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The Crisis and Opportunity of Information War

A Monograph
by

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ABSTRACT

THE CRISIS AND OPPORTUNITY OF INFORMATION WAR by MAJ Kevin B. Smith, USA, 40 pages.

This monograph focuses on the possibility of defeating any and all enemies with an information-intensive force. Clearly, no one currently possesses this capability. However, in the intermediate and long-term, such a force may be within the reach of any post-industrial nation. This monograph explores why this is so, and identifies the major technological 'benchmarks' that must be achieved in order to enable a purely third wave force.

Starting with the agrarian notion of the center of gravity, and continuing to the concepts of industrial systems, this monograph will briefly analyze the theories of each of the two preceding 'waves' to determine potential loci of decision.

The monograph describes how information systems are starting to form around discrete technological benchmarks that, when eventually integrated, will form a 'knowledge engine' powerful enough to enable commanders to locate and attack the systemic weak point(s) of any enemy. Where possible, case studies will be used to show how this information technology is being used today. Each case study will contain reasonable estimates on where the particular technology involved is trending.

The monograph then applies the prototypical third wave knowledge engine against the potential vulnerabilities found in both agrarian and industrial armies.

The monograph reaches two conclusions. The first is that rudimentary forms of the third wave knowledge engine already exist and are in use. Further, it appears that research being conducted now by a variety of civilian and governmental agencies will greatly enhance the performance of these engines over the near term. Second, it is very likely that major obstacles to the full implementation of these information systems will come from within the Army itself.

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SECTION ONE

INTRODUCTION

Alvin and Heidi Toffler's recent book, War and Anti War, poses a dilemma for any army aspiring to a third wave (post-industrial) status. To be effective across the spectrum of conflict, Toffler's third wave army may have to defeat any one, or a combination of, three types of opponents: an army raised from an agrarian culture, an army raised from an industrial culture, or an army raised from an information culture. Some believe that a post-industrial force must retain the ability to defeat each of these three types of enemies in a symmetrical fashion, that is, to retain a light infantry force for counter-insurgency, a heavy industrialized force for major land warfare, and an information-intensive force to execute the tenets of the Military-Technological Revolution.

This monograph focuses on the possibility of another option -- that of defeating any and all enemies with an information-intensive force. Clearly, no one currently possesses this capability. However, in the intermediate and long-term, such a force may be within the reach of any post-industrial nation. This monograph explores why this is so, and identifies the major technological 'benchmarks' that must be achieved in order to enable a purely third wave force.

Primary and Secondary Research Questions

The primary research question addressed in this monograph is "What would allow Toffler's 'Third Wave' army to defeat any opponent?" This line of inquiry requires the monograph to address two secondary questions as well: "How are first and second wave opponents defeated?" and "What are the components of a third wave army that must exist in order to achieve the required decisive effect on first and second wave opponents?"

Assumptions

This monograph makes several explicit assumptions. First, that data processing technology will continue to improve over time. Second, we assume that information, by itself, can do very little. Information must be applied by either man or machine to be successful. We assume, however, that with better information, fewer men or machines will be required to perform the same task.

Limitations

This monograph is limited by the number and detail of case studies possible within the length. Additionally, information about the current existence and uses of third wave 'knowledge engines' has not received proper academic attention.

Delimitations

This monograph is concerned with only a small piece of the realm most appropriately called information war theory. It is specifically focused on the major trends seen in decision support systems at the operational and strategic levels of war. Other portions of information war such as targeting, media, or psychological operations will be addressed, but only as a product of the decision support system. Additionally, the monograph avoids treatment of classified topics, and relies completely on open source documents.

Methodology

The length of the monograph prevents the application of the pure clinical method in answering either the primary or secondary questions. An abbreviated clinical method will be employed with the use of a limited number of case studies. Although this methodology has inherent flaws in the subjectivity of case study selection, the analysis and derived conclusions will hopefully have a broader application and impact upon future theories of decision support and information war.

Starting with the western agrarian notion of the center of gravity, and continuing to the concepts of industrial systems, this monograph will briefly analyze the primary sources of power for both agrarian and industrial armies. Theoretical constructs of center of gravity and systems architecture will allow a discussion of those elements most vulnerable to attack by a third wave 'knowledge engine.'

The 'knowledge engine' envisioned by this monograph is a consolidation of several data-processing technologies: first, a large number of storage sites for information in the form of digital data bases or text; second, a data transmission network that connects these information storage sites; third, an advanced form of search and retrieval software that can locate relevant electronic data and return it to a central location; finally, a collection of expert system and artificial intelligence routines that will make sense out of the retrieved data.

The monograph will then examine several case studies and open-source literature to identify the primary technological trends that will eventually enable the creation of a decisive knowledge engine. This third section will describe how information systems are starting to form around discrete technological benchmarks that, when eventually integrated, will form a 'knowledge engine' powerful enough to enable commanders to locate and attack the systemic weak point(s) of any enemy, and conclude with a description of the most probable form of a future knowledge engine.

The fourth section will apply the prototypical third wave knowledge engine against the potential vulnerabilities found in both agrarian and industrial armies. This analysis will serve to answer the primary research question.

The initial research indicates two conclusions. The first is that rudimentary forms of the third wave knowledge engine already exist and are in use. Further, it appears that research being conducted now by a variety of civilian and governmental agencies will greatly enhance the performance of these engines over the near term. Second, it is very likely that major obstacles to the full implementation of these information systems will come from within the Army itself.

SECTION TWO

THE AGRARIAN, INDUSTRIAL, AND INFORMATION ERAS

Introduction

This section explores the close relationship between a society and the armed force it is able to produce. A number of conceptual frameworks are available for this analysis, including Walt W. Rostow's The Stages of Economic Growth,[1] and Zbigniew Brzezinski's Between Two Ages.[2] For the purposes of this monograph, however, the framework for analysis consists mainly of the three types of societies and their corresponding militaries noted in Alvin and Heidi Toffler's War and Anti-War.[3]

The Agrarian Society and Military

The agrarian society is predominately based on technology that predates Newtonian science. Economic output, and the corresponding quality of life within an agrarian society rises and falls with the seasonal output.[4] Usually, however, an upper limit exists on the arable acreage and the output per acre, based purely on the level of technology available.[5] Any change is excruciatingly slow -- new technology from other economies, designed to increase output, usually fails to take hold because of a fundamental lack of technical understanding required to maintain it. The means of production, preservation, and distribution of goods is a local effort, and tends to isolate social structures within a family, or hamlet orientation.[6] Illiteracy rates are high: information flow is limited, since transfer is by word of mouth, and storage of information is in the collective social memory. The agrarian society, while backward technologically, is often finely developed in the social and political sense -- with deeply held religious beliefs, extensive rules on behavior, relationships between people, between people and government, the use of force and conflict resolution. Individual worth is often gauged by the degree of harmony one can reach with one's surroundings. Because of the compartmentalization and independence of the agrarian society, central government is never on a firm footing.[7] Agrarian societies (and religions) often see the temporal dimension as circular, characterized by repetitious seasonal periods.

Wars fought by agrarian societies are quite often value-based conflicts, fought with simple technology.[8] A central government may purchase complicated weapons on the international market, but the populace can neither maintain them, nor use them effectively. Put simply, the source of an agrarian society's strength lies within the realm of people. Agrarian societies often store information in the collective social memory through memorization of stories or songs passed down from generation to generation. For this reason, wars can often last for decades, or even centuries.[9] Instead of the industrialized or Western notion of rational thought concerning conflict -- particularly the balance of the political objective with the ways and means available -- one often finds decisions made by tradition, or even mysticism. Agrarian wars can be marked by an absence of a recognized set of rules, and thus pose a problem for the opponent societies. An industrial or post industrial army often refers to conflict involving agrarian societies as 'low-intensity' conflict, while not fully realizing that it is the highest form of war available to the agrarian society.

The Industrial Society and Military

As a general rule, the primary force behind an industrial society is economic progress. The structures of societal values, politics, and economics are transformed to sustain the primary force of economic growth. Technology is exploited, infrastructure investment increases, and the central government becomes stronger. Formalization of institutions (church, legal, financial, etc.) provides an industrial society with homogeneity and structure.[10] Information flow and the collective memory is characterized largely by books stored in libraries. Individual worth is often proportional to the degree of control one can impose on one's surroundings. The concept of compound interest becomes ingrained into habits and institutions. Modernization of the economy is considered a serious, high-order political business. Modern technology is extended across the economic activity and, in every aspect, the strength of an industrial society lies in its ability to construct, maintain and use machines to extend man's effort. The growing industrial society finds a stable place in the international economy.

The wars of industrial societies often take the form of interest-based conflict -- the acquisition of larger markets, land mass, or resources. Industrial societies make war in an industrial fashion, consisting of mass-mobilization, mass training, mass production, the application of massive force, and the existence of 'rules' of war.[11] Industrial wars are usually shorter -- quicker to terminate and resolve -- especially when the war begins to threaten the overriding goal of economic growth.

