Dynamic Service Aggregation in Electronic Marketplaces

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In first-generation electronic marketplaces service providers post information about their products, and service consumers post information about their needs. The matching is based on a market-dependent ontology, and standardised negotiation processes are supported by market mechanisms like auctions and exchanges. The final result is a one-to-one business relationship managed directly by the parties, outside the boundaries of the electronic marketplace. For second-generation electronic marketplaces the focus shifts on complete solutions. The capability to aggregate multiple services in order to match a specific service request should be provided as an internal service from electronic marketplaces. As an alternative, the electronic marketplaces should at least enable specific service providers to sustain effectively aggregation-oriented business models.

After an overview of electronic marketplaces, we introduce the concept of e-services as electronic virtualisation of standard business services. We then present DySCo (Dynamic Service Composer), which includes a model and a reference infrastructure for e-service management and composition. Based on DySCo, a prototype has been developed for dynamic service aggregation through negotiation in multiple marketplaces. The prototype is presented, and the implications of the underlying business model are discussed.

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Keywords: electronic services, electronic marketplaces, service composition, service delivery, B2B interaction processes.

Introduction

E-business and e-commerce have certainly attracted a lot of attention from software vendors, system integrators, solution providers, and ultimately from businesses and the research community. The overall idea of e-business and e-commerce revolves around offering to customers and business partners the capability to automate their interaction with the sales or procurement department of a company. The underlying assumption is that the Internet acts just as an additional channel, and the impact on businesses is mainly in terms of increasing the speed of existing production processes. The e-service model [13] challenges this assumption, and proposes a far more pervasive view of what the Internet can do for businesses.

In the e-service model, any type of asset can be exposed as a service to potential users inside and outside the boundaries of a company. As a consequence, the way in which companies can acquire the assets they need to sustain their business processes is impacted. The focus shifts from the connection to a specific business partner, to the definition of a specific business need. The link with the specific business partner that offers the best conditions for a service, at every point in time will be built exploiting the aggregation power of open electronic marketplaces [1].

The first step to turn an existing asset or service into an e-service revolves around accessibility. The electronic virtualisation of the service has to provide communication channels that support automated conversational capabilities. Automation is fundamental at each step of the service delivery chain. Beyond the basic capability to exchange electronic messages using standard protocols on top of an XML transport, the business logic behind the service provision and partner interaction has to be enforced. For example, the service offer has to be presented in a way that allows automated discovery to take place. The service description should enable advanced offer-request matching (beyond the basic pricing), as well as automated negotiation on contractual terms and parameters. The role of advanced directory services (e.g. UDDI), and in particular of electronic marketplaces is fundamental. An e-service is not a standalone entity; rather it is a first-class citizen of a highly dynamic ecosystem enabled by e-marketplaces.

The second step towards the realisation of the full potential for the e-service vision focuses on composition and interaction orchestration. Beyond business conversations for point interactions [22], an e-service has to expose all the interaction processes involved in the service delivery. Far from saying that a company should expose its core competences, the requirement is to handle the business networks dynamically created by each and every instance of service delivery [2, 25]. A service delivery may no longer be a one-to-one (buyer-to-seller) relationship. As an example, let us assume that the company iBuild has selected the company iMove for a shipment contract. The final product of iBuild may be packaged by a company iPack, and iBuild may want iMove to interact with iPack for arranging the logistics behind collecting the goods. Similarly, iMove operational structure may be such that it focuses on hub-to-hub transport using lorries, and it relies on partners for the hub-to-customer transport. In the case of the service sold to iBuild, iMove may select (directly or using an e-marketplace) a company iVan to do the first leg of transport. As a consequence, iVan has to synchronise with iBuild and iPack. The end customer will still be iBuild in the same way as the overall responsibility for the end-to-end transport will still be on iMove, as far as both iBuild and iMove are concerned. The interesting thing to observe is how in the scope of a specific instance of service delivery, multiple parties are dynamically pulled together. Some of them know some of the others, but in some cases (e.g. iVan) the service providers might not have had previous relationships. From an operational point of view, an e-service should be able to cooperate with a dynamically selected mix of other e-services. This imply the capability to automatically verify the behavioural compatibility of the various execution processes, as well as the capability to adapt them (within feasibility boundaries) in order to make cooperation possible.

