The Study on Convergence Platforms and Services for Next Command and Control Systems in Korea Military

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Abstract

The Command and Control Systems (C2Ss) have played very critical roles in enabling the warfighting functions to be efficiently organized and executed in network centric operations environment (NCOE). Over several decades, military services of each country have contrived the advancement plan for operating C2Ss in order to adjust the state of the art technologies and new operational concepts. However, operational concepts and system architectures have not been changed fundamentally since it has not seemed to be necessary. In these days, it becomes time to think of the changes; new environments are coming such as Big Data, Internet of Things and Cloud Computing and those changes will not be evitable in future battle fields. In this paper, we studied the challenges for C2Ss, especially in Big Data environment. By studying the cases of Republic of Korea Army's C2Ss, we present probable suggestions for next C2Ss such as convergence platforms, adaptive and semantic message formats, SOA (Service Oriented Architecture), battlefield data center, analytic tools, and agent services.

Keywords*: Command and Control System, Big Data, Network Centric Operations Environment, SOA, Convergence Platform*

1. Introduction

The Command and Control Systems (C2Ss) enable the warfighting functions to be efficiently organized and executed in network centric operations environment (NCOE) by means of network enabled command capabilities. The C2Ss have been an essential element to make our troops acquire the initiative and maintain the spatial and temporal superiority against enemy units. However, the advancement in information and communication technologies persistently demands incremental transformation and improvement [1].

Korean C2Ss started in 1990s for sharing battlefield information between commanders in network centric operations. Indeed, Korean C2Ss have been being rapidly enhanced and upgraded comparatively for a short period [2]. However, operational concepts and system architectures have not been changed fundamentally since it has not seemed to be necessary. However, it becomes time to think of the changes; new environments such as Big Data, Internet of Things and Cloud Computing are coming and it will not be evitable in future battle fields.

Smart devices are getting pervasive and various. In near future, most of weapons and even warriors will be equipped with heterogeneous and multiple devices for transmitting and sharing information. Data types will become various and data volume will increase fast. Not only simple and structured messages but also complex and unstructured messages will be generated and exchanged. More dynamic tactical web pages, audio and video clips will be used more frequently. C2Ss will be increased in number to satisfy their own purpose; nevertheless higher level of interconnectivity between them will be required.

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This paper is for studying the challenges to next C2Ss, especially preparing Big Data environment in military based on the case of Korean ATCIS (Army Tactical Command Information System). We will deal with challenging issues and promising approaches about convergence platforms and military services.

The rest of this paper is organized as follow. We introduce the C2S called ATCIS in Section 2. The challenging issues are presented in Section 3. In Section 4, definition and characteristics of Big Data will be summarized. Then, we suggest promising approaches for the future in Section 5. Section 6 concludes the paper.

2. Command and control system in Korea

The commander executes military operations with command and control over his forces. To manage military operations under control, efficient methods and resources are required. In definition, command and control system (C2S) is the facilities, equipment, communications, procedures, and personnel essential for a commander to plan, direct, and control operations of assigned and attached forces pursuant to the missions assigned. In the broad sense, C2S means all methods, resources, and even non-physical procedures and protocols [3, 4]. However, the facilities, equipment, procedures, and personnel have not been innovated much and those impacts have been marginally enhanced comparing with information and communication technologies. Thus, the information and communication system is broadly recognized as the C2S itself. In this paper, we consider C2S as an information and communication system in the narrow sense.

2.1 What is ATCIS

Most of the Services of each country have developed and operated their own C2S. In Republic of Korea Army, ATCIS has been the main system for supporting military operations. ATCIS is an information system for tactical command posts from Corps to Regiment / Brigade in order to provide a vital sensor-to-shooter link, apply automated business rules, and support decision makings by commanders [5].

Literature studies for operating concepts were conducted in 1990s and development program was initially started at 2001. The first development was finished at the end of 2004 and the systems were fielded up to 2008. The second version was developed from 2006 and 2008 and all first systems were upgraded till 2010. Currently, the third version is being on the stage of operational test and evaluation which will be finished by the end of 2016.

