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The Future of Command and Control

Topic: Edge Organizations

Title: Command and Control at the Edge

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Abstract

Command and control in a net centric sense involves the dynamic allocation of resources to opportunity in the pursuit of mission accomplishment. It is an intramural competition for means and privilege. Edge organizations are best positioned to engage in this competition in a manner that is most beneficial to the networked whole. However, personhood at the nodes complicates this process because the egocentric nature of human interaction works against the emergence of edge organizations and edge like behavior. Ironically, a more efficient and democratic means of performing this allocation process is possible in the world of machines. This paper is a sweeping thought piece that will explore the dynamics of edge interaction when humans are the primary actors at the nodes and how current notions of command and control may change dramatically as the edge becomes increasingly populated by machines. Because man and machine are fundamentally different, alternate modes of command and control will likely be necessary to lord over the interaction within and across the boundaries of these two distinct entities in the future. The notion of an edge organization itself may very well become subsumed by the larger changes that these new modes will engender.

Who Or What is the Edge?

The network metaphor is widely used today to generically address the impact of information age advances in the business of defense. A network in its most basic form involves the dynamic interaction of nodes, the connections that link them and the systems management processes that govern this interaction. The systems management processes and functions in a network construct roughly equate to our current notions of command and control in military operations. While the actual process of command and control in the information age is widely debated, the precise nature of the nodes that are governed by such processes is often assumed into the background. The question that is overlooked in much of today's thinking about command and control is the following: "Does it make a difference whether the node at the network's edge is a man or a machine?"

“Power to the Edge” is the underlying philosophy behind the defense department’s continued transformation towards network centric warfare. The stated vision of the Assistant Secretary of Defense, Networks & Information Integration (ASD NII) / Chief Information Officer, Department of Defense is as follows: “People throughout the trusted, dependable and ubiquitous network are empowered by their ability to access information and recognized for the inputs they provide.” It is about the *empowerment of individuals* at the network’s edge through effective information access and usage in an environment of mass connectivity. It is about the man, not the machine.

Most command and control models affecting nodal interaction explicitly or implicitly assume personhood at the edge. Human-centered interaction and autonomy lies at the heart of these transaction threads in whatever form they may take. For example, this assumption is implicit in the invocation of knowledge management processes like TPPU (task, post, process, use) or in the use of market based mechanisms for valuing information content that flow into and out of networked communities of interest for subsequent action. It is explicitly affirmed in the trigger pulling phases of the fire control loop in real time detect to engage sequences. Whether the unit of action at the edge is a soldier, a tactical aircraft, an unmanned system, or an inanimate sensor, the manifestation of command and control principles ultimately co-opts human agency in some form. This stands to reason because command and control is a human construct by design. In these interactions, the human is the noun and the machine is the adjective.

Man Versus Machine

Shared situational awareness and self-synchronization represent a duality of the highest order to which network centric operations aspire. This duality ascends beyond the mere plumbing of the physical domain and the symbol shuffling aspects of the information domain. In knifing through to the cognitive and social realms, our existing command and control frameworks have crossed the chasm into activity spaces where the price of admission is human consciousness. Metaphorically speaking, the activity has moved from mere physics and chemistry to biology. Machines, at present, are subtly excluded

from full participation in these constructs. This discrimination, however, is understandable. Machines as will be discussed later cannot make volitional choices nor can they dynamically and coherently cycle up and down different levels of unitary abstraction such as can be found in various echelons of command or other modes of identity coalescence. The reason for this lack of ability is that a machine cannot perceive itself as a self nor can it know that it knows. Human cognition is, fundamentally, a first person phenomenon. Command and control is the externalization of a first person will onto third person objects. Machine world interaction is a pure third person dynamic. The machines' participation in the first person world of human cognition will always bear the mark of a truncated metaphysic. The absence of introspection, reasoning, and basic thinking relegates machines to secondary roles as appendages to their human hosts. To the extent that man and machine are both nodes in a network centric framework, not all nodes are created equal in terms of theoretical access to means and opportunity. Some, by definition, are more equal than others regardless of the appropriateness of such an arrangement. The privileged status of humans in current command and control practices may limit the potential of network centric operations.

