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Command and Control (C2) Nodes in an
Enterprise Environment

Dagohoy H. Anunciado

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Framework for the Dynamic Establishing of Command and Control (C2) Nodes in an Enterprise Environment

C2 Architecture

Dagohoy H. Anunciado

Dagohoy H. Anunciado
SPAWARSYSCEN 24226, San Diego, CA & Naval Postgraduate School, Monterey CA
53605 Hull St Bldg A-33
San Diego CA 92152-5001
619-553-5604/619-553-6025 FAX
doug.anunciado@navy.mil

Abstract

This research presents a framework to aid in the dynamic and controlled establishing of Command and Control (C2) nodes in an enterprise environment. The dynamic and controlled establishing of C2 nodes might provide an advantage to military forces in maintaining robust C2 operations during continually changing threats.

This proposed framework describes the characteristics of a generic C2 node and the policies that govern the establishing of C2 nodes into an enterprise of C2 nodes.

1.0 Introduction

A mechanism to support the dynamic and controlled establishing of Command and Control (C2) nodes might provide an advantage to military forces. One advantage would be the maintaining of a robust C2 operation during continually changing threats. This robust operation would occur while C2 nodes connect and disconnect from the enterprise supporting the operation. This enterprise is composed of computer, network, and sensor systems.

An assumption of this research is that an enterprise supporting a mission or multiple missions to be successful requires the enterprise to support the full spectrum of conflict and all three activity levels of war. The spectrum of conflict ranges from military operations other than war to general war, and the three activity levels of war are strategic, operational, and tactical. [MCDP1] The enterprise contributes to the success of a mission by have the right tools for the task provides a better chance of fulfilling the mission that a force is given.

A second assumption is that small successes along the path of mission completion will lead to the successful completion of the mission. The third assumption is that the path of mission completion is roughly traced by policies. A policy is a plan of action to guide decisions and actions. [WIKI]

Section 2.0 of this paper describes policies governing C2 nodes and the breakdown of C2 node policies into macro and micro policies. The generic capabilities of a C2 node are described in Section 3.0. Section 4.0 provides a description of the generic characteristics of a C2 node. And the conclusion of the paper is found in Section 6.0

2.0 Policies Governing C2 Nodes

A policy is a plan of action to guide decisions and actions. [WIKI] This research will provide the framework for specify the characteristics of a C2 node and the policies that govern the establishing of C2 nodes into and out of an enterprise. A C2 node itself can be composed of computer, network, and sensor systems, but its composition allows for no or limited configurability.

For this research, policies are broken down into two groups: macro and micro policies. In this paper macro policies are policies defined in the political domain, while micro policies are the detailed implementation of macro policies. The goal of this research is to provide a high level description of the determining computer interpretable macro and micro policies. These interpretable policies are used to establish an enterprise of C2 nodes. For this paper, the focus will be on describing computer interpretable micro policies for establishing a C2 node into an enterprise of C2 nodes.

Policies give guidelines on what needs to be done or constraints on how a task is to be accomplished.

The idea is that an enterprise of C2 nodes will receive input from sensors and other information sources and will be able to provide options of solutions to a command or mission problem given a set of policies and command orders. Orders and requests for services will also need breaking down into computer interpretable orders and requests in a similar fashion as policies.

2.1 C2 Node Macro Policy

For the purposes of this paper macro policies are policies defined in the political domain and only referred to here at a high level. Macro policies are usually broad in nature, but may have specific key features. The proposed framework for this research will attempt to translate these policies into manageable sub policies, which in turn are further broken down into micro policies. These micro policies would be interpretable by computer systems.