Given their fundamental role as enablers for the e-service model, in the first part of this document we present an overview of electronic marketplaces. The focus is on the business perspective, and on a basic categorisation framework. A definition for e-services is presented, and the compositional aspects of the e-service model are discussed. We then introduce DySCo (Dynamic Service Composer), which includes a model and a reference infrastructure for e-service management and composition we developed in HP Labs. Based on DySCo, we also developed a prototype for automated service aggregation in the freight market. The prototype is described, and the business impact of the proposed model is discussed.

Overview of Electronic Marketplaces

The notion of electronic marketplace (e-marketplace) derives from the aggregation of a number of integrated business services, enabled and delivered via the Internet [4, 8]. The characteristics of an electronic marketplace (e.g. membership, regulations, service offer) depend on the organization that offers the e-marketplace itself. Such organization is referred to as e-market maker [2]. E-market makers are business-to-business intermediaries. They operate in the supply chains in various vertical and horizontal industries, with the aim of introducing new efficiencies and new ways of selling and purchasing products and services [17, 26].

An e-market maker provides content, value-added services, and often (but not always) commerce capabilities. An e-marketplace is managed either by a third-party vendor or by multiple dominant participants within the community. E-market makers aggregate content, provide value-added services, and offer multiple vendor alternatives. At a very high level, e-marketplaces can be segmented into three types. These three types include the following:

- Vertical marketplaces
- Horizontal marketplaces (also known as "functional marketplaces")
- Enabling technologies

Vertical marketplaces, as the name suggests, serve a specific vertical industry, such as chemicals, electronic components, bandwidth, and so on. These marketplaces focus on understanding industry practices, and automating the inter-company interaction aspects of business processes [9]. They automate vertical supply chains by digitising and normalizing product catalogues; they create market opportunities by developing product exchanges.

Horizontal marketplaces span across industries and automate functional processes, such as maintenance, repair, and operations procurement, project management, human resource services, advertising, IT services, and so on. Horizontal marketplaces aim at making these processes more efficient; often these horizontal marketplaces are an extension of enterprise software or services (such as buy-side software or IT outsourcing services).

The enabling technologies provide a platform upon which vertical and horizontal marketplaces are built. These technologies are marketed by organizations such as Ariba, CommerceOne, TRADEX Technologies, BusinessBots, Trading Dynamics, Moai, and so on. These companies sell products that provide information publishing tools, catalogue software, business process workflow features, transactional capabilities, auction/reverse

auction capabilities, translation capabilities for multiple standards and formats, transaction data-scraping capabilities, payment services, and customer relationship management functionality. Vendors of enabling technologies usually employ a business model based on a combination of software licensing, custom consultancy, installation services, and, significantly for traditional software vendors, on transaction fees for the goods and services negotiated [15]. The e-market makers operating the horizontal and vertical marketplaces employ business models based on advertising revenue, subscription fees, and/or transaction fees.
Beside the general classification [16] based on vertical vs. horizontal, e-marketplaces can be classified depending on two key aspects: level of transaction automation, and impact on pricing and sales models (Figure 1). Based on these criteria, four main category of e-marketplace emerge:

- Content and/or community portals
- Channel enablers
- Commerce hubs
- Dynamic marketplace

This classification is crucial in order to understand the real impact that e-marketplace can have on businesses, as well as the different pictures that businesses have of electronic marketplaces [9].
In the remaining part of this section, we characterize in more detail and present some examples of existing e-marketplaces for each category.

Content and Community Portals

Content and community portals [3] provide value-added content, such as specification sheets and part descriptions for design engineers, buyer guides for small companies, and even hosted software. They may also provide bulletin board functionality for sellers and buyers to post information about products and services they want to buy or sell. These portals earn revenue by posting advertisements or collecting subscription fees. Alternatively, they may earn revenue by charging sellers a finder's fee for successful sales leads. In general, buyers and sellers can "find each other" in a content and community portal, but they cannot close transactions. Examples of content and community portals are VerticalNet, Smart Online, and QuestLink.
As an example, VerticalNet operates about forty web sites devoted to a specific topic or industry. Examples include Photonics Online, Pollution Online, Meat and Poultry Online, and PropertyAndCasualty.com. Each site has a similar appearance and includes news, member-generated content, chats and forums, buyer guides, and career information. VerticalNet is a sales lead channel and receives a finder's fee for successful leads. VerticalNet is adding transactional capabilities, so its sites will migrate to the efficient commerce hub or dynamic marketplace models.

