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Challenges to Military Tactical Communications and Information Dominance

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Presentation Overview

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- Purpose
  - Identify potential technology and standards opportunities
    - Significantly advance military wireless tactical communications while promoting Information Dominance.
- Agenda
  - What is “Information Dominance” and how does it impact military tactical wireless communications demands.
  - Tactical wireless communications networks report card.
  - Information sharing and coalition operations.
  - The new SDR software revolution and impacts on SCA solutions
  - References and Contact Information.

Mission Essential Communications

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"Information Dominance"

Impacts on

Military Wireless Communications Demands

Information Dominance

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- Definitions
  - Superiority in the generation, manipulation, use of information facilitating a clear military operational advantage.
- Value proposition
  - Provides significant benefits to optimize decision making and maximize warfighting effects.
- Other motivations
  - ***"Need to keep up".***
    - ***Aggressive growth trends across all worldwide information domains, operating environments.***
  - It's a "Big Data" deal (world is shifting rapidly into "Big Data" and "Internet of Things" paradigms).

Information Growth Trajectories

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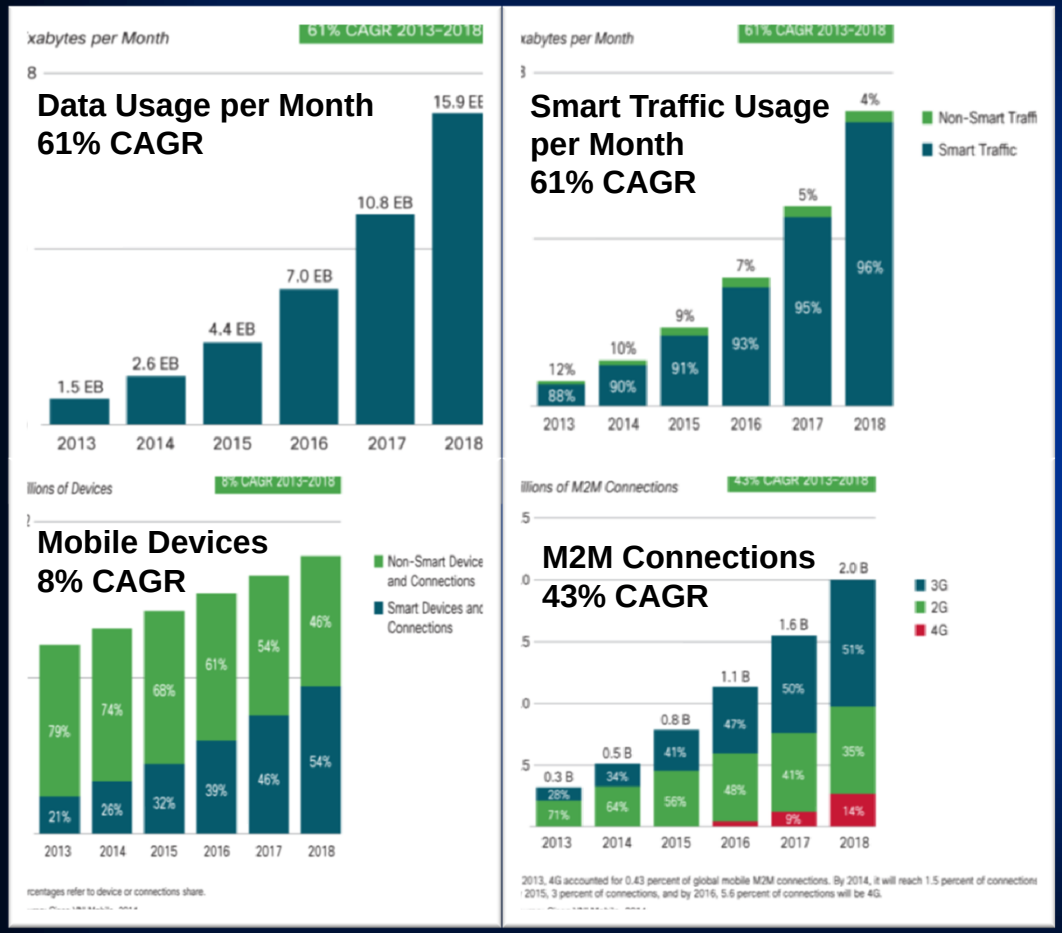
- Commercial mobile communication growth rate projections from 2013 – 2018 (Cisco Data Traffic forecasts [1]).



