The Agility Advantage:
A Survival Guide for Complex Enterprises and Endeavors

Dr. David S. Alberts

Last revised June 27, 2011

Chapter 7: The Information Age

Origins of the Information Age

It seems to be taken for granted that we, at least in the developed world, are currently in the information age. It also seems to be common wisdom that despite the dramatic changes that have taken place as a result of the widespread availability of sensors, communications networks, and computers (desktops, laptops, tablets, PDAs, smart phones, point of sale equipment, etc.), we are far from fully realizing the potential of commercially available, information-related technologies. The organizations to which we belong are still in a process of adapting themselves. As a result, we are far from fully realizing the potential power of the information that is readily available.

While it is certainly the case that we have yet to fully exploit the opportunities presented by existing information technologies, it is becoming more and more apparent that what most people think of as the information age is rapidly being transformed into a new age. To understand why this is the case, it is necessary first to review the origins of the information age and its defining characteristics in terms of means, limits, and self, and compare these to the emerging realities of the 21st century. This section focuses on the nature of the information age while the following section introduces and provides a name for this new age.

Some claim that the information age dates back to the 19th century and the invention by Samuel Morse of the telegraph.[1] By this logic it could also be claimed that the information age dates back to the invention of the printing press in 1440 by Johannes Gutenberg. Or indeed back to 888, the earliest known example of block printing, the *Diamond Sutra*, a Buddhist scripture. These inventions involve improvements in our ability to capture (record for later use) and disseminate information. Humans have always needed information. Some information could be directly obtained from organic

[1] This claim was made in an exhibition at the National Museum of American History entitled *Information Age: People, Information, and Technology* (http://photos.si.edu/infoage/infoage.html). I found a reference to this exhibit when I googled information age to see what some of the different perspectives were. Wikipedia was the first item that appeared, and incidentally shared the view that the information age dates to the telegraph along with the above. Our book *Information Age Anthology* (Papp and Alberts) was the fourth item that came up and the first reference to a book on the subject. The third item that appeared is a magazine called the *Information Age*.

sources, one senses, and when they were invented, directly from various sensors (e.g., spyglasses), while other information could only be obtained second hand from others, or later on from books, and more recently from online sources. Thus, humans have always needed to capture information, communicate it to others, store it, and provide a means of accessing stored information for a wide variety of purposes.

Over the years there have been many inventions that have continued to improve information reach (ability to provide, at least a subset of available information to others that are not synchronous in time and space) and richness (the capability to represent information).[2] Until the information age however, an individual's access to information that could not be directly sensed or communicated (that which had been previously captured and stored) and to other individuals (as sources and stores of information, knowledge, expertise, and perspective) was, in practice, highly constrained by the costs, time, and distance. In addition, one had to pay a large penalty in reach to gain richness, and vice versa. Figure II-1, Pre Information Age Richness v. Reach Tradeoff, depicts this penalty in the form of a concave transfer function.