The Information Society and Military

The primary force behind the emerging post-industrial society is its ability to use information effectively.[12] While the industrial society extended man's effort through the brutish use of mass-produced machines, the post-industrial society extends and refines the use of specialized machines through increased knowledge.[13] The post-industrial society is characterized by electronic information flow and manipulation in its many forms, but primarily through the computer chip. Information and collective memory is stored in massive electronic archives, and this data moves across vast networks to be fused into new information. Individual worth is measured in how easily one can access and fuse on-line information into knowledge.[14] Industrial-era societal structures begin a still ill-defined transition into newer structures designed to support the flow of information and creation of knowledge. Normal industry remains important, but the emphasis has shifted from mass production of crude machines into specialized production of task-specific 'intelligent' machines.[15]

Post-industrial wars are characterized by the extensive use of information to identify key targets in a system, and their subsequent destruction or disruption by precise means.[16] Post-industrial militaries must also deal with the political and social phenomena caused by a near-instantaneous media that enjoys the same level of information technology as the military.[17]

	Agrarian War Locus of Decision = People	Industrial War Locus of Decision = Machines	Information War Locus of Decision=Info
Large Army	-Single Crushing Battle -Mass for Effect	- Industry Prerequisite - Manpower Mobilization - Size and Durability	- Information Replaces Brute Force - Effect without Mass
Close Combat	- Prerequisite for Victory - 1st Order Effects	- Other Loci of Decision Appear strat bombing, etc.	- Multiple Loci of Decision - Precision Strike - Non-Lethal
Role of Commander	- Lead by Personal Example - Sees Entire Battle	- Resource Manager - Sees Through Staff	- Central Electronic Location - Information Manager - Media Manager
Role of Individual	- Mass of Individual Combats - Unit of Work	- Man's Effort Extended by Machine - Machine is now Unit of Work	- Machine Effort Extended by Information - Information is Unit of Work
"Coin of the Realm"	- Muscle	- Mechanization	- Computerization

Table 1. Characteristics of 1st, 2nd, and 3rd Wave Warfare

Combinations. The three societies above are archetypal in nature. In real life, each society exhibits a variable mix of two or more of the cultural and war-fighting models mentioned above. The U.S. Military, for instance, currently exhibits characteristics from both industrial and post-industrial societal models.

This three-tiered societal model allows us to analyze the strengths and weaknesses of each society. The next section develops the idea of the third wave 'knowledge engine,' which will be theoretically applied to the weaknesses of each society in order to assess its potential as a war-fighting tool.

SECTION THREE
CREATING THE THIRD WAVE
KNOWLEDGE ENGINE

Introduction

Compare the nature of technical information twenty-five years ago with what we see today. In 1967 Don Fabun, author of The Dynamics of Change, noted that ". . .the amount of technical information available doubles every ten years; throughout the world, about 100,000 journals are published in more than 60 languages, and the number doubles every 15 years."[18] In this era of written, paper data, anyone attempting to wade through the available information was faced with a series of challenges. First and foremost, the researcher previously had to have access to a library - a repository of paper data. Next, in order to deal with the mass of data, the researcher had to ". . .develop methods which sort the data and hopefully highlight the information that is relevant to a particular problem or decision at hand."[19] Obviously, both the mass of data and the time available to researcher had a tremendous impact on the quality of the research.

By 1987, the problems associated with basic research had fundamentally changed. Paper text was still being published, but more and more, the media of choice was electronic. The number of articles, manuscripts, journals, and technical reports available electronically had reached 1.7 billion, and were increasing by an order of magnitude every decade.[20]

Emerging Third-Wave Knowledge-Engines

An argument might be crafted to suggest that we will never get this burgeoning mass of information under control. However, as the following case studies and other evidence in this section will explore, tools to manage this sea of information were crafted as early as the 1970's, and the tools under construction now will make those that came before them pale by comparison. Many of these tools were and continue to be constructed by the federal government, and they all share certain common elements -- data storage, data transmission, data mining, and synthetic tools to make the data more understandable.

NASA and MTPE

Over the next few years, NASA will launch nineteen Mission to Planet Earth (MTPE) satellites to study every square inch of the earth's surface with a wide variety of sensors. When operational, the MTPE system will generate the equivalent of 27 million books every ten days.[21]

To put this in perspective with our 1967 researcher mentioned above, 27 million books is the current holdings of the Library of Congress. When complete, the mission will have archived over 10 petabytes (10^{16}) of data, roughly equal to 10 billion books (370 Libraries of Congress).[22] And this is only one data collection system out of hundreds with potential military use.

In order to handle this huge volume of data, NASA commissioned the design and construction of a data management system that will allow geophysicists to

> . . . go on expeditions for correlations between various sets of data, without knowing in advance what they might find. The computer uses 570 Intel reduced instruction set microprocessors yoked together.[23]

The company contracted to produce NASA's knowledge engine contributes the success of the program to the ever-decreasing costs of processing.

The Department of Justice's PROMIS

Early in the 1970's, the Justice Department funded a project to develop computer tools to manage legal cases stored in a variety of electronic data bases across the country. Around 1975, the Justice Department selected one program, called Prosecutor's Management and Information System (PROMIS), to continue into full-scale development. PROMIS allowed the Justice department to examine each case by ". .

.defendant, arresting officer, judge, defense lawyer . . ." or by any other name or place mentioned in the data base.[24] But the real power of PROMIS, according to the president of the company that wrote it, was its ability to "...integrate innumerable databases without requiring any reprogramming . . . PROMIS can turn blind data into information."[25] The Justice Department accepted delivery of the first version of PROMIS, and the Company that developed it, INSLAW, went public in the early 1980's with Federal permission to market a public version of PROMIS.

PROMIS works like this: A Federal prosecutor's office is researching a criminal narcotics case. The prosecutor knows that the defendant has retained a counsel named Mr. Martin as defense. The prosecutor's office enters Mr. Martin's name as a query into the system. PROMIS automatically connects the prosecutor's computer with as many other similar systems as desired, nation- or world-wide. The PROMIS system then searches every data element of the scattered data bases to try and match Mr. Martin's name. In a matter of minutes, the PROMIS system has printed out the specifics of every case that Mr. Martin has dealt with. From this search, the prosecutor's office learns that (a) Mr. Martin specializes in defending narcotics cases in New York and New Jersey, (b) Mr. Martin has defended the same defendant three times before, and (c) the bail money and fines resulting from the previous court cases have been provided by a series of small businesses owned by a group suspected of having ties to organized crime. The Federal prosecutor's office now has reasonable suspicion enough to begin an investigation of Mr. Martin, the collection of small businesses, and their owners under federal racketeering and conspiracy statutes. This level of information would have been inaccessible before 1983. Such information, useless while residing in scattered locations, suddenly becomes a solid basis for investigation and further prosecution of conspiracy-related crimes.

After going public in the early 1980's, INSLAW used private moneys to improve the original PROMIS -- improvements that included its adaptation to a 32-bit architecture that ran on a very fast DEC VAX computer, and more powerful search and communications functions. Aware of a potential $3-Billion market in legal management, INSLAW wanted to market this enhanced PROMIS software in the public sector.[26]

It was at this point, according to the investigation later conducted by the House Judiciary Committee, that the Justice Department decided that it could not allow PROMIS to be marketed in the public sector.[27] Thereafter, according to the investigation, the Justice Department essentially conspired to pirate the enhanced software and bankrupt the parent company, INSLAW.[28]

The Department of Justice had discovered that PROMIS was not only good at managing legal cases -- it was also excellent at tracking terrorists and intelligence operatives. When the full scope of PROMIS' capabilities were realized, Justice developed a plan to distribute PROMIS to a wide range of intelligence services around the world, with one important modification -- the addition of a code 'trapdoor' that would allow US intelligence to surreptitiously enter into the database of the host and remain undetected. Thus, by the end of 1983, two main versions of 'Enhanced PROMIS' existed: a master version used by the U.S., and a client version used by the intelligence services of at least 80 nations around the world.[29]

How effective was PROMIS in the hands of client states? According to testimony given during the Congressional hearings by an Israeli agent "PROMIS was a very big thing for us . . . it was probably the most important intelligence issue of the '80's because it just changed the whole intelligence outlook. The whole form of intelligence collection changed. . . (it) was perfect for tracking the Palestinian population and other political dissidents."[30] If PROMIS was this effective in the hands of client states, one might infer that it was doubly effective in the hands of the U.S. intelligence operatives who were gleaning information through electronic 'backdoors.'

The Treasury Department's FinCEN

In April 1990, fifteen years after the first PROMIS version was tested, the Treasury Department unveiled FinCEN, a Federal organization designed to "map the digital trails of dirty money."[31] FinCEN uses a piece of software currently referred to only as "Artificial Intelligence/ Massive Parallel Processing" (AI/MPP) to search for financial activity that matches patterns used by drug lords, terrorists, and foreign intelligence services.[32]

Unlike PROMIS, however, AI/MPP was designed from the start to integrate data bases belonging to the CIA, IRS, FBI, DEA, Secret Service, National Security Council, the State Department, the Currency and Banking Retrieval System, and the Federal Financial Database (FDB) -- to name only a few -- in addition to the PROMIS-like capability to handle a wide variety of data from other sources without reprogramming.[33] In July, 1993, AI/MPP was integrated with state and local law enforcement data bases. The Treasury Department is reportedly seeking direct access to the networks that control automatic teller machine (ATM) transactions and credit card approvals -- thus enabling a real-time tracking capability. Peter Djinis, director of the Treasury Department's Office of Financial Enforcement called AI/MPP "...the first ever government-wide, multi-source intelligence and analytical network brought together under one roof. . . ."[34] (As a side note, while researching FinCEN, more information was found concerning the CIA's DESIST computer system -- apparently organized along the same principles as PROMIS and AI/MPP).

