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Ubiquitous Reconfigurable Computing for Net-Enabled Capabilities in Commercial and Military Systems: Technology, Social, and Economic Perspectives

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Outline

- Net-Enabled Capabilities
- “Thin Applications” & Network Centric Computing
- Ubiquitous Reconfigurable Computing
- Technology Requirements
- Network-Centric Fabric
  - Support By Ubiquitous Reconfigurable Computing Fabric
- Economic Implications
- Social Implications
- Summary

Net-Enabled Capabilities

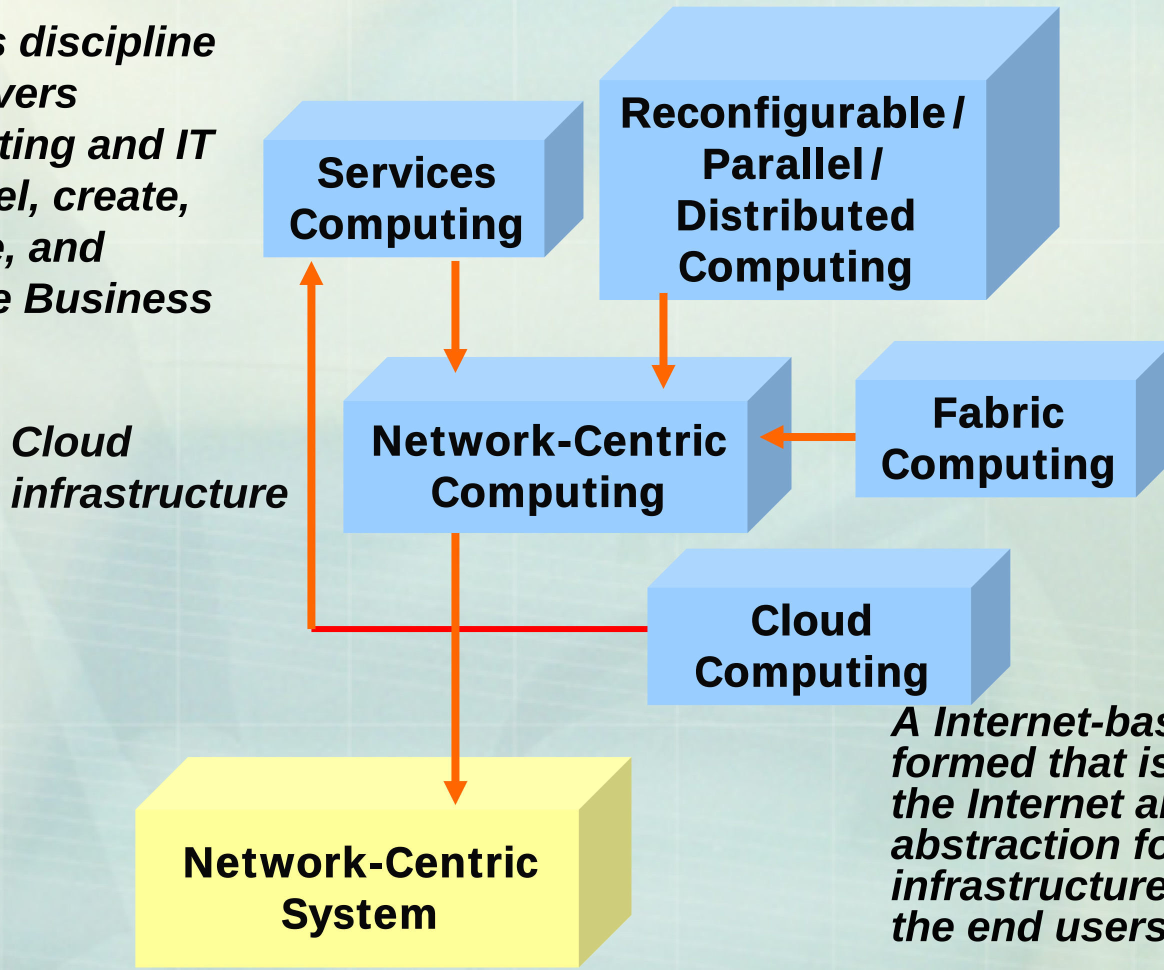
- A concept that uses information advantage, enabled by information and network technology, into a competitive mission advantage through the robust networking of well informed geographically dispersed entities driven by a common architecture
  - Network-Centric Operations (NCO) is an overarching military doctrine that utilizes this Net-Enabled Capabilities.
  - NCO Industry Consortium (http://www.ncoic.org)
    - A non-profit organization of industry members, government stakeholders and academia whose primary mission is to facilitate global realization of the benefit inherent in Network Centric Operations
    - Currently has over 100+ members
    - NCOIC has several technical teams and working groups developing technical products for NCO
- Few Examples of Network-Centric Systems Applications
  - National Emergency Response Systems
  - Search and Rescue Systems
  - Military Reconnaissance Systems

