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Mission Oriented C^2: Command and Control Systems as Knowledge Systems

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Mission Oriented C^2:
Command and Control Systems as Knowledge Systems

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Abstract

This article explores a new approach for developing command and control systems suited for the information age: a mission oriented approach. The article will present a method of solving the information overflow problem burdening commanders in the battlefield. A mission oriented system contains the operational knowledge as a collection of missions; each mission displays all information relevant to the mission, presented in stages, thus allowing the user to advance along the mission. By presenting the information in the context of a mission, the commander will get only the information needed to complete his operational tasks.

A mission oriented system will provide a framework in which distributed forces around the battlespace could build a common situation picture. The common situation picture is built jointly all through the mission and is updated constantly by the users who share the mission. This is the common language shared by the mission participants; on its basis, they will manage reality in a synchronized fashion.

C^2 systems development established around the idea of the mission will allow C^2 systems to focus on the knowledge the users need instead of focusing on managing the information the systems have.

1 Introduction

1.1 Purpose

This article explores a new approach for developing command and control systems suited for the information age: a mission[1] oriented approach. The article demonstrates the benefits of this approach and its implications in C^2 systems development.

The article is organized as follows:

The first chapter sets the article's purpose and defines a short terminology. The second chapter describes the way information technology revolutionizes our world. The third chapter relates the information overflow problem to the operational world and lays the foundation for a knowledge oriented solution. Chapter 4 defines what a mission oriented C^2 system is and elaborates on the characteristics of such a system. Chapter 5 comprises of conclusion remarks.

1.2 Terminology

Function – A logical entity that defines a role in the system, which the user of the system can fulfill.

IT (Information Technology) – An area of computer science that deals with the management and processing of data.

Operational State – Characterizes the type of activity being executed by an operational unit.

Web Services – A software component that exposes its functionality through standard Internet protocols.

Infostructure – A collection of components and systems that provide all entities in the organization with high quality information services.

2 Turning Information into Knowledge

2.1 The Information Age and the Problem of Information Overflow

Latest advances in communications and information technology, as well as the ability of individuals and organizations to exploit the possibilities provided by the great advances in these technologies changes the ways of our life.

We live in a new era; the Information Age. Information changes the way people accumulate wealth, modifies the way power is distributed, generates exponentially growing levels of data and increases the tempo of our lives.

We wish to point out two of the main changes brought upon us by the information age[2]:

- From industrial to specialized manufacturing – the assembly line of the industrial age has been replaced by the highly segmented market of "tailor-made" products. An example of this trend are the newspapers of the past compared to the CNN news site, which offers news according to one's personal preferences.
- Break of professional hierarchies – in contrast to the industrial age where low-levels managers usually controlled all the professional information held by their employees, managers in the information age cannot usually grasp all the information needed by their subordinates. This has led to the development of new management methodologies, emphasizing enterprise vision as an alternative method to business leadership.

2.2 Information Overflow

New information technologies enable people to act in the information domain in magnitudes never seen before. This is evident in the dimensions of time and capacity: the time to gather information needed for a certain decision has shortened noticeably. At the same time the quantities of information that can be gathered in that short period of time have grown much greater than what has been possible in the past.

The building block of the information age is data: a collection of facts, measurements, observations, etc. Information is the product of fusing data together and putting it in a specific context. The large quantities of easily available information have created a problem of information overflow. Today's information consumer is busier with sorting irrelevant information than in locating new information resources. An example can be taken from Internet search engines, which try to retrieve relevant search information using various technologies[3]. The need to cope with the problem of information overflow has created a new products market – Knowledge Services.

2.3 Knowledge Services

Knowledge is a model of reality, based on information known about that reality. The knowledge consumer uses it to control and manipulate reality. One example of a knowledge service is consumer sites on the Internet[4], which gather product information from many commercial sites and present it to the potential consumer in a way that helps to carry out a purchase. The consumer can find a variety of services, beginning with lists of existing models of the requested product, through price

comparison and articles discussing the properties of different models, and ending with the actual acquisition process taking place in the chosen commercial site. The knowledge is embodied in the model created: which information should be presented to the consumer in order to help achieving the intended goals and in which context should it be provided. Knowledge services focus on the service required by the user and not on the information; as a result, the user is relieved from the task of sorting large masses of irrelevant information and can focus on getting the services desired.

