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XML-based Web Services Technology to Implement a Prototype Command and Control System

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ABSTRACT

A command and control system is a complex system of systems. For its ability to improve the command and control efficiency and multiply operational capability, command and control system investment is always a benchmark for military modernisation. However, most command and control systems were independently developed, validated and approved as a stand-alone solution to reflect service requirement rather than joint focused. These stovepipe systems not only have an adverse impact on joint or coalition operation, but also are fairly difficult to integrate and interoperate effectively with other systems. To solve these problems, the study applies XML standard to redefine the structured radar track and global positioning system (GPS) positioning data formats. Radar tracking data and GPS positioning data generator were implemented to simulate air and land targets. In addition, the static intelligence databases, such as order of battle, were built for information exchange with other systems. Sensors, GPS, and intelligence web services, including simple object access protocol (SOAP) and web service definition language (WSDL) are constructed to provide near-real-time static intelligence and dynamic track services. All relevant command and control centres may subscribe the necessary services from the service providers to work together with their own systems for mission needs. The implementation of result demonstrates XML-based web services technology and makes command and control system integration easy, flexible, and cost effective.

Keywords: SOAP, WSDL, command and control system, XML-based web services, intelligence web services, military modernisation, radar tracking data, target simulation, stovepipe systems, simple object access protocol, web service definition language

1. INTRODUCTION

To promote operation capability, many countries have invested a great deal of time and resources to establish command and control (C2) systems. Using information strength, one can achieve decision-making superiority. Command and controlsystem integrating operation, intelligence, logistics, and personnel functions across different organisations and agencies is a huge and complex system of systems. Over the past years, command and control systems were independently developed, validated, and approved as a stand-alone solution to reflect service requirement rather than joint focused. To be effective, organisations must share information across dissimilar, independently developed systems that involve diverse languages, cultures and command structures. Consequently, the integration of heterogeneous deployed command and control systems, called stovepipe systems, should

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be prioritised for enhancing inter-service interoperability and information sharing among different systems.

The typical representatives of system integration technology are OMG CORBA, Microsoft DCOM, and Sun RMI. However, the traditional distributed computing technologies have the following disadvantages:

- CORBA or DCOM are too complex to implement.
- Unless the objects are in the same architecture, interoperability problems can not be avoided.
- These technologies are only applied for intranet rather than internet, which has a firewall mechanism to deter the entrance of machine codes CORBA or DCOM generate. As a result, the application of CORBA or DCOM has the inherent limitation[2].

For joint or coalition operation needs, any particular service system should interoperate with other service systems, agency systems, and allies systems for information sharing. XML technology provides a standard for data interchange. XML is a data markup language like HTML, using bracketed tags to describe the structured data. With HTML, the tags primarily relate to the formatting and display of the text. With XML, the tag is extensible, anyone can define a tag to describe the attribute of the text.

If the developers or persons applying agree on their use of the tag definitions, then these can understand the context of the text exchanged between them. Consequently, XML is particularly well suited for web environments and allows the information to be both human and machine readable, and is able to enhance the integration of system in a distributed computing environment. Based on XML technology, web services are software components that are loosely coupled, encapsulated, and can be contracted using standard Internet protocols. Web services are able to facilitate web-based system integration in an easy and cost effective way.

In recent years, MITRE Corporation, a US government-owned not-for-profit and development corporation, has made much efforts on information exchange between command and control systems using XML technology. The legacy message text formats (MTFs) have been transferred into XML-MTFs to implement automated decision-making processes of military operations[3]. MITRE also helped US Military to establish a joint battlespace infosphere (JBI), called information supermarket, where information providers submitted the data to JBI, and information consumers extracted data they required from the JBI. The goal of JBI is to provide the right information at the right time so that commander can do the right things at the right time in the right way[4]. The core technologies of JBI are XML and web services.

In the command and control integration and interoperability issue, Republic of China Armed Forces also face the same challenges as US. In this study, these new technologies were adopted to implement a prototype command and control system. The system will integrate air track, land track, and static intelligence database services to generate a common operating picture (COP) in a network environment.

2. SYSTEM OVERVIEW

2.1 Prototype System Architecture

The developed prototype system consists of several main components like track generator, track web service, intelligence database, and client view. The system architecture is shown in Fig. 1.

