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NAVAL POSTGRADUATE SCHOOL

Monterey, California



THESIS

**WEB-BASED COLLABORATION TECHNOLOGY
AND REQUIREMENTS FOR PEACE
OPERATIONS**

by

Madalyn A. Spivey

March 2002

Thesis Advisor: Nancy Roberts
Co-Advisor: Don Brutzman

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**WEB-BASED COLLABORATION TECHNOLOGY AND REQUIREMENTS FOR
PEACE OPERATIONS**

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Peace Operations include Peace Making, Peace Building, and Peace Support.

Although information-sharing systems may exist within individual organizations, to date no interoperable information regime exists that can link all players who participate in providing aid during a Complex Humanitarian Emergency. Effective information sharing between civilian and military organizations is needed to enhance operational efficiencies, therefore saving lives, resources, and promoting rapid recuperation and reconstruction.

An off-the-shelf collaborative software package with a common architecture and common templates, standard protocols, and centralized database might initially serve as a collaboration platform. Extensible Markup Language (XML,) XML-based languages, and Resource Description Framework (RDF) are important technologies that must be utilized extensively to enable this environment. Additionally, WebDAV (Web-based Distributed Authoring and Versioning) integration can provide an infrastructure for platform-neutral asynchronous collaborative authoring via the Internet.

Internationalization (I18N) and localization (L10N) addresses differences in language requirements and local expectations that reflect our differences in cultures. Existing collaboration COTS architectures form a basis with which developers can integrate XML technologies. The “Ideal” collaborative environment must include asynchronous and synchronous collaboration capabilities, as well as capabilities that will enable users to rapidly locate personnel, organize and conduct virtual teams and meetings, provide information delivery to personnel, and provide sufficient security mechanisms.

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I. INTRODUCTION

A. MOTIVATION

The purpose of this thesis is to propose a potential system to promote information-sharing among civilian and military entities for the purpose of planning, executing, and providing feedback on the effectiveness of international efforts to provide relief for humanitarian disasters and reconstructing war-torn societies. By identifying potential Web-based collaboration technologies, Web-based software architectures, and commercial off-the-shelf (COTS) software packages, and developing criteria to evaluate the software, example requirements are outlined that have the potential of meeting the needs of the stakeholders.

B. KEY LISTING OF THESIS QUESTIONS

Pertinent questions addressed by this thesis include:

- What technologies exist to support collaboration at the operational level during peace operations?
- What requirements can be met by Web-accessible XML-based languages for such shared information architectures?
- What criteria should be used to evaluate software packages?
- What software packages are recommended to facilitate peace operations at the operational level?

C. RATIONALE OF WHY THIS RESEARCH IS IMPORTANT

The key to providing aid in complex emergencies requires promoting the ideas of peace, living together, human rights and integration of vulnerable groups--in one word: democracy (Manenti, p. 3.) Decentralized Cooperation (DC) is an innovative tool used for community empowerment that promotes bottom-up initiatives and can defuse isolation. DC addresses systematic co-operation between local communities in countries that need support and local communities in donor countries.

The characteristics of DC are territorial, connected, integrated, participatory, sustainable, partnerships, and vision. "Territorial" portrays a small, well-defined area, which will permit the local community to actively participate. "Connected" describes the linkages between local government and national and international policies. "Integrated" is the association of health, education, income, environment, and human rights as components of development. "Participatory" describes the decision-making process between civil society and public institutions. "Sustainable" is the maintenance of support for linked communities beyond the conclusion of a co-operation project. "Partnerships" describe the relationships among linked communities. "Vision" portrays the promotion of common interests as processes that improve economic indicators, quality of human relationships, and individual opportunities all over the world. (Manenti, p. 7.)

DC has been extended to provide a method to coordinate humanitarian aid in countries affected by either natural or man-made disasters. An appropriate parallel can be made between DC characteristics and the challenges inherent to collaboration. Information sharing in a Peace Operations environment requires vision and must be territorial, connected, integrated, participatory, sustainable, and partnership-dependent. Success in post-Cold War

peace and humanitarian operations depends on effective information sharing among diverse civil government, non governmental organizations (NGO's,) and military entities. Information sharing enhances operational efficiencies—saving lives, resources, and promoting rapid recuperation and reconstruction. Such collaboration can additionally promote information transparency, i.e. providing critical information for others to understand missions and activities in the field. Although information-sharing systems may exist within individual organizations, to date no interoperable information regime exists that can link all players who participate in providing aid during a CHE. (U.S. Institute of Peace.) This is a major shortfall in information architecture design and technology management which, if addressed, can provide a major improvement in peace operations and refugee relief. Such efforts are critical for peaceful resolutions of armed conflicts and remove several of the root causes of international terrorism

The U.S. Institute of Peace's objectives in promoting an information-sharing regime in peace support and humanitarian operations are:

- To build a core of recent case studies and distill lessons learned from the adoption and implementation of information and communications strategies in peace and humanitarian operations, and
- In collaboration with their partners, to develop a strategic information plan applicable to peace and humanitarian operations that addresses data requirements and standards; human and technological resources; overall coordination, planning and evaluation; and the eventual transference of assets to indigenous institutions and organizations.

An off-the-shelf collaborative software package with a common architecture and common templates, standard protocols, and centralized database would enhance operational efficiencies and facilitate rapid recovery and reconstruction. Although collaboration for the purpose of providing relief for humanitarian disasters and reconstructing war-torn societies is challenge for all stakeholders, the task may be significantly improved through utilizing information technology to support advanced planning, concerted execution, and feedback of the effectiveness of relief efforts.

D. THESIS ORGANIZATION

The Thesis Organization consists of 5 chapters: introductory motivation and overview, background and related work, a discussion of enabling technologies for Web-based Software Architectures, an example Web-Based Information Architecture for Peace Operations, and Conclusions and Recommendations. The Thesis also includes a list of acronyms and references.

