Digital Business Ecosystem

Workpackage 36

Composed Service Accounting Architecture Definition

Deliverable 36.1

State of the Art in Accounting for Composed Services

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Short Description:

The aim of this document is to provide a State of the Art report of standards and technologies relevant to the area of accounting for composed services and to provide a basis upon which the DBE specific accounting solutions will be based. The document is written within the context of DBE and as such addresses mainly open standards and solutions in the service accounting space and the composed service accounting space.

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Executive Summary

The aim of this document is to provide a State of the Art report of standards and technologies relevant to the area of accounting for composed services and to provide a basis upon which the DBE specific accounting solutions will be based. The document is written within the context of DBE and as such addresses mainly open standards and solutions in the service accounting space and the composed service accounting space. The document is divided into 5 sections. The first section gives an introduction to network service accounting and standard architectures which provide solutions. The second section provides a view of standardisation bodies and their involvement in the accounting standardisation process. Section 3 looks specifically at web services and how accounting principles are applied to this space. Section 4 examines the world of service composition and looks at accounting challenges in service composition and how these challenges have been addressed by research. Finally, section 5 concludes by describing the relevance of the research to DBE and which of the standards will be used to implement the open source accounting solution in the DBE project.

In summary, the outcome of the study is that while well established reference architectures and process are in place in the area of service accounting, no satisfactory means of accounting for automatic service composition exists and that further research in this area is required..

1 Introduction to Network Service Accounting

IPDR.org[1] defines Accounting as:

> *The process of collecting and analysing service and resource usage metrics for the purposes of capacity and trend analysis, cost allocation, auditing, and billing, etc. Accounting management requires that resource consumption be measured, rated, assigned, and communicated between appropriate business entities.*

This definition provides both the purpose and requirements of a network service accounting system in a concise and clear manner.

A business view of the network services world consists of buyers and sellers. The buyers are those who use services from the service providers, the sellers. Users (customers) may be related to a service provider via a contract, which might define which services can be utilised and when they may be accessed. The contract also defines how the customer will be charged for service usage. This contract may be of a generic nature whereby the same contract may apply to many customers, or it may be tailored to a customer's specific needs. The customer may be an individual, a group or a corporate customer.

In order to charge the customer for usage it is necessary to monitor and account for that customer's usage. Traditionally charging for telecommunication type services has been simply based on capability (e.g. 56K, T1, T3 etc.) and duration of availability (dial-up, monthly etc.). The customer is charged the same even if not using the full capabilities of what is available. With the convergence of many communication technologies towards IP-based, QoS-driven and usage-sensitive services, together with the rise of web services in the B2B world, these simple charging strategies will not be adequate. What is required are charging systems which are more flexible and can take into account QoS guarantees and volume. These charging systems must also allow for discounting when delivered services do not fully satisfy the terms of the contract between consumer and producer.

A network service accounting system, as seen in Figure 1, typically comprises four separate layers, namely Metering, Billing, Rating and Mediation. These layers are discussed below.

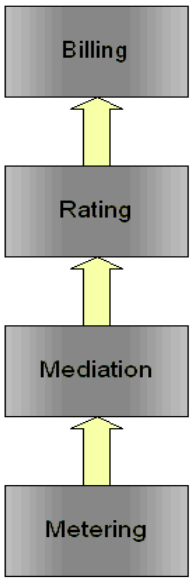


Figure 1: A view of a Network Service Accounting System.

1.1 Metering

The metering layer is the layer closest to the service consumer and has two primary functions:

1. Metering is responsible for recording service usage.
2. Metering is responsible for exposing this collected data to the next layer, Mediation

1.2 Mediation

There are essentially three different aspects to the Mediation layer:

1. Mediation is concerned with the collection of usage data by interfacing with the metering machines. This input will vary according to the Network/Service Element being monitored.
2. Mediation is also responsible for transforming the unprocessed accounting data received from the Service Elements into data which is more suitable to the needs of the *Rating* layer.
3. It is also responsible for distributing this data to the *Rating* layer.

1.3 Rating

This level is also sometimes known as *Charging*. Rating is concerned with calculating a monetary value for each record received from the Mediation level. The Rating can be considered to have the following functions:

1. The Rating layer must receive the records to be charged for from the Mediation layer.
2. Each record received from the *Mediation* layer must be examined to select an appropriate charging regime i.e. determine which service category the record represents. This in turn allows the system to determine how this usage data should be charged.
3. Having determined what service category is being charged the Rating layer must then calculate the charge for the record in question. This is done by first calculating the tariffs by using some of the fields within the record.
4. Using these tariffs, together with other values extracted from the received record, the Rating layer can calculate a charge for the record. These are stored in a data structure called a *Charge Record*. A single Charge Record is produced for each usage record received.
5. The charge records are delivered to the Billing layer. The charge record references the charge amount together with a service type as well as the *charged party*, which indicates which customer is to be charged for the service usage.

1.4 Billing

Billing is concerned with the consolidation of charge records, as well as the additional Subscription Charges (extracted from the customer contract) with the view to creating a periodic billing account per customer in the customer database. Having received charge records from the *Rating* component this data must be stored until the customer contract triggers a periodic billing. The billing system will then consolidate the stored charge records for this customer and also take into account any subscription and/or set-up charges that the customer contract specifies. This consolidation allows for the creation of a bill per customer.

1.5 Peer-to-Peer Service Accounting

So far the descriptions above are concerned with an accounting architecture which applies to client-server infrastructures. In the P2P world (such as DBE), there is no central accounting authority as there is in the traditional telecommunications accounting architecture. A well established accounting architecture does not yet exist in the P2P world. However, there is an amount of research in this area being carried out. This research has been largely focussed on a market paradigm as a means of trading services as opposed to defining architectures to process charging and billing for individual service usage. Some examples of research in this area are described briefly below.

MMAPPS

The IST MMAPPS (Market Management of Peer to Peer Services) project [2] is looking at how services can be traded in P2P applications. The project views the provision and consumption of services in P2P environments as a marketplace and is enhancing schemes, such as micro-payments, with more innovative, non payment-based accounting schemes such as ratings, where individual members of a particular community receive a rating score based upon their contribution. This rating then affects how other members provide services to that individual.

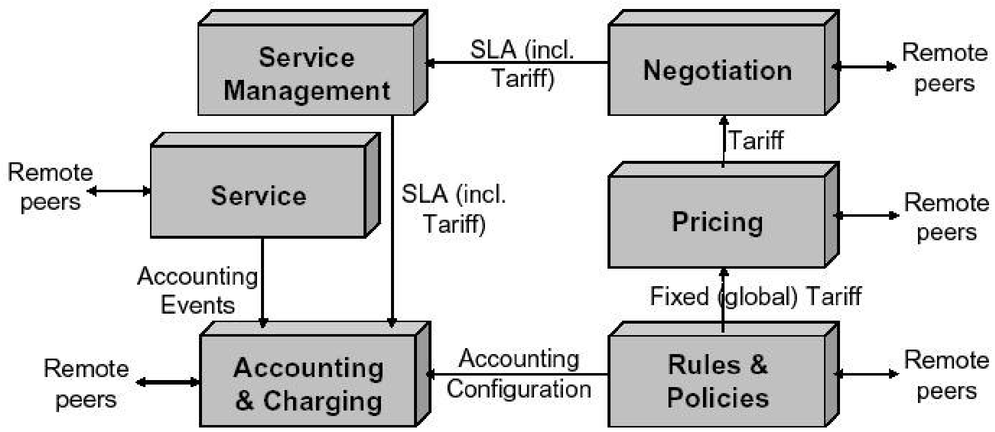


Figure 2: The Accounting and Charging module with associated modules in MMAPPS

During the service preparation phase, the pricing module selects the tariff which will be used to account for usage of a particular service. As the tariff has to know the characteristics of the service to account for, it is developed in advance closely together with the service. The corresponding tariff parameters, however, are usually set dynamically and can be different on every peer. Optionally, fixed application-wide tariff parameters can be used which need to be specified by the Rules & Policies module.[3]

MMAPPS have also adopted a token-based approach to provide accounting and distributed pricing facilities to P2P service provision. With this approach, tokens are traded for service usage. A file-sharing scenario is discussed in [4]. The project has defined an abstract architecture [5] satisfying this token based approach which can be seen in the diagram below.

