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Position Paper

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Science and technology related to computing and communications have made remarkable progress in the 50 short years of their modern existence. The focus on innovation has been, and largely remains, on aspects related to the building of components and infrastructure. Arguably, we have reached the stage where significant future progress on developing agile and interactive enterprises, whether public or private, governmental or commercial, requires more attention to application-level considerations.

Recently, our attention has been directed towards coordinating group (multi-agency) responses to natural and terrorist disasters, especially preparedness, real-time situation assessment, joint (unified) planning and timely (completion-time sensitive) responses. These requirements demand, in turn, attention to operational protocols that support coordinated intra- and inter-enterprise behaviors (especially matters of policy, capability and authority) and a set of network- mediated (cyber-physical) services that *allow* effective collaboration in the face of anticipated threats, crisis detection and response, and post-crisis administration (remediation). Attention to these matters requires a move towards specification and development of cyber systems and services capable of supporting *federated governance* of sovereign application-level entities.

Operational cyber-physical protocols supporting governance of federated systems, a “constitution” for intelligent cyberspace entities, represents a Grand Challenge, one significant not only in its technical dimensions, but also in its cyber-social (cultural and political) dimensions. Beginning from the perspective of our “common defense” has significant historical precedence.

1. What are the three fundamental limitations of today’s cyber-physical systems?
   1.1. Lack of a coherent and standardized concept of *cyberspace governance* (cooperative interaction models) supportive of efficient collaboration and effective synchronization (policies, resources, accountability) among federations of sovereign entities (enterprises)

1.2. Given 1.1, lack of a broadly relevant *theory of unified command (decision) and control* applicable to [semi-]autonomous and self-regulating enterprises (*edge organizations*) interconnected by a cyber-physical infrastructure
1.3. Lack of [scale-free] cyber-physical *application quality of service* (AQoS performance) metrics

2. What are the three most important research challenges?
   2.1. Defining a cyber-physical object and establishing a unified (and unique) naming (addressing) scheme, including integration of a geospatial (e.g., tessellated, quantized and indexed) reference model (DERM) and an infospatial (IPv6) model—the result a *cyberspatial reference model*—aka, *the geospatial internet*
   2.2. Development of a science of network-mediated governance (e.g., expanded cybernetics) capable of supporting specification of an *application services framework* for grid-based (distributed) real-time enterprise operations
   2.3. Identity, policy and capabilities management services sufficient for efficient dynamic scheduling within and among cooperating entities, whether bound by cyber-physical infrastructure in peer-peer or superior-subordinate relationships
3. What are promising innovations and abstractions for future cyber-physical systems?
   3.1. Real-time distributed system invocation services (e.g., trans-node thread scheduling as in the *Distributed Real-time Specification for Java*)
   3.2. Emerging *theories of enterprise command and control* (e.g., US DOD requirements for unified—joint—command systems and post-Katrina requirements to provide dynamic coupling of local, state and federal agencies and their systems), including work by this author
   3.3. Integrated stationary and mobile voice, video and data (including chat, net meetings, software-defined radios, etc) in support of secure (pushed and pulled) communications between/among collaborating human and synthetic actors responsible for enterprise governance
4. What are possible milestones for the next 5 to 10 years?
   4.1. Charter and establish a community standards project (via NIST, OMG, OASIS, etc) to establish a *cyber-physical governance framework* (NOT the management of cyber-spatial infrastructure per-se, but rather governance of federations of end-systems—applications—that utilize services of a cyber-physical infrastructure in order to “form a more perfect union”), by 4Q07
   4.2. Release initial subset (core) of cyber-physical governance framework standards, by 4Q08

4.3. Produce initial subset cyber-physical governance services (reference implementation), by 4Q09
4.4. Establish one or more academic "centers of excellence" to pursue the net-centric governance as it relates to public policy, healthcare, homeland defense, industrial innovation, federal, state and local (civil) governance, etc. (4Q10)

Biography

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Dr. Bayne is an executive, writer, philosopher, scientist, entrepreneur and senior technologist with over 30 years of academic and commercial experience, including over 20 years in chief technology (CTO) positions. He founded and successfully operated three businesses, two of which were sold to global engineering companies, the third he currently manages. He has a PhD Electrical Engineering (communications and control theory) & Computer Science from the University of California, Santa Barbara, 1976. He was full professor at California Polytechnic State University (SLO) from 1973-1984. In 2002 he founded Meta Command Systems, Inc., a professional consultancy and software development company specializing in *Enterprise Command and Control* (EC2), software and systems. In addition to his CEO duties, Dr. Bayne holds the position of Senior Consultant to the Office of the Assistant Secretary of Defense for Networks and Information Integration (OSD/NII). He has authored over 20 papers in the last five years and recently completed a book entitled *Creating Rational Organizations—Theory of Enterprise Command and Control*.