the allocation of decision rights to the collective, patterns of interaction and information sharing behaviors among the entities of the collective and the distribution of information among these entities (NATO SAS-65, 2010) (Figure 1).

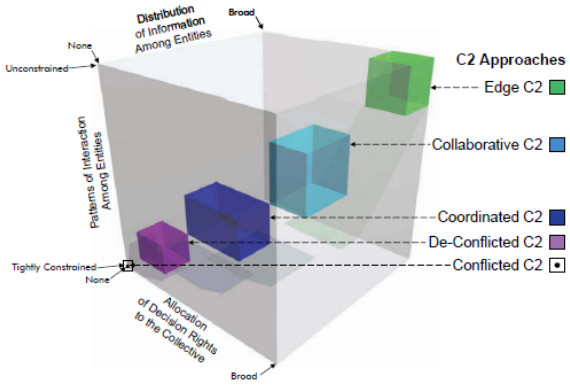

Figure 1. N2C2M2 - C2 Approaches and the C2 Approach Space

A broad distribution of information among entities with unconstrained patterns of interaction among them and a broad allocation of decision rights in the collective depict what is called an Edge C2 Organization.

The authors believe that social networking and crowdsourcing are potential methods of setting up and expanding an agile Edge C2 Organization while supporting agile decision making processes important to a CIMIC scenario.

2.1. Social Decision Support Systems (SDSS) and Social Network Analysis

Today, one of the most promising trends in the decision support and Command and Control areas seems to be social support for decision making. Access to the social support tools can be enabled by utilizing web technologies that are easy to access via network-connected mobile devices.

The authors investigated the state of the art of concepts related to a Social Decision Support System (Turoff et. al., 2002) and a Socially Supported Decision System *(SSDS) (Garrido and Faria, 2008);* then analyzed a Social Decision Support mechanism based on the friends networks concept (Yung-Ming Li and Yi-Lin Lee, 2012) and have now designed and developed a prototype toolset that supports the new framework. Furthermore, it will be utilized in future research to test the validity of this approach as framed by both perceived effectiveness as well as current theories of Social Decision Support. These theories consider the inter-relationship of group composition, group influence processes, individual preferences and collective responses.

If we define social decision making as the process that takes every individual's local decisions and generates a collective response, then in terms of group decision making, two aspects are important: normative and informational influence. Normative influence is based on the desire to conform to the expectations of others, and informational influence is based on the acceptance of information from others. These aspects are also true when applied to problem-solving tasks and collective recall.

A social decision support system (SDSS) allows users in a network-based environment to form a decision group and participate in a collaborative decision making process. In Edge C2 organizations related to a CIMIC environment, it is assumed that there are two main groups: the elite few who are the decision makers and their close staff of specialists and analysts, and everybody else who is participating (the "crowd").

Given the effect that crowdsourced information can have on decision makers, this project may need to demonstrate how it can understand each member of the crowd by recording their otherwise invisible social and spatial relationships (based on GPS information) over time and provide an index of the timeliness and quality of any unique information that each member provides.

Social network analysis, as a methodology for understanding complex patterns of interaction is primarily focused on discovering friend connections, leaders, influential people and friends (Yung-Ming Li and Yi-Lin Lee, 2012).

By leveraging social networks analysis over a period of time, effective automated analytics may provide an indicative value of the trustworthiness and value of every piece of crowdsourced data (whether that be an individual's contribution or aggregated information from multiple sources) for the decision making process. Data that has a low trustworthiness can be automatically excluded from the main data source (the "Common Synthetic Environment Service") and instead can be included in a counter-intelligence database that is available for further analysis. This automated approach supports increasing the volume of real time information and so is an important component that must be in place before broadening the concept of the "crowd" to include civilians on any large scale. We believe that large scale crowds will be part of future EDSF systems.