Network-Centric Computing

- Network-centric computing advances net-enabled capabilities of Data/Information everywhere and control of everywhere
  - This capability is enabled through the use of ubiquitous and adaptable computing and communication networks whose nodes have been enhanced with advanced embedded hardware and software
- New approaches to nodes on the network are required
  - “Thin applications” (where the software on each node has just enough capability to use the information and knowledge processing power of the fabric)
  - Abstracting the hardware in the fabric means that applications may not have any knowledge (completely transparent)
    - Underlying hardware and the same application software can run on any computing element in the network
- Low power and low cost network-centric system solutions further helps in optimizing the performance and collaboration of users of the network-centric system
  - Users should adapt their “computing culture” to take full advantage of the network-centric computing

Network-Centric Computing

A cross discipline that covers Computing and IT to model, create, operate, and manage Business



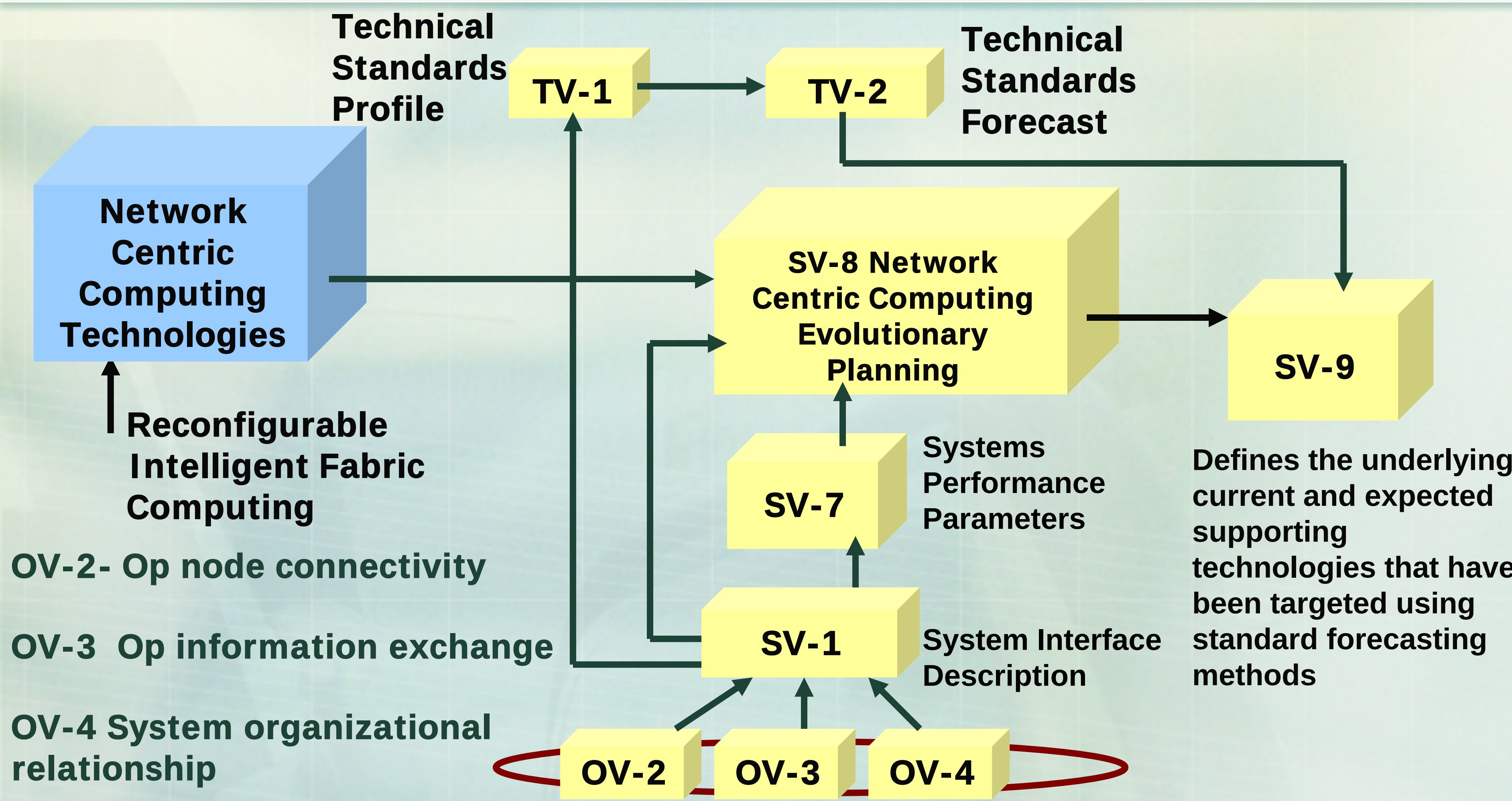
A broader extension of a Grid architecture applied across a variety of levels of scale (from a network on a chip to global networks)

