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Research Article

Web Service Metering

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Abstract: Web services are increasingly being deployed for commercial business applications. An important management component is the Accounting Framework that handles the metering and accounting of service usage. Metering is the function that collects the information regarding the resource usage of a certain service by the consumers. Users can then be charged and billed as per their usage of the service. Traditional rating systems meter the usage of physical resources such as CPU, disk space or network usage such as bandwidth. In web services, unlike the traditional environment, users do not directly consume these physical resources, but instead remotely and indirectly use the service provider resources. This study proposes a metering framework for web services to measure the service usage and record the information using the standard Internet Protocol Detail Record format. The proposed framework has been implemented and tested by extending the RADIUS protocol to measure and record web service usage. The metering framework has been tested using a sample web application with multiple web services.

Keywords: IPDR format, usage data record, web service accounting, web service metering

INTRODUCTION

Rapidly growing network usage creates measurement challenges. Initially, many service providers used a flat-rate monthly billing model to attract a critical mass of online customers. This model was rarely profitable and as usage exploded, customers began to demand varying levels of Internet access and Quality of Service (QoS) in short, requiring Service Providers to differentiate their service offerings. It is now critical for Service Providers to be able to measure exactly how the service is being used. Usage data allows them to right-price differentiated services, improving margins and increasing profitability. In a market with intensifying competition, the ability to generate revenue based on differentiated services is critical to the future business success for Service Providers.

Web services are application components that are accessible over standard and open protocols; (Albreshne *et al*., 2009) Web Service Description Language (WSDL) to describe the web service, Simple Object Access Protocol (SOAP) for exchanging messages, Universal Description Discovery and Integration (UDDI). Web services are published by service providers in UDDI and users discover the services by querying the registry. Users obtain the web service URL from the registry to invoke the web service. Users have to be charged for the usage of the web services as per charging policies defined by the service providers. Metering is the function that collects and records the usage of the web services (Ruiz-Agundez *et al*., 2010). The web services usage information is used for billing purpose (Zhang *et al*., 2005).

An Accounting management framework should provide for metering, charging, accounting, billing, payment and auditing (Zhang *et al*., 2005). In our previous work, we had proposed a generic model; Policy Based Accounting for Web Services (WS-PACT) for the automation of the accounting functions (Muthu Lakshmi and Anand, 2012a). We had proposed a generic charging policy to provide flexibility in specifying the pricing strategies which can be used to calculate the cost of services and resources usage (Muthu Lakshmi and Anand, 2012b). This study focuses on metering which monitors and records the web service usage.

LITERATURE REVIEW

To the best of our knowledge, there have been very few efforts at metering and accounting for Web services. Van Le *et al*. (2004) proposed an accounting model with two types of agents for measuring the usage data; session agent and accounting agent. In the service session user's credit information is available and account agent receives and makes the information

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noticeable to service provider. But the relationships between these agents were not modelled. Albaugh and Madduri (2004) have proposed a utility management infrastructure for atomic web services. Resource usage consumption is monitored at service providers and reported as metering records. The details of sensors used for metering are however, not discussed. Serra da Cruz *et al*. (2003) have presented an approach for monitoring web service usage through web service log architecture, named WSLogA. The study focuses on how data captured by WSLogA can be structured to support decision-making. Details of metering and logging have not been discussed.

Zhang *et al*. (2005) have described an accounting architecture for the process of collecting web service usage information for the purpose of charging and billing. They have discussed the challenges related to web service metering; location of the meter, attributes to be measured and have also given a raw data record format for metering. They have discussed their architecture with a sample application but have not presented the implementation details.

Stamatis *et al*. (2011) have proposed smart metering for timely monitoring of energy consumption and production using internet technologies. They have suggested the use of Advanced Metering Infrastructure (AMI) to measure, collect and analyze energy usage of advanced devices, such as electricity meters, gas meters, water and other utility meters on demand or on predefined schedule. They have implemented utility metering as a web service and have discussed the issues related to metering such as, timing of meter reading, volume of meter readings, storage of data and handling of metering requests.

Papazoglou and Yang (2002) have presented a design methodology for web services and business processes. They have differentiated between service interface for describing business process and service realization which is the implementation of the web services. They have proposed a metering and accounting model for usage-based billing. They have suggested the establishment of contracts between the service providers and users such as Service Level Agreement (SLA) for different payment possibilities such as fee-for-use model, the subscription model and the lease model. Implementation of metering has not been discussed.