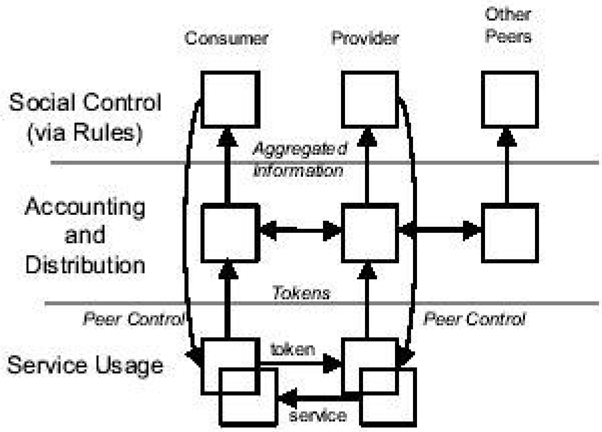


Figure 3: MMAPPS Token-based Peer-to-Peer Economics Architecture

JXTA

Project JXTA[6] started as a research project incubated at Sun Microsystems to address the peer-to-peer space. JXTA technology is a set of open, generalised peer-to-peer protocols that allow any connected devices on the network to communicate and collaborate. JXTA peers create a virtual network where any peer can interact with other peers and resources directly even when some of the peers and resources are behind firewalls and NATs or are on different network transports.

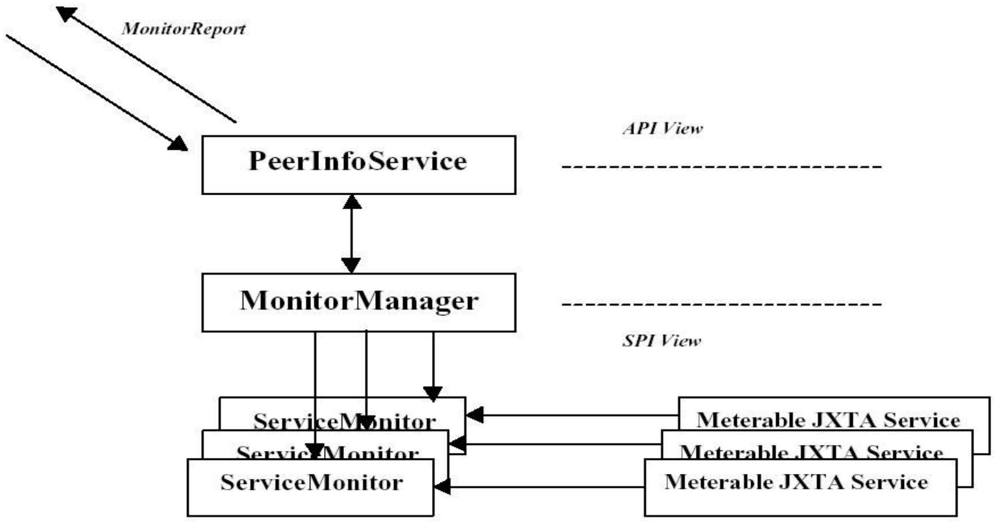
JXTA Compute Power Market Project

The Compute Power Market (CPM)[7] Project uses an economic theory approach in managing computational resource consumption and provision in peer-to-peer computing. It allows application users to access computing power with ease and simplicity. It also allows consumers to choose computing power/resource providers that offer cost-effective services on demand. The project is concerned with creating a competitive market approach to service oriented P2P computing. A position paper explaining the project is available[8]

JXTA Metering and Monitoring Project

The primary goal of the JXTA Metering and Monitoring project[9] is to provide a dynamic and extendible framework for gathering and reporting metrics about JXTA services running within PeerGroups. The types of metrics maintained for a service will be defined on a per service implementation with an XML representation of each type of metric. In addition to providing an API for obtaining metrics from PeerGroups running locally, the optional JXTA Peer Information Protocol (PIP)[10] is a specified means for obtaining these metrics from remote peers.

Figure 4: JXTA MMP Architecture



The MonitorManager choreographs all cumulative and asynchronous reporting of metered data. It provides a SPI (Service Provider Interface) view to the underlying Services via ServiceMonitors. The MonitorManager interacts with all registered ServiceMonitors delegating appropriate information and requests to the service-specific ServiceMonitors which will internally optimize and collect their own data.

JXTA-Monitor

JXTA-Monitor[11] is a monitoring tool that captures messages between JXTA Peers. While the project seems to focus on these messages as a means of debugging JXTA applications, it is a simple step to adapt this as a means of metering JXTA services for accounting purposes. The architecture is shown below and takes the approach of inserting the monitor as an intermediary between the peers exchanging messages by implementing it as a JXTA RendezvousPeer in the netPeerGroup. The project has provide a GUI implementation of this monitor, primarily used for debugging. The JXTA applications themselves do not have to be modified in order for the monitor to extract the messaging data.

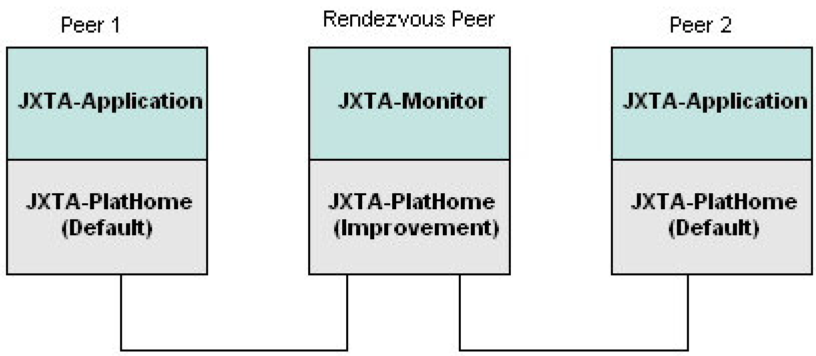


Figure 5: JXTA-Monitor Architecture

2 Standardisation Bodies

There has been much work done in the area of standardising the network service accounting process. Most of the standardisation efforts have concentrated at the business layers of the process, namely mediation, billing and inter-OSS (Operation Support System) communications. There is little evidence of standardisation of generic service usage data at the metering level. Below is a description of the most prominent standardisation bodies in the field and a description of their input to the standardisation efforts.

2.1 IETF's AAA

The IETF's[12] AAA[13] (Authentication Authorisation and Accounting) Working Group focuses on the development of requirements for Authentication, Authorisation and Accounting as applied to network access. This Working Group is focused on the development of an IETF Standards track protocol, based on the DIAMETER[14] submission.

RFC 2975 [15] defines the system in IP-based networking to control what computer resources users have access to and to keep track of the activity of users over a network.

- Authentication is the security service of identifying the individual user of a particular service, usually based on a username and password. Authentication is based on the idea that each individual user will have unique information that sets him or her apart from other users.
- Authorisation is the process of granting or denying access to network and services resources once the user has been authenticated. The amount of resources the user has access to depend on the user's contract agreement with the provider (network or service).
- Accounting is the process of keeping track of a user's activity while accessing the network resources, including the amount of time spent in the network, the services accessed while there and the amount of data transferred during the session. Accounting data is used for trend analysis, capacity planning, billing, auditing and cost allocation. It requires that resource consumption be measured, mediated, rated, and communicated between appropriate parties.

2.2 ITU-T

The International Telecommunications Union Telecommunication Standardisation Sector (ITU-T) [16] is one of the three sectors of the ITU[17] working on the production of high quality standards covering all fields of telecommunications. ITU-T provides standards (known as Recommendations) to the telecommunications industry. These standards are non-binding but are in wide use as they provide guarantees of inter-connectivity and inter-operability of the global telecommunications infrastructure.

The ITU-T consists of 13 study groups. Tariff and accounting activities are mainly investigated in Study Group 3. It develops charging and accounting/settlement mechanisms for network capabilities and services features made available by new technologies such as IP based networks.

The ITU-T is responsible for Recommendation Q.825 [18], which specifies how CDRs (Call Detail Records) are produced and managed in a telecommunications network environment. Each call produces one or more records describing events that occurred during the life of a call. Data may be

produced in real time (single CDRs), near real-time (blocks of CDRs), or as batch files of CDRs.

2.3 TeleManagement Forum

TeleManagement Forum (TMF)[19] is a non-profit organisation comprising 340 global industry leaders in the operation and management of communication services. The purpose of the organisation is to provide leadership, strategic guidance and practical solutions in this sector and to this end oversees several technical programs. One of these programs is the NGOSS[20] (Next Generation Operation Support Systems) which provides an industry-agreed business solution framework for next generation OSS. NGOSS provides business process automation through its enhance Telecom Operation Map (eTOM) [21] which is the most widely used and accepted standard for business process in the telecommunications industry. The eTOM can be seen below in Figure 2.

Recently the ITU-T have ratified the eTOM as an official ITU-T standard. This moves the eTOM to formal adoption with the publication of the ITU's M.3050[22] Recommendation.