Human Nature and Edge Organizations

Network paradigms with humans at the edge have unique challenges. It has been said that it takes a network to defeat a networked adversary (e.g., Al Qaeda). The network that is required is not only that of an operational concept or an infrastructure capability. Perhaps, most importantly, it is one of organizational design. Dr. David Alberts and Dr. Richard Hayes correctly assert in their book *Power to the Edge* that enormous upheaval to existing cultural norms will be inevitable in shifting to edge like models in the future from the hierarchical frameworks employed in the past.¹ Barriers to embracing true peer to peer constructs in organizational design are extraordinarily high because they war against the tendencies of something more fundamental – human nature.

Human nature seeks hierarchy. The notion of a pecking order is inherent in the human experience. It does not have to be taught. Hierarchy is how you keep score in measuring

who has power. With power comes efficacy. Inside every person is a *heart of darkness* as Joseph Conrad intimated in his book bearing the same namesake. This darkness expresses itself as an endless struggle to exert self-will – the drive to be the sole master of one’s destiny. This drive inevitably clashes with the same drive in others. Ultimately, power is about the ability to create a desired effect through the exercise of one person’s command and control over another as C. S. Lewis so elegantly describes in *The Abolition of Man*.² Politics, organized religion, war and even entertainment in the form of “reality TV” are just different stages in which the drama of horizontal competition between independent agents exercising their own free will is played out. How often do we see in nearly every avenue of human endeavor instances where the best solution or the right answer or the correct course of action is intentionally neglected? Instead, what prevails is oftentimes the agenda of particularly efficacious partisans with self-serving interests who, through a combination of manipulation, shrewdness, negotiation and luck happen to win out. In fact, it is the very notion of enlightened self-interest that forms the basis of our entire system of capitalism.

Recent studies in behavioral economics argue for a more altruistic outlook on the human condition, asserting the primacy of socialization and cooperation over egocentricity in a kinder, gentler environment of reciprocity.³ These studies, however, tend to artificially isolate the mechanism of observed behavior from the totality of the human experience as known and lived by real people in the first person. Altruistic reciprocity is the behavioral exception that proves the rule of self-directed human tendencies. Instances or seasons of self-abnegating behavior have always been observed. In keeping with the principles of Ockham’s Razor, the most direct explanation for such action is that it served the interest of the individual to be selfless in those particular instances or seasons of renunciation. Augmenting this position with convoluted abstractions of trust, collaboration and other noble motives injects additional complexity without commensurate explanatory power. Selfish behavior does not have to be those that create pure economic benefit for the perpetrator. The sought after benefit may be psychic or spiritual or may satisfy a countless number of other need dimensions. The true motivation of individuals is necessarily opaque to outside observation and analysis, no matter how rigorous or

scientific – because it is personal. Since each of us is a person, we are all experts to some degree on the subject of self. We all have inside information in at least one case. Honest reflection will likely reveal the insight that in the first person world of human cognition, warring impulses like envy, spite, and pride are those that come most naturally to us.⁴ We get these for free which is to say that our natural state is fallen. The suspension of these impulses for a time requires a willful act of commission. However, all human endeavors eventually regress back to their natural state causing conflict with other selves, the hallmark of human existence throughout history. From The Bible to Plato's *Republic* to the basic tenets of modern day game theory, the egocentric tendencies of human nature are well documented.

Power in varying forms is the fuel that enables the exercise of one person's command and control over another. Once someone experiences true power, he or she will not likely relinquish such power willingly to another person even if unmatched benefit can be realized by all in doing so. The individual's natural tendency will be to maintain his or her power at all costs regardless of the consequences to the larger community. This phenomenon plays out daily, far and wide, from corporate boardrooms to children's playgrounds to local politics. Even concerted attempts to instantiate egalitarian philosophy in government as well as in systems of religion have exhibited this characteristic of self-directed behavior in the exercise of power. History has shown that socialistic constructs in government tend to produce a concentration of power in the few who then lord over the many to ill effect. History has also shown that religion is not immune to the intoxicating effects of individual power either. In a pluralistic belief system like Hinduism, a de facto equality amongst all gods is assumed, including that which exists in each person – the god within. Interestingly, the great Hindu epics are littered with endless war and killing as each god asserts its autonomy and will against all others even though all are supposedly a part of the same godhood.⁵ Ironically, this pantheistic philosophy also gave birth to the caste system, a fiercely deterministic hierarchy if there ever was one. In the end, the primacy of self seeking human behavior tends to limit the efficacy of peer to peer constructs in human interaction.

