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The application of MDA in distributed services of Run-time Infrastructure

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Abstract –This paper proposes the application of Model Driven Architecture (MDA) for distributed services Run-time Infrastructure to achieve reusing simulation services and communicating in heterogeneous network environments. Platform-Independent Model (PIM) is built based on simulation services definition in service-oriented distributed Run-time Infrastructure by interface definition language Slice to describe simulation service and special data structure. The simulation service model is mapped to Platform-Specific Model (PSM) by slice mapping tool. The paper achieves the heterogeneous communication between federation, simulation services and Simulation Service Management Bus (SSMB) by same communication protocol. In practice, this solution is effective for simulation services reuse and communication in heterogeneous network environments.

Keywords –MDA; service-oriented; service-oriented distributed Run-time Infrastructure; Simulation service

1. Introduction

United States Department of Defense (DOD) published M&S Master Plan (MSMP) and established universal simulation technology architecture. The core of this plan is High Level Architecture (HLA). An HLA Run-Time Infrastructure (RTI) is a software implementation of the Interface Specification. The RTI actually provides the services defined in the interface Specification. It separates the simulation application and underlying communication layer to supply simulation run management ability for simulation application. It is a base infrastructure for distributed simulation scalability [1]. However, its drawbacks have been revealed in the practice and application during a long time [2]. For example, language binding and platform binding lead to RTI cannot independent of the special developing language and platform; the central mode of RTI also becomes a bottleneck for RTI.

Researchers combine the Service Oriented Architecture (SOA) idea with HLA/RTI to solve many problems in RTI [3].Web service is viewed as main method for achieving SOA. However, many researchers also find deficiencies in the practice and application in the process of achieving

Service Oriented HLA/RTI based on web service [4][5][6][7][8] [9][10][11]. For the reason of web service have many deficiencies for solving many drawbacks in large-scale and highly distributional simulation with RTI, applying no-web service to achieve service oriented RTI is also a choice. Hence, the next problem is how to reuse simulation service.

This paper propose distributed services of Run-time Infrastructure based on MDA ,which is able to separate business logic and soft support environment and map the model to PSM by model mapping mechanism[12]. Lighted by this idea, this paper builds PIM for simulation service, in which simulation and the data structure is described. Simulation service model is mapped to PSM by model map mechanism. Hence, developers can reuse legacy simulation service model by platform specific model interface and achieve communication between different services with unified interface and protocol.

2 An overview of MDA

Currently, MDA is the significant direction of research and development of software engineering. It is carried out by the Object Management Group (OMG)[24]. It intends to promote the use of models as fundamental way of designing and implementing different kinds of systems. Under proposed standard by OMG, the software system's modeling action drive the system development. This mode is able to separate the business model and implementation platform. Hence, the developer can processes the business logic emphatically regardless of implementation detail. This method ensures that business model can be reused and the whole system has reconstructing ability. Services based different technologies can be generated by formalizing the business request [27]. Unified Model Language (UML),

Common Warehouse Meta-model (CWM), Unified Process Model (UPM) are different meta-model in the development of software. Meta Object Facility (MOF) is defined to achieve request in next abstract layer.

The core of MDA is model driven which is take model as centre. MDA gives relevant description model by the business request description, system function, system architecture design and the system implementation of platform technology:

(1) Computation Independent Model (CIM) is able to describe the system work in the phase of system request.

(2) PIM is able to describe system architecture from the angle of function design. It is independent of technology detail and described by UML.

(3) PSM is able to is able to describe the solution based on specific middleware environment which include CORBA, EJB, SOAP、ICE and so on.

(4) Implementation Specific Model (ISM) is able to describe the last detail of programing.

PIM is a model built according user request. It is in charge of describing the function. PSM describe the relevant implementation form in specific platform. In the process of MDA developing, it required compile PIM and mapping rule for specific platform. And then, PIM is mapped to the PSM automatic by mapping rule. Last, transform the PSM to code. It can be shown in the figure 1.

