Affordable C2 Hardware and Software

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Abstract

Joint Vision 2010 describes an approach about joint warfare of the future, and it depends on and highlights the contributions of air power. Accordingly, the Air Force's vision of Global Engagement flows from Joint Vision 2010. The Air Force's Strategic Plan outlines the core competencies that are necessary for Global Engagement. The capability for attaining the desired capabilities and goals of these visions depends on an adaptive, unified, dynamic aerospace C2 system. The unified C2 system will provide for the capability to dynamically assess, plan, execute, and project aerospace power in a joint environment. However, this capability must overcome the challenges of complexity and ultimately affordability, if it is to become a real system. In addition, future dynamic C2 systems must be integrated into a system of systems to be effective. This paper discusses development approaches and technologies that offer significant savings in overcoming the complexities of fielding a unified C2 system. Specifically, this paper covers how existing aerospace platforms can affordably insert the technology necessary to operate with the future dynamic C2 systems. Furthermore, the paper discusses how C2 systems can be benefit from the use of system level design representations and modeling.

1.0 Introduction

In *Joint Vision 2010*, the Chairman of the Joint Chiefs of Staff has provided a common direction for our military services into the next century. This vision calls for the capability to dominate an opponent across the range of military operations, i.e. Full Spectrum Dominance. The plan to achieve this goal comprises four operational concepts to guide future joint warfare development - Dominant Maneuver, Precision Engagement, Full-Dimensional Protection and Focused Logistics. In addition, Full Spectrum Dominance requires Information Superiority, the capability to collect, process, analyze and disseminate information while denying an adversary's ability to do the same.

Essential to attaining the future capabilities and goals outlined in high-level documents such as *Joint Vision 2010*, the Air Force's *Global Engagement* vision, and the Air Force Strategic Plan, is enhanced command and control (C2). The systems that will provide this enhanced C2 will operate in an operational environment that contains numerous interconnected sensor and strike systems. Since the new C2 systems will pass and receive data and information to these other systems, the C2 development approach requires methods that reduce design complexity and implementation costs. Modeling and simulation is a key method that can satisfy this need. In addition, new technology is needed to allow the existing systems to be affordably upgraded so as to communicate with the new C2 systems.

2.0 System Level Design Representations and Modeling

Future aerospace C2 system will interface to a system of intelligence, surveillance, and reconnaissance platforms. The result is a system of systems. As shown in the following figure, this system of systems is the top level of an architectural hierarchy.

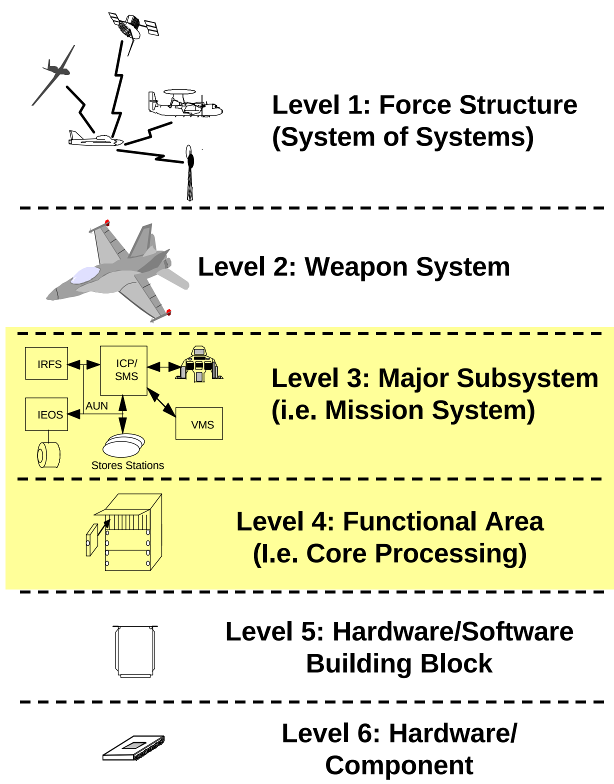


Figure 1

The complexity of building a C2 system and modifying existing weapon systems to operate as a unified system of systems can be managed through the use of simulation and modeling. Specifically, by applying the principles of Simulation Based Acquisition (SBA) and designing with the Unified Modeling Language (UML) and System Level Design Language (SLDL). The following sections will discuss these areas in more detail.

