Requisite Agility

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The ability of software-intensive systems or organizations to respond rapidly to changing demand is a key determining factor in their achieving business or mission objectives [Alberts 03]. Because of the primacy of achieving objectives to all organizations—in the U.S. Department of Defense (DoD), civilian government, and industry—understanding of the agility needed to respond to changing demand is a key challenge on the research agenda of the SEI Integration of Software Intensive Systems (ISIS) initiative. The ISIS team is developing the SoS Navigator, a growing set of modeling techniques that offer insights into the relationship between systems or organizational structure and agility.

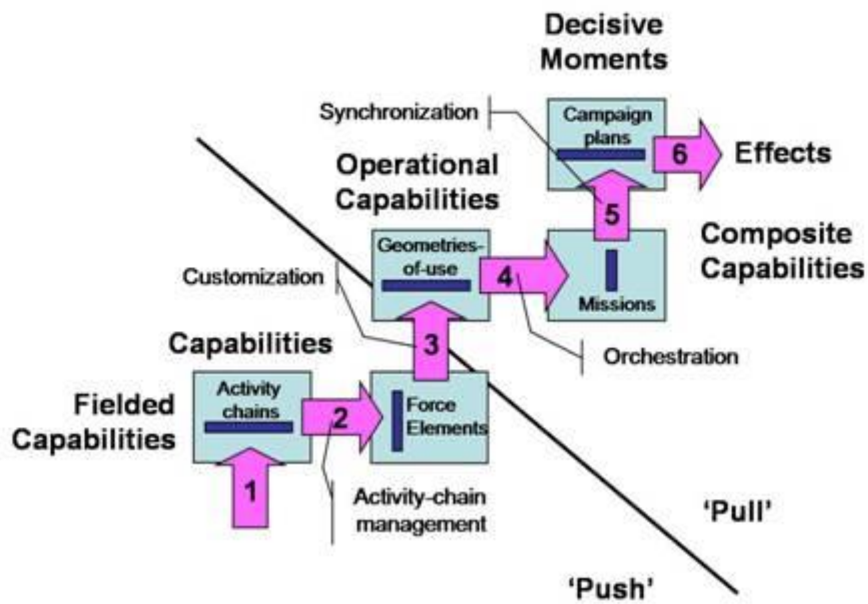

Figure 1: Modeling Requisite Agility

Figure 1 labels the outputs of the various matrix groupings according to a military context; hence fielded capabilities, operational capabilities, and so on. These labels change to fit the domain of interest (e.g., perhaps protocols, modalities, treatment plans, and the like in the medical domain).

The contrast between traditional systems engineering and system-of-systems approaches highlights the different nature of response to demand. Following traditional systems-engineering precepts and practices, a supplier organization composes fielded capabilities—products or services—in response to a requirements-driven process. This activity is represented on the "push" side of Figure 1. Many traditional systems suppliers stop with a push approach, defining their relationship to their customers in terms of supplying fielded capabilities (arrow 2). In such a supply-side model, the use of their products or services to create operational capabilities (arrow 3) and ultimately to accomplish end effects (arrow 6) is left to the customer's organization.

Unlike traditional systems engineering practices, the SoS Navigator approach makes use of distributed collaboration that requires building an explicit awareness of the demand or "pull" implications of the customer's organization. On this *pull* side of the model depicted in Figure 1, composite capabilities (arrow 4) put together by a customer are synchronized (arrow 5) to create the decisive moments required to produce the effects (arrow 6). Keeping with the military context, a decisive moment might be a sequence of events that a force is trying to effect or to prevent. In the medical domain, decisive moments might be a sequence leading to a treatment option such as medication or therapy [Boxer 08]. The composite capabilities are in turn orchestrations or arrangements of operational capabilities (arrow 3).

These orchestrated operational capabilities (arrow 4) hold a special place at the nexus of the supply- side *push* and the demand-side *pull* activities. We call these orchestrations "geometries-of-use." Geometries-of-use are the particular ways in which capabilities need to be put together to meet demand. The variability across these geometries-of-use defines the **requisite agility** of the system of systems—that is, the system of systems is required to provide these geometries-of-use (as specified in the matrix generating arrow 4) to be able to respond to the decisive moments addressed by arrow 5.

Geometries-of-use are the units of requisite agility, due to the pivotal push-pull (supply-demand) paradigm shift that is so critical to our conceptual framework [Boxer 06]. Brewer et al. define requisite agility as the capacity to innovate quickly in the face of rapid technological change [Brewer 06]. They derive it from Ashby's cybernetics work where he defined "requisite variety" as [paraphrasing] "the capacity of a biological system to regulate or adapt to an environment, [and] if the focal biological system is attempting to regulate the behaviors of others in a common environment, then the variety of moves must equal or exceed theirs" [Ashby 63]. Brewer et al. go on to assert from "Ashby's law" that "it is not enough for an agency to have a sufficient variety of moves. It must also be able to execute these moves quickly enough to be effective" [Brewer 06].

Requisite agility is one of the SoS Navigator's fundamental concepts.[1] It allows demand-side behaviors to be arranged according to demand-in-context, instead of around the capabilities on the push side of the model (i.e., capabilities of constituent systems/organizations that are likely to be over-determining or design-time constraining). When the system of systems can support a variety of geometries-of-use on the demand-side, it benefits from an infrastructure that is more flexible and adaptive to anticipated and unanticipated demands. In other words, its infrastructure has the agility needed for its use to be determined closer to runtime.

While it might seem to be a worthy goal, it is not sufficient to have a stockpile of geometries-of-use against the possibility of facing different forms of demand. Rather, it is necessary to have the agility to respond quickly to variations in demand. This is not to say that we are proposing automation of this entire model into a real-time adaptive super machine. We are simply advocating that the socio-technical processes required to respond to changing demand can be described (modeled) and better equipped to handle change if the organization is driven from a demand-side perspective rather than a supply-side perspective of the constituent parts.

[1] Other fundamental concepts are the SoS enterprise and the purchaser-provider boundary; supply, demand, and organizational context; the gap between supply and demand; context-of-use; the double challenge of governance and demand; and the implications of decentralized governance. All of these concepts are explored in an upcoming SEI technical note, SoS Navigator 2.0: A Context-Based Approach to System-of-Systems Challenges (CMU/SEI-2008-TN-001); the double challenge has also been examined in a previous column [Boxer 07].

At the same time, however, we are excited about the potential for software services acting as constituent parts to automate more and more of the existing geometry-of-use space in order to create new possibilities on the demand side. These techniques or models allow us to reason about the granularity of those software services, the support structures required, reuse potential, cost of alternatives, prioritization of value, labor verses automation tradeoffs, and interoperability risks—what we call SoS Navigation.

References

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About the Authors

Bill Anderson is a senior member of the SEI technical staff. Bill's research interests include integration and interoperability of complex software systems, COTS and reuse management, cost estimation, and business case justification of complex systems. A former Vice President for a Fortune 500 company, Bill is broadly experienced with factory floor and business; processes, support systems, automation, and management. He has many years of experience in large system project management and has successfully led operational, financial, product line, and new product launch groups.

Phil Boxer has been a strategy consultant to organizations since the late 1970s, supporting leadership teams across many different industry sectors, both public and private. His focus is on the challenges organizations face from asymmetric forms of demand and the mitigation of risks associated with failing to develop requisite agility. He has developed a number of supporting methods and tools needed to support strategy formation and collaborative design processes, including visual PAN and its associated forms of analysis. He is a senior member of the technical staff of the Integration of Software-Intensive Systems (ISIS) team at the Software Engineering Institute.