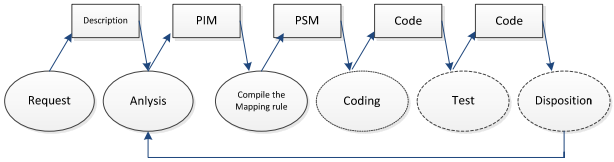

Figure 1. MDA develop process

It seems to be same lifecycle in the development phase between MDA and traditional software. However, they are difference in essence. Traditional software cares for design and implementation in development lifecycle. In comparison, MDA cares for model. The detailed development step can be shown in the figure 2.

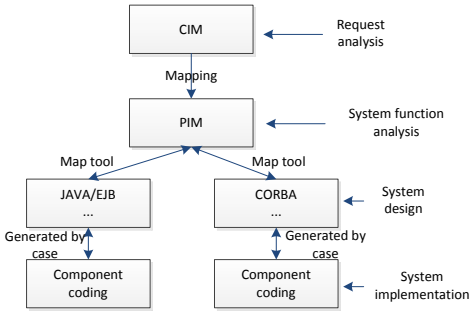

Figure 2. the specific development mode based on MDA

3. Distributed Service in Run Time Infrastructure (DSRTI)

Service oriented idea stem from the theory of Separation of concerns (SOC) which is the process of breaking a program into distinct features that overlap in functionality as little as possible. A concern is any piece of interest or focus in a program. Typically, concerns are synonymous with features or behaviors. The method of component-based achieves SOC in practice based on component. Service Oriented defines the use of services to support the requirements of software users. In a SOA environment, nodes on a network make resources available to other participants in the network as independent services that the participants access in a standardized way [17] [18]. For the merit of decoupled service component, SOA have many advantages such as strengthening resource reusable rate, improving system scalability, reducing time and cost for system developing and distribution, and so on[20][21][22][23]. These advantages are just required by distributed simulation. These advantages can be applied in developing service oriented simulation system. DSRTI stem from this a point of departure.

The main idea of DSRTI achieve RTI is using the idea of service oriented by decoupled the service of RTI as federation management service, time management service, object management service, ownership management service, interactive class management service and so on. It can be shown in the figure 3.

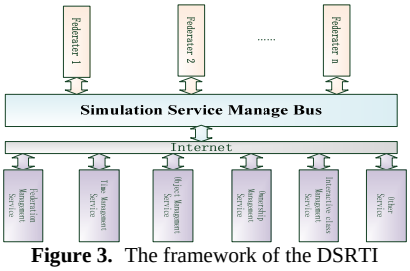

Figure 3. The framework of the DSRTI

From the figure, we can see that each service published in dispersed node in the internet and Simulation Service Manage Bus (SSMB) is in charge of managing and dispatching simulation services. Simulation consumer does not directly interactive with simulation supplier but to research the service in the register center in SSMB. Simulation service supplier publishes the service on SSMB to ensure lower the dependence between different services. The process of calling service in DSRTI can be shown in the figure 4.

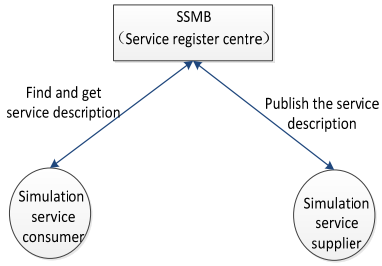

Figure 4. the process of dispatching simulation service in DSRTI

4. Implementation of MDA in DSRTI

MDA is a method of software development, and SOA is good at dealing with interaction and integration problem in heterogeneous system from the angle of

software system structure to generate service base on different technologies by formalizing the relevant business request. At the same time, the design of SOA make the description of information and service independent of development language and other technology in detail. It should be a wise choice of guiding SOA development with MDA in heterogeneous environment. The detailed process is as follow: first of all, take simulation as center and build CIM by demand analysis; second, build PIM by CIM; last, map the PIM to PSM and adjust the model by analysis of data and run result. In the whole process, simulation service is main an object of study. The whole process can be shown in the figure 5.