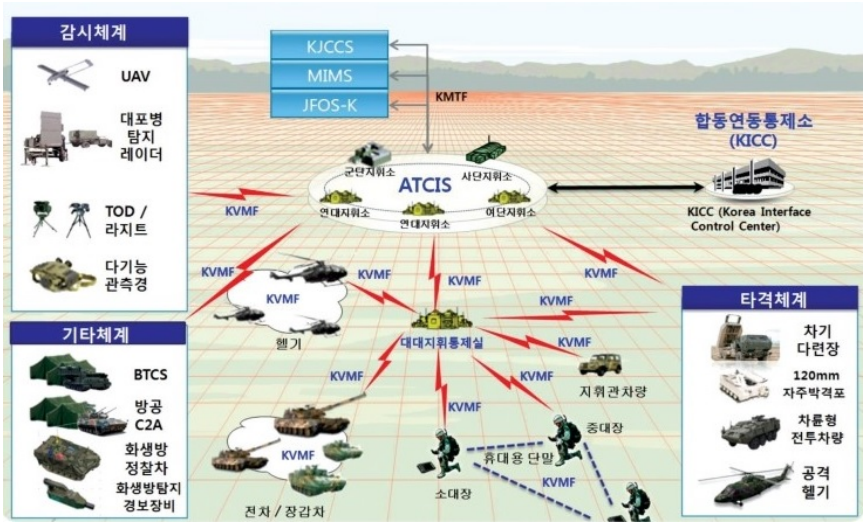

Figure 1. C2Ss in Korea Army [6]. The Korea Army officially does not provide the English-version picture depicting operating concepts of C2Ss in Korea Army. For the reader's convenience, the top-left box shows weapon systems for surveillance such as UAV (Unmanned Aerial Vehicle), anti-artillery tracking radar, TOD (Thermal Observation Device), etc. The bottom-right box represents attacking weapons like multiple rocket launching system, 120mm mortar, and so on. The bottom-left box includes other weapon systems. KVMF stands for Korea Variable Message Format which is the standard message format in exchanging messages in CNRS (Combat Net Radio System).

2.2 System Components and Characteristics

ATCIS consists of various commercial-off-the-shelf and military solutions. Roughly speaking, ATCIS is composed of common software, applied software, and security system. The common software is for providing basic services such as COP(Common Operational Picture), message exchange, office productivity tools. The applied software is for operating each warfighting function like Intelligence, Operation, Fire Support, and Operation Sustainment. The last one, the security system, is for protecting from malfunction software and activities, monitoring key systems and networks, and keeping the backups of system and users' data. In ATCIS, the interoperability is one of most important capabilities as you see in Fig 1.

ATCIS shows interesting characteristics as listed below:

1. ATCIS is the unified system including most of battlefield functions. In case of ABCS (Army Battle Command System) which is the C2S of U.S. Army, it is the system of systems. The ABCS uses different system per battlefield function. However, ATCIS was intended to avoid a stovepipe and loosely coupled architecture.
2. ATCIS is the maneuverable system supporting TOC (Tactical Operational Center) on the move. The tactical shelter mounted on the tactical vehicle has key machines like servers, backbone devices, etc.
3. ATCIS is the distributed system in case of tactical network's disconnection. The assumption is that tactical network cannot be perfectly reliable, thus each troop over regiment runs its own system.
4. ATCIS is the double dual system for enhancing survivability. Especially, the main server should avoid single point of failure. Each troop has double shelters and double servers as one system.
5. ATCIS provides main functions in interoperability with various weapon systems.

During the last decade, ATCIS has been progressively upgraded trying to accommodate the state of the art technologies and new operational concepts. However, Korea Army has been recognizing several issues which are now will be in the near future.

3. Challenging Issues

Smart devices are getting pervasive and various. In near future, most of weapons and even warriors will be equipped with heterogeneous and multiple devices for transmitting and sharing information. Data types will become various and data volume will increase fast. Not only simple and structured messages but also complex and unstructured messages will be generated and exchanged. Here are some challenging issues we are having or we will have.

3.1 The stovepipe and loosely coupled architecture should be avoided

The ATCIS begins to be ramified by new subsystems. ATCIS was originally designed to mainly support commanders, so all functions and relevant data were refined on the basis of probable CCIRs (Command Critical Information Requirements). Thus, several subsystems for each battlefield function are being developed and fielded now.

3.2 The hidden value of operating data should be retrieved

Similarly with normal enterprise systems, ATCIS piles up a lot of operating data and does not utilize them well. Korea Army has conducted many exercises and piled up massive data in the system. However, ATCIS does not have efficient analysis services such as data mining, machine learning, etc. If we cannot make use of historical data those means nothing but the waste of storage.

3.3 Interoperability between systems or platforms should be a requisite condition

Current ATCIS interoperates with over 10 weapon systems such as UAV (Unmanned Aerial Vehicle), TPS-830K, TPQ-36/37, etc. However, the number of interoperated weapon systems in the next version of ATCIS will be over 40. To make the matter worse, the number of interoperation requests is being increased steadily. Nonetheless, ATCIS should support the seamless interoperation between systems and platforms.