2.2. Edge Command and Control Systems

Virtual C2 systems should provide embedded decision support functionalities through suitable "user friendly" decision support tools that are integrated throughout the C2 environment. Latest trends in the development of C2 tools are the use of Intelligent Agents (IA) and remote collaboration where social networking and crowdsourcing can be viewed as the most extreme forms of remote collaboration.

According to NATO's N2C2M2, an Edge C2 system is basically characterized by a robustly networked collection of entities having widespread and easy access to information, sharing information extensively, interacting in a rich and continuous fashion, and having the broadest possible distribution of decision rights. While the objective of an Edge C2 is to enable the collective to self-synchronize, in an edge organization there is a configuration of the participants that have no predefined structure. Participants are not assigned to teams or roles, and every participant has access to all information sources (NATO SAS-65, 2010). The authors outline an Edge C2 system that can be defined as a crowdsourced environment where a dispersed leadership and a socially networked crowd take part in the decision making processes, providing valuable feedback and opportunities by rendering timely and relevant information. The application of the concepts related to Social Decision Support systems and Edge systems and organizations can be successfully applied to develop what the authors called the Edge Decision Support Framework. This framework can benefit from information provided by a crowd to support a timely decision making process in an emergency management environment.

3. CIMIC EMERGENCY MANAGEMENT SCENARIO

To define the needs and requirements for a Social Decision Support Framework to enable Edge C2 Organizations, the authors proposed an emergency and incident management scenario where both civilian and military organizations, with very different cultures and agendas, must work together to share information beyond a negotiated shared networks environment (Dekker 2002). In this information environment, military and civilian C2 headquarters have to communicate with each other to share information in a shared synthetic environment. This 'peer to peer' style arrangement is common to emergency services, as each unit or assets will tend to cover a geographical area and work within that area whilst communicating with peers in other areas. (Houghton J. R. at all. 2004).

The aim is then to outline potential solutions that will best fit the needs of emergency management plans and requirements focusing on the following challenges (Office of the Emergency Services Commissioner, 2012):

- Historic emergencies: provide easy online tools for data recording, event and analysis timelines, event and response visualization that can be made accessible based on the roles and privileges provided to decision makers,

analysts, researchers, partner organizations and the wider public citizens
- Working with community groups before, during and after emergencies: the framework must provide methods to actively support the review of emergency services activities and an organization's emergency management response
- Joint services collaboration and events management, coordination and control: in a government context this includes defense forces, firefighter, healthcare, civil protection forces, police and volunteers. In an organization's context, this includes all its suppliers, staff, partner organizations, government services, media/PR and other organization and communities affected in the event.

The proposed Edge Decision Support Framework (EDSF) would enable organizations to work separately and with other organizations, governments, emergency services, the media and industry representatives. This approach is likely to lead to a wider range of issues to be faced sooner which may raise the tempo of the operation and necessitate a coordinated response. If achieved, the response will potentially better address community needs and concerns throughout the planning, response and recovery cycle, which may reduce the overall cost and duration of the response.

4. THE EDGE DECISION SUPPORT FRAMEWORK (EDSF)

A decision support framework enables an Edge Organization to better leverage human resources (cross functional teams) creating self-synchronized relationships between subordinated, parallel and upper levels of command by gathering feedback, orders and distributing tasks to the assigned assets (Biagini and Turi, 2011).

4.1. The EDSF Concept

The authors believe that applying the N2C2M2 maturity model principles and leveraging the knowledge and interest of large groups of people will affect the way decision making processes are supported (such as using concepts from crowdsourcing) so that a traditional command and control environment can transform into an Edge Organization. This demands an organizational shift and it also requires individuals in the organization to lead and interact differently. Creating new practices, norms and strategies will further embed new behaviors into the organization (Self R. L., 2010). In the opinion of the authors, this kind of evolution may depend on new technology, but must be driven by leadership towards a new culture. In that case, Information and Communication Technology (ICT) solutions have to support the shift in organizational culture. This process will be accelerated by providing easy to use, efficient tools that are widely adopted and properly secured.