With this in mind, are edge organizations likely to emerge in the business of defense of all places? The prospects for such a radical change are questionable. Military training and discipline, funneled through hierarchical design, equip the fighting force with the wherewithal to exhibit “unnatural” behavior such as selflessness when such sacrifices are required. It is precisely the non-edge like construct and governing processes of the military that assist in the inculcation of such behavior. The à priori rules and structure for membership in the armed services are made unequivocally clear to potential candidates through intense indoctrination and codified through practice over time. The well understood hierarchy of rank and its associated expressions of power help suspend the gravitational pull of self directed behavior in military organizations. It is through this mechanism that the full force and effect of symbols and rich tradition can be viscerally felt at the individual level and applied to noble ends. The U.S. Marine Corps is particularly effective at leveraging nodal distinctness with a person’s natural instinct for hierarchy to create a special organization comprised of “The Few. The Proud.” Eliminating or reducing the significance of foundational hierarchies in military organizations in a move to edge like structures may unwittingly destroy the primary means of instilling the necessary impulses that are crucial to effectiveness at the war fighter level.

There are also less high-minded and more practical reasons why edge organizations may be difficult to implement in many environments. The reason why we differentiate the general officer from the corporal or the Ph.D. from the unlearned is to ensure that the signal to noise ratio of a credible source is not lost in an environment that would otherwise drown in a cacophonous sea of opinions emanating from a world of supposed equals. The whole point of having job titles or rank or specific identification with particular communities of interest is to create separation from the masses so that the bearers of those designations can better avail themselves of opportunity, resources and attention. Of course, such separation itself is created and reinforced by the rules and governance of the most effective nodes in a self-perpetuating way. Explicit nodal differentiation is inherent in the exercise of power in human interaction. Stated differently, every individual thinks that he or she is “special” and will pursue courses of

action that reflect this belief. However, the egalitarian philosophy that underlies authentic peer to peer constructs discounts such pre-ordained uniqueness and assumes a level playing field of access to means and opportunity amongst all nodes.

Interestingly, we do see instances of authentic edge like behavior in certain pockets that are tightly governed by a transcending unifying principle, such as radical extremism. The self-sacrificial dimensions of human behavior in terrorist networks like Hamas or Al Qaeda are under girded by such ideologies. The willful forfeiture of life by suicide bombers to a larger cause, however misguided, is an exception to the more common rule of self-preservation. While the act appears to be selfless on the merits, it is not at all obvious that the true passion in the heart of the bomber is indeed sacrificial. Ironically, these acts may be the most selfish of all as the bomber effectively kills the entire world to him self in the desperate attempt to satisfy the unknown will of Allah, thereby, hoping to gain access to paradise. Regardless of motivation, it is still this feature that makes the global war on terror so difficult to prosecute because each terrorist cell or node considers itself to be expendable. Insofar as all nodes are equal in this regard, such networks are truly center-less. Is it really possible to implement center-less organizational design and behavior in the absence of extreme ideologies when humans are the primary actors at the nodes? Absent such ideologies, power to the edge as a concept may devolve into nothing more than molecularized politics if personhood remains the primary unit of action at the edge.

Edge Organizations in the World of Machines

But, what if the edges in a network centric environment are comprised of machines and not humans? As discussed in the article “Anatomy of Network Centric Warfare,” network survivability in an environment of ubiquitous connectivity is linked with the ability to absorb rampant mortality among most nodes without having the network’s essence be compromised.⁶ Thus, operational concepts dealing with highly networked environments will eventually favor the substitution of machines for men so that nodal attrition dimensions can be properly leveraged. How does command and control change

if the unit of action at the network's edge is a machine that can take the form of an autonomous vehicle, a robot or even just a mere software code module?