A Internet-based ("cloud") is formed that is a metaphor for the Internet and is an abstraction for the complex infrastructure that is hidden for the end users

Network-Centric Computing Challenges

- Network-centric computing is being driven by necessity and market demands for equipment manufacturers to create bigger, faster, better systems, which equates to more complex environments such as a "network-centric" environment
- Scaling is a major problem for traditional distributed processing methods as the complexity of network centric systems increases.
  - What we need is a virtual pooling of computing resources by using multiple processors/boards/systems serving the needs of the market
  - Two factors contribute to the advancement of the network-centric computing model
    - Ubiquitous network technologies- Gigabit Ethernet and IP Protocols
    - Embedded Reconfigurable Computing Hardware and Software
- Middleware for embedded communications from multiple processors, boards and systems to communicate and share data creates a capability for multiple heterogeneous hardware platforms supporting network-centric system interoperability
  - Data can be freely exchanged between them

Network-Centric Computing in Systems Architecture View

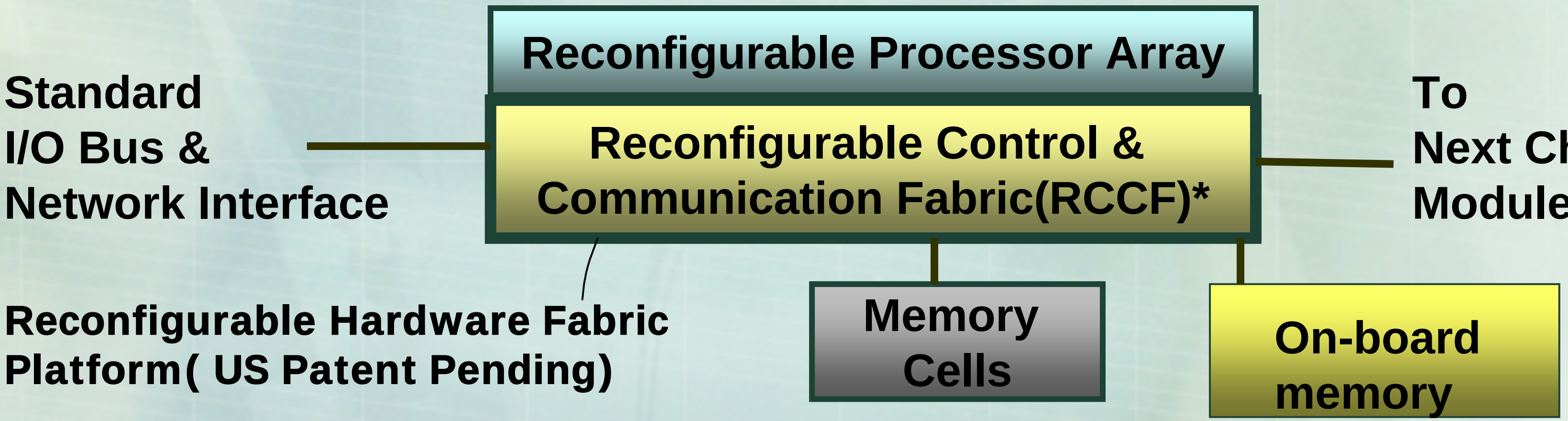


Ubiquitous- Computing everywhere and in everything

- Sensor Network Reconfigurable Computing and SoC Integration
  - Using intelligent computing technologies, low cost, high volume sensor nodes are realizable due to a high level of chip integration (i.e. System-on-a-chip).
  - These sensor nodes can operate more efficiently in a distributed environment using cognitive reasoning for making collaborative decisions, improving the quality of information and real-time sensing control.