From an ICT point of view, the culture change could be enhanced by the development of a set of tools capable of enabling reliable C2 processes across potentially distributed teams who may have limited and unreliable access to network and communication connectivity.

To enable greater reliability during disasters where existing mobile networks and internet are temporarily disrupted, several approaches are suggested to be used concurrently:

- Applications should support offline usage. For instance, web-based tools can utilize HTML5's local storage feature
- Peer to peer and wireless ad hoc networking technology may provide an alternative ad hoc network where devices can act as access points to reconnect other secured peers into any available network that can reconnect some or all team members and data services
- Support for network-wide awareness and control of available bandwidth through the peer to peer network so that critical information and media can be prioritized by decision makers to avoid message flooding when the network has limited bandwidth

The authors propose the EDSF concept as a state of the art solution that provides distributed decision makers with a shared decision making environment which offers shared situational awareness supporting:

- broadening intelligence gathering by adding crowdsourced information that has been filtered through automated analysis techniques
- distributed cross-functional teams

This concept is made possible by the integration of Virtual Worlds and web technology that visualizes the stream of event data provided by a services layer referred to as the Common Synthetic Environment (Biagini and Joy, 2012) Service (CSES).

4.2. The EDSF Architecture

The EDSF's use case is designed around the CIMIC emergency management scenario that focuses on a virtual collaborative environment to support decision-making and intelligence gathering and analysis processes between military and civilian communities of interest.

The key point of this framework is to provide an effective real-time web-based collaboration and events management tool that can be used for both simulation training and for real operations to provide users with an online solution that is easily deployed and practical in training and operational contexts. Therefore it must

contain the functionality needed to match an emergency response system and a training and user performance tracking system.

The framework architecture is designed for potentially large numbers of geographically dispersed users (i.e. several communities of practice) to access the same stream of event data (including information, media and services) using a variety of devices (smart phones, tablets, computers, etc). Services plug into the architecture to extend the platform: these include GIS mapping, eLearning and analytics. (Figure 2).

The main components of this framework are:

- The Common Synthetic Environment Service
- The Virtual Command Center application
- The Citizen 2.0 application

Current systems in the emergency management field are complex, non-web-based, non-user friendly and lack multi-community structures needed to bridge multiple organizations into a common transparent decision making process. Other challenges are: the download and installation of software and web browser plug-ins is forbidden by most ICT security administration policies; and, there are network constraints that limit the bandwidth in mobile wireless networks that can cause high call volumes and uncontrolled information and media sharing to wipe out bandwidth and render the mobile networks useless.

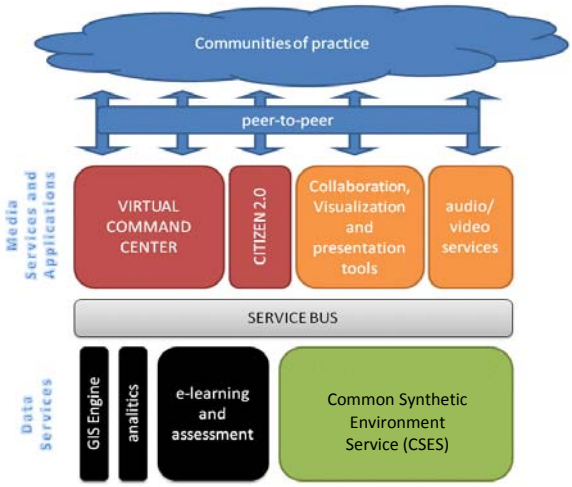

Figure 2. EDSF Architecture

This project aims to overcome these common barriers and challenges to create a new approach to remote collaboration and network management backed by a platform framework that has embedded training & assessment capabilities. The main novel features of the platform are:

- No software downloads needed to access web-based collaboration, crowdsourcing and training services
- M&S immersive simulation can be integrated using a 3D plug-in for web browsers
- Unique peer to peer networking technology can enable mobility devices (smart phones, tablets and laptops) to operate despite network outages or limited bandwidth environments
- Flexible data visualization suiting strategic and tactical views
- Web-based GIS supporting massive data sets and intuitive intelligence representation
- Secure document management where partners do not have to share files: instead they share low risk metadata that allows for information to be re-composed behind secure networks

