OBJECTIVE: Develop a set of real-time multi-platform data synchronization and coherency (DCS) algorithms to support an extensible and evolvable Distributed (i.e., multi-platform) Common Operational Picture (DCOP) subsystem.

DESCRIPTION: A Navy requirement exists to expand its sea-based advantage through increased capability. This need can be addressed by providing technology that has the potential to improve ship combat effectiveness and efficiency by significantly improving cross-platform data transfer and subsequent improvements in multi-platform situational awareness data coherence, thus reducing the management complexity of the overall battlespace. This reduction in battlespace management complexity may allow for a commensurate reduction in the number of platforms needed in a specific tactical arena, improved affordability, and an improvement in the overall tactical efficiency of the battle-group as a whole (i.e., the whole is greater than the sum of its parts). Such improvements to both ship and battle-group tactical efficiency may prove exceedingly cost-effective and lead directly to the “creation of a more lethal force by improving command, control and effectively delivering lethal force within a joint environment” (see 2018 National Defense Strategy [Ref. 1]).

The current AEGIS combat system implementation does not include a comprehensive distributed capability for capturing the complete battlespace operational, environmental, and tactical picture in a coherent integrated manner. Currently available commercial systems and software, which might be considered for adaptation to our needs (e.g., the FAA Air Traffic Control System hardware & software), are dated in their designs, and lack the flexibility and track capacity required to adequately address Navy tactical needs. Specifically, currently available commercial technology is limited in that it lacks the capability to track, identify, and manage complex air, surface and subsurface entities and threats present in the DoD environment.

Work has been done on distributed database system design over the years [Ref. 2]; however, the real-time performance parameters and constraints imposed by Navy tactical requirements on a viable common operational picture (COP) battlespace monitoring and data information subsystem contain a unique set of constraints (i.e., to provide consistent and synchronized fire control quality targeting data) mandating substantial innovation be applied in order to develop a workable solution. The DCOP DCS algorithm set and its associated architecture must be capable of supporting real-time battlespace COP data access control (to eliminate data access race conditions) and multi-platform DCOP data coherency and synchronization mechanisms as a modular part of the overall DCOP architecture. A new capability needs to be developed within AEGIS (as well as any future proposed combat system architecture) in order to present a COP to the combat systems watch stander, which provides that watch stander with complete situational awareness. The Navy needs an innovative method of ensuring real-time data synchronization and coherency across multiple ship- and shore-based platforms implementing a DCOP software subsystem. The focus of this topic is the development of a set of algorithms, and an associated software framework, capable of providing and maintaining real-time fire-control quality data for any and all combat systems applications utilizing the DCOP. Any subsystem which provides such a capability should include detailed engagement-quality track data, identification data from various sources, estimated platform sensor and weapons capabilities derived from organic and
The DCOP multi-platform data synchronization and coherency algorithm set should be considered in context with an appropriate DCOP software architectural model, data model (DM), and DM markup language. These components, when considered as a whole, should be capable of supporting the functional capabilities and requirements needed to provide a comprehensive real-time battlespace DCOP to each Navy or allied warfighting platform capable of hosting a DCOP subsystem.

The DCOP data synchronization and coherency algorithm set system model contains the following major components. First, it must contain the DCOP architectural model, software framework, and Applications Program Interface (API), which provides a mechanism for dynamically loading and managing software modules implementing DCOP capabilities and a DCOP API. This API provides various combat systems applications with a real-time mechanism for accessing battlespace COP data in a manner which is independent of the method by which such data is stored and maintained within the DCOP subsystem. Second, the DCOP Data Model, which defines the architecture of the actual DCOP software data structures, must be designed to reflect a parametric model of the actual battle-space and the various entities (friendly, hostile, or neutral platforms and their sensors, weapons, etc.) populating it. Lastly, the DCOP multi-platform data synchronization and coherency algorithm set and its requisite architecture, which has the responsibility of ensuring that each of the various executing DCOP instances and their associated data models residing on the participating DCOP platforms, must maintain a common synchronized and coherent picture of the overall battle-space. The technology sought focuses specifically on the development of this component, but it is important to recognize that the product of this topic is intended for integration with the other DCOP components described.

The DCS algorithms should be capable of monitoring the overall battlespace picture and the various elements and entities within that picture. The algorithms should also be capable of coordinating the real-time synchronization of the data model instances on each participating DCOP platform to ensure COP coherency across the entire DCOP network. In the event that real-time data coherency becomes compromised due to communications issues (e.g., adversary jamming, weather issues), the DCS algorithms must be capable of tagging the impacted non-organic (i.e., off-board) sensor-sourced data structure elements with appropriate coherence-focused “senescence and reliability” metrics. Metrics include, but are not limited to, data update delay in milliseconds, average delay jitters, and multi-source correlation. The algorithms must also be capable of synthesizing an overall Quality-of-Service (QOS) and reliability metric intended to give the operator and/or any combat systems applications an indicator as to the staleness or reliability of the data for any particular battle-space entity.

