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Push or Pull? Ensuring Commanders, Planners, and War Fighters Get the Information They Need

By

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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The appropriateness of the recent military trend of developing pull-based command and control information dissemination systems has not been adequately studied for its ability to achieve information superiority and overcome security and administrative overhead problems. This paper describes information dissemination approaches, their advantages and drawbacks, and suggested modifications or replacements of current distribution processes and system architectures.

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Abstract

Current and planned pull-based systems for distributing critical war fighting information within the United States military have serious limitations with regards to limiting distribution, ensuring receipt, and administrative overhead. These systems should either be replaced with information broadcast (or pushed) to appropriate recipients or modified with controls and procedures to resolve these key issues.

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Introduction

Current and planned pull-based systems for distributing critical war fighting information within the United States military have serious limitations with regards to limiting distribution, ensuring receipt, and administrative overhead. These systems should either be replaced with information broadcast (or pushed) to appropriate recipients or modified with controls and procedures to resolve these key issues.

The recent military trend has been to produce Internet-like systems that allow units to download the command and control (C2) information they choose. This approach is popular for three reasons. First, Desert Storm commanders were unhappy with the exclusively push-based C4I systems that alternately provided an overwhelming information flow and yet at times did not provide the information they sought. Second, it springs from the commercial market and off-the-shelf software applications are available. In light of 1990s acquisition reform, the drive for off-the-shelf solutions to military requirements has never been stronger. Second, these commercial solutions are frequently available more quickly and are more likely to be interoperable due to industry standards. However, the appropriateness of this Internet-like system for military information dissemination has not been adequately studied in light of current and potential problems. This paper will describe information dissemination approaches, their advantages and drawbacks, and suggest modification or replacement of current distribution processes and system architectures.

Command and Control Information

Information superiority is the ultimate goal of DoD's Command, Control, Communications, and Computer Information for the Warrior (C4IFTW). As outlined in Joint Vision 2020, information superiority leads to decision superiority by providing the right information to the right people quickly enough to make correct decisions and act before any

potential adversary can decide upon a course of action. In addition, information superiority is intended to enable U.S. forces to react to unfolding situations before our enemies can take action.

While, military C2 information spans the same spectrum as military commands and operations, C2 systems and their source data cannot be easily categorized within that range. Intelligence Information, planning guidance, battle space awareness, and sensor information can have relevance and impact at the strategic, operational, and tactical levels. While senior commanders and planners are normally tasked with broader missions than tactical combatants, they may rely on some of the same source information. By nature of their perspective, however, they require different forms of presentation and dissemination. Some C2 information, such as the common operating picture information about a military operation, is already pushed to users rather than having them search for it. End users, however, are not given the choice about which data to receive and how they wish to have it delivered.

As a consequence of the Desert Storm information fire hose, where war fighters and planners were overloaded recipients of all the information that could be provided, the US military information dissemination paradigm shifted toward pull-based delivery[1]. In this model, subordinate units pull strategic and operational level planning information from sites provided by higher-level organizations. Locally, the fielded units push information to the war fighters. This final step is frequently a manual translation of information from an information system to a combatant or weapon systems.

[1] Atlantic Intelligence Command. Future Directions for Information Management. Electronic Presentation, (1999), 2.

Some of the tactical information can be transmitted directly to weapons platforms from sensors, but this is clearly the exception. These 'sensor to shooter' capabilities are the cornerstone of network-centric warfare, but for this concept to become reality, a delicate balance of push and pull must be achieved across all levels of C2 information distribution. Clearly this efficient information flow requires well thought-out processes as surely as it needs technical solutions. The technical decision concerning push or pull information dissemination must be made based upon definition of the desired information flow processes and understanding of the technology. The first step is to understand how push and pull schemes operate, what types of information flows they reflect, their advantages, disadvantages, and options.

Pull-Based Approaches to Information Dissemination

Pull-based systems are those that are designed for information users to locate and download the information they require for their missions. "'Pull' implies the provision of tailored information upon specific request."[2] The clear analogy to users on the Internet is obvious. This distribution method makes sense for learning about a topic, conveying day-to-day administrative information, reading news material, and other non time-sensitive data. Other classes of information are not, however, as well suited to pull-based distribution.