3 Information Overflow in the Operational World

3.1 Information Oriented C^2 Systems

The problem of information overflow, which exists in the world of business, is valid in the operational world as well. Infostructure in the information age will ensure unbounded availability of information to all participating forces within the battlespace. That stands in contradiction to previous state, where information flow was restricted (sometimes on purpose) and highly interconnected with the hierarchy of command.

Information flow does not promise an improvement in C^2 capabilities. What is necessary for efficiently functioning command and control is not the amount of information gathered, but rather key information components available on demand and provided to decision makers in a usable form[5].

Command and control systems built today do not solve the information overflow problem; instead, they focus on the information they manage. The main function of such systems is data storing and maintenance of its integrity and coherence. These kind of systems have substituted the manual record archives and communication systems employed before the computer era. The functionality, the graphical interface, and human engineering all follow the data structure of the system.

Targets management systems are examples of such systems. They enabled the user to enter target data, to retrieve existing targets with different queries, and to update the data of a specific target. The system does not include the knowledge needed to accomplish the mission of target destruction. The user has to pick the suitable targets by himself, find the relevant shooters and allocate targets for them. The knowledge regarding the methodology of how to accomplish the mission is user oriented and not system oriented.

Information Oriented Systems are tools to manage data; the knowledge of how to use these tools to achieve the user's goal lies within the user.

3.2 Knowledge Oriented C^2 Systems

One must find a solution to battlespace information overflow, in a similar way to the one chosen in the business world: building operational knowledge services. Let us start by defining what a service is:

A Service[6] is a software component that:

a. Exposes functionality while hiding its internal information sources. The information sources can be varied (databases, web serves, mail servers etc.) and physically distributed in the network.

b. Can be accessed from anywhere in the organization.

A knowledge service is a service that provides a model of reality and functionality that enables the user to manage and change that reality.

An example of an operational knowledge service can be the "communication device maintenance" service (this service does not yet exist, but could have come in

handy in a few cases in the past). This is a software component which supplies the actions needed to prepare the device for use – how to recognize a problem, what is the best way to fix it and where can one find the needed parts for the repair process. The service will provide a "make an order" function that allows the user to order parts directly from the unit's logistics center. The service will include graphics and animation to guide the user in each step of the process. It will also supply access to information related to the device: training and technical literature, an FAQ file, and the discussion group "How to fix a two-way radio transceiver with your hands tied behind your back…".

An operational knowledge service will use the organizational infostructure in two ways:

- As an access protocol, allowing users and other services to access the knowledge service, from anywhere in the organization.
- As a unified access point to the data needed by the knowledge service, disregarding the varied information sources distributed over the network.

An operational knowledge oriented system is built upon a collection of operational knowledge services tailored for the needs of certain users. Like the business world, operational knowledge systems present information in a certain context. While in the business domain, the context is the business process; here in the operational domain, the context is the mission.

A knowledge oriented system is a tool for managing the user's operational goals; the knowledge of how to achieve these goals lies within the system.

4 Mission Oriented C^2 Systems

4.1 Definition

A mission is the context of a certain operational process. This context represents the knowledge present about the operational process.

The description of the mission answers the questions of what decisions and actions are expected to be taken by the user at any phase during the operation, which information should be presented in order to help achieve the mission and in what context should this information be presented. The mission enables the user to build a knowledge model, which reflects reality, and is the means to manipulate reality.

A mission oriented system is a collection of missions. Each mission changes the state of the system: only information and operations relevant to the mission should be presented. The role of the system is to lead the user along the mission, at each phase presenting just the information needed to achieve that phase and to move on to the next.

To better understand how a mission oriented system serves a needed function in the battlespace we will demonstrate the work of an intelligence officer using a mission oriented target attack system to perform a "targets allocation" mission.

First, we present the phases the intelligence officer follows when executing the mission:

a. Objectives plan phase – review the attack plan and determine which objectives are to be obtained.

b. Targets filtering phase – for each objective, retrieve all targets in the chosen objective perimeter.

c. Blue forces shooters filtering phase – retrieve all blue forces having firing range on these targets.

d. Allocation phase – for each target, match an attacking force considering the following: proximity, target type, attacking force's means and ammunition.