4.3. The Common Synthetic Environment Service (CSES)

The Common Synthetic Environment Service (CSES) is a distributed metadata-driven web service. It provides access to a range of parallel data services within each organization's network. The flow of information from multiple systems can be collated and shared based on user access rights to provide the intelligence required to operate a Distributed Command and Coordination Center that the authors refer to as the Virtual Command Center where information that is available to the user can be visualized on his or her local device. The high level metadata language used by the CSES to exchange references to other data is a way to create a real interoperability layer between military and civilian information systems as the core language. The CSES enables secure information and models to remain within network boundaries but the metadata held by each network's CSES could potentially be synchronized across public and secure networks. Depending on IT policy requirements, this synchronization may be achieved via a middleman CSES service that never connects two networks together at the same time but is only accessible on one network at a time. In this way information can be provided between separate secure systems and where the metadata formats (IMML (Immersive Media Markup Language) and Metaforik formats) are used to re-compose local information and models into models within a Virtual Command Center. This approach provides an interoperability service layer between military and civilian C2 systems that also supports visualization of the data.

The CSES becomes a data discovery service and format converter that is able to receive and export in a range of languages (Biagini and Joy, 2012) (Figure 3).

The CSES is the core technology within the framework that supports the discovery of data regarding the area of operations. It is the point of access to range of underlying systems such as existing terrain databases, live data feeds, 3D model repositories and historic knowledge bases. These data sources are

treated as sources of layers of information for users within the Virtual Command Center. The user's view can be based on what is appropriate for the user's function. Users that require a tactical view can see an immersive 3D representation, whereas users that require an operational view can see a text and 2D representation of the same operating environment.

In a complex information environment a fundamental requirement is comprehensible and unambiguous communication and representation of knowledge.

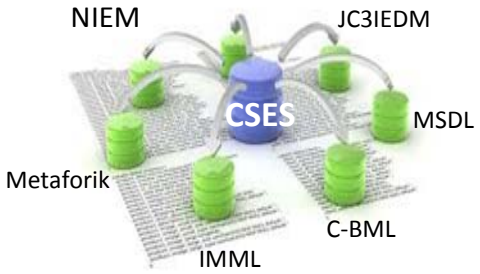

Figure 3. CSES logical architecture

This is especially critical, and difficult, as the framework can be used for multi-organization collaboration (including joint, multinational, inter-governmental and interagency services), where people have to cooperate remotely and cannot rely on common cultural reference points and assumed knowledge.

The need to develop a common operational language, that should be read and understood both by human beings, simulated entities and robots, has driven a variety of applied research activities involving scientists, academia, industry and military organizations. Valuable results include the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML). Both languages have begun to be included in the latest Command and Control (C2) and simulation systems and are being developed by NATO and the SISO (Simulation Interoperability Standard Organization) standardization process. Both Languages share a common database model the JC3IEDM (Joint Command, Control, Consultation and Information Exchange Data Model). This model is being ratified by NATO countries under NATO 5525 STANAG. Another relevant information exchange model, suitable to be implemented with the CSES, is the USA National Information Exchange Model (NIEM) it is under development and version 3 will be released on December 2013.

As the state of the art of these research activities, the Coalition Battle Management Service (CBMS) is a technical infrastructure that enables the exchange of resources (orders, reports and requests) between C2 systems, simulation systems and robotic forces. CBMS is a collection of composable web services that can be orchestrated to support the needs of a particular federation. CBMS is currently implemented as a service oriented architecture with an interrupt mechanism, a filtering mechanism and a data distribution mechanism that can be used to support the validation, storage, search and exchange of XML based languages (Diallo et al. 2011).