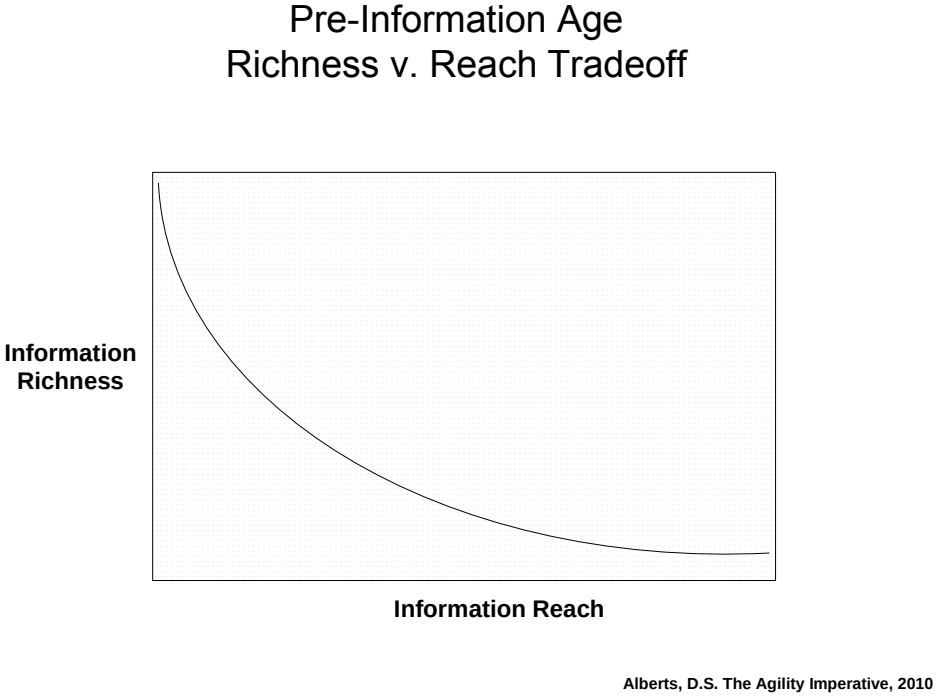


Figure II-1

[2] See *Understanding Information Age Warfare*, p.46, for a discussion of richness and reach. These concepts were introduced in Evans and Wurster's book *Blow to Bits* to explain how the internet has changed the economics of information. In UIAW we added a third dimension, the quality of interactions which is the key enabler of the age of interactions to be discussed in the next chapter.

As information and communication technologies continued to improve, it became not only possible to improve both reach and richness simultaneously, but to do so affordably. These developments changed the economics of information and the shape of this transfer function from a concave to a convex curve (see figure II-2, Information Age Richness v. Reach Tradeoff).

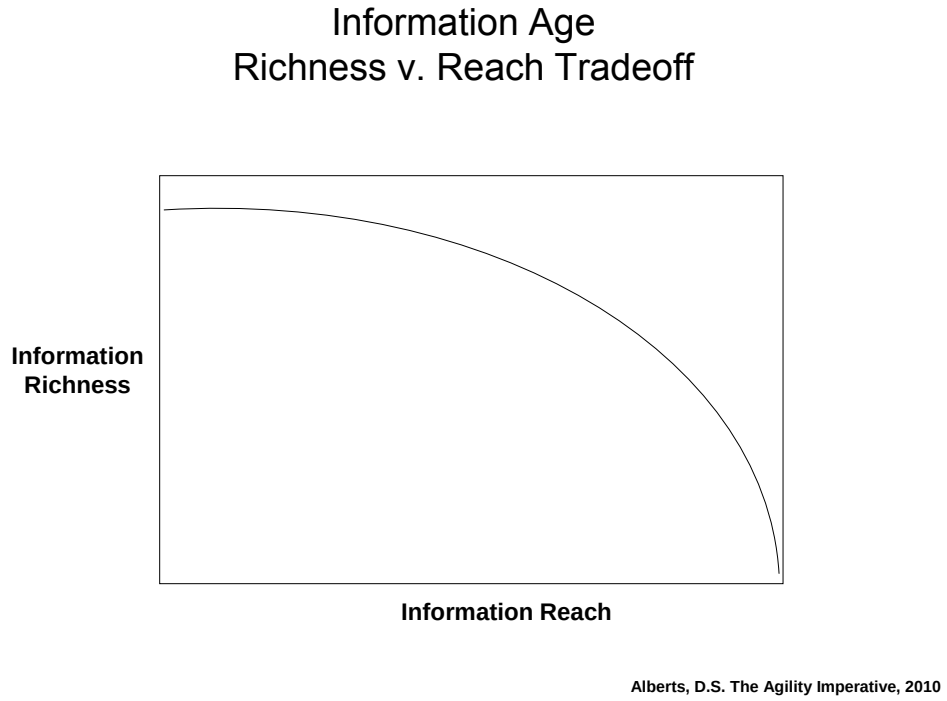


Figure II-2

The beginning of the information age (or indeed any age) does not occur with an invention or set of inventions. Nor does it occur when these inventions become widely available. Rather ages begin only when the changes that were enabled by a set of technologies are manifested. Ages begin when business as usual changes. There is a lag between the development of new technologies and capabilities and the onset of a new age; in this case a lag between the inventions that affected the capture and communication of information and the dawning of the information age. This lag amounts to the time it takes to commoditize and disseminate a technology or set of technologies, have them adopted, and then for the changes enabled by these capabilities to be manifested in a variety of adaptations including changes in micro and macro economics, politics on a variety of scales, and individual and societal behaviors.

