Implementing Software Building Blocks to Create an Inter-Enterprise B2B Service Management Environment: The FORM perspective.

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New generation IP-services are forecasted to be the future technology enablers of commercial Business-to-Business (B2B) services and solutions. The Information Societies Technology (IST) FORM project has defined an open development framework for the management of these new B2B enabling environments. A key element of the framework is the concept of reusable components or Building Blocks for the rapid development of inter-enterprise management solutions. This paper presents the FORM open development framework and its application in the design and implementation of a federated billing and accounting solution for inter-enterprise service management.

1. Introduction

The liberalisation of the telecommunications industry has resulted in a proliferation of new services and service providers. This has stimulated rapid growth in the worldwide B2B e-commerce market. From an estimated B2B market of $2 - $3 billion in 1998 [1] present figures project $2.7 trillion worth of e-commerce transactions for 2005 [2]. The nature of telecommunication networking is changing from traditional circuit-switched networks onto less structured IP backbone networks [3]. As the new IP-based services market expands rapidly, the upsurge in the level of B2B interactions creates new service requirements in the areas of customer service access, security, billing and Quality of Service (QoS). An important feature of the new environment is the creation of composite services (service sets) created from the integration of services provided by ISPs, Virtual Private Network (VPN) and application service providers, as well as backbone operators. In such an environment B2B requirements can no longer be economically met through the provision of non-dependent standalone services. Many small to medium size enterprises (SMEs) do not possess the resources to indigenously capture every service that they require and hence find it more economic to outsource their service needs to service brokers (Inter-Enterprise Service Providers). This Inter-Enterprise Service Provider (IESP) is responsible for the generation of Service Level Agreements (SLAs) with the service consumer and the establishment of service provisioning Contracts with various Service Providers (SPs) that can assure conformance to these SLAs for the consumption of their respective services.

This paper presents an Open Development Framework to support the development and maintenance of Inter-Enterprise Services. It will also provide an intermediate overview of the application of the framework to the development of a federated billing and accounting solution.

2. The FORM Open Development Framework

The emergence of an IESP-based environment requires new models for the development and integration of communication management solutions. The IST project FORM (www.ist-form.org) is developing and validating such a model, which it has labelled the ***Open Development Framework*** (ODF). The FORM project is focussed on addressing the interdependencies between the System Development value chain and the Service Provision value chain. A key goal is to develop an architectural framework, which would enable each player to develop management systems according to their own service management needs but in a way that is of common benefit.

The System Development chain must address the challenges of integrating separately sourced software to satisfy rapidly changing management system requirements. The software industry is moving towards the (re)-use of component-oriented "off-the-shelf" software and model-driven approaches to the software lifecycle. Applying this to the market for communication management software requires new architectural and modelling principles to be shared between Standards Bodies, Independent Software Vendors, System Integrators and System Customers (i.e. the Service Providers). In an open service market the Service Provision chain must support the need for different service providers to collaborate through seamless service management in a rapidly changing technological and service market environment. Enterprises require the ability to dynamically create, reconfigure and dissolve business collaborations. The FORM project explores this requirement through developing and implementing scenarios around the concept of Inter-Enterprise Service (IES) Provider environments.

The framework presented in Figure 1 below shows the subcomponents of the ODF. The framework is intended to be generic and extensible. The concerns addressed by the four portions of the framework are:

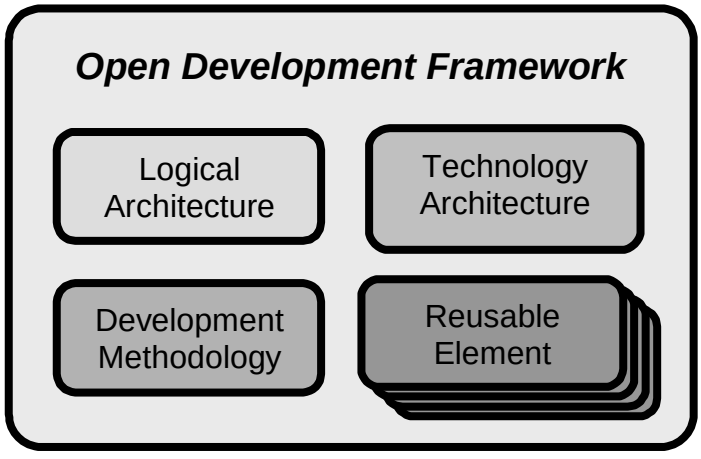

Figure 1: FORM Open Development Framework

- **Logical Architecture:** The logical architecture describes the structural concepts of the Framework in a manner independent of any implementation technology. The core structural concept is the software Building Block (BB) which implements a number of Contracts via which inter-BB interactions occur. Systems are described in terms of Business Processes and Business Roles. Reference Points (RP) that highlight inter