Example macro policies are as follows:

1. Do not negotiate with terrorists
2. Free sea lines of communications – sea passage

2.2 C2 Node Micro Policy

For this paper, C2 node micro policies are policies derived by sub macro polices. These sub macro policies are decomposed macro policy. C2 node micro policies are translated into computer system interpretable policies that will guide the establishing of C2 nodes. These C2 nodes are established based on the constraints of the micro policies to fulfill the computing needs for accomplishing a mission. For micro policy to be computer system interpretable, ideally an executable C2 node policy description language is needed to describe policies and methods developed to translate a micro policy to a computer executable micro policy. Figure 2-1 below is a depiction of this translation process. The policy described by the description language needs to be executable so that computing systems may run the policy in order to fulfill the policy or return possible alternatives or needed resources in order to provide a partial solution or acceptable solution. This policy description language and methods for translating sub macro policies to micro policies is beyond the score of this paper.

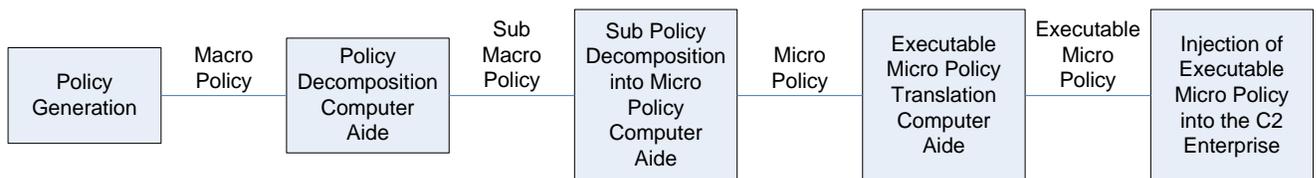


Figure 2-1 Notional Translation Sequence for Creating Executable Micro Policies

Figure 2-2 below depicts an enterprise of C2 nodes with a potential addition of a C2 Node not part of the enterprise. The *C2 node oracle* contains profiles of all nodes in the enterprise and each profile includes the capabilities of that node. A *C2 node* that adds unique or additional capabilities to the enterprise would first register its capabilities with the *C2 node oracle* and the methods to access those capabilities. The *C2 node* would then be inserted into the enterprise and begin providing service for its capabilities.

Removal of C2 nodes would ideally follow a similar process as adding a C2 node. The C2 node and its capabilities would be deregistered from the *C2 node oracle* and then the C2 node removed from the enterprise. The process of the adding and removing a C2 node based on policies provides a way to maintain a robust enterprise by constraining what can be a disruptive activity to only what is needed to fulfill a mission and policy objectives.

Mechanisms, other than polling, would be used to determine if a C2 node is not operating or not providing services for the C2 node registered capabilities. The use of polling would place an overhead on the enterprise network that diminishes the usefulness of the network and thus would degrade the capability of the enterprise in supporting the completion of a mission.

This architecture is similar to Domain Name Service (DNS) for the internet where distributed hierarchical servers maintain a database of network names that cross reference to internet protocol (IP) address. Although the C2 Node architecture would be more dynamic in the establishing and disestablishing of C2 nodes than the DNS infrastructure. [Mock87]

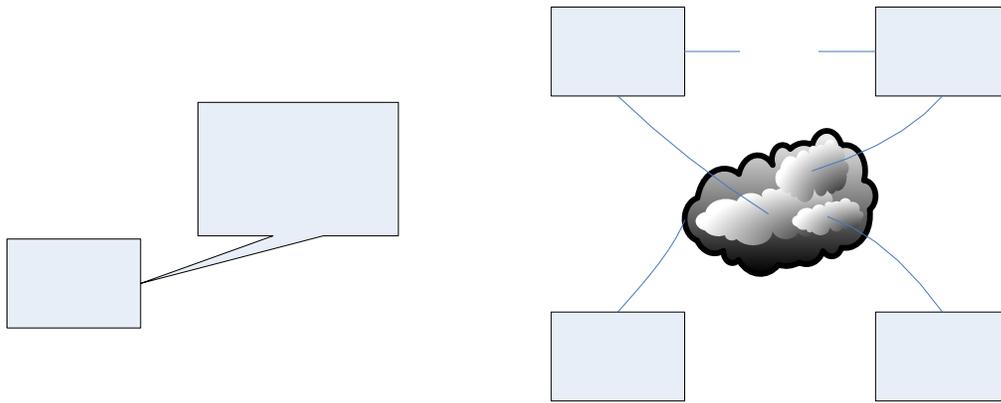


Figure 2-2 Enterprise of C2 Nodes with Potential C2 Node Addition

3.0 Generic C2 Node Capabilities

This section will describe the generic capabilities of a C2 Node.