It is very possible that machines can instantiate power to the edge in its purest sense because they are not ambitious. A machine's lack of sentience ensures that its behavior is not impeded by all the affections that cause human interactions to deteriorate into endless power struggles. Machines do not understand volition nor can they exercise it because they are not and can never be conscious and mindful in the same way as humans. Views to the contrary are often anthropomorphic exercises in dubious speculation. Opposition to such speculation is far and wide ranging from computer scientist and composer Jaron Lanier to philosopher John Searle to the mathematical theorems of logician Kurt Gödel.^{7,8,9}

Inherent in machines is a world of pure cause and effect grounded in the basic stimulus / response experience. Machines lack the organic ability to dynamically transact a logician's ground / consequent thought model that underlies the human's use of inference as an aid in decision-making.¹⁰ But machines can be trained to exhibit cognitive-like behavior. For instance, a system of weight pattern adjustments such as can be found in various forms of learning used in neural network development can create the appearance of intelligence. However, to appear is something entirely different from the utter actuality of being. The immeasurable gulf between shallow machine resemblance versus the vibrant reality of human cognition is best illustrated by John Searle's discussion of the Chinese room metaphor.¹¹ While a non-Chinese literate individual may be able to pass the Turing Test by using a code book to correctly respond to inquiries made in Chinese, this demonstration of understanding is nothing more than symbol shuffling. In other less, tightly controlled circumstances, its limitations will become readily evident. Such are the limitations of machines. Similarly, to the unconscious inhabitant of a fictitious world of pure chemistry, the letters on a page are nothing more than carbon, resins and other substances. But to the denizen of the higher order world of human cognition in which art is understood, appreciated and valued, they are the enduring works of Shakespeare. No increase in computational sophistication or efficiency however

infinite can bridge this fundamental gap in being and understanding. As a result, shared awareness and self-synchronization in complex activities such as is common in military operations are a doubtful proposition in the world of machines because they lack the epistemological reasoning ability of humans. The most basic of these and the least attainable by machines is self-awareness. If there is no self-awareness, there can be no shared awareness. Indeed, if there is no self-awareness, then all of life is nothing more than irrational objects in motion. If the basic notion of “I” or “Me” is non-existent as it is in the machine world, there can be no “social” environment in which the drama of free agent interaction can play out. Lacking this robust medium of exchange, there can be no real exercise of choice. True volition is one of the features that distinguishes man from the brutes. How much more so when compared to inanimate machines. Man and machine are fundamentally different. This difference is not one of degree but rather, in kind across all relevant dimensions of existence. The command and control concepts that govern these two entities will likely be different as well.

In a machine world, all nodes are essentially equal because equality as a concept would have no meaning. None are accorded with special, pre-ordained access to opportunity and means over any other node. Efficiency in resource allocation is not hindered by political agendas. A machine world is one of pure action. With machines, it is all about doing and not being. Again, being would have no meaning. Machines can never internalize the concept of “ought to have done something” versus just simply doing it. There is no *á priori* scheming towards selfish ends nor is there any semblance of introspective angst post outcome. They are what they do. In the “just do it” world of machines, means and opportunity accrue to those that do the most in a cosmic game of competitive learning. A true meritocracy emerges which forms the basis for real peer to peer interaction. Consequently, command and control frameworks designed by humans specifically for the agnostic interactions of machines may have untapped potential in actualizing certain aspects of power to the edge.

One of the keys to crafting effective command and control architectures and operating rules in the machine world is the notion of transducer physiology originally developed by

Nobel laureate physicist, Max Delbrück with other purposes in mind.¹² Very simply stated, a transducer paradigm involves the conversion of specific input signals into certain reflexive behaviors. The aggregate embodied action of a networked whole is the emergent result of agents reflexively responding to signals in a horizontal clash of behaviors. The goal of the command and control architect is to create the conditions that lend themselves to a therapeutic range of reflexive outcomes linked with various inputs in any given scenario. In some respects, the objective is to engineer a biological system in the machine world that does not require conscious decision-making at every turn. The key to such a future system may reside in the innovative exploitation of pattern recognition capabilities and a focus on proximal systems.