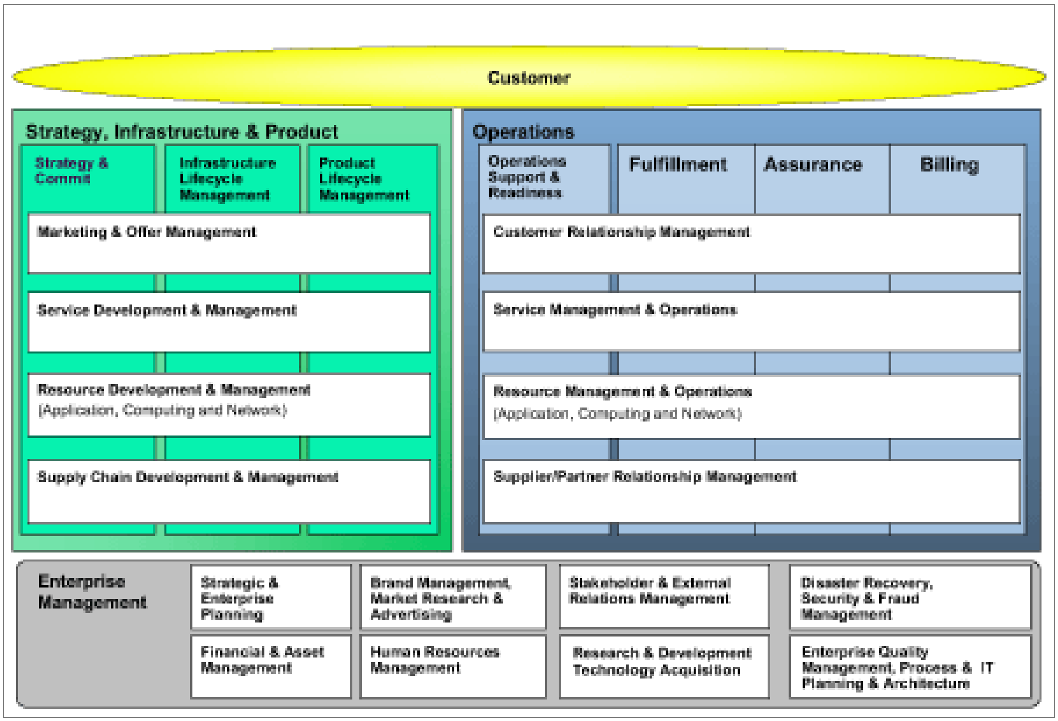


Figure 6: TM Forum's enhanced Telecom Operation Map

2.4 IPDR.org

The Internet Protocol Detail Record (IPDR) organisation's [1] Network Data Management – Usage (NDM-U) specification [23] defines standardised interfaces, protocols and record format to facilitate the flow of usage information between from IP network elements managers to support systems. This specification has been evolving since 1999 and is currently at Version 3.1.1.

IPDR.org has adopted the TMF eTOM [21] model as a driver in defining the roles and interfaces of its specifications relative to operation support systems. This is due to the wide acceptance of the eTOM as the de facto model of business process in the telecommunications industry.

IPDR.org is probably the most significant current standardisation body in terms of balancing the business needs of service providers with the technical requirements of the accounting management infrastructures.

2.4.1 High-Level NDM-U Model

The NDM-U defines a high-level layered model including: a network and service element layer, mediation layer and business support systems layer. This is shown below in Figure 3 and is based on the familiar service accounting model adopted from the telecommunications industry.

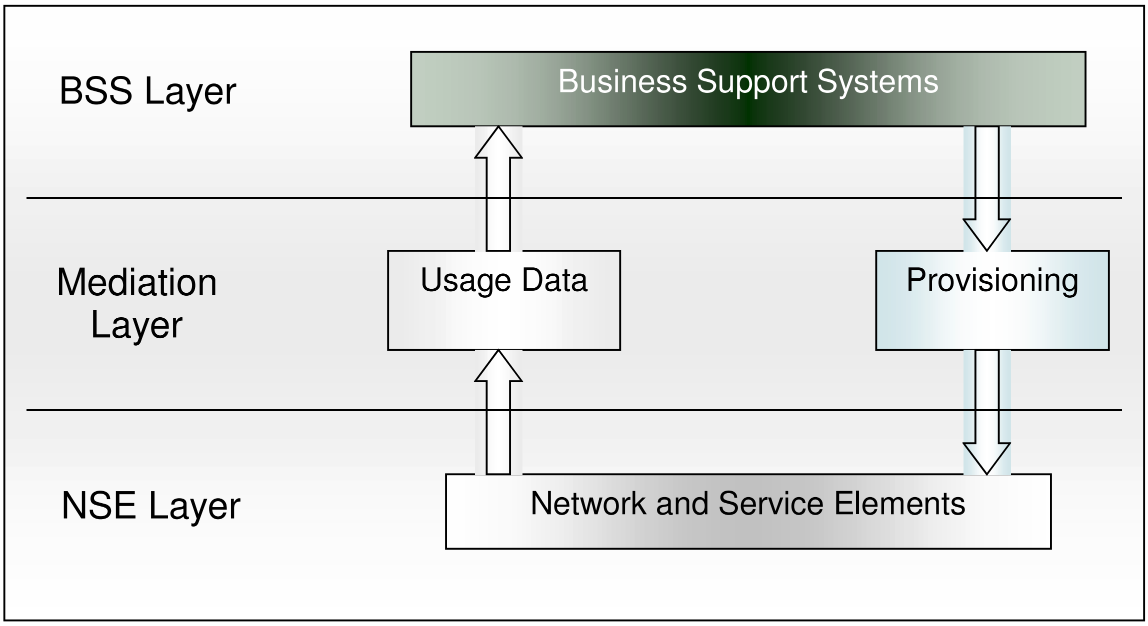


Figure 7: High-Level NDM-U Model

The NSE (Network and Service Elements) layer consists of all the network and service elements required to provide an IP-based service to a particular customer.

The mediation layer sits between the network infrastructure and the business support systems. It provides the facilities to collect all usage data from various services and pass it to the business support systems (BSS).

The BSS layer consists of the customer facing services deployed by a service provider to support IP business operation. Some examples include billing, customer care, analysis and reporting.

IPDR.org NDM-U plays 3 primary roles in the transfer of the usage data as shown in the high level model.

1. A flexible IPDR record format that is powerful enough to satisfy the needs of the mediation and BSS subsystems.
2. A set of well-defined interfaces facilitating the transfer of IPDR records through the layers and to enable IPDR compliant components to be easily inter-changed.

3. A common format allowing IPDR records to be stored and retrieved by any IPDR compliant component.

2.4.2 NDM-U Reference Model

IPDR.org provide a general reference model which defines the actors and interfaces involved in the exchange of this data. This is shown in the NDM-U reference model diagram.

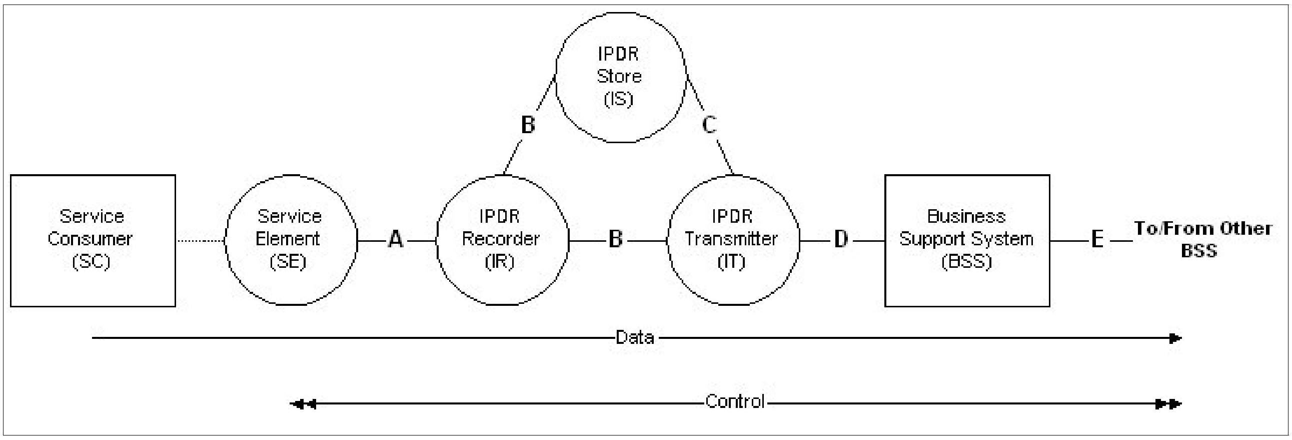


Figure 8: IPDR NDM-U Reference Model

Metering is performed at the Service Element while the Mediation layer is represented by the IPDR Recorder, IPDR Store and IPDR Transmitter component set. The Rating and Billing requirements are satisfied by the BSS components.