Arguably the delays involved in exploiting new technologies have diminished with each successive age. The information age thus began not when information and

communication technologies were invented, but rather when success in various arenas no longer depended on an industrial model. When, for example, success in business no longer depended on significant amounts of land, labor, or capital.

Information Age Defined

There have been many definitions of the information age. The following are a few that are representative of the commonalities and diversity of the definitions that have been offered.

> a period beginning in the last quarter of the 20th century when information became easily accessible
> —wordnetweb.princeton.edu/perl/webwn
>
> characterized by the ability of individuals to transfer information freely, and to have instant access to knowledge that would have been difficult or impossible to find
> —en.wikipedia.org/wiki/Information Age
>
> a form of culture where electronics joins members of diverse cultural backgrounds together. Greater quantities of information than ever before are available to individuals, yet certainty about the way systems operate is less and more subject to question
> —oregonstate.edu/instruct/anth370/gloss.html
>
> the current stage in societal development which began to emerge at the end of the twentieth century. This period is marked by the increased production, transmission, consumption of and reliance on information
> —cyber.law.harvard.edu/readinessguide/glossary.html
>
> Global social organization. Automation increases efficiency in manufacturing…Information based industries arise.
> —infinicorp.com/VEX/appendix/technology-classification.htm
>
> the future time period when social, cultural, and economic patterns will reflect the decentralized, nonhierarchical flow of information
> —www.globalsecurity.org/military/library/policy/army/fm/3-61-1/gloss.htm

Definitions of the information age, like the definitions of previous ages, tend to focus on either technology, society, or both. Some definitions reflect a belief that technology drives society, some the reverse, and some that technology and society changes are inter-related. In the mid-1990s, at the request of the then president of the National Defense College, this author embarked on a project to develop (with co-editor Daniel S. Papp) a multi-volume *Information Age Anthology*[3] to explore the nature of the information age and create source material for educational institutions who it was felt were not adequately focused on these issues. In our preface to the first volume, we identified complexity and change as the defining characteristics of the information age. This was an acknowledgement of our discomfort with the increased complexity and the accelerating pace of change we were experiencing. We believed that a sea change was upon us. However, the complexity and change we were reacting to is still bedeviling us more than a decade later. As we shall see, the information age has sown the seeds for even greater complexity and an even more rapid pace of change even as it has given us new tools to cope with these. Uncomfortable levels of complexity and change are not unique to the information age. Rather they are a signal that a new age may be dawning.

In the introduction to this anthology, the following definitional description of the information age is provided.

> The Information Age. That is what many pundits, writers, and analysts have already labeled these concluding years of the twentieth century and the beginning of the twenty-first century. This characterization of our time is based on the widespread proliferation of emerging information and communications technologies and the capabilities that those technologies provide and will provide humankind to overcome the barriers imposed on communications by time, distance, and location and the limits and constraints inherent in human capacities to process information and make decisions. Advocates of the concept of the information age maintain that we have embarked on a journey in which information and

[3] This anthology is available at the DoD CCRP website www.dodccrp.org. The links to the three volumes are: Volume I – in four parts Part 1 - Information and Communication Revolution; Part 2 - Business, Commerce, and Services; Part 3 – Government and Military; Part 4 – International Affairs http://www.dodccrp.org/files/Alberts_Anthology_I.pdf Volume II – National Security Implications of the Information Age http://www.dodccrp.org/files/Alberts_Anthology_II.pdf Volume III - The Information Age Military http://www.dodccrp.org/files/Alberts_Anthology_III.pdf

communications will become the dominant forces in defining and shaping human actions, interactions, activities, and institutions.