Dr. Rodney Brooks, Director of the MIT Computer Science and Artificial Intelligence Laboratory pioneered some interesting work with robots that demonstrated the possibilities of this paradigm.¹³ His work was discussed at length in Kevin Kelly's book, *Out of Control*.¹⁴ Brooks demonstrated a way to create intelligent behavior without the use of a central authority to mediate the horizontal interactions of networked nodes. Kelly summarizes these findings:

“With no centrally imposed model, no one has the job of reconciling disputed notions; they simply aren't reconciled. Instead, various signals generate various behaviors. The behaviors are sorted out (suppressed, delayed, activated) in a web hierarchy of subsumed control.”¹⁵

A pedestrian example of the desired characteristics can be seen in the simple act of hitting a baseball, a task that is anything but simple at the major league level. As the ball leaves the pitcher's hand and accelerates towards the plate, the batter is faced with a real time decision of whether or not to swing and how. The batter's various sensors in the form of eyes, ears and skin surface sensitivity may receive conflicting signals that must be resolved in a split second to effectively prosecute a ninety-five mile per hour fastball. The mixed signals are not consciously mediated but are simply competed. The resultant action is the product of the winning impulse or combination of impulses that is then reinforced if successful or re-competed if unsuccessful. Successful behavior becomes

reflexively instantiated in muscle memory for future employment. Command and control in the machine world is about designing reflexes and not about creating thinking machines.

Brooks' theory of a subsumed architecture is analogous to the commonly understood defense construct known as "system of systems." The difference here is that subsumption is not only a theory of new system creation but also of how control is exerted in highly networked environments. Interestingly, the notion of hierarchy does not disappear even in the edge-centric world of machines. It is manifested in the notion of localized chunking of control. Kelly states that,

"no distributed system can survive long without nested hierarchies of lateral, bottom-up control. As influence flows peer to peer, it coheres into a chunk...which then becomes the bottom unit of a larger web of slower actions."¹⁶

Power ultimately flows to the chunks that do the most. In the machine world, where it is all about doing, "the more you do, the more you get."

The Converging Worlds of Man and Machine

The challenge of the future will be in creating a dynamic frontier between different dimensions of interchange involving man-to-man, man-to-machine, and machine-to-machine. Any future concept of edge organizations must address the unique dynamics inherent in all three layers of abstraction and the crossover points that mediate their interaction. For example, one of the advantages of properly functioning machines is that they can be relied upon to follow orders regardless of threat or consequence to self – because there is no self. This advantage stands in contrast to the human "defect" of behavioral unpredictability, especially when the person's life is in danger. In those instances where a mission cannot tolerate the risk of human whimsicality, machines make for an interesting operational substitute. However, most situations will require an assorted combination of volitional nodes operating in concert with automatons.

Much of today's thinking and practice of command and control is oriented towards the pure volitional layer, that of man-to-man. Our thinking becomes progressively impoverished as we descend to the man-to-machine level and is all but nonexistent in addressing the machine-to-machine world. Even our current notions of human in the loop interaction with machines are, typically, just a monotonous extension of man-to-man concepts with the machine representing nothing more than a mechanical or intellectual prosthetic of sorts. The highest forms of current machine usage (e.g., sophisticated software programs) effectively act as pre-positioned units of human thought. These mental caches of sorts leverage the time dimension ahead of need by forward deploying thought modules that can be invoked by circumstance. Even still, the man remains the primary pivot point, the ultimate arbiter of weighty choices. However, these existing constructs begin to break down when the performance defining aspects of specific activity spaces eventually become largely dependent on the efficiency of machine-to-machine interaction. We are already seeing the limitations of human in the loop constructs in broad-based intelligence gathering. The sheer volume of information overload from myriad sources is becoming problematic. The higher order functions of the human in applying intuition and reason are not being accessed and applied efficiently because the data deluge is clogging the front end of the knowledge management process. Machine-to-machine synthesis will be on the critical path in addressing the ever widening differential delta between the timeliness of asynchronous and synchronous transactions and the seamless transition between the two realms of activity. Additionally, unlocking the potential of new operational concepts like swarm based behavior of networked micro-sensors will also require new modes of machine intra-nodal interaction as well as the externalization of the output with humans that are lording over the mission. Exploration of alternative command and control approaches focused purely on machine-to-machine interaction may provide unanticipated benefits in addressing classes of problems, heretofore, unsuited to current modes of resolution that are human centric. The fundamental recognition that command and control constructs designed for humans are not necessarily efficacious in the world of machines is the first small step in unleashing new possibilities in network centric operations.