1. Computer Processing Unit (CPU) Performance. Each node will have a computer processing unit with a performance measurement such as cycles per second usually measured in Gigahertz (GHz).
2. Storage Capacity Available. Storage capacity is the measure of hard drive space available to the C2 node. This hard drive space may be provided internal to a computer system support a C2 node or as a separate device such as a Storage Array Network (SAN).
 - a. Input and Output (I/O) per second. Input and Output that the hard drive or SAN is capable to supplying to the C2 node.
 - b. Average Data Size. Average data size that come into and out of the C2 node.
3. Transaction Performance. The measure of transactions that the C2 node can service per second.
 - a. Transactions per second (tps). Performance unit of measurement.
 - b. Average Data Size. The average data size of a transaction that the C2 node services.

Description of
Capabilities
this C2 Node
Provides

C2
Node

4. Network Bandwidth Available. The external network bandwidth available to a C2 node.
5. Network Paths Available. The external network paths available to a C2 node
 - a. Network Delay. Each network path inherent and transient delay.
 - b. Network Jitter. The variability in packet delay on a network. [SCI04]
6. Services Provided
 - a. Imagery. Images taken from various means, e.g., satellite, unmanned aerial vehicle (UAV), or manned reconnaissance.
 - b. Maps. Digital map products.
 - c. Map Features. Digital geospatial features that can be plotted on a digital map.
 - d. Intelligence. Intelligence products, .e.g., potential enemy composition and weaponry.
 - e. Tracks. Representation of an entity on with a C2 node. The representation is usually graphical and displayed using geospatial data.
7. Patterns of Service Usage. Statistical usages patterns of services provided by a C2 node.
8. Number of Concurrent Users Supported. The number of concurrent users that a C2 node can support.

5.0 Generic C2 Node Characteristics

This section will define the generic characteristics of a C2 node.

Below is an IDEF0 model of a generic C2 node.

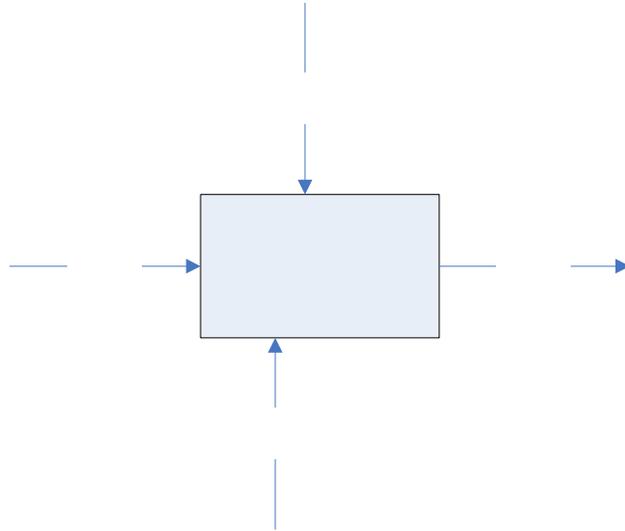


Figure 5-1 Generic C2 Node IDEF0 Model

Table 5-1 provides the generic input characteristics of a C2 node. Table 5-3 provides generic output characteristics of a C2 node. While Table 5-4 and Table 5-5 shows the generic control and mechanism characteristics of a C2 node, respectively.

Table 5-1 Generic C2 Node Input Characteristics

| Inputs | | |
|--|------------------------------|---|
| Type of Data | Method of Data transport | |
| | Messages (Transport Packets) | Data Stream (Transport Virtual Circuit) |
| Command from Superiors | X | X |
| Request for Resources <ul style="list-style-type: none"> • CPU Computation • Storage Capacity • Network Bandwidth | X | |
| Events | X | |
| Raw Sensor Observation | X | X |
| Situational Awareness | X | X |

Gene
Contr

C2 Pro

Generic
Mechanism

Table 5-2 contains example sensor providers at each of the activity levels of war.

