A More Intelligent Network
Sharing
More Intelligent Information

1. Introduction:

The Department of Defense is more dependent on information sharing than ever before. Distributed decision-making is the core to most DoD plans. Since problems have increased in complexity, more capable solutions are needed. There are many aspects of this issue. This paper will focus on just a few of them:

1. Embedded Intelligence of the Global Information Grid (GIG)
2. Information Structure for Complex Decision-making
3. Life Cycle Costs Associated with Advanced Capabilities

Global events have the potential to disrupt (or place dynamically changing demands on) the GIG. Human operators may not have the capacity to comprehend the complexity of the situation when operating under stress. Errors in human judgment as well as threats from external forces have the potential to disrupt vital communication and disable timely decision-making. The Net-Centric Data Strategy (NCDS) highlights goals for an intelligent, adaptive GIG.

In addition to the infrastructure for sharing information, the ability to extend decision-making capabilities beyond just sharing structured and unstructured data needs to be provided. Future systems will be hybrids of human and autonomous systems. Autonomous systems including UAVs, UUVs and UGVs will be integrated with human operated systems. These systems will have to collaborate to pursue individual and collective goals. NCDS goals highlight the need for visible and understandable information. This information will include "active information" or policies that describe how complex problems are to be addressed. A better method of describing complex behaviors in an explicit manner is required when defining information packages that could define policies for execution by humans or by intelligent devices.

The cost for creating this added level of intelligence must be considered. Just adding more hardware will not do the job. Instead, a solution should be provided that addresses the need for rapid cost-effective development of cognitive models that can respond to complex, dynamic, non-linear, inter-related problem sets.

Knowledge Enhanced Electronic Logic was developed specifically to allow devices to execute human judgment when applied to real-time adaptive systems. It allows human domain experts to capture, test, package, audit and explain policies to address complex problem sets. It is supported with a "dynamic graphical language" that allows dynamic, non-linear, inter-related, multi-dimensional problems to be addressed without requiring knowledge of high level mathematics. This makes it suitable for use by humans that understand the problems, rather than mathematicians and software engineers. The models themselves can be used to share complex concepts between human users. Once created, the cognitive models can be deployed across the GIG for use in network attached devices. Additional tools support real time monitoring of the cognitive processes.

The GIG and its many application domains, as well as embedded “edge systems”, are places for KEEL decision and support applications.

2. Alternative Means of Defining and Executing Intelligent Behavior

2.1. Intelligence of the Global Information Grid (GIG)

The last decade of GIG development focused first on the transport infrastructure (satellites, fiber optic cabling, routers redundancy, security) and then on data sharing, including rationalizing databases, web browser user interfaces, search engines, etc. The next decade will need to consider rationalizing processes that use data-driven C2 applications that perform situation assessment, planning, and plan execution among allied and foreign agencies.

2.1.1. Conventional Approach to Added Capability: Adding Increased Processing Power and Network Bandwidth

Industry has continued to pursue the increase in chip density to provide higher performance computers. Parallel processing allows computation to be shared between processing elements. Memory densities continue to rise, allowing more complex solutions to be housed in local systems. Distributed computing, SOA, SaaS, cloud computing are all architectural concepts to decentralize the computing process.

While these techniques certainly allow more information to be processed, they potentially add complexity into the systems. This complexity has the potential for adding risk to the systems. These systems could benefit from embedding levels of human-like intelligence which would allow them to operate autonomously under stress.

2.2. Information Structure for Complex Decision Making:

Neither the English language nor complex mathematics provide both easy to use AND explicit mechanisms to document and explain complex scenarios. The English language fails to explicitly define all information items in measureable terms. Complex mathematics, while providing an explicit means of documentation, is not easy to use by the majority of the population.

2.2.1. Conventional Computer Languages (Rule-based systems)

Since the advent of the digital computer (the von Neumann architecture), computers have been processing rules and numbers. Numerous languages and packaging techniques have been developed to process IF | THEN | ELSE sequential logic. In the past, functional decomposition and object-oriented programming focused on code reuse and modularity. High level languages streamlined the process. Rule-based systems have been fundamental to most automated solutions that are available today. Computer scientists have attempted to exploit the capabilities of computers to create forms of artificial intelligence.

As these techniques were challenged to address more complex, dynamic systems their costs to develop and maintain them escalated. Complex mathematics has been and is required to address non-linear systems. There are extremely high costs associated with translating ideas into mathematical formulas, and then into software “code” before it can be tested. The resulting large monolithic computer programs are often so large that they cannot be easily understood. The conventional approach has been to continually develop faster and faster computers with more and more memory in order to keep up with the more complex rule sets (programs). Once the complex solutions are developed, the domain expert who had the idea, or the individual that had the responsibility for the policy that was to be captured, had almost no chance of understanding how it was actually implemented. Using conventional methods to extend complex, inter-related, rule-based systems has the potential of introducing “bugs” into the system that (in safety critical systems) has the potential of catastrophic errors.

