Chapter 17: Agility Related Hypotheses

Looking at the conceptual model of agility from its *value view* identifies the links in its value chain that connect the characteristics and behaviors of entities to mission outcome measures as a function of circumstances, which allows us to construct an agility map for the entity in question. This value view provides a point of departure in the search for markers of agility. The search for markers involves an exploration of self. Within self, in our case a collective engaged in a complex endeavor, the process view identifies the relationships and interactions that exist between and among individuals, organizations, and infostructure, and suggests that the agility of one entity depends on the agility of other entities.

The statements above about the nature of agility (whether about the links in the value chain or the relationships between and among the agility of entities) are testable hypotheses. To begin with, these hypotheses can be expressed in generic form (without the specification of specific variables to be manipulated or observed). A set of these generic hypotheses are presented below, grouped by whether the independent variable is a characteristic or capability of a system, individual, or organization (group, team, or a collection of organizations).

Generic hypotheses are, in fact, conceptual templates that need to be instantiated in the context of a specific experiment or analysis. As evidence from different experiments and analyses accumulate, these generic hypotheses can be tested and a general theory of agility can be developed. Given the complexities that exist, particularly in the context of collectives in complex endeavors, it will be important to understand not only that a particular hypothesis is supported by the evidence, but under what conditions and circumstances. A number of these generic hypotheses have been instantiated in a set of experiments involving both human participants and agents with a set of context-specific independent variables (the treatments in an experiment) and a set of dependent variables (the measures of value). The results of these experiments will be reported in the next part of this book

Infostructure (System) Agility

The mission of the infostructure is to collect, process, and provide secure and appropriate access to quality information in a timely manner. The potential

agility of the infostructure depends on its characteristics and capabilities. The first two infostructure hypotheses listed below can be used to explore the link between infostructure characteristics and capabilities, infostructure performance, and infostructure effectiveness and efficiency. The agility-related impacts of a variety of infostructure design, implementation, and investment decisions can be ascertained by looking at their immediate consequences in terms of network connectedness and performance. The third hypothesis involves the identification of infostructure-related markers of agility—variables that are links in the value chain that connect infostructure effectiveness/agility to task accomplishment.

Infostructure Hypothesis 1: Network Connectedness Impacts Infostructure Performance

Connectedness is a characteristic of a network and is a property of the links between and among the nodes. As the ratio of links to nodes in a network increases, connectedness increases. A minimum of n-1 links is necessary to ensure that each node is connected to every other node either directly or indirectly. Networks in which there is a path between every node and every other node are called *connected*. Less than n-1 links means that at least one node is not connected to another node. In this case, the network is called *disconnected*. Thus, networks with less than n-1 links must be disconnected. However, simply having n or more links does not mean that a network is connected because some of these additional links may simply create additional paths between and among nodes that are already connected. As the number of links increase,[1] the number of nodes that are directly connected increases.[2] In addition, a connectedness ratio greater than 1 means that, for at least some nodes, there are multiple paths between them. Therefore, connectedness is related to redundancy and therefore, resilience. Connectedness is also related to average path length—the higher the connectedness, the lower the average path length. This could have an impact on network performance in a number of ways. While this hypothesis may seem obvious or even tautological, except in extreme cases, the impact on agility of increased connectedness may be difficult to quantify and will certainty vary as a function of other individual and organizational characteristics and capabilities and approach. To illustrate the impact of connectedness, a series of experiments were conducted that varied in their connectedness to include cases where at least

[1] Assuming they are unique links not simply additional links between two nodes that are already directly connected,

[2] Different paths are not necessarily independent—that is, they may share a link in common. In graph theory terms, this is referred to as edge independent.

one node was disconnected from all other nodes. These are reported on in the next part of the book.

