SHARING SERVICE RESOURCE INFROMATION FOR APPLICATION INTEGRTATION IN A VIRTUAL ENTERPRISE

Modeling the communication protocol for exchanging service resource information

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Keywords: Resource sharing, Protocol modeling, Business integration, EAI, Grid computing, Web service

Abstract: Grid computing and web service technologies enable us to use networked resources in a coordinated manner. An integrated service is made of individual services running on coordinated resources. In order to achieve such coordinated services autonomously, the initiator of a coordinated service needs to know detailed service resource information. This information ranges from static attributes like the IP address of the application server to highly dynamic ones like the CPU load. The most famous wide-area service discovery mechanism based on names is DNS. Its hierarchical tree organization and caching methods take advantage of the static information managed. However, in order to integrate business applications in a virtual enterprise, we need a discovery mechanism to search for the optimal resources based on the given a set of criteria (search keys). In this paper, we propose a communication protocol for exchanging service resource information among wide-area systems. We introduce the concept of the service domain that consists of service providers managed under the same management policy. This concept of the service domain is similar to that for autonomous systems (ASs). In each service domain, the service information provider manages the service resource information of service providers that exist in this service domain. The service resource information provider exchanges this information with other service resource information providers that belong to the different service domains. We also verified the protocol's behavior and effectiveness using a simulation model developed for proposed protocol.

1 INTRODUCTION

Integrated services using grid and web service technologies are increasing. Using these technologies, we can orchestrate several business applications and share more resources in the network autonomously. In an enterprise or a virtual enterprise, EAI (enterprise application integration) tools are used to integrate several applications and resources in the enterprise network. This service architecture needs to define mechanisms for creating, naming, and discovering transient service instances. In addition, it also needs to provide location transparency and multiple protocols for binding a service instance. That is the initiator of the integrated service or resource-sharing service has to be able to answer questions such as: "which server is the target application with the name "A" running on", "which server has sufficient CPU power to deal with our request", and "which server has the lighted load?."

In the above architecture, the information service should be designed to support the initial discovery and ongoing monitoring of the existence and characteristics of resources, services, computations, and other things. Hereafter, we call these characteristics service resource information (SRI). Some SRI may be static and long-lived while other service information may be highly dynamic. For example, computation specifications like CPU power, operating system name, and memory size are static SRI, but the CPU load of the application server is highly dynamic SRI.

Yamada H. and Kawaguchi A. (2005).
SHARING SERVICE RESOURCE INFROMATION FOR APPLICATION INTEGRTATION IN A VIRTUAL ENTERPRISE - Modeling the communication protocol for exchanging service resource information.
In *Proceedings of the Second International Conference on e-Business and Telecommunication Networks*, pages 109-116
DOI: 10.5220/0001408801090116

The most successful and famous wide-area service resource discovery mechanism is the domain name service (DNS). This is based on server names. Its hierarchical tree-like organization and caching methods take advantage of rather static information like names. However in grid computing and web service environments, the initiator of the integrated services requires specific sets of service information attributes, for example, the application name, and required operating system in order to provide the optimum service quality. The scheduling policy engine can calculate and determine the appropriate set of required service resources using the SRI obtained by the discovery mechanism. In particular, dynamic service resource information like CPU load is one of the important parameters. Unlike the discovery mechanism using static service resource information, the search mechanism using dynamic SRI can benefit from a certain degree of approximation. For example, such a discovery mechanism can search for the server whose CPU load is less than 30% or idle disk space is larger than 6MB.

This paper is organized as follows. Related work about discovery of SRI is summarized in Section 2. Several concepts that define the architecture for systematically exchanging SRI are introduced in Section 3. Using a simulation model developed for the proposed protocol (Yamada, 2004), we verify the protocol's behavior and effectiveness in a case study in Section 4. Section 5 summarizes the proposed protocol and mentions further studies.