domain communication exist between many of the Business Roles. To promote the reuse of Contract Specifications, each specification is described in a technology neutral format. This involves specifying the information passed via a Contract through reference to an External Information Model (EIM). The impact of standard bodies on the preceding concepts is quite important. The Application Component Team (ACT) within the TeleManagement Forum (TMF) for instance, has produced the GB909 document, which is a set of requirements for generic telecommunications Building Blocks [4], a subset of which has been adopted by FORM as a set of development requirements. The concepts of Building Blocks and Contracts were informed by these requirements. The TMF's NGOSS (New Generation Operations Systems & Software) [5] initiative builds upon the GB909 requirements described above and aims to produce an architecture for component-based management systems, an aim very similar to that of the FORM Framework. Another driver of the logical architecture is the work from the TINA (Telecommunications Information Networking Architecture) consortium. Though the TINA Consortium [6] is no longer active, several of its architectural concepts are used in FORM. Elements of the ODL (Object Definition Language) evaluated in TINA and now standardised by the ITU [7] have informed the FORM BB specification schema, in particular the inclusion of references to Contracts that are required by a BB.

- **Development Methodology**: The development methodology provides the processes and notations needed to develop BBs and most importantly to assemble systems that conform to the Framework. The primary modelling notation used is UML (Unified Modelling Language), though the potential of XML for Contract specification is also being examined. The Rational Unified Process (RUP) [8] is used as a partial template to integrate the following modelling techniques: use case modelling, business process modelling and analysis modelling along with a variety of other modelling approaches supported by UML.
- **Technology Architecture:** The technology architecture addresses how the concepts expressed in the Logical Architecture can be implemented using a range of technologies. For each technology a single mapping between the meta-model for technology neutral Contract specification to the native meta-model of the technology is sought. Adaptation to allow interoperability between Contracts implemented in different technologies is also addressed. In this portion of the framework the work is influenced by various technologies and software paradigms. For example, the Java2 Enterprise Edition (J2EE) framework (EJB, JSP/Servlets, JMS etc.) and XML technologies are currently being assessed in FORM.
- **Reusable Elements:** The reusable elements portion of the framework is the repository for reusable software products that result when the framework is applied to a particular application domain, e.g. the IES Management domain addressed in FORM. The principle types of reusable entities are: Business Role definitions, Reference Points, Contract specifications and their grouping into BB Specifications and BB implementations.

The application of the generic framework to the IESP context results in an ODF conformant system that is a specialisation of the framework. Such a specialisation is illustrated in the design and development of the IES federated accounting and billing system below. A key aspect of the specialisation is the specification of reusable elements, termed Building Blocks.

3. Development of an Inter-Enterprise Service Federated Accounting System

3.1. B2B accounting and the need for Federated Accounting

The liberalisation of the telecommunications market and the emergence of the B2B market have a major impact on how services are accounted and billed for. From a service usage accounting perspective, this new B2B environment creates a number of important challenges. The first issue is that of the operation of services across multiple administrative domains. Customer services may either be supported by multiple service provider networks or be composed of services provided by multiple service providers. Secondly services tend to be supported by customer SLAs and customer defined QoS. The main impact on service billing is the complexity of the resulting B2B business model and the customers' expectations for a single service access point and an integrated bill. As a consequence B2B billing systems must be capable of generating a service bill that integrates the charges for the various subservices of a composed service, while at the same time integrating any discounts or costs in line with the customer SLAs. For instance, charging for a customer service such as Voice over IP (VoIP) may require the integration of ISP connectivity and VoIP service provider charges as well as any discounts due to the customer. Present day billing systems are not able to cope with the complex billing methodologies for these next-generation network services. It is acknowledged widely that it is through its billing system that a business communicates with its customers. Furthermore, optimising billing is a crucial service differentiator in a liberalised telecommunications industry and has become a vital parameter for the survival of service providers. Hence, an integral attribute of any IESP is the ability to perform federated accounting and it is envisaged that such an Inter-Enterprise solution will not take off if it cannot be accounted valuably.