To explore this hypothesis, one needs to specify both a quantitative measure of connectedness and a measure of infostructure performance. There are a number of measures that reflect the degree of connectedness. One measure that takes into consideration extra links is called the *edge cut* and is simply the minimum number of links (called edges in graph theory) that if removed makes a connected network into a disconnected one. Another measure is the maximum number of links that could be removed without the network becoming disconnected (this would be the number in excess of n-1). A third measure, and the one I will use later in the analysis of experimental data, is the ratio of links to nodes. I choose this measure to use because it normalizes the measure of connectedness to the size of the network and also captures the degree to which there are extra links and hence duplicate paths without being complicated.

Infostructures can vary in capability and sophistication and provide a variety of information- and communications-related services. In addition, to providing basic communications connectivity, infostructures may provide a number of value-added services that either enhance the quality of available information or the nature of the interactions between and among individuals or organizations. Various measures of infostructure effectiveness reflect the degree to which these services are provided. In figure IV-17, there is a box labeled access that serves as a bridge between the infostructure and the value model whose output is a measure of task accomplishment. Therefore, one measure of infostructure effectiveness that should be developed is the degree to which the information available was in fact available to the individuals and organizations that needed the information. There are a number of factors that can affect this, for example, the degree to which information is discoverable. Given that the quality of available information is both a direct and indirect function[3] of infostructure capabilities, this would also be a useful measure, although some care needs to be taken to identify the reasons for observed changes in this measure. The ability of an infostructure to enforce policy is also an important measure.

Infostructure Hypothesis 2: Network Performance Impacts Infostructure Agility

[3] Direct because it is a function of collection and analysis capabilities. Indirect because it is a function of both access to information and the interactions between and among individuals and organizations.

Network performance measures include throughput, latency, delay, and jitter[4]. Throughput is a measure of how much information can transit the network while the other measures are related to the time it may take for a signal to go from one node to another and the variations in the time delays. Network performance can be adversely impacted in a number of ways. For example, if the network is overloaded or is degraded by conditions or has suffered damage, throughput will be reduced and delays increased. Uncertainty regarding the probability of messages getting through will also increase. When there are long messages involved (many packets of data), it is possible that a large variation in the delays (jitter) can result in out of order packets (or even short messages) that can have an impact in its own right. Clearly, network performance is also related to connectedness as a function of the alternate paths available. Given that the performance of a network can vary considerably over time and that its performance is related to task-generated activity, it requires extensive network data collection (instrumentation) and understanding of the tasks that load a network to be able to predict the relationship between performance and task accomplishment.

Having developed measures to quantify network connectedness, network performance, and infostructure effectiveness, all that remains is to identify the ways in which circumstances should be varied to ascertain if these changes in circumstances have a significant impact on infostructure effectiveness and hence, by definition, on infostructure agility. Included in the experiments reported on in the next part of this book are experiments that, to illustrate a change in circumstances, varied the amount of noise in the available information (signal to noise ratio). It was found that the relationships between measures of infostructure characteristics and performance and task accomplishment did indeed depend on circumstances.

Among the circumstances of interest is the loss or degradation of a link(s) or node(s) either permanently or temporarily. Infostructures that degrade gracefully and/or can recover quickly from such events clearly are more agile than those that cannot. The loss of links or nodes can be represented by different degrees of connectedness, while the degradation of these can be represented by reduced levels of network performance. Experiments in which links or nodes went down were conducted to illustrate the characteristics necessary to recover from this kind of loss.

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[4] For a discussion of network performance and design there are any number of textbooks. One can be found online at Purdue.edu: http://www.cs.purdue.edu/homes/park/cs422-intro-2-06s.pdf.

Infostructure Hypotheses 3: Infostructure Effectiveness/Agility Affects Shared Information and Information Quality (Individual)

With the exception of the engineers that design and develop infostructures, the performance of these infostructures is not an end unto itself. They exist to support individuals and organizations in the performance of a variety of tasks. This hypothesis links information effectiveness and agility to a mission value chain based on the network-centric value chain that expresses the tenets of net-centricity. If this link and the other links on the value chain are supported by empirical evidence then we would conclude that shared information and information quality (individual) are markers of agility.