The Future of Edge “Organizations”

All three levels of interaction involving man and machine will be important in the future with none likely to disappear from the trade space. However, the real breakthroughs in harnessing power to the edge may not necessarily emanate from the creation and implementation of organizational constructs or processes focused purely on the man-to-man level of interchange. They are equally if not more likely to emerge from innovatively exploiting new possibilities in pure machine world interaction. But, there is a price to be paid to gain access to these new possibilities. A magician’s bargain appears. To command and control the soul-less interaction of reflexive nodal behaviors with any effectiveness, the human must let go of the steering wheel. He must relinquish some control in order to gain the benefit of having any at all. The human must step outside the actual system rather than remain a central player in it. For emergent control to express itself in the manner that Alberts and Hayes suggest is necessary for edge power to be fully realized, the machine must become primary, the human secondary at the machine-to-machine level and possibly even at the transitional man-to-machine layer.

The human’s new role in a machine world will likely resemble that of a playwright or director but no longer that of the main performer. To more effectively leverage command and control in a machine driven world, the human must cease to be a major element in the system itself. Rather, the human must ascend to a higher, god-like role that cannot be encapsulated by pure physical instantiation. His presence will be felt as an invisible force that animates the system as a whole but does not express itself as an actual fact within it. Just as a painter’s creativity, soul and designs are expressed in a painting, the artist himself does not reside within the confines of the actual canvas. The power to create efficacy over a soul-less system of interaction must be exercised from a vantage point above and beyond that system by a soulful agent so that the networked whole does not become infinitely regressive.

While the current manifestation of such new constructs is embryonic at best, the type of future that they portend is intriguing. Underlying some of today’s transaction oriented

activities in highly networked environments, we see the duality of man as creator or director and machine as doer. This is particularly evident in the world of finance and economics. From Turbo Tax programs for the masses to automated credit determination to online market making and trading mechanisms, we are beginning to see the ascendancy of machines and their inextricable links to supposed human centered interaction. Here, the edge organizations of import are not really that of the individuals, companies or institutions involved in the transactions. Rather, it is the edge interactions of the machines themselves, instantiating the command intent of their sentient creators, which determine whether efficient markets do or do not emerge. However, this larger collective benefit comes at a cost expressed in the form of lessened direct control by any one human actor. Viewed in aggregate, we are the creators and beneficiaries of a global enterprise in which the machinery of the system is now more primary than any particular human node that interacts with it. The logic of networks in ubiquitously connected environments tends to favor the system over the individual – the needs of the many do outweigh the needs of the few. While humans may be uncomfortable with network logic, machines have no such concerns. That is why, in the end, the behavioral characteristics of edge organizations as embodied by machines may be more fruitful ground for experimentation than fiddling with human centered organizational design and managing the endless psychological dramas that would always likely ensue.

The human must become the adjective and the machine the noun or the verb if highly networked environments are to be synergistically leveraged for the good of the whole. Let man think, create and manage but let the machine do the doing. In the net centric world of the future, that may be the edge. If and when this sort of world should emerge, the notion of organization will gradually dissipate and become subsumed into a larger, more vicarious construct – a simulation. The pioneering work taking place in brain-computer interfaces provides a fleeting glimpse of a not too distant future in which the tenuous line separating where man ends and machines begin starts to blur.¹⁷ Life will then have begun to imitate art and a “Matrix like” universe of new possibilities will be opened.

End Notes

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