  - Reconfigurable Fabric Computing (RFC) provides the flexible connectivity of these sensor nodes to service dynamic application needs.
  - RFC easily integrates other key devices to provide a distributed computing fabric that offers computing at the edge of the network
- Context Aware Computing
  - Systems adapt to their environment by switching communications seamlessly between different available networks made visible to the software
- Collaborative Computing (User Interaction and Experiences)
  - Collaborative computing to share and relay information in such a way that cultivates team review, interaction and collaborative experiences

Reconfigurable Technology Requirements and Hardware Fabric

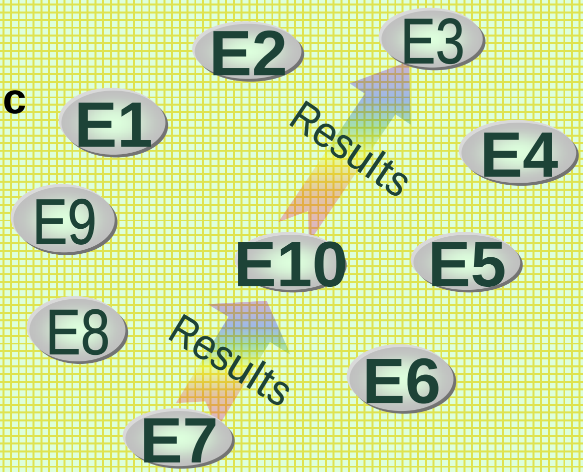
- Need Generic platforms (pre-designed) building block architectures to rapidly build and deploy systems for a given range of applications
  - Platform consists of GPP, RTOS, I/O blocks, Memory Blocks, Reconfigurable Processors, Bus Interfaces
- Need Low-cost, Low Power and Lower Size Integration Solutions
  - Integrate on a System-on-Chip (Fabric on a chip)
- Need flexibility and increased lifetime
  - Reconfigurable Computing adds to increase life time via on-the fly fault tolerant solutions
  - Quick response to changing standards



Network-Centric Fabric

Network-Centric Fabric- ***an interwoven mesh*** **with (Reconfigurable Hardware Fabric Support)-** As users need more computational power, they simply upgrade to high level of computational power on the network that pools resources and even dynamically change the computational capabilities