The accounting and billing sub group within the FORM project has applied the ODF in the design and implementation of an IES federated accounting and billing system. The FORM accounting and billing management research area include:

- Calculating and providing a charge for the services provided.
- Enabling customers to access and query accounting and billing information on demand.
- Providing federated accounting support.

The following sections describe the application of the framework to the design and implementation of the IES federated accounting and billing system.

3.2. Methodology

The FORM methodology addresses the challenge of providing a component-oriented approach to the development of business process driven management systems for B2B services. The FORM methodology is based on UML and incorporates two integrated development guidelines namely:

- Guidelines for the development of re-usable management components (termed Building Blocks)
- Guidelines for construction of B2B management solutions implementing management Business Processes (using FORM Building Blocks).

The FORM methodology proposes a business process driven approach to the construction of management systems solutions based on re-usable software components (or Building Blocks). The FORM methodology was developed in parallel with the design of the federated accounting and billing system.

The initial system architecture was hence structured following the TMF Telecoms Operations Map (TOM) [9] business processes, but immediate mapping to a set of BBs as recommended by the guidelines, was not seen as relevant at the initial stages of the project. Business Processes were instead mapped to a set of functionalities partially fulfilled by existing components that were retrospectively grouped as BBs. Missing components were then developed following the guidelines for the development and specification of BBs. The initial result is that feedback to the methodology guidelines was provided both in terms of adapting legacy components to such BBs systems and by directly using the BB development methodology to develop missing functionalities.

3.3. Federated Accounting Logical Architecture

There are two main standards that heavily influenced the logical architecture of the IES federated accounting and billing system, the TMF TOM and the Internet Protocol Detail Record (IPDR) [10] TOM provides a generic, high-level process model for telecommunications management. FORM adopted the notion of using Business Processes Modelling for deriving system and BB requirements. FORM does not advocate a generic process model, but the generation of domain specific models that potentially reuse and refine some of the process definitions of the TOM, e.g. an IES Business Process Model for federated accounting. Once the relevant business processes were clearly identified, they were extrapolated to BB contract specifications.

The IPDR.org Network Data Management - Usage (NDM-U) [11] specification provides a framework for a standard mechanism to exchange usage data between the different providers in the IESP federated accounting system by referring to the functional operation within the TOM. The XML record structure and service definitions provides a means to represent service usage information in a consistent, self-describing, human readable format. These structures allow for the creation of documents by one provider's system e.g. a third party service provider, in a format that can be understood and easily used by another system in another provider domain e.g. for the Billing / Rating Engine in the IESP domain.

The FORM Framework is structured around the following architectural principles:

- Management Systems are constructed partially or fully from Building Blocks.
- Building Blocks are atomic units of Deployment (one can be replaced in a running system without requiring other BBs to be replaced).
- Building Blocks are atomic units of system management.
- Building Blocks support multiple interfaces types and multiple instances of those types. These interfaces are termed Contracts.
- The Logical Architecture does not prescribe the technology used to implement Building Blocks or their Contracts.
- A Contract can support multiple business transaction operations.
- The information passed via a Contract is expressed by reference to an External Information Model.
- Building Blocks can be grouped into Building Block Groups. This is the typical unit of purchase from a Software Vendor (though sale of individual BBs is possible as a BB Group with a single member).
- Reference Points identify boundaries over which interactions occur between two Business Roles identified for a Business Domain (e.g. IES). Reference Points can be mapped to one or more Contract Specifications

These broad principles have been used to structure the federated accounting and billing logical architectural model as presented in Figure 2.