E. SUMMARY

This thesis identifies Web-based collaboration technologies, software architectures, and COTS software to promote information-sharing among civilian and military entities participating in Peace Operations through addressing the key thesis questions. Developing a Web-based information-sharing architecture are critical for peaceful resolution of armed conflicts and remove several of the root causes of international terrorism.

II. BACKGROUND AND RELATED WORK

A. INTRODUCTION

Collaboration tasks in a Peace Operation may range from document and resource management to instant messaging and video conferencing. Assessing the needed collaboration level and performing a requirements analysis will ensure the technology helps, rather than hinders, stakeholders. It is also necessary to understand the organization of Peace Operations to determine system requirements.

B. DEFINITION OF COLLABORATION

Collaboration is derived from the French verb *collaborer* (*col* means “together,” and *laborare* “to work.”) Random House Webster’s College Dictionary defines collaboration as “to work, one with another; cooperate, as on a literary work. An alternate definition from the same source is “to cooperate with an enemy nation, especially with an enemy occupying one’s country.”

The five sociological elements of collaboration are: transmutational purpose, explicit and voluntary membership, organization, an interactive process, and a temporal property (i.e. time.) (Roberts and Bradley, 1991.) A transmutational purpose is one in which an activity is shared and goal-directed. Explicit and voluntary membership is one in which parties participate freely. Organization involves both planning and coordinating tasks, and is characterized by interdependence and joint decision-making. The interactive process is a self-critical interaction among the participants. The temporal property element (time) shows

the fact that collaboration is specific to a common end and concludes after the accomplishment of a goal.

The combination of these elements yields the following comprehensive definition: *collaboration* is a temporary social arrangement in which two or more social actors work together toward a singular common end that requires the transmutation of materials, ideas, and/or social relations to achieve that end. (Roberts and Bradley, 1991.)

There are three levels of collaboration. At level 1, individuals who are not part of a working group or team operate independently and interactively to pass documents back and forth to accommodate their own specific needs. Individuals with common interests operate at collaboration Level 2 to exchange information, but not to achieve a common goal. Level 3 collaboration involves participants working as a team to achieve a common goal. Asynchronous collaboration capabilities supports collaboration levels one and two, while synchronous collaboration supports collaboration at the highest level. Table 1 shows collaboration types and capabilities.

COLLABORATION TYPE	CAPABILITIES
Asynchronous collaboration	Email Electronic bulletin boards Electronic document/file "rooms" Threaded discussion databases, People locators Group calendars
Synchronous collaboration	Electronic whiteboards Awareness knowledge Live audio/video conferencing Text-based chat sessions

Table 1. Collaboration types and capabilities.

Asynchronous collaboration allows data to be sent as soon as it is ready, regardless of whether recipients are ready to receive it. This type of collaboration includes email (with attachments,) bulletin boards, electronic “rooms” where members can store and access common documents and files, threaded discussion databases, people locators, and group calendars. Synchronous collaboration (also referred to as “real-time collaboration” manages the sending and receiving of audio, video, and dynamic text, but only one user can dominate a discussion at a time. Synchronous collaboration capabilities includes electronic whiteboards, awareness knowledge, live audio/video conferencing, text-based chat sessions.

C. DEFINITION OF PEACE OPERATIONS

Peace Operations are requiring an increasing amount of time and resources within the government of the United States and those of other nations. The Conceptual Model of Peace Operations (CMPO) was developed by analysts through a series of interactive workshops to satisfy the necessity to understand the processes of peace operations (Davis, pg. 3.) When modeling using the CMPO, various information bases, linkages, tasks, and organizations are modeled for the purpose of representing the functions, processes, and information flows of Peace Operations. Relationships and linkages between concurrent processes that occur within an operation are also provided.

Peace is order with justice. An individual’s concept of self and a comparable understanding of one’s place in society characterize order. The fulfillment of basic needs such as food, shelter, self worth, and security are implications of order. Justice is adherence to a rule of law and is not as intuitive as order. (Davis, p. 4)

Peace Operations consist of Peace Making, Peace Building, and Peace Support. Peace Making is accomplished by diplomats (envoys of Governments, groups of states, regional organizations, or the United Nations) and uses diplomacy and mediation to address conflicts in progress and attempt to bring them to a halt. Negotiations, fact-finding, and working on agreements are also Peace Making tasks. The focus of Peace Making is resolving the root causes of the conflict.

Peace Building activities are those that reassemble the foundations of peace and provide the tools for building on those foundations something that is more than just the absence of war. (Report on the Panel on United Nations Peace Operations, Part II) Humanitarian Aid Workers, Human Rights Monitors, Elections Monitors, teachers and consultants on democracy and civil society all help accomplish these necessary tasks. Non-Governmental Organizations (NGO's) and Private Volunteer Organizations (PVO's,) along with specialized agencies of the United Nations such as the United Nations High Commissioner for Refugees and Human Rights (UNHCR,) all deal with Peace Building.

Peace Support Operations (Peacekeeping) is accomplished by military, police and, occasionally, contract forces. Because of the varying effectiveness of these providers, the military performs this process most often. Necessary functions include Observation, the Use of Force, Liaison, Command and Control, Presence Operations, Logistics, and Security. Peacekeepers maintain a secure local environment for Peace Building. The two are inseparable because while Peace Builders may not be able to function without the Peacekeepers' support, the Peacekeepers can't depart the area without the Peace Builders' successfully achieving stability.

As illustrated by the previous description of Peace Operations, there are many interdependent functions that need to occur in a concerted manner in order to ensure the success of the Peace Operation. Integrating Information Technology may aid in this process, but poorly planned and poorly integrated IT can pose obstacles to cooperation. Consequences can be more serious than wasted labor and may range from minor problems such as miscommunication of policy up through failure to promulgate information on security threats and major changes in the operational environment.

D. SUMMARY

Sociologically, collaboration consists of three levels of cooperation. Level three is the highest, requiring teamwork to achieve a common goal. In a technical sense, asynchronous collaboration supports levels one and two, while synchronous collaboration supports level three. The success of stakeholder collaboration during Peace Operations depends heavily on participants' understanding of Peace Operations. The Conceptual Model of Peace Operations outlines the processes of peace operations and illustrates relationships among information bases, linkages, tasks, and organizations.