The nodes are defined as follows:

Service Consumer:

This is the human or machine initiating requests for services from the Service Element (SE). The Service Consumer requesting and receiving service is typically the end user or end system. Note that an SC may request services from an SE via another SE that is providing access to the Internet, thus involving more than one SE in the provision of a given service.

Service Element:

This is the set of equipment and software that provides a valuable service to a Service Consumer. The Service Element provides access to services and a requested resource, authenticates Service Consumers, authorises access, performs accounting measurement for resources provided, provides services requested by Service Consumer, and performs accounting measurement for services provided.

IPDR Recorder:

IPDR Recorder packages usage information into IPDRs, it presents a stream of IPDRs to an IPDR Store and/or an IPDR Transmitter. Multiple Service Elements can be connected to a single IPDR Recorder.

IPDR Store:

This is the entity that provides persistence to the IPDRs recorded by an IPDR Recorder. The IPDR Store receives IPDRs from an IPDR Recorder and packages them into IPDR documents (IPDRDocs) which are then stored in a non-volatile medium. The IS, also, provides a repository of IPDRDocs for transmission or retransmission of selected IPDRDocs by the IPDR Transmitter to one or more Business Support Systems. An IPDR Store can receive IPDRs from one or more IPDR Recorders and the IS can deliver IPDRDocs to one or more IPDR Transmitters.

IPDR Transmitter:

The IPDR Transmitter delivers IPDR documents to Business Support Systems. These documents may be retrieved from an IPDR Store, or they may be created directly by the IT. This entity performs three principal functions: 1) Packaging of IPDRs from the IPDR Recorder into IPDRDocs; 2) Organisation of IPDRDocs containing usage of the same service type into Groups; and 3) Transmission (or retransmission) of IPDRDocs from Groups to one or more Business Support Systems, using one of a set of transfer protocols. An IPDR Transmitter can deliver IPDRDocs to one or more Business Support Systems.

Business Support System:

This entity is any system that implements a technical or commercial function to perform one or more processes in a telecommunications enterprise. A Business Support System receives IPDRDocs from an IPDR Transmitter, processes the information in the contained IPDRs for use in the commercial activities of a Service Provider, and presents information for transmittal to other Business Support Systems. A Business Support System can receive IPDRDocs from one or more IPDR Transmitters.

The interfaces are defined as follows:

It should be noted that the IPDR NDM-U specification is focussed on the definition of the IPDR Documents, the information content of these documents and the interfaces between the IPDR Transmitter and the BSS. The D interface is fully specified but the other interfaces are identified as an aid to understanding the infrastructural and business issues involved.

A Interface:

Apart from recognising the fact that Service Element and IPDR Recorder communicate across this interface, IPDR does not address details of the A interface. This is largely a proprietary interface being vendor specific in format. In addition to being equipment-level in detail, data transferred on the A interface is often incomplete for business purposes. For example, interim usage details are common. Interim usage details are describing a service delivery event that cannot be correctly interpreted without context provided by other data. For example, “Start Call” and “Stop Call” entries must be correlated to each other in order to determine call length. Other examples of interim entries might be: Start Application, Service Query, Connect additional line to conference, Drop line from conference, Convert text message to voice, etc.

B Interface:

This interface is

The B interface delivers IPDRs from IPDR Recorders to IPDR Stores and to IPDR Transmitters. The payload conforms to the schema definition of an IPDR. The transfer protocol is not currently defined.

C Interface:

The C interface delivers of IPDR documents from the IPDR Store to the IPDR Transmitter. Each IPDRDoc contains one or more IPDRs from a particular Service Element served by a given IPDR Recorder. The transfer protocol is not currently defined.

D Interface:

The D interface delivers IPDR documents from IPDR Transmitters to Business Support Systems. The transfer protocol for this interface is defined by the NDM-U specification.

E Interface:

The E interface is responsible for delivering IPDR documents from one BSS to another. The transfer protocol is not defined by the NDM-U specification.

2.4.3 IPDRDoc

IPDR.org defines a master IPDR Document XML schema which contains elements that are common to all IP-based services. This forms the basis of the data structures defining the data passed around an IPDR compliant accounting management system. Service specific schemas extend from this master schema in order to provide the usage attributes which describe usage events for a particular service type.

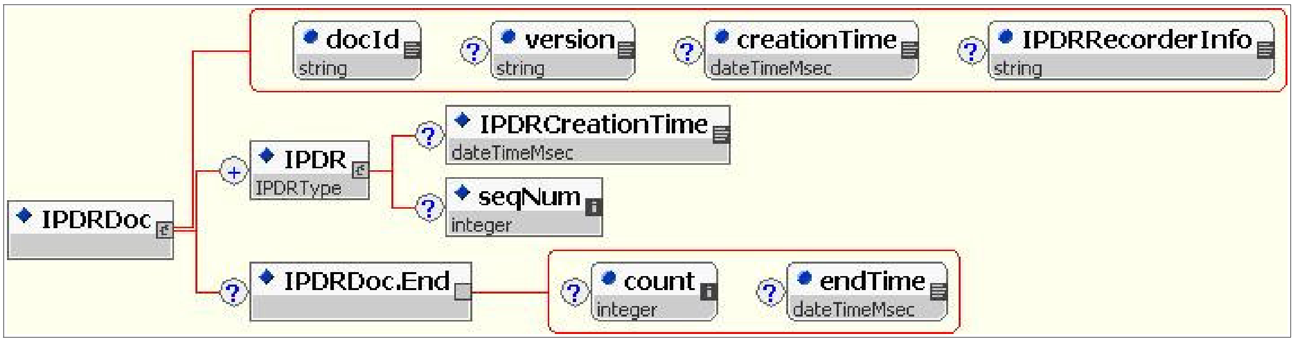


Figure 9: Graphical View of the version 3.1 IPDRDoc schema

Within the data structure, an IPDRDoc can contain one or more usage records (IPDRs). Details of the service usage are contained within each IPDR. Since version 3.0 of the IPDRDoc schema, no service usage child elements of the IPDR element are defined in the master schema. These service usage child elements are now defined by the service specific schema definitions, where the IPDR element is extended. Service specifications written in accordance with NDM-U 2.0, 2.5, and 2.6 are backward compatible but are not forward compatible. 3.x Service specifications are not backward compatible [24].

Currently IPDR.org has defined the following 3.x service specific specifications:

- Public WLAN Access
- Streaming Media

- Voice over IP
- E-Mail
- DOCSYS™ 1.1 Service Flow Metering
- Wholesale

The following are only available in accordance with the 2.5 specifications:

- Access and Authorisation
- Application Service Provision
- Internet Access
- Video on Demand

2.4.3.1 IPDR Element:

The IPDR element of the IPDRDoc schema is where service specific schemas apply their extensions to the base schema. The IPDR element is intended to provided information about the 5 W's of the service usage. In this regard it is intended to give a complete set of business details required to account for the service usage. See table 1:

W Component	*Refers to*
Who	*Who is responsible for the service usage that this record refers to?* *e.g. UserID*
When	*At what time was the creation of this record triggered?* *e.g. EventTime*
What	*What is the service?* *What are the units of measurement?* *What are the quantitative values?*
Where	*What Service or Network Element triggered this record?* *What is the Source Identifier? What is the Destination Identifier?*
Why	*Why is the Service or Network Element reporting this data?*

Table 1: The Five Components of the IPDR

2.5 W3C and OASIS

The World Wide Web Consortium (W3C) [25] and the Organisation for the Advancement of Structured Information Systems(OASIS) [26] are developing interoperable technologies capable of

leading communication and commerce on the Web. While W3C has taken the leadership of any technical evolution on the Web taking advantage of the convergence between computers, telecommunications and multimedia technologies, OASIS' focus is on driving the development, convergence and adoption of e-business standards for industries.

W3C comprises several activities that are organised into five distinct domains:

1. Architecture domain: develops the framework of the web.
2. Document formats domain: defines formats and language that will present information to the user accurately.
3. Interaction domain: works towards improvements in human-computer interaction.
4. Technology and Society domain: develops the infrastructure to address legal, social and policy concerns.
5. Web Accessibility Initiative: pursuing accessibility of the Web through research and development, and production of guidelines.

The W3C is responsible for the emergence of the eXtensible Markup Language [27] and Web Services [28] that now serves as a basis for most of the standards for information exchange.

Industry members of OASIS form technical committees in the following areas:

- *Horizontal and e-business framework*
- *Web Services*
- *Security*
- *Public Sector*
- *Vertical industry applications*

The Business Transaction Technical Committee's [29] purpose is to develop technology for business transactions on the Internet.