Table 5-2 Example Sensor Providers at the Three Activity Levels of War

| | Sensor | Platform |
|-------------|---|------------------------------------|
| Strategic | Visible (Imagery) Near Infrared Far Infrared (Thermal) Radar Laser Signal Communication | Satellite [Short] |
| Operational | Visible (Imagery) Near Infrared Far Infrared (Thermal) Radar Laser Signal Communication | Satellite UAV Manned Vehicle |
| Tactical | Visible (Imagery) Near Infrared Far Infrared (Thermal) Radar Laser Signal Communication | UAV Manned Vehicle Person |

Table 5-3 Generic C2 Node Output Characteristics

| Outputs | | |
|--|------------------------------------|---|
| | Method of Data transport | |
| Type of Data | Messages (Transport Packets) | Data Stream (Transport Virtual Circuit) |
| Command to Subordinates | X | |
| Result of Request for Resources <ul style="list-style-type: none"> • CPU Computation Results • Storage Capacity Request Status • Network Bandwidth Request Status | X | X |
| Collaboration with a Community of Interest | X | X |
| Situational Awareness | X | X |

Table 5-4 Generic C2 Node Control Characteristics

| Controls | | |
|---------------------------|------------------------------------|---|
| | Method of Data transport | |
| Type of Data | Messages (Transport Packets) | Data Stream (Transport Virtual Circuit) |
| Computation Constraints | X | |
| Storage Constraints | X | |
| Network Constraints | X | |
| Environmental Constraints | X | |
| Micro Policies | X | |

Table 5-5 Generic C2 Node Mechanism Characteristics

| Mechanisms | | |
|------------------------------|------------------------------------|---|
| | Method of Data transport | |
| Type of Data | Messages (Transport Packets) | Data Stream (Transport Virtual Circuit) |
| Intelligence Analyst Product | X | X |
| C2 Operator Product | X | |

Figure 5-2 Maps the C2 Node capabilities to consumer request for service within the enterprise.

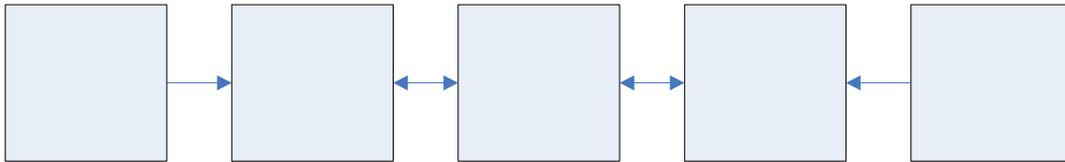


Figure 5-2 Mapping of C2 Node Capabilities to Consumer Request for Service

6.0 Conclusion

The paper describes the framework for the dynamic and controlled establishing of C2 nodes in an enterprise environment. Establishing of a C2 node into an enterprise is governed by micro policies. These policies are derived from macro policies that provide guidance on how and when a C2 node is added or removed from an enterprise. These C2 nodes provide services to support the successful accomplishment of a mission. Since C2 nodes are added or removed base on the fulfilling of a mission and policy objectives, the robust of the enterprise is maintained by minimizing such disruptive activities.

7.0 Notes

[MCDP1] *Warfighting*, United States Marine Corps Doctrinal Publication 1, 1997.

[Mock87] Mockapetris, P., *Domain Names--Concepts and Facilities*, RFC 1034, Nov 1987, www.dns.net/dnsrd/rfc, Accessed 02/17/2006.

[SCI04] "Better Videoconferencing Requires Less Computer Network System Software Tools," *ScienceDaily*, June 24, 2004, Accessed 02/17/2006.

[Short] Short, Nicholas M., *The Remote Sensing Tutorial*, <http://rst.gsfc.nasa.gov>, Accessed 02/17/2006.

[WIKI] Definition of Policy, www.wikipedia.org, Accessed 01/04/2006.

Raw C2 System
Node Service
Capabilities Capability

Sen