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III. ENABLING TECHNOLOGIES FOR WEB-BASED SOFTWARE ARCHITECTURES

A. INTRODUCTION

The Semantic Web is the vision of an extension of the current World Wide Web, one of which will facilitate the well-defined meaning of information, which will enable computers and people to work in an enhanced cooperative manner. This environment is conducive to software agents that can surf the web to perform sophisticated tasks for users.

The Web has developed more rapidly as a medium of documents for people than one that machines can understand. To this end, computers cannot automatically process data and information. The Semantic Web proposes to resolve this problem by eliminating the difference between document types, commercial and academic information, and information initiated from varying media types, cultures, and languages. Subsequently, World Wide Web universality will increase.

A well-functioning Semantic Web requires the ability for computers to process structured collections of information utilizing inference rules that can guide them in automated reasoning. The challenge of the Semantic Web, therefore, is to provide a language that expresses both data and rules for reasoning about the data and that allows rules from any existing knowledge-representation system to be exported onto the Web (Berners-Lee, Hendler, and Lassila, pg.3.)

B. EXTENSIBLE MARKUP LANGUAGE (XML) AND RELATED TECHNOLOGIES

Extensible Markup Language (XML) is an important technology for developing the Semantic Web. XML is a set of rules that enables the delivery of SGML information over the Web while overcoming the limitations of HTML. SGML (Standard Generalized Markup Language, prescribes the rules for creating a specific markup language such as HTML and provides the capability for creating any desired set of tags (Arbortext, pg. 1.) HTML is the current markup language for delivering documents over the Web. Its popularity is due to the fact that it is very simple, it has a built-in screen formatting style, linking is easy, it supports forms, and it is easy to program. Although HTML is successful in deploying home pages and small websites, its limitations are evident in intranets and extranets, which are large and business-critical applications. The limitations include limited structure, limited reuse, limited interchange, limited automation, and searches that produce too many “hits.”

XML is a markup language for documents containing structured information. It allows for a text design formats that will enable computers to easily generate and read associated files. XML is also a metalanguage, a language for describing other languages, which allows users to design their own customized markup languages (schemas) for different types of documents. XML is being progressively designed by a Working Group (consisting of about fourteen companies and organizations with a strong interest in either providing or utilizing XML tools) of the World Wide Web Consortium (W3C,) which establishes specifications for Web technologies to ensure the highest possible degree of interoperability and utility.

According the W3C, XML will:

- Enable internationalized media-independent electronic publishing.

- Allow industries to define platform-independent protocols for the exchange of data, especially the data of electronic commerce.
- Deliver information to user agents in a form that allows automatic processing after receipt.
- Make it easier to develop software to handle specialized information distributed over the Web.
- Make it easy for people to process data using inexpensive software.
- Allow people to display information the way they want it, under style sheet control.
- Make it easier to provide metadata -- data *about* information -- that will help people find information and help information producers and consumers find each other.

XML was created out of the need to structure, store, and send information and is not intended to replace HTML. However, XML will replace HTML where HTML provides insufficient retrieval precision or data reusability, and will coexist with HTML in many environments. Additionally, XML can serve as an SGML output format. (Mulberry Technologies, Inc.)

XML focuses on describing data and information, while HTML focuses on displaying data and information. Unlike HTML, whose tags and structure is predefined, XML is free and extensible, allowing authors to define their own tags and document structure. DTD's (Document Type Definitions) are used to describe the data and are self-

descriptive. The tags leave the interpretation of the data to the application that reads it. Elements, the information marked by tags, may be further described by attaching attributes, which are name-value pairs. A particular benefit of the syntax is that it is easily processed by machine, while remaining understandable to humans.

XML is a family of technologies that include Xlink and Xpointer, CSS (Cascading Style Sheet Specification,) XSL (Extensible Stylesheet Language,) XSLT (Extensible Stylesheet Language Transformation,) DOM (Document Object Model,) and XML Schemas. The W3C XML Query Working Group has developed goals, requirements, and usage scenarios for the Query data model, algebra, and query language. Table 2 shows XML technologies and their capabilities.

XML TECHNOLOGIES	CAPABILITIES
Xlink	Adds hyperlinks to XML files
Xpointer	Points to parts of XML documents
XSL	Expresses style sheets
DOM	Manipulates XML files from a programming language
XML Schemas	Defines XML-based formats
XML Namespaces	Associates URLs with tags and attributes

Table 2. XML technologies and capabilities.

Xlink and Xpointer define a standard way to represent links between resources. While Xlink deals with adding hyperlinks to an XML file and gives the author control over the semantics of the link, Xpointer is a syntax for pointing to data within an XML document.

(Walsh, pg 1)

Since authors can define tagsets in XML, browsers need a structure (stylesheet) to define tag names and their meanings, enabling the display of formatted text. CSS provides the

syntax for element style. XSL stylesheet is an XML file (written with XSL, which uses XML syntax.) The more powerful XSLT transforms XML into HTML, rendering XML stylesheets readable by browsers that do not support XML. The translation occurs either inside the browser, or at the server before transmission. It can also specify transformations from one vocabulary of XML to another, and from XML to plaintext (UCC XML FAQ.)

The Document Object Model is an API (Application Programming Interface) that enables programmers to develop applications which work on all browsers, servers, and platforms. The DOM facilitates programs and scripts in dynamically accessing and updating document content, structure, and style. It is platform and language-neutral. The DOM evolved through the vision of a combination of HTML, style sheets, and scripts, allowing documents to be animated. This fusion has been coined “Dynamic HTML,” and the W3C DOM Working Group has taken on the responsibility of ensuring interoperability and scripting-language neutral solutions. Although the XML specification provides the syntax and grammar for XML, API’s enable the access of XML content in an application.