Individual Agility

The tasks taken on by individuals reflect their assigned or self-assigned roles, responsibilities, interests, experience, and expertise, as well as their personalities. Virtually all these tasks involve sense-making. The first of the generic hypotheses listed below focuses on the link between infostructure effectiveness and agility and individual effectiveness and agility. The second hypothesis focuses on the relationships between and among individual characteristics and cognitive capabilities and their effectiveness and agility. The third hypothesis involves the identification of markers of agility—variables that are links in the value chain that connect individual effectiveness/agility to task accomplishment.

Individual Hypothesis 1: Infostructure Effectiveness and Agility Impacts Individual Effectiveness/Agility

The most obvious measures of individual effectiveness in the context of a set of sense-making-related tasks are the correctness of the individual's perception, the time required for an individual to develop the correct understanding, and the resources utilized. In some cases, an individual's role and responsibilities will involve more than just reaching a correct conclusion. They may also involve being a team player. Thus, an additional measure of effectiveness, one dealing with the degree to which an individual shares information and interacts in an appropriate manner with others, should be included in agility-related analyses. Otherwise, one may reach the conclusion that an individual is effective when

that individual hoards information and/or passes bad or irrelevant information to others.

Individual Hypothesis 2: Individual Characteristics and Cognitive Capabilities Impact Individual Effectiveness/Agility

To explore the relationships between individual characteristics and capabilities and individual effectiveness, variables that represent specific characteristics and circumstances of interest need to be identified. Some of the characteristics and cognitive capabilities of interest include: propensity to share, task versatility, and cognitive bandwidth. To explore individual agility, variables related to key changes in circumstances that promise to have a significant impact on individual performance need to be identified. These include variables related to the nature of the task (task difficulty, time pressure, and task criticality). It is possible that problematic infostructure performance can be compensated for by certain individual characteristics and capabilities or that desirable infostructure performance levels can be negated by some individual propensities and behaviors.

Individual Hypothesis 3: Individual Agility Impacts Quality of Understanding (Individual), Information Quality (Average), and Shared Information

Given that individuals have historically been the component of organizations that have exhibited the agility required to compensate for the shortcomings of formal structures, processes, and other capabilities and/or unanticipated events, it seems clear that individual agility and organizational agility are closely related. Clearly, individuals that can maintain high levels of awareness and develop correct understandings under a range of circumstances (agile individuals) make a significant contribution to individual effectiveness. However, it is probable that individuals who are agile contribute not only by being more effective themselves, but also by making others more effective as well. Therefore, this hypothesis links individual agility not only to the quality of understanding (which should contribute to individual effectiveness) but also to the quality of the information that is available to others and the extent to which this information is shared. Both these measures are key links in the network-centric value chain and have been shown to create the conditions necessary for self-synchronization. If this hypothesis can be supported by analysis and empirical evidence, then we could conclude improved quality of information and a higher degree of shared information are markers of agility.

Organizational (Collective) Agility

The missions taken on by organizations and collectives are often not a matter of choice but a matter of necessity. As is the case with the tasks taken on by individuals, virtually all of these involve individual sense-making. For organizations and collectives, they also involve shared sense-making. The first of the generic hypotheses listed below focuses on the link between the approach and policies that can be employed by entities to shape and constrain individual roles, responsibilities, and the interactions permitted on the one hand, and organizational effectiveness and agility on the other hand. The second and third hypotheses focus on the interrelationships between information, individual, and organization agility. These generic hypotheses also address the relationship between organizational and collective agility.

Organization Hypothesis 1: Approach/Policy Impacts Organizational Effectiveness/Agility

The location of the organization within the approach space is a matter of policy, although it may be constrained by infostructure capabilities. Organizational effectiveness can be measured by whether or not the mission or task was accomplished and by how long it took to accomplish the mission. If the mission is accomplished, the efficiency with which the mission was accomplished is also of interest. This can be measured by how many resources were required.

