Pushed to the Edge

How edge computing is a model for future warfighting

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Look at your phone. Consider how it works. It lies at the distant end of a long chain of connections, all of which lead back to a central processing and storage node of some sort—a data center, or "the cloud." Every time you transmit or receive information with your phone, the data travels across the entire network and back again, hopping from node to node until it reaches your screen. The world is covered in these sprawling, but largely invisible, hub-and-spoke networks; in 2019, there were more than 2.5 billon smartphones worldwide.[1] These networks are connected by long chains of radio waves and cables to massive libraries of digital information. Every day more spokes are added to the network and the libraries get bigger, and more information flows along the chain of connections.

But that is not how your phone will work in the future. The next revolution in communications technology is edge computing. Rather than sending information back to a central node, "[e]dge computing offers a more efficient alternative: data is processed and analyzed closer to the point where it's created."[2] Because the chain of connections is shorter, the data does not have to travel as far to be processed and stored. Less traffic on the network results in greater efficiency. Computer processing power is decentralized and pushed to the edge of the network—hence, "edge" computing.

Today, the Marine Corps is organized like a hub-and-spoke network. Small units are like your phone: they lie at the distant end of a long chain of connections leading back to a central node. In order to succeed on the battlefields of the future, however, the Marine Corps will have to shorten those connections and push expertise and decision-making authority to the edge of the organization. Adopting edge computing as a model could help the Marine Corps solve a major warfighting challenge that it will face in the future operating environment: the skyrocketing requirement for technical expertise at the tactical level.

What is Edge Computing?

People are generating more information than ever, and devices are too as they become increasingly smart and connected to one another via the Internet of Things. The amount of information created by connected devices threatens to overwhelm the current hub-and-spoke system. Edge computing is a solution to that problem. Here is how, as explained by a Federal Communications Commission report on the topic:

> Edge technologies make it feel like every device is a supercomputer. Digital processes become lightning fast. Critical data is processed at the edge of the network, right on the device. Secondary systems and less urgent data are sent to the cloud and processed there ... When paired with 5G, which promises faster speeds and lower latency, edge computing offers a future with near real-time, back-and-forth connections.[3]

The key innovation of edge computing is that computer processing power is pushed to the fringe. In contrast to the current system, computing power is decentralized and distributed. Instead of being just one node in a massive hub-and-spoke network, devices become their own hub or part of a much smaller, and therefore faster, hub-and-spoke arrangement.

How Edge Computing Differs from Other Decentralized Models of Warfighting

The concepts of decentralization and distributed operations are nothing new to the Marine Corps, of course. "Decentralized" appears five times in *Warfighting*, which says that "in order to generate the tempo of operations we desire and to best cope with the uncertainly, disorder, and fluidity of combat, command and control must be decentralized."[4] The 2019 *Commandant's Planning Guidance* (*CPG*), which mentions "distributed" thirteen times, observes that "Marines must be comfortable with chaos, comfortable with mission tactics, and comfortable operating in a highly distributed manner across any potential battlefield."[5] The concept of distributed operations lies at the heart of expeditionary advanced base operations (EABO).[6] But unlike the concepts of decentralization and distributed operations—which are largely focused on pushing decision-making authority to the lowest level—edge computing is about pushing *computing power* to the outer bounds of the network.

Computing Power in the Marine Corps

Computing power can be thought of as the resources available to perform

an operation. More computing power means operations are completed faster.[7] In the current hub-and-spoke communications system, computing power is largely centralized in the hubs. With edge computing, much of that computing power will be pushed to the spokes, reducing the need to transmit data through the network. The result will be more computing power closer to the problems that need to be solved. Because there will be less traffic between hubs and spokes, the network as a whole will become more efficient, and hubs will be freed up to perform other tasks.