A schema is a model that describes the structure of information. XML schemas describe models (outlining the arrangements of tags and text) for an entire class of documents and allow machines to carry out rules made by people. The purpose of both a DTD (Data Type Document,) and an XML schema is to define XML documents and allow machine validation of document structure. Models are described in terms of constraints, which define what can appear in the document. The two constraints that limit models are content model constraints and datatype constraints. Content model constraints describe the order and sequence of elements, and datatype constraints describe valid units of data.

A valid document does not violate the constraint of the model. XML technology is important for the scope of this thesis because in a Peace Operation scenario, because collaboration among stakeholders requires a flexible and extensible platform. XML removes two constraints that were holding back Web developments:

- Dependence on a single, inflexible document type (HTML) and
- The complexity of full SGML, whose syntax allows many powerful, but hard-to-program options.

XML simplifies the levels of optionality in SGML, and allows the development of user-defined document types on the Web (The XML FAQ, UCC, pg. 6)

The average XML user only needs a browser that supports XML. Some components are still being implemented, so some features may still be undefined. Popular XML browsers include Opera for Windows 4.0, Microsoft Internet Explorer 5.x and 4.x, Netscape Mozilla Milestones: Project SeaMonkey, Netscape 6 (preview release 1,) Netscape Communicator 4.7, and JUMBO (Java Universal Markup Browser for Objects.) Existing HTML files will work in XML if they are converted to conform to a new document type, but a corresponding style sheet must be written. HTML files can also be edited to conform to XHTML. (Sall, 1,2)

Popular commercial database/content management systems and desktop publishing software includes TAMINO from Software AG, eXcelon from Object Design, Inc., and ADEPT Editor from ArborText. Additional software for specific interpreted languages and other specialized tools include Bean Markup Language (for configuration and wiring,) Dynamic XML for Java (for attaching Java displays and behaviors to XML trees and subtrees,) Apache XML Project, and RDF for XML by alphaWorks at IBM.

Information on a network connecting different types of computers must be interoperable with all machines and cannot be restricted to a computer type. This information must be also be in a format that facilitates re-use to minimize wasted time and effort. Additionally, proprietary data formats, such as Lotus Notes or Microsoft Word may not be an option for maintaining control of and facilitating information-sharing during Peace operations because when control lies in private hands, these platforms can be changed or withdrawn without notice.

Although globally distributed information may be accessed by the World Wide Web, information discovery and access is improved through the incorporation of metadata (structured data about data.) To affectively facilitate metadata use among applications, semantics, syntax, and structure conventions must be adhered to. Semantics of metadata describes its meaning. Syntax is the systematic arrangement of data elements for machine-processing, and facilitates the exchange and use of metadata among multiple applications. Structure is a formal constraint on the syntax, and allows for interchangeability of resource description community-defined packages of metadata.

C. RESOURCE DESCRIPTION FRAMEWORK (RDF)

RDF (Resource Description Framework) is the second important technology for developing the Semantic Web. It is a metadata framework that provides interoperability among applications for the exchange of machine-understandable descriptions of resources on the web. RDF also provides better precision in resource discovery than full text search and future-proofing applications as schemas evolve. Further development will enable RDF to also provide:

- A uniform query capability for resource discovery
- A processing language for automated decision-making about Web resources
- A language for retrieving metadata from third parties. (W3C RDF FAQ)

RDF was developed through the efforts of the W3C out of the need for metadata communities to provide a robust and flexible architecture for supporting metadata on the web. With RDF, structured metadata can be encoded, exchanged, and reused. Vocabularies are sets of metadata elements, or properties defined by resource description communities. Standardizing vocabulary declarations encourages the reuse and extension of semantics among disparate information communities, and XML syntax provides for metadata exchange and processing. (Miller, pg. 2)

RDF specifications provide an ontology system to support Web knowledge exchange. The ontology, the third basic component of the Semantic Web, and is a document or file that formally defines the relations among terms. For instance, if a program compares information across several databases and encounters terms that have the same meaning, an ontology page solves the problem of multiple definitions. The meaning of terms or XML codes used on a Web page can be defined by pointers from the page to an ontology. (Berners-Lee, Hendler, and Lassila, pg.5.)

RDF can be used in application areas such as resource discovery, cataloging, intelligent software agents, content rating, collection descriptions, and intellectual property right description. RDF, combined with digital signatures, is the basis for electronic commerce and collaboration “Web of Trust.”

For the scope of this thesis, RDF would provide interoperability among stakeholder computer systems. For instance, if a stakeholder wants to search individual databases within

the Peace Operation Network for information regarding a mission or task (either manually, or through the use of an intelligent software agent,) RDF framework resource discovery would provide better search engine capabilities and cataloging provides for content and content relationship descriptions at particular pages. Secure access or transactions over the network could be verified with digital signatures.

D. INTERNATIONALIZATION (I18N)

Internationalization (abbreviated I18N) describes the process of designing and developing programs and software products so it can be adapted to various language and regions to function in multiple locales. The Internationalization process involves identifying the locale in which the application will be utilized, designing the appropriate features, and writing the code that will function well in the supported locale. Locale is defined as a set of conventions affected or determined by human language and customs, as defined within a particular geo-political region. These conventions include (but are not necessarily limited to) the written language, formats for dates, numbers and currency, sorting orders, etc.

I18n was developed when programmers discovered that making changes retroactively to applications that were written in one language, or even developing parallel versions, resulted in a lengthy, expensive product cycle (Tang, pg 1.) Even software that was functionally suitable for use in multiple countries had menus, dialog boxes, and messages that facilitate the user interface, were written in the program source code. Translating source files are difficult, time-consuming and expensive because the combination of linguistic and engineering skill sets are uncommon, mistakes are made easily, and occasionally, the resulting translated code does not function as expected. .

Software developed in recent years with the multi-locale computing requirements in mind is less expensive reach global markets sooner. This “globally enabled” software supports a variety of languages, cultural conventions, encodings, fonts, and additional features that make it useful in a multitude of countries and regions. Examples of culturally dependent data include messages, labels on GUI components, sounds, colors, graphics, icons, currencies, dates, times, and numbers.

