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Research on Service Bus of Network-centric Simulation

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Abstract. When high level architecture is used to build complex systems in support of modeling and simulation, the problems are low level of interoperability and poor reusage. Based on the concept of service-oriented and distributed technologies, a service bus of network-centric simulation is proposed. Definite the concept of community of service and service bus, establish the architecture of simulation service bus and its implementation framework, analyze three key technologies of its implementation process. The primary research and practice show that: the proposed simulation service bus can support to run community simulation tasks based on Internet and provide a reference for building a service-oriented environment of network centric simulation.

Keywords: Service-oriented; network centric simulation; HLA; simulation service bus

1. Introduction

The High Level Architecture (HLA), with object oriented concept, improves the “interoperability and reusage” of modeling simulation system, which is recognized as the industry standards. Along with the enlargement and complexity of simulation system’s scale and structure, because of its poor “interoperability and reusage”, HLA can not afford when it comes to support building new distributed modeling simulation system, which is distributed, heterogeneous, cooperating, interacted and reusable[1]. Especially, the application of service oriented concept[2] and the distributed technique (grid technique and cloud computing technique[3]) in engineering or other field, has resolved the various resources’ problem of dynamically sharing and reusing safely, cooperated interacting, and dynamically optimizing running. But how to introduce the concept and technique of service-oriented and cloud computing to the field of modeling and simulation, to support building and running new distributed modeling and simulation system? It is a problem crying for being resolved, and has become a hot research point[3,4].

1.1. Technical development history of HLA

In the early ‘90s, HLA was developed by the department of defense of USA, to improve the interoperability and reusage of simulation. With new simulation demands brought forward continually, HLA can not meet the needs. For example, the static FOM and SOM structure of HLA restricts the sharing and reusage of simulation resources seriously. Thus, HLA provided HLA Evolved edition[5] in 2010, mainly improved in 4 aspects, exploration, disposition, network centric and capability strengthening. Whether can HLA Evolved version meet simulation users’ demand? It needs to be checked by practice.

1.2. Service-oriented simulation technique presentation

Service-oriented concept applied in simulation building, differs form HLA in the reusage of simulation resources and the mode of simulation building. With the service-oriented concept, as long as these resources be shared in the service way, all can be reused. There are two ways to construct the simulation framework with service-oriented concept, one is based on the framework of HLA, such as HLA Evolved, XMSF[6]; or build simulation resources administration services based on Web Service/Grid, using grid technique or cloud communicating technique, such as cloud simulation platform. The other way is to build new service-oriented simulation architecture, abandoning the framework of HLA, such as net centric simulation architecture[2][4]. The first way is on the leading position, But the second way has abandoned the restriction of HLA, and has a bright future.

1.3. Simulation task community

Simulation task community is a new construction mode of simulation application based on network-centric simulation architecture, which is similar to federation of HLA, and simulation cloud in cloud simulation flat. It is created task oriented, when the task is completed, simulation task community will be released immediately, whose members are distributed on the network as various resources and installed systems. The creation of simulation task community can be deployed by users themselves. The deployed simulation task community description includes resources collection, services collection and services relation collection:

Suppose $R = \{R_1, R_i, ..., R_j, ..., R_n\}$, where R_i illustrates the i th simulation resource, $S = \{R_1.S_1, R_1.S_2, ..., R_i.S_j, ..., R_n.S_m\}$, where $R_i.S_j$ shows the j th service of the i th simulation resource,

$L = \{R_1.S_1 \to R_2.S_1, ..., R_i.S_j \to R_n.S_m\}$,

where $R_i.S_j \to R_n.S_m$ illustrates that the transfer of the j th service of the i th simulation resource depends on the m th service of the n th resource.

1.4. Simulation Service Bus

Simulation Service Bus (SSB) is the supporting environment to run the simulation tasks community, is the main part of network-centric simulation operation supporting flat, in charge of the service location of simulation resources, the pre-configuration of services, the services transfer and the reliable service communication and exchanges. SSB mainly adopts the technique of news middle-software to map with news to services, completes the transfer and communicate of services via subscription /distribution of messages.

The complete services transfer is via inputting parameters by the transferor (or with no input parameter), then the service communicates, and the transferor gets the output parameters (or with no output parameter). The service encapsulates the “input parameters” and “output parameters” into message and names the message uniquely. By service the transfer user publishes “output parameters” message, subscribes “output parameters” message. The service subscribes “input parameters” message, publishes “output parameters” message. Then the service transfer is completed. Figure 1 illustrates how to put the simulation resources into messages.