If the Marine Corps was a computer, then Marines would be the resources available to it to perform operations. Put differently, Marines—not systems—are the computing power of the organization. As *Warfighting* reminds us,

> [t]echnology can enhance the ways and means of war by improving humanity's ability to wage it, but technology cannot and should not attempt to eliminate humanity from the process of waging war.[8]

The Growing Need for Technical Expertise at the Tactical Level

Technical expertise is a major form of computing power in the Marine Corps. Because the Marine Corps is currently organized in a hub-and-spoke configuration, that expertise is largely concentrated at the top of the organization. That is where you will find space, cyber, electronic warfare, and other technical experts. Indeed, the higher you go up the chain of command, organizationally, the more technical expertise you will typically find. Headquarters units tend to hoard experts. The Marine Corps is not unique in that regard. Most organizations are similarly configured because centralizing expertise is efficient, as it is for many other resources.

Technical experts often ply their trade in HQMC. There, they advise senior leaders charged with organizing, training, and equipping the force. Their technical expertise is translated from the hub to the rest of the force, via subordinate organizations, through tactics, techniques, and procedures (TTPs)—what button to push, what knob to turn, or where to put the antenna. If a unit in the FMF encounters a technical issue that it cannot solve, it reaches back to the experts at the hubs.

But in future warfare, that model is unlikely to work, for two reasons. First, as the *CPG* and the EABO concept acknowledge, "the ability to command and control in a contested information network environment is paramount."[9] In this future operating environment, the spokes will not be able to reliably communicate with the hubs, so centralizing expertise will be a failing strategy. What is efficient in peacetime will not work in wartime. As Christian Brose points out in his recent book, *The Kill Chain: Defending America in the Future of High-Tech Warfare*,

> [t]o the extent that future battlefield communications networks will still possess hubs, they will take the form of distributed manned systems acting as mobile command and control centers[.]

In Brose's analysis, "[m]ilitary communications will continue to become more decentralized and more distributed" because they will be increasingly vulnerable to attack.[10]

Second, warfare is likely to become increasingly complex and will demand increasingly sophisticated technical expertise at the tactical level. According to Brose, aspects of future war will verge on science fiction. He describes battlefields in which ubiquitous sensors—paired with artificial intelligence, semi-autonomous robot swarms, and long-range weapons—make physical maneuver all but impossible. Anything that can be sensed will be killed. As maneuvering in the physical world becomes more difficult, conflict will shift to the realms of cyber, space, and electronic warfare. Future combat will be about degrading the enemy's ability to gather, share, and process information while preserving one's own ability to do so.[11]

Moving the Corps to the cloud, Edge Computing and the Internet of Things are about providing Marines at the small unit tactical-level access to the information they need wherever they need it. ***(Photo by Jennifer Gonzalez courtesy Marine Corps Systems Command's Cloud Technology Summit.)***

Although the U.S. military will have fearsome technology at its fingertips, so will its peer adversaries. That will result in a paradox: on one hand, the United States will possess sci-fi technologies capable of dominating the battlefield; on the other hand, because the enemy will have similar technologies, those sci-fi capabilities are likely to be disrupted and countered at every turn. Future warfare will be characterized by this ebb and flow, as combatants compete for technological superiority. The result will be a battlefield that oscillates between high- and low-tech, dominance and disadvantage. The light switch will be

flicked on and off until one combatant gains enough of a technological edge to win.

As a result, it will no longer be enough to merely follow TTPs. Marines will have to know more than what button to push or what knob to twist. They will have to understand not just what their technologies do but how they work and will have to be capable of mixing and matching them in creative and unorthodox ways. Marines will have to pair advanced technical skills with a sophisticated understanding of how technologies like "artificial intelligence, robotics, additive manufacturing, quantum computing, and nanotechnology,"[12] to quote the *CPG*, interact with and affect one another.

The Solution

This presents a dilemma: how can the Marine Corps reconcile the increasing need for technical expertise at the tactical level with the reality that, in future conflict, the spokes will be cut off from the hubs? One answer is to adopt an edge computing model.