2 RELATED WORK – DISCOVERY OF SRI

SRI discovery mechanisms based on static resource attribute like a file name are discussed in P2P computing environments. In P2P computing, SRI is used to search for the server location. There are various searching mechanisms. For example, Gnutella (Gnutella) uses flooding method. Freenet (Clarke et al, 2000) uses a combination of informed request forwarding and file replication methods. These discovery methods are based on static SRI.

The decentralized resource discovery method in the grid environment is discussed in (Iamnitchi et al, 2001). The basic framework of this discovery mechanism is the request-forwarding mechanism. In this framework, one or two SRI providers are considered and the provider server is called a peer or node. A virtual organization has one or two nodes. Each node can store service resource information and provide service information about one or more resources. The initiator of the coordinated service sends a request to the node. The node responds with the matching service resource description if it has the requested service information. Otherwise, the node forwards the SRI request to other nodes. If a node can respond to the request, it directly answers the initiator. This framework needs a membership protocol. Each node should know the other nodes to which it forwards requests when it cannot respond.

In Web services, UDDI (Universal Description, Discovery, and Integration) (UDDI) is the information provider. The service provider registers the service information including the XML code (WSDL (Web services description language (WSDL)) access the service provider. The requester first accesses UDDI and learns how to access the target service provider. A quantitative study of the information service is the starting point.

The grid information service architecture was proposed in (Czajowski et al, 2001). It consists of two components: highly distributed service information providers and specialized aggregation directory service providers. The information provider deals with dynamic information about grid resources and the aggregate directory service provider deals with static information. The information provider sends a registration message to the aggregate directory. Communication among different aggregate directory providers and among different information providers is not explicitly considered. The service information flow follows a tree structure.

One example of a resource information service is the network weather service (NWS) (Wolski, 1997). In this service, several sensors are implemented in nodes or links in the network and they monitor resource consumption. The collected sensory data is sent to the central database. The data is analyzed by several statistical methods. The central database corresponds to the information provider.

In the discovery mechanism proposed in this paper, the service resource information providers exchange SRI each other. We also regard the SRI provider as the nodes in (Iamnitchi et al, 2001). We introduce the concept of the service domain like that in autonomous systems (ASs) in BGP (border gateway protocol). A virtual enterprise has several service domains. The application service providers are managed in one service domain. The SRI provider stores the static and dynamic SRI of all service providers in the service domain. The SRI provider establishes connections between neighboring SRI providers in different service domains. The initiator of a coordinated service sends a request to the SRI provider. Because the service information provider exchanges the SRI with other SRI providers, it can responds to the request. The exchange of SRI is similar to the exchange of NLRI (Network Layer Reachability Information) in BGP.

3 ARCHITECTURE MODEL

3.1 Overview

In this paper, we consider three players: SRI provider, service provider, and requester (the initiator of the coordinated service). The service provider is the server that provides the application services, for example, processing the requester's computation or providing the files. The SRI provider is the server that manages the SRI of the service providers and exchanges the service resource information about the managing service providers with other service resource information providers. The requester asks the service resource information provider, obtains the service resource information, and decides which server it should access based on the obtained service information and the scheduling rule, and finally accesses the service provider where the target application service is running.

In grid computing, two protocols are used: grid information protocol (GRIP) and grid registration protocol (GRRP) (Czajowski et al, 2001). GRIP is a protocol for looking up SRI and discovering the appropriate server. The requester uses it. GRRP is a protocol for sending the service information from the service provider to the SRI provider.

In (Czajowski et al, 2001), the following architecture is considered. This architecture has information providers and aggregate directory service providers. The service resource information provider manages the SRI about several service providers. The aggregation directory service providers communicate with the SRI provider and manage the aggregated service information. The requester can ask either provider. In this architecture, communication among different information providers and among the aggregate directory service providers is not explicitly considered.

