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Adapting Commercial Mobile Networks Technology for Battlefield Communications

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Overview

Traditionally, military communications networks have been proprietary, using line of sight and/or satellite radio communications to provide the most advanced and secure service possible. However, proprietary solutions are lagging commercial telecommunications innovation, which is delivering advanced mobile data capabilities and massive economies of scale. This was evidenced during recent operations in Iraq and Afghanistan, where U.S. military networks based on proprietary radio communications were less agile and reliable than the commercial cellular infrastructure the enemy utilized.

The solution may seem obvious at first glance—the military can simply buy and deploy commercial products from telecommunications equipment manufacturers (TEMs). When this approach was explored, the nodes were cumbersome and lacked mobility. Furthermore, the solution couldn't support ad-hoc communications and in turn, wasn't easily customizable; thus, it couldn't deliver the reliability and security the military requires. These problems drove the military to modify its wartime communications networks, changes that included more compact and robust networks that were still based on standards-based 3G cellular technology with an eye on LTE for future deployments.

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The adoption of commercial, standards-defined cellular technology solves the agility, reliability and cost challenges. But other technology is needed to deliver an ultra-mobile solution that also supports an ad-hoc network rollout and the network-of-networks concept, both of which are central to next-generation, network-centric warfare. Technological advancement is needed to miniaturize the entire network—from base stations through to the network core—into a small, ruggedized platform. This enables an entire network to be picked up and moved, or even carried in the pack of a soldier. Such ultra-portable cellular networks require a combination of hardware and optimized software that meets stringent size, weight and power (SWaP) requirements.

This capability has been demonstrated by Radisys by combining Trillium 3G and LTE software stacks, media server software, and Radisys small form factor and defense-specialized COM Express computer modules, all of which provide the necessary technology for today's military-portable communications networks and services. The solution runs on a single, power-efficient Intel® processor capable of supporting an entire Evolved Packet Core (EPC) network. This solution also scales to higher capacities when running on other platforms, such as a network appliance or Advanced TCA (ATCA).

Evolving Battlefield Cellular Communications

Soldiers today are more networked and have more information at their disposal at the edge of the battlefield than general officers did in command posts just a few years ago. Network-Centric Warfare, where everyone and everything is connected to the network (Figure 1), has the ultimate goal of information dominance and complete situational awareness. This requires sensing the entire environment—360 degrees around each friendly combat unit—and using sensor data to understand precisely the adversary's intentions and actions, and link all advanced weapons platforms, sensor systems, and command and control centers.

Figure 1. *Network-Centric Warfare*

Network-Centric Warfare

Situational awareness is vital in order to prevail in combat. Troops and their commanders must decisively observe, orient, decide and act;[1] and if they can get inside the adversary's decision cycle,[2] they will be victorious in each individual combat engagement. This objective requires low-latency, high-throughput networks capable of moving data in real-time, as well high-performance compute engines, like today's ATCA compute engines, that also deliver high reliability and high availability.

The number of sensors deployed on the ground or aloft continues to soar, as does the volume of data being gathered for intelligence, surveillance and reconnaissance (ISR). For example, in Afghanistan today, more than 53 terabytes of data are gathered every single day, mostly by unmanned aerial vehicles (UAVs). At the start of the war in Afghanistan, a single terabyte of data was considered to be a large volume of data.

Secure Mobile Networks

"Our troop-carried equipment has also significantly reduced in size, which will ultimately allow more mobility and agility of the entire network in any environment. We are now working toward using the individual warfighter—whether in the air, in a vehicle or on foot—and personal radio to act as a single repeater that will route and retransmit information on-the-move across the battlespace,"[3] says Brigadier General Michael E. Williamson, Joint Program Executive Officer Joint Tactical Radio System.