2.1 Simulation Based Acquisition

The vision for Simulation Based Acquisition (SBA), adopted in 1997 by the Acquisition
Council of the Department of Defense (DoD) Executive Council for Modeling and Simulation (EXCIMS), is "an acquisition process in which DoD and Industry are enabled by robust,

collaborative use of simulation technology that is integrated across acquisition phases and programs." SBA promises to reduce the cost of system development by avoiding the need to build expensive hardware and software first in order to determine the necessary processing resources, communication link bandwidth, and resource management techniques. An architecture description is necessary for SBA. Accordingly, models of the system under construction will have to be developed. However, each level in the architecture will be modeled with a design language suitable for the particular domain. For example, the hardware components (Level 6) may be modeled using VHDL while the hardware/software building blocks (Level 5) may use the Unified Modeling Language.   A System Level Design Language (SLDL) is suitable for Levels 1 through Level 4.

2.2 Unified Modeling Language (UML)

The Unified Modeling Language (UML) is a language for specifying, constructing, visualizing, and documenting the artifacts of a software-intensive system.   UML is nonproprietary and open to all. As a result, UML is widely used by software and system developers. However, UML is a visual modeling language, not a visual programming language. It does not have all the necessary visual and semantic support to replace programming languages.   Fortunately, UML does have a tight mapping to a family of OO languages, so the transition from modeling to programming is seamless.

2.3 System Level Design Language (SLDL)

SLDL is a language environment for the specification and high-level design of microelectronics-based systems. SLDL is focused on system-on-a-chip design constraints and behavior at architectural levels prior to HW-SW partitioning. However, nothing limits its use in the higher levels of the system. Work is ongoing to create a standard SLDL. Once complete, SLDL will enable engineers to describe embedded systems to any desired degree of detail and that will allow engineers to verify and/or validate those systems with the appropriate tools.

3.0 Upgrade Technology

New upgrade technology is needed to achieve the interoperability required between the C2 system that supports the Air Force vision of Global Engagement and the sensor and strike platforms. Existing systems will have to be upgraded to become interoperable with future C2 systems if the Air Force concept of dynamic aerospace command is to be realized.   Cost is the major barrier to these upgrades. The following sections describe key software technology that will enable existing systems to be upgraded to meet the need for C2 interoperability.

3.1 Object Request Broker (ORB) Technology

An ORB is the software technology that manages communication and data exchange between objects. The ORB is a vital component in supporting a unified C2/strike system. It promotes the interoperability of distributed object systems by allowing objects from different sources (written in different languages, and executing on different platforms) to communicate with one another via the ORB.

The ORB establishes the client-server relationships between objects. Using an ORB, a client can transparently invoke a method on a server object, which can be on the same machine, across a network, or with respect to a military C2/strike application, across a system of systems. The ORB intercepts the call and is responsible for finding an object that can implement the request, pass it the parameters, invoke its method, and return the results. The client does not have to be aware of where the object is located, its programming language, its operating system, or any other system aspects that are not part of an object's interface. In so doing, the ORB provides interoperability between applications on different systems in heterogeneous distributed environments and seamlessly interconnects multiple object systems. The ORB is critical enabling technology for a dynamic C2 system to operate within a system of systems.

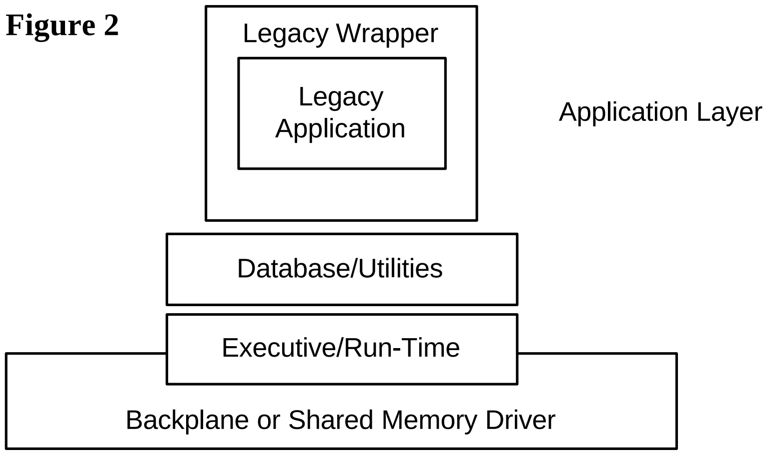
3.2 Software Wrapper Technology

With respect to performance and affordability, it is difficult to avoid the influence existing (legacy) systems will have on future Air Force C2 systems. The C2 systems needed to support the Air Force vision of Global Engagement will have to interface with numerous existing weapon systems. However, many of these existing weapon systems were designed to operate and fight almost autonomously. They lack the ability to pass digital information within an integrated, dynamically adaptive C2 system. Accordingly, without a strategy to affordably upgrade existing systems to function within the new C2 environment, conditions will not change significantly. This section describes an approach that uses software wrapper technology to support the affordable insertion of new functions within fielded weapon systems. These new functions will enable the fielded weapon systems to connect to the global information grid envisioned by the Air Force.