This description of the information age incorporates most of the ideas contained in the examples of the definitions listed above and more. Some of the key ideas contained in these various views of the information age are:

1. Technologies that make it easier to capture, store, access, and exchange information are becoming ubiquitous.

2. These capabilities are making distances (physical, economic, cultural, social) less relevant.

3. As a result, we are able to have access to more information from a greater variety of sources.

4. These capabilities will to some extent overcome human information processing limitations.

5. These capabilities have and will continue to change our institutions and societies.

Clearly the nature of the information age is difficult to adequately capture in just a few words. To understand the import of an age, one needs to take a systematic look at the changes to means, limits, and self.

Information Age Means

In economic terms, the information age involves a re-alignment of the sources of value—the raw materials needed for value creation. Of the traditional means of production (value-creation) land, labor, and capital, the creation of wealth in the information age no longer depends on land nor, for that matter, on physical labor. Capital is still required to start up, but the amount required is far less relative to individual means than ever before. The human component in means has shifted from a physical contribution to a cognitive contribution. The human component in means has shifted from a physical contribution to a cognitive contribution that is measurable not in terms of physical effort or work (calories), but rather means in ideas. In the information age, firms succeed by leveraging information and communication technologies (as raw materials) to amplify an idea to create value on a significant scale. This is true even if the company is producing a concrete product like concrete.

If one looked at the composite of say the Fortune 100 companies and classified them by the nature of their products and business models, one would find a point in time when a historic change occurred, when the number of firms that had products that depended directly on information and communication technologies (providing means) and/or firms whose business models depended on ideas enabled by these technologies to create competitive advantage became significant. This would include not only those firms that produced and sold the direct products of these technologies (e.g., Xerox, IBM, AT&T) but those firms who created value by leveraging these technologies.

We'll look at examples from Cemex and FedEx. Cemex revolutionized the cement industry by breaking with the tradition that required job site to schedule cement truck deliveries well in advance (sometimes several days). This allowed the cement companies to optimize their production and delivery schedules by forcing job sites to play it safe (since they had to pay for a delivery whether or not they were ready to accept it—cement has a brief shelf life once in a mixer). Good for the cement company, not so good for construction companies. Cemex used information and communication technologies to enable a change in this business model that allowed job sites to order in near real time. In the company's own words:[4]

> Our new web-based inventory management system allows our customers to focus on their construction projects, without worrying whether there's sufficient cement in their silos. This new system automatically communicates and coordinates cement deliveries among our customers, our carriers, and us; enables us to monitor, replenish, and optimize cement-inventory levels at our customers' ready-mix plants; and keeps our customers apprised of the status of their cement deliveries.

FedEx differentiated itself by providing not only improved shipping services, but by also providing something new: information about the status of shipments. With the success of FedEx, tracking information is now the norm; that is, it is now business as usual in the shipping business.

A business model describes an entity's approach to creating value to gain or maintain a competitive edge in a particular space. In order to recognize when the business model of an organization, an industry, or a governmental agency is an information age model, one needs to look at how a better product or service, reduced time to market, or a better

[4] See Cemex website (http://www.cemex.com/ps/ps_cs.asp).

price (or some combination of these value-enablers) is being achieved.[5] Information age business models[6] create competitive advantage in their ecosystems by developing information and communications technologies and by leveraging these technologies. In order words, they sell information, use information to enhance their products and services, or provide the means to create and distribute information. These entities are creating competitive advantage by using an information age model instead of an industrial age model and, as a result, are dominating their competitive spaces making other entities adapt to remain competitive.

The information age is thus about information becoming a strategic asset. This new reality extends far beyond the world of business where value can be reduced to traditional economic measures like return on investment or market share. For example, in the world of geo-politics, the information age makes it possible for non-state actors to possess sufficient means, using the power of information to influence large numbers of people, to rival state actors. Recent events in Iran, Tunisia, and Egypt show the power of social networking to mobilize large numbers of individual actors to challenge the power of the state. These efforts do not always succeed in effecting changes, at least immediately, but they are having a profound effect on the relationship between governments and the governed. They also demonstrate the increasing degree to which events are inter-related. The popular uprising in Egypt was clearly influenced, perhaps even enabled, by the events in Tunisia.

