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TECHNICAL
REPORT

The Impact of Network Performance on Warfighter Effectiveness

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Summary

The concept of network-centric operations (NCO) was described by the GAO (2004) as follows:[1]

> The emerging concept of networked operations, referred to by DoD as network-centric operations [NCO], involves developing communications and other linkages among all elements of the force to create a shared awareness of operations.

The objective of the research effort described in this report is to quantify the marginal impact of networking as part of an effort to evaluate the concept of NCO. Three sets of capabilities initially identified as relevant are

- Sense/acquire data.
- Disseminate and communicate data.
- Interpret, fuse, and react to the data.

These capabilities correspond to the sensing, communication, and cognitive factors, respectively, that are analyzed in this work. In addition, we observed that the force makeup is an additional factor that has a marginal impact along with these three sets of factors.

In this report, we take our definition of "cognitive" from Gartska (2000), who defines a "cognitive domain" as

> the mind of the warfighter and the supporting populace. This is the domain where battles and wars are won and lost. This is the domain of intangibles: leadership, morale, unit cohesion, level of training and experience, situational awareness, and public opinion. This is the domain where tactics, techniques, and procedures reside.

This is broad and difficult to quantify. In this report, the focus is narrowed to a small but critical subset of cognitive parameters, namely, accuracy of assessments of available targets and the rate at which they can be prosecuted (we call these collectively "targeting ability"). One specific objective of this report is to discuss the relative impact of all of the aforementioned factors on overall warfighter effectiveness.

A multi-agent-based, force-on-force simulator tool called Map Aware Non-Uniform Automata (MANA) was used to evaluate warfighter effectiveness for a simple urban scenario.

[1] Alberts, Garstka, and Stein (1999) specifically define NCO as "the information superiority–enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve: shared awareness, increased speed of command, a higher tempo operations, and greater lethality."

Agent-based simulations (ABS) utilize little to no scripting of movements and are made up of multiple agents and objects that behave autonomously.

Tens of thousands of MANA runs were conducted in an attempt to examine the impact of varied cognitive, communication, and sensing factors on warfighter effectiveness using a data farming process. Statistical analysis for numerous simulation results, as part of the data farming exercise, quantified the correlation between the factors discussed above and warfighter effectiveness.

In this report, we explicitly incorporated one of the costs of networking by modeling the capacity limits of a communication channel as a result of congestion. One clear conclusion: Warfighter effectiveness was affected by many of the parameters considered, including the parameter called communication capacity. Specifically, effectiveness, as measured by a loss ratio, could be cut in half without sufficient capacity; message latency (delay) affected warfighter effectiveness by as much as 50 percent for a given capacity in a selected scenario. On the other hand, improvements in effectiveness brought about by increasing communication capability eventually diminish. We also observed that while network capability may sometimes increase warfighter effectiveness, sometimes the force makeup is insufficient to support improvements in effectiveness. By some measures (loss ratio, or LR), increased networking capability worsened the outcome.

Agent-based simulation is relatively new in terms of utilization for analyses of force-on-force combat scenarios. Certainly, more validation will be needed. Furthermore, the results in this report may be sensitive to the assumptions that are made with regard to network architecture, force makeup, and technology performance. Although a large space of possibilities was explored for the parameters under consideration, all results need to be taken in the context of the specific scenarios simulated. Nonetheless, the results show how agent-based tools can be exploited to quantify the marginal impact of networks and networking performance to warfighters.