> Traditional applications for information distribution and retrieval are based on a client-server—or request-reply—model, also known simply as "pull." In this model, the user initiates information retrieval, and data traffic flows through the network in a point-to-point unicast. While the client-server model supports a wide range of successful large-scale network applications, it also has limitations. For example, it requires users to know a server's ID to initiate a connection and also to check the server

[2] Federation of American Scientists. "GCCS Global Command and Control System." Nuclear Forces Guide. 23 June 1997 < http://www.fas.org/nuke/guide/usa/c3i/gccs.htm > [26 January 2001].

periodically to refresh frequently updated information (the latter is called the "active client" problem).[3]

With the cancellation of the World Wide Military Command and Control System (WWMCCS) modernization efforts in the early 1990s, plans for its replacement Global Command and Control System (GCCS) and related subsystems shifted toward loosely organized, pull-based systems. GCCS is not a system per se, but a superset of many heterogeneous subsystems connected through a common information sphere and transmission media. This design differs from previous generations of stand-alone C2 systems, such as WWMCCS, in that these new systems communicate via the Global Information Grid (GIG), use generic hardware, and provide functionality via software tools. The GIG consists of distributed global networks, computer hardware and software, space-based C2 support, and other related support systems[4].

In theory, GCCS is required to support both "a push or pull basis as required by the CJTF."[5] In practice, GCCS still relies on client-server pull of information to users. This is supplemented with a wealth of additional C2 information published via web pages that information consumers must locate and download as needed. All of this publication and dissemination occurs across systems including the Secret Internet Protocol Router Network (SIPRNet), the Non-classified Internet Protocol Router Network (NIPRNet), and the Joint Worldwide Intelligence Communications System (JWICS).

In a purely pull-based model, Joint Task Force planners in conjunction with higher direction would develop a target list and publish an Air Tasking Order (ATO) for an air

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[3] T. Liao, "Global Information Broadcast: An Architecture for Internet Push Channels." IEEE Internet Computing 4(5): 16.

[4] A. Money to Principal Staff Assistants, Office of the Secretary of Defense, 22 September 1999, "Global Information Grid," Office of the Assistant Secretary of Defense, Washington, D.C.

[5] Federation of American Scientists. "GCCS Global Command and Control System."

operation. Local units subsequently download the ATO through the SIPRNet, the Contingency Theater Automated Planning System (CTAPS), or GCCS. Individual missions are then broken out of the order, assigned to aircrews, planned (frequently with significant coordination between units), and executed.

Advantages

The clear advantages to pull-based information dissemination models are that they typically use off-the-shelf hardware and software components, are responsive to user needs, empower distributed decision making, and mirror the now pervasive Internet. The impact of acquisition reform has been to force acquirers to justify *not* using commercial off-the-shelf (COTS) technology. The contrast between the failed WWMCCS modernization efforts and the steadily progressing GCCS program is vivid. It should be noted that while COTS products certainly reduce development cycle time and initial acquisition costs, their long term maintenance, migration, and support costs may be higher than in-house developed applications[6].

Beyond acquisition style, the widespread availability of information is popular among end users. Planners and commanders at virtually every level are free to access whatever information they deem necessary to accomplish their missions. Thus information consumers can innovate and improve their own capabilities and performance. Finally, the concept of web surfing, downloading files, and sending electronic mail are now familiar to nearly all military members. That experience makes using pull-based systems easier than learning a new proprietary system.

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[6] J. Jarzombek, "The Double-Edged COTS IT Sword." Crosstalk, 11 (April 1998): 2.

Drawbacks

While these systems offer convincing benefits, their drawbacks must also be acknowledged. These problems fall into administrative overhead, delivery verification, and security related categories. While access to virtually unlimited information can be considered a benefit, it can quickly lead to information overload. A lack of quality search tools and intelligent agents makes finding the necessary information far more difficult than if it were only sent directly to those individuals and units that require it. For information producers, posting new information on a web page is relatively simple and quick, but still demands some overhead beyond producing the initial analysis.