In commercial environments, web service providers need to charge their users based on their service usage. Meters are needed even in flat rate services for enforcing policies such as usage quotas. Web service meters have to be deployed to record session time, data downloaded or transferred and usage of other resources. Enabling such metering and accounting components for web services is an important and essential component of web service accounting and management.

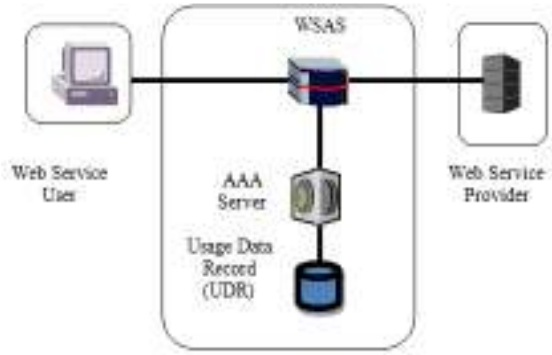

Fig. 1: Block diagram of radius protocol for web service metering and accounting

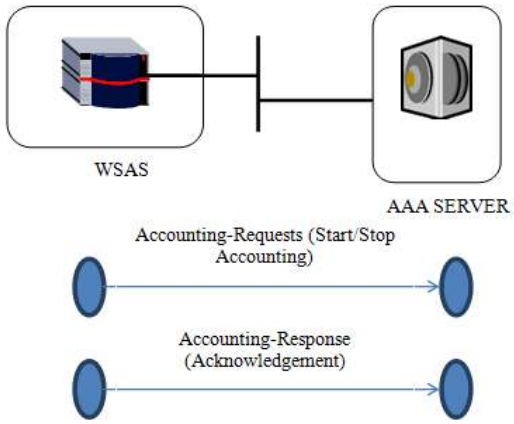

Fig. 2: AAA accounting flow

METHODOLOGY

WS-PACT, our generic model for web service accounting proposes the use of an AAA (Authentication Authorization Accounting) server to maintain the service charging policy and manages the web service usage data records and accounting records. The proposed metering framework is given in Fig. 1.

It is proposed to use a Web Service Access Server (WSAS) to monitor and manage a group of users. Users register with AAA server and also specify the web services they wish to access. The user credentials and web service access details are stored in the AAA server. A payment component would be associated with web service usage and the details would be available in the charging policy. Users request for web services and their usage are monitored by WSAS.

At the start of a session, the user sends the credentials for authentication to WSAS. WSAS creates an authentication request and forwards it to the AAA server. The AAA server verifies the user's credentials, retrieves user's web service authorization details and sends the information to WSAS. WSAS matches the web service usage requests of users with the authorization information to verify if the user has permission to access the web service. Access to the web service is disallowed by WSAS if authorization is not

present. Once the session is established, WSAS forwards accounting start packet to the AAA server as shown in Fig. 2.

The server acknowledges the receipt of the accounting packet. At the end of the session, accounting stop packet is sent to the AAA server. If the network connection were to break in the middle of the service, WSAS terminates the user's session and accounting stop packet is forwarded to the AAA server. All message communication is done using the SOAP protocol. WSAS meters the resource usage time and number of bytes transferred and forwards to the AAA server. The usage data is stored at the AAA server and can be queried by service provider and service clients. The metered data can be used for accounting and audit.

The standard IPDR (Internet Protocol Detail Record) format (Bella *et al*., 2005) is proposed for recording the usage data. IPDR format is defined and supported by a consortium of leading service providers and vendors of network equipment. IPDR organization Network Data Management-Usage (NDM-U) specification defines standardized interface, protocols and record format to facilitate the flow of usage information between IP network elements managers and support systems (Cotton, 2002). NDM-U defines a high-level model comprising of a network and service element layer, mediation layer and business support system layer. The network layer consists of all the network and service elements required to provide an IP-based service to a particular customer. The mediation layer provides the facilities to collect all usage data from various services and pass it to the Business Support Systems (BSS). The BSS layer supports IP business operation, such as billing, customer care, analysis and reporting.

NDM-U 3.1.1 defines schemes for encoding IP usage records known as the IPDR records. Two methods for encoding data XML and XDR are provided in IPDR (Andrew, 2009). XML has the advantage of being human-readable and highly flexible. XDR has been developed to solve the information density issue of XML. It is binary and much more compact and efficient than XML. Conversion between the two formats is easy and straightforward.

