UT-TP-2

Commercial Wireless Networking Explained: Building Next Generation Military Networks with Commercial Technologies

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Tutorial Abstract
This tutorial provides an overview of commercial wireless networking technologies within the context of the commercial domain and the potential roles of these technologies in the evolving network-centric warfighting force. Commercial wireless networking technologies continue to impact the world socially and economically as the wireless Internet becomes more pervasive with rapidly increasing deployments across the world. This wireless outgrowth of the Internet has been fueled by the development of wireless technologies such as the nearly-ubiquitous IEEE 802.11 wireless local area network (WLAN) family of standards (WiFi), broadband wireless access technologies such as the IEEE 802.16 standards family (WiMax), and wireless personal area network (WPAN) technologies such as the IEEE 802.15 standards family (e.g. Bluetooth, ZigBee). Evolving cellular technologies (2.5G, 3G, 4G) provides increasing capability and support voice applications as well as high-bandwidth data services and growing Internet accessibility across wide geographic areas. Advanced cognitive radio technologies are emerging (e.g. IEEE 802.22) that have the potential to provide significant enhancements in capability. Architectural visions such as IMT-2000, IMT-Advanced, and IMS aim at combining this wide variety of wireless access technologies in a way to enable advanced models of information and content distribution. Such proliferation will continue to push networking technologies and deployed systems that are highly capable, flexible, and scalable.

Concurrently, the military is undergoing a "transformation" to a network-centric warfare (NCW) paradigm. In the NCW paradigm, more importance is placed on the collection of, dissemination of, synthesis of, and action on information by lightweight, highly-mobile, highly-lethal forces. This warfighting paradigm is predicated upon the presence of a robust, highly-capable, highly-interoperable, readily deployable and manageable, and secure networking capability to provide ubiquitous “anytime, anywhere, to anyone” communications. The composite of these networks will constitute the emerging Global Information Grid (GIG), a world-wide IP-based DoD network that is intended to remove communications as a constraint to the warfighter and his warfighting tactics.

There is a persisting interest within the DoD community to leverage commercial Internet and wireless networking technologies in order to achieve this desired network-centric capability. This is understandable given the commercial wireless Internet possesses many of the characteristics desired in the military counterpart. Subsequently, there continues to be an increasing number of military networks that are at least partly-based upon commercial wireless technologies and practices. However, these commercial technologies were not designed to meet military requirements, and as a result they may not perform well for all applications. If improperly applied within the military domain, they could represent a regression of capability. In fact, commercial technologies are often defined to meet rigidly-defined performance goals and a narrow set of use cases. These constraints often result in

poor performance when the network technologies are applied outside of the original scope, even within the commercial domain. Thus, it is important that the military communications community understand these technologies from a variety of perspectives.

Gaining a deep understanding, however, is a daunting task given the sheer volume of technologies being developed in the commercial domain. What are the basic capabilities of these technologies? What are the drawbacks? How do they relate to one another (complimentary vs. competitor)? Are the technologies interdependent on one another? Even within the context of commercial deployment, it is difficult to understand the 'big picture' that represents the emerging commercial wireless architecture. Attempting to apply these technologies to the military domain, which is complicated by stressing usage cases, difficult environments, and different requirements, in manner that will result in effective solutions, is an incredibly complex task. However, understanding these technologies and how they relate to one another can enable the military community to identify gaps between technology and military needs, identify potential shortcomings that may induce operational constraints, and work to design military-specific augmentations as necessary to bridge these gaps and maintain a technological edge against potential adversaries who also have access to these same commercial technologies.

The goal of this tutorial is to provide a comprehensive overview of key existing and emerging commercial wireless network technologies. This tutorial would provide attendees technical knowledge on pervasive commercial wireless networking technologies and techniques and issues related to internetworking these various technologies. This tutorial will focus upon standardized commercial technologies, while refraining from presenting academic proposals from literature (there are too many technology proposals within the literature to realistically cover, even at a high-level, in a single tutorial session). However, the tutorial will analyze the impact of industry forums such as the WiFi Alliance and WiMAX Forum, on the shape of deployed technologies, as well as address select proprietary technologies that are seen as potentially disruptive (e.g. WiMedia).

The tutorial will begin by providing an overview of key architectural visions that play an important part in the developing wireless Internet, including:

• IMT-2000

• IMT-Advanced

• IMS

The tutorial will then provide a brief overview of key pervasive commercial network technologies including:

• IEEE 802.11 WLAN technologies (802.11a, b, e, g, i, n, s, r, w)

• WPAN technologies (802.15.1/.2/.3/.4, Bluetooth, ZigBee, UWB)

• Wireless broadband access technologies (802.16-2004, 802.16-2005, 802.16m, 802.20, WiMAX, WiBRO)

• Cellular communications (1G→2G→2.5G→3G→4G)

This discussion will provide an overview of what they are, a historical context of how these technologies came into being, the problems they are designed to solve, what are their basic capabilities and characteristics, how they relate to one another, and their high-level strengths and weaknesses.

