

Charging for Dynamically Composed Services in the Digital Business Ecosystem

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Abstract: The ability to compose, on-demand, networked software services to meet evolving requirements is an important step towards the development of digital business ecosystems that allow participants realise novel business models. In this paper we address a crucial issue that must be addressed before dynamic service composition becomes commercially viable – how users can be charged for the use of such services. We first discuss the challenges relating to charging for composed services of which the accounting system may have no prior knowledge. We then present a two-phase rating process that generates charges associated with dynamically composed services in accordance with potentially complex charging agreements between providers of the individual services comprising these services.

1. Introduction

Many in the business and research communities are pursuing the vision of digital business ecosystems – distributed software environments through which organisations can seamlessly access customised, potentially disposable, services to aid them carry out a myriad of tasks. These services can be either pure software applications, or “real world” services represented by a software wrapper supporting automated transaction processing. Full realisation of this vision requires deployment of facilities for the dynamic discovery, composition, interoperation and execution monitoring of a potentially huge number of available services. The European Commission funded Digital Business Ecosystem (DBE) FP6 integrated project [1] is building such an environment (“the DBE”), via which businesses, in particular small to medium enterprises (SMEs), can interact within a pan-European ecosystem to provide access to arbitrary services that the DBE helps compose together to meet particular needs. The DBE will provide sophisticated structural and support software services that harness the scientific principles of self-organisation and self-optimisation to intelligently match organisations with dynamically composed services that are continually optimised to satisfy evolving business requirements.

Businesses utilising DBE services will need to be charged and billed in accordance with their service usage patterns. In any business environment charging processes are of crucial importance, thus the commercial success of the DBE, or indeed any environment supporting dynamic service composition, will be contingent on the ability of providers to charge and collect fees for service usage. Given that there will be no *a priori* knowledge of the structure of, or business model associated with, dynamically composed services, the design and deployment of a sufficiently flexible accounting system is a challenging task. In this paper we describe how the accounting infrastructure of the DBE is being designed to cope with charging for dynamically composed services. In particular, we present a novel two-phase rating process for generating service related charges that allows service

providers straightforwardly dictate how their services are to be charged for when used in conjunction with other services they provide, or with services offered by other providers.

The paper is structured as follows. First we provide an overview of accounting systems in general, highlighting previous work relating to charging for composed services. Then we briefly describe the DBE, focussing on the structure of the DBE run-time environment and the accounting related facilities provided therein. This is followed by a discussion of the particular requirements for charging for dynamically composed services in the DBE. We then introduce the two phase rating process, illustrating its operation via a description of a use case scenario for a composed web-based email client composed service. Finally, we summarise the paper and indicate areas of planned future work.

2. Accounting Systems for Networked Services

Accounting involves the collection and analysis of service and resource usage metrics for purposes such as billing, capacity and trend analysis, cost allocation and auditing. It requires that service consumption be measured, rated, and that resultant charging information be communicated between appropriate business entities. As shown in Figure 1 accounting systems for networked services incorporate subsystems for metering, mediation, rating and billing.