Currently, FinCEN is co-managing a multi-million dollar contract with the Department of Energy's Los Alamos National Laboratory to produce a modeling system that will draw transaction data from AI/MPP and create digital models of entire financial systems. [35]

Wall Street and the Data Miners

In the 1970's, 'technical analysis' of the Stock Market was "largely an image builder," -- a sales angle designed to lure new customers to the brokerage house.[36] By the early 1990's, technical analysis had become the "whole deal . . . . If you don't have it . . .you get crushed."[37] Why this transition took place is a good example of the power of third-wave knowledge engines to tackle seemingly chaotic phenomena (like the stock market).

Before the 'quants' (quantitative analysts) invaded Wall Street, playing the market was patriarchal and intuitive -- traditional results of the specialization of knowledge about unpredictable phenomena.[38] The 'quants' changed this traditional approach through the use of computers, large databases and automated analytical tools. The common methodology is similar to other examples in this section:

- The first step is to fill a large database with a wide variety of market data stretching back ten to fifteen years.

- Second, the analyst examines historical relationships between variables such as price, volume, Federal Reserve Board activity, etc., with tools like the IXL software (discussed below). This initial analysis provides the analysts with causal relationships between the data.

- Third, the analyst constructs his 'system' -- a model of the causal relationships between the data elements. This model is then applied to the historical database in a day-by-day manner -- much as if the analyst was examining the daily fluctuations of an actual market. During this application, the model sends 'buy' and 'sell' signals to the analyst, which are recorded over the full extent of the database. The analyst will continue to add more data to the database, and fine tune his model over time, until it is predictive to the point of maximum profit.

- Finally, the analyst uses the model to conduct actual trading. Although these steps have been described here as sequential, they can obviously overlap and blend into an iterative process that continuously refines the accuracy of the analyst in actual trading.

The future of the 'data miners' on Wall Street seems assured, especially when one considers the increasing power of data processing:

> The next generation of computer architecture, be it massively parallel programming or 64-bit addressing or hyper- or meta-computing, essentially is going to be data mining where the data is searched in even finer granularity to discover patterns that even this generation cant get at.[39]

Induction on Extremely Large Databases

The use of PROMIS and AI/MPP creates knowledge by matching different data elements in a variety of data bases. In the case of IXL, a software tool designed in 1987 by a company called Intelligence-Ware, the artificial intelligence routine embedded in the program is afforded no such luxury -- its job is to enter a collection of data bases and find causal relationships on its own. IXL roams freely through the database, without the need for the user to define specific criteria.[40] IXL

> . . . Statistically analyzes the database to form and test hypothesis about relationships in the data . . . and goes on to use machine-learning algorithms to produce rules that generalize the information in the database.[41]

IXL is the first commercially successful example of "machine learning programs," which refers to a program's ability to discover or learn information by itself.[42] IXL translates its findings into percentage or confidence factors between dependent and independent variables.[43] In essence, IXL is an early version of an automatic 'systems modeler' that can generate causal relationships between phenomena using empirical data -- similar to the classified effort underway for AI/MPP.

Model-Based Reasoning

In August, 1983, IntelliCorp introduced a piece of software called the Knowledge Engineering Environment (KEE). KEE was designed to provide researchers with the ability to use large amounts of data to construct complex models -- representations of the function and structure of systems -- of a variety of phenomena.[44] Using Artificial Intelligence routines, and the information provided by the researcher, the KEE environment constructs a system model that includes concepts, concrete objects, attributes, and relationships. Using this model, the researcher can determine how different parts of the model act when the entire system is 'articulated' through a range of inputs. KEE can also determine critical points and paths in the model that are sensitive to failure.[45]

Natural Language Processing

In the early 1960's, a research effort to train computers to understand human speech began in universities around the country. The problem quickly went beyond the electronic recognition of discrete sounds.

and progressed into what has become known as Natural Language Processing (NLP). NLP is an area of computational science focused on modeling the nuances of human language in order to allow a computer to understand the information contained in sentences.[46]

In essence, an NLP computer analyzes the words, grammar, and syntax of either speech or written text in order to generate information that is processable by a computer. The formal analytical engine resident in NLP software structures the data in a text string so that ". . .the system can use its knowledge in conjunction with a problem-solving system to make deductions, accept new information, answer questions, and interpret commands."[47]

With the advent of NLP, we note a distinct difference between systems such as PROMIS and AI/MPP -- which are designed to extract discrete pieces of information such as names, dates, or locations, from a data base -- and the use of NLP to extract relevant information directly from text files.

One current example of NLP is a research project called 'Studies in Information Filtering Technology for Electronic Resources' (SIFTER). SIFTER provides the user a very powerful tool to search through information stored at Internet sites around the country. Using NLP, SIFTER dashes through entire text files and extracts individual pages, paragraphs and sentences that match the search criteria.[48]

The Electronic Library

While PROMIS and AI/MPP required existing databases to explore, NLP needs text files -- such as books, manuscripts, or news articles stored in digital form. This section briefly describes the current status and trends of electronic text storage -- the electronic library. In fact, the world's great libraries share a common vision- "Books once hoarded in subterranean stacks will be scanned into computers and made available to anyone, anywhere, almost instantly, over high-speed networks."[49] One of the forces that will make such electronic libraries inevitable is the organic decay of paper:

> Joseph Price, head of technology at the Library of Congress, estimates that each year 80,000 of the items on its shelves

become so brittle that their pages can no longer be turned. The only way to save the text is to copy it onto another media. Today, the medium is typically microfiche, but Price reckons it will soon be some form of optical disk.[50]

One of the important aspects of the electronic library, and of other elements of the knowledge engine, is that they are not confined to the United States. The French national library, for example, is in the process of scanning 100,000 great works of the 20th century as chosen by a committee of notable French citizens-- "Through designated computer networks, these books will be made available far beyond the walls of the library..."[51] Efforts in the British Library resulted in transmitting more than 3 million bits of text worldwide, and 12-15 million items in the British Library's electronic catalog will become available over the British research network, JANET, by the summer of 1994.[52]

Many universities, businesses, and research labs routinely store large amounts of electronic data in a variety of formats. These scattered 'pools' of data are essentially land locked without some means of moving the data to a variety of geographically-scattered data consumers. The next case will discuss the different means available to move large quantities of data across the office or the globe.

"Data Pipes"

In order to function properly, the future knowledge engine must also have the ability to transport large amounts of data over long geographical distances. In essence, the knowledge engine must be able to connect itself to 'data pipes' - communications networks with large data throughputs.

Most personal computer owners are familiar with communications through a modem and public phone line. Quite often, however, larger computers use dedicated switching and transmission systems. One can divide 'data pipes' into three general categories:

- Local Area Networks (LAN). Many business and learning institutions install dedicated communications networks that serve to connect all their computing resources together. Normally, because the network is custom-designed, the throughput can be considerable - often approaching 100 megabits per second.[53]

- Regional Networks. Larger businesses and Universities that maintain branch offices often lease dedicated phone lines to transfer data. Most phone companies maintain the capability to provide special, higher-quality lines for this purpose. The throughput, however, still generally falls well below that enjoyed by the custom-designed LAN.[54]

- National Networks. National networks are normally a conglomeration of a wide variety of regional or special-purpose networks that agree to a common standard, such as the 'TCP/IP' protocol used on Internet.[55]

Often, as different regional networks grow in size and are conglomerated into larger national networks, a network 'backbone' is identified by national agencies such as the Department of Defense(DOD) or the National Science Foundation (NSF):

> The Merit Computer Network, managed by Merit, Inc., a consortium of Michigan Universities, began in 1972 as one such regional network with initial funding from the NSF. . . It quickly grew in size, self-supported by member universities. In 1987, NSF awarded Merit a grant to administer the NSFNet backbone for five years. . . By 1991, the speed of the links was increased to . . T3 circuits at 45 Mbps. [megabits per second].[56]

The National Science Foundation Network(NSFNet) now serves as one of the major backbone networks comprising the United States' portion of the Internet. NSFNet connects " . . . more than 3,000 networks at university and college campuses, business and industrial research laboratories, and governmental research centers throughout the world."[57]

Currently, the United States enjoys a lead over Europe and Japan in the development of high-speed data-transfer networks for research and education, and the current state of the art is represented primarily by the Internet, a loosely organized system of interconnected, unclassified computer networks linking over 500,000 computers nationwide and overseas. The Internet includes government-funded national backbone networks and publicly and privately funded regional networks operating at 1.544 megabits per second (T1), as well as private local-area networks transmitting data at speeds of 10 megabits per second to 100 megabits per second.[58]

This growing ability to transmit huge volumes of data across vast distances provides the third wave knowledge engine with the ability to access a steady stream of information from a wide variety of sources world wide.

Analysis

The preceding cases have outlines a number of technological 'benchmarks' around which the conceptual knowledge engine will be built. 'Initial drafts' of the knowledge engine already exist, in the forms of PROMIS and AI/MPP. The purpose of this section is to analyze these benchmarks and provide trends as to the direction of their development.

