ISBN 978-981-11-3671-9
Proceedings of 2017 the 7th International Workshop on Computer Science and Engineering (WCSE 2017)
Beijing, 25-27 June, 2017, pp. 434-438
doi: 10.18178/wcse.2017.06.074

A Battlefield Situation System Based on Service-Oriented Architecture

Lin Xueren [+] and Zhang Kangming

Academy of Equipment, Beijing, China

Abstract. Battlefield situation system is an important platform for commanders to perceive the battlefield situation and command in modern warfare. Service-Oriented Architecture(SOA) is characterized by low coupling, strong scalability and high flexible with multi-source heterogeneous battlefield situation information. This paper analyzes the functional requirements, system components and key technologies of the situation system, introduces the characteristics of the SOA architecture, the hierarchical model and the classification method, and puts forward a service-based situation system architecture.

Keywords: service-oriented architecture, situation system

1. Introduction

With the rapid development of computer, communication, geographic information technology and sensor technology, the battlefield information integration is getting smart and complex. This requires the command automation system to provide an intuitive, clear and concise real-time battlefield situation presentation for the commanders at all levels to assist decision-making, thus shorten decision-making time and improve operational command efficiency.

Battlefield situation is the definition and description of the distribution of battlefield forces, the battlefield environment and the situation development [1]. Battlefield situation awareness and collaborative command system[2] not only enables commanders to have an intuitive, rich, comprehensive grasp of the battlefield situation, but also provides combat deduction, thus providing commanding officers with effective decision support. Service Oriented Architecture (SOA) is business-oriented, emphasizing business domain analysis and modelling. Based on the service sets shared across the organization, SOA provides a means to effectively reuse and integrate existing resources, providing an agile, highly flexible, distributed system integration solution.

This paper studies the application of service-oriented architecture technology in situation system, and proposes a service-oriented architecture of battlefield situation system. The rest of this paper is organized as follows. In Chapter 2 we first discuss related work about applications of SOA and architectures used in battlefield situation systems. In Chapter 3, we present the SOA-based battlefield situation system framework with the requirement analysis and three-layer model. Finally, in Chapter 4, we illustrate each layer's function in the proposed battlefield situation architecture, before concluding the paper in Chapter 5.

2. Related Work

In traditional software design, the architecture is static and cannot be changed after deployment. In SOA, a basic building module is not a component, but a service. Service-Oriented Architecture is dynamic in that applications can be made up of existing services at runtime [3], and the architecture can be dynamically changed at runtime to meet new software requirements. SOA allows new services to be added to the system

[+] Corresponding author. Tel.: 010 66364482.
E-mail address: 624738001@qq.com

without stopping the application at runtime. In addition, new applications can be combined with existing services by simply changing the workflow specification without changing the underlying SOA framework. This is not possible in traditional software architectures. The key point is that the SOA-based application architecture can determine the runtime while maintaining the underlying SOA framework. There are several application of SOA architecture, Including IBM SOA Foundation architecture[4], SAP NetWeaver [5]. W.T. Tsai [6]categorizes SOA architectures into tuples depending on the specific needs of the application, which is based on four parameters:Structure (whether is static or dynamic), Reorganization (whether has dynamic reorganization capability or not), Fault tolerance(whether has fault-tolerant communication backbone, fault-tolerant control services, or no fault tolerance), Systems engineering support (whether has SOSE support or not).Through the above four basic parameters of the different combinations, SOA architecture can be constructed according to the system architecture needs to achieve different configurations to meet the complexity, reliability, efficiency, adaptability, and other different needs.

As situation information do not have unified description standard, the compatibility between various types of situation services is poor, and the service interfaces are not unified. It is difficult to implement flexible integration and utilization of situation information under large data conditions. The fundamental way to solve this problem is to establish a practical system architecture.

3. System Overview

Usually, SOA application framework is divided into five tiers, which shown in Fig.1, from bottom to top lies Presentation, Business Process Choreography, Services, Enterprise Components and Operating Systems. It also provides additional functions such as Integrated Architecture and QoS, Security, Management and Monitoring for those five tiers.

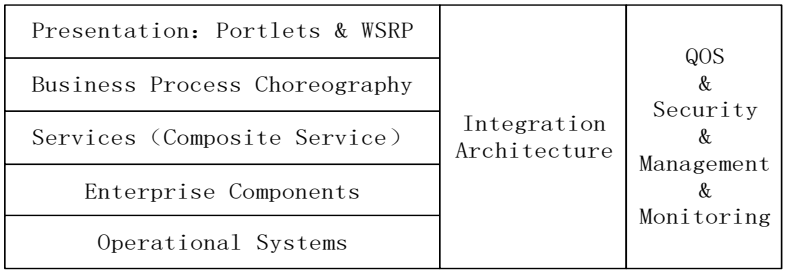

Fig.1: Layers of SOA.