Taking into consideration the state of the art of the development in this field the authors are investigating how C-BML and MSDL can be incorporated or implemented via or within a unique high level metadata XML schema to represent data coming from a C2 data model into a virtual world and vice versa. Furthermore, this metadata XML schema should align and bridge properties between both languages and above all it should make it possible to efficiently describe how related pieces of information can be visualized in a virtual world synthetic environment. A potential authors' solution is that it can be achieved by extending IMML.

Immersive Media Markup Language (IMML) is a lightweight interactive 3D XML specification that is suitable for visualizing complex multimedia, interactions and scenarios in a 3D space using a small amount of highly readable XML. IMML aims to be abstract enough that it can be used in conjunction with multiple devices and clients that use a range of 2D, 3D or Augmented Reality visualization as well as proprietary and/or open formats to render the scene on a device. A virtual world implementation supporting IMML is also suited to receiving real time updates from external services and data feeds that stimulate the visualization. Finally, IMML is easily generated or controlled by other computer languages making it a useful markup language for dynamic and adaptive immersive environments.

The proposed architecture consists of converting the database model into an XML schema, performing an automatic, reliable and efficient mapping between the schemas representing the exchanged source and target data by means of the XSLT language. (Figure 4).

Figure 4. CSES Data Exchange Mechanism logical architecture

The authors' approach has the capacity to preserve the integrity constraints of the relational schema, which allows checking the XML document for anomalies or incoherencies before updating the relational database from the XML document. It also captures the hierarchy of the tables in the target database, which guarantees that the automatically generated Structured Query Language (SQL) queries will be correctly performed. Moreover, the language converter includes a rule base allowing a coherent and secure mapping between the exchanged data sources for database integrity.

The converter needs to use an XML-based mediation framework designed to meet future needs. Therefore the framework must be ready to implement future interoperable languages beyond C-BML and MSDL.

By utilizing IMML, all virtual world information and user input can be contained in an abstract metadata format that can be rendered on the users' device to suit the users' specific visualization needs. Immersive Media Markup Language (IMML) is a specification that:

- Defines the positions and functionality for objects in 3D space, describing a 3D scene
- Is capable of being included within other IMML files as widgets for code reusability
- Defines the interaction and use of different forms of media and graphical user interface elements (3D, video, music, 2D images, text output and additional services such as VoIP)
- Defines how objects interact in a multi-user (networked) situation
- Includes interactivity between elements including real world conventions (e.g. physics) and stimulation from external systems
- Supports extensibility through scripting languages and plug-ins that can define API interfaces within IMML.

4.4. The Virtual Command Center platform

The Virtual Command Center offers a range of innovations and utilizes state of the art approaches to crowdsourcing information, integrated simulation for virtual and live training and operation support in an agile way. The concept integrates the latest virtual world simulation technology with social networking, collaboration and knowledge management capabilities. It offers significant innovation if integrated with:

- Geographic Information System (GIS)
- Peer-to-peer (mesh) networking
- Data visualization and representation of incidents
- Secure data and document sharing
- e-learning and online training assessment
- A Common Synthetic Environment Service architecture (CSES)

The Virtual Command Center provides a multi-dimensional visual environment that increases affordances and supports bringing together the best team from wherever they are around the world. This enables the creation of virtual cross-functional teams in a boundless Command Post where the people who have critical knowledge, expertise and access rights can be brought together as an effective team despite the fact that team members are physically distributed (Biagini and Joy, 2012).

This platform is built around two main views of the same environment: The Meeting view and the fully 3D Sandbox view. Both views share the same data but these are accessed and visualized with different technology and in a different way.

4.5. The Meeting View

The Meeting view is a 2.5D multimedia environment designed to support fast, easy, low bandwidth remote collaboration and decision making process using a web-based suite of tools. It can be accessed via network connected devices. A web browser is required, but no additional software or plug-in is needed to access the Meeting. The Meeting view provides chat, slide presentations, low fidelity life-like user avatar representation and participant feedback mechanisms. This view can integrate external web content such as web pages, maps, Audio/Video conference tools, audio conferencing, 3D embedded windows, advanced data visualization and data analysis capabilities (Figure 5).