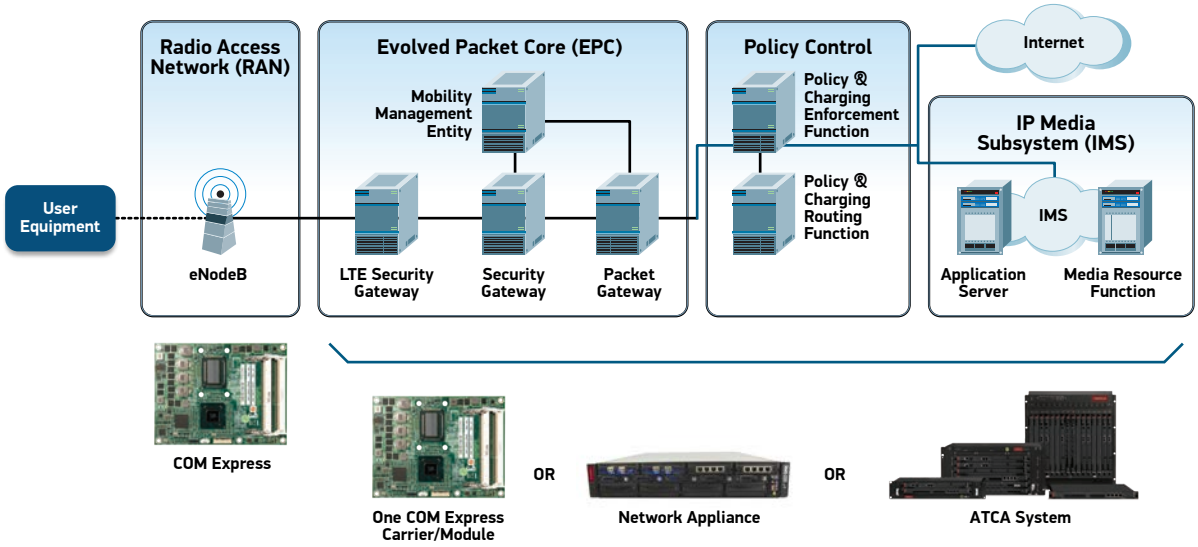


Figure 2. *End-to-End LTE Infrastructure*

He adds, "These are the kinds of things that will increase situational awareness and keep our warfighters safe. However, it is not just building smaller and faster. It is also about building protection into the network. As much as building the network is a priority, securing the network is equally important."

Compact Cellular Networks

With the purpose of reducing size and cost, some military equipment vendors have revamped their telecommunications system architecture, so now the core network is the size of a shoebox and costs around one-tenth that of legacy solutions. Moreover, these systems support 3G and an easy transition to LTE, a technology the military is anxious to deploy to increase transmission rates by about five times over 3G.

"We took all the cellular capabilities of commercial technology and focused on rapid deployment and tactical operations, and now soldiers in the battlefield can pass information in real-time across cellular networks." says Alex Watson, Chief Executive Officer, Battlefield Telecommunications Systems.

In order to offer an out-of-the-box core network solution for 3G or LTE, the functionality of as many as eight different network elements must be collapsed into one. The relevant LTE network elements comprising the EPC and policy control are shown in Figure 2.

All of these network elements can run on a single system, and depending on the required capacity, it can be designed with a COM Express carrier/module, a network appliance or an ATCA system. These hardware platforms will also simultaneously support media processing functions for a range of applications, including Voice over LTE (VoLTE), voice mixing, streaming audio or conferencing with live video share. This can be achieved using the IP Multimedia Subsystem (IMS) specification, which is commonly deployed on 3G networks worldwide, and now in 4G/LTE networks. Fortunately, existing IMS infrastructure can remain intact (with minor changes) since its flexible architecture was designed to work with nearly any access network. IMS can be implemented with a software media server, which is discussed in a later section.

COM Express architecture can also be used to design an eNobeB, which connects end user handsets to the core network via an LTE radio interface.

Core Network Software

Trillium Protocol Software from Radisys enables equipment vendors to more quickly develop a reliable out-of-the-box core network solution for 3G and LTE network software. The solution replicates the functionality of the necessary network elements and merges them into one, such that 25 or so protocols run reliably on a variety of Radisys hardware platforms. The Radisys 3G and LTE protocol software solution, shown in Figures 3a and 3b, provides the vast majority of the code needed.

The software is field-hardened and proven, given that it's used by three of the top four mobile equipment manufacturers. In addition, Trillium 3G and LTE software have been adopted by over 60 commercial customers and are the foundation of mobile networks across the globe. Radisys also supplies the LTE protocol software for base stations, so the entire network can use fundamental software from a single vendor, which reduces risk and increases reliability.