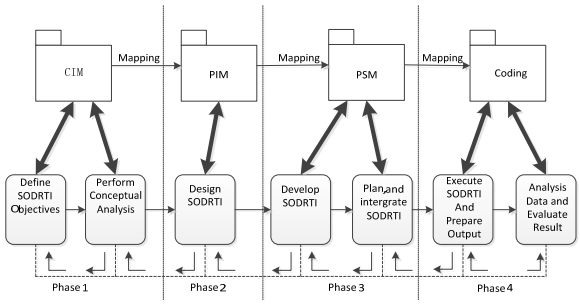

Figure 5. The development process of DSRTI based on MDA

4.1. CIM

CIM is the first layer in the whole software development architecture based on MDA. Its main function is to describe business logic accurately and be convenient for specialist in relevant area to understand. It is also required to be transformed to PIM conveniently under engineer guiding. The process of building CIM should meet follow request: it should supply structured process model elements and the relation between modeling elements to abstractly describe complicated business process structure for user to clearly understand the business logic; it should be convenient for system analyzer to extract necessary information to build PIM. Taking federation management service as example, graphically represents of CIM process model by Unified Modeling Language (UML)[25].It is can be shown in the figure 6.

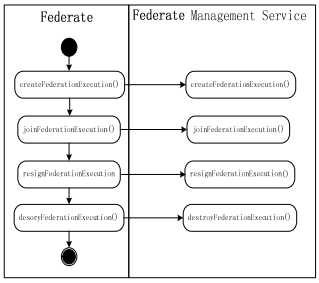

Figure 6. Federate management service represented by UML

4.2 PIM

PIM, which is highly abstract model and independent of specific technology, bridge the gap between CIM and PSM. In DSRTI based on MDA, PIM which is able to entirely describe is built based on HLA interface standard. For the reason of regardless of platform and implementation technology, it is an important base for communicating in heterogeneous network environment based on unified interface standard to achieve communication between different platforms. PIM can be divided two types: domain Facilities models and pervasive services model.

Domain facilities models are used to directly describe standardized function in business domains. In DSRTI, services can be divided into federation management service, time management service, object management service, ownership management service, interactive class management service and so on based on service function. Pervasive services model is used to describe common service in many platforms such as event notification, object security, transactions, etc. In addition, hardware and software attributes like scalability, real-time, fault tolerance, etc. PIM need to be described by data type, interface, inheritance and collection. Both of UML and Interface Definition Language (IDL) in CORBA can be used to describe the simulation service model. In this paper, UML service model is build based on service oriented idea. The meta-model allows atomic service component and composition service component to model. The core of the meta-model is service which supplies a set of services interface and each interface have service operation. It can be shown in the figure 7.

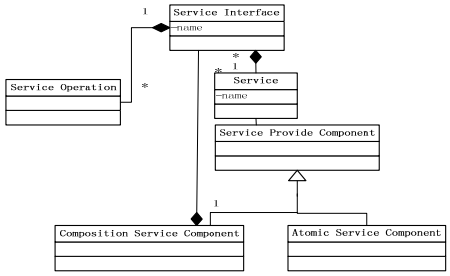

Figure 7. Service meta-model

Slice (Specification Language for Ice) is the fundamental abstraction mechanism for separating object interfaces from their implementations. Slice establishes a contract between client and server that describes the types and object interfaces used by an application. This description is independent of the implementation language, so it does not matter whether the client is written in the same language as the server [26]. Here, we take slice language as standard for PIM because it supply all mechanisms for description of simulation service model .Taking federate management service as example, the PIM can be built as follow:

```
#endif
Federate management service definition:
 #ifndef RTI_FederationManagementService
#define RTI_FederationManagementService
module DSRTI
{
interface FederationManagementService
{void createFederationExecution(string executionName, string FED) throws RTIexception;
void destroyFederationExecution(string executionName,long FederateHandle) throws RTIexception;
```

long joinFederationExecution(string yourName, string executionName, FedAmb *fedambptr, out string fedfile) throws RTIexception;

void resignFederationExecution(ResignAction theAction,long FederateHandle) throws RTIexception;

……};

};

#endif

4.3 PSM

PSM is the specific implementation technology for PIM. PIM can generate one or more independent PSMs. In SORTI, slice tool is used to map the simulation model to specific platform or language such as c++ , c# , JAVA , PHP , Python and so on. It can be shown in the figure 8.