These components are described as follows:

- *Track generator*: For simulating the physical radar track and GPS track, a track generator was used to produce radar and GPS tracks periodically whose formats are assumedly USMTF and GPRMC. The purpose was to demonstrate the application of data exchange by transferring USMTFs and GPRMC formats into XML formats.
- *Track web service*: A track web service was implemented to provide consumers such as command and control centres to access the track data from tracks database via SOAP and WSDL technologies. The track web service can be dynamically interfaced and invoked by other components for their mission needs.
- *Intelligence web service*: The intelligence web service is to provide consumers to query the

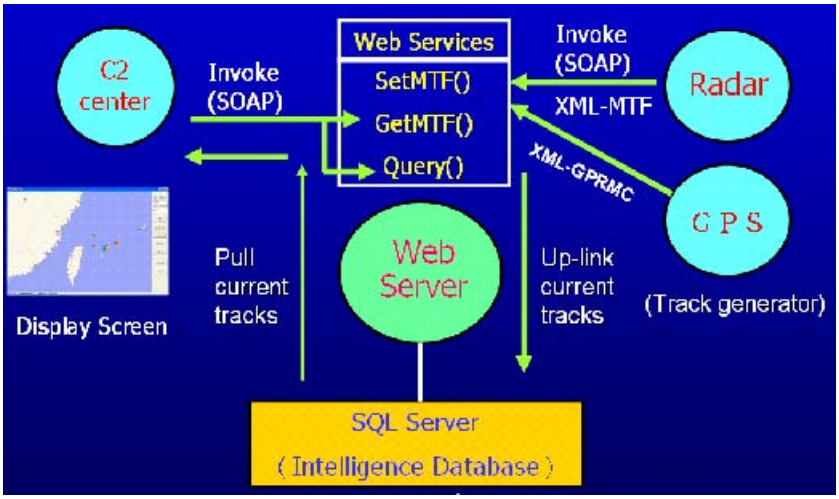

Figure 1. System architecture.

static intelligence data such as order of battle and topography from the common intelligence database.

- *Client view*: The client view is to integrate the track and intelligence web services distributed in a network. The track and intelligence information is shown in GUI with digital map. The client or command and control centre can integrate the different web services and redesign these for their mission requirements.

In this study, Microsoft IIS 5.0 was used as web server and database system was Microsoft SQL Server 7.0 desktop. CASE tool for web services and client application development was Microsoft Visual Studio 2003 and programming language was Visual Basic .NET.

2.2 Web Services Architecture

W3C describes that web service is a software component designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the web service in a manner prescribed by its description using SOAP messages, typically conveyed using popular HTTP protocol with an XML serialisation in conjunction with other web-related standards[5].

There are four main components in web service operation as shown in Fig. 2:

- *eXtensible Markup Language* (*XML*): XML is the base of web services. It is a markup language adding a tag to the context of data. Unlike HTML, XML is a flexible, self-defined and well-structured language. When XML is parsed by a parser, data can be extracted easily.

- *Simple Object Access Protocol (SOAP)*: SOAP is an XML protocol for web services. SOAP provides a service-oriented architecture for server-to-server and server-to-device communication via a variety of underlying protocols[6]. SOAP is like an envelope which contains the messages which are required to be sent, and also provides binding information of invoking web service.

- *Web Services Definition Language (WSDL)*: WSDL is similar to IDL of CORBA and provides

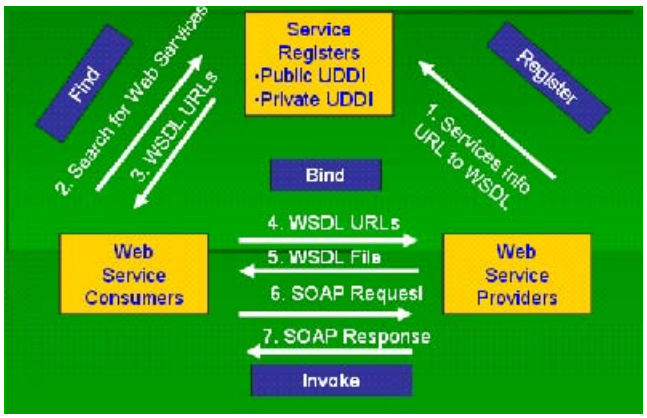

Figure 2. Web services operations.

the interface of web service. WSDL describes the name, function, parameters, location, and data type of services in a XML format.

- *Universal Description, Discovery Integration (UDDI)*: UDDI is a registry mechanism and is used for the advertisement, cataloguing, and integration of web services.