Unlike the familiar models of decentralization and distributed operations, the edge computing model of warfighting would emphasize not only pushing decision-making authority to the lowest level but also pushing expertise—the computing power of the Marine Corps—to the edge. To succeed in future conflict, it will not be enough to flatten decision making. The Service will also have to flatten the hierarchy of technical expertise. That does not mean every squad leader should have a PhD. The pyramid of expertise cannot be flipped entirely upside down. Senior leaders also need technical experts to advise and guide them. But the typical practice, in which headquarters units hoard experts in the name of efficiency, must be reconsidered.

What Needs to Change?

In future conflict, Marines operating in EABs will have to understand and be able to troubleshoot their sci-fi technologies. In order to succeed even when their spoke is disconnected from the hub, small units will have to be self-reliant when it comes to fixing and employing the high-tech systems at their disposal.

That means the Marine Corps will have to recruit, train, and deploy Marines with those skills and that knowledge. Training will have to go beyond button-pushing and basic maintenance. It will have to give Marines a big-picture understanding of how systems work and why. Because so many systems use the Global Positioning System, for example, small units will need Marines who know how it works and understand how its vulnerabilities might be exploited by the enemy. They will also need Marines who understand how their systems might be vulnerable to cyberattack and can recognize when they have been compromised. The list goes on. In order to achieve this level of technical expertise, the Marine Corps will have to target recruits with the aptitude for it and train them appropriately.

It also means the Marine Corps will have to make the hard choice to push experts away from the headquarters units where they typically reside to the very edge of the organization. Efficiency must give way to resiliency. Pushing experts to the tactical edge will have the added benefit of enabling small units to train their own Marines rather than sending them to school. Organic experts will be able to tailor training to the needs of the unit, further increasing edge computing power.

Finally, the Marine Corps will have to move beyond the concepts of decentralization and distributed operations and begin thinking in terms of edge computing. Pushing decision-making authority to the lowest level is not enough. Computing power needs to accompany it so that the spokes have the resources they need to make decisions and operate independently. That would also free up computing power at the hubs to tackle different challenges, increasing efficiency. Edge computing should be the model the Marine Corps patterns itself after.

Conclusion

Future battlefields will be characterized by rapid oscillations between high- and low-tech as combatants struggle for technological superiority. In that environment, the traditional hub-and-spoke model for communications will fail. So too will the traditional hub-and-spoke model for organizing militaries. As a result, the Marine Corps needs a new approach. The edge computing model of warfighting would push technical expertise—one of the most powerful forms of computing power in the Marine Corps—to the tactical edge in order to enable decentralized decision making and distributed operations. Like the smart devices of the near future, small units, powered by organic technical expertise, must be able to solve problems on their own, at the edge.

Notes

1. Laura Silver, "Smartphone Ownership Is Growing Rapidly Around the World, but Not Always Equally," *Pew Research Center*, (February 2019), available at https://www.pewresearch.org.

2. Staff, "What Is Edge Computing?" *IBM*, (n.d.), available at https://www.ibm.com.

3. Walter Johnson, et al, "5G Edge Computing Whitepaper," *FCC Technological Advisory Council*, (n.d.), available at https://transition.fcc.gov.

4. Headquarters Marine Corps, *MCDP 1, Warfighting,* (Washington, DC: 1997).

5. Gen David H. Berger, *Commandant's Planning Guidance*, (Washington, DC: July 2019).

6. See generally, Marine Corps Warfighting Lab, Concepts & Plans Division, "Expeditionary Advanced Base Operations (EABO) Handbook: Considerations for Force Development and Employment," (Quantico, VA: June 2018).

7. Staff, "Computer Power," *PCMag.com*, (n.d.), available at https://www.pcmag.com.

8. *Warfighting.*

9. *Commandant's Planning Guidance.*

10. Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare*, (New York, NY: Hachette Books, April 2020).

11. Ibid.

12. *Commandant's Planning Guidance.*