The problem is that smart devices for each weapon systems have different platform, message format, and cryptograph. It is very hard and extravagant to make it work correctly. Some weapon systems require time-sensitive message exchanges, so corresponding solutions like DDS (Data Distribution Service) are required.

3.4 Enormous data should be handled properly

It must be not such difficult to predict that overall data volume on tactical communication network will increase. In near future, most of weapons and warriors will be equipped with heterogeneous and multiple smart devices for transmitting and sharing information. Data types will become various; complex and unstructured messages will be generated and exchanged. Thus, created data volume will increase fast. The requirement will be to deliberately handle data generation and dissemination in tactical networks.

4. Big Data era in Battlefield

The emergence of Big Data is an important event also for military C2S. Then, what caused the emergence of Big Data? First, new and advanced information and communication technologies make it easy and convenient to generate data and share information with smart devices. Second, pervasive intelligent devices and services promote the sharp growth of data. Third, it becomes important to fetch the hidden value for intelligent services like gold digging in Western Era. As the number of data and the size of data are increased fast with heterogeneous and complex datasets, it is demanded to mine the datasets to retrieve the hidden value. Simultaneously, note that Big Data era is inevitably coming into the battle fields.

4.1 What is Big Data

In academia and industry, Big Data has different points of views, so it has different definitions. In this paper, we follow the definitions is [7-9]. The Apache Hadoop defined Big Data in 2010 as datasets which could not be captured, managed, and processed by general computers within an acceptable scope. Similarly, McKinsey and Company defined Big Data in 2011 as datasets which could not be acquired, stored, and managed by classic database software.

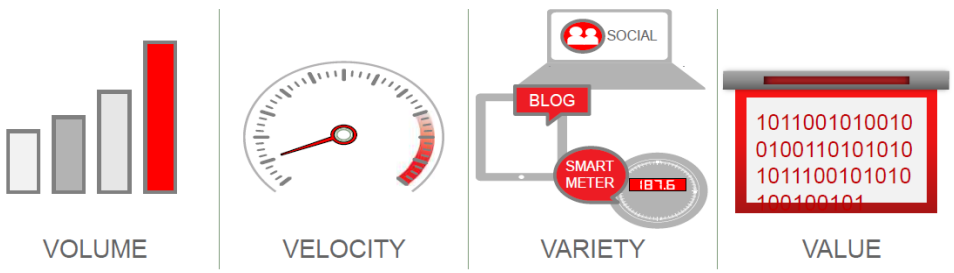

Figure 2. Big Data's 4V's [10]

Big Data's characteristics can be modeled as 4V's: Volume, Velocity, Variety, and Value. Volume means that data scale becomes bigger and bigger. However, a lot of generated messages are periodical and redundant. Velocity means that data generating, acquiring, storing, and analyzing should be conducted within a tolerable time. Variety means that data patterns and data types are so various including large size of messages. And Value means that we can dig out some useful hidden values, but the gold is buried with very low density.

4.2 Challenges of Battle Field in Big Data era

For Big Data environments in battle field, it is necessary to know and prepare upcoming challenges in advance. In [7], there are some detail characteristics of Big Data and we present probable challenges to military operations in Battle Field.

In data representation, weapons and even warriors will have heterogeneous and multiple devices for transmitting and sharing information and exchanged data will vary in types too. At the same time, seamless interoperability between weapon systems should be achieved.

In data redundancy and compression, messages by weapons and warriors become pervasive and abundant in tactical communication networks. However, those messages are highly redundant and exchanged frequently and periodically. Thus, it is important to efficiently compress those sets of message.

In data life cycle management, pervasive and abundant message will be piled up incessantly, but those messages have a time limit. On the other hand, those can be useful in analysis. Thus, it is necessary to refine and rearrange battle field information with discretion so as not to lose its own meanings and values.

In analytical mechanism, we need analytic services such as data mining, machine learning, etc. There are already several useful analytic tools, but those are not originally designed for big datasets which will be increased in size and number. Furthermore, Big Data consists of relational databases and non-relational databases. Analytic tools will be different from existing solutions.