Ensuring receipt by appropriate end users frequently requires an additional communication – whether a follow-up e-mail or telephone call. A final difficulty is that each update of information on pull-based systems necessitates another round of follow-up communication to ensure information consumers received the new data. The alternative is to have units working from different plans and information – an untenable situation that could easily cause horrific consequences.

Security also represents a clear challenge for pull-based systems. In general, posted information is available to all sites with access to the SIPRNet. This provides a level of security by limiting access to only DoD personnel. The widespread intra-DoD availability contrasts sharply with strict 'need-to-know' security policies relating to classification of materials and poses an obvious OPSEC risk. In practice, task force planners have noted that units with no 'need-to-know' are accessing posted data and that the overhead in maintaining the current data and notifying users of updates is significant. This same problem makes pull-based systems problematic for allied or coalition operations. Restricting information access

for non-US forces are more likely when pull-based systems force decision makers into an all-or-nothing choice. The Advanced Battlespace Information System (ABIS) task group concluded much the same, "Though it is one model for the future military information grid, the Internet lacks crucial attributes such as security and resource allocation based on (mission) priority."[7] Together, these problems make a "push" technique or major modifications to the current approach attractive.

Possible Solutions To Drawbacks

Most potential solutions to these pull-based methodology problems improve individual problems but at the same time impair some benefits or exacerbate other drawbacks. Clearly a balance between security, availability, and administrative overhead must be found.

Site-based password-protection is the simplest solution to excessive information access. This technique could easily limit data release to those units having 'need-to-know' as determined by the information provider. Since this solution reduces the benefit of broad information access, it must be used to limit only critical information so that a balance can be achieved between security and availability. Passwords have been incorporated on many SIPRNet, NIPRNet, and JWICS web sites. The password approach creates additional overhead for each information provider – determining who to grant access to and managing that access.

Another potential access-limitation solution is a profiling technique that would provide access to mission-related information based upon user, organizational, or position-based categories. Again, a balance must be struck between access and security. This

[7] Joint C4ISR Decision Support Center. "Advanced Battlespace Information System (ABIS) Task Force Final Report." C4ISR Decision Support Center Digital Reference Library. Arlington, VA: Joint C4ISR Decision Support Center, 1996, p. 3-8

solution significantly increases administrative overhead by adding complex profile and access management responsibilities. Thus, sites and users would require classification and profiling as a DoD management function of the information sphere.

A third partial-solution is to stick with standard pull-based techniques and equip information consumers with intelligent agents that can locate information they need. The DARPA Control of Agent Based Systems (CoABS) Program and Grid seeks to enable this scenario by providing distributed agents, protocols, and descriptive services[8]. This alternative has shown promise in limited demonstrations, but will require modification of current C2 data stores and maturation of the state-of-the-art technology. Future plans for GCCS includes Information Dissemination Management (IDM) tools to allow CINCs, CINC staffs, and Joint Task Force components to establish information profiles governing what information should be made available within their AOR[9]. At this point, such tools have not shown ability to ensure users find the information they need or limit the volume of data to a manageable amount.

Subscription lists combined with notification tools for specific information are a final potential solution to pull-based difficulties. Posting C2 information on web sites would be supplemented with notification utilities that let information consumers know that new information is available provide receipt confirmation to information producers. This solution does not limit information access, solves the notification problem, but also requires some overhead for managing subscriptions.

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[8] Global Infotek, Inc., "The CoABS Grid." DARPA Control of Agent Based Systems (CoABS) Program. March 2000. <http://coabs.globalinfotek.com/coabs_public/coabs_pdf/gridvision.pdf> [25 January 2001].

[9] Defense Information Systems Agency, GCCS User CONOPS. Arlington: 1995.

A summary of these pull-based techniques is shown in Table 1. Since none of the solutions solves all of the problems alone, it is worthwhile to consider them in combination. Site passwords, in combination with intelligent consumer search agents and notification tools are potentially the best-balanced solution to administrative overhead, information availability, and security concerns. Unfortunately, off the shelf intelligent agent technology is not yet mature enough for fielding. Tools such as the CoABS Grid are merely experiments and require extensive adaptation of existing web-based sites to function. Although better than manual searching, other more common agents have not been proven to reliably locate all requested relevant information. Thus, the array of pull-based options is currently insufficient and thus indicates that it would be helpful to study broadcast (or push) based models to help find a comprehensive information dissemination solution.