E. LOCALIZATION (I10N)

Abbreviated I10n, Localization requires modifying a software product to fit the requirements of a particular locale and may include customizing features and translating user interface, documentation, packaging, and dialog box geometrics. The resulting product must be tested to ensure it works at least as well as the original. Text translation is the most time-consuming, and data such as sounds and images may require localization if they are culturally sensitive. (Tang, pg 3.)

F. WEB-BASED COLLABORATION TECHNOLOGIES: WEBDAV

WebDAV (Web-based Distributed Authoring and Versioning) is a set of extensions to the HTTP protocol that provides an infrastructure for asynchronous collaborative authoring via the Internet. It is platform-neutral and allows web development teams and other workgroups to use a remote web server to develop, edit, and manage a live or staged website. Overwrite prevention, properties, remote file management, version management, advanced collections, and access control are WebDAV’s key features that streamline collaboration and workflow. (Whitehead, pg 2.) Table 3 shows WebDAV capabilities and technical features.

Locking prevents web team members from overwriting each other's changes. When two or more people collaborate on the same, unversioned document, it is possible to lose changes made by contributors as changes are written without merging in previous changes. This loss of modifications is called the "lost update" problem.

WebDAV uses shared and exclusive locking to prevent lost updates. Shared locks (also known as advisory locks or reservations) allow more than one author to modify a document at a time. One author notifies the computer of his or her intentions of editing a document, and the computer documents the intention. If a second author who submits an intent to edit the same document, the computer will announce that another user is editing the document. The second author may still edit the document by contacting the other author to negotiate access. With exclusive locking, when an author informs the computer of his or her intention to modify a document, the computer locks the document.

WebDAV CAPABILITIES	TECHNICAL FEATURES
Overwrite Prevention	Shared locks Exclusive locking
Properties (name-value pairs)	Create Remove Query Hypertext linking
Name Space Management	Copy Move List resources
Version Management	Multi-author collaboration. Document revision storage.
Advanced Collections	Add resources/specify order in a collection
Access Control	Access rights

Table 3. WebDAV capabilities and technical features.

Other authors who desire to edit the same document are denied access because only the owner of the lock has modification privileges. A file can be opened online and edited offline because it isn't necessary to maintain a network connection during the time the lock is applied to a file.

Typical Web search engines often return a large number of undesired results to queries. To better focus queries, properties (also known as metadata—information about information) can be used to search for web resources, which will reduce the number of undesired query results. Since WebDAV facilities include creating, modifying, retrieving, and deleting metadata from multiple schemas, the most appropriate schema can be used in any context. Properties also allow the ability to make hypertext links between pages of any resource type.

Name space management is the creation, removal, and automatic consistency maintenance of collections containing sets of resources. The ability to receive a listing of resources in a collection and to copy and move Web pages is also included in name space management. Since there are two classes of properties: live and static, copy and move functions pose the problem of property behavior after a copy or move. Static property values remain the same until explicitly modified. Live property values have syntax and semantics enforced by the server and may vary.

Version management is the ability to store important revisions of a document for later retrieval. It also supports collaboration by allowing more than one author to modify the same document in parallel tracks. Advanced collections create the ability to add members to a collection pointing to any resource on the Web. Collections may also be ordered, allowing a client to specify specific ordering of resources in a collection. Access Control is

the ability to limit access rights on resources. Another one of the latest WebDAV features include SSL (Secure Sockets Layer) technology, which provides 128-bit encryption for all transmissions (Moore, p.1.)

Since Web browsers are designed to retrieve Web resources, not provide direct access to protocol methods, browser must be extended to initiate the protocol request. To extend the browser for WebDAV implementation the user needs request URI, request header, and request body headers. The request URI identifies the location of the resource addressed by a protocol method. The request header stores parameters needed by a method such as PROPPATCH, PROPFIND, COPY, MOVE, MKOL, LOCK, and UNLOCK.) For example, a request header would be needed to identify the destination for the COPY method. Additionally, the request body stores parameters needed by a method (in this case, names of properties retrieved by the PROPFIND method.)

Vendors implementing WebDAV technology include Oracle, Microsoft, Oracle, Apple, Novell, and Adobe Systems. Oracle's IFS (Internet File System) and 9iAS Portal, Release 2 (scheduled to launch by December 2001) supports WebDAV. Microsoft's SharePoint Portal Server, Office XP, and Windows XP are built-in WebDAV support. A remarkable feature of Windows XP is that any application running on top of Windows XP is WebDAV enabled, as well. Mac OS X and Novell NetWare 5.1 and 6 currently possess WebDAV capabilities. (Moore, pg 2)

WebDAV technology can successfully be integrated in a Peace Operation or Disaster Relief environment for the purpose of coordinating tasks from a project management point of view. Additionally, WebDAV future work will include designing a "security management" component in order to administer a large number of complex hyper-linked

documents/metadata and a large number of collaborators with differentiated security requirements. (Neumann, p.10)

Workshops to develop the Conceptual Model of Peace Operations yielded a formidable list of participating organizations, information bases, processes, functions, and tasks. For example, involvement of up to 85 organizations to coordinate up to two hundred processes and functions, and up to six hundred tasks is typically necessary to carry out one Peace Operation. The document management features in a tool such as the WebDAV-enabled Acrobat 5 or a variety of other project management tools could solve the problem of tracking task progress and completion.