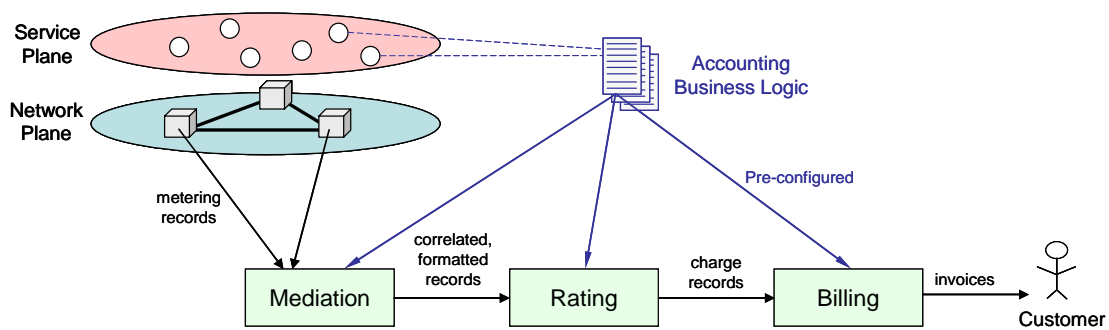


Figure 1: Generalised Accounting System for Networked Services

Metering takes place within the network infrastructure; it is concerned with the accurate recording of service usage data and exposing collected usage records to the mediation subsystem. Mediation involves reliable collection of usage records from metering devices; correlation of records relating to the same service usage sessions; transformation of disparate metering record formats into a common format suited to the needs of the rating subsystem; and reliable transfer of processed records to the rating subsystem. Rating involves the application of models (charging schemes) for the mapping of usage data to monetary units based on various criteria. Each record received from the mediation subsystem is examined and the appropriate charging scheme is applied, resulting in the generation of a charge record. Finally, for post-paid customers, the Billing subsystem collates charge records for individual customers, who are invoiced on the basis of these charge records, any additional subscription fees and discounts.

Accounting for services, including composite services, whose characteristics are known in advance is a mature area. For example, in the telecommunications domain there is wide deployment of complex mediation, rating and billing systems which support sophisticated usage- and content-based charging models for pre-paid and post-paid, private and corporate customers. In such systems the components involved in the accounting process must be manually pre-configured to account for specific services at the time those services are initially deployed. This will not be the case for composed services dynamically created and

executed within a short time span – business logic for accounting must be automatically configured when service compositions are initially constructed, or subsequently modified.

Despite its importance, accounting for composed services has received little attention in the published literature. Bhushan et al. [2] propose a system architecture that supports the requirement for service providers to cooperate in the provision of composed services in a federated manner and share the generated revenue. However, they address only statically composed services – accounting components would still have to be pre-configured with the relevant accounting logic. Agarwal et al. [3] propose a method for metering and accounting for composite e-services that is not dependent on *a-priori* knowledge of the service composition. However, their approach supports only two specific service pricing models (flat rate per amount of resource used and flat rate per transaction). More significantly, the charge for an invocation of a composed service will always be the summation of the charges associated with standalone invocations of the constituent services; this will not always reflect the potentially complex business relationships between the service providers.

3. The Digital Business Ecosystem

The evolution of the Internet towards an integrated platform for service provision has been hampered by difficulties in efficiently translating new business requirements into deployed services. This has motivated significant research work on the specification of business modelling languages that can provide semantically enriched models of both business requirements and the services that meet them, with the aim of expediting the mapping between the two. Because of their semantic richness, these models can facilitate automated reasoning on the nature of service offerings, thereby supporting the construction, adaptation and evolution of service chains (or service compositions) that satisfy business requirements.

The DBE integrated project [1] focuses on the development of an open-source distributed environment (the DBE) that can support the spontaneous creation of applications through the composition of (not necessarily open-source) software services and components. In doing so the project is adopting the business modelling approach described above, but complementing it with the adoption of evolutionary algorithms inspired by biological processes, that provide bottom-up incremental improvement of business models through run-time feedback on service performance. The DBE is being targeted primarily towards SMEs, who will be able to concatenate their offered services within service chains formulated on a pan-European basis. By offering access to a large pool of service providers and consumers, and itself providing advanced recommendation systems and evolutionary algorithms, the DBE will support continued global optimisation of service chains, benefiting all actors, in particular SMEs [4].

From an architectural perspective the DBE can be viewed as consisting of a service factory environment and a service execution environment. Clients of the DBE will use the service factory environment to specify business models and generate associated software artefacts for subsequent implementation, composition and use. The service execution environment hosts implemented services, managing the process of registering, deploying, searching for, recommending, composing, retrieving and consuming services. In this paper we are concerned mainly with the service execution environment, specifically with the accounting infrastructure embedded therein.