Push Based Techniques for Information Dissemination

In contrast to pull-based models, push systems eliminate the time-consuming and tedious information search problem through a new procedure for information discovery and dissemination. The basic operational concept is that users query a channel guide (or mobile agent) for available information channels, subscribe to some of them, and then continuously receive information. That is, the process of information acquisition changes from user-initiated pull to provider-side push.

	Security/Availability Balance	Administrative Balance				
	Limit Information Access	Broad Information Availability	Ease of Finding Information	Information Overload	Overhead	Notification
1. Pull-based system	Poor	Excellent	Poor	Poor	Good	Poor
2. Pull-based supplemented with site passwords	Good	Good	Poor	Fair	Fair	Fair
3. Pull-based supplemented with profile-based access	Good	Fair	Fair	Fair	Poor	Poor
4. Pull-based with intelligent consumer search agents	Poor	Excellent	Good	Good	Good	Poor
5. Pull-based with subscription notification	Poor	Excellent	Poor	Fair	Fair	Excellent

Table 1: Pull-based Alternatives and Their Associated Advantages and Disadvantages

In the complementary "push" model, users sign up for applications that send the information directly to them, rather than fetching it themselves. True push applications should work like a radio channel. Streaming audio is an example of today's increasingly capable Internet push systems. Experts have found this method superior for certain classes of information dissemination. According to a respected French research engineer and system architect, Tie Liao, "The push model addresses the active client problem and is therefore more suitable for distribution of frequently updated information to mass consumers."[10] Several additional advantages can be achieved for military C2 systems using broadcast technologies.

[10] T. Liao, 16.

Advantages

The key advantage push-based systems offer is enhanced information security. Only users authorized to receive specific information will receive it. At the same time, these applications fit the GIG and they do not preclude other information from being widely accessible via web pages. Push-based systems also save information consumers search time and facilitate announcement of new information channels by employing directory channel guides while the push delivery ensures up-to-date information. Standard software functionality, which provides stream statistics and reliability information, could easily be adapted to provide verification of receipt to information disseminators.

Drawbacks

Aside from knowing what information to push to which users, the second biggest drawback to push-based C2 applications is the likelihood that they will require proprietary or custom software applications. This opens the door for expensive and lengthy software developments—which are avoided by using COTS-based, Internet type systems. Several promising products are either now available or being researched to provide off-the-shelf broadcast capabilities to overcome the need to develop custom applications. In addition to acquisition difficulties, push systems add access management overhead to the information disseminator.

Possible Push-Based Solutions

The *Minstrel* push system's approach is to define an open protocol standard for push systems. *Minstrel's* architecture, employs a hybrid broadcast protocol and a hierarchic transport infrastructure to allow the system to extend to the large numbers of users envisioned with Internet broadcasts (Figure 1). This means that various sites throughout the

military information sphere would be required to perform channel functions (such as repeaters, caches, and proxies). This distribution of transport functions would reduce overhead of original source information servers and could even lessen the impact of a denial of service attack. *Minstrel* includes authentication and security modules originally conceived for e-commerce security and privacy, but equally applicable to limiting broadcasts to authorized users.