A software wrapper is an adapter or a shell, which isolates a software component from other components and its processing environment (its context). The wrapped component becomes a software object. Its operational capability (functions and data) is encapsulated, and it can be integrated through its standard interface with other software objects to form a complete program on a single or distributed processor host. The wrapper manages the timeliness of all shared and external data, and provides any necessary transformations. For upgrades involving the addition of new C2 interoperability functions, the goal is to develop this new application using the latest software engineering techniques (such as object oriented design) and languages (Ada and C++) with minimal concessions to the internal structure of the legacy system.

Wrappers are generally applied at the application domain level. They act as clients and servers to the encapsulated component. The following figure illustrates a general wrapper structure for an operational flight program on a single processor. The legacy application interfaces with other applications and other layers only through the wrapper.
Overall, the wrapper architecture is tailored to the specific legacy operational flight program environment.

Figure 2



3.3 Integration and Automation

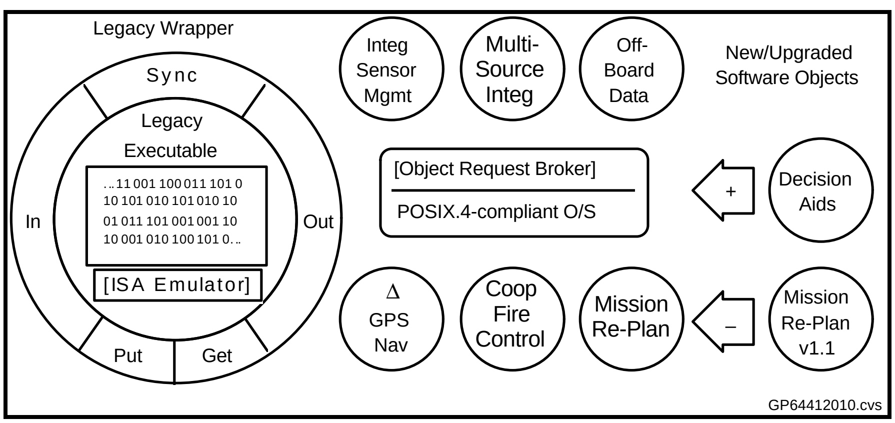


Figure 3

This use of software wrapper technology and ORBs, as illustrated in the figure above, allows the existing weapon system software to be treated as an object so as to interface within the object based C2 environment of the future.

Automation is critical in the development of these wrappers, else there would be little cost advantage over the unaffordable approach of rewriting all the existing software. The figure below illustrates the process.

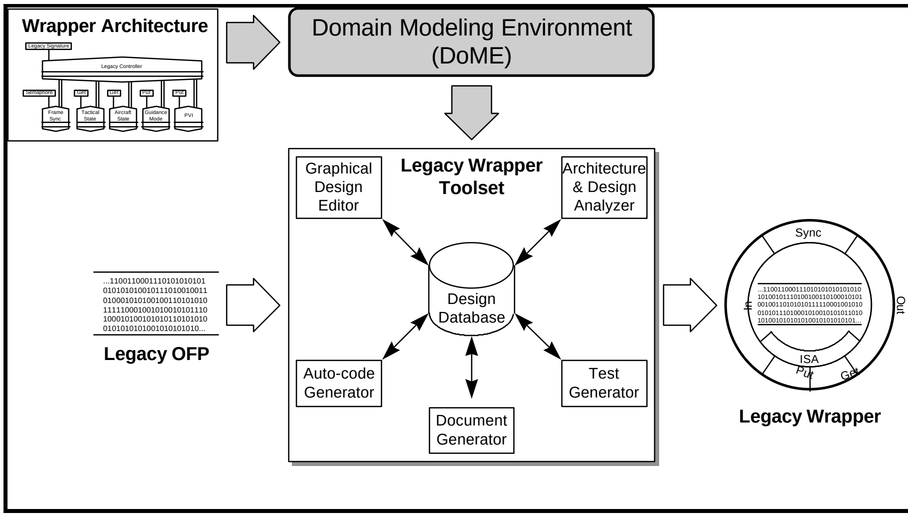


Figure 4

4.0 Summary

In summary, the information based C2 vision for 21st warfare will only occur it we can overcome the fiscally constrained realities of the current period. Therefore technologies that promote affordable development and implementation are required. This paper describes how approaches for reducing the complexity and cost of integrating C2 systems within a system of systems. In addition, dynamic C2 will require that existing systems be upgraded to satisfy the need for interoperability. This paper described technology that will enable systems to be affordably upgraded.