This study proposes the use of IPDR for web service usage. IPDR was initially designed for IP-based services to create and promote the adoption of interoperability standards for exchanging service usage and control information between IP network or hosting elements and operations. However, IPDR is a generic format that can be used to represent any type of service used. The structure of IPDR allows one or many usage records which are service specific.

IPDR identifies five typical attributes to describe a particular usage event. They are "who, what, where, when and why" values (Bernd and Ruben, 2002). The XML format for a sample web service UDR is given in Fig. 3.

IPDR document permits an IPDRDoc to contain many IPDR usage records. The IPDR record has been defined to contain information about the user, service provider and metrics. The web service user is identified by user name, the service provider and web service name identify the web service for which usage records is being maintained. The start and end time of the usage event is recorded. Usage measures for data download and upload has been given in MB. It can be seen that other web service usage data can be easily incorporated.

The web service usage is maintained in the UDR database by the AAA server. The metered data can be aggregated and used for accounting and audit purposes.

```
<? xml version="1.0"?>
<IPDRDoc
xmlns="http://www.ipdr.org/namespaces/ipdr"
xmlns:xsi="http://www.w3.org/2000/10/XMLSchema-instance"
xsi:schemaLocation="http://www.ipdr.org/namespaces/e-book.xsd"
docId="g8e0ca84-2222-11b2-85ef-fd66246596bb"
CreationTime="2013-11-11T11:10:00Z"
IPDRRecorderInfo="TEST"
version = "3.1">
<IPDR>
<seqNum>1</seqNum>
<IPDRCreationTime>2013-11-11T11:30:00Z</IPDRCreationTime>
<UserName>XYZ </userLoginName>
<WebService ProviderName >ABC</ WebService ProviderName >
<WebService Name >E-book Download </ WebService Name >
<StartTime> 2013-11-11T11:10:00Z </ StartTime >
<EndTime> 2013-11-11T11:23:00Z </ EndTime >
<Usage measures >
    <Download Size_MB> 14.49</ Download Size_MB >
</ Usage measures >
</IPDR>
</IPDRDoc>
```

Fig. 3: Sample web service UDR

RESULTS AND DISCUSSION

RADIUS (Remote Access Dial in User Services) is a standard protocol that is used for authentication and accounting of telecommunication usage (Rigney *et al*., 2000). RADIUS was standardized by IETF (Internet Engineering Task Force), as an access server authentication and accounting protocol. It is a client/server protocol that runs in the application layer, using UDP as transport. RADIUS protocol has been modified and extended to meter web service usage and store the data in the defined IPDR format.

Free radius-server-2.2.0 is a modular, high performance free suite developed and distributed under GNU GPL which has been modified and extended for implementing metering of web service resource usages. Ubuntu 12.04 LTS server has been used as the operating system. The free radius suite includes radius server, radius client library and an apache module and additional radius related utilities and development. The Radius Server is a daemon that runs radius protocol server.

The successful installation and configuration of radius server was tested using the command $ radtest radius setup RADIUS localhost 1812 testing 123 in debug mode.

The output obtained is given in Fig. 4.

The results show that the request sent by WSAS has been accepted. If the installation is not successful, then the message "Access-Reject" would have been obtained.

A sample web application was used to test the metering of web service usage. LAMP (Linux Apache MySQL PHP) server and MySQL version 5.5.24 were used to store and maintain logs at server. Apache web server 7.0 was used for configuring the web service users. Front end design was done using PHP.

A sample E-Book application written in Java was implemented for on-line reading and facility for e-book download. The application had web services for book