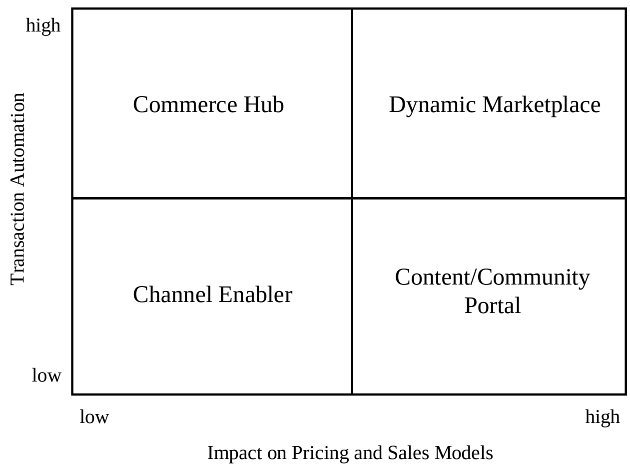

Figure 1: E-marketplaces classification

Channel Enabler

Channel enablers [2, 26] are common in industries in which suppliers heavily rely on channels of distributors, brokers, and agents. In such situations, suppliers may be hesitant to initiate direct sales. In industries characterized by this dynamic, e-market makers have mainly two choices: become a virtual distributor (and compete with the channel), or enable the channel. Channel enablers sell a commerce software and hosting solution to help the channel to participate in e-commerce.
An example of a channel partner is ChannelPoint, which provides an insurance distribution solution. ChannelPoint's solution includes a software and networking platform, as well as professional services, that enable insurance brokers and agents to lease or build a storefront on the Web, to obtain Extensible Mark-up Language (XML)-structured data from carriers, and to automate the workflow associated with the insurance sale and post sale processes.
Another example of channel enabler is iPrint.com. Best known for its consumer-oriented Web storefront for printed materials, iPrint.com also provides a software and network solution for distributors of paper product manufacturers. The company provides commerce-oriented software that accommodates the many variations associated with printed materials (font type, font size, font colour, paper grade, paper size, and so on). iPrint.com hosts a marketplace and data centre. The business model for this solution involves a percentage of the transaction. The percentage varies by volume, and ranges from 3 percent to 11 percent or more. iPrint.com may also receive an advance against anticipated revenue. In this model, the fees are paid by the manufacturer.

Commerce Hubs

Commerce hubs [16] aggregate suppliers' catalogues and create product taxonomies that enable better buying decisions. They decrease telecommunications costs for both buyers and sellers, and they become virtual distributors offering suppliers a new channel (as in the case of e-Chemicals). They provide integration to back-end systems, sometimes

through enterprise procurement applications that they develop (e.g. Chemdex), distribute or link to (e.g. SciQuest), or offer through software adapters (e.g. Networld Exchange). They provide real-time pricing, order status and, in some cases, product availability information.
The model on which commerce hubs are based works best for products that are standardized, do not require customisation, and for which a price arrangement has been negotiated [25]. They help sellers reach new buyers, but their value is even bigger for buyers. Buyers are supported with buying power aggregation, efficient product-searching capabilities, integration to back-end systems, and spot buying services.
The business model for commerce hubs can be a combination of three elements: (1) a percentage of the transaction, (2) aggregation of suppliers' goods, negotiation of a volume discount from suppliers in advance, and mark-up of products for sale to buyers, and (3) subscription fees from buyers or sellers.
Instill, in the food service industry, is a significant example of commerce hub. Instill connects food services providers (for example, restaurants or hotels) with distributors. It connects these organizations in an Internet-based trading network that operates much like a VAN or an extranet.