E1-E10: Network-Centric Entities (Operational Nodes)



Fabric Actions (US patents Pending)**
Computing: process, reconfigure elements & test results
Network: data transfer
Security: authentication, encryption
Cognitive: reasoning & case file compilation

Dynamic Activity=> Event Sequencing (Sequence Diagram)

Time

Economic Implications

- Higher net-centricity demands more global collaborations of Nations
  - Global Economy is directly impacted by Security Threats to Information Infrastructure
    - Secured Interoperability is a MUST
- Power To The Edge (User)
  - In the future, platforms will evolve from being networked entities to being nodes in the network, to organizing efforts like “packs” and “swarms”
  - This notion will be transformational consisting of ever-larger numbers of smaller dumber “thin applications” and cheaper hardware components
  - These collections of entities will ultimately become dynamically reconfigurable highly specialized components that work together like the cells of our bodies
  - We can have “Power to the Edge” in which lot of the functions that currently reside inside the user’s computer can be migrate to the network-- moving the applications <u>inside</u> the network
  - This results in <u>significant economic advantages</u> for edge users!

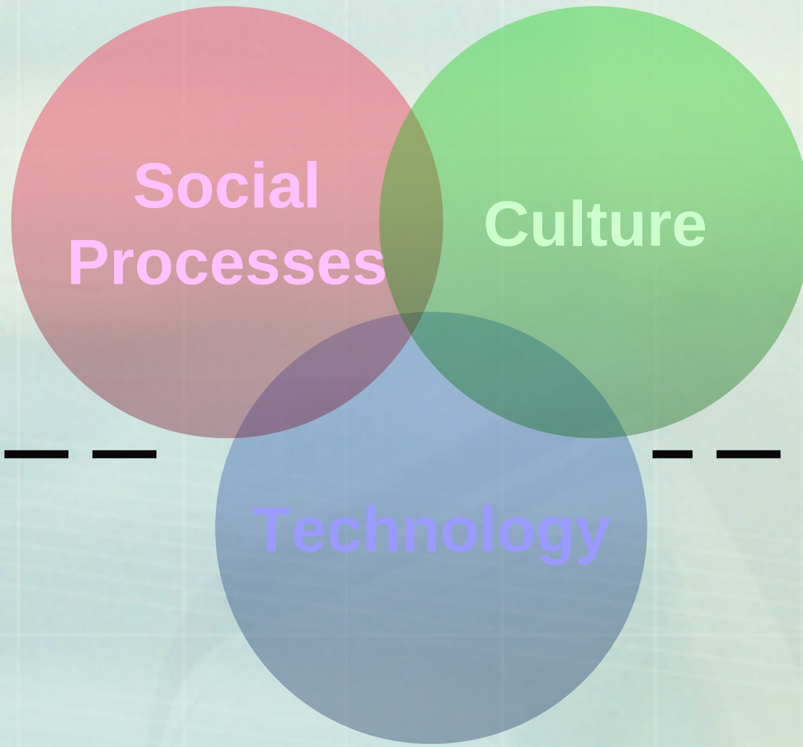
Economic Implications (Continued)

- Power To The Edge (continued)
  - The data, the storage and much of the processing will reside at the edge of the network
  - With this "network-centric" approach, one can access <u>much</u> more storage, memory and processing power
    - The economy shifts from PC to Network World
  - As users need more computational power, they simply use the high level of computational power available on the network
    - Resources are pooled across the Network-- dynamically apply computational capabilities as needed
- No need to upgrade PCs each year to get the next fastest processor
- The network also masks the complexity and incompatibilities of operating systems
  - Allows users to move between applications and releases without draining out hundreds of dollars of software investment

Social Implications

KEY ELEMENTS!