In this paper, we consider the architecture shown in Figure 1. The SRI providers manage the SRI about all service providers in the service domain and communicate with other SRI providers in order to exchange the SRI that each service provider manages. The requester can access a nearby SRI provider and ask for a SRI of the service provider that can provide the application service that the requester desires. Let us call the communication protocol between the SRI providers service domain information protocol (SDP).

Here we introduce the concept of the service domain (SD), like that in anonymous systems (ASs) in BGP, which is defined as a group of service providers. The information provider is the representative of the service domain. A unique number is assigned to the service domain. Let us call it the service domain number. The SRI provider communicates with all the service providers. The service provider registers the SRI and reports the current load status (a dynamic resource attribute) in order to update the registered SRI. If the service provider stops providing the registered service, a request to discard the SRI is sent to the SRI provider. The SRI provider also communicates with the other SRI providers to exchange SRI with them. Let us call a peer for exchanging service information a neighbor.

SDP can control and modify service resource information and associated attributes. For example, if the service resource information provider requires that a neighboring SRI provider does not forward the received SRI to any other information providers, then SDP stops it being forwarded.

This mechanism is similar to the control scheme in BGP. In BGP, the device manager can configure the route map in order to control the forwarding route information. Because the scheme for exchanging SRI is based on BGP, SDP can also control the SRI. SDP creates and maintains the SRI base (SIB) in the SRI provider. When this SRI provider receives an update message from a neighboring SRI provider, it updates its SIB table. Figure 2 shows an example. SD_path is included as one of the associated path attributes. This shows the service domain numbers for delivering the registered service resource information. For example, an application called "AP_1" is running on service provider "SP3". This SRI is created in the SRI provider with service domain number 3. This service information is delivered via service domains 3, 2, and 1 to "IP_1".

3.2 Service domain information protocol

Like BGP, SDP first tries to establish connections with neighbors listed in the configuration file. The procedure for establishing an SDP connection is the same as that in BGP. First, the OPEN message is exchanged. Then, the KEEPALIVE message is exchanged. Finally, the UPDATE message containing the service resource information is exchanged and the SRI provider updates the local SRI base (SIB). Once the SDP connection has been established, UPDATE and KEEPALIVE messages are exchanged between neighbors when there is and is not, respectively, new SRI.

The SDP UPDATE message has a service information field instead of the network layer reachability information (NLRI) field in the BGP UPDATE message. This field stores the service information including the application name, CPU power level, and CPU load status. The static SRI is configured in SDP. The configured SRI is exchanged through the SDP connection with other SRI providers. This mechanism is the same as the NLRI in BGP. On the other hand, dynamic SRI is also exchanged. When the CPU load status in the service provider is changed, the service provider reports the current SRI that needs to be updated. This SRI is set in the service information field in the SDP UPDATE message and is exchanged among neighbors. In BGP, the network route information redistributed from interior gateway protocol (IGP, e.g., OSPF and IGRP) is dynamically set in the NLRI field in the BGP UPDATE message. The neighbors that receive the SDP UPDATE message also update their SIB and send the updated service resource information to their neighbors.

The path attributes are also considered in SDP protocol like in BGP. They are used to select the appropriate SRI among multiple entries in SIB. These entries have the same information about the application name and server names and IP address but they have different path attributes. In the current version of the developed simulation SDP model, the following are considered as SDP path attributes: origin, SD path, community, and local preference. Here, the origin means how to obtain the service information and has two values: “DFP” or “ESDP”. “DFP” means that the SRI is obtained from the service provider by the registration protocol or is statically configured in the SRI provider. “ESDP” means that the SRI is obtained from another SRI provider. The SD path means the set of SD numbers of the service domain along which the SDP UPDATE message traverses from the original information provider to this information provider. The local preference means the preference of the original SRI provider. The SRI selection rule is defined as follows in the current version. First, path attributes preferences are compared. The SRI entry that has the larger preference value is selected. Second, if the preference values are the same, the lengths of the SD path attributes are compared. The SRI entry with its shorter SD path is selected. If the SD path lengths are also the same, the values of the origin are compared. Here, we select the SRI entry with “DFP” rather than that with “ESDP”. If the SRI entries have the same values for the above condition, finally, we compare the identifiers of the advertising SRI providers. The SRI providers have unique identifiers. In this model, the largest value among the IP addresses of the interfaces is assigned as the SRI provider identifier. The SRI entry that is advertised by the highest SRI provider identifier is selected. We can consider several alternative rules for selecting the SRI entries. And the path attribute can be modified in the SRI provider when the SRI provider exchanges service resource information with neighbors as in BGP protocol. A sophisticated scheme for controlling the path attributes is for further study.