Adobe Acrobat, Version 5.0 has features that allow users to collaborate on and edit PDF documents via the Web. The new version allows the uploading of comments and edits to a shared data repository, which can be read and written to by others connected to the Web server. After collaborators make comments, a facilitator reconciles the comments and uses them to make changes to the source file

In addition to document management features, Acrobat 5.0 utilizes FDF files, which can contain comments and forms-based data (facilitating workflow management.) Developers can use Adobe's DF Software Developer Kit (SDK) to extract metadata from FDF files for submission to a Web environment using XML flags. (Zipper, pg. 3)

G. COLLABORATION SOFTWARE

The latest collaboration software infrastructures allow users to collectively work on issues ranging from product design, engineering, and production planning, to program-management, supply-chain and life cycle management. Popularly known as Groupware,

these software packages have a variety of features, the most popular of which include email, instant messaging, chat, and whiteboard capabilities. Microsoft Exchange Server, Cybozu Office 3, and TeamCenter are just a few of the Groupware options currently available on the market.

Microsoft Exchange Server storage group capability (allowing a group of databases to be managed from a single administrative point,) unified messaging platform (for e-mail, voice-mail, fax, and page messages,) instant messaging, and support for WebDAV and XML make it an attractive option for both small businesses and large distributed enterprises. (www.microsoft.com/exchange/default.asp.) Additionally its chat, data, audio, and video conferencing, workflow management, security, and system monitoring features are particularly useful in a Peacekeeping environment.

Cybozu Office 3 web-based groupware offers many of the features in Microsoft Exchange server, but for at least \$40.00 less per user than many of the leading groupware packages. A multi-platform license prevents additional costs related to changing server Operating Systems, and HTML customizability features will easily allow for Internationalization and Localization. (www.linux.about.com)

TeamCenter by Inovie proved to be a flexible, sufficient in-house solution. Cross-platform interoperability (to include Unix, Windows NT, Linux, Solaris, and Mac OS) is its major strength, along with the capability to allow users full concurrent access to all product functions without user lockout (thanks to what Inovie calls TeamNative Behavior, which instantly makes changes across the workgroup when items are added or deleted from a project.)

BEA Systems Inc.'s Java-based WebLogic Portal provides Portal Foundation Services, Personalization and Integration Management, Intelligent Administration, and Integration Services (www.javaworld.com.) Portal Foundation Services simplify portal development, maintenance and security while Personalization and Integration Management improve the user experience through targeted incentives. Intelligent Administration reduces administrative backlog and portal ownership costs, and Integration Services reduce integration costs and facilitate application integration throughout and beyond the enterprise. Notable features are business logic and process flow mapping tools that require programming expertise. (Borck, pg 1)

H. SUMMARY

XML, RDF, I18N, and L10N are important concepts to implement in a web-based Peace Operation information-sharing network because these are enabling technologies and functionalities that will render information more meaningful to both stakeholders and computers. XML and RDF will add "Semantic Web" qualities to the collaboration system, while I18N and I10N will address differences in language requirements and local expectations that reflect our differences in cultures. Software with interfaces that let programs modify their behavior for operation in specific language environments will remain useful regardless of country, region, or language. WebDAV technology implemented in Adobe Acrobat reader is just one of many examples of new technologies being paired with existing applications to automate and simplify a process such as document control and version management.

IV. EXAMPLE WEB-BASED INFORMATION ARCHITECTURE FOR PEACE OPERATIONS

A. INTRODUCTION

Information-sharing among civilian and military entities in peace and humanitarian operations can enhance operational efficiencies, saving lives, resources, and facilitating rapid recuperation and reconstruction. Policymakers, peacekeepers, international aid managers, and local authorities may all benefit from well-planned and well-integrated Information Technology to enhance communication, collaboration, task planning and resource management.

B. COLLABORATION SYSTEM REQUIREMENTS

Two sets of issues must be addressed before establishing a Web-Based Information Architecture for Peace Operations:

1. Data collection, exchange standards, metadata
 - Identification of information needs and data sources
 - Establishment of definitions, standards, and methods (with due regard for individual and institutional privacy and information validity and integrity) for data acquisition, collection, analysis, retrieval, and exchange.
2. Technological Resource requirements
 - Web-based
 - Off-the-shelf
 - Sustainable
 - Reliable

- User-friendly inputs/outputs
- Interoperable with a range of governmental, international, and non-governmental organization information systems (common architecture, templates, platform, network, and standardized protocols.)
- Support for both Synchronous and Asynchronous collaboration
- Centralized database
- Project management tools
- Multi-level security support
- Performance effectiveness evaluation tools

C. THE 'IDEAL' COLLABORATIVE ENVIRONMENT

In addition to asynchronous and synchronous collaboration capabilities, the ideal collaborative environment must include these additional capabilities:

- Rapidly find the right people with the right expertise
- Quickly organize and conduct virtual teams and meetings
- Enable cross-organizational collaboration to support the business lifecycle
- Build, find, and exchange information across organizational boundaries
- Deliver the right information to the right people as soon as it is available
- Provide and maintain sufficient security, and
- Employ technology and community standards. (Dargan)

In a Peacekeeping environment, stakeholders must be able to quickly identify, locate, and contact subject-matter experts or staff to enable collaboration. The ideal collaboration system could display a menu that would allow participants to select from subject-matter areas

and identify personnel (gaining information such as the individual's full name, job title, organization, contact information, levels or access, and areas of expertise.) A search capability will enable users to locate participants with partial information (such as a first name.)

In a crisis situation, the critical concern is the ability to contact individuals in certain organizations for the purpose of quickly organizing and conducting virtual teams and meetings. Products such as Lotus' Sametime and AOL's Instant Messenger provide instant notification of users that are on-line that another user wants to talk to them. Sametime takes notification a step further by phoning and/or paging the individual. The ideal collaboration system could conduct a desktop teleconferencing session by providing a set of virtual conference rooms that could be scheduled so that sessions could be conducted at an appointed time. Although users may be remotely located, their images could be projected onto a "virtual conference room table" during the session.

Internal and interagency staff members need to be able to brainstorm and exchange insight on task planning, and follow up on task progress to enhance timely completion. Integration of workflow tools would facilitate task tracking. Popular project management tools such as Mesa/Vista Project Manager and WebProject offer a variety of workflow tools. (Benett, pg 2)

Building, finding, and exchanging information across organizational boundaries require rapid, intelligent search tools that can look for keywords. Users would be able to define the context of a keyword or phrase. Implementation of metadata and RDF (the metadata framework that provides interoperability among applications for the exchange of

machine-understandable descriptions of resources on the web) will provide for better precision in resource discovery.