Table 1. Big Data's Characteristics in [7] and Battle Field's Challenges

Big Data's Characteristics	***Battle Field's Challenges***
Data representation - Heterogeneity in type, structure, semantics, organization, granularity, and accessibility	- Weapon systems use various types of data - High level of interoperability are required
Data redundancy and compression - High level of redundancy in datasets	- Messages by weapons and warriors are pervasive and abundant - Frequent and highly redundant messages flow in tactical networks
Data life cycle management - Pervasive sensing and computer data - Which data should be discarded	- Systems have to refine battle field information with discretion so as not to lose important value
Analytical mechanism - Analytical algorithm for relational and non-relational database	- Analytic services are required like data mining, machine learning, etc
Data Confidentiality - Manipulation vs. protection of sensitive information	- System function and data should be allowed to properly authorized participants - Secret and confidential data should be prevented from searching by a third party
Energy Management - Data Center consumes huge energy	- Data center operates in the rear area and extracts useful values to help commanders make better decisions in time - Data center needs broadband backbone and constant power source

Expandability and scalability - Analytic system must be able to process increasingly expanding and more complex datasets	- System of systems is required - Systems should be scalable and handle the data within their capabilities
Cooperation - In analysis of datasets, experts in different fields are required	- Experts of each warfighting functions should be involved to develop and operate analytic services

In data confidentiality, system functions and data should be allowed to properly authorized participants. Secret and confidential data should be prevented from searching by a third party.

In energy management, data center operates in the rear area and extracts useful values to help commanders make better decisions in time. Data center needs broadband backbone and constant power source.

In expandability and scalability, system of systems is required. Systems should be scalable and handle the data within their capabilities.

In cooperation, experts of each warfighting functions should be involved to develop and operate analytic services.

5. Suggestions

So far, we have discussed what is command and control system, what is Big Data, and what kind of challenges will come in future battle field. Note that Big Data has close relation with battlefield. Here are some probable suggestions what we have considered so far.

5.1 Convergence platforms

The main issue in developing C2Ss is that each weapon or each function has requested its specific solutions. Consequently, it causes big issues in interoperability since each system has different hardware, software, cryptography, and so on. For example, armored vehicles have different systems so that they cannot easily exchange messages and run applications from other BMS (Battle Management System).

Thus, it is necessary to develop convergence platforms in hardware and software. In software, a platform-independent operating environment, called common operating environment (COE), should be developed and applied to all types of devices. In hardware, platforms should be merged and classified according to operating conditions.

5.2 Adaptive and semantic message formats

There are several message standards in C2Ss which make it also difficult to satisfy the tightly coupled interoperability. Common but adaptive message standard are required, and also it should work in fluctuating network conditions. Message items are predefined in the meta-data repository. It is also necessary to define messages for interoperation with international military systems. Each item has unique meaning for all systems to understand. Messages are adaptive composed according to network conditions

5.3 SOA through entire echelons

There are several C2Ss in Korea military according to echelons and warfighting functions, and it causes loosely coupled cooperation in military operations and plural devices to each warriors. If possible, a warrior should have single terminal and he can make use of authorized services regardless of spatial and temporal conditions. To make it work, we suggest a Battlefield Service Repository (BSR) by which each service can be subscribed and distributed on demand. Common services are autonomously decided by warrior’s assignment, responsibility, device, etc.

5.4 Battlefield Data Center

Even though there will be various kinds of data formats and types in future battlefield, it should be deliberately handled by the form of database and all data should be generated, acquired, and managed from each weapon system and warrior. So, all activities are initially logged as a Personal database and personal DBs are automatically converged in Group database. For providing high level of services, some of Group databases are forwarded into the battlefield data center.

5.5 Analytic tools and agent services

Future warriors in Big Data environment will demand adequate supports from C2Ss. The hidden values in enormous operating data are mined at data center and given to each warrior. Efficient analytic tools and data experts are demanded. Based on Personal DB, the system will determine which information should be given to the warrior such as what the warrior is missing and what he has to do.

6. Conclusions

The C2S makes the warfighting functions organized and executed in battle field in order to make our troops acquire the initiative and maintain the spatial and temporal superiority against enemy units. In these days, it is not possible to execute military operations without the information systems. Furthermore, smart devices are getting pervasive and various. Most of weapons and even warriors will be equipped with heterogeneous and multiple devices for transmitting and sharing information. In this paper, we explained as the Big Data era in battle field.

We noted that the Big Data era is definitely inevitable in future NCOE by relating Big Data's characteristics to battle field's challenges. We studied the challenges to next command and control systems preparing Big Data environment and some suggestions for the future are presented. We proposed convergence platform, adaptive and semantic message formats, SOA, battlefield data center, analytic tools, and agent services. Simultaneously, it is also important to constitute an expert committee and build up relevant regulations and organizations.

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