Key Trends

- Transition to smart devices.
- "Internet of Things"; M2M: sensors, meters, appliances, Smart Grid, ITS, wearable devices (biometrics), etc.
- Video dominance.
- Cloud applications offload memory/processing limits.

Consider as scalable proxies for military tactical communications growth trajectories.

Tactical Wireless Communications Networks Performance and Reliability

Tactical Networking Report Card

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- Are military tactical wireless communications networks *"making the grades"* today?

Grades

  - Do networks require too much overhead to plan, configure and use? What about network startup times? Late entry? ☐
  - Does network routing converge reliably within a "reasonable period of time" for an expected number of nodes? ☐
  - Does throughput meet mission information demands, both in terms of volume and latency? Will it scale for tomorrow? ☐
  - Do network achievable topologies meet anticipated communications ranges including staging scenarios? ☐
  - Do networks sustain connectivity with nominal link outages? ☐
  - Are networks sufficiently energy efficient (i.e., facilitate reasonable radio battery life, thermal dissipation)? ☐

Would consumers be satisfied or switch Service Providers?

Key Considerations

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- ***"More, not less".*** Information Dominance drives escalating communications demand all the way to the edge!
  - More volume, velocity and variety of information collected and disseminated across force; *stay ahead of the threat*.
  - Leverage "Big Data" paradigm to augment engagement analysis, facilitate highly effective decision making.
- ***"Not just about Soldiers".*** Use and reliance on non-solider based communications in tactical environment.
  - Vehicles, soldiers, robots, sensors, repeaters, other.
  - Growing reliance on "Internet of Things" paradigm; M2M.
- ***"Simpler is better".*** Reduce, don't add to mission burdens.
  - Plug and play deployments; Intuitive device usage (< training) [2].
  - ***Conceal underlying technology from warfighters.***
  - Energy efficiency, minimize battery encumbrance.

Technology / Standards Opportunities

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- Network Architecture
  - Highly scalable with significantly greater node densities.
    - ***> Connectivity, better coverage, more reliability, energy efficiency.***
  - More efficient spectrum utilization
    - Spectrum sharing, opportunistic TX, channel densities, BW aggregation.
  - Higher throughput able to scale with growing demands.
- Waveforms Applications
  - Dynamic Spectrum Access (DSA), enabling:
    - Frequency reuse, interference mitigation, dynamic TX power control.
    - Electronic Warfare (EW) for electronic protection, obfuscation, other.
  - Disruption Tolerant Networking (DTN).
  - Limit network overhead.
  - Network routing advances (i.e., swarm intelligence [3]).
  - Designed for energy efficiency.

Technology / Standards Opportunities

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- Network Security
  - Address potential DSA vulnerabilities (i.e., denial of service)
  - Passive attack prevention (i.e., transmission monitoring).
  - Compromised node detection and isolation.
- Network Management
  - Highly social, autonomous network elements.
  - Over-the-Air (OTA) reconfiguration.

Avoid "death by configuration"

Engineers / IT folks not required.....

- Devices
  - Multiple transceivers for higher connectivity, use of DSA [3].
  - Much simpler, more energy efficient radio devices which are military hardened and secure.
  - Stop being impeded by rapid pace of commercial technology cycles, leverage!

Broad improvement opportunities for higher grades.

Information Sharing and Coalition Force Operations

Key Considerations

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- *"More often, not less."* Continued growth of cooperating multi-national coalition forces across the globe.
  - U.S. strategic direction to operate with allied and coalition forces.
- *Growing Diversity.* Compositions are complex.
  - Former or even current adversaries ("*frenemies*").
  - Not just military: agencies, multiple categories of first responders.
- *Increasing Tempo.* Traditional information sharing inefficient.
  - Minimal touch-points: Liaison Officers, secure fax, secure telephone, equipment loans for interoperable communications.
- *"Information sharing dichotomy."*
  - Relevant and timely coalition secure information sharing while simultaneously preserving sovereignty of specific national interests.

Must protect our warfighters, prevent "Taliban on Channel 2".

Information Sharing Challenges

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- Information sharing spans multiple domains:
  - Language, nomenclature, syntax, semantics.
  - Cultural differences.
  - Education and training levels.
  - Security policies and coordination.
  - Technology compatibility gaps.
  - “Data Integrity”: consistency, accuracy, reliability.