The solution provides a high level of interoperability and scalability, enabling many protocols to be consolidated onto one platform of nearly any size. This is because the software architecture is very flexible, in that it supports a mesh—a network of networks—in a manner that is standards compliant. Moreover, the solution delivers very high throughput since one of Radisys' core competencies is a deep understanding of how software scales on Intel® architecture. Equipment manufacturers also benefit from Radisys' ability to integrate, optimize and customize the software for its customers.

Software Media Server

This battlefield communication solution includes media processing applications deployed on IMS infrastructure, as shown on the right side of Figure 2. Radisys has built a strong reputation as the global leader in carrier-class media processing with its existing IP media server hardware products, which include the Radisys Software Media Server (SWMS).

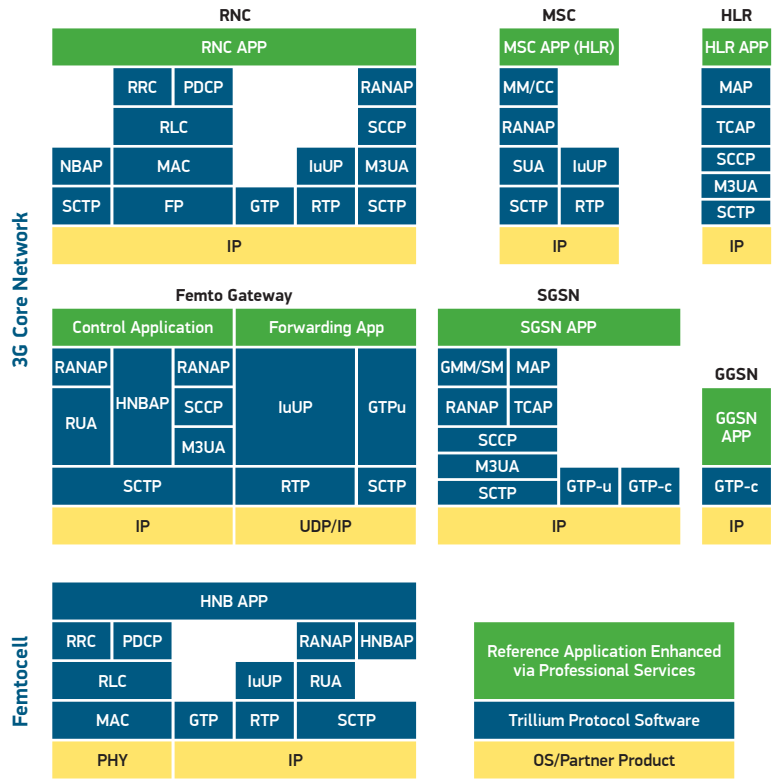


Figure 3a. *Trillium 3G Protocol Software from Radisys*

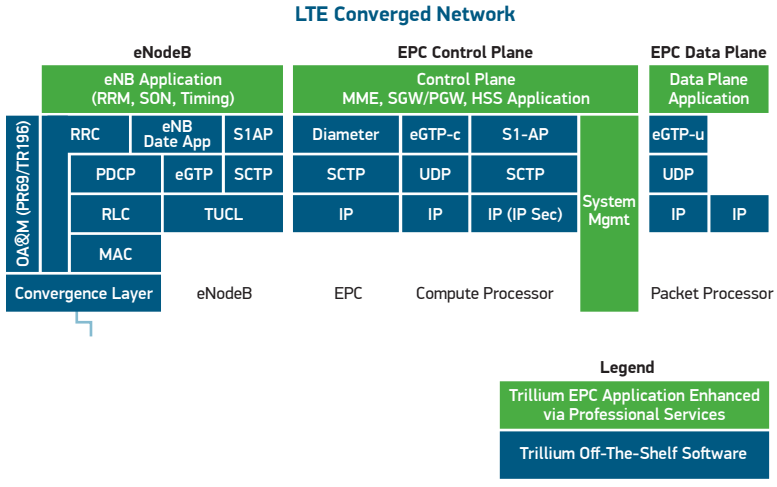


Figure 3b. *Trillium LTE Protocol Software from Radisys*

This is a Linux-based, SIP media server designed to install and operate on Linux-based COTS hardware servers, and it has a proven track record in 3G and LTE network deployments. The SWMS's capabilities allow for real-time voice and video conferencing real-time communications in the battlefield and push-to-talk services over ad-hoc cellular networks, as well as other applications, including:

- *IP Voice Conferencing:* Vehicle-to-vehicle and local area conferencing, which can run on the "spare capacity" of other x86-based systems deployed in the vehicle.
- *Voice/Video Conferencing:* For large scale deployments, the Radisys SWMS supports talking and sharing of the same visual information (i.e., streaming HD video) between multiple resources over a broad area.
- *Video Distribution:* Data store for further analysis and forensics, along with other capabilities such as "Forward to coordinate with adjacent organizations" and transcoding.