Information Storage

In each case above, some form of information storage exists from which to draw the raw data. In the case of IXL, PROMIS and AI/MPP, information storage takes the form of a variety of geographically scattered databases. A **database** is an electronic storage location in which discrete data elements, such as names, addresses, dates, account numbers, etc., are stored according to a pre-determined scheme. This method of storing data has been refined over the years, and the number and quality of data bases continues to grow.

In the case of the electronic library, information storage takes the more familiar form of documents stored on a magnetic media. The computer stores the documents as long contiguous strings of text. Efforts are currently underway in libraries across the globe to scan paper texts into electronic storage. Future publishing may, in fact, be conducted completely through electronic media, with writers transmitting manuscripts directly to publishers -- or even directly to consumers.

The volume of both databases and stored text is expanding rapidly. Information on nearly every subject imaginable is available now through on-line systems such as Internet and NEXIS.[59] Additionally, the technical means to store this data is reaching vast proportions, as evidenced by NASA's MTPE project.

Data Pipes

The trend world-wide is an increase in the volume and capability of digital communications. Additionally, these transmission means are often established between organizations already possessing considerable reservoirs of stored information. Traffic on NSFNet, alone, has increased by more than 25 times in the last 2 years. In order to solve the problems created by this rapidly growing use, an effort is nearly complete to increase data throughput on a major portion of the United States' Internet to 1.544 megabits per second (the 'T1' standard)[60] and 45 megabits per second (T3), and Federal plans are underway to develop the National Research and Education Network (NREN) that transmits at speeds between one and three gigabits -- the equivalent of 150-200 hardbound books per second.[61] As telecommunications technology improves, we should expect these rates of transmission to increase, and their cost to decrease.

Information Mining

Information mining is the process of sifting through the storage medium for pieces of data that impact on the subject of interest. Mining data from a large number of databases is a relatively simple function of comparing large numbers of data elements to find matching contents through a query. Mining data from stored text uses NLP to extract the relevant data from entire text strings. The data gained from either a database search or an NLP search are then stored for future manipulation during the research process.

In the case of both PROMIS and AI/MPP, the software has the ability to both connect itself to, and understand the data from, a wide variety of data bases. The ability of the 'master' PROMIS (U.S. version) to surreptitiously gain entry into a 'client' PROMIS provides an exponentially larger set of available data. The ability of AI/MPP to tap into intelligence, financial, and law enforcement data bases simultaneously, again provides a much larger set of available data on any person or group who comes into contact with any of these institutions.

Two other elements are important to understanding the nature of 'information mining' software. First, many of the systems currently in use are nearly 20 years old - hence they represent older, less efficient software; second, and perhaps most important, is the fact that governmental agencies have found PROMIS so useful that they seized the software from its proprietary owner.

Natural Language Processing software, such as SIFTER, continue to emerge as the text searching equivalents of PROMIS and AI/MPP. With NLP, digital libraries can serve a considerably greater function than the more rudimentary databases used by PROMIS. A researcher will shortly be able to send an NLP query to an electronic library to extract all data concerning any particular subject.

One important point to emerge from recent research is that the 'data surface' of all possible information is much too large to be examined by one single computer. This means that the function of information mining will probably have to be distributed to the storage facility itself, with the researcher sending only a query from a remote site.[62]

Model Building

'Model building' is something everyone does, but few are aware of -- it is an integral part of problem solving in any field of study. As a rule, people build conceptual models from a very early age - "You would not be able to think if you were incapable of building models."[63] What most people have generally not done, however, is ". . . build a model explicitly so most people could understand it and perhaps use it."[64]

A model is how we conceptualize and explain the different phenomenon we notice around us. It is a chain of cause and effect relationships that usually has its roots in a set of observations, and it represents the basis for any theory. Explicit models have great utility in exploring how things work:

> An explicit model is a laboratory for the imagination. You can tweak a model to see how it responds. You can argue whether the threads of logic really do knit together in a consistent fashion. You can explore its strengths and limitations. You can even make guarded predictions and then argue how good (or poor) those predictions might be.[65]

It is important to remember that very few models are complete -- that is, that very few models represent each and every causal relationship of the phenomenon under scrutiny. However, it is equally important to consider that a model does not need to replicate the complete phenomenon -- only to include ". . . those features of reality that are essential . . ." to understand that phenomenon.[66] Additionally, one of the key reasons why most models do not replicate the entire phenomenon is because of the ever-present constraint of time and resources. This restriction to modeling -- time and resources -- is one of the reasons why the modeling software described below is critical to the construction of the knowledge engine.

Once the data has been 'mined' from the data bases, the researcher is still left with the task of making some sense out of it. In the case of AI/MPP, this task is handled by an integrated modeling system that can build complex models of money flow. In the case of IXL, the data is analyzed by artificial intelligence routines to provide a list of relationships between different data elements. IXL provides the researcher with an "If-Then" statement of probabilistic cause between dependent and independent variables. The KEE software allows the researcher to build complex models of entire systems in terms of, concepts, objects, attributes and relationships. In the case of AI/MPP and KEE, the software allows the researcher to 'run' the model, and search it for critical points or processes that can cause systemic failure.

The model building element of the knowledge engine is the fourth and final piece of the knowledge engine. With it, a researcher can understand and make use of a vast quantity of data. With all four pieces integrated into one, the researcher has an extremely powerful tool at his disposal.

Synthesis

Let us imagine a point in the near future, when all of these technology benchmarks - information storage, data pipes, information mining, and model building -- become integrated into a knowledge engine (at least one such system -- the AI/MPP software used by the Treasury Department -- is already integrated from the storage to the modeling). The integrated knowledge engine would be able to do the following things:

- Access huge volumes of electronically stored information quickly and accurately.

- Extract from the data base discrete pieces of information on any particular topic.

- Divide information into categories and then analyze it to find causal relationships between phenomena.

- Form theoretical systems models out of the analyzed data that allow relatively precise prediction of a wide variety of human and physical phenomena.

- Allow the researcher to 'articulate' the systems model through a range of activities to identify specific parts as critical, redundant or unnecessary.

In essence, the integrated knowledge engine would provide a previously unimaginable level of induction (specific to general) to a researcher. Additionally, the ability to create a model, articulate it, and then update it with new data would provide an equally unimaginable level of deductive (general to specific) capability. To appreciate the full impact of the integrated knowledge engine, we must first examine the nature of knowledge about phenomena in our world today.

Climbing a 'Ladder of Knowledge'

Phenomena, on this world at least, can perhaps be divided into three categories which simplify the discussion. The first category is the set of phenomena in which causality is easily isolated. For example, one can state with relative certainty the cause and effect at work behind a wide variety of physical phenomena. In fact, the causal relationship is so sure that one can create deterministic models that predict exact behavior. Many of these phenomena take place with 'closed systems' of knowledge.

The second category of knowledge is a bit more diverse, and consists of phenomena characterized by stochastic causal relationships. This is the case where the phenomenon is characterized by a centrality and constant distribution of outcomes. Most natural phenomena fall into this category; they are understandable and predictable only within the boundaries established by the measured distribution. With stochastic phenomena, we recognize that the system of knowledge is not completely closed, and that we have an incomplete knowledge of the causal factors that create the distribution of outcomes. As the distribution of outcomes becomes less central, the predictive capability of probabilities decreases.

The third and final category of knowledge deals with phenomena that exhibit true chaotic tendencies - that is, the inputs to the system cause completely random, unbounded, and unpredictable outputs. We might say that such phenomena exist in completely open systems of knowledge where an impossibly large number of causal factors exclude the possibility of predictability. Some hold that human behavior falls into this category.

We can, in fact, trace the development of human knowledge along these three waypoints. At some point in our not too distant past, most -- if not all -- phenomena fell into the chaotic category. Without a framework of thought required to rationalize why things happened (commonly referred to as pre-Newtonian), they were explained by invoking 'deus ex machina' -- the work of gods.

As the methods of logic and observation developed, people began to observe causal relationships between events -- and they gradually ceased to be explained as an act of the gods. For many phenomena, however, there was still an uncertainty in prediction caused by the failure to identify all the causal factors underlying a phenomena. Knowledge thus remained in the stochastic realm until the methods and instruments of measure were precise enough to eliminate the sources of the stochastic error in the prediction. Knowledge of any phenomena, at this point, becomes deterministic.

We can perhaps envision the 'ideal' knowledge engine which proceeds along this hierarchy of knowledge in a predictable manner. First is the effort that enables a knowledge engine to access and analyze a very wide variety of information dealing with deterministic phenomena and closed systems of knowledge. Virtually any information dealing with physical laws, accepted definitions, or observed events can be immediately accessed and analyzed. The next step in the hierarchy is the ability to access and analyze stochastic data. Finally, after perhaps decades of developmental work, the ideal knowledge engine would begin to catalog and analyze chaotic phenomena. Along this route, the wealth of information processed by the knowledge engine would make it possible for stochastic phenomena to be more fully understood, thus turning them into deterministic phenomena. Similarly, the effort could move chaotic phenomena into the stochastic category. At each step, epistemic justification is automatically sought, conflicting data identified and resolved, and related phenomena checked for causal relationships.

The operation of the integrated knowledge engine, in theory, will therefore trend toward perfect, justifiable, causal knowledge of all known phenomena. Traditionally, this level of knowledge is reserved for deities, and perhaps that is where it should remain. Any nation, any party armed with the ideal knowledge engine would have the ability to obliterate any opponent by an infinite number of means - physical, emotional, political, environmental, genetic, etc. Additionally, any party armed with the ideal knowledge engine could prevent any other party from gaining parity in the knowledge race.