2.6 OSS through Java Initiative

The introduction of Next Generation networks and the services they will provide highlight the lack of interoperable Operation Support Systems (OSS) and Business Support Systems (BSS) required to sustain their function. The current OSS market is fraught with proprietary systems that present costly resources to maintain and update when new network and service types are introduced. The OSS through Java Initiative [30] attempts to inject a unified component based approach to OSS and BSS implementation using a common set of Java APIs that capture the essential functional domains of modern support platforms. Much work has already been accomplished by standards bodies and industrial fora in capturing requirements, business processes and architectural specifications for modern OSS and BSS systems. Drawing on the knowledge and experience of groups such as the 3^{rd} Generation Partnership Project (3GPP), 3GPP2, Mobile Wireless Internet Forum (MWIF), TeleManagement Forum (TMF), Internet Engineering Task Force (IETF), and Internet Protocol Detail Record organisation (IPDR) the Initiative will produce a set of Java class hierarchies (and source code) representing particular functional areas of an OSS. The OSS Solutions are based on Java 2 Enterprise Edition technology (J2EE^{TM}). Currently APIs for six functional areas are being specified through the Java Community Process [31]. They are Service Activation, Quality of

Service, Trouble Ticket, Billing, Inventory and Service Quality Management.

The TMF [19] have issued a white paper which discusses the complementary nature of OSS/J to NGOSS [32].

2.7 3GPP

The 3rd Generation Partnership Project (3GPP) [33] is a collaboration agreement between a number of telecommunications standards bodies referred to as "Organisational Partners". The current Organisational Partners are ARIB, CCSA, ETSI, T1, TTA, and TTC. The goal of the partnership is to produce Technical Specifications for a 3rd Generation Mobile System based on the evolved GSM core networks and the radio access technologies that the Organisational Partners support. The current work of the Architecture and Telecom Management sub-groups of the Services and Systems Aspects group within the 3GPP has produced a number of standards with relevance to charging and billing within an IP based service domain.

The 3GPP has also joined effort with ETSI [34] and the Parlay organisation's [35] Content-based Charging Working Group to deliver the Open Service Access (OSA) APIs specifications, which include accounting and charging management [36]. These standards provide an important reference base for all accounting related matters such as record format and charging.

2.8 Parlay Group

The Parlay Group[37] is an open multi-vendor consortium formed to develop open technology-independent application programming interfaces (APIs) enabling: technology, Internet and eBusiness companies, independent software vendors (ISVs), software developers, network device vendors and providers, service bureaus, application service providers (ASPs), application suppliers, and large and small enterprises to develop applications and technology solutions that operate across multiple networking platform environments.

Of particular interest in terms of accounting is Parlay's Content-Based Charging Working Group [38] which was formed in order to define a charging API that fits different application types. The group operates within the Joint Working Group (JWG)[39], as provided for by the European Telecommunications Standards Institute (ETSI)[34]/Parlay cooperation agreement. One of the objectives of the Content Based Charging Working Group is to *"allow third-party application providers to take advantage of the large subscriber base and well-established business relationship between network operators and their subscribers and from existing billing infrastructure"*. The goals are threefold:

1. *Employ the charging, rating, and billing capabilities of telecommunications networks to charge subscribers for all kind of applications.*
2. *Enable independent software vendors (ISVs) and application service providers (ASPs) to create applications that support accounting and charging.*
3. *Allow ASPs to charge subscribers for the services and applications they provide in a simple, affordable way that helps mask payment policy (prepaid/postpaid) from application providers, mask payment type (credit card, cash, bank withdrawal) from application providers, and avoids the need to establish and maintain own subscriber database and billing processing facilities for application providers.*

3 Web Services and Accounting

This section will look at accounting in the area of web services. The section will initially provide an introduction to web services, then look at how accounting for these services can be achieved through the use of open standards and open source technologies.

3.1 Introduction to Web Services

A basic description of a web service is simply an interface to a software service using the World Wide Web as the communications infrastructure. Typically this interaction occurs by an application sending a SOAP [40] request over HTTP[41], although web services are not restricted to these protocols. Web services are generally described using WSDL (Web Service Description Language) [42]. When the service has received the request it performs some processing to satisfy that request and returns a response.

The proliferation of these types of service in recent years has lead to web services being perceived as a simple, flexible and effective means of conducting business over both public and private IP networks.

The architectural concept upon which Web services are based[43] is that of Service Oriented Architectures(SOA). These architectures are popular enterprise models as they facilitate business processes. A service oriented architecture consists of three components, the service provider, the service broker and the service consumer. The provider publishes his service with the broker which provides facilities for a service requester to find published services. The requester then binds to the discovered service via the service provider and makes use of the service. The diagram below shows these web service components and how they interact.

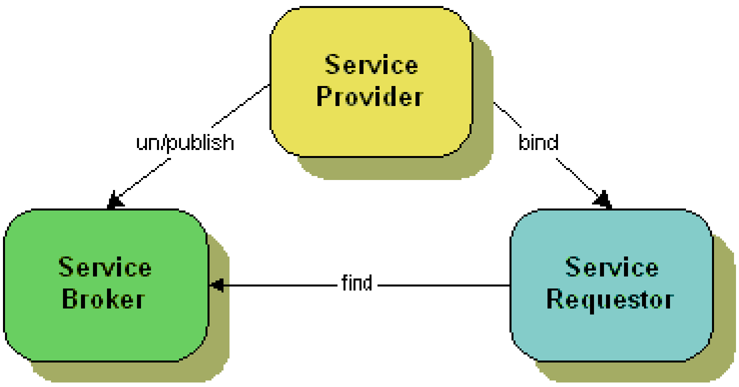


Figure 10: Web Service Components

3.2 Accounting for Web Service Usage

Similar metering, charging and billing solutions that apply to the traditional telecommunications services also apply to service charging. This section shows how each of the layers of this model apply and are being adopted in the web services arena. The fundamental difference in the application of this model to web services model is at the service metering level.

The rest of this section will examine each of the accounting levels in relation to web service

accounting, particularly those providing open standard solutions.

3.2.1 Metering

As already stated, the purpose of metering is to measure the service usage. With traditional telecommunications type services, this usage metering is largely concerned with information such as duration of call, the endpoints of the call and other network level parameters. However, with web services usage metering is often more concerned with the extraction of messaging data related to an appropriate charging scheme, which can potentially be specific to an individual service instance. In the web services domain, this is normally achieved through the application of handlers which "listen" to the messages being passed between the consumer and the service. Information such as operation names, parameter types and values as well other service specific properties can be extracted from the message context and the SOAP message. One such example is in Apache's Axis [44] framework, where all messages passing through the axis engine have an associated message context which can be interpreted by a customised handler. A metering handler acts as an interceptor of service requests and responses, extracting suitable logging information and exporting this metered data to a metering service. After the handler is finished extracting logging information, the engine passes the message to the next handler in the chain.

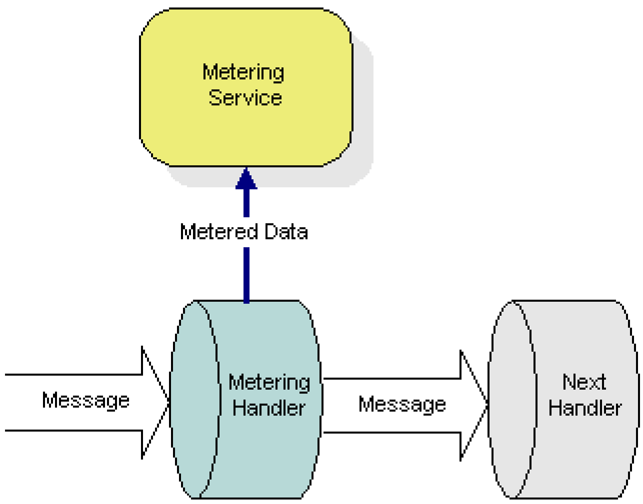


Figure 11: Web Service Metering Reference Model

Axis Handlers

The Axis approach provides three layers at which message handlers can exist, namely transport, global and service. At each of these layers the Axis engine is responsible for the discovery and execution of these handlers at that layer. All handlers implement an `invoke(MessageContext ctx)` method where the handler implements logic for its specific role in the chain (a set of handlers).

On the server side of the message path, a *TransportListener* converts the protocol specific message (e.g. a SOAP message) into a *MessageContext* object , adding any extra properties and passes this *MessageContext* to the Axis engine who orchestrates how this object is passed to the installed request handlers onto the service itself and back out through the layers via the installed handlers. Request messages go respectively through the transport layer first, then the global layer and finally

the service layer. Response messages are passed through the layers in the opposite order, service, then global and finally transport. A metering handler would be installed at either a global level to measure activity across all service requests or at the service level to meter on a service specific basis.