Dynamic Marketplaces

Dynamic marketplaces [14, 15] employ a commerce model whereby product pricing is negotiated within the marketplace through auctions, reverse auctions, request for proposal/request for quote processes, or bid-ask matching exchanges. In the literature there are three main types of dynamic marketplaces: seller advocates, buyer advocates, and neutral exchanges.
Seller advocates are all about exploiting the Internet's power to connect to buyers and finding new and better channels for sellers. Seller advocates usually focus on sales or auctions of off-spec or secondary products, new products or other products for which scarcity is driving up prices, and information on transactions that lets sellers see their average deal sizes (and other metrics), and lets buyers review their winning and losing bids. Seller advocates' value lies in providing sellers with the ability to sell products through new channels or at higher prices than otherwise possible. The value also lies in helping sellers find the market value of scarce products (for example, in new product introductions).
Buyer advocates partner with buyers to provide stronger buying power and increased access to suppliers. FreeMarkets is an example of a buyer advocate. FreeMarkets targets buyers of custom-engineered parts. It provides purchasing consulting services, and hosts an anonymous reverse auction online. To ensure the success of its reverse auctions, FreeMarkets maintains a stable of negotiators behind the scenes to stimulate the sellers to lower their prices. Other buyer advocates seek to aggregate purchasing power of small buyers.
Online exchanges are neutral, managing purchases and sales among multiple buyers and sellers. The online exchange can be characterized a few elements. The commerce model is usually bid-ask (with the exchange keeping the spread, which may range from a few basis points to 8 percent). In an exchange, buyers can be sellers and vice versa. Exchanges drive what in the literature is referred to as “market liquidity” (that is, a critical mass of buyers and suppliers). They work best for commodity and near-

commodity products, for which structured descriptive information facilitates reasonable price/quality comparisons.
There are many examples of exchange, including Altra (energy and liquid fuels), Arbinet (telecommunication bandwidth), ChemConnect and CheMatch (chemicals), and PaperExchange.com (containerboard, paperboard, fine paper).

E-Services Vision

Until recently, the Internet was about the creation of e-business and e-commerce systems, and it was dominated by web sites and storefronts. We have now entered the next Internet evolution: the proliferation of e-services. E-services are modular, nimble, electronic services that perform work, achieve tasks, or complete transactions [12]. Almost any asset can be turned into an e-service and offered efficiently via the Internet to drive new revenue streams. Chapter 1 of the Internet was about businesses getting wired to their employees, customers and partners; key business processes getting linked to the Internet, and a critical mass of consumers coming online.
Chapter 1 was about the creation of e-business and e-commerce systems that form a critical foundation. Businesses were learning how to use what looked like a promising new tool. Now, the Internet is ready for its next evolution. It won't be about businesses looking at the web as a technology. Internet has been absorbed into the core business infrastructure, and businesses are ready to capitalise on this new asset. Chapter 2 of the Internet will be about the mass proliferation of e-services.
These services will be modular and combine and recombine to solve problems, complete transactions, and make life easier. Some will be available on web sites, but others will be delivered via TV, phone, pager, car, email in-box, or virtually anything with a microchip in it. Some will even operate behind the scenes, automatically working on behalf of consumers and providers.

A definition: *an e-service is any asset that is made available via the Internet to drive new revenue streams or create new efficiencies.*

In Chapter 2, successful companies will be those that determine how to turn their assets into services delivered via the Internet. Successful companies will adopt an entrepreneurial approach to looking at their assets—figuring out how to best leverage not only their core business offerings, but also their proprietary processes, data, relationships, knowledge, experience. In Chapter 2, we will see more companies turn these assets into services and offer them via the Internet.
From a technology perspective, there is a proliferation of initiatives in the industry and within standard bodies aimed at better exploiting the potential that the Internet has for businesses. Leveraging these efforts, HP [12] is promoting a comprehensive framework oriented towards making the e-service vision become a reality. The ability to expose services in a way that they can be automatically visible and accessible to potential customers is the focus of this service framework specification (SFS). The work described in the next sections of this paper is based on such framework.
The SFS [12] defines standard business and technical conventions that allow e-services to dynamically interact with each other. These interactions which include discovery,

negotiation, composition, measurement and monitoring are based on a common interaction model and enables disparate business processes (whether RosettaNet or ebXML) to be represented as a standard SFS conversation on the Internet. Using a common means of defining and implementing Internet e-services, companies can deploy e-services that can collaborate across organizational and market boundaries. Market makers, aggregators, and auction services can freely interact in a dynamic, yet secure open services marketplace. In such a dynamic market place the SFS adds value in the form of cross-platform interaction, componentisation, diverse business models and end-to-end service provisioning.