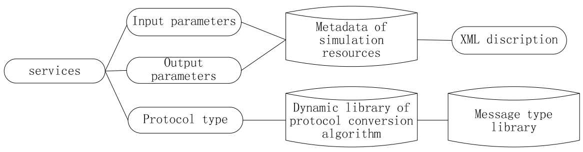


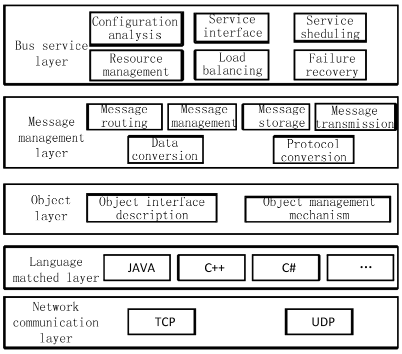
Figure 1: Process of messaging the service register of simulation resources

2. Simulation Service Bus Architecture

Simulation service bus architecture is shown in Figure 2. The structure is divided into five: network communication layer, language matching layer, object layer, message management layer and bus services layer. Which the network communication layer, language layer and object layer resolve the problem of information transmission of simulation service bus in heterogeneous environments. While the message management layer, mainly resolve problem of information exchange between the simulation services. Service layer mainly provides management to service access to the bus.

3. Implementation of simulation service bus architecture

Simulation Service Bus mainly consists of the server (DB-Server) and agent (SSB-Proxy), shown in Figure 3. SSB-Server functions mainly include the registration of simulation tasks community service available, the analysis of community configuration information, service scheduling, service failure recovery, the load balancing of services, and so on. Functions of SSB-Proxy is to complete the information transmission and exchange among members of the simulation tasks community and among the core services of the simulation tasks community , mainly includes service calls, messaging, message storage, message routing, data conversion, protocol conversion. SSB-Proxy uses a distributed messaging publishing/subscription mechanism. When a member has information to publish, it is server-side, while the subscription is a client.



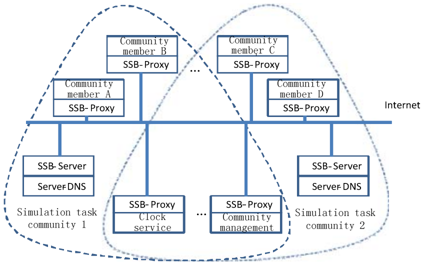


Figure 2: SSB architecture Figure 3: SSB implementation architecture

Each tasks community, has a Server Domain Name Server (Server-DNS), is the server-side of SSB. The bus agents of community members point to the server (By setting the target server's IP address and port number) when configuration. The publishing / subscription of messages between services of all members also points to the Server-DNS. It is the SSB-Server and the SSB-Proxy to match the published/ subscribed massage type and IP address among member services. Achieve redirecting messages between services (i.e., message routing).

4. Key technologies

4.1. Language-independent technology on SSB platform

Services provided by simulation tasks community members are heterogeneous (The service may reside on different operating systems, be developed using different languages). Therefore, the simulation service bus requires the running environment to implement language-independence on the platform. In communications, to solve platform language-independence with object-oriented methods is a good choice, Such as CORBA, DCOM and other technical. Therefore, in the simulation service bus architecture, the object layer and language matching layer are designed, in order to achieve platform language-independence.

4.2. SSB service independent technology

In simulation tasks community the concept of service-oriented is a broad service. As long as the simulation resources are willing to provide resources, regardless of the delivery of simulation resources, simply follow the simulation task community services description standard, after serving and messaging process of simulation task community, then the resources can be service resources of simulation task community.

4.3. Dynamic migration technique of SSB services

The fault discovery of simulation task community members and their dynamics migration, are completed by management service, the core service of simulation task community. And the dynamic migration technique of SSB services is a process when SSB discovers a service close to collapse, or a certain service has collapsed, how can SSB replace the service with another or reboot the same service to return to the current state. The difficulty of service dynamic migration is how to keep the synchronous state of the migrated service. Figure 4 presents a service migration solution.

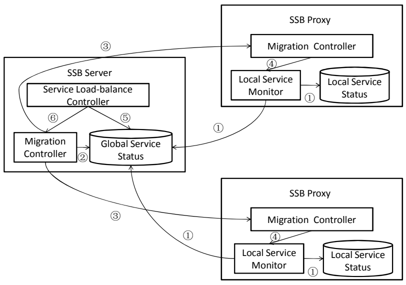


Figure 4: A service migration solution

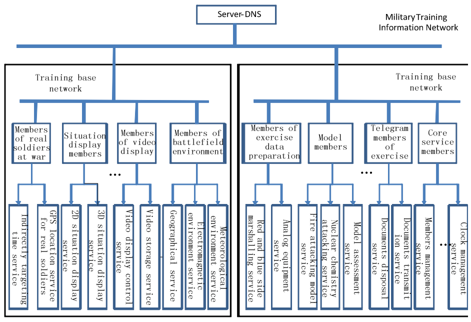


Figure 5: SSB prototype system application

5. Conclusions

Based on the open source code of ICE（the Internet Communication Engine）[7], a prototype system of SSB is developed, relying on military information network, applied in cross-unit training simulation exercises co-organized by a number of training bases. Application environment is build as is shown in Figure 5.

Preliminary studies indicate that the simulation service bus can provide a reference for the building of the running supporting environment of service-oriented network centric simulation. The next step: (1) Simulation service resources can be scheduled by the current simulation service bus, but for the scheduling of computing resources, storage resources, data resources, communication resources, which is more fine-grained, has not been considered, and that is needed for further research. (2) Facing internet-applications, the access security mechanism of simulation service bus needs further study.

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