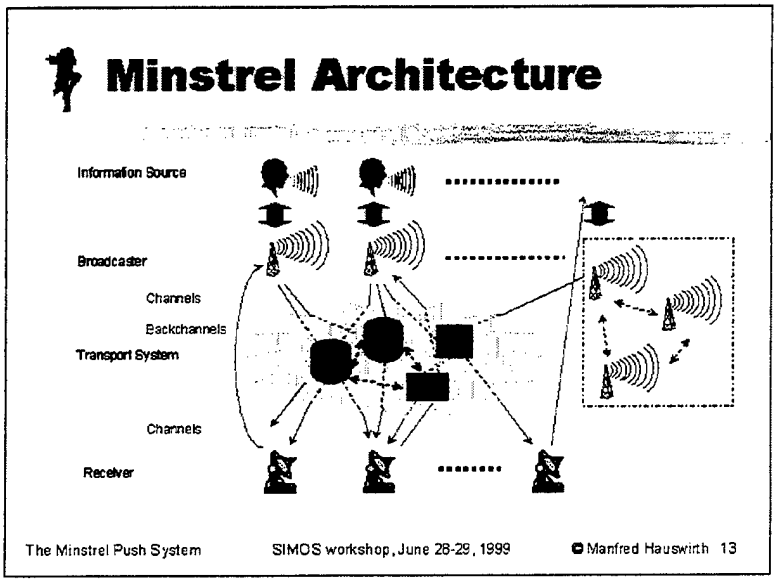

Figure 1: Minstrel Communications Architecture[11]

Like *Minstrel*, Global Information Broadcast (GIB) bases information distribution on the well-known publish-subscribe model. The GIB model comprises three key concepts:

- a publisher entity that provides information to users,
- a subscriber entity that receives and consumes information, and
- a channel abstraction that defines an information service provided by a publisher[12].

[11] M. Hauswirth, "The Minstrel Push System." Paper Presented at 5th SIMOS Workshop on Knowledge-based Interactive Multimedia Systems (Vienna, 1999): 13.

[12] T. Liao, 17.

Figure 2 illustrates the publisher and subscriber relationships. Users can get information about a channel via the publisher's advertisement service. This publish-subscribe model uses a new type of directory service to support information dynamics that are not met by keyword search services. If interested, users subscribe to the channel through an agreement with the publisher, which is completed via the registry service. If the publisher grants the subscription, the user receives address, encryption, and other information necessary to receive the channel.

After the user becomes a subscriber, the publisher will send the channel through the data delivery service. "This generally means that a program will run continuously at the user's desktop, although this is not mandatory. The received information might be maintained in a local cache so that the subscriber can view it at any convenient time."

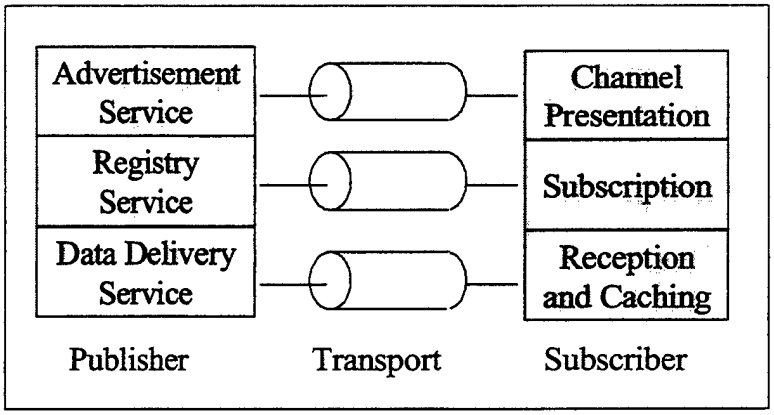

Figure 2: Publisher-Subscriber Information Distribution Model [13]

This architecture can be implemented on an Internet, wide area network (WAN), or local area network (LAN) level provided a Multicast Backbone is installed throughout the information transport infrastructure.

[13] T. Liao, 17.

Global Broadcast Service (GBS) is the most recent example of a US military push dissemination application. It was primarily designed to provide high throughput broadcast of U.S. military information across the globe. It consists of broadcast, terminal, and space segments. The focus has been on providing much needed bandwidth to forward deployed units via 18-inch antennas. At the same time, planners have wisely employed open architecture to facilitate communication with other information sources via the Defense Information System Network (DISN). This system can carry a wealth of C2, planning, and intelligence information and reportedly has the potential for supplementing pushed data with user-requested information but is really a temporary bandwidth solution rather than a long-term C2 dissemination model.[14]

All of the push options presented clearly overcome some serious reliable data delivery problems found in pull-based methods. The commercial, research, and GBS alternatives involve significant overhead, but could potentially make all user-selected information available via broadcast. Unfortunately, the GBS system does not help users locate the information they require and only provides limited user ability to customize data collection. A summary of these options is shown in Table 2. Again, none of these options present a complete solution to information dissemination; so further study and a composite solution are likely necessary to solve the US military's current C2 information dissemination problems.