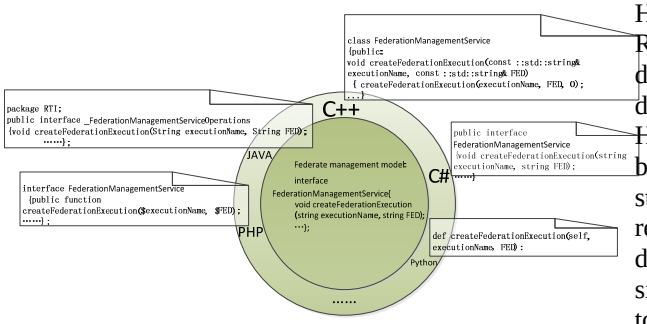

Figure 8. the schematic diagram of from PIM to PSM

4.4 coding

In the phase of simulation service coding, combine the PSM and legacy simulation model to achieve simulation coding. The legacy simulation service can be reused by properly rectifying the according with simulation interface. Taking the federated service as example, creating federate operation interface is in federate management service. In HLA 1.3 standard, the interface is defined as:

createFederationExecution(const* char executionName, const char* FED).

However, in PIM, the interface is defined as :

void createFederationExecution(string executionName, string FED).

Where the PIM is mapped to PSM the interface by slice tool as:

void FederationManagementService I::createFederation-Execution(const string& executionName, const string& FED, const Current&)

Apparently, the parameter type is different. It should be very trouble and difficult to rectify all the parameter in HLA 1.3. Here, we choose the solution that transforms the parameter from PSM to corresponding interface to reuse the legacy simulation model. This solution is able to reuse the legacy service but doesn't have to change the parameter in legacy simulation.it can be shown as follow:

void FederationManagementService I::createFederationExecution(const string& executionName, const string& FED, const Current&)

{ const char* executionName =executionName.c_str();//transform the parameter

const char* _FED = FED.c_str();//transform the parameter type

createFederationExecution(executionName, _FED) ; //reuse the legacy service

} ;

In addition, many services should be test to analysis the stability and reliability of the simulation service. If the simulation result doesn't meet the expected effect, simulation should be rectified in previous step.

5 The interoperation in heterogeneous for DSRTI

With the development of the network technology, distributed simulation has been significantly developed. However, because there are many different versions of RTI distributed simulation system, which is developed in different platforms such as windows, unix/linux or with different languages such as c++ and java and so on, Heterogeneous systems lead to difficult communication between different simulation programs and dada structure. In a similar way, it also leads to lower the reusable value of the simulation service for the reason of difficult to interoperate between federations and simulation with different versions. Hence, it is important to integrate and coordinate heterogeneous simulation services which were developed in different platforms or different languages in a unified platform. A effective solution to achieve interoperating between simulation services is to build a Unified Simulation Service Interface (USSI). Under the same interface, federate, SSMB and simulation service can interoperate with each other regardless of the difference technology in detail.

5. Conclusions

In recent years, the combination of MDA and DSRTI is main tendency for the theory and method of software development and it is best choice for interoperating between heterogeneous simulation services. In this paper, MDA is applied to solve the problem existed in reusing the simulation services and communicating in heterogeneous network environment. The method and step are described in detail by specific example. Taking create federate as example, build CIM by UML and build PIM by slice language. The transformation between PIM and PSM is achieved by slice mapping tool. At last, achieve reusing legacy simulation service and communicating in heterogeneous network environment. In the future work, the message transportation mode will be studied to promote the communication ability.

Acknowledgements

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