Existing Approaches to Service Composition

Most of the existing e-service models and infrastructures approach the virtualisation of a service focusing on the problem of automated access. Corollary services revolve around the discovery (brokering) of service providers offering services matching a given service description. Example of this approach can be found in the solutions behind practically every existing web site and EDI-based extranet solutions [23].
COSMOS [10] and Aurora [18] are two substantially equivalent examples of advanced architectures for e-service management. They enhance the standard open market approach to e-services (based on the find and use model) with workflow-based facilities to statically connect existing e-services together. The network of services deriving from this integration constitutes the backbone for the creation of a new service. This was the approach used also in the Arjuna project [19].
The service model subsumed by these solutions is the one of a functionally complete service. When a service is completely implemented, it is externalised using a functional interface. For service discovery, a service description is usually provided based on some type of ontology (e.g. UDDI). The infrastructure then enforces the access to the service through the conversational schema specified by the interface. Agent-based solutions for e-service platforms substantially follow similar approaches in terms of service virtualisation. The differences in terms of interaction model do not bring major changes in the service integration model [24].
Main limitation of such a model is the rigidity in the interconnection and integration between services. Implementing integration logic into the structure of a service increases the complexity of the service. Moreover, the adaptation of the service to new environmental conditions requires the re-engineering of the service itself.

Service Composition Model in DySCo

DySCo (Dynamic Service Composer) is a framework for e-service management and composition we developed in HP Labs in the past two years. Main elements of the framework are a service model and a reference infrastructure for system implementation. The service model in DySCo is based on the ideas of functional incompleteness, multi-party orchestration, and dynamic service composition. A service can be partially incomplete in terms of implementation, provided that in its electronic virtualisation indications are present about the kind of support services it needs to be integrated with, as well as the type of integration required to become fully functional.

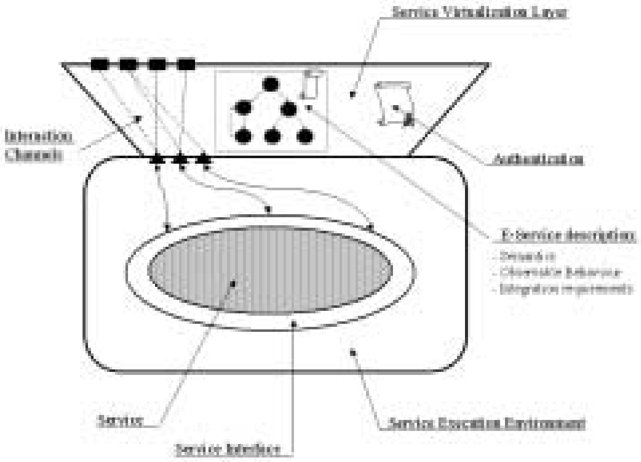

Figure 2: E-service model

In the virtualisation layer (Figure 2) that makes a service become an e-service, the focus moves from the access logic to the integration logic. The challenge for the service provider is to adopt an integration model based on roles and behavioural descriptions. The traditional approach would be to first find a service provider (based on what it does), and then working on the integration with internal processes (based on how it does it). With e-services, the idea is that the search for a service provider (including negotiation activities) is based also on its operational model. The customer interaction process is something that the customer is exposed to anyway. The idea is to expose it in the first place, so that both service consumer and service provider can better evaluate their operational compatibility. Third parties may also be involved in the services delivery, and their role can be specified in the same way.

Assuming a service offer organised around this model, the operational structure of the service itself can be designed with a new approach. First the need for specific support services is identified. Next the expected interaction processes with the potential service providers is identified. At this point the service can be actually put on offer on a conditional basis. A specific service instance is sold, only if the adequate support services can be purchased. The concept of adequacy is heavily based on operational compatibility, in order to ensure a smooth execution of the overall service. The implications on pricing and availability are significant.

The advantage of this approach over existing ones derives from the fact that the e-service can actually deliver something that the service alone is not capable of. A service provider can focus on the implementation of the core aspects of a service. The e-service infrastructure will take care of the integration with the most suitable e-services, to completely enable the new e-service (Figure 4). Integration logic coexists with service logic, still remaining two separate entities in terms of management and visibility.