The intelligence officer is working with a C^2 mission oriented system. Figure 1 illustrates a mission oriented C^2 system, which includes a "mission container" – a collection of all missions the user can operate. The user chooses the "targets allocation" mission from the mission container and in response, the system changes to "targets allocation" mode.

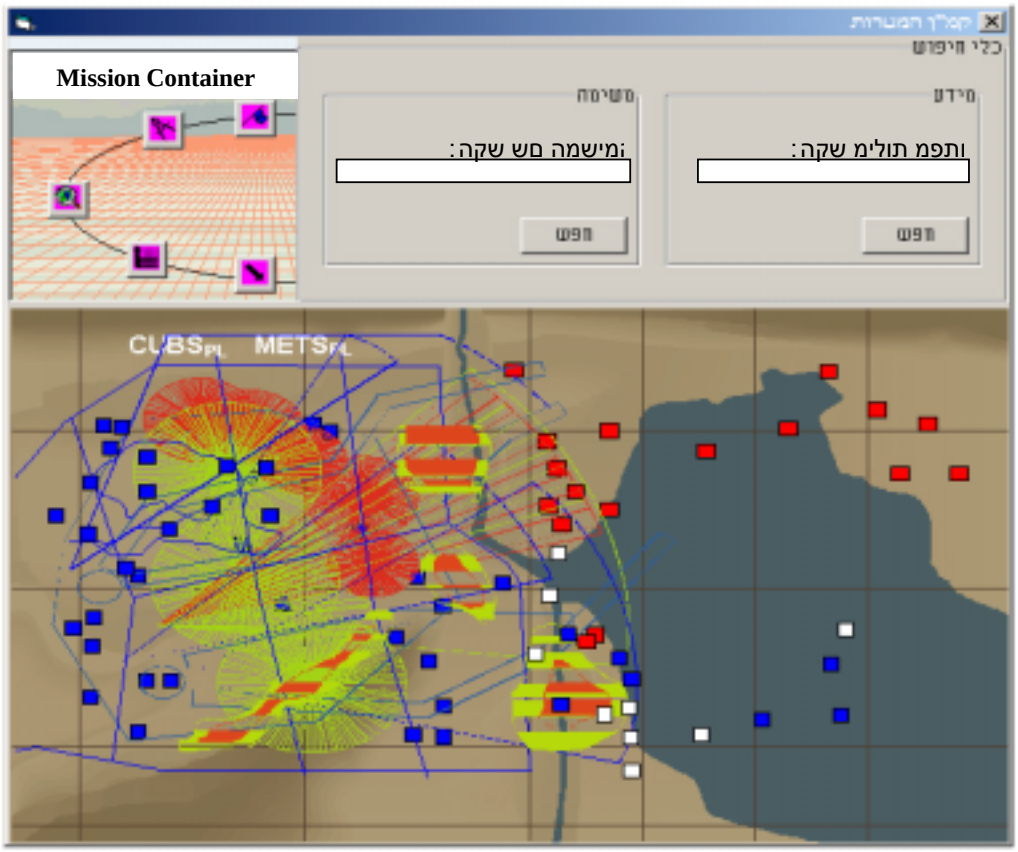

Figure 1 – A Mission Oriented C^2 System

In this mode, the mission's knowledge model is presented to the intelligence officer. The model will include all information relevant to the mission, presented in stages, thus allowing to advance along the mission. In each stage, the information is presented in the appropriate context:

- Objectives plan stage – the system presents the relevant objectives, significant to the current stage of the battle. The system allows to see properties of each objective (including the objective's required goals and the current assessment of reaching these goals) and to choose the objectives required to continue and work upon.
- Targets filtering stage – the system presents targets that need immediate attention in the objective's perimeter. The system allows viewing the properties of the target (including the enemy forces occupying the target, target exact location and the last update time of the target's information).
- Blue force shooters filtering stage – the system presents the blue forces operational picture, suggesting only forces relevant to the targets selected in the previous stage. The system allows viewing force properties (such as the exact location, fitness, weapons, and current ammunition status).

- Allocation stage – the user can match blue forces from the previous stage with their attack targets. The generated model is used as the basic model for the actual attack preformed by the blue forces enabling to close the "Fire Cycle" with the blue force shooter selected.

The user can traverse the different stages of the mission at any given moment. The order between the stages of the mission is flexible and the system allows the user to operate in the manner chosen. Nonetheless, the system defines a clear outline of the mission so that the knowledge about this mission is embedded in the system.