How we Organize, Operate and Interact in an Intelligent Fabric environment



Our willingness to trust the Intelligent Fabric and work together via the Fabric

Technology is important, not in itself, but as an ENABLER for achieving the benefits of the Intelligent Fabric

Social Implications (Continued)

- Edge Users have to change their behavior to *fully utilize* the power of the Intelligent Fabric!
  - Just imaging the world's best mainframe programmer of the 1960's, confronted with today's workstations and the Internet…
  - They would find terms and concepts alien to their proven ways:
    - "Surf the Web and Google some Blogs regarding Cloud Computing"
- Requires socialization of people to behave in ways that may be significantly different than what they've learned in the past
  - Work in ad hoc teams, with people that they've never met, to quickly accomplish some activity as a group
    - Individual benefit is more in their contribution than in the final result– "What's In It For ME" (WIIFM) moves from solving MY problem to being valued as a knowledge contributor in a larger social context
  - To rely on each other, and rely on networked resources that are not under their immediate control (not even know where the people and resources are located)

Social Implications (Continued)

- Some other serious barriers to Cultural and Social Transformation to fully utilize the power of the Intelligent Fabric
- Security and information privacy issues
  - Anonymous activities may encourage snooping and prying and socially-unacceptable activities, without fear of reprisals
  - Concern regarding one’s Intellectual Property (IP): will my work be stolen and someone else claim it as their work?
  - Concern regarding one’s financial or socially-sensitive information: will someone use this to steal from me? Blackmail/pressure me? Deny me employment or insurance because of medical conditions?
- Trust actions performed “behind their back”
  - Reputation on the line if the Intelligent Fabric obtains incorrect or mis-interpreted results
  - Potential for legal liability if professional recommendations made based on use of resources not owned by the professional

Summary

- Network-centric reconfigurable computing advances net-enabled capabilities of
  - Data/Information and Control (Ubiquity) everywhere
- Power to the edge is way to go today moving from platform centric computing to edge computing with reconfigurable computing resources
- Future of network-centric computing relies on added reconfigurability
  - Adding reconfigurable fabric permits quick hardware upgrades and a system constraint driven customization
- The network-centric computing can also result in large economic and social impacts as societies continue their transition from the Industrial Age into the Information Age

Presenter's Brief Biographies

- Dr. Tirumale K Ramesh is a Boeing Technical Fellow and Chief Technologist-AMSE Virtual Operations at The Boeing Company. Dr. Ramesh's current work at Boeing involves leading a Network-Centric Live, Virtual, Constructive (LVC) Architecture Capability Team for AMSE-Virtual Operations. As a member of NCOIC, he is working on several technical initiatives for NCO technical development. Dr. Ramesh also led a Boeing Corporate Research on Advanced Embedded Computing and Network research funded by NCO Thrust. He has held Senior Technical positions at Lockheed Martin Corporation and IBM. Dr. Ramesh started his career at Indian Institute of Science, Department of Aerospace Engineering and later he joined Indian Space Research Organization (ISRO) Satellite Center working in the early part of Indian Space Program from 1977-81. He has been granted US and UK patents and has several patents pending. He has over 50+ technical publications in IEEE sponsored conferences and journals. Dr. Ramesh is an active Senior Member of IEEE and serves on Technical and Conference Board of IEEE CS

- Kenneth Cureton is a Senior Network-Centric Systems Engineer and Engineering Manager for NCO System-of-Systems Architecture Integration. He is currently assigned as the Technical Lead for Boeing in the NCO Industry Consortium (NCOIC), and serves as the Chair of the Engineering Processes Functional Team. In his prior role, Cureton managed Strategic Architecture development efforts, including systems engineering and ongoing development of a common interoperable, network-centric architectural reference models. Prior to joining Boeing in 1987, Cureton served as Vice President, Research and Development for Computer Systems at Command Computer Service, Inc. in La Mirada, Calif. Cureton also serves as Adjunct Faculty at the University of Southern California (USC) teaching in the network-centric systems program.