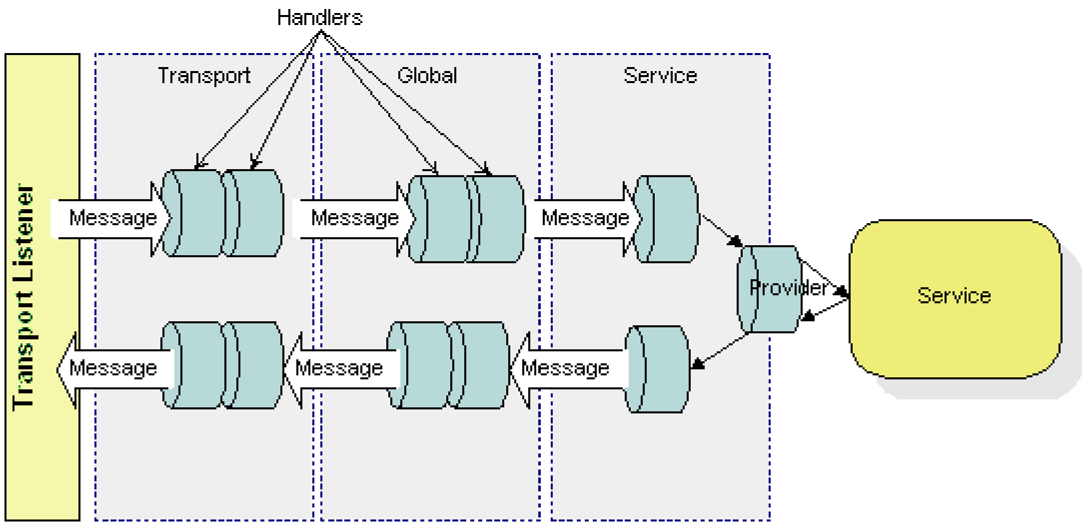


Figure 12: Axis Engine Server Side Message Path

On the client side, the Transport Sender handler is responsible for creating the SOAP message and performing the necessary operations to deliver the SOAP request and retrieve the response to and from the destination SOAP server. On the client side the request messages go first through the service layer, then through the global layer and finally through the transport layer. Response messages go first through the transport, global and service layers respectively.

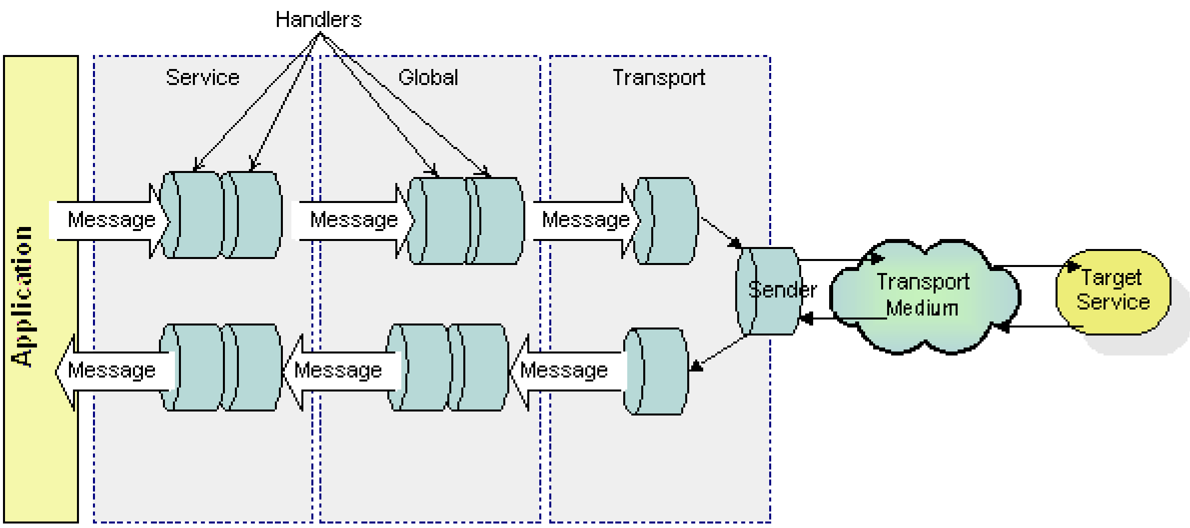


Figure 13: Axis Engine Client Side Message Path

3.2.2 Mediation

As previously stated the roles of mediation are to retrieve the raw usage data provided by the metering service, transfer this data to a format more useful for upper level business driven processes. The mediation also packages this service usage data into related divisions.

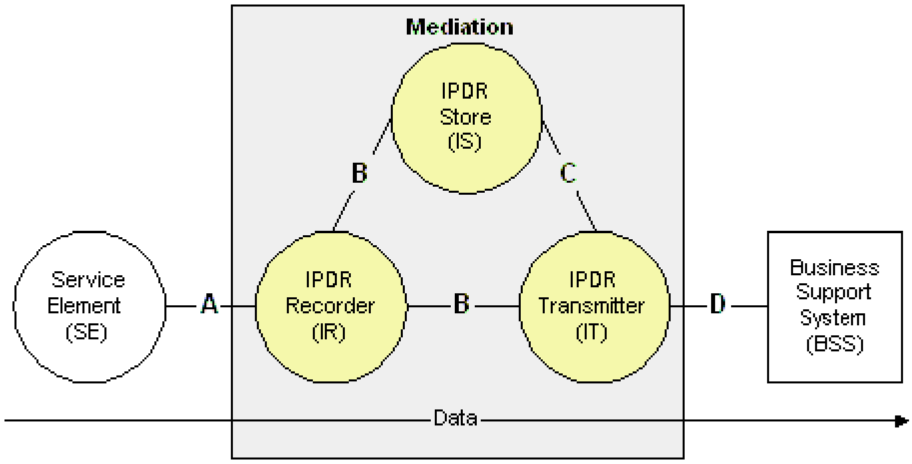


Figure 14: Mediation and the NDM-U Reference Model

IPDR NDM-U

In the case of the specific system being IPDR.org NDM-U [23] compliant, mediation would be responsible for the following roles:

1. *Retrieving the metered data. This is provided by the IPDRRecorder component performs across the A interface and converts this data into IPDRs.*
2. *Packaging the IPDRs into IPDRDoc elements. This is achieved by both the IPDRTransmitter and also by the IPDRStore.*
3. *Persisting this data achieved by IPDRStore component.*
4. *Packaging related IPDRDocs together and transmitting these packages to appropriate BSS.*

In the case of billing, the BSS would provide rating and billing services

This mediated data is also useful for processes other than charging and billing, such as resource planning, statistical analysis, anomaly detection and other data driven processes. Other BSS systems would be deployed for utilising this data for such purposes.

3.2.3 Charging

The relationship between the customer the provider and the service is defined via a contract (in the telecommunications world this contract is know as an SLA(Service Level Agreement). This contract specifies the legally binding aspects of the customer/provider relationship and normally contains details on service availability guarantees, charging mechanisms, discount agreements, payment

agreements etc. It is the application of the contractual agreement to the mediated usage data which a rating engine use to determine the cost of a service usage.

The model below demonstrates how this interaction occurs at the rating level of the accounting reference architecture. In the model the rating engine receives mediated data from the mediation service. Upon examination of the service usage the rating service queries the CRM system for details of the customer contract that applies to this particular service usage. The contract determines how the usage is to charged for. For example the contract will provide a charging algorithm that enables the charging service to apply a specific charge to a specific service usage. The contract might also specify that in the case of a contract violation (e.g. a degradation in the expected service delivery) a certain discount will apply. The rating service is responsible for applying these rules to the mediated data and deriving a charge for service usage through the application of charging algorithms and appropriate discounts.

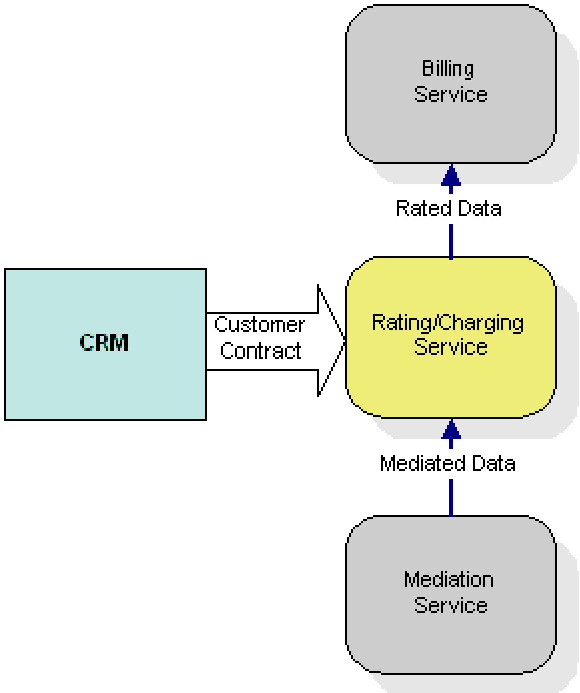


Figure 15: Service Charging Reference Model

IPDR NDM-U

In the case of the above model being implemented in an IPDR compliant manner, the mediated data is IPDRDoc XML documents and the interface between the mediation service and the rating service is the *D* interface which is fully specified by the NDM-U[23]. The interface between the rating service and the billing service is the *E* interface, whose responsibility is specified by the NDM-U but not the implementation.