User interface engineering in a mission oriented system surrounds the user's missions. The system options are organized in accordance with the operational needs. Choosing a mission causes the system to display just the information needed to complete the mission. In addition, the system will allow the user to retrieve more required information. A mission oriented system solves the information overflow problem by focusing on the user's interests and not on the data managed by the system.

The collection of missions offered by the system is derived from the user's function and the operational state. Thus, the combination of function/operational state established the specific missions offered by the system, and these are the missions available to the user with the system's startup. The system will also include tools for discovering missions available on the network, missions that were not pre defined for this specific function/operational state combination.

A mission oriented system contains the operational knowledge as a collection of missions; each mission presents to the user the information needed to accomplish the mission.

4.2 The Mission as a Shared Awareness Framework

A mission does not stand on its own. The "targets allocation" mission we analyzed in the previous section concerns more users then only the intelligence officer. There are artillery officers in charge of supporting fires, logistics officers in charge of re-supplying the shooter units, surveillance officers in charge of gathering the needed information etc. We have to analyze the concept of the mission in a wider context and in separation from the needs of a single user.

A mission can be shared by many users. In the course of a mission, a picture of reality is created. This situation picture reflects the decisions made by the users about actions taken to accomplish their operational goal. The situation picture presents a model of reality: the data relevant to the mission and the relationships between these pieces of data.

The situation picture generated is shared by the relevant users. The picture is built jointly all through the mission and is updated constantly by the users who share the mission. This is the common language shared by the mission participants. This way a common awareness is achieved and shared among the participants.

For example, the mission oriented target attack system we discussed in the previous section will be installed on systems on all forces across the battlespace. Figure 2 illustrates a mission oriented C^2 system, which includes a "participation card" as part of the mission. This card lists all users involved in performing the

mission. Each user can see if the other users are on-line with the mission looking at the V mark on the "participation card". Each user can view the picture seen by the other users by choosing him from the list.