3. SYSTEM IMPLEMENTATION

3.1 Assumptions

For system implementation, the following assumptions have been made:

- The radar can provide the target tracks periodically.
- GPS system can receive the positioning data periodically.
- The radar track formats are USMTF and stored in a text file.
- GPS positioning formats are GPRMC and stored in a text file.
- The agreement on the tag or element names in XML formats has been reached.

3.2 XML-USMTF Transfer

The US message text format (USMTF) is the standard format used by the Joint Forces and Coalition Allies for the past two dacades. It support the full spectrum of military operations, including air,intelligence, logistic, and medical. These legacy messaging standards have proprietary formatting rules and which make these difficult to leverage commercial off-the shelf (COTS) tools for message processing and component integration support. The birth of XML technology has taken the world by storm, by only adding the tags in MTF using XML standard, can improve the ability of the system to find, retrieve, process, and exchange large amounts of information across systems, organisations, and formats boundaries. XML technology makes system integration and interoperability easy.

Recently, MITRE has made much efforts in XML-MTF schema and document specifications for use by the US Military and Joint Forces. This method was reused to transfer MTF into XML format for data exchange. The prototype system developed integrates air tracks in command and control systems. Assuming the original air track format is MTF, the following example is considered to analyse:

AIROP/020200Z/6/US/FTR/F15/TN:401/LM:2300N12300E/CRS:180/SPD:600KPH/ALT:12000FT//

After adding the tag to name each data element of MTF, the result is shown as follows:

```
<?xml version="1.0"?>
<Operation>
<op_type type="Air Operation">
<DateTime>020200Z</DateTime>
<Quantity>6</Quantity>
<Country>US</Country>
<Catalog>FTR</Catalog>
<Type>F15 </Type>
<TrackNumber>401</TrackNumber>
<Axis>2300N12300E </Axis>
<CRS>180</CRS>
<Speed>600</Speed>
<Altitude>12000</Altitude>
</op_type>
</Operation>
```

When the tags were added in MTF message, command and control system could understand the number '6' means the quantity of aircraft via XML parser.

3.3 XML-GPS Transfer

Besides air track, one would like to track the positioning data of mobile vehicles such as tanks

from GPS. Therefore, one needs to transfer GPS message into XML format. Assuming the original positioning format is GPRMC, which stands for recommended minimum specific GPS/TRANSIT Data. The GPRMC format[10] is shown in Table 1.

Table1. GPRMC format

	$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh
1.	UTC of position fix. (hhmmss.sss)
2.	Data status (V = navigation receiver warning, A= locate successfully)
3.	Latitude of fix. (ddmm.mm)
4.	N or S
5.	Longitude of fix.(dddmm.mm)
6.	E or W
7.	Speed over ground in knots
8.	Track made good in degrees True. (0.0~359.9)
9.	UT date (ddmmyy)
10.	Magnetic variation degrees. (000.0~180.0)
11.	E or W
12.	Checksum

The following is an example of GPRMC message:

$GPRMC, 161229.487, A, 25.0377, N,121.3366, E, 0.13, 309.62, 120598, 1.2, E , *10

Similarly, one can also transfer GPRMC into XML called XML-GPRMC as shown below:

```
<?xml version="1.0"?>
<Operation>
<op_type type="GPRMC">
<UTC>161229.487</UTC>
  <Status>A</Status>
 <latitude>25.0377</latitude>
  <dir_of_lat>N</dir_of_lat>
<longitude>121.3366</longitude>
 <dir_of_long>E</dir_of_long>
  <TrackDegree>0.13</TrackDegree>
  <UT_Date>120598</UT_Date>
  <MVG>1.2</MVG>
  <dir_of_MVG>E</dir_of_MVG>
  <Checksum></Checksum>
</op_type>
</Operation>
```

3.4 Web Server Side

The server side of the system is responsible for providing all kinds of services such as radar tracks, land tracks, and intelligence data. Web server is a service provider and can be distributed everywhere in a network. Only the consumers have to find the location of web service via UDDI, they can request the service via WSDL and SOAP message.

3.5 Client Side

The clients or users are the web service consumers such as command and control centres. The command and control centres can request the web services they need, distributed in a network. In this study, command and control centres invoke the air tracks, land tracks, and intelligence web services to be displayed in GUI. The command and control centres can have the common operating pictures and intelligence supports and are able to command and control. In addition, the different levels of command and control centres can integrate the web service with their own legacy systems according to their mission requirements.