3.2.4 Billing

Having received the charge records, the Billing Service will consolidate those records and issues bills to the end-user based on the service contract. In the billing level the contract will contain information regarding, billing periods, payment methods, etc. The model for this process is shown below.

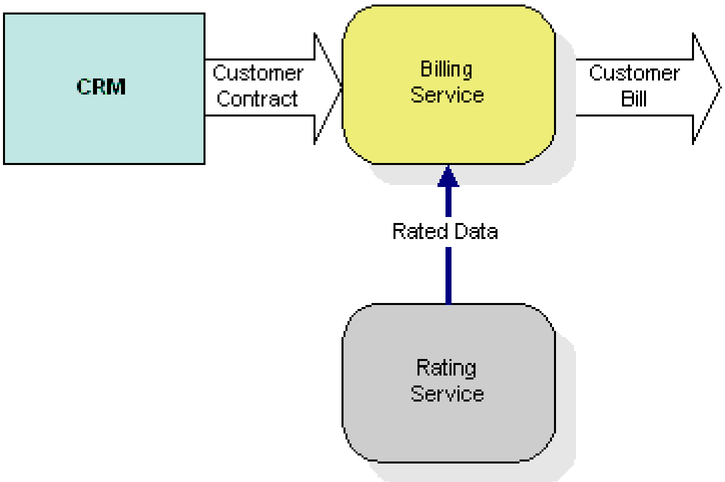


Figure 16: Service Billing Reference Model

IPDR NDM-U

In an IPDR compliant billing system the interface between the rating service and the billing service is the *E* interface, i.e. the inter-BSS interface. The data format is not specified by the NDM-U[23].

4 Service Composition and Accounting

This section will look at accounting in the arena of service composition. The section will initially provide an introduction to service composition, then look at how web services are currently being composed in industry and finally an examination of work done with regard to accounting for these service compositions.

4.1 Introduction to Service Composition

An overriding goal of the Digital Business Ecosystem is to help SMEs discover and access products or services that best suit their business needs. In many cases a number of services will be linked in chains of arbitrary complexity in order to deliver the desired functionality. Such service chains are commonly referred to as "service compositions" and the process of integrating pre-existing services into richer, composite services is termed "service composition." In the context of DBE we are interested primarily in automated service composition, which, broadly speaking, involves the following tasks:

- Representation of the tasks that a service composition is constructed to achieve
- Discovery of the set of services available to take part in a service composition
- Representation of the characteristics of available atomic services and other composite services in a manner that supports automated reasoning as to which are appropriate for inclusion in a service composition for a specified task – a process termed "service brokering."
- Construction of the service composition itself, involving the expression of the flow of control and information between the elemental services of the composition
- Control of the execution of the service composition

Automated Service composition has been a research topic for many years, however recently the main impetus for this work stems from the emergence of web services and the possibility of composing them to make services tailored to specific requirements available over the Web. In particular Web Services Description Language (WSDL) and its standardised binding to SOAP (and hence to HTTP) offers the potential for a common communications infrastructure in support of composed services. This has led to the development of XML based languages to define and support composition between WSDL service definitions, e.g. BPEL4WS supports the exchange of service composition patterns between tools.

Whilst significant progress has been made regarding the mechanics of automated service composition bridging the gap between the model of the task that a user wants to be executed and the service composition models that express how this task can be accomplished. This mapping from task specification to service compositions requires modelling of the real world context in which the user expresses task requirements. This modelling is supported by ontologies, which provide a means of capturing and representing semantic information. In the context of web services this type of approach is seen in the DAML-S initiative, which employs the DAML+OIL ontology language to provide semantic mark-up of web services. Widespread use of WSDL to define services, coupled with the semantic richness added by DAML-S is likely to encourage the application of rules-based reasoning, situation calculus and other AI techniques to the service composition problem.

Much of the focus of DBE is on the introduction of intelligence into the service brokering aspects of service composition, through the application of the fitness landscape and associated algorithms. Clearly in a real world scenario the pricing of services will be one of the primary criteria that SMEs

will wish to be taken into account during the service recommendation process. This relates directly to the generation of a pricing model for the composed service itself, a model which should capture the sharing of revenue between the entities contributing constituent services and address the accounting actions to be taken in scenarios where the functionality of the composed service cannot be delivered in entirety.

4.2 Composing Web Services

Currently specification for web services are largely concerned with the atomic representation of service interactions. The next step in the development of web services will be standardised means of composing web services in order to satisfy specific business needs.

4.2.1 W3C – Web Services Choreography Working Group

W3C[25] has a working group called Web Services Choreography Working Group[45] whose primary goal is stated in the group's charter as *“to create the definition of a choreography, language (s) for describing a choreography, as well as the rules for composition of, and interaction among, such choreographed Web services. The language(s) should build upon the foundation of the Web Services Description Language”* [46].

The working group have issued three documents, all in the working draft, concerning the requirements[47], the information model[48] and the description language[49] of web service choreography.

4.2.2 Syntactic and Semantic Approaches

As outlined in Srivastava and Koeller's paper[50], there are two main approaches to the composition of web services. The first is an syntactic business driven approach based on developing XML-based standards to formalize web service specification, flow composition and execution. The second approach comes from the semantic web community, where the composition is derived from reasoning about the web services through examining pre-conditions and effects whose terms are defined using ontologies. Below is a brief introduction to a popular example of each of these approaches.

BPEL

Business Process Execution Language (BPEL) [51] for Web Services is an XML-based web orchestration language designed to enable task-sharing for distributed computing solutions using web services. BPEL is promoted by IBM, Microsoft and BEA and is a successor to IBM's WSFL and Microsoft's XLANG. BPEL4WS has facilities for sequencing commands, looping, conditional jumping, launching asynchronous and synchronous operations, message correlation and more. BPEL is written in scripts and executed using a BPEL orchestration engine. There are a number of BPEL platforms and engines available such as Collaxa's BPEL Orchestration Server[52] Service Orchestrator[53] and BPWS4J[54]. Recently an open source engine from ActiveBPEL[55] was released.

WS-CAF

Web Services Composite Application Framework (WS-CAF)[56] is set of three specifications concerning context [57], co-ordination[58] and transaction management [59]. These specifications are designed to solve problems that arise when web services are composed together and to provide information sharing and transaction processing. This framework is being endorsed by Arjuna Technologies Limited, Fujitsu Software, IONA Technologies PLC, Oracle Corp and Sun Microsystems.

OWL-S

The Semantic Web Services arm of the DAML[60] program is developing an OWL-based[61] Web Service Ontology, OWL-S[62] (formerly DAML-S), as well as supporting tools and agent technology to enable automation of services on the Semantic Web. OWL-S supplies Web service providers with a core set of mark-up language constructs for describing the properties and capabilities of their Web services in unambiguous, computer-interpretable form. OWL-S mark-up of Web services will facilitate the automation of web service tasks including automated web service discovery, execution, interoperation, composition and execution monitoring. The latest full release is version 1.0 [63]. OWL-S does not in itself address issues of service composition but provides a means for service providers to describe their services in terms of the service profile, the process model of the service and the execution (grounding) of the service. In this regard OWL-S is an enabler of service composition rather than a means of executing such a process. It is the role of external tools to manage the composition and subsequent execution of services.

4.3 Composed Services Accounting

Issues raised when accounting for composed services are largely the same as those when accounting for atomic services. The fundamental challenge particular to composed service accounting is how to provide as customer with a single bill which combines atomic service usage charges for composed services into a single charge for the composed service usage. This challenge has been addressed by the IST FORM and the work done by this project has fed into a standards submission to the OMG [64].

4.3.1 FORM

The IST project FORM [65] recognised that the emergence of the B2B market was influencing how services were being provided, charged for and billed. One of the challenges addressed by the project was that of providing a service bill that integrates charges for individual service usage of which a composed service is comprised. The functional requirements for the federated accounting system are mainly derived on the basis of the TMF TIM (Generic Requirement for Telecommunication Management Building Block) framework[66].

To satisfy this problem the concept of an Inter-Enterprise Service Provider (IESP) was introduced. This IESP effectively acts as a broker and mediates between the service user (B2C or B2B) and the third party service providers (B2B). The IESP consolidates the charges from third party service providers and provides the end-user with a single bill.