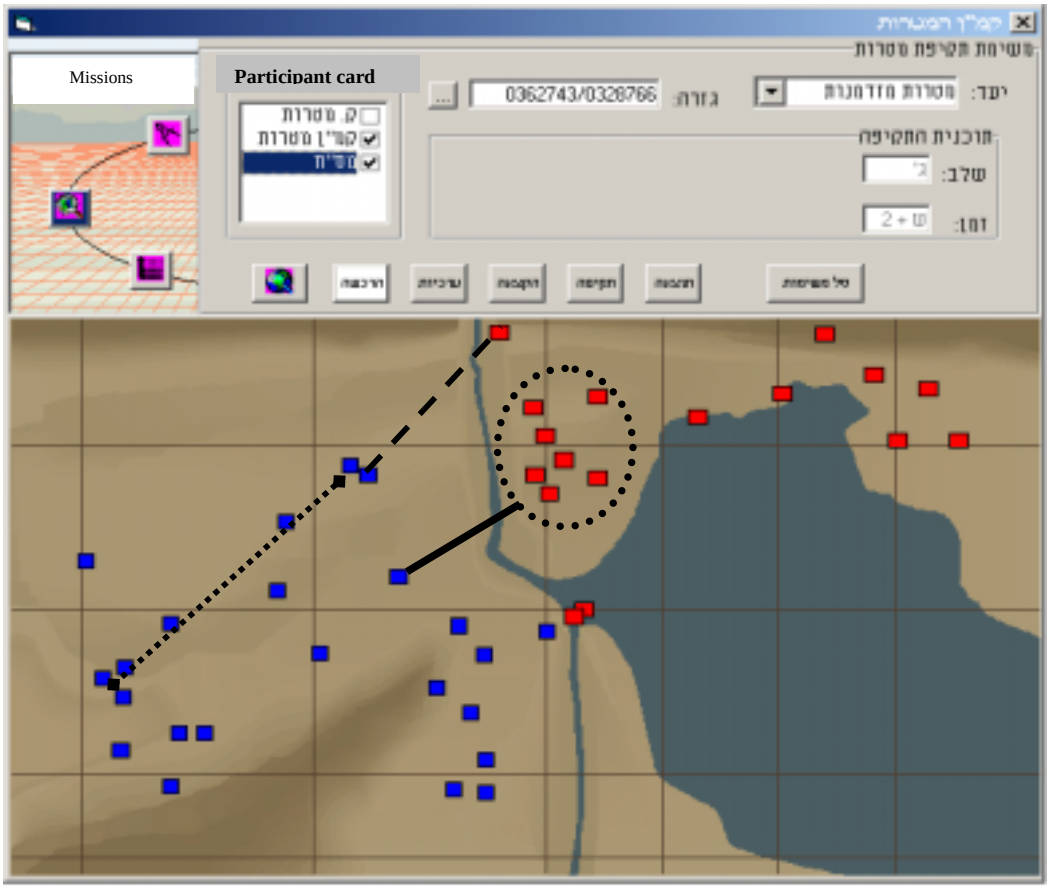

Figure 2 – A Mission Oriented C^2 System showing a "participation card"

Working the mission together, the system will present the intelligence officer user with quality targets, marking a target for attack will pop an "Attack Request" at the relevant blue shooter's system. The completion of the "Fire Cycle" will be executed in parallel on all the participating forces systems – Executing the mission in a synchronized way between all relevant forces in the battlespace.

A mission oriented system will include virtual collaboration tools for managing the mission. Each of the participating forces will change the parameters of the knowledge model that are under his responsibility, the system will present the effect of the change on the model to all other participants in the mission. The activity of each force in the mission will bring, in the end, a stable and agreed common model of reality.

A mission oriented system allows the participants to manage reality through the common model built in the framework of the mission. The mission also creates an association between the planning and execution processes. The situation picture built in the framework of the mission is on the one hand the situation estimate and planning

tool and on the other hand, the execution models through which forces are controlled. The result will be an integrated process for planning and execution[7].

Managing reality based on a common picture, shared by forces around the battlespace will allow forces to act in a synchronized fashion in order to complete their mission, even outside the sturdy framework of detailed orders and inflexible hierarchy. These forces are self-synchronizing forces, acting to complete the mission on the basis of the shared awareness achieved between them.

A mission oriented C^2 system will provide a framework in which distributed forces around the battlespace could build a common situation picture; on its basis, they will manage the reality in a synchronized fashion.

4.3 Characteristics of a Mission Oriented C^2 System

A mission oriented system will be composed from a set of services; each service embodies the knowledge of a certain operational mission. The system will exist in a networked environment and will rely on the services of the infostructure for an undisrupted flow of information.

4.3.1 Composed from a set of services

A mission oriented system will be built from a collection of services working together to satisfy the user's needs. The different services are loosely coupled so that the development process of such a system can be a plug & play production.

The ability to build a system from a collection of services will enable procurement techniques balancing in-house development and outsourcing. Selecting the correct services for a certain user and connecting these services between them will be the way to "tailor-make" a system suitable for a specific user[8].

4.3.2 Embodies operational knowledge

A mission oriented system embodies the operational knowledge. Each mission creates a certain model of reality:

- The mission presents information in a certain context with the intention of creating a certain image of reality. This image serves the user trying to manage and manipulate reality through the mission. For example, an intelligence officer picking targets to be destroyed in an objective will only receive information about targets in the perimeter of the objective.
- The mission presents the inner connections of entities within the model. For example, allocating targets to a blue shooter will show the expected shortage in ammunition.
- The mission enables the user to control reality through the model. For example, activating EW devices from the "targets allocation" model discussed earlier.

The quality of the knowledge model is depended upon:

- Uninterrupted flow of information. The more information (crude data, processed information, etc.) made available to the mission the more

accurate model of reality will be built by the system. The infostructure is responsible for maintaining an uninterrupted flow of information answering the mission needs.

- Formulization of operational knowledge. A better analysis of the mission will yield a more accurate model, representing the operational knowledge and allowing the user to better manage and change reality. An analysis of a mission includes operational functions involved in the mission, the interaction between these functions, and the information needed for each function to complete its task as part of the mission. Take notice that the mission analysis should take into consideration the new capabilities of the information age. These capabilities represent new operational opportunities not always visible to the operational analyst.