3.1 The DBE Service Execution Environment

Figure 2 below illustrates the main component types constituting the DBE service execution environment. Here we will provide a brief description of the functionality of these components; a fuller discussion of them can be found in [4].

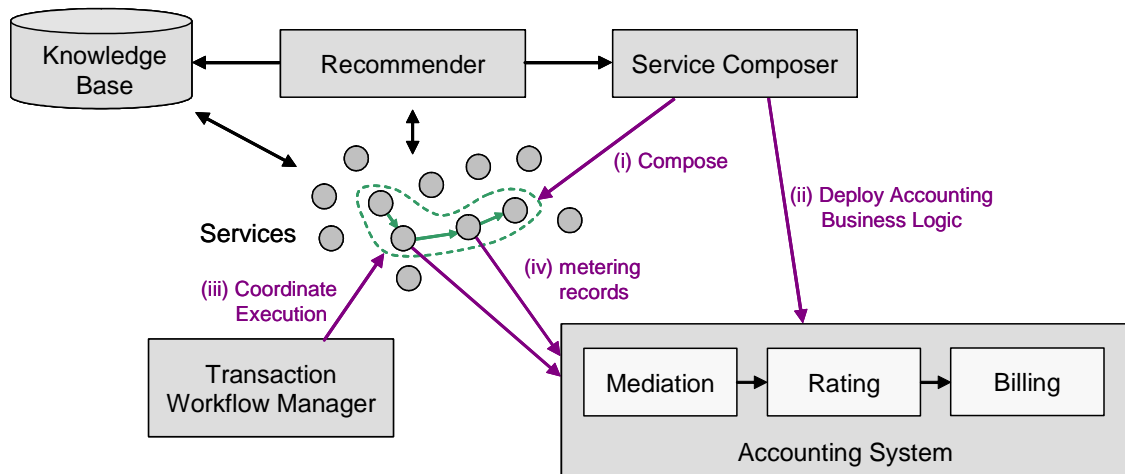


Figure 2: The DBE Service Execution Environment

The Service Composer (SC) component is responsible for constructing service compositions to meet specific requirements captured in the DBE service factory environment. The Recommender component provides the service composer with ranked lists of services that could fulfil specific functions within a service composition. To rank services in this manner it uses historical information relating to service use and performance, which is stored in the Knowledge Base repository. This information is organised as a “fitness landscape,” which assigns fitness levels to services on the basis of a range of criteria; the fitness landscape is also used as the main input into the evolutionary algorithms that optimise service compositions throughout their lifetimes. Once service compositions are constructed, their actual execution is coordinated by the Transaction Workflow Manager (TWFM). As individual services are consumed metering records detailing their utilisation patterns are generated and forwarded to the Accounting System, which is comprised of components for Mediation, Rating and Billing.

4. Dynamically Composed Service Charging Requirements for the DBE

In this section we discuss the main requirements for charging for dynamically composed services in the DBE. As a starting point we note that, from the charging perspective, service providers can adopt a number of approaches in offering services via the DBE, specifically:

- *Services are registered as atomic services:*
In this approach services appear to the DBE as individual (non-composed) services for which metering records identifying the service type in question are generated, and for which specific charging schemes are available. Note that these services may actually be realised by the provider as compositions of other DBE/non-DBE services, but for commercial reasons the provider may wish to hide this fact from the rest of the DBE;
- *Services are registered as atomic services and the provider itself controls generation of charge information for the service:*
In this approach services again appear to the DBE as atomic services, even if they are actually realised as service compositions. In this case the provider also takes responsibility for generating charge information for the service, either by maintaining its own rating engine, or by using a rating engine provided by a trusted third party. Thus, if the service is itself used as part of a “higher-level” service composition, its rating engine would be queried by the rating engine responsible for the higher level service – thus, the DBE needs to support some form of distributed rating;