Information Age Limits

The shift from the physical to the virtual has profoundly altered constraints related to time, distance, weather, geography, and mass. Information, once only available in a physical form, can now be stored and moved virtually. The technologies associated with information have also had a dramatic effect on both the economics of information and in turn, on the costs involved in every link of the value creation chain. More affordable computers and less expensive communication costs result in the wider dissemination of these capabilities creating opportunities to reach people, improve processes, and create new markets. This makes it possible for almost everyone, not just governments or large corporations, to have instant access to information and to effectively communication and interact with an arbitrarily large number of other individuals, regardless of distance or governmental interference. Previous limits or

[5] NCW Figure 3 page 31.
[6] See NCW chapter on Information Age Organizations pp. 25-51 for a discussion of how Information age Organizations were found to be creating competitive advantage.

constraints that involved a lack of relevant, accurate, timely, and assured information have been relaxed or eliminated.

Thus, the new economics of the information age have freed us from previous limits on means; that is, lower costs have increased the availability of information and communication capabilities. This has offered opportunities to improve, and indeed, develop new value creation processes. The book *Network Centric Warfare* contains a discussion of how commercial organizations were (in the 1990s) leveraging information age technologies to create value in new ways. These included one or more of the following: creating and leveraging improved awareness and shared awareness, substituting information for mass or human resources, creating virtual organizations, virtual collaborations, virtual integration, self-synchronizing distributed efforts, precision manufacturing and retail, and focused logistics. Each of these was made possible by the relaxing of one or more constraints or limitations that existed prior to the information age.

Information Age Entities

The information age is not only about the opportunities provided by information-related technologies, but about the conditions and problems that their adoption and utilization create. Two of the challenges that have frequently been discussed are 1) changes in the amount of time decision-makers have to make decisions prompted by the widespread awareness of events as they are unfolding as a result of the availability of information and 2) the ability of others to obtain and leverage the latest information age technologies. In fact, cutting-edge technologies are often obtained and used by small groups well before larger, more bureaucratic organizations can acquire them. As a result of 1) decision-makers certainly feel pressured to act, and as a result of 2) may actually need[7] to respond more quickly to situations that are increasingly more complex.

The democratization of information has created pressures to act ever more quickly. The sights and sounds of disasters and expectations (perhaps somewhat unrealistic) of rapid response is putting increasing pressures on governments and other institutions to move ever more quickly. Whether it be in disaster relief endeavors such as the 2004 Asian tsunami, the Katrina hurricane along the Gulf Coast of the United States in 2005, or most recently an earthquake in Haiti in 2010.

[7] Whether they actually need to or not depends on the particular circumstances, but there is certainly a perceived need to respond more rapidly.

While information technologies and their widespread availability have indeed created pressures to respond more rapidly to events, they have also provided enhanced means to do so. This is because of a combination of the following: the time it takes to become aware of an event is reduced as information can travel across the globe almost instantaneously; analysis and consultations require less time, aided by information processing and display capabilities, even if the participants are geographically dispersed; the lag time between a decision and a response can also be reduced. However, there is a limit to one's ability to decrease response time while maintaining the ability to make good decisions. This limit is a function of the nature and capabilities of self. Entities need to change not only what they do and how they do it, but they may also need to change who they are to take advantage of the opportunities created by information age concepts and technologies.

In fact, organizations have not only used information age technologies to improve their products and services, but, to varying degrees, have also changed themselves and their relationships to one another. In political or geo-political terms, these changes are reflected both in their instruments of power and in the relative significance of various actors on the world scene. In organizational terms, it is not only about their products and services, but also about the form and structure of their organizations. For each of us, on a personal level, the information age is about a change in the ways that men and women conduct their affairs.[8]

Information age capabilities have hastened and broadened a movement to outsourcing. It is now not uncommon to find many individuals who may seem to outsiders or even to some insiders to be employees of an organization who are actually not employees but who are either self-employed contractors or who work for a company to whom the work has been outsourced. These individuals may wear a corporate uniform, they may sit in offices along with actual company employees, and they may be, in fact, a majority of the work force. Outsourcing clearly increases the complexity of self but also has the potential for increasing agility. What impact does this have upon the organization and upon organizational structures? Does it alter the culture? Does it affect trust relationships? Does it give rise to a different sort of informal organization? Is outsourcing no longer a choice but a necessity to compete? While the answers to each of these questions is undeniably yes, it remains for us to fully understand the nature of the changes that outsourcing causes to organizations, and how these changes affect an entity's agility.