4. ANALYSIS OF RESULT

In this section, a scenario is used to demonstrate system functions in client side as shown in Fig. 3. First, 13 air tracks (including seven red Hs and seven blue Fs symbols) and one land track (green dot symbol) were provided randomly and the track data was updated every 5 seconds. Second, it was sent to database for storage and to keep the track data updated. Then, one could start retrieving the track web service from database by clicking the retrieve button. On clicking the retrieved button, the responded track data flows into the client application

program. Third, client application program begins to interpret the track data and displays the symbol, identification number, speed and heading on digital map. Finally, a query was made to the radar coverage service from intelligence database and which is shown as blue circles on the screen. The client side also can choose on or off switch to decide whether to trigger the track or intelligence service according to their own requirements.

5. LESSON LEARNT

The analysis of the result shows that XML is useful and easy to implement for tactical data exchange. In particular, the legacy system can also become web service producer via XML representation. The basics of XML are fairly simple. This is one of XML's great strengths. The most difficult part is getting the developers of disparate systems to agree on the tag or element names. This is often a painful process and independent of technology. Often, a lot of time spent to reach this agreement among the relevant organisations. For the purpose of demonstration, the study just uses radar tracks and GPS positioning messages, in fact the other information related to warfighting also can follow the same method to become web service providers. The consumers can make their own value-added applications by invoking web services distributed in a network.

6. CONCLUSION

Before XML and web services, integration was very difficult and expensive, either at data, application level or at process level. The study demonstrates that XML can promote the data exchange capability, no matter what its original format is. Only by adding the tag of data element, the data becomes easily recognisable. This study also shows that XML-based SOAP and WSDL web service technologies not only facilitate the integration of new and legacy systems but also enhance system interoperability.

In the developed prototype system implementation process, command and control centres can dynamically integrate the various sensor and intelligence web services to meet their mission needs, no matter where these web services are distributed in a network. Accordingly, the commander of a command and controlcentre has the situation awareness capability and can make the right decision at the right time in the right way. In the foreseeable future, the use of XML-based web services in system development and integration aspects will become the mainstream,

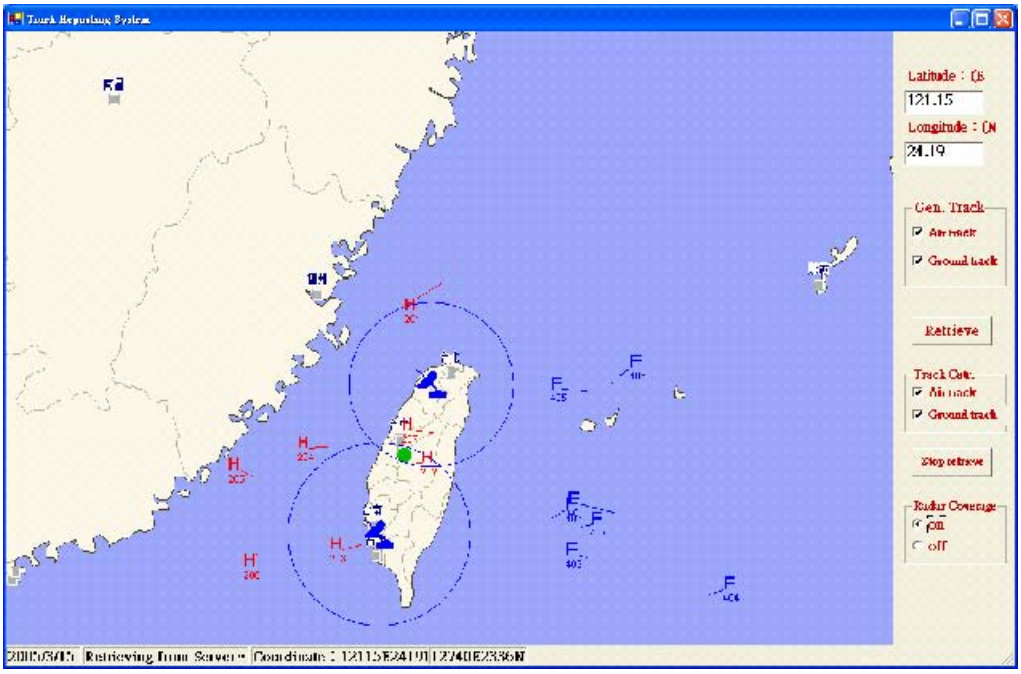

Figure 3. Client view of system.

and will not only save money but will alsoreduce training time.

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