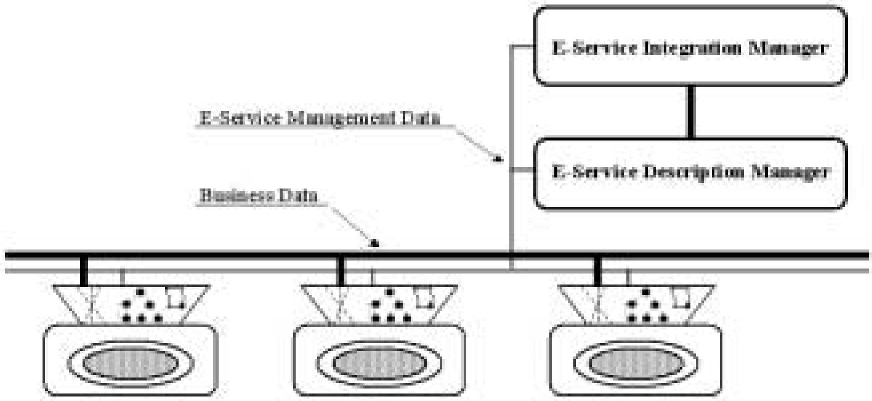

Figure 3: E-service infrastructure

The enhancements with respect to standard conversation-based approaches (e.g. FIPA [7]) are in terms of the source and the use of the meta-information for service interaction. The interaction dialogues can be automatically generated depending on the roles that a specific partner service plays. Provided that all the roles are covered, it should be transparent if just one or more service providers cover them. The emphasis is definitely on the orchestration for the work of a number of partners, more then on a set of one-to-one conversations localized at specific points of a service execution.
Concerning the implementation of systems based on the service model proposed, DySCo mainly provides the blueprint for the infrastructure required. Different technologies and solutions can then be used for the implementation. An example is given in the next section. Description of the semantics, observable behaviour and integration requirements of a service (e-service description), and enactment infrastructure for e-service integration (e-service infrastructure) are discussed in more detail.

E-service description

The semantics and characteristics of a service (e.g. cost, availability, response-time, available options) are described with an ontology-based approach, and encoded into XML documents. Observable behaviour and integration requirements are captured using a workflow-style approach. A service is associated with a process describing the interaction of the service with the outside world. The integration with other services is captured by the interaction processes expected with these services. The emphasis is on roles more then on specific services/service providers.
The formalism for describing the interaction process has (as an indication) the basic capabilities required by the standard proposed by the Workflow Management Coalition [11] for workflow specification formalisms. The idea is to be able to express the fact that actions/events happen in a certain sequence and under a certain set of conditions. The formalism offers the capability to express well-defined process structure. It is also flexible in terms of the description of the observable actions/events associated with the nodes in the process. An XML-based approach is used, whereby a specific DTD is defined for the description of the process structure, as well as for the observable actions and conditions.

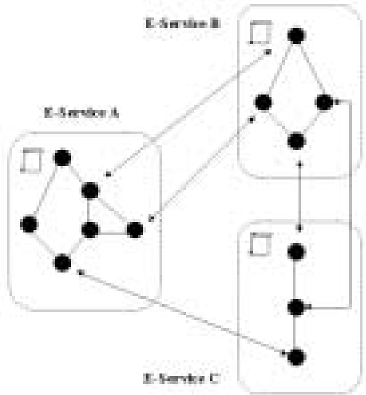

Figure 4: E-service integration

Execution infrastructure

The service virtualisation layer (Figure 2) is the part of the e-service infrastructure that enacts the e-service description for a service. Among the main activities it is in charge of, there is the management of the interaction channels (e.g. monitoring, activation, and translation), as well as the management of the service observable behaviour (for each e-service instance). The description of the observable behaviour declared by an e-service is used in order to monitor the actual behaviour of the service, as well as dynamically manage the service requirements depending on the evolution of specific service instances.
E-service descriptions are deployed in the service virtualisation layer, and managed by a specific component of the e-service infrastructure (Figure 3), that we refer to as e-service description manager. The description manager, among other activities, maintains the ontology shared by the e-services, and supports the e-service integration manager by providing information about services with specific semantics, interaction behaviour and characteristics.
Together with static information about e-service descriptions, the description manager can handle dynamic information about other characteristics of an e-service (like pricing, availability, and load). The integration manager can use this information in order to make convenient choices during the e-service integration process. The e-service integration manager is in charge of the choices in terms of which services should be integrated and the way they interact (Figure 5). The integration can be required on a "per service" basis, on a "per service instance" basis, or intermediate solutions.
In a simple situation, the integration consists in finding a service whose semantics and behaviour match the one required by one (some) of the roles in the initial E-service description. If this is not possible, the integration manager can try to reproduce the semantics and behaviour requested for a role by