[8] Taken from the preface to Volume I of the *Information Age Anthology* (Papp and Alberts, 1997).

The information age has also affected the most senior positions in organizations, those designated as Chief (insert blank) Officer. These top-level positions reflect what an organization thinks is existentially important. Hence, the arrival of chief information officers is a signal of the arrival of the information age and the duties that they are assigned as a reflection of their view of the nature of the information age. While the first chief information officers, or CIOs, may have been appointed in the 1970s,[9] the information age would not be well-established until it became the norm for firms to have a CIO. Early CIOs were focused almost exclusively on information technology (IT)—a reflection of both the cost of these investments and a general lack of understanding how best to get a proper return on these investments. At that time, computers were very expensive (mainframes) and needed to be managed centrally.

The introduction of the personal computer (PC) in the early 1980s changed the IT landscape. As communication networks became digital (routers instead of switches), communication and information processing technologies and the systems they created began to merge. As a result of these advances, the role of CIOs has evolved over time. By the last decade of the 20th century, many CIOs were responsible for far more than IT acquisition and maintenance. How an organization views the role and responsibilities of the CIO is an indicant of what age the organization is in. Organizations that have CIOs that are focused on IT and not information, have in reality C*IT*Os, and are still in the industrial age. Those whose CIOs actually have power over the way organizations create and leverage information, have moved into the information age.

In 1996, Congress passed a law that required all federal agencies to have a CIO that reported directly to the head of the department or agency.[10] This legislation was focused primarily on both improving the acquisition, use, and disposal of information technology.[11] However, this legislation also requires heads of executive agencies to establish goals for improving the efficiency and effectiveness of agency operations and, as appropriate, the delivery of services to the public through the effective use of information technology.[12] Some have interpreted this legislation to mandate an information age transformation of the federal government because it also mandated the heads of executive agencies to analyze the missions of the executive agency and, based upon the analysis, revise the executive agency's mission-related processes and

[9] http://www.eds.com/services/whitepapers/future_cio.aspx

[10] Later collectively known as Clinger-Cohen Act, Congress passed the Information Technology Management Reform Act of 1996 and the Federal Acquisition Reform Act of 1996.

[11] Information Technology Management Reform Act of 1996 – Section 5112 Paragraph B Use of Information Technology in Federal Programs. This Section enumerates the responsibilities of the Director OMB.

[12] IBID, Section 5123 Performance and Results-Based Management, Paragraph (1).

administrative processes before making significant investments in information technologies that are to be used in support in the performance of those missions.[13] This language takes pains to caution executives not to simply automate business as usual, but to rethink the way they deliver their agency's services in light of the opportunities provided by IT.

This legislation reflects an information age expectation that decision-making and business processing can be greatly improved by information technology. Organizations in both industry and government have invested large amounts of their scarce funds in building infostructures that make it possible for individuals throughout an organization to be better informed and better connected. The ability to improve situational awareness at all levels of an organization naturally leads to two questions. First, how could improved awareness benefit the organization? Second, is it worth the investments that have been and continue to be made? To answer these questions, one needs a conceptual framework and a metric of value for information.

Value of Information

If the information age is all about the relative importance of information as a means, and the impact that this increasingly important source of wealth and power is having on entities, then it stands to reason that it would be useful to be able to measure the value of information. A measure of the value of information could be used to determine the value-added by a new or improved information-related technology or by an adaptation of process or organization.

Part I discussed the characteristics of problem difficulty. What made one problem more difficult than another, one situation more daunting than another? In this discussion, the point was made that situation, tasks, and problems all involve choices or decisions. Success in these endeavors requires that correct decisions are made in a timely manner. An approach to measuring the value of information is to ascertain the impact of information on the quality of decision-making.

Decision theory[14] provides an approach to measure the value of information by examining its impacts on the expected value of a given decision (or set of decisions).