4 CASE STUDY

In order to verify and analyze the protocol behavior and effectiveness, we developed a simulation model of proposed protocol by OPNET (Yamada, 2004). Using this simulation model, we considered the following virtual enterprise system.

4.1 Network model

In this case study scenario, three companies that have their own networks decide to make a virtual enterprise, as shown in Figure 3. The core network is created and these companies’ networks are connected to the core network. The routing architecture is as follows. The OSPF routing protocol with each different tag number is running on each company’s network. In the core network, OSPF routing protocol is also running. Each company’s network has a different AS number. The AS numbers of networks 178.0.0.0/8, 192.0.0.0/8, and 200.0.0.0/8, are 100, 300, and 200, respectively. In the edge routers of each network, BGP protocol is configured. Exterior BGP (EBGP) connections are established between the edge routes in each network and the core network. The Interior BGP connections are fully meshed among edge routers in the core network. The redistribution command is configured in the edge routers of each company's network. The outside routes obtained by BGP protocol are redistributed into ones by OSPF routing protocol and the routes in the company's network are also redistributed into ones by BGP protocol. Synchronization is off in the BGP configuration. The SRI and router node are connected by RIP protocol. In order that each is reachable from others, redistribution is also done in the router. The SRI provider is located for each service domain as in the following table.

4.2 Service domain configuration

Each company's network has two service domains. Their service domain numbers are 1780 and 1781 for network 178.0.0.0/8, 1920 and 1921 for network 192.0.0.0/8, and 2000 and 2001 for network 200.0.0.0/8.

SDP connections are established among the SRI providers in a fully meshed manner.

Table 1: Service resource information provider

Name	Interface IP address	Local SD	Local AS
service_manager_0	178.0.100.2	1780	100
service_manager_1	178.0.101.2	1781	100
service_manager_2	192.0.60.2	1920	300
service_manager_3	192.0.61.2	1921	300
service_manager_4	200.0.60.2	2000	200
service_manager_5	200.0.61.2	2001	200

4.3 Service resource information

In this case study, we considered the two types of the SRI: static and dynamic information. The SRI attributes are service provider's IP address, running application name, CPU power, and CPU load in this scenario.

The static SRI that each service resource information provider maintains is shown in Table 2. Here, the CPU load was fixed at time of the configuration and does not change. The dynamic service resource information was modeled as follows. Except for the CPU load, the other attributes were configured as shown in Table 3.

In this case study, the CPU load for the dynamic SRI is modeled as follows. We considered that the service resource update notification for dynamic resource information occurred according to some stochastic distribution (in numerical results, we considered the Poisson process). In order to determine the CPU load at the epoch of the update notification, we also configured the upper and lower bounds. If the outcome of the uniform distribution was less than the lower bound, the CPU load was low (L). If it was larger than the upper bound, the CPU load was high (H). Otherwise the CPU load was medium (M). If the CPU level changed from the previous level, an update message was created and exchanged among other SRI providers.