2.2.2. Extensible Markup Language (XML)

One of the most significant advancements in information modeling and information exchange has been the development and use of XML and associated technologies. The use of XML DTDs (Document Type Definitions) and XML schemas (more detailed definitions) have allowed a formal categorization of data. Tags that are readable by both humans and computers allow information to be organized for archival and retrieval. Numerous tools are available to help humans package their information in XML structures. Information that has been packaged as XML can more easily be manipulated through structured databases. Different communities can create their own DTDs and schemas relevant to their specific problem domains.

Structured data by itself does not describe how it is to be used.

3. Knowledge Enhanced Electronic Logic (KEEL Technology)

KEEL is a base level technology that can be used as a foundation for creating, testing, packaging, auditing and explaining solutions to dynamic, non-linear, inter-related, multi-dimensional problem sets. When embedded in devices it can be used to provide 100% explainable auditable behaviors. The KEEL “dynamic graphical language” allows complex models to be created with relative ease.

3.1. Embedded Intelligence of the Global Information Grid (GIG) and Edge Devices (Processing Intelligence)

KEEL "Engines" process information in a new way. Unlike sequential processing, rule-based systems (where a programmer defines rules to get answers) using KEEL Technology, a domain expert defines how factors are inter-related. Information is processed in parallel (during a cognitive cycle) and answers are observed. KEEL Engines operate in a manner similar to an analog system where information items are interpreted for value, and inter-related functional relationships balance to address conflicting goals. Developing KEEL-based systems is a rapid, iterative process as one continually adds new factors into the decision-making model and tests how the factors interact with others. The KEEL "Engine" is constructed while the model is being created and is instantly available for testing. The systems can evolve; becoming more and more capable over time. Small, high-performance cognitive functions (KEEL Engines) can be integrated into almost any software application or device. This makes them suitable for operation anywhere within the pantheon of C2 architectures and applications.

KEEL Technology is platform and architecture independent. Cognitive models can be created in almost any language (C, C++, C++.NET, C#, Java, Flash, Octave (MATLAB), Python, Visual Basic, VB.NET, and others). KEEL Engines can be deployed as standard web services for SOA, SaaS, or cloud computing.

3.2. Information Structure for Complex Decision Making (Defining Intelligence)

The KEEL "dynamic graphical language" provides a new way to define and document complex behavior. Using this graphical language it is easy to visualize how complex problems are decomposed and how information elements are valued. When one is focusing on a more intelligent grid, one must consider how information is described and used. KEEL Technology provides both a way to define complex information models and a way to process them. Complex models can be created in days, rather than in months or years.

In many cases individuals who are responsible for addressing complex problem sets need tools and techniques that allow them to develop and refine their own understanding of the problem sets. The interactive nature of the KEEL language allows them to test different concepts, make changes, and observe impacts "immediately". The KEEL language helps humans "think". The resulting KEEL model is 100% explainable and auditable. An XML model defines the problem set and can be shared across the GIG when it is necessary to share problem solving skills.

KEEL Technology is supported with formal user's documentation, training material, code walkthrough documentation, system engineering tools, and auditing tools for reverse engineering decisions and actions made by devices and autonomous systems.

3.3. Life Cycle Costs Associated with Advanced Capabilities

The learning curve is very short to become productive with the KEEL dynamic graphical language. Dynamic, non-linear models can be created in minutes. More complex inter-related, multi-dimensional models can be created in days. No knowledge of advanced mathematics is required. Conventional code implementing the KEEL cognitive engines is automatically generated.

Complex KEEL models can be easily understood using the KEEL language. Dynamic functional relationships can be monitored and reverse engineered. Flexible, adaptive models can be easily extended.

All of these features help manage life-cycle costs associated with creating and using complex policies that will be necessary to support future operations.

4. Conclusion:

KEEL Technology supports the need to define complex behaviors and add intelligence to network operations today to enhance the resilience of the GIG without adding complexity to the system.

KEEL Technology also supports the need to enhance decision-making in general by providing a language to describe how to interpret complex problem sets in a dynamic environment.

A platform technology like KEEL Technology that is compatible with almost any architecture is needed to address complex problem sets that must be addressed now to meet the needs of future weapon systems, financial systems, transportation systems, utility systems, etc.; especially those systems that require that they be both explainable and auditable.

KEEL Technology also addresses the need to manage life cycle cost issues and also to support the rapid development cycle that will be required to address constantly evolving scenarios.

KEEL Technology supports these needs now. KEEL Technology is only available from Compsim LLC, the inventor of the technology.

Plan of Action:

Organizations with the responsibility to meet the needs for better and faster decisions should become aware of KEEL Technology in order to remain competitive. Once those organizations validate for themselves that KEEL Technology can provide a better mechanism for describing and executing complex, auditable behaviors (policies), KEEL Technology should be incorporated into collections of available technologies. This will increase capabilities and reduce life cycle costs.

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