The tutorial will then go on to provide a detailed overview of a select set of key emerging disruptive wireless technologies including:

• IEEE 802.11n, IEEE 802.11s

• WiMAX (Fixed, Mobile, 802.16m)

• Next-generation cellular communications (e.g. LTE, UMB)

• Cognitive Radio (e.g. IEEE 802.22)

Each technology discussion will consist of the following sub-topics: 1) a description of the historical lineage of each technology, 2) the key design goals and usage cases for each technology, 3) some typical deployment models of the technology, 4) an overview of the technology itself and its key features and capabilities, 5) a survey of the current equipment market (typical off-the-shelf product capabilities and profile (size, weight, power, etc.)), 6) on-going standardization efforts, 7) on-going and envisioned deployment activities, and 8) strengths and weaknesses within the context of military usage. Presentation of the different technologies aims to remain neutral to preclude any bias towards one technology as a more suitable candidate to another for any particular application. A commercial 'big picture' will be provided, showing what role these technologies serve within the commercial domain, the competitive landscape, how these relate to commercial architectural visions such as IMT, and how all these technologies together form the emerging wireless Internet. This commercial ‘big picture’ will then be compared and contrasted with the emerging military communications architecture, with key similarities and differences identified.

Presenter Biography

The tutorial will be conducted by Mr. Jack L. Burbank of The Johns Hopkins University Applied Physics Laboratory (JHU/APL). Mr. Burbank leads the Wireless Networking section within the Communications and Network Technologies group of JHU/APL. Mr. Burbank is an expert in the area of wireless networking, and has been focused on the application of commercial wireless networking technologies to the military context. Mr. Burbank's background is in communications theory, wireless networking, IP internetworking, satellite communications, communications vulnerability analysis, and computer simulation of communications systems. Mr. Burbank leads a team of network engineers at JHU/APL that participates within the Internet Engineering Task Force (IETF) and the IEEE 802 standards organization. Mr. Burbank's research interests include electronic attack of wireless networks, mobile ad-hoc networking, wireless MAC design, cross-layer design, and cognitive radio. Mr. Burbank's recent work projects include research into adaptive augmentation of the 802.11 MAC to improve scalability and efficiency while maintaining backwards compatibility, analysis and development of concepts for Naval MANET sensor networks, DoD analysis of commercial MANET routing protocols, and the application of commercial

wireless broadband technology in the design of a United States coastal area network capability. Mr. Burbank has published numerous technical papers, reports, and book chapters on topics of wireless networking (both terrestrial-based and space-based) (see reference list for a partial list), and led commercial wireless network tutorials at MILCOM 2005 and 2006 conferences, as well as being sought out to give on-site commercial wireless networking tutorials. Mr. Burbank is a professor of networking and telecommunications in The Johns Hopkins University Part-Time Engineering Program, and is a member of the IEEE and ASEE.

References

[1] “Key Challenges of Military Tactical Networking and the Elusive Promise of MANET Technology,” Jack L. Burbank, et al., IEEE Communications Magazine, November 2006, pp. 39-45.

[2] “WiMAX Past, Present, and Future: An Evolutionary Look at the History and Future of Standardized Broadband Wireless Access,” Jack L. Burbank and William T. Kasch, WiMAX Handbook, CRC Press, September 2007.

[3] “WiMAX and Global Wireless Internet Architecture,” Jack L. Burbank and William T. Kasch, WiMAX Handbook, CRC Press, September 2007.

[4] "Physical Layer Performance of the IEEE 802.11b WLAN Standard in Outdoor Applications: A Case Study in Yuma, AZ," William T. Kasch, Jack L. Burbank, and Julia Andrusenko, 12th Annual Wireless Personal Communications Symposium, 6 June 2002.

[5] “Performance of the IEEE 802.11b WLAN Standards for Fast-Moving Platforms,” William T. Kasch, Jack L. Burbank, and Julia Andrusenko, Proceedings of the 2003 International Telemetry Conference, October 2003.

[6] "A WLAN Concept for Data Acquisition from Multiple Target Vehicles," W.D. D'Amico, J.L. Burbank, W.T. Kasch, and J. Andrusenko, Proceedings of the 2003 ITC, October 2003.

[7] "COTS Communications Technologies for DoD Applications: Challenges and Limitations," Jack L. Burbank and William T. Kasch, Proceedings of the 2004 IEEE MILCOM Conference, October 2004.

[8] "Transforming Legacy Network Systems for use in the Army Future Force," Jack L. Burbank and William T. Kasch, Proceedings of the 2004 IEEE MILCOM Conference, October 2004.

[9] "The Application of Commercial WLAN Technologies for Military Operations," Jack L. Burbank and William T. Kasch, Proceedings of the 14th Virginia Tech/MPRG Wireless Personal Communications Symposium, 9-11 June 2004.

[10] "Enhanced Efficiency and Flexibility while supporting QoS Concepts: An Adaptive MAC Framework for 802.11 WLANs," Jack L. Burbank and William T. Kasch, Proceedings of the 2005 Canadian Conference on Electrical and Computer Engineering (CCECE), May 2005.

[11] "Cross-Layer Interactions: A Framework for Adaptable Communications," Jack L. Burbank, Ross E. Conklin Jr., William T. Kasch, and Robert A. Nichols, Proceedings of the 14th Virginia Tech/MPRG Wireless Personal Communications Symposium, 9-11 June 2004.

[12] "The Evaluation of Wireless Networking through ACTION," William T. Kasch and Jack L. Burbank, Proceedings of the 2005 IEEE MILCOM Conference, October 2005.