Table 2: Static service resource information entry

Server IP address (manager #)	Running application names	CPU power/ load
178.0.120.10(0)	ap_1, ap_2, ap_3, ap_4	H/H
178.0.121.20(0)	ap_4, ap_6	M/M
178.0.102.10(1)	ap_1	L/L
178.0.103.10(1)	ap_2, ap_3	H/M
192.0.110.10(2)	ap_7, ap_8, ap_10	M/H
192.0.111.11(2)	ap_2	H/L
192.0.112.10(2)	ap_3, ap_8, ap_9	H/M
192.0.140.10(3)	ap_1	L/L
192.0.141.20(3)	ap_7, ap_8	H/M
192.0.142.10(3)	ap_3, ap_5	M/H
200.0.90.10(4)	ap_1, ap_4, ap_6, ap_8	H/H
200.0.91.20(4)	ap_4	L/L
200.0.80.10(5)	ap_2, ap_11, ap_12	H/L
200.0.81.10(5)	ap_5, ap_13	L/M

Table 3: Dynamic service resource information entry

Server IP address (manager #)	Running application names	CPU power
178.0.126.1(0)	ap_31, ap_32	M
178.0.127.11(0)	ap_33, ap_35	H
178.0.128.20(0)	ap_34	L
178.0.129.22(0)	ap_36	M
178.0.52.10(1)	ap_41	L
178.0.53.10(1)	ap_42	H
178.0.54.20(1)	ap_43	H
192.0.130.10(2)	ap_57, ap_58, ap_59	M
192.0.131.11(2)	ap_52	H
192.0.132.10(2)	ap_53, ap_58, ap_59	H
192.0.150.10(3)	ap_61	L
192.0.151.20(3)	ap_67, ap_31	H
192.0.152.10(3)	ap_32, ap_35	M
200.0.95.10(4)	ap_41, ap_34, ap_53, ap_58	H
200.0.96.20(4)	ap_61	L
200.0.85.10(5)	ap_57, ap_32, ap_58	H
200.0.86.10(5)	ap_59, ap_43	L

4.4 Exchanging the service resource information

In the simulation experiment, we considered the following scenarios. Here, we set the mean value of the update notification interval is 15 and 30. The lower and upper bound were set to 0.3 and 0.6, respectively.

Here, we focused on the SRI table maintained in service_manager_0. Table 4 shows the part of the SRI in the service_manager_0. We focused on the entries of ap_3. This resource information was statically configured in the SRI provider. Because these entries were statically configured, their CPU load attributes did not change. There were four entries. The service provider is selected among these four entries based on the selection rule.

Next, table 5 shows part of the table at 300, 400 and 800. Here we focused on the entries of application, ap_32. There were three entries for ap_32 in these tables. This application was dynamically registered in the SRI provider, so, the CPU load attribute of these entries varied. If the policy for selecting the service provider was that a lower CPU load and higher CPU power were the best, then at 300, the requester selected 178.0.126.1. At 400, the requester selected 200.0.85.10. And at 800, if the requester's policy gave priority to the CPU power, then 200.0.85.10 was selected. Of course, we can consider the various selection policies.

Let us consider the case where the SRI provider with the service domain 2001 wants to reject access from requesters in outside networks. Then, this service resource provider sends an update message in which the CPU load attribute in server 200.0.85.10 is set to "H". So, the other SRI provider receives the message and set the CPU load attribute to "high". Therefore, the requesters in an outside network can never access server 200.0.85.10. Using this service information discovery mechanism, the manager of the virtual enterprise system can configure the strategic policy to block the access.

Table 4: Service resource information table (We focus on ap_3.)

IP address	CPU power	CPU load	Source protocol	SD path
192.0.112.10	H	M	ESDP	1920
192.0.142.10	M	H	ESDP	1921
178.0.103.10	H	M	ESDP	1781
178.0.120.10	H	H	SDP	-

Table 5: Service resource information table (We focus on ap_32.) At 300

IP address	CPU power	CPU load	Source protocol	SD path
192.0.152.10	M	M	ESDP	1921
200.0.85.10	H	H	ESDP	2001
178.0.126.1	M	L	SDP	-

At 400 seconds

IP address	CPU power	CPU load	Source protocol	SD path
192.0.152.10	M	H	ESDP	1921
200.0.85.10	H	L	ESDP	2001
178.0.126.1	M	H	SDP	-