Hardware Platforms

Equipment manufacturers can develop military communications solutions using Radisys products offered in a variety of platform architectures and form factors that include COM Express, ATCA and rack mount (i.e., network appliance). Since Intel processors are used across the board, developers can leverage a common code base.

Rugged and Reliable

In order to deliver ruggedized and reliable platforms, Radisys employs HALT (Highly Accelerated Life Testing) and HASS (Highly Accelerated Stress Screening) testing. The roots of HALT and HASS processes can be traced back to 1969, when Dr. Hobbs developed advanced practices for increasing equipment reliability and ruggedness.

The premise is to subject products to extreme environmental conditions up until the point of failure in order to determine the weakest aspects of the design. Subsequently, primary, secondary and tertiary failures are removed by reengineering and redesigning the product until the fundamental limits of technology are reached (i.e., the physics of semiconductor devices). As a result, the product has an increased functional and physical design margin, which safeguards against failure. After a Radisys design is released to manufacturing, 100 percent of the products are subjected to HASS screening, comprising test limits that can be set beyond the product specification to ensure a wide operating margin. For safety-critical applications, HALT/HASS testing is a necessity.

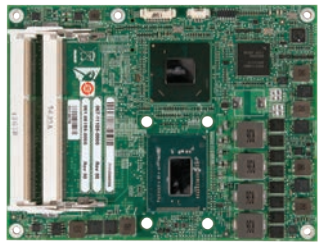
Highly Compact and Portable: COM Express

Radisys COM Express modules, when combined with a customizable carrier board, provide a COTS-based hardware solution. Based on 3rd generation Intel® Core™ i7, Core™ i5 and Core™ i3 processors, these modular, ruggedized computers support a wide range of performance requirements. They are specifically designed to support extreme field conditions:

- 40°C to +85°C operating temperature range, and tested to extended shock and vibration specifications
- Upgradeable, 95mm x 125mm PICMG standard form factor enables technology insertions
- HALT/HASS tested
- ECC memory for higher data reliability
- Intel® technologies to improve security (see Intel® Technology sidebar)

Intel® Technologies

The Radisys CEQM77 COM Express combines the performance of the quad-core 3rd Generation Intel® Core™ i7 processor with Radisys design expertise to provide breakthrough processing performance on a basic size Type 6 COM Express Revision 2.0 module. This processor has a dramatically improved on-chip graphics engine, which benefits military surveillance and other imaging-intensive applications. Select Radisys COM Express modules also incorporate several advanced Intel technologies that can make systems more secure, easier to manage, more stable and faster.



Radisys CEQM77 COM Express

- **Intel® Virtualization Technology (Intel® VT)**[4] improves the reliability, stability and security of virtualized environments.
  - System developers can minimize the harm caused by malware or unintended software interactions (e.g., blue screen) by running software in secure partitions, thereby increasing system stability.
- **Intel® Trusted Execution Technology (Intel® TXT)**[5] supplies additional security protection.
  - Hardware-based security features integrated in the processor, chipset and the trusted platform module (TPM) run mission critical applications in a safe partition, protect crucial platform data, and keep malware from launching.
- **Intel® Hyper-Threading Technology (Intel® HT Technology)**[6] delivers more horsepower when multi-tasking.
  - Each processor core maintains two execution states, meaning it can process another task if the task it's executing stalls (e.g., waiting for an I/O device), thus eliminating wasteful idle time.
- **Thermal Monitoring Technology** continually monitors the operating temperature of the processor.
  - If the processor temperature rises above specification due to environmental conditions (e.g., desert), its operating frequency and voltage can be reduced to maintain reliable operation.
- **Enhanced Intel® Speedstep® Technology** allows the system to dynamically adjust processor voltage and core frequency.
  - Particularly useful for battery-powered devices, this technology enables the system to conserve energy when the processing demand decreases.
- **Intel® Advanced Encryption Standard—New Instructions (Intel® AES-NI)**[7] adds hardware assisted data encryption.
  - Data encryption of confidential data is much faster—up to four times (serial mode) or ten times (parallel mode)—without slowing down the system.[8]