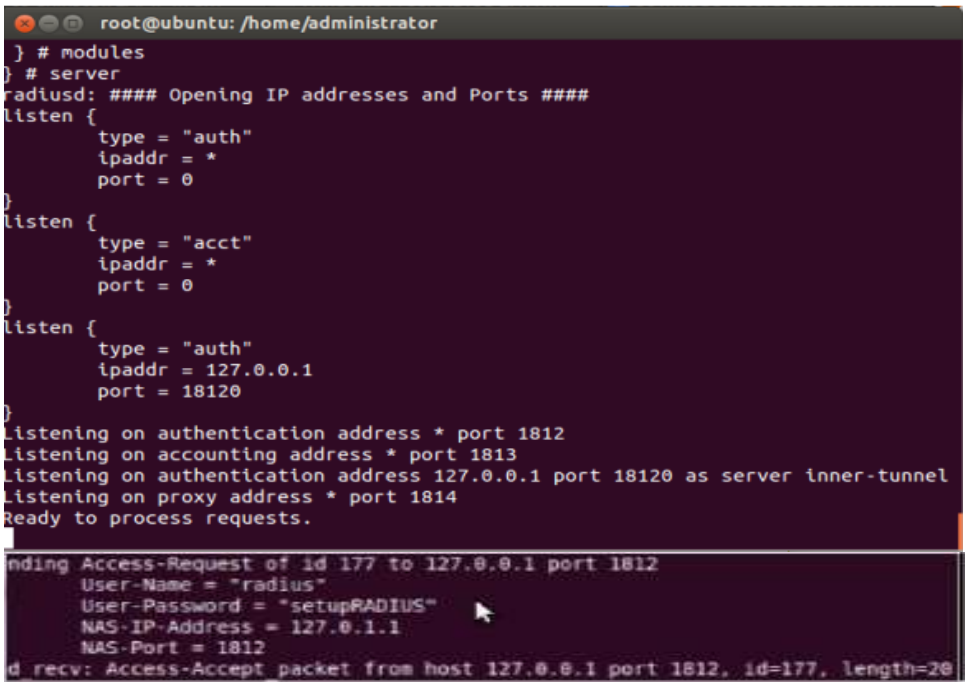

Fig. 4: Radius server configuration

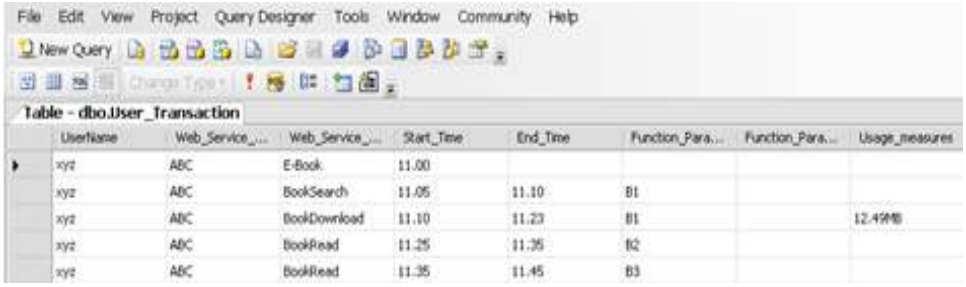

Fig. 5: Usage record log

search; online reading service and book download operations. The service provider of the book service would register with an AAA server for metering of the usage of the E-Book web services. The users of the web services would also have to register with the AAA server, giving details such as name, address, email–id, etc. When the registration is complete, the service requestor becomes a legitimate user of the book service application and the user password would be stored in an encrypted form in the AAA server. When a user requests for a service, they first communicate with WSAS. The user would send the user name and password for authentication to AAA server. AAA server would authenticate the users with the stored user details. Authenticated users are permitted to access the service. All communication to the service provider is also routed via WSAS.

Session time and book download time and data volume in bytes was metered. The web service usage details of users are tracked and updated in the Usage Data Record (UDR) database once a minute (60 sec). This tracking time can be updated as per application requirements. This type of metering is known as request-based or transactional metering, as usage for a user is tracked and updated only during the start and end of request execution (Kumar *et al*., 2008).

A sample screenshot of usage records for a user is shown in Fig. 5.

The first entry indicates the log-in time when the user is authenticated. The data indicate that the user first searched and then downloaded a book. The user then reads a book online. The user can be charged based on the service provider charging policies.

Different pricing schemes such as Pay-per-use, content based, time based and function based may be defined by service providers to charge for web service usage. For the sample web service, for instance, different costs may be attached to each of these functions of search, download and online reading. Additionally, the charges could vary depending on the type of resource accessed. For example, reading charges for book B2 may be different from the reading charges of book B3.

CONCLUSION

The ability to effectively and efficiently charge for the consumption of resources represents an important competitive advantage for any service provider. Hence, usage metering and billing are critical operational support activities for a web service provider.

A metering framework has been proposed for measuring service usage for web services. The standard IPDR format has been used for defining and recording the service usage. RADIUS protocol that is used for authentication and accounting of telecommunication usage has been extended to measure and record web service usage. Web service metering has been implemented and tested for a sample web application scenario.

A complex web services may be created by the composition of one or more simple or atomic web service. This composition would also affect pricing and accounting. As future work, it is planned to extend the protocol to cover metering for such complex web services and to comprehensively cover and test different functionalities of web services.

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