At 800 seconds

IP address	CPU power	CPU load	Source protocol	SD path
192.0.152.10	M	H	ESDP	1921
200.0.85.10	H	H	ESDP	2001
178.0.126.1	M	M	SDP	-

4.5 Update traffic

Figure 4 shows the sent traffic generated by this protocol from the service_manager_0 in this case study scenario. When we set the mean value of the update notification interval to 15, the generated traffic was larger than that when the mean was 30. When the lower and upper bounds were set to 0.2 and 0.9, that is when the frequency of CPU load status changes was low, the generated traffic was the smallest. The update traffic generated by this SDP protocol depended on the registered SRI, update notification frequency, number of the neighbors, and strategic policy.

5 CONCLUSION

In order to coordinate several applications and share service resources autonomously, a service that provides SRI is important in grid computing and Web service environments. This paper presented a communication protocol for exchanging SRI among wide-area systems and showed its behaviour using a simulation model. This communication protocol is based on BGP. In future, we will expand its attributes and introduce several strategic policies for exchanging SRI. We plan to extend the protocol that exchanges SRI among IP peers in a further study. To reduce the number of SDP sessions, hierarchical architecture and functions are useful for dealing with the scalability issue. In the BGP, the route reflector mechanism reduces the number of iBGP sessions and enables us to make a scalable network. We plan to expand our proposed SRI exchanging protocol, which has the same mechanism as the route reflector in the BGP. The created SRI table is used to determine which server is appropriate for the request. We will develop a simulation model that autonomously simulates the application integration according to the business process. We will develop modeling to evaluate service performance when this protocol is applied to the application orchestration system.

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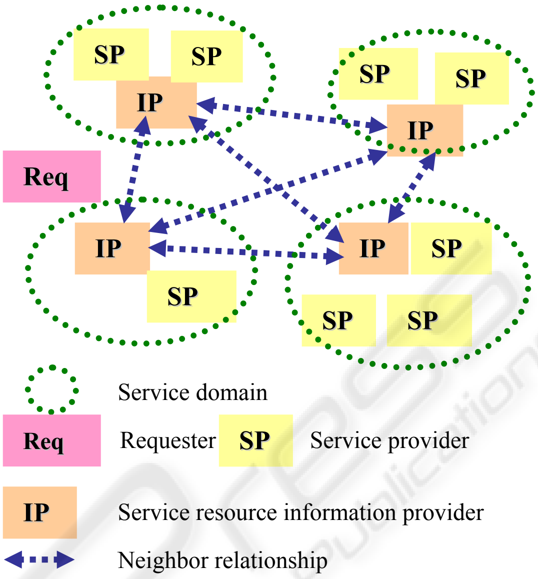
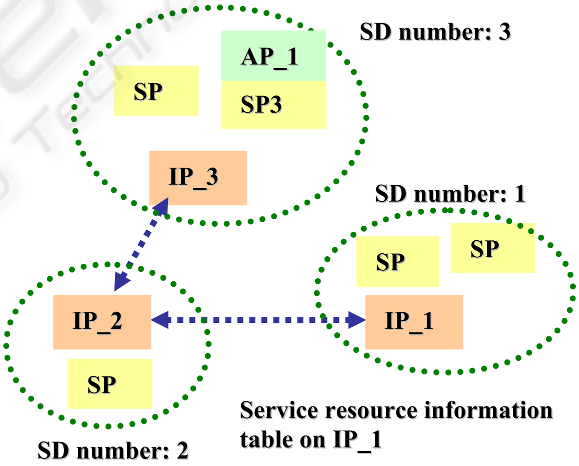