In reality, no knowledge engine will reach the theoretical limit of omniscience. The issue, then, is how far the integrated knowledge engine must be pursued in order to guarantee victory in a conflict. At each level in this hierarchy of epistemology, serious obstacles exist that may only be overcome through the expenditure of tremendous resources at the national level. This issue sets the conditions requisite for an information arms race -- couched in terms of climbing up the three hierarchical levels of knowledge development described above -- that will continue for decades to come.

SECTION FOUR

APPLICATION OF THE

THIRD WAVE KNOWLEDGE ENGINE

This section explores how the integrated knowledge engine might be used in a conflict between a post-industrial power and three potential foes -- another post-industrial country, an industrial enemy, and an agrarian foe.

The basic construct used throughout this section is a Tofflerian one: First, that the primary strength of an agrarian power lies in the realm of people; Second, that the primary strength of an industrialized power lies in the ability to harness machines to do man's work; And third, that the predominate characteristic of a post industrial power lies in its ability to use machines to do man's thinking.

Third Wave vs. Third Wave (3v3)

In this case we envision two post-industrial powers locked in struggle. Both nations have down-sized their 'brute force,' industrial-era militaries, and rely instead on the precise application of both destructive and informational elements of power. In this case, where may the locus of decision lie?

Clearly, precise application of anything requires the use of some form of the knowledge engine. Can the opponent's nation be driven to collapse through precise application of economic, diplomatic, environmental, or informational elements of power? If so, the necessary antecedent would be the application of the knowledge engine to first model and then identify the critical elements within the societal systems. We are far beyond the warning in the 1976 version of FM 100-5 "If it can be seen, it can be hit, and if it can be hit, it can be killed." We are now in an era of "If a system can be modeled -- it can be made to collapse."

What is it that makes a system 'collapsible?' First, it requires that the system is, in fact, a system -- with components, inputs, outputs, processes and linkages; Second it requires that, within the system, there are components, processes or linkages that are :

- Necessary to the functioning of the particular system.
- Unique in the sense that the component, process or linkage is uncommon and unduplicated.
- Disruptable by action on its inputs, outputs, or internal processes.
- Irrecoverable in the sense that the whole system cannot regenerate the component in time to avoid systemic failure or defeat.
- Discernible in the sense that each of the four criteria above can be discovered or inferred by an inquisitive enemy.

In a Third Wave vs. Third Wave scenario, both opponents would seek to disrupt the other's ability to use information. Thus, each of the criteria above would be applied to the knowledge engine technological benchmarks outlined in the preceding section:

	Information Storage	Data Pipes	Information Mining	Model Building
Necessary	Yes	Yes	Yes	Yes
Unique	No	Yes	No	Yes
Disruptable	No	Yes	No	Yes
Irrecoverable	No	No	No	Yes
Discernible	Yes	Yes	Yes	No

Table 2. Application of Systems Disruption to the Knowledge Engine in a 3v3 Conflict

The table above is a brief analysis of the ability of Third Wave forces to attack each other's knowledge engine. The rationale of each part of the analysis is expanded below.

Information storage is a necessary part of the knowledge engine, but its distributed commercial nature makes it far from unique. Currently, data is stored in thousands of universities, businesses and government agencies, and the trend will be towards more decentralization. Because of this decentralization, information storage will be hard to disrupt, unless unique data resides only in one location. Many data storage centers maintain what is known as 'hot sites' where their data is duplicated and stored on a regular basis, making disruption more difficult, and recoverability easier.

Data pipes, as discussed earlier, are necessary parts of the knowledge engine. They transmit at different rates, depending on their geographic coverage and custom design. So called 'backbone' data pipes are indeed unique, but techniques pioneered by the major telephone companies make an absolute disruption of data flow unlikely, and the loss of any one part of the network a recoverable event.

Information mining will probably occur at the storage site itself, as a result of a query from the researcher. Because of this, information mining shares the same systems qualities as data storage itself.

Model building is perhaps the weakest link in the entire system. It must currently be done at one site by specialized software. It is not only necessary to the process, but unique and irrecoverable as well. However, because it is unique, the location of the modeling software is hard to discern, and therefore difficult to disrupt.

The most likely opening moves of a symmetrical 3rd Wave war may take the form of a 'Counter-Knowledge' fight in which each side attacks the other's ability to use information. The means used could include sabotage, false information, invasive viruses, or precision strikes to disable the opponent's knowledge engines.[67] The attack means may enter the system through the same data pipes they are designed to disrupt. Once this is achieved, the victor may quickly shift into a very precise phase of 'systems attack' which would try to disable major institutions, industries and societal systems which had previously been modeled to a great degree of accuracy.

Third Wave vs. Second Wave (3v2)

Although Second Wave militaries produce combat power through the production and subsequent mass use of machines, they must confront one enduring truth: A mechanized army can produce combat power only when the potential of a formation is enabled by the external conditions. The design, manufacture, transportation, and distribution of war materiel all must happen before its use at the pointed end of the spear. Where then, in this chain of events is the exact 'source of power'? If it can be shattered anywhere along its length from the factory to the front, then no singular center of gravity exists.

The realization of this produced a theory of warfare referred to here as 'systems attack':

> Another collapse form that still holds considerable (even increasing) sway is the form of 'systems attack.' This theory starts with the assumption that virtually any social entity -- be it political leadership, industry, the population, or the military itself -- can be conceptualized as a 'system of systems.' Within this construct, the modeling of the enemy system would point out the critical nodes, or functions that, if effectively attacked, would cause the functional collapse of the system as a whole. This form, championed by air power and 'targeting' theorists since Douhet, is a logical way of approaching industrial war.[68]

We can envision several possible scenarios resulting from a 3v2 conflict. In the first, an entire range of social systems is first modeled by the knowledge engine, and the model articulated to locate critical nodes in each system. In each specific case, the knowledge engine would have to determine the criticality of each of the society's sub-systems:

	Industry	Transportation	Government	Military
Necessary	Yes	Yes	Yes	Yes
Unique	?	?	?	?
Disruptable	?	?	?	?
Irrecoverable	?	?	?	?
Discernible	Yes	Yes	?	No

Table 3. Application of Systems Disruption to a 2nd Wave Nation in a 3v2 Conflict

The critical nodes of the industrial-era force thus identified by the knowledge engine would then subjected to precision attack from extended distance.

A second possible scenario in a 3v2 conflict involves the systematic destruction of only the enemy military through the application of precision weaponry. Many feel that this scenario would resemble the combined air and ground campaign against the Iraqi Army during Operation Desert Storm.

A third possible scenario involves the application of the knowledge engine on the political system of the 2nd Wave Nation. The knowledge engine would be tasked to identify the primary players, their motivations and weaknesses. A precise application of information war would then be applied to the enemy's political leadership, forestalling their use of force altogether. A primary example of this technique was the information campaign focused on the country of Guatemala in 1954.

A Third Wave vs. Second Wave Scenario - Guatemala

In 1954, the Government of Guatemala began drifting towards the left -- responding more and more to overtures from Moscow. An exiled Colonel named Armas gained the support of the Central Intelligence agency in a effort to overthrow the left-leaning Arbenz government.[69] A key element of the operation was establishing clandestine radio transmitters, known as the 'Voice of Liberation,' (VOL) to broadcast a mixture of fact, disinformation, and entertainment to the large number of short-wave sets throughout the country. The chief of VOL explained the technique:

> We must begin with the big lie -- that we are really broadcasting from within Guatemala. Given the absolute necessity for that deception, we must avoid saying anything which can be proved false. The smallest mistake will be used by Arbenz to ridicule us. If we must lie again, we have to be sure it's a big one and worth the risk. Once we have established credibility we must define the issues for each of the (population). . . and, at the proper time, tell them what action is expected of them. Timing is important. . . .[70]

The team knew that they had only six weeks to prepare the battleground of ideas before Colonel Armas would lead his army of exiles across the border into Guatemala on June 18. Within a week, VOL had plunged the previously peaceful Guatemalan countryside into turmoil.

President Arbenz himself began to deepen the crisis. Soon after the broadcasts started, a shipment of Czech weapons arrived by sea, and were distributed to Guatemala's reactionary home guard -- largely controlled by a political faction loyal to Arbenz . VOL quickly capitalized on these events by first, broadcasting that the Arbenz regime entertained expansionist notions. Second, VOL claimed that this act was a slap in the face of Guatemala's regular military. The Arbenz regime did nothing to counter either of these half-truths, and the turmoil mounted. Cracks began to widen between the government and its military. After a leaflet mission over the capital and an impassioned VOL speech by an impassioned air force 'defector,' Arbenz grounded his air force for the duration.[71]

One VOL broadcast asked the population friendly to the forces of COL Armas to light candles so that air force defectors could bomb those areas not lit. the next day ". . . Arbenz's Chief of Secret Police drove through the neighborhoods of Guatemala City, announcing that anyone apprehended assisting the enemy by lighting candles would be executed."[72]

This pattern of action and reaction continued throughout the following weeks, with Arbenz neither able to locate the transmitters, nor to offer convincing 'counter-truth.' Instead, each ill-advised statement and reaction ". . . added to the stature and credibility of the broadcasts. . . ."[73] In one case, the VOL team staged their own capture during a broadcast, whereupon Guatemala's government radio announced that the rebel radio station had been captured. The next day, when VOL returned to the air "from a new location," it wore the authenticity of government recognition.[74]

On D-Day, VOL began broadcasting from Colonel Armas' notional command post. Armas had, in fact, crossed the border, but clandestinely, and only with a small group of followers. He had neither the men nor the materiel to mount a serious attack of any sort on the Arbenz Government.