High Performance Flexible Server: Network Appliance

The Radisys RMS-220 Network Appliance is a 20-inch deep, carrier-grade network appliance platform designed with both flexibility and serviceability in mind. The RMS-220 allows up to four front I/O modules, five front storage modules (HDD or SSD), redundant AC or DC power supply units (PSUs), and front serviceable fans that can be replaced in the field without de-racking the system. Key features are:

- Intel® Xeon® processor E5-2600 processor (dual socket)
- NEBS Level-3/ETSI compliance
- RAID levels 0, 1, 5, 10
- Dual redundant hot-swappable AC or DC high efficiency power supplies

Highest Performance, Carrier-Grade: ATCA

Radisys T-Series ATCA platforms deliver the high-density input/output (I/O) and throughput needed to keep up with increasing access speeds, such as 40G LTE. The platform is customizable to support specialized applications for any telecommunications environment, including deep packet inspection (DPI), security and EPC functions. This solution provides a carrier-class foundation upon which to build telecom-grade applications with the following attributes:

- 10G to 40G+ throughput
- Full-redundancy
- Standards-compliant hardware and software
- Highly scalable, high density
- Lowest cost per bit

Enabling Network-Centric Warfare

The need to quickly communicate actionable information between the command center, troops in the battlefield, unmanned vehicles and other military assets is giving rise to network-centric warfare and operations. An integral component is battlefield cellular communications, which is undergoing transitions from 3G to LTE and from proprietary to COTS-based platforms. For next generation warfighter communications, Radisys provides comprehensive support—both hardware and software—for standards-based solution for both 3G and LTE networks.

Equipment manufacturers can take advantage of Radisys COTS reference designs for base stations and core networks that can reduce development time and speed up time-to-market. Whether using COM Express, ATCA or network appliance-based solutions, Radisys hardware platforms, based on power-efficient Intel processors, deliver the performance needed in a compact environment.

References

[1] Referencing Air Force Col. John Boyd's OODA Loop.

[2] Referencing the October 2011 Armed Forces Journal article "Goodbye, OODA Loop" by retired Army colonels Kevin Benson and Steven Rotkoff http://www.armedforcesjournal.com/2011/10/6777464.

[3] Source: http://www.ground-combat-technology.com/gct-home/402-gct-2012-volume-3-issue-2-april/5481-qaa-brig-gen-michael-williamson.html.

[4] Intel® Virtualization Technology (Intel® VT) requires a computer system with an enabled Intel® processor, BIOS, and virtual machine monitor (VMM). Functionality, performance, or other benefits will vary depending on hardware and software configurations. Software applications may not be compatible with all operating systems. Consult your PC manufacturer. For more information, visit http://www.intel.com/go/virtualization.

[5] No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel® TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). Intel® TXT also requires the system to contain a TPM v1.s. For more information, visit www.intel.com/technology/security. In addition, Intel® TXT requires that the original equipment manufacturer provides TPM functionality, which requires a TPM-supported BIOS. TPM functionality must be initialized and may not be available in all countries.

[6] Intel® Hyper-Threading Technology requires a computer system with an Intel® processor supporting Hyper-Threading Technology and an Intel® HT Technology enabled chipset, BIOS and operating system. Performance will vary depending on the specific hardware and software you use. For more information, see http://www.intel.com/content/www/us/en/architecture-and-technology/hyper-threading/hyper-threading-technology.html; including details on which processors support Intel HT Technology.

[7] Intel® Advanced Encryption Standard—New Instructions (AES-NI) requires a computer system with an AES-NI-enabled processors, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on select Intel® Core™ processors. For availability, consult your system manufacturer. For more information, visit http:///software.intel.com/en-us/articles/intel-advanced-encryption-standard-instructions-aes-ni.

[8] Performance results have been estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.

About the Intel® Intelligent Systems Alliance: From modular components to market-ready systems, Intel and the 200+ global member companies of the Intel® Intelligent Systems Alliance provide the performance, connectivity, manageability, and security developers need to create smart, connected systems. Learn more at: intel.com/go/intelligentsystems-alliance.

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