A proactive security system would protect the ideal collaborative environment from malicious codes or viruses, deny unauthorized access, and detect and disable intrusions before compromise occurs. Public Key Infrastructure can be leveraged to implement a digital signature system for accessing organizational applications, systems, data, and devices, which would also address problems such as I.P. spoofing, denial-of-service attacks, unauthorized participation in collaboration sessions, and intrusions that exploit operating system weaknesses.

While employing industry standards and commercial standards-based products is important for ensuring application and data interoperability, organizations must define their own standards to personalize systems and ensure system capabilities will enable users to meet previously-defined goals and objectives. However, collaboration tool features are constantly evolving, hence the need for consortiums that will continue to monitor and facilitate product development and interoperability standards.

D. DISCUSSION OF ENABLING TECHNOLOGIES

The enabling technology areas required for the development of a collaborative system architecture are:

- A distributed communications infrastructure,
- A core processing system, and
- A set of user applications

Figure 1 shows the collaborative system architecture along with three other supporting functional partitions: data interfaces management, user system interfaces, and system support services. This architecture can be repeated across n hardware systems, as necessary.

The user system interfaces provide the functions of :

- accepting data from a source and processing/formatting the data for presentation to a user, and
- accepting data from a user and processing/formatting it for presentation to a source.

(A “user” can be either human, or inanimate, such as an intelligent agent.)

Examples of user system interfaces include display system interfaces, imaging system interfaces, and audio system interfaces.

Different types of data from all components of the collaborative system architecture are managed by the data interfaces management component. This component also has the capability to manage and control all repositories of information and databases in use within participating organizations and seamlessly present them as one logical data system to users. Data interfaces management services include access and archive management, manipulation management, and composition management. Operating systems, memory managers, data buses, and system clocks are the system support (low level processing) services.

Applications such as COTS software tools, models, simulations, distributed white boards, VTC systems, or email are the resources needed by a user to perform tasks. The core processing system provides seamless integration of applications needed to support users.

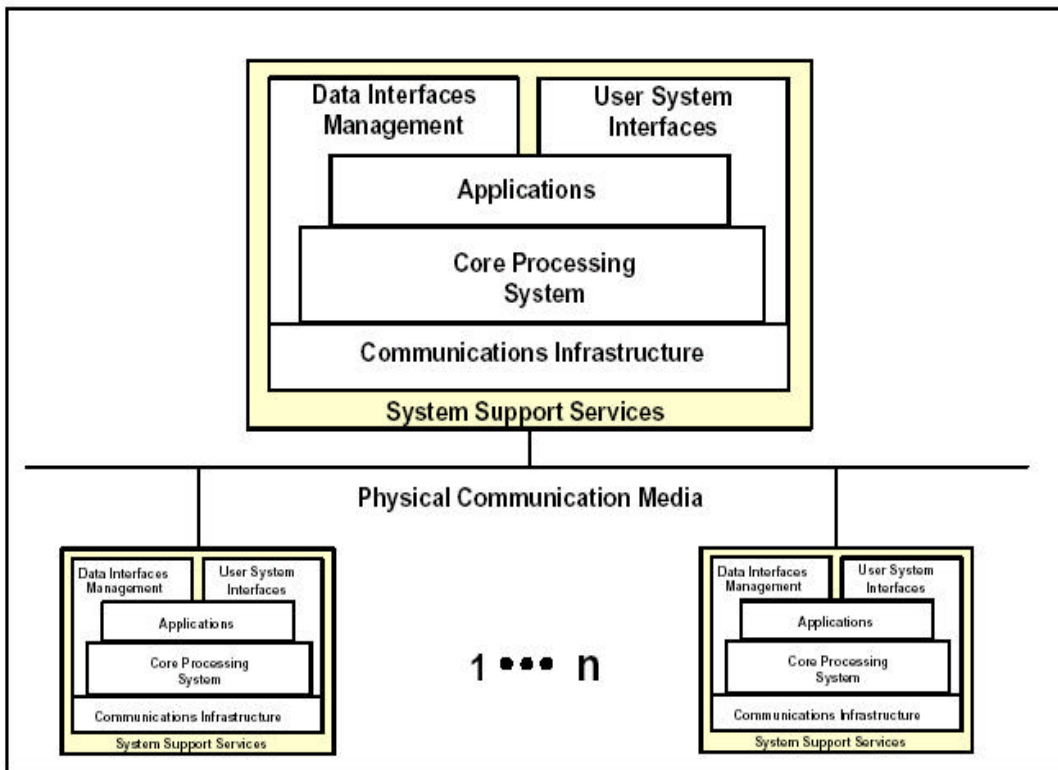


Figure 1: Enabling technologies for a collaborative system architecture (Sanders & McQuay, pg. 6)

The three functional areas of the core processing system are:

- applications support services that enable applications to be controlled and interfaced to the collaboration system
- common product and process object model management services that enable collaboration assets to function within a physical resource location, and
- collaboration infrastructure services that enable common collaboration models to function within and across physical resource locations.

The Communications infrastructure is the computer network. The network supports users in searching repositories for resources needed to conduct application processes or solve problems. Acquired mission-specific resources must then be configured into an executable process that can be started and stopped as needed. An additional task of networks is linking hardware and software together for data and information processing, to solve problems, and to execute applications.