Since in SOA, all functions or services are described using the description language, and its interface whose definition is independent of the hardware platform, the operating system, and the programming language that implements the service, can be accessed through the network with matched access control permission by user configuration. Then, from user side, it allows services built in a variety of such systems to interact in a unified and universal manner. Users can build, deploy, and integrate these services without relying on the application and its technology platform, thus increase application flexibility.

In this paper, we mainly focused on the compositions of basic components of the third and forth tiers.

3.1. Requirements Analysis

Based on Service Oriented Architecture (SOA), various applications, services and devices can be directly connected to achieve the consistency of data acquisition and exchange between different platforms[7], thus provides a new solution to realize battlefield environment information collection, spatial geographic information sharing and battlefield target integration. Using XML Web Service technology and Geography Information System technology, which can not only solve the problem of multi-source and heterogeneous data, the problem of providing standard interface, but also complete the reuse of module and then make the development much easier.

To meet the needs of the battlefield situation system demands, the architecture proposed should contains features as follows.

1) Multi-source data access. Able to integrate different types of data to provide targeted access.

2) Rigorous user access control policy. Different user role have different access rights.
3) Geo-spatial information with multi-dimensional display. Using GIS to achieve realistic two-dimensional, three-dimensional situation information display.
4) Real-time situation display and situation assessment. Through business logic to achieve auxiliary decision-making.
5) Flexible expansion and deployment under different scale. The architecture makes situation system flexible to accommodate different application scenarios.
6) Upgraded online without interruption of service. Using version control to achieve a stable online upgrade.
7) Self-test and fault analysis. Self-diagnosis is possible when errors and exceptions are detected.

3.2. System Modeling

According to the analysis of system requirements above, the batterfield situation system is generally divided into three layers, namely data layer, service layer and application layer. each of them will be elaborated in chapter 4.Data layer mainly consists of spatial database, target database and label database, which provides data support for the whole system and ensures the sharing of data resources in the system.Service layer provides various battlefield business implementation services and data access services, providing interfaces for the upper operational applications. It also consists a key part naming knowledge support which acted as mid-ware for flexible services configuration and management. With knowledge support part, it enables services across the enterprise being shared in order to combine business processes that adapt to business changes.Application layer includes applications like the battlefield environment settings, military situation plotting and target display etc. User can call the service interfaces provided by the service layer to in application development stage. A simple situation system architecture is presented as follows in Fig. 2.

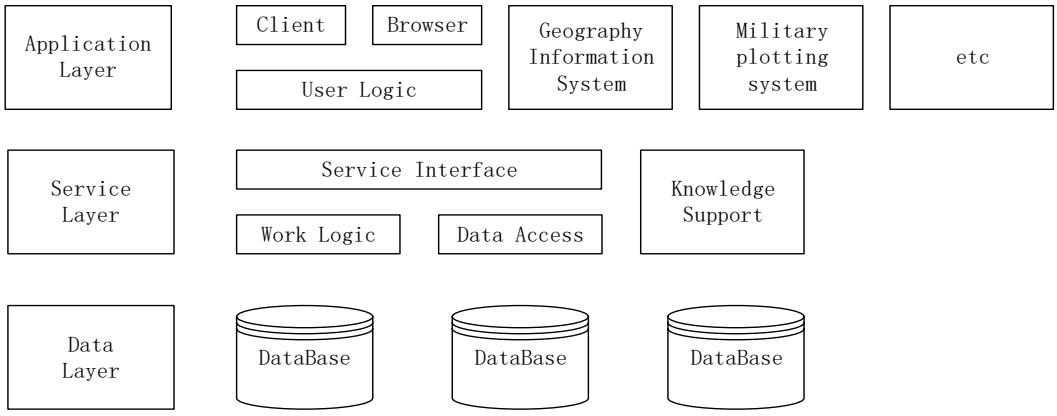

Fig. 2: Abstract model of three-layer situation system.

4. System Architecture and Composition

Chapter 3 has gave the system requirements analysis and a three-tier system structure. This chapter mainly introduces the detailed architecture of the system and functions of each layers in this proposed system.

4.1. System Architecture

Fig. 3 below shows the three-layer service-oriented battlefield situation architecture diagram, naming the application layer, service layer and data layer. The application layer provides presentation of basic user application and control functions; The service layer provides service interfaces, including target access, task management, data access, communication, plotting, detection, logging, user management, system information, etc. The data layer includes the battlefield situation database, the target management database, the geographic information system database and the military plotting database. Details will be introduced in following sub-chapter.