4.3.3 Networked

A mission oriented system is a distributed system deployed upon a network infrastructure (the infostructure). The following characteristics can be observed for a networked system:

- Accessible anywhere. A mission oriented system exposes its missions to activation from anywhere on the network. For example, a platoon commander can access the "communication device maintenance" service from the field helping him to repair a broken down communication device on the battlefield. This allows us to replace mass with information: instead of sending a technician to the field, we have virtually copied his knowledge into the network making it accessible wherever needed.
- The mission consumers are unknown in advance. Since the mission is accessible through the net then the consumers of the mission, their quantities, and the nature of their usage are unknown beforehand. Moreover, another mission can act as a consumer as well. These facts force us to build missions as highly reliable components, dealing with issues like: load balancing, unexpected input and exception handling, quality of service, etc.[9]
- Virtual collaboration and shared awareness. The accessibility of the mission from the network allows users to collaborate in building a knowledge model. A mission oriented system will include tools that enable users to work on the same information without disrupting each other's work. These tools will allow a group of users to view a knowledge model, each seeing a representation of the model with only the details he needs. All other users of the model will observe every change made in the model by one of the users.

4.3.4 Infostructure based

A mission oriented system relies on the infostructure to receive the following services:

- Uninterrupted information flow. As mentioned in the previous section the quality of the knowledge model depends (among others) on the information it is based upon. Systems built upon the infostructure will only state the information they need. The infostructure will take the responsibility of bringing the needed information to the system, and keep that information up to date.
- Hiding information resources. Information resources needed by a mission oriented system are varied (databases, web servers, mail servers, etc.) and are distributed throughout the network. The infostructure will hide the details of gathering the information from the different resources. The system built upon the infostructure will only have to state the needed information, without mentioning its source or location. The infostructure will find the relevant resources, gather up the information, and disseminate it to the consuming system.
- Hiding information consumers. Every system is also a producer of information. The consumers of that information can be many and varied, and can change dynamically. Systems producing information should not be concerned with who the consumers of that information are. The infostructure will be responsible for taking the information from the producing system to the consumers.

5 Conclusions

5.1 Summary

This article presents a mission oriented approach to building C^2 systems as knowledge systems. A mission oriented system contains the operational knowledge as a collection of missions; each mission presents to the user whatever information is required to accomplish the mission.

Accomplishing a mission is an integrated effort by a group of operational users. A mission oriented C^2 system provides a framework in which distributed forces around the battlespace could build a common situation picture; on its basis, they will manage the reality in a synchronized fashion.

Managing reality based on a common operational picture, shared by forces around the battlespace, will allow forces to act in a synchronized fashion in order to complete their mission, even outside the sturdy framework of detailed orders and inflexible hierarchy.

These self-synchronizing forces, acting to complete the mission based on shared awareness achieved between them are the answer to information age challenges.

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[1] The terminology of "mission" borrows from the idea of "Mission Oriented Command" (AUFTRAGSTAKTIK). "Mission Oriented Command" is a philosophy of command, which highlights distributing command authority to the lower levels of command. The military leader informs in his orders only the "What" of the mission, the details and knowledge of the "How" is left in the hands of his subordinates.

Tazpit (Issue no. 21) – Issues in command and control (Tel-Aviv: Ministry of Defense Publishing), 16-26.

[2] See: Toffler Alvin, *War and Anti-War – making sense of today's global chaos* (U.S.: Warner Books, 1995) for a discussion of the profound change of the information age.

[3] For example, the Google search engine uses matrix multiplication to find web pages with the most links and returns them as most relevant for the search. http://www.google.com/technology/.

[4] For example, http://www.shopping.com. Note that this site provides knowledge services (price comparison, on-line store selection etc.) as well as information infrastructure services (serves as an information base for other consumer sites, like: http://www.epinions.com).

[5] *Command and Control, MCDP-6* (Washington, D.C.: Department of the Navy, HQ US Marine Corps, 1996), 33-60.

[6] The latest advances in this area are Web Services.

See: http://msdn.microsoft.com/webservices/understanding/ for Microsoft's version of component oriented development.

See: http://www.sun.com/sunone/wp-arch for Sun's vision of the Web Service world.

See: http://www-106.ibm.com/developerworks/webservices for IBM's way of thinking on the matter.

[7] See: Alberts S. David, *Network Centric Warfare* (Washington D.C.: CCRP Publications, 1999), 157-186.

[8]See: Szyperski Clemens, *Component Software – beyond object orientedprogramming* (London: ACM Press, 1999, pp 5-6) for a discussion on the concept of Component Assembly.

[9] See: Kirtland Mary, *A Platform for Web Services* (Microsoft Developer Network, 2001).