E. EXAMPLE WEB-BASED INFORMATION ARCHITECTURE FOR PEACE OPERATIONS

The Web-Based Informational Architecture for Peace Operations should be served with a PC running Windows NT or a comparable operating system, with a Java/XML-based web server such as IBM WebSphere, and a database such as IBM DB2. Applications could include the Mesa/Vista (a web-based collaboration tool that utilizes Java, JavaScript, and XML technologies.) Mesa/Vista provides a horizontal service layer, on top of which the product supports integration with additional tools. Additionally, it acts as a rich services environment that understands a variety of vertical project applications called plug-ins. Although Mesa does not possess capabilities to generate Gantt charts, histograms, resource

leveling data, or budgetary estimate data, it can interoperate with a variety of project management tools such as Microsoft Project and Cayenne's Teamwork. Mesa can support email HTML publishing, and access control based on user profiles (Benett, pg. 2.) Embedded with Verity Inc's OEM software, it would also be able to read and index office document formats such as Microsoft Word. Another strong plus is LDAP directory services and a search engine.

Webproject is an alternative to Mesa/Vista. It has all-Java implementation, but provides distributed decision-making through its real-time chat, voting/survey application, email notifications, and threaded discussion groups. Additional capabilities include the ability to support virtual status meetings.

F. SUMMARY

Before establishing a Web-based Information Architecture for Peace Operations developers must establish data collection methods, exchange standards, metadata, and technological resource requirements. The "Ideal" collaborative environment must include asynchronous and synchronous collaboration capabilities, as well as capabilities that will enable users to rapidly locate personnel, organize and conduct virtual teams and meetings, provide information delivery to personnel, and provide sufficient security mechanisms. A collaborative system architecture includes a distributed communications infrastructure, core processing system, and a set of user applications.

Although a variety of applications exist to promote collaboration, the best solution is to apply different technologies as needed to accomplish specific goals. Technologies will

continue to evolve, and industry and organizational standards will be clarified, which will enable users to target mission-specific collaboration tools.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis identifies Web-based collaboration technologies, software architectures, and COTS software to promote information-sharing among civilian and military entities participating in Peace Operations through addressing the key thesis questions. Developing a Web-based information-sharing architecture is critical for peaceful resolution of armed conflicts and remove several of the root causes of international terrorism.

Sociologically, collaboration consists of three levels of cooperation. Level three is the highest, requiring teamwork to achieve a common goal. In a technical sense, asynchronous collaboration supports levels one and two, while synchronous collaboration supports level three. The success of stakeholder collaboration during Peace Operations depends heavily on participants' understanding of Peace Operations. The Conceptual Model of Peace Operations outlines the processes of peace operations and illustrates relationships among information bases, linkages, tasks, and organizations.

XML, RDF, I18N, and L10N are important concepts to implement in a web-based Peace Operation information-sharing network because these are enabling technologies and functionalities that will render information more meaningful to both stakeholders and computers. XML and RDF will add "Semantic Web" qualities to the collaboration system, while I18N and I10N will address differences in language requirements and local expectations that reflect our differences in cultures. Software with interfaces that let programs modify their behavior for operation in specific language environments will remain useful regardless of country, region, or language. WebDAV technology implemented in

Adobe Acrobat reader is just one of many examples of new technologies being paired with existing applications to automate and simplify a process such as document control and version management.

Before establishing a Web-based Information Architecture for Peace Operations developers must establish data collection methods, exchange standards, metadata, and technological resource requirements. The “Ideal” collaborative environment must include asynchronous and synchronous collaboration capabilities, as well as capabilities that will enable users to rapidly locate personnel, organize and conduct virtual teams and meetings, provide information delivery to personnel, and provide sufficient security mechanisms. A collaborative system architecture includes a distributed communications infrastructure, core processing system, and a set of user applications.

No single collaboration technology exists that will meet all of the needs of stakeholders in a Peacekeeping environment. Integrating enabling technologies for web authoring and document management with existing COTS collaboration software that provides email, group calendars, instant messaging, an electronic white board, audio/video conferencing, and chat rooms will provide the means for meeting many of the requirements to complete Peacekeeping tasks.

Merging XML and RDF technologies will facilitate further defining the meaning of and adding machine readability to existing information. To this end, developers may implement intelligent software agents in providing information needed for decision support. Internationalization and Localization techniques will further personalize and customize collaboration systems by making them language and locale-specific. Enabling

communication through language translation and respect for culturally-determined web aesthetics will encourage stakeholders to work together.

B. RECOMMENDATIONS FOR FUTURE WORK

Recommendations for future work include developing a prototype of the Web-Based Information Architecture for Peace Operations and implementing it into a Peacekeeping environment. Dealing with the organizational, social, and cultural aspects of implementing this system in a Peacekeeping setting may prove to be as great a challenge as the technical aspect. Further research of workflow systems (organizationally aware groupware that captures knowledge of the organizational activity) for possible implementation would help specify, execute, monitor, and coordinate the flow of work within the Peacekeeping environment.

The House of Representatives approved the development of a security-building program at the Naval Postgraduate School (NPS) in Monterey, California on December 19, 2001 at the request of Rep. Sam Farr (D-Carmel.) The NPS security building program benefits soldiers from nations that participate in peacekeeping missions, and military officers and civilians from nations that are rebuilding after long periods of conflict. Support for the program will enable the development of technologies such as the Web-based Information Architecture for Peace Operations that will strengthen security, support economic and political reconstruction of war-torn societies.

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LIST OF ACRONYMS

API	Application Programming Interface
CMPO	Conceptual Model of Peace Operations
COTS	Commercial Off the Shelf Software
CSS	Cascading Style Sheet
DC	Decentralized Cooperation
DOM	Document Object Model
DTD	Document Type Definition
FDF	Form Document format
HTML	Hyper Text Markup Language
I18N	Internationalization
L10N	Localization
NGO	Non-Governmental Organization
OS	Operating System
PDF	Portable Document Format
PVO	Private Volunteer Organization
RDF	Resource Definition Framework
SDK	Software Developer Kit
SGML	Standard Generalized Markup Language
SSL	Secure Socket Layer
UNHCR	United Nations High Commissioner for Refugees
VTC	Video Tele Conferencing
W3C	World Wide Web Consortium
WebDAV	Web-based Distributed Authoring and Versioning
XML	Extensible Markup Language
XP	Extreme Programming
XSL	Extensible Style Language

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