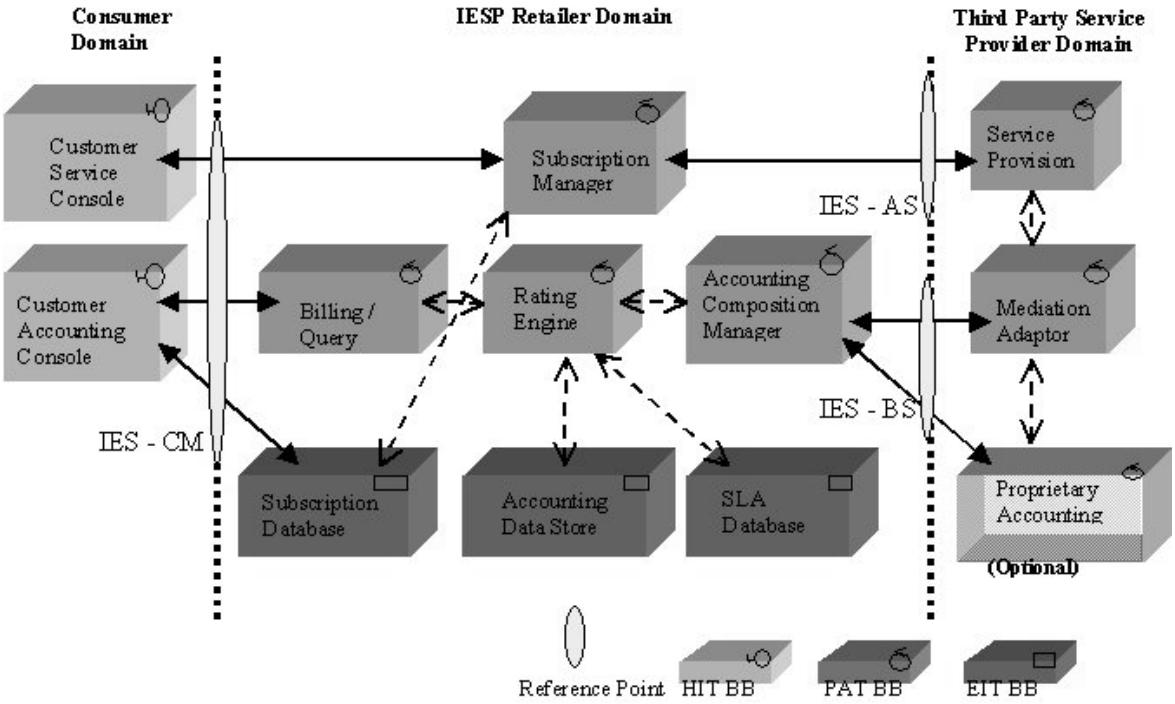

Figure 2: FORM IESP Federated Accounting Logical Architecture

Figure 2 shows the initial federated accounting logical architecture. The charging and billing business processes that this architecture incorporates have been extracted from the FAB (Fulfilment, Assurance, and Billing) concepts of the TMF TOM and these processes provide the context from which various billing scenarios are mapped out. The architecture addresses TOM Billing issues of network data management (service mediation), rating/discounting and invoicing/collection in each of the respective domains identified in Figure 2. The billing scenarios take into account the general FORM context of a retailer, i.e. the Inter-Enterprise Service Provider (IESP), providing a variety of services to its customer in cooperation with third party service providers, such as VPN Service Providers or Internet Telephony Service Providers. A customer approaches the IESP with service requests and service level requirements. The IESP constructs an SLA with the customer by matching the customer requirements with previously specified third party SP Service Level Specifications (SLSs). After the SLA has been accepted, the customer uses the service and the IESP handles all future customer interactions e.g. customer care functionalities, such as billing, further SLA negotiation, or the handling of customer trouble reporting (i.e. one-stop shopping), which allows the SP to concentrate their resources around their core competencies. These scenarios present a two-way information flow between the customer and the third party SP, with the IESP fulfilling the role of information coordinator. The IESP coordinates the flow of SLA information from the customer to the third party SP and the flow of service related information from the third party SP to the customer, while manipulating the information to fulfil the data requirements of either party. TOM supported the definition of the business processes through which this information traverses and the extended IPDR model provided a standard means to represent the service related information being passed through all these processes.

3.4. Federated Accounting Technological Architecture

The initial implementation of the Federated Accounting system described above covers a wide range of technologies. Some initial components were implemented or re-factored using CORBA technology. This was the case for the Rating Engine (Figure 2) and most of the service provisioning and mediation components. For these components the event-based integration paradigm chosen was a CORBA event service. The technology integration decision for the newly implemented components was influenced by the widespread discussions concerning the J2EE technology set. The following sections present some of the findings regarding the mapping of the 3 different GB909 Building Blocks (Human Interaction, Process Automation and Enterprise Information BBs) requirements with various J2EE technology framework components (EJB, JSP, JMS, etc…). Some of the BBs in the customer care side of the system were built using different components of the J2EE technology framework. Although the work on this part of the system is still at the stage of early prototyping, initial assessments show that some of the GB909 requirements do improve the overall quality of the implementation and can be practically fulfilled using the J2EE technologies. Detailed technological mappings between the GB909 BB requirements and the J2EE technology framework are provided below:

- *Human Interaction BB mapping*

Java Servlets and Java Server Pages (JSPs) provide a means by which to implement packaged components that meet some of the requirements of the TMF GB909 Human Interaction Building Block (HIBB) specifications. HIBBs are concerned with providing the functionality required to meet the business process automation needs of human users, by providing a means by which humans can make use of the functionality of Building Blocks in all three tiers of the architecture. A primary requirement of a HIBB is that of deployable unity, this can be achieved by packaging all elements of the Building Block e.g. XML, Servlets, JSPs, Images, HTML, JAR files etc. into one deployable file called a Web Application Archive (WAR) file. WAR files that conform to version 2.2 of the Servlet API Specification can, in theory, be deployed on any server that supports the specification. To simplify the flow of functionality through a HIBB, JSPs map the meaning of information that is received from other BBs into suitable UI representations and Servlets map the meaning of user interactions into suitable contract invocations on PABBs or EIBBs. These contract invocations (e.g. on a remote EJB in a PABB) can be achieved in the J2EE environment using a remote method invocation (RMI, RMI-IIOP) or a Java Messaging Service (JMS) solution.

- *Process Automation BB mapping*

The mapping from Process Automation to Enterprise Java Beans has been achieved by the FORM accounting and billing team. The current version of the J2EE specification enables the development and deployment of EJBs or rather a set of EJBs as re-usable units of software to achieve business logic. A rather interesting characteristic of the J2EE framework is that it keeps progressing and improving. In fact in the next version of the Java 2 Enterprise Edition technology platform, the emphases will be placed on inter-enterprise functionality, particularly eXtensible Mark-up Language (XML) Services. Another major improvement will be the incorporation of the Java Messaging Service (JMS) API into the base J2EE platform. With the integration of JMS, the EJB specification will introduce a new type of bean, the message-driven bean. This should help in resolving some of the Process Automation difficulties encountered within the FORM BB implementation of the IESP federated accounting and billing system. Regarding the mapping of the PAT BB to a deployable unit, the GB909 recommends the use of one .jar (Java Archive) file containing EJB's classes.

However, in practice, it appeared that for deployment and management purposes, the .ear (Enterprise Archive) packaging fulfils more PAT BB requirements. The .ear files allow the inclusion of several .jar files, which can be either EJBs or support libraries which makes the packaging logic more explicit.

- *Enterprise Information BB mapping*

When evaluating EIT BBs against J2EE implementation offerings, various findings can be extracted from the usage of entity beans with Enterprise Information. Entity Beans provide an effective solution for providing a standard way to persist domain models. Before entity beans, people had to write their own persistence frameworks or rely on proprietary relational mappers. Encapsulation of a persistence mechanism is achieved using either Bean Managed Persistence (BMP) or Container Managed Persistence (CMP) as defined by the EJB specification. However, the use of entity beans presents some drawbacks. Entity beans have associated overheads as they use distributed network calls and require transactional deployment descriptor settings, even though most developers wrap them with session beans. Hence, Entity Beans require a lot of extra coding to achieve their requirements. Therefore a debate has started on whether Java Data Objects (JDO) provide a better solution than Entity Beans. JDO are simple, plain Java classes that provide the same benefits as Entity Beans, but in a much simpler and more effective way. However, JDO do not address the distribution or the transactional properties of such data objects. It is therefore difficult, at this stage in their development, to conclude if JDO provide a better mapping to EIT BBs, since in relation to the GB909 EIT BB requirements, it is necessary to provide the EIT BB with robustness. And such robustness can only be achieved if distribution, transaction, security, etc… features are available.

Overall the use of J2EE technology framework, in the development and deployment of a federated accounting system, has proved very useful and compliant with the goals of developing accounting BBs. However, these technologies are still evolving and therefore not perfect in all aspects. Two important limitations were found. In relation to persistence and entity beans, the specification provides for container-managed persistence (where the underlying storage is automatically accessed by the bean's container), however it does not provide for complex relationships between pieces of data. For example, it does not support the idea that data may span multiple tables in the underlying database. In such cases requiring semantic integrity between data items, it was necessary to write bean-managed persistence code that makes the beans themselves less portable. Regarding asynchronous messaging, the lack of support for asynchronous messages between components was highlighted. This forces components to become more closely coupled than would otherwise be necessary (in contradiction of GB909 guidelines). It should be noted however that both these problems are being addressed in EJB 2.0, but at this time it is still in draft form and implementations of the draft vary in their quality.