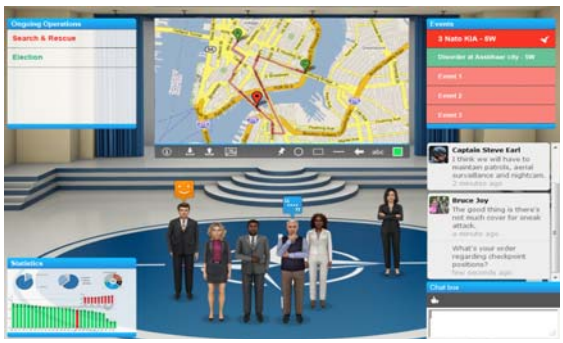

Figure 5. Virtual Command Center (Meeting View)

This suite is designed to give decision makers and analysts a simple, intuitive and agile planning and execution support tool that provides instant shared environment that supports the visualization of a shared situational awareness. It can be extended to provide access to a potentially wide range of tools compliant with IMML, Metaforik, C-BML, MSDL and JC3IEDM.

4.6. The 3D Sandbox

The 3D Sandbox is the immersive 3D virtual world environment. Though it may show the same map as the Meeting view, the 3D representation offers a more detailed view of the environment through the three dimensional views that support tactical planning.

Both the Meeting view and the 3D Sandbox view access and display customized views of the Events Stream layer and the ongoing operation layer. (Figure 6).

Figure 6. Virtual Command Center (3D Sandbox)

Using the Virtual Command Center it is possible to represent the working processes of a real world Command Center within a virtual online remote tactical operation center that is easy to access and intuitive to use. The 3D Sandbox environment could be enlarged to match the entire layout of the physical HQ that it is supplementing or representing for training purposes.

4.7. The Citizen 2.0 Application

The Citizen 2.0 application enables crowd participation within the EDS framework. It is designed for web and mobile devices so that users on smart phones, tablets and any Internet connected devices with a web browser can access the tool.

In specific operational contexts such as CIMIC operations, it is worth considering the potential benefits and risks of enabling information from civilians to be included in the crowdsourced information gathering. The mobile version of the app should be easy to use and enable members of the "crowd" to provide concise and accurate geo-located reports on what they discover and to capture and upload or stream live multimedia such as video and photos to provide useful evidence of events as well as receive inbound chat messages from command.

The app focuses on mobile devices for a number of reasons:

- The mobile device offers client-side GPS data providing accurate location data that is only partially trustworthy, but where the device can be located and the data verified by both the telecommunications service provider via cell phone tower triangulation and GPS systems themselves to confirm the validity of the GPS location data related to a report from the user of the device
- People on the scene of an event can stream live video and photo imagery and the mobile app knows if the footage is live or not
- By tracking the activity of the devices in an area where an incident is occurring and gaining information from multiple sources the EDS is able to collate the related content and enable analysts to quickly show the latest trusted data to decision makers based on crowd data that complements traditional data sources.

The application design provides a standardized "wizard" interface to take user information and generate a report in C-BML format (or equivalent) so that it can be automatically consumed within the EDS framework as data available to analysts and decision makers. This speeds up information discovery and may shift some of the analyst's tasks away from volume data entry to higher level analysis. Larger volumes of data over longer periods of time in defined formats from the same crowd of informants will expose patterns of intelligence that can provide insight into the crowd and lower the risks of counter-intelligence and misinformation. This can transform counter-intelligence efforts into rich sources of intelligence that includes networks of users, positions across time and the actual counter-intelligence imagery used to attempt to fool decision makers.

The authors focus on emergency and incident management operations where citizens could play an active role in providing live data to authorities, but are also investigating specific military operations focusing on military crowdsourcing. This military crowd could help a commander, staff or analysts to solve a specific operating problem in either a classical military situation or in a stability operation in a crisis response mission by providing a larger pool of infield data and imagery to draw upon.

