Application of Metcalfe's Internet Value Law to NCW Battlespace Communications Networks

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The inventor of the Ethernet and recipient of the 1966 IEEE Medal of Honour Robert Metcalfe had the Metcalfe law named after him in 1993 by George Gilder publisher of the influential Gilder Technology Report. Gilder named it twelve years after Metcalfe proposed the relationship between "monetary" value of a network and number of members[1] of the network.

The foundation of Metcalfe's law is the observation that in a communications network with N members, each can make (N–1) connections with other members. If we assume that all connections are equally "valuable", then the total "value" of the network is proportional to N(N–1), that is to first order of magnitude roughly N^2. The big "if" assumption made by Metcalfe was that all members are equally valuable. For example given a network with 100 members, there are 9900 different possible connections that one member can make to another. If for example the network doubles in size, to 200, the number of connections doesn't merely double, to 19800, it quadruples to 39800. Admittedly the notion of "value" is somewhat vague, however the basic idea the law attempts to convey is that the more people you can communicate with the more valuable the network. Metcalfe's original point was to explain the existence of a cost-value crossover point where a critical mass must be reached before which "commercial" networks don't pay. The cross-over point occurs where the linear increase of network cost growth cuts the quadratic value of the network curve.

Other network value laws have been proposed. Recently Briscoe et al have proposed the N log (N) law to challenge Metcalfe's. However the basic tenant that N^2 connections are at least possible (even if they are not used) is still assumed.

It should be noted that these laws are growth laws, which means they cannot predict the value of a network from its size alone. However if we ascribe a valuation at one particular size, we can estimate its value at any future size, all other factors being equal.

Briscoe et al admit that "our newer N log(N) valuation of a communications network oversimplifies the complicated question of what creates value in a network; in particular, it doesn't quantify the factors that subtract from the value of a growing network, such as an increase in spam e-mail", safety intrusion, viruses. Briscoe admits that the law "cannot be proved, in the sense of a deductive argument from first principles. The N log(N) valuation for a network provides a rough-and-ready description of the dynamics that led to the disapointingly slow growth in the value of dot.com companies".

These laws can be argued to be true for any type of information or communications network, whether it involves telephones, computers, users of the World Wide Web or NCW "powered" battlespace communications networks.

The idea of exploring the applicability of Metcalfe's and other network value laws to "military-tactical" networks is therefore very tempting. If these laws can be justifiably applied to such problems, then they may help to provide us with a set of analytical tools that can be used to assess the future military networks we are designing today. The analysis would be aimed at guiding current governments' investment and technology decisions in order to practically optimise the future cost/benefit achieved from new Net-Centric networks and assets into the tactical battlespace.

We therefore expect that the candidate law will need to be flexible enough to cope with a range of network member types, but it will also need to be able to cope with the variability of the battlespace, because unlike civilian networks which tend to be static (albeit growing), tactical networks are far more dynamic. For example the N nodes in an Army Brigade will behave differently to those in an Airforce Squadron. Military networks have other major differences and currently they tend to be substantially hierarchical technical architecture and controlled by a hierarchical command chain. This means that not all nodes are allowed to or wish to be connected to each other. In the Military clusters are strongly coupled eg Brigade versus Close Air Support Squadron.

[1] The "member" in the Internet context is a source node which creates information or is a sink node which represents a consumer of information.

There is a further consideration about interconnecting battlespace networks. If Metcalfe's law is true then if an Australian Infantry Platoon network which is made up of say 33 members is connected to a Four Ship Mission (4 F/A-18 Hornets) and a single rogue soldier, then one would argue that the larger Platoon network should interconnect with the rogue soldier regardless of its relative size because all members have equal value. However the larger Platoon network is less likely to connect. The Platoon network believes it is helping the smaller rogue soldier sub-net. In military networks there is strong relative value put on members. The members could be ranked with the Four Ship mission being ranked first. The Infantry Platoon could be ranked second and the single rogue soldier last. One can argue that there will exist vast "tails" of relative importance of members of battlespace networks. While concentrating rank in the most valuable members of the battlespace there is a lot of hidden value in the tail. In the "Asymmetric Warfare" battlespace the single soldier can present as the most valuable member of the network. The question that one must pose is what happens when we combine these insights into the law?

The future effects our military commanders are expecting to see by building net-centric tactical networks and nodes to connect to them have been articulated in this article. These include increasing operational tempo, increasing lethality and reducing fratricide amongst others. It seems logical that all these outcomes will be positively influenced by the planned networks; however at present there are few models to help us understand the cost/benefit relationship and importantly how to modify our networking plans in the future to practically maintain an optimum cost/benefit outcome should unforseen events occur. The authors intend to continue researching the questions proposed in this article and present the finding to the readership in future articles.

References

Air Power Studies Centre May 1999, NCW A Place in our Future GPCPTP Peter Layton

Metcalfe's Law is Wrong, IEEE Spectrum November 2006, Bob Briscoe, Andrew Odlyko and Benjamin Tilly

http://www.cs.ucl.ac.uk/staff/B.Briscoe and http://www.dtc.umn.edu/~odlyzko

Department of Defence, Force 2020, Public Affairs and Corporate Communications, Canberra, June 2002

Department of Defence, Australian Defence Doctrine Publication-D.3 Future Warfighting Concept, Policy Guidance and Analysis Division, Canberra, December 2002

Department of Defence, Australian Defence Doctrine Publication-D.1 Enabling Future Warfighting: Network Centric Warfare, Australian Defence Force Military Strategy Branch, Canberra, March 2004.

Networking the Hardened and Networked Army

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The Hardened and Networked Army (HNA) is Army's response to the requirements of the Defence 2000 White Paper. The Government made it clear that they required Australian Land Forces to have sufficient firepower, protection and mobility to provide a clear advantage in any likely operations in the Defence of Australian interests.

The delivery of the Networking component of HNA is the responsibility of the Director of Network Centric Warfare – Army. The aim for Networking the Army, as laid out in the Networking Army Campaign Plan (NACP) is to:

"Ensure that all elements of deployed force can rapidly exchange information with joint, coalition and other agency elements. Networking will enhance combat power, lethality, survivability and sustainability by providing greater situational awareness, faster and more informed planning and decision making and improved detection and acquisition. All soldiers and platforms on the battlefield will be capable of rapidly transferring information between command and control, sensor, and effects nodes."

The ultimate objective for Army is to field two enhanced Networked Brigades, inclusive of support elements by 2015. Each Brigade will be capable of enhanced warfighting in a joint and coalition environment. By 2015 Army will be postured to assist in the transformation and networking of the remainder of Army.