[14] J. M. Delpino, C. L. Leonard, et al. The Global Broadcast Service: A System Overview and Acquisition Summary. (Los Angeles, 1997): 3.

	Security/Availability Balance	Administrative Balance				
	Limit Information Access	Broad Information Availability	Ease of Finding Information	Information Overload	Overhead	Notification
1. Generic Push-based system	Good	Good	Fair	Good	Poor	Fair
2. Minstrel	Excellent	Good	Good	Good	Fair	Fair
3. GIB	Excellent	Good	Good	Good	Fair	Fair
4. GBS	Excellent	Fair	Fair	Good	Fair	Fair

Table 2: Push-Based Alternatives and Their Associated Advantages and Disadvantages

Procedural and Technical Recommendations

Recommendations from this study are divided into near-term and mid-term solutions to the C2 information dissemination problems of administrative overhead, ensuring receipt, and security. The near-term solutions could be implemented immediately, while mid-term solutions require additional study of industry state-of-the-art to ensure technical solutions coincide with likely industry progress.

Near-Term Solutions

The simplest and fastest solution to the immediate problems of security and notification with the current pull-based systems is to incorporate website passwords to limit access to certain critical information. For example, current target lists and flight schedules could be restricted to those forces involved in a particular operation and their chain of command. Some sites have already begun using passwords, but no clear guidelines have been established. As previously mentioned, information providers could use the authorization lists and organizational information requirements to maintain an up-to-date subscription list, but are subscribers organizations, positions, or individuals? Easy answers to this question are compounded by short-term deployment rotations that demand different solutions than long-term in place operations. In addition, pull applications should be

augmented with channel guides or directories and search tools to facilitate 'smart-pull'. This will minimize administrative impact for information not already broadcast via GBS. Finally, the standard directories should be advertised via joint publications and source information locations should be added to communication annexes of plans and orders.

In addition to the immediate fix for the pull based systems, a thorough, joint study of dissemination requirements should be conducted based upon the needs of C2 information consumers (both positions and organizations) as well as characteristics of the information itself. Specific types of information should be studied to determine their implications on military operations and thus the best dissemination techniques. The goal of this study should be to validate the need for both broadcast and pull-based information dissemination and to identify the types of users and information by preferred distribution methods.

Mid-Term Solutions

While the ultimate answer to the military's information dissemination problems is not absolutely clear today, it is obvious that certain types of information (e.g. the common operating picture) by their nature lend themselves to broadcast systems while others (e.g. country reports and OPLANS) are better suited to pull-based circulation. Similarly, war fighters, in contrast to planners, are more likely to require that information be pushed to them due to time constraints. The results of the aforementioned information and consumer profiling studies would clarify information distribution requirements for military communications planners.

Based upon these studies, standardized broadcast and pull-based systems should be deployed. In all likelihood, these systems will be largely derived from commercial software tools that can operate over the GIG, DISN, or other standard transmission media. The

ultimate solutions will differ from current systems allowing authorized users to receive C2 information via push or pull as appropriate for their needs. This can be accomplished using subscription techniques for access. It should also be built upon authoritative data and analysis sources to minimize data replication except as necessary for transmission. This vision is consistent with results of the ABIS task force[15] and the Commission on Roles and Missions of the Armed Forces[16] regarding C2 systems. As a final procedural supplement, preferred information dissemination concepts must be codified in joint publications, operating procedures, plans, and orders.

[15] Joint C4ISR Decision Support Center. "Advanced Battlespace Information System (ABIS) Task Force Final Report." C4ISR Decision Support Center Digital Reference Library. Arlington, VA: Joint C4ISR Decision Support Center, 1996, p. 1-10.

[16] Institute for Defense Analyses. Assessment of Command, Control, Communications, and Information Technology: Commission on Roles and Missions Issue No. 22. IDA Paper P-3088. Alexandria, VA: 1995, p. 29.

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