On the 25th of June, VOL went for the second 'big lie.' It broadcast that there were two columns of rebel soldiers advancing on the capital.

The highways quickly filled with a stream of traffic and refugees. Simulated coded messages were transmitted over VOL to notional rebel commanders. On Sunday, the 27th of June, Arbenz resigned and drove to the Mexican embassy, where, along with 600 followers, he requested political asylum.[75]

There are variety of paths available for a Third Wave military in a conflict against an industrialized nation. Application of precision weaponry over vast distances can disable a wide variety of institutions. Application of precisely-crafted informational campaigns can drastically effect political decision making as well.

Third Wave vs. First Wave (3v1)

An agrarian nation displays three typical responses when faced with a higher-tech opponent. It can mass its manpower in a Napoleonic mode in order to maximize its 'muscle' output. It can try to adopt the tools of industrial war despite the cultural and educational boundaries that prevent its full utilization. Or it can adopt an insurgent modus operandi that serves to offset the technological advantage inherent in the structure of its opponent.

Clearly, this last case is the one that most bothers the theoretician. For the previous half-century, the application of high technology to a pre-Newtonian agrarian conflict has often met with failure, especially when confronted with communist-led insurgents. If we assume an agrarian insurgency as the worst case for the third wave military, we can examine several case studies for clues to the possible outcomes.

El Salvador

For over 150 years, El Salvador had been a very unpleasant place to live. The country suffered through 6 Indian rebellions between 1832 and 1898. Between 1880 and 1930, a series of coffee growers with little concern for public welfare ruled the nation. After decades of abuse, the ideology of Communism was readily grasped by the rural population in the early 1930's.[76]

In 1931, a prescient military attaché reported seeing "nothing but limousines and oxcarts" in the streets, and predicted that, while a communist revolution might be delayed 10-20 years, it would come eventually and it would be bloody.[77] That same year, the first communist revolt started.

In order to retain power, President Martinez immediately declared elections, and registered a majority of the voters. From these registrations, he compiled lists of the communist party members, and then unleashed the National Guard. In the resulting massacre, known as 'La Matanza,' the government killed over 20,000 communists and sympathizers within two months.[78] Throughout the 1940's and 1950's the Left in El Salvador made a slow comeback. By 1960, Leftist Army officers staged a coup, which was countered the next year by Army officers from the right wing.

Fearing further coups, and with support from the United States, the Government of El Salvador launched an intelligence-gathering effort called ANSEAL. ANSEAL quickly built up a cross-indexed archive of information on leftist elements.[79] By 1970, ANSEAL had informants all over El Salvador, and one citizen in 50 was an 'ear.' [80] With the information provided by ANSEAL, the government of El Salvador was able to effectively fight communist insurgents until peace negotiations began in the late 1980's.

In the case of both the 1931 rebellion, and the violence of the early 1960's, the Government prevailed primarily due to the ability to compile cross-referenced lists of Communist insurgents and sympathizers.

Philippines

The same mechanism proved important in the Philippines. Information played the key role in the destruction of the Huks. The Army received information from a captured communist officer that much of the Huk politburo. . . was hiding in Manila. . . on 18 October 1950, twenty-one Military Intelligence Service (MIS) men surrounded a house in downtown Manila and arrested 105 people, including most of the members of the Huk politburo.[81] With their political leadership shattered, and the Communist party files in the hands of the Army, many of the remaining communist supporters fled the country.

Vietnam

The communist struggle for control of Vietnam began in the ea..y 1900's. Both the British and French authorities were ineffectively in combating the insurgencies because of a lack of knowledge about the communist leadership structure, which was tightly compartmentalized. In late 1930, a COMINTERN agent, Joseph Ducroux, was captured by the British in Malaya. He provided the British with a list of names that included the Politburos of each major communist party in Southeast Asia. Ho Chi Mihn, Giap, and Tran Phu -- among others -- were on this list, and subsequently imprisoned in 1931.[82] The knowledge gained through the 'Ducroux List' resulted in the ". . .total destruction of the Southeast Asian Comintern apparatus . . .and the collapse of the Indochina Communist Party. . ."[83]

Analysis

All these cases have at least one thing in common: the insurgency collapsed or stayed dormant as long as the authorities possessed the names of the insurgent leadership. In several cases, the knowledge of these names resulted from the capture of a single individual (Ducroux or the Philippines). In other cases, the infrastructure was identified through the method of cross-index filing of names, places and activities -- exactly the same thing that the PROMIS system excels at.

In fact, there is good evidence to support that the PROMIS system was used to compile and track the names of political dissidents who opposed the U.S. Administration's foreign policy in the 1980's. In a Senate Subcommittee hearing during the Iran-Contra investigation, we note that the National Security Council had made

> . . . contacts with the Federal Emergency Management Agency [FEMA] in the sense of dealing with opponents [American citizens] of U.S. foreign policy toward Central America in the case of a war between the United States and Nicaragua. And it came out that there were actually plans on file to sweep people up -- sweep activists up -- in case of a war in Central America.

> . . . The Inslaw PROMIS software itself had that purpose. . . and more important, had the full capability of doing it. It is the Cadillac of software systems . . . tying directly into the . . . Federal Emergency Management Agency's plan to arrest, jail and hold in detention camps political dissidents.[84]

One of the enduring parts of a successful counter-insurgency over the last 80 years is the exploitation of information about known insurgents and sympathizers. The case studies above show that this database has been created in several ways: first, through the chance exploitation of a captured insurgent; second, through the manual collection and cross-indexing of individual files; or third, through the use of a knowledge engine like the PROMIS system. One may infer that a third wave military can actually be more effective at combating an agrarian insurgency than its second-wave counterpart. One can even forecast a future where 'guerrilla' wars are never fought, but rather kept in a perpetual stage of 'other than war' by the repeated preemption of a variety of factors -- guided by a knowledge engine.

Conclusions

This section applied the third wave knowledge engine to three different militaries in order to gain some insight into the potential of a pure third wave military. One might easily see the advantages that such a system would provide within the limited scenarios offered here. Conversely, other parts of this monograph have illustrated that significant obstacles remain to the full development of the knowledge engine.

Several important conclusions, however, can be made at this point. First, governments around the world have found even the prototypical knowledge engines to be absolutely invaluable in gaining information out of a impossibly huge mass of data -- and then using this information to make national security decisions. Second, information technology is clearly trending in the directions that will enable the knowledge engine to be built -- and these trends are accelerating. Finally, we are not the only country possessing these capabilities, or aware of their potential.

When the knowledge engine is eventually built, it will probably be decisive in the same way that nuclear weapons were decisive. Unlike nuclear weapons, however, the knowledge engine will be usable, largely innocuous -- even invisible -- even when applied. The issue we must confront in the concluding section is the Army's institutional response to third wave war in general, and the potential of the knowledge engine in particular.

SECTION FIVE

CONCLUSIONS

This monograph has tried to illustrate the notion that a third wave military has the potential to be much more than a collection of second wave machines with computers inside. Throughout the di.cussion, the monograph has described the rudimentary forms of knowledge engines that were designed in the 1970s and are in use today at the highest levels of government, and in a majority of intelligence, law enforcement, and financial institutions. The conclusions section will try to do three things; first, it will briefly summarize the probable future trends of knowledge engines; second, it will try to answer the "so what?" question -- "What does all this technology mean for the Army, and the future of land warfare?"; finally, it will briefly examine the Army responses to the still-vague potential of the knowledge engine.

Knowledge Engine Trends

One can perhaps discern several trends in the use of today's rudimentary knowledge engines. First, and possibly foremost, today's knowledge engines are used by governments to enable more effective control over their population and enemies in a variety of ways -- through exhaustive analysis of financial, legal, law enforcement, or intelligence databases. In effect, if a person comes into contact with any of the institutions responsible for any of these areas, he or she can be monitored, modeled, and investigated. The trend is toward increasingly detailed levels of scrutiny in nearly every facet of everyday life.

Second, early versions of the knowledge engine, such as PROMIS, have shown remarkable flexibility in dealing with dissimilar formats and storage mediums. Additionally, PROMIS demonstrated a flexibility that allowed it to work in both the legal and intelligence fields. The Treasury Department's AI/MPP system - designed a decade later -- shows the ability to not only mine data from a very wide variety of dissimilar institutions, it also combines the ability to model any of the data collected into a working system. The trend for the future seems to be toward more flexibility in the handling of greater amounts of dissimilar data, and for a gradual merging of knowledge engines at higher levels of government.

Finally, while the initial source of data was largely discrete elements stored in a pre-formatted database, the techniques of Natural Language Processing will allow knowledge engines to reach directly into text files (dissertations, theses, technical reports, etc.) and extract data to be modeled. This trend, if maintained, would allow the researcher to construct working models of virtually any social or physical system known to man, and to predict the effect of any action under consideration.

These trends portend the creation of a locus of power -- the power to control people, systems, and nations -- far beyond that imaginable today.