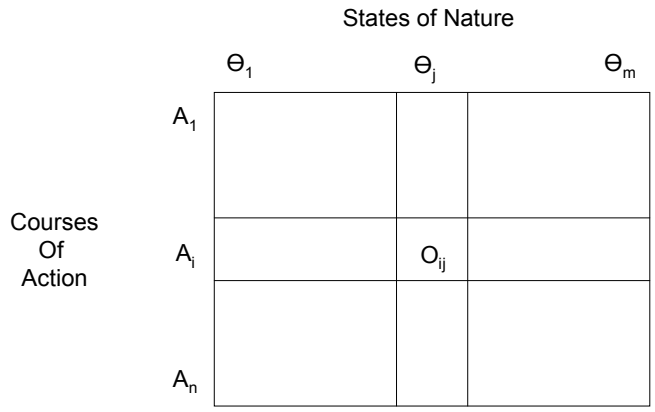
---

[13] IBID, Section 5123 Paragraph (5).

[14] Two sources for those who want to become familiar with traditional decision theory are Miller, D. W. and Starr, M. K., *Executive Decisions and Operations Research*, Prentice Hall, and Raiffa, H. and Schlaifer, R., *Applied Statistical Decision Theory*, Wiley.

The theory approaches decision-making rationally by estimating the expected value of each of a number of courses of action. A decision-theoretic approach to decision-making is based on the problem formulation provided in figure II-3 below:

Decision-Theoretic Problem Formulation



$$\max EU(A_i) = \Sigma\, p(\Theta_j)\, U(O_{ij})$$

Where

A_i = i^{th} course of action

Θ_j = j^{th} state of nature

O_{ij} = outcome that occurs if one takes the i^{th} course of action is taken and the j^{th} state of nature occurs

$p(\Theta_j)$ = probability that the j^{th} state of nature will occur

$U(O_{ij})$ = utility of the ij^{th} outcome

Σ = sum over all j

$\max EU(A_i)$ = Find course of action with the maximum expected utility

Figure II-3

An information-centric view of the world argues that information is a strategic asset and that better information from a larger variety of sources contributes to improved decisions by improving the ability to:

1) Identify a more complete set of courses of action or options to choose among.
2) Identify a more complete set of possible states of nature.
3) Estimate the probabilities associated with various states of nature.
4) Predict the outcomes that could be expected to occur.
5) Understand the utility of various outcomes.
6) Calculate expected utilities.

Improved decision-making (better, faster, and more efficient decisions) is a critical link in conceptual models and value chains dating from the mid-1970s. Figure II-4 depicts the OODA loop that dominated military command and control analysis circa 1975.

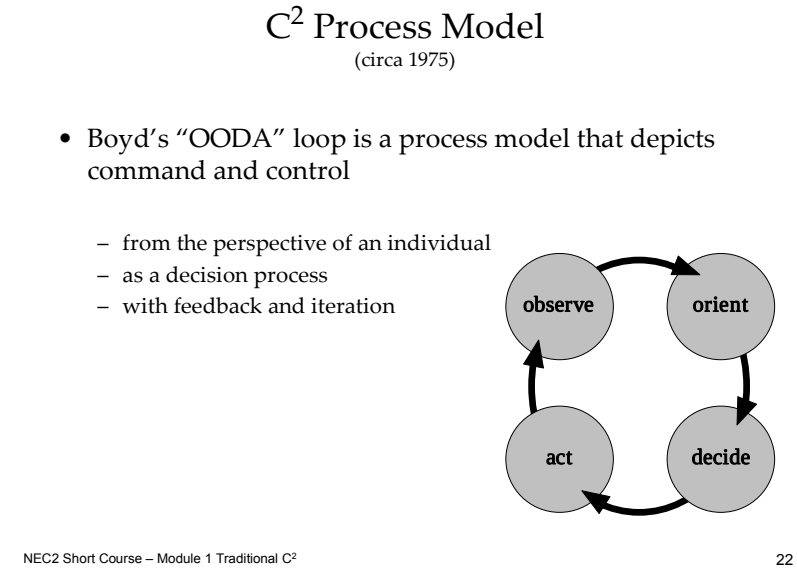


Figure II-4

This simple feedback process model clearly implies a value chain where better observations (improved quality of information) leads to better awareness of the situation (orientation), which in turn leads to better decisions and more effective actions. In this conceptualization of command and control, it is the existence of feedback that corresponds to control. Implicitly, it is also an instantiation of the commander-centric view that prevailed at the time and, to some extent, still persists despite the harm it has caused organizations.