- Varying types, complexities and orientation of information:
  - Simple message exchanges.
  - Weather data, logistics, transportation data.
  - Integrated command and control.
  - Situational Awareness (SA), Common Operating Picture (COP).

Exacerbated by growing information volume, velocity and variety.

Technology / Standards Opportunities

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- ***Tactical networks and edge devices are the "pointy end" of coalition force information sharing challenges.***
- Network Architecture
  - Heterogeneous edge devices simultaneously support *multiple "Communities of Interest"* with appropriate levels of trust.
  - Information translation / transformation close to source provides greatest operational flexibility, but highest security risk.
  - Simple, efficient, securely controlled Key Management functions.
- Waveform Applications
  - *Both* specification level and software portability level sharing.
    - Specification sharing between "cordial" partners, software applications sharing between highly "trusted" partners.

Technology / Standards Opportunities

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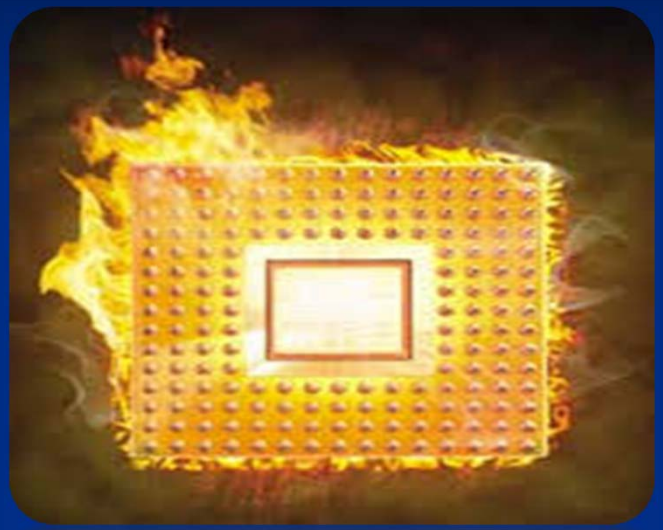
- Information Security
  - Shareable security functions (i.e., Suite B, FIPS 140, PKI).
  - Protect against passive and active attacks, from outside and inside.
  - Role based operational policies with strong user authentication (i.e., biometric), dynamically tunable to engagement needs.
- Devices
  - Trusted separation of security domains; cross domain solutions.
  - Cognitive Radio capabilities to simplify user experience.
- Standardization
  - Device network interoperability verification before deployment.
  - ***Build on WINNF International Radio Security Services API [8]***
    - Facilitates open standardization and protected interests.
    - Transformation layer; protected APIs exposed only as needed.

The New SDR Software Revolution?



Screaming fast and "flaming hot" not really better!

Digital “Free Lunch” Program

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- Moore’s Law
  - Gordon Moore’s 1975 observation: “Integrated circuit transistor density doubling would occur every 24 months”.
  - Impacts of Moore's Law
    - Smaller chip size (die shrink); Lower cost per transistor.
    - Shorter device life-cycles, increased rate of obsolescence.
- Dennard Scaling [4]
  - As transistors got smaller, power density was constant.
  - Facilitated clock speed improvements.
- Transistor density was aligned w/ device energy efficiency.

“Moore’s Law gives us more transistors and Dennard Scaling makes them useful.” - Bob Colwell (Intel, DARPA)

End of the "Free Lunch"