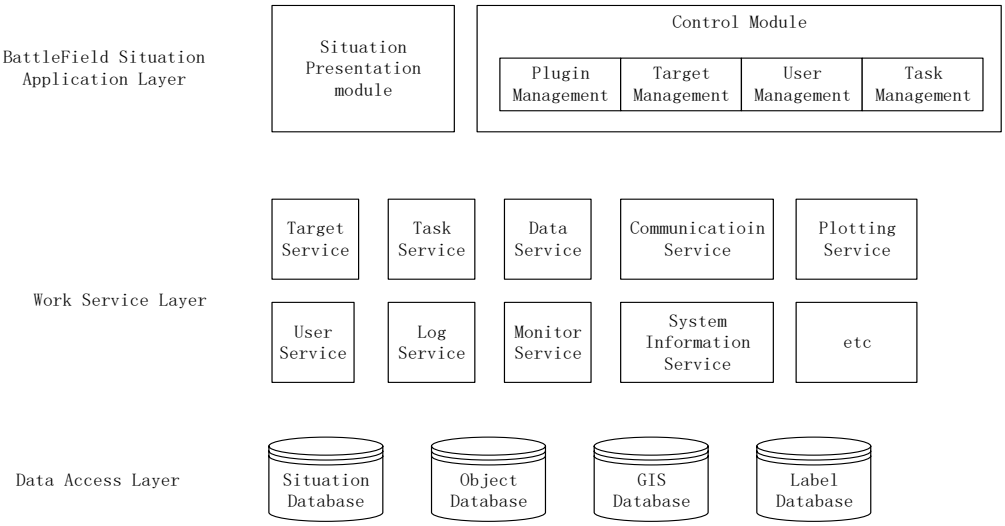

Fig. 3: SOA of BattleFiled situation system.

4.2. Data Layer

According to the classification of situation data, the data layer includes the battlefield situation database, the target management database, the GIS database and the military plotting database four basic data storage and access. The data source comes from the data nodes (sensors), the existing combat system, the existing database infrastructure and command or cooperation instructions directly from the combat units. Use data mining technology to identify potential threat targets' intention, and transform situation information into knowledge to assist decision-making.

Within development of Database layer, we can deploy metadata technology, consistent network information flow technology, distributed data management technology to achieve the distributed management and consistency of access of situation data.

4.3. Service Layer

The service layer provides the encapsulation of interfaces for realizing various functions, which is convenient for component reuse and can provide dynamic management, which facilitates the "plug and play" of service modules on different platforms. It can shield details through the form of API to provide a set of services to improve the Portability, adaptability and reliability. In fig.3 above, service layer contains components to achieve various functions, including user business services and public services. The system can be dynamic loaded while implementation for different demands.

- User service.

The user services set includes battlefield target management service set, battlefield task tracking and processing set, intelligence information data fusion set, and situation diagram plotting service set, etc. The battlefield target management service set provides interfaces for target status inquiring, combat unit status inquiring, combat unit commanding, etc; The situation diagram plotting service set provides user with interfaces to call in potting both sides situation status and mission process, establish system of high-precision positioning, navigation, precise timing to meet increased space coverage, increase longitude and accuracy requirements.

- Public service.

The public services set includes user management service set, logging service set, monitoring service set and system information service set. The user management service set provide interfaces for user rule control and assignment; The logging service set provides reading and writing service access interfaces; The monitoring services set provides administrator with ability to quickly monitor and diagnose system faults; The system information service set provides basic information inquiring services.

4.4. Application Layer

Application layer interacts with the user, receive user requests, forward the request to the appropriate business logic for processing, and then post the processing results to the user. Application layer concludes

user application of a variety of situation services. The situation presentation module call a variety of services through the control module, then display the situation information. In fact, the services and service control center is connected to the bus backbone (such as ESB) in Fig.4. The control center according to the workflow specification, determines the connection and message transmission between the services, and then fulfilled user's requests and realize the situation functions.

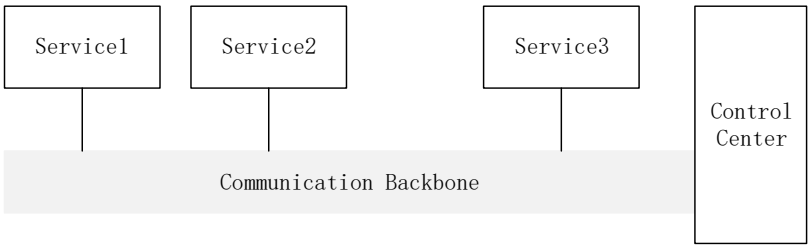

Fig. 4: Diagram of application configuration by service control center.

User can access situation information data via desktop applications or web browser applications. With the idea of modular software, the software module can be expanded and strengthened simply by simply configuring the new module without modifying the architecture and application, thus realizing the "plug and play" of the service module. A desktop application or web application server queries the service needed through a service registry, call the service from the service layer over the network without knowing the implementation details of the service, after calling, show the results in the form of web page or windows.

5. Conclusion and Future Work

The application of service-oriented system architecture in situation system not only solves the problems of system heterogeneity and software modularization, but also greatly reduces the pressure of a large number of battlefield data that the client has to deal with. It provides new ideas for the future development of a new generation of integrated battlefield situation system. In the study, data and service versioning, data transmission performance, as well as reliability, security, there are still urged for future research.

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