- *Services are registered as composed services and the services comprising that composed service are identified:*

In this approach the structure of the offered composed service is transparent to the accounting system. Metering records are generated by the (atomic) services comprising the composed service, and the accounting system needs to identify these records as relating to an invocation of the composed service. The composed service may or may not have a specific charging scheme associated with it; if not, the rating engine must be able to calculate charges on the basis of the collection of charging schemes associated with the individual services comprising the composed service;

Clearly, the DBE accounting system in general, and the rating process employed by rating engines in particular, must support all three of the approaches described above. For the third approach, which we expect to be the most prevalent in the DBE, it is of critical importance is that the rating process is able to detect the context in which a service it is rating is being executed – as a standalone service, or as part of a particular composed service that in turn might be part of a composed service (creating a service composition “hierarchy”). We argue that services themselves should not be aware of their full execution context, at least for accounting purposes. This means that metering records associated with services should not have to contain the information necessary to identify the service’s full execution context, which should simplify service implementation. Instead, relevant context information should be provided to the rating engine prior to service invocation; thus, the rating engine must be configured on-the-fly with this information as the services are dynamically composed and invoked by other DBE components.

Assuming a rating engine can identify metering records it receives as belonging to a particular invocation of a composed service it must then calculate the charge for this invocation on the basis of the service usage information contained in these records. To do this the most straightforward approach would be to simply sum the charges associated with the invocations of individual services comprising the composed service, thereby arriving at a charge for the composed service invocation. However, we believe this is not a suitable approach, since it does not recognise the potentially complex business agreements that may be in place between the providers of the services comprising the composed service. For example, a provider may wish to provide discounts if two or more of the services it provides are used together, or if its services are used in conjunction with services provided by a partner provider. Alternatively, a provider may wish to impose penalties if its services are used in conjunction with those of a competitor. The rating process must therefore be sufficiently flexible to reflect business agreements between service providers.

5. The DBE Two Phase Rating Process

To meet the requirements outlined in §4 we propose that DBE rating engines employ a two phase rating process. In phase 1 of this process, services comprising a composed service are rated as if they are being executed as “standalone” services, leading to the generation of interim charges for each of these services. In phase 2, the interim charges are modified in accordance with provider specified rules specifying how charges are to be modified if that provider’s service(s) are used with other specified services in the context of a composed service. To facilitate the two phase process we utilise two-part charging schemes: part 1 dictates how charges are to be calculated when the service is invoked in isolation, and part 2 dictates any modifications to these charges if other specified services are present.

For the purpose of rating, we view composed services as hierarchical collections of atomic and composed services, as illustrated in Figure 3 below. We refer to the service at the top level of the hierarchy as the “master composed service”. Services at the bottom of the hierarchy must all be atomic services (from the rating engine’s perspective). All DBE services have associated with them a *providerID*, which uniquely identifies their provider

within the DBE; they have a *serviceID*, which uniquely identifies the service amongst the set of services offered by their provider; and an *instanceID* which distinguishes between multiple instances of the same service type (for example, serving different geographical markets). Therefore, the tuple of (*providerID*, *serviceID*, *instanceID*) uniquely identifies a service instance across the entire DBE.