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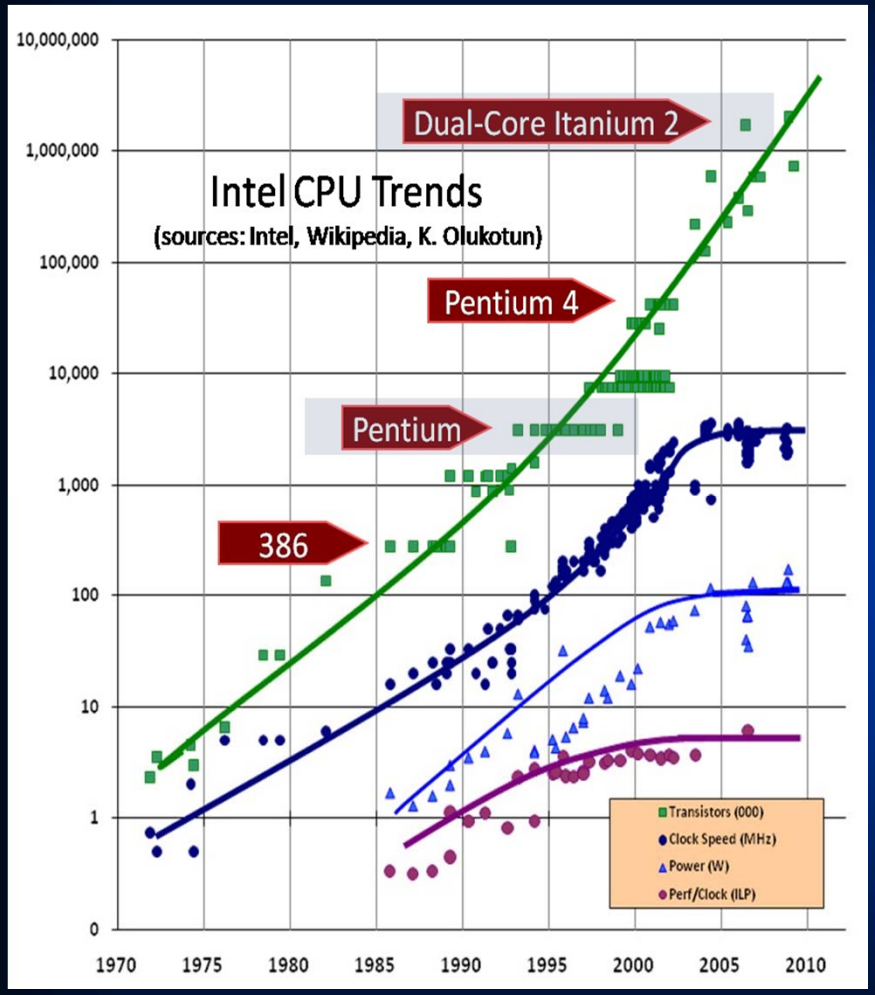
Transistor scaling and voltage scaling are no longer aligned.



- "Moore's Law" enduring as transistor density continues to increase (albeit maybe slower).
- Dennard Scaling has ended [5].
  - Much lower energy efficiencies.
  - Significant leakage current and associated thermal impacts.
  - Clock speeds have plateaued.
- Instruction level parallelism (ILP) reached practical limits.
- Multi-Core processing fabrics.
  - Incremental processing power.
  - Potential for dark silicon effect.
  - What about the Software??

Multi-Processing and SDR SW

- Today's SDR processing architectures
  - Parallelism mostly at device level (GPP, DSP, FPGA).
  - Large monolithic software baselines (MSLOC).
  - Software abstracts away processing hardware details.
  - Multi-threading models inconsistent, non-optimized.
  - Current data sharing and security design models tend to serialize processing.
- Other multi-processing considerations [6,7]
  - OS / compiler multi-processing support (Processor Affinity).
  - Interconnect overheads, memory contention.
  - Input / Output bottlenecks.
  - Workload balancing.

SCA and Multi-Processing

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- ***"Good News"*** – SCA underlying technologies are sound:
  - Component based development (CBD) technology provides foundation for multi-processing software solutions.
  - Middleware with shared IDLs for component connections facilitate both processing element independence and parallelism.
  - Middleware solutions have evolved to support different device types
    - (GPP-> DSP-> FPGA) and multi-core architectures.
- ***"Not so Good News"*** - SCA waveform applications can be:
  - Designed towards serialized processing (i.e., networking security).
  - Highly optimized to meet waveform performance.
  - Limited by real-time embedded OS processing capabilities.
  - Limited by SCA waveform architecture and protocol designs.
  - Limited by hardware platforms lack of configurability.

Technology / Standards Opportunities

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- Systems
  - Future systems architectures that are designed to support both parallelism and energy efficiency.
    - Networks, waveform applications, security models, standards.
- Hardware
  - Transition from dedicated or programmable HW to dynamically reconfigurable, highly scalable, energy efficient HW processing solutions (i.e., clock gating, data movement optimization).
- Software
  - Evaluate multi-processing models, frameworks and toolsets.
  - Investment in parallel processing SW skills development.
  - Assess current platform and waveform application impacts and enhancement opportunities.

Time for action is Now! IC solutions are not waiting…

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Contact Information

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"Helping clients develop innovative strategies, plans and technical solutions for Mission Essential Wireless Communications Worldwide"

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