This IESP is a real world organisation, (like any other service provider), who is responsible for providing a composed service offering to its customers. From the consuming customer viewpoint, the service is offered by the IESP. The end-customer is unaware of the individual services that are utilised by the IESP to make up this service offering. The IESP is then responsible for the service composition and the management of relationships, contracts, usage data and financial transactions with the third-party service providers.

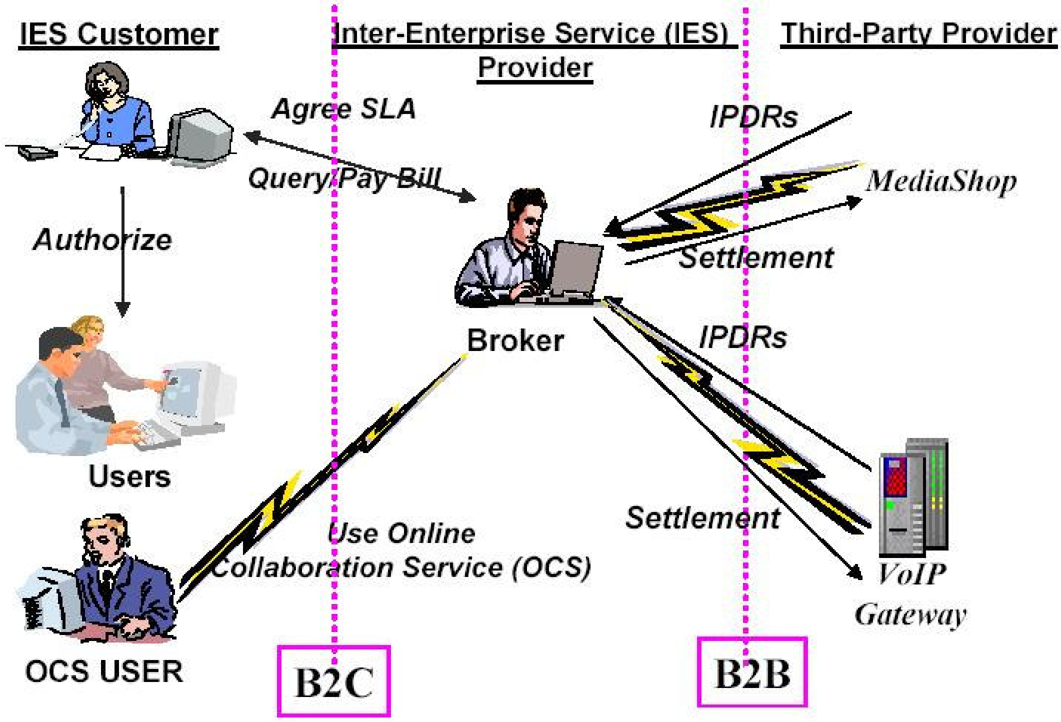


Figure 17: The FORM project's Federated Accounting Business Context

In this federated accounting, the IESP is responsible for all interactions with the customer ultimately consuming the services offered. The IESP takes care of SLA (or contract) management, customer account management and customer billing and payment. The service provider issues usage data to the IESP who uses this data to consolidate composed service usage and bill the IES customer for the total usage including a mark-up imposed by the IESP for their mediation service provision.

The IPDR common data formats were adopted as a means of information exchange between the various parties. In order to facilitate the IESP charging mechanism in this federated inter-enterprise billing system, the project extended the IPDR master [23] schema to include charging information. This was termed an E-IPDR (Enhanced Internet protocol Data Record). The extension added a CE (Charge Entry) element to the master IPDR schema. This means that usage data passed from the third part provider to the IESP might contain charging data as well as raw usage data.

The CE element contains details of the settlement charge (amount the IESP is charged by the third party supplier) and also the customer charge (amount the IESP charges the customer).

In the event of the charge not being present in the usage data, the IESP uses its contracts with its service providers to ascertain the cost of its service consumption using its own charging and billing system. The resulting (settlement) charge is inserted into the E-IPDR Charge Entry along with the customer charge. These IPDRs are now consolidated to provide a customer bill, regardless of whether the service provider has invoiced the IESP for the usage. This approach means that the customer receives a bill for the composed service usage without knowledge of the individual service charges that are incurred by the IESP.

4.3.2 OMG Federated Charging and Rating Facility

In October 2001 the OMG issued an RFP (Request for Proposal) [67]. The request was for proposals which addressed the following accounting issues:

1. *Enabling retailers to charge users for 3rd party service/content provision*
2. *Provision of information to end-users regarding immediate (after usage) estimated accounting information.*
3. *Collection of service usage data from various sources, e.g. Network Operators, Internet Service Providers*
4. *Specification of accounting records that can be used to collect accounting data*
5. *Providing the charging information to a billing interface*

In response to this request a submission was made by Fraunhofer FOKUS and Deutsche Telekom, who took the work done in FORM and enhanced it to meet the requirements of the call for proposal. This initial submission (called Distributed Accounting Facility or DAF)[68] has gone through several iterations and is now a Final Adopted Specification called Federated Charging and Rating Facility(FCR)[69].

The final specification provides a set of use cases, a set of interfaces to facilitate the system implementation and an examination of the information model and extension to it.

4.3.2.1 Information Model

This information model extension is very similar to the E-IPDR produced by FORM and a graphical representation of the IPDR element including the FCR CE(Charge Entry) is shown in the diagram below.

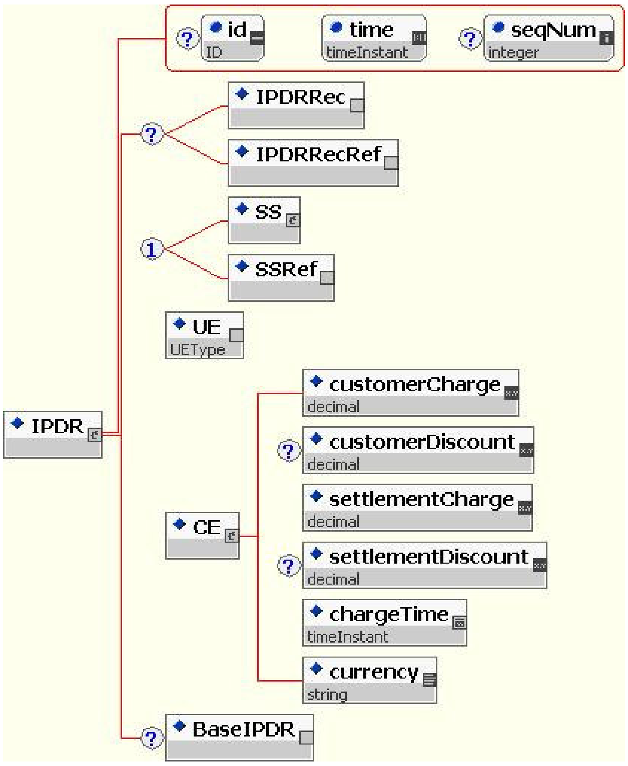


Figure 18: Extract of OMG FCR Facility's E-IPDR schema

4.3.2.2 Interfaces

In addition to providing an information model, the FCR also provides a set of interface specification to allow other OSS systems to interact and also for FCRs to exchange information. These interfaces are modelled using UML and the FCR also provides a set of IDL files to enable the interfaces to be implemented in a CORBA compliant manner.

The FCR interfaces are briefly described here:

`i_userInterface:`

This interface provides a facility for the end-user to query historical data from the FCR

`i_acctInfoExchange:`

This allows different FCRs to communicate

`i_usageMediation:`

The purpose of this interface is to allow a service element, a network element or a metering service to interact with the FCR

5 Conclusion

The current state of the art of service accounting shows that a considerable amount of work is already in place in standardising the processes and information modelling in the domain. The IPDR reference model as well as the IPDR.org's NDM-U specification are intended to answer many of the requirements in a service oriented architecture, such as DBE. The IPDR data record as an extendable XML schema is the perfect instrument through which DBE service usage can be represented. The IPDR reference model provide a set of interfaces as well as a set of components upon which a open source accounting solution can be developed for DBE.

In terms of accounting for composed services it is intended to make use of the OMG's Federated Charging and Rating facility to charge and bill for composed services in DBE. Such a facility will map itself well to the manual composition of DBE services in the first phase of the project. However, in terms of automatic composition of services in the second phase of the project, the concept of the IESP is probably not in itself a complete means of accounting for such composition usage. Further research is required in this area to satisfy this requirements.

In addition, it is intended that a mechanism for service usage metering (similar to the pattern described in Section 3.2.1) will be deployed in DBE in order to fine-grain monitor DBE service usage. Such a mechanism will not only be useful for financial accounting, but is also an enabler for authentication, authorisation and QoS metric measurement.

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