Figure II-5, dating to the same time period, presents a value model focused on the enablers of decision quality. The model was intended to provide a basis for assessing the value of the processes and systems that support decision-making. Since measuring

decision quality in real-world situations is somewhat problematic,[15] this model also introduced intermediate measures or indicants of decision quality. Readers will note that these indicants are derived from the idea of the decision theory based concept of the value of information.

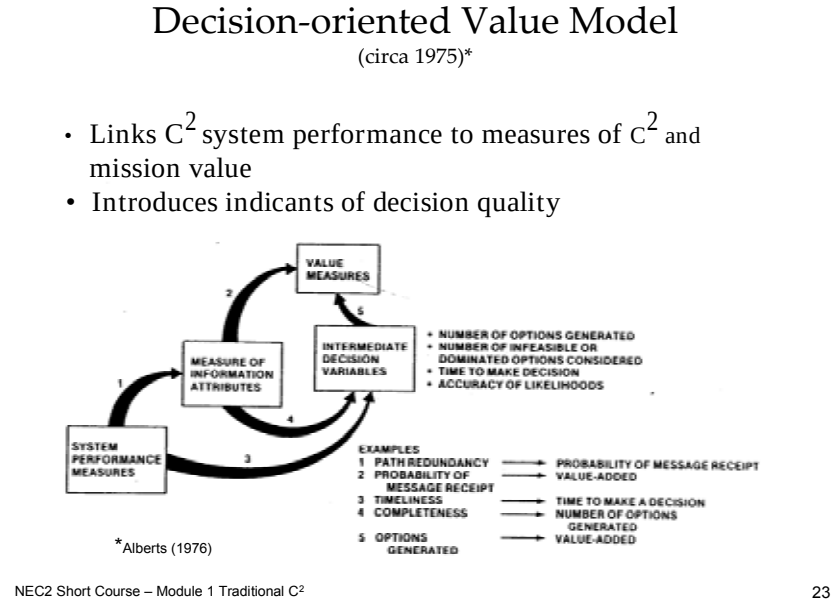


Figure II-5

The quality of the decisions that are made on the one hand is directly linked to the quality of awareness and shared awareness and on the other hand for more effective and efficient actions. Actions, in turn, are linked to the quality of outcomes—the bottom line. Both these views emphasize information and the critical role information plays in decision-making. This focus on the link between information and decision-making is second nature to those who have adopted what they think of as an information age perspective. Unfortunately, such an exclusive focus on the information component of the value chain ignores an equally important enabler of value creation, an enabler that can make an indispensible contribution to not only information quality, but also to an

[15] The most direct method for determining decision quality (correctness, timeliness, etc.) is to know ground truth. Another popular approach is to see what actually happened—if the outcome was a good one, then the decision was considered a good one. Clearly, this does not account for all of the factors that affect outcomes. In fact decisions can be perfect, and things do not actually turn out as well as expected. A better way to measure decision quality is to see if the decision made was the best that could be expected, given the information and knowledge available. This approach also has its problems. All of these require a great deal of information and understanding. The intermediate measures are meant to be used when it is not possible to link with any degree of certain specific decisions to specific outcomes. Given the complexity inherent in the 21st century, this will be most of the time.

organization's ability to leverage information. This enabler, which is central to the new age, will be discussed later in this book.

Based on a belief in the power of information and its critical link in creating value, organizations have invested considerable sums in IT and in building systems to capture, transmit, process, and display information. Whether or not in practice these investments pay off, depends on the ability of organizations to co-evolve their concepts of organization, and their approach to command and control (in military organizations) or management (in civilian organizations). Co-evolution also requires changes to education and training to create the appropriate mindsets, knowledge, and skills.

The following section discusses the efforts of military organizations to affect an information age transformation. That is, to transform the way they are organized and do business so they can better leverage information technologies and information to improve decision-making and the processes that support decision-making.