Figure 1: Architecture



Service resource information table on IP_1

AP name	SP name	SD_path
AP_1	SP3	3 2 1

Figure 2: SD_path

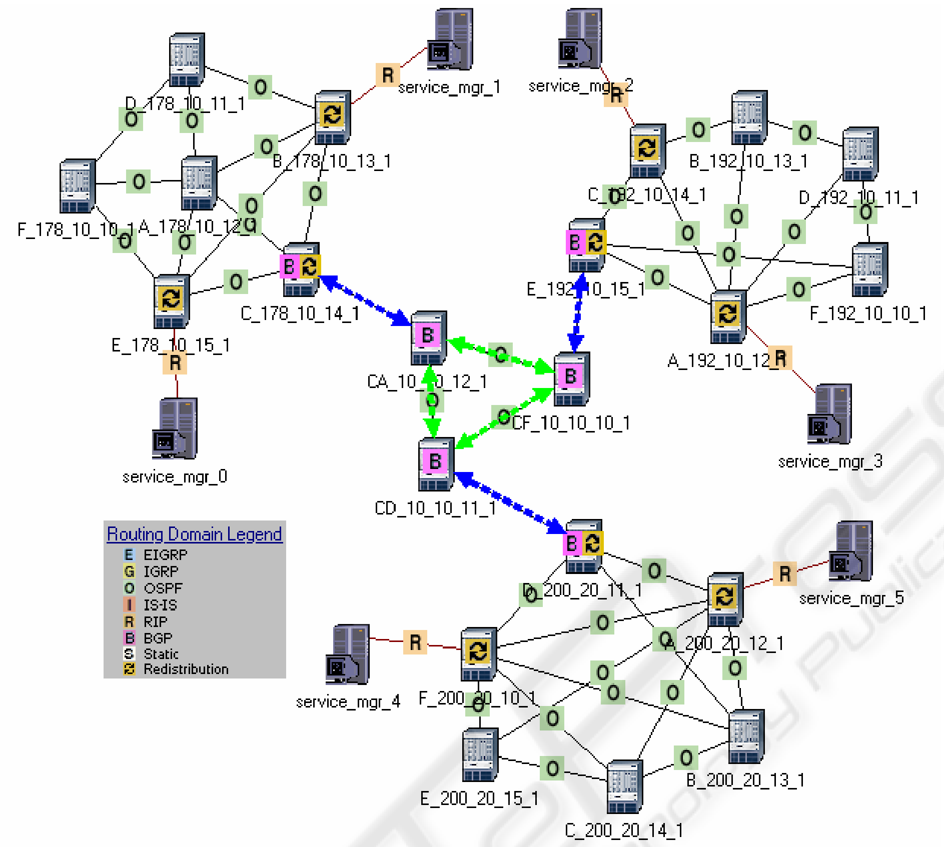


Figure 3: Case study network.

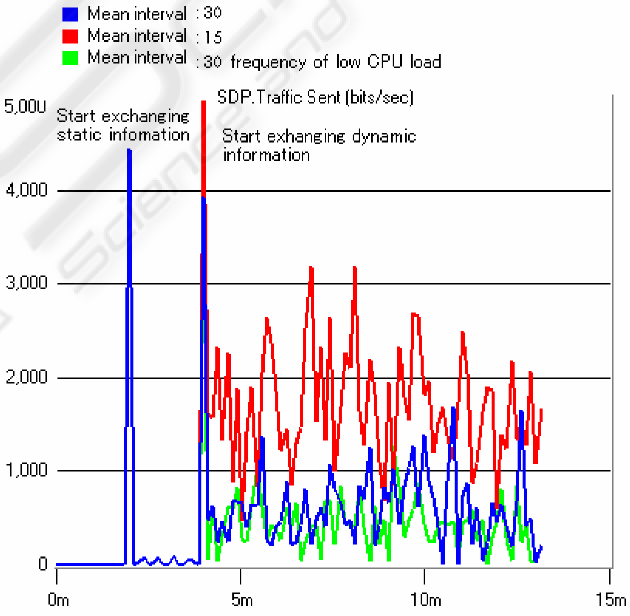


Figure 4: Traffic sent from service_mgr_0.