There are a wide range of technical challenges to address with the use of the Citizen 2.0 application, especially in the military scenario. We propose the following capability requirements and responses:

- Challenge: Low bandwidth networks with large numbers of users offering data
- Response: Enable the command to remotely control what data is sent through the network by all of the Citizen 2.0 applications so that specific devices can stream their data to be viewed by decision makers without having other devices flood the network with data

- Challenge: Networks will be disrupted at critical times
- Response: The Citizen 2.0 application should support, utilizing all networks available to it, the users to easily activate the device as a wireless bridge so that other local devices can connect and share any network access together. Furthermore, to minimize flooding mobile data networks with reconnection attempts and using secure peer-to-peer technology to enable data to be sent through the peers, this application then should reconnect the network connectivity between the command center and all of the devices in the crowd
- Challenge: The devices in the crowd may be standard COTS phones and other portable devices so are insecure
- Response: Devices in the crowd authenticate via their device ID, phone number and its phone tower triangulation location via the telecommunications provider and its GPS location via the application. Users of the devices authenticate by logging into the application using their username and password and can be required to provide imagery including live video or photos of themselves and their surroundings. This should ensure that the analysts are certain of whom they are talking to and getting data from.

Additional opportunities exist if the server-side system supports various intelligence capabilities such as:

- Reputation profile building for each "citizen" that can provide insight into the reliability of information provided (this follows the eBay user reputation model)
- Trap misinformants and misinformation in a “honey pot” database for counter-intelligence analysis that mimics the response of the CSES but is in fact an information space specifically for content that is deemed to be or likely to be counter-intelligence
- Potential for highly localized crisis updates to flow back to citizens as alerts and to joint taskforces as alerts or even as tasks provided by the inbuilt messaging system to support actions. This has the potential to enable a potentially controllable “little brother” deterrent against insurgents within highly populated urban areas where any citizen can provide key identity information in real time.

In summary, the Citizen 2.0 app is the application within the EDSF architecture that provides all of the crowdsourced information to the CSES (Figure 7).

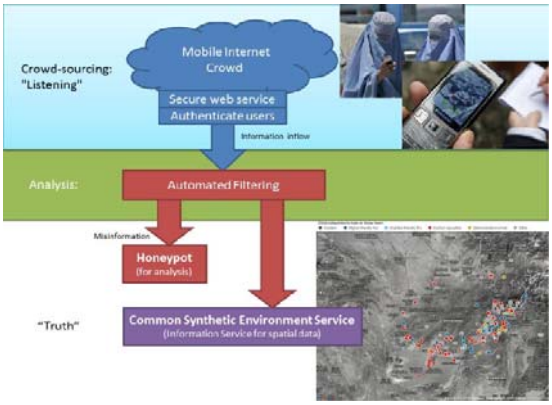

Figure 7. Citizen 2.0 logical architecture

5. CONCLUSION

The outcomes of this research established the milestone of the conceptual architecture for building what the authors call an Edge Decision Support Framework. It is based on social networks and virtual world technology assuming to be initially operated to support Decision Makers and Staff training in a CIMIC general purpose emergency and incident management environment. The prototype, now under development, can be used to build and customize applications to support decision making process and operations. This framework uses extensively “Open Source Intelligence” (OSI) through social networks, virtual worlds and mobile technologies.

The CSES forms a genuine interoperable service layer based on implementing standard languages, common data models and supporting adding more language importers and exporters when required in the CIMIC environment.

This paper presented main aspects of the research made to specify an Edge Decision Support Framework (EDSF) targeted to organizations requiring interoperable command and control environments, and the set of initial software specifications for the web-based prototype application in development:

- HTML and XML technology to reduce the IT challenge of supporting new desktop applications and/or web plug-ins that require download and installation on every device needing to access the virtual command environment
- Integration between virtual worlds, web browsing 2.0, 2.5 and 3D technologies to let users decide which of them is best suited to support their decision making process
- Capability to be used as a stand-alone system

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