The DCS algorithms will also be capable of prioritizing and tagging battlespace entities with respect to a set of overarching operator- and Artificial Intelligence-based application-specified threat identification parameters. The algorithms must also be capable of utilizing that data to determine requisite cross-platform and sensor data update rates for each entity within the battlespace, with the intent of minimizing cross-platform data update bandwidth requirements by reducing update rates for non-threatening and slowly changing or moving battlespace entities.

Both the DCOP algorithms and their associated architectural models shall be well documented, and conform to open systems architectural principles and standards [Ref. 3]. Implementation attributes should include scalability and the ability to run within the computing resources available within the AEGIS combat systems BL9 or later environment. The algorithms, as well as any hosting system requirements, should be designed using modular principles with these goals: (i) eventual utilization of the DCOP Application Program Interface (API) for abstracted data structure access; and (ii) the eventual implementation via a dynamically installable software module within the DCOP dynamic loadable module software system architectural model.

Any developed software should be compatible with the C++ programming language and capable of installation within a prototype DCOP subsystem via the use of DCOP modular runtime loading mechanism. The DCOP host subsystem execution environment will be hosted on a Linux (Redhat RHEL 7.5/Fedora 29/Ubuntu 18.4.1 or later) processing environment as a standalone application (i.e., no critical dependencies on network-based remotely hosted resources, save for sensor data emulators or network-based connections to other running DCOP instances). The prototype DCOP multi-platform data synchronization and coherency algorithm suite implementation will demonstrate the following abilities. First, it must demonstrate the ability to successfully coordinate battlespace COP real-time data synchronization and maintain coherency across 10 or more executing DCOP instances hosted on separate computing platforms. Second, it must demonstrate the ability to successfully tag appropriate data elements within the DCOP data environment with QOS reliability metrics reflecting a loss of QOS when a DCOP communications channel between two or more DCOP instances is compromised or disabled. Third, it must demonstrate the ability to dynamically set DCOP data element update parameters based on operator specified threat identification parameters. Lastly, it must demonstrate the ability to successfully update the DCOP algorithm set software module within an executing DCOP subsystem implementation without impact to the performance of non-organic databases, and observationally derived behavioral data for each tactically relevant entity or non-combatant entity within the battlespace. The subsystem must be modular in nature and support the sharing of the COP across all participating platforms within the battlegroup in a manner that ensures the real-time data coherency of the COP on every platform.
that executing instance.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been be implemented and approved by the Defense Security Service (DSS). The selected contractor and/or subcontractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DSS and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Design, develop, and deliver a concept outlining the algorithms needed to implement a DCOP multi-platform data synchronization and coherency capability meeting the requirements and capabilities as outlined in the Description. Establish feasibility of the concept through modeling and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Produce a prototype DCOP multi-platform data synchronization and coherency algorithm suite. Implement the prototype and demonstrate the following abilities. First, it must demonstrate the ability to successfully coordinate battlespace COP real-time data synchronization and maintain coherency across 10 or more executing DCOP instances hosted on separate computing platforms. Second, it must demonstrate the ability to successfully tag appropriate data elements within the DCOP data environment with QOS reliability metrics reflecting a loss of QOS when a DCOP communications channel between two or more DCOP instances is compromised or disabled. Third, it must demonstrate the ability to dynamically set DCOP data element update parameters based on operator specified threat identification parameters. Lastly, it must demonstrate the ability to successfully update the DCOP algorithm set software module within an executing DCOP subsystem implementation without impact to the performance of that executing instance. Demonstrate the prototype capabilities outlined above during a functional test to be held at an AEGIS and/or Future Surface Combatant (FSC) prime integrator supported Land Based Test Site (LBTS) provided by the Government, representing an AEGIS BL9 or newer combat system environment. It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL-USE APPLICATIONS: Support the Navy in transitioning the DCOP multi-platform data synchronization and coherence algorithm set prototype for Navy use. Integrate the algorithm set and DCOP subsystem software into a prototype combat system, consisting of one or more of the following: AEGIS BL9 (or greater) or Common Core Combat System (CCCS) experimental prototype implemented on a virtualized hardware environment within an AEGIS compliant land-based testbed.

This technology has potential for dual-use capability within the commercial Air Traffic Control system in future development of an air traffic “common operational picture” capable of handling complex traffic control patterns.

REFERENCES:


KEYWORDS: Data Synchronization and Coherency Algorithm Set; Synchronized and Coherent Picture of the Overall Battlespace; Operational Picture Data Access Control; Real-time; DCOP; COP Synchronization of the Data; Resilient Multi-platform Distributed Common Operational Picture; Common Synchronized and Coherent Picture; COP; DCOP