So What?

What does all this technology mean for the Army, and the future of land warfare? Over the last several millennia, armed forces have had to close with and destroy an organized opponent, often followed by the forceful coercion of the enemy population. With the support of a rudimentary knowledge engine, such as those described above, an armed force can conceivably do far more damage with far less deployed combat power. With the support of a mature knowledge engine, it is not inconceivable to consider the application of long range precision weaponry as the decisive act in war, nor to disregard the power of a knowledge engine in controlling an enemy population without the introduction of physical force.

Barriers to the Development of a Knowledge Engine

Part of the conclusion must be devoted to the examination of the Army's institutional response to the Tofflerian concept of winning wars with information. This examination will include a brief analysis of the Army's central paradigm, and a survey of Army efforts to date regarding information war.

The Army's Central Paradigm

In order to isolate the fundamental paradigm of the U.S. Army, the keystone manual FM 100-5 was analyzed over the course of fifty years. This analysis (see Appendix A) searched for words like 'decisive,' or 'burden of victory' to help identify the primary paradigm of the institution.

> *Armies are critical to national survival. They are decisive through their ability to apply power over the land. Victory in battle is key, and the decisive element within the battle is the close fight. It is the will and vision of the commander that animates the close fight, and often the moral qualities of man are decisive.*

The Army's central paradigm has been adhered to over centuries because of the soundest rationale -- it works, and we've won wars with it. The success of any paradigm, over time, has the effect of strengthening it, making it harder to change. Thus, when rapid change occurs, as it did during the transition between our agrarian and industrial societies, the result is often a long, painful, and costly transition. It is for this reason alone that the Army faces a difficult task in transitioning to the age of information warfare.

Key indicators of the problem in transition will probably take on the following forms:

- A drive to kludge parts of the new era onto the old -- in essence, insert computerization into every industrial-age machine in the inventory. Information technology will be focused on efforts to perfect the old paradigm, much like the insertion of the rifle into Napoleonic close order formations. A case in point is our construction of huge 'data pipes' and processors to support distributed simulation in the training of industrial era warriors, when the resources might be better spent in refocusing them in the direction of knowledge engine construction.

- An extended effort to make the weapons and formations of one era competitive with newer informational approaches to warfare. In effect, industrial formations will try to apply the precision effects consistent with a third wave approach.

- A calcification of the personnel promotion system designed to preserve the central paradigm.

Problems in Transition

In the mid-1980's, the commander of the U.S. Army's Training and Doctrine Command (TRADOC), GEN Maxwell Thurman, fashioned an far-sighted program to develop the Army's future information war potential. He hand-selected ten of the Army's best young minds to attend graduate-level schooling in artificial intelligence and expert systems. These captains returned with master's degrees in hand and immediately set to work tackling some of the Army's biggest data-management problems. After two years of civil schooling, and a tour in data processing at an early point in their career, many of these officers were then passed over for promotion because of a lack of field time with troop units. In some cases, these bright ex-officers formed their own companies and began charging the Army substantial fees for services that could have been bought for a song had they stayed in the service.

Another far-sighted Army project, the Army Corporate Data Base (CDB), was designed to build conceptual data models of complex systems (similar to KEE, described in Section Three, above). The CDB project was suspended because proponent interests kept the participants from agreeing on". . . terms, data dictionaries, etc."[85]

The TRADOC General Officer Steering Committee met in the late 1980s to determine the Army's artificial intelligence and robotics requirements. They recommended 43 specific programs. A majority of the recommendations had to do with improvements of existing or planned equipment. The aids to decision making resided mostly in the combat support and combat service support areas. TRADOC saw no need to help the close combat fighters with their decision making tasks.[86] The Fiscal Year 1992 TRADOC Study Program Update lists 380 studies, only one of which is directly targeted at improving decision support of the commander. Again, most of these studies are aimed at incremental improvements to industrial-age weapons systems.[87]

These vignettes illustrate the tremendous problems inherent in changing institutional behavior -- particularly an institution as traditionally-minded as the military. One bright spot on the horizon, however, is mentioned in the FY 1994 Army Science and Technology Master Plan:

> Research in artificial intelligence, expert systems, decision theory, and information fusion is performed to provide reliable, real-time tactical command and control information as well as analysis and assessment capability. Emphasis is on developing algorithms that can deal with vast quantities of data that have a degree of uncertainty and incompleteness and with the difficulties associated with the rapidly changing complex battlefield environment. Parallel and distributed processing, and distributed databases are of fundamental importance requiring further research.[88]

The focus of this effort, however, remains on the refinement of our capability to prosecute close combat -- a capability that may be eventually be marginalized by the construction and exploitation of the knowledge engine.

Recommendations

In the Chinese language, the same cruciform symbol can mean 'crisis' and 'opportunity' simultaneously. The impact of the information age on the Army as an institution is possibly the most important military question of our era -- and within it are carried the seeds of both crisis and opportunity. Much like the earlier transition between agrarian and industrial societies, much of the key information required for sound institutional decision making is missing, or confusing. Under such conditions, the central paradigms of any institution remain strong, and difficult to change.

The solution, in the Author's opinion, is for the Army to begin a transition that will place it at the forefront of practical knowledge engine construction and application. Such an effort includes the following elements:

- Accelerated research and development of the four major technological benchmarks of the knowledge engine: Information Storage, Data Pipes, Information Mining, and Model Building.

- Development of precision attack means that can target a wider variety of societal systems without the need to resort to lethal force.

- The opening of alternate career paths for personnel adept at developing and using information-age tools.

- The creation of organizations designed primarily to operate knowledge engines and exploit the information derived from them.

This transition effort does not require discarding of the current paradigm, but rather recognizes the need to continue to field a symmetrical response to any first or second wave threat during the transition period, which (if the last transition period is any indication) may take a full half-century to complete.

If the Army retains the paradigm of the decisive close battle -- at the expense of new possibilities -- then it is likely to pass into relative obscurity well within the next half-century. The full maturity and exploitation of the 21st Century knowledge engine may make the application of brute force a sideshow. Entire regions or populations may be laid to waste by a variety of 'systems collapse' techniques made possible by the precise data mining and modeling capability inherent in the knowledge engine. One may prefer to think about it in terms of the 'new high ground,' or think about it perhaps in terms of the replacement for the nuclear weapon -- regardless of the exact analogy we erect, we must begin to move towards it, or risk being consumed by it.

Appendix A

Tracing the Paradigm

This appendix will try to track doctrinal trends since 1941 in order to spot a conceptual region of stasis that the Army appears to return to after transient political, societal or technological change.

The 1941 version of FM 100-5 stated that the Army would fight with large units in close combat, and that infantry was the close combat arm.[89] Additionally, the "...the worth of the individual man is still decisive. The open order of combat accentuates his importance."[90] If doctrine is based on theory, then the locus of theory antecedent to the 1941 version of FM 100-5 would have perhaps telescoped through the following paradigm:

> *Large Armies are the decisive weapon in war. They are decisive through their ability to win the close fight. Within the Army, it is the infantry which is decisive in the close fight and, within the infantry, it is the worth of the individual man which remains decisive.*

By 1954, the proliferation of nuclear weapons threatened to make the Army obsolete. To many of that period, the Army had become ". . an auxiliary service (retained) for ceremonial purposes while the Air Force girds it loins to fight our wars."[91] The 1954 version of FM 100-5, written in the midst of the atomic battlefield debate, maintained that Army forces were the decisive component of the military structure. Further, that while the use of weapons of mass destruction was expected, it would not be decisive. Finally, decisive combat operations were primarily conducted by infantry or armor.[92] Given what we know today about a nuclear battlefield, and what many knew or suspected then, this line of doctrinal reasoning goes far beyond hyperbole. Tracing these doctrinal statements back to their necessary antecedent theoretical roots presents us with a rather reactionary version of the previous paradigm:

Armies are the decisive weapon in war. They are decisive through their ability to win the close fight, regardless of the effects of nuclear weapons. Within the Army, it is the infantry and armor which are decisive in the close fight . Given this, it is the worth of the individual soldier that remains the decisive force.

By 1962, the Army had created largely political responses to the threat of the nuclear battlefield -- primarily in the form of the Pentomic structure and an elevated reliance on tactical nuclear weapons. But the rhetoric and new materiel development designed to retake budgetary high ground were challenged by traditionalists who "...resisted any deviation from the principle that man remained the most important factor in the Army and in warfare itself."[93] The assumptions in the 1962 version of FM 100-5 fail to mention any service as the decisive force. Additionally, the doctrine stated that general war will be characterized by an initial period of nuclear strikes, followed with airborne troops in Airmobile operations.[94] In this doctrine, the Army was required to accept heavy losses in equipment and personnel on a battlefield where weapons of mass destruction caused fires to be superior to maneuver.[95] The 1962 doctrine was a major disruption to the paradigm of war held for centuries:

Nuclear fires are the decisive weapon in war. Within the Army, it is only airborne or heliborne forces which are fast enough to make an impact at all. The worth of the individual soldier is no longer the decisive force.