Organizational agility is a reflection of the relative effectiveness of different approaches (set of policies) under different circumstances. Circumstances of interest include: the difficulty of the mission or task and the mix of individual characteristics.

Organization Hypothesis 2: Infostructure Agility Impacts Organizational Effectiveness/Agility

Using the same measures for organizational effectiveness just mentioned, this hypothesis explores the combination of variations in infostructure agility (and hence effectiveness) and approach. To determine the sensitivity of combinations of approach and infostructure agility, both should be varied.

Organization Hypothesis 3: Individual Agility Impacts Organizational Effectiveness/Agility

This hypothesis explores the mix of individuals with different levels of agility.

Entity Relationships

Organizations and collectives are composed of a set of entities (individuals, teams, and systems), each of which has a set of characteristics and behaviors that determine its potential and manifest agility. However, the agility of an entity or set of entities (e.g., an individual or a set of individuals) can enhance or constrain the agility of other entities. It is important to understand these interdependencies. The following generic hypotheses address these relationships.

Relationship Hypothesis 1: Individual Agility Can Compensate for a Lack of Organizational Agility

Organizational agility is directly related to the organization approach that has been adopted and the policies and processes being employed. The organization approach selected determines how decision rights are allocated, what interactions are prescribed or permitted, and how information is distributed. These serve to constrain the actions of individuals and teams in organizations and organizations in a collective. However, depending on a number of factors, entities have some degree of discretion that they can use to find a way to get things done. For example, an individual could decide to do a job not assigned or assigned to someone else if necessary, share information with someone that is not on the normal distribution list, try a nonstandard approach, or consult the informal organization. At times, these actions may not be explicitly sanctioned or even explicitly prohibited. In these cases, individuals may risk punishment to get the job done. There is an old Navy saying that *It is better to beg forgiveness than to ask permission*. These behaviors are manifestations of initiative (innovativeness) and without them many organizations would suffer immeasurably. Thus, the willingness of entities to take initiative when necessary could make up for the lack of agility associated with specific organizations' approaches.

Relationship Hypothesis 2: Individual, Organization, Collective Agility Can Compensate for a Lack of Infostructure Agility

A lack of infostructure agility translates into degraded performance under some circumstances and conditions. This generic hypothesis focuses on whether, and under what circumstances, the agility of individuals, organizations, and collectives can compensate for the degraded performance of the infostructure. This generic hypothesis can be instantiated by a set of treatments where one or more of the entities possess one or more of the components of agility (e.g., flexibility). There are numerous possibilities to explore. For example, if a particular mode of communications goes down, interrupting the flow of information between a given pair of entities, one or more of the affected entities could compensate by taking one or more of the following actions:

- revise the objectives of their assignment
- temporize (delay)
- choose another course of action
- change their decision/decision process to account for increased uncertainty
- find a workaround or alternate mode of communication
- change their organization/approach

Relationship Hypothesis 3: The Agility of One or More Entities in a Collective Can Compensate for a Lack of Agility in Other Participants

The maturity of an entity's approach to collective action is a function of how much of the approach space is available to the entity. That is, how many different ways can an entity organize, work with, and interact with, others. The ability of a collective to effectively function is directly related to the combination of approaches adopted by participating entities. Some combinations of organization approaches can lead to dysfunctionalities (an inability to connect the dots or develop shared awareness and shared understanding); while other combinations simply constrain effectiveness or efficiency (serve to constrain the pace of operations), and others get the most out of the capabilities possessed by participating entities (enable synergies).

Given that complex endeavors are both dynamic and complex, the effectiveness/efficiency of each of these combinations may change as the situation changes. This could make what was an acceptable combination at time t unacceptable at time $t + \Delta t$. This then requires that one or more entities switch

organization approach to create an acceptable effective-efficient combination in current circumstances and conditions.