To conclude on the technology part of the framework, a major concern when approaching the technology architecture of the federated accounting and billing system was the inter-operability between systems that reside in different domains. Difficulties were encountered when attempting to use CORBA/IIOP or J2EE/RMI to cross domain boundaries over the Internet. The main reason for this was security firewalls. To alleviate these problems, initial research and prototyping using a new technology neutral WebSevices technique has been initiated. The initial concept is to wrap BBs at their boundary edges as WebSevices with a SOAP/WSDL external interface. The initial prototyping of such WebSevices has been successful and such WSDL definitions have helped in providing a meaningful mapping of interfaces to Contracts as defined in GB909.

3.5. Reusable elements

The concept of software reusability is well established within the software industry. The potential for economies through object reuse and inheritance has been the driving force behind the emergence of object-orientated software. The availability of "off-the-self" software solutions is rapidly becoming a reality in today's IT industry. However, in the current telecommunications industry the availability of re-usable software as components for application development remains an aspiration rather than a reality. This is particularly true in relation to accounting software solutions. The integration and management of off-the-shelf accounting components has not been effectively achieved in the telecommunications environment in the past. Hence, the work carried out on this IES federated accounting and billing system is concerned with developing a set of re-usable elements or BBs. Although the work is still in progress, some potential re-usable elements have been identified. For example, the Rating Engine, although not developed initially as a BB, has been fully re-engineered to match some of the GB909 PAT BB requirements.

4. Conclusion: Findings & Future Work

The development of the federated accounting and billing system described throughout this paper was distributed between two different research teams within the FORM project, namely the Telecommunications Software Systems Group (TSSG), Waterford Institute of Technology, Ireland and GMD – Fokus, Berlin, Germany. These billing group teams have provided a clear validation of a portion of the ODF by successfully integrating the management of the different federated accounting and billing system BBs, developed on both sites.

Furthermore, the successful development of a federated accounting and billing system further validates the FORM IESP approach, as the ability to perform federated accounting has been identified as a critical factor determining the validity of such a broker entity. Federated accounting refers to the ability to aggregate the charges of different Service Providers in alternate domains into a total service charge on a single bill. It must also support the ability to decompose this total to obtain the usage data (for trouble reporting reasons etc.) from each of the respective Service Providers that have contributed.

At this early stage in this research project it is difficult to fully validate the TMF Building Block concept of component reusability (discussed in section 3), as the prototyping approach adopted by the project does not reflect a true commercial environment. However, the project has initiated a second phase of prototyping where further investigation and enhancements of the criteria for reusability will aid in the clarification and validation of the reusability concept of BBs.

To date, the development of the ODF has highlighted several inadequacies in relation to the validity of the development methodology in a commercial environment. Many aspects of the ODF are supported by the fact that RUP is a commercially driven methodology. However, the support for BB development and integration in this RUP process is non existent, hence an extension of RUP to support the development of BBs has been undertaken by the project. The validity of the work carried out in defining commercially viable requirements is further complicated by the fact that commercial partners in the project are attempting to validate such BB guidelines.

The concept of shared information modelling is another major issue that has surfaced while assessing the integration of BBs into different systems. To be reusable in different systems BBs need to express information in a common manner, otherwise efficient communication is not achievable.

The NGOSS work addresses the issue of a shared information model. Within the ODF context, FORM defines this information model as an External Information Model (EIM) or, to be more precise, as the expression of information exchanged at system and domain boundaries within BB Contracts in a common way. Since the investigation of the EIM has just commenced, no definite conclusions can be drawn. However, initial indications suggest that this External Information Model will be driven by DMTF Common Information Model (CIM) concepts.

To conclude, this paper has presented an intermediate overview of the Open Development Framework being developed in the IST FORM project and the subsequent application of this initial ODF to the development of a federated accounting and billing system. The FORM project has introduced the concept of an IESP as a broker entity to outsource service management and the provision of services to any customer regardless of the size of the customer organisation. The IESP concept supports the future growth of an effective B2B communications environment. The introduction of the IESP presents benefits for both the Service Provider and the customer. It abstracts customer care requirements away from the Service Provider, allowing it to focus its resources on its core competencies (i.e. service provision). The IESP also provides the customer with a customised service, tailored to their critical requirements, along with extensive customer care facilities including customisable integrated billing, extensive fault reporting etc. The accounting and billing team have prototyped a fully operational federated accounting and billing system that propagates data from the network level through mediation, composition, rating and finally to billing. In the second prototyping phase, it is proposed that the reusability of the constituent BBs of the system will be demonstrated on a more commercially viable level.

Finally, the successful prototyping of the federated accounting and billing system also validates the logical, technical and methodological concepts presented in the FORM Open Development Framework.

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