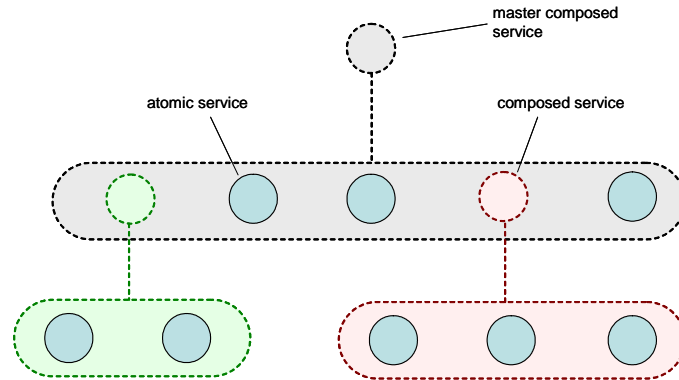


Figure 3: Composed Service Hierarchical Model for Rating

When a TWFM invokes a master composed service it assigns a *transactionID* that uniquely identifies this invocation of the master composed service during the timeframe between initial invocation and the completion of all processing associated with that invocation. The TWFM then provides all services comprising the master composed service with this *transactionID*. All Metering records relating to these services will contain this *transactionID*, as well as the *providerID*, *serviceID*, and *instanceID*. In addition, the TWFM indicates to the rating engine that an invocation of the master composed service with the specified *transactionID* is commencing, and provides it with details of the associated service hierarchy. The presence of the *transactionID* in all metering records provides a means for the accounting system to identify a service’s execution context.

As the services are executed, metering records relating to them are generated and transferred to the rating engine; these records are rated using part 1 of the charging scheme associated with that service. This is phase 1 of the rating process; it results in the generation of interim charge records for the invocations of the associated service instances.

In the phase 2 of the process the rating engine modifies the interim charge records generated in phase 1 as dictated by the part 2s of the relevant charging schemes. Firstly, the rating engine contacts other rating engines to ascertain charges associated with any services it was not itself responsible for rating. It then iterates through the levels of the service hierarchy, starting at the bottom: for each set of services comprising a composed service at the next level up, the part 2 of the charging scheme of each of these services is examined to ascertain if the presence of the other services in the set necessitates a modification of the interim charge for that service. If so, the charge modification is calculated. Once all of the set of services has been processed, the modifications are imposed and the modified charges are summed, providing a charge for the composed service. Note that charge modifications only occur on the basis of those services that a service is directly composed with. Finally this process arrives at a consolidated charge for the master composed service.

5.1 Worked Example: Charging for a Web-based Email Client Service

In this section we provide a worked example of the operation of the two phase rating process. The example service is a simple composed web-based email client. As shown in Figure 4 below, the service is comprised of a web based GUI service and a composed

service providing email transfer functionality. The latter is itself comprised of an SMTP service (for sending email) and an IMAP services (for receiving, storing and managing email). In our scenario provider A is providing both GUI and the SMTP services, whilst provider B provides the IMAP service. Provider B could be a user's provider in his/her home country, whereas provider A could be a local provider in a country that the user is visiting on business. We assume that provider A offers a percentage per-service discount every time one of its services is directly composed together with a provider B service.

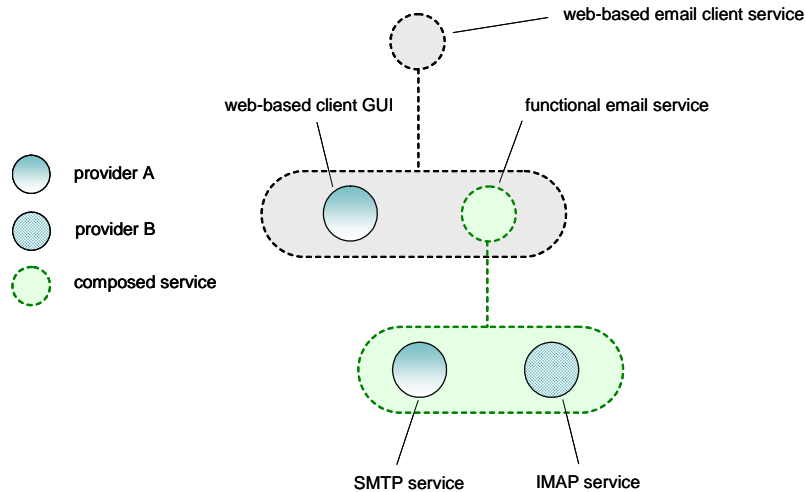


Figure 4: Composed Web-based Email Client Service

Below are simplified charging schemes for each of the atomic services:

| | |
|----------------------|---|
| <i>ProviderID:</i> A | <i>ServiceID:</i> SMTP |
| <i>Part 1:</i> | Charge = <NumberOfEmailsSent> * €0.06 |
| <i>Part 2:</i> | If Provider(<OtherService>) = B then: Discount = Charge * 0.10 |

| | |
|----------------------|---|
| <i>ProviderID:</i> B | <i>ServiceID:</i> IMAP |
| <i>Part 1:</i> | Charge = <NumberOfEmailsReceived> * €0.04 |
| <i>Part 2:</i> | |

| | |
|----------------------|---|
| <i>ProviderID:</i> A | <i>ServiceID:</i> Web-based GUI |
| <i>Part 1:</i> | Charge = <HoursOfUsage> * €0.05 |
| <i>Part 2:</i> | If Provider(<OtherService>) = B then: Discount = Charge * 0.10 |

Let us assume that in the course of a single day the user is logged into the web-based email client service for 8 hours continuously, sending 25 emails and receiving 40 mails:

Phase 1:

$$\begin{aligned}
 \text{GUI Interim Charge} &= 8 * \text{€}0.05 &= \text{€}0.40 \\
 \text{SMTP Interim Charge} &= 25 * \text{€}0.06 &= \text{€}1.50 \\
 \text{IMAP Interim Charge} &= 40 * \text{€}0.04 &= \text{€}1.60
 \end{aligned}$$

Phase 2:

$$\begin{aligned}
 &\text{Bottom Level (SMTP and IMAP):} \\
 \text{SMTP Charge Delta} &= -(\text{€}1.50 * 0.10) &= -\text{€}0.15
 \end{aligned}$$

| | | |
|--|---|---------------------------------|
| IMAP Charge Delta | = | €0 |
| Transfer Charge | = | (€1.50 - €0.15) + €1.60 = €2.95 |
| Middle Level (GUI and Email Transfer Service): | | |
| Email Transfer Delta | = | €0 |
| GUI Delta | = | €0 |
| Master Composed Service Level: | | |
| Charge | = | €0.40 + €2.95 = €3.35 |

In this case the final charge is €3.35, compared to an amount of €3.50 were the individual service charges summed. The discount on the SMTP service was applied only in the case where it, as a provider A service, was directly composed with a provider B service.

6. Summary and Future Work

From a business perspective a critical issue to be addressed before dynamic service composition can be deployed is how to charge for usage of such services. If this cannot be done in a manner reflecting the business and contractual relationships between providers of the constituent services of a composite service, the commercial potential of such systems is clearly limited. This paper has discussed some of the issues relating to accounting for dynamically composed services, concluding that accounting systems must be substantially re-engineered before commercial environments like the DBE can be realised.

Focussing on rating aspects, we presented a novel two-phase rating process based on the use of two-part charging schemes that is being implemented as part of a DBE rating engine service. This process has been designed with the goal of allowing service providers the ability to offer incentives (and potentially disincentives) for using their services in conjunction with services of other providers. It therefore plays an important role in fostering coordination, cooperation and competition between DBE service providers. From a user's perspective, the process will allow delivery of lower cost service compositions, particularly once it has been enhanced to play a role in the service composition process itself.

Future development of the two-phase rating process will initially centre on enhancing the process to allow it handle the relaxation of some current assumptions. For example, the assumption that all transactions complete successfully is unrealistic, thus the process should address issues relating to the partial rating of a composed service. Once the process has been generalised we will address what role it can play in the DBE service composition process. In particular, rating engines could provide a recommender / service composer with estimates of the likely cost associated with employing a service in a composed service, crucial in cases where cost is the main criterion for recommending use of particular services. In the longer term we intend to turn our attention to the myriad issues involved in billing and payment processing for composed services for which it may be unclear who owns the services, or is responsible for meeting agreed service level agreements.

7. References

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