By the time the 1968 FM 100-5 was written, the Army was focused in two directions -- Europe and Vietnam. A war in Europe would, of necessity, require the Army to use a nuclear battlefield doctrine similar to that sketched out in 1962. The problem was that ". . .the Army hadn't thought through the use of nuclear weapons. . . the Army never related the weapon to the battlefield, and how . . . to fight under the conditions that a nuclear war would create in the forward areas."[96] The Vietnam focus, on the other hand, allowed the doctrine to drift back towards the 1941 paradigm. The 1968 doctrine maintained that there existed a real threat to national security and interests that required a standing army. Additionally, the Army would fight as combined arms, with maneuver forces supported by all other branches. The 1968 manual also mentions the growing political influence on war, and the necessity for the Army to be prepared to cover the globe to fight protracted 'cold war engagements' for the purpose of containment.[97] Thus, while admittedly difficult to construct a single paradigm from this doctrinal mosaic, it might go like this:

> *If nuclear fires are used, they will be the decisive weapon in war. However, if they are not used -- and we can now envision many scenarios where they won't be used -- then the Army is the decisive instrument. Within the Army, the combination of all arms supports the decisive maneuver arms (armor and infantry).*

The Yom Kippur War of 1973 shifted the paradigm yet again. The devastation of the conventional battlefield now began to approach that of the nuclear in terms of casualties and equipment losses. In response to the lessons of this war, GEN William DePuy created a paradigm that represented the predicted battlefields of West Germany. Battle would be won by the side that could service targets best on a countryside with 1200 meter intervisibility. The locus of decision was the ability to aggregate enough technological force ratio superiority to win the target servicing ratio fight.[98] Additionally, the first fight <u>had</u> to be won both to allow reinforcements to reach Europe and, perhaps, to forestall the use of NATO's tactical nuclear weapons.[99] Within this severe target servicing paradigm, the system with the most rapid, accurate, and lethal anti-armor capability would be key. For this reason, the 1976 FM 100-5 held that the tank was the most important weapon in land combat.[100] The paradigm that emerges from the doctrine retreated from both the impact of nuclear weapons and the importance of man on the battlefield.

> *We envision one primary scenario where the quantity and quality of materiel aggregate into the locus of decision. This locus is the ratio of target servicing at close range. The Army is the only instrument capable of creating this decisive effect.*

Within the Army, the combination of all arms supports the decisive target servicing arm (armor).

The 1982 and 1986 versions of FM 100-5 reflected not only an institutional rejection of GEN DuPuy's vision, but also a renaissance in military thought. The doctrine linked the levels of strategy, operational art, and tactics -- as well as offering useful conceptual notions of a battlefield framework and battlefield operating systems. Within this renaissance of thought, however, a locus of decision can still be detected - ". . .the ability of Army units to fight. . .remains critical to the national survival."[101] Additionally, we note that the locus of the operational level, or the campaign ". . . is the identification of the enemy's operational center of gravity - and the concentration of superior combat power against that point."[102] At the next level down, we note that battles determine the course of the campaign. Within battles, while deep and rear operations are critical, "Close operations bear the ultimate burden of victory or defeat."[103] Additionally, man's relationship to success in battle is well defined - "When physical strengths are nearly equal, the moral qualities of . . .both soldiers and leaders are always decisive."[104] Thus, as we 'peel the doctrinal onion,' we again find, at its center, a paradigm whose locus rests on close battle and the worth of the individual.

Armies are critical to national survival. They are decisive through their ability to apply power over the land. Victory in battle is key, and the decisive element within the battle is the close fight. It is the will and vision of the commander that animates the close fight, and often the moral qualities of man are decisive.

Appendix B

Key Terms

AI/MPP: Artificial Intelligence / Massive Parallel Processing is the current name of the analytical portion of the Treasury Department's knowledge engine. The term 'Artificial Intelligence' (see below) refers to the fact that much of the data analysis is performed by computer algorithms specifically designed to replicate part of the human thought process. The term 'Massive Parallel Processing' refers to a computer hardware architecture that increases the speed of the analysis. It involves dividing any computational task into discrete components, and then feeding each component into its own separate processor at the same time.

Artificial Intelligence: An umbrella term that describes a group of advanced computer science technologies aimed at imitating certain aspects of human thinking; The term encompasses such diverse areas as expert systems, natural language processing, computer vision, machine learning, and robotics.

Causal Relationship: A statement describing the connection between two events -- one of which is the antecedent cause of the second event. This second event is known as the effect. In many cases, one effect may have several causes. In those cases where the knowledge of the causal events is used to precisely predict the effect, we categorize the phenomenon as 'deterministic.' In those cases where the knowledge of the causal events can only be used to provide a probability of a certain outcome, we categorize the phenomenon as 'stochastic,' or 'probabilistic.' In the cases where the knowledge of causal events provides no clue as to the form of the final event, we categorize the phenomenon as 'chaotic.'

Closed System: A closed system of knowledge or reasoning is one where all cause and effect relationships are known, and all phenomena are deterministic in nature.

Data Pipe: A network of wire, fiber-optic, or radio communications that are able to transfer data at relatively large rates. The rates are measured in throughput, which is an expression of 'bits' per second.

Database: A Database is a combination of a computer program and an electro-magnetic storage medium. The computer organizes and then stores discrete pieces of data according to a user-defined relationship. The computer software is then capable of extracting the data according to a variety of user- prescribed queries. There are three primary types of data bases: Flat - in which data is simply stored in a sequential manner with no other structure; Hierarchical - in which data is stored according to a 'tree-like' structure that arranges the data according to a single attribute; Relational - which stores data with links which connect all or many attributes of a data record to similar attributes of other records.

Expert System: A computer system whose goal it is to make decisions or plan as well or better than experts in a particular domain. Expert systems are created by joining computer programmers and domain experts into a common 'knowledge engineering group' which examines and then codifies all the assumptions, heuristics, and knowledge associated with a particular task.

Hot Site: A second, or backup, storage area where the computer files of large businesses or universities are duplicated and stored. A hot site is always contracted by any institution whose data archive size exceeds its ability to profitably 'back up' on a regular basis.

Information Mining: A process of searching through large numbers of separate data storage facilities to extract information that impacts on the decision-making process.

Internet: A collection is a "worldwide collection of interconnected computer networks, ranging from large networks, such as the National Science Foundation Network(NSFNet), which is a U.S. 'backbone' network, to medium-sized networks, such as the New York State Education and Research network (NYSERNet), to small local area networks (LANs) found on most university campuses and throughout many commercial firms and public institutions."[105]

Knowledge Engine: The 'knowledge engine' envisioned by this monograph is a consolidation of several data-processing technologies: first, a large number of storage sites for information in the form of digital data bases or text; second, a data transmission network that connects these information storage sites; third, an advanced form of search and retrieval software that can locate relevant electronic data and return it to a central location; finally, a collection of expert system and artificial intelligence routines that will make sense out of the retrieved data.

Machine-Learning: A subset of artificial intelligence which generally refers to the ability of a program to discover or learn information on its own. In essence, a program capable of machine learning is capable of discovering new rules or patterns by analyzing a set of examples.

Megabits: A common measurement of computer data volume. As an example, this forty-page monograph contains over 16,000 words and 107,366 characters. Each character takes one byte to store, and a byte is usually equal to 8 bits (each bit is stored either as a zero or a one). Thus, this monograph is equal to about 1.3 megabits of data volume. A 400-page book would equal roughly ten times the data volume required to store this monograph.

Modem: A communications device that enables digital data to be sent over phone lines as a rapid series of tones. Modem throughput is measured in terms of data volume per unit of time.

Network 'Backbone': A communications link (data pipe) that carries the majority of data between users in a network. In the case of Internet, public funding allows the purchase of dedicated data transmission lines that currently function at a throughput of 45 megabits per second (equal to 4-5 hardbound books per second). The high throughput lines normally connect the largest computer facilities in the network.

Natural Language Processing: Is a subset of artificial intelligence that deals with understanding spoken or written language. A computer program with natural language processing ability applies an expert system of grammar- and syntax-based rules to extract processable information from text or speech.

Parallel Processing: Most desktop computers use the traditional 'von Neuman' sequential process of computation. This process divides the overall task into discrete operations, and then performs each operation in sequence. It is now widely recognized that many tasks can be performed by parallel processing. This process divides the overall task into discrete operations, and delivers each task to a separate central processor. Thus, hundreds or even thousands of central processors can be linked together on a common task, and perform that task much faster.

Reduced Instruction Set Computing (RISC): Central processing units (CPU's) receive their instructions from two places: the program and the internal operating system. Within the last 5-10 years, computer designers have created a variety of methods to reduce the number of internal steps necessary to perform a CPU-level task. One of these methods is to design CPU's that use fewer instructions in both the internal operating system and the external program. These new CPU's, and the software that accompanies them are referred to as RISC processors.

T1 / T3: 'T1' is one type of standard data pipe used in the United States and other countries such as Japan and Korea. The T1 standard has a throughput of 1.544 megabits per second (which is the throughput needed to transmit this monograph in less than one second). The more-advanced T3 standard has a throughput of 45 megabits per second (which can transmit 30 monographs per second). Legislation is now pending to establish a National Research and Education Network that will have a backbone throughput of between 1 and 3 gigabits per second. Europe uses a standard known as 'E1,' which differs from T1 in throughput and protocols.

TCP/IP: Transmission Control Protocol / Internet Protocol was developed by the Defense Advanced Projects Agency (DARPA) in the late 1970's. TCP/IP provides the Internet with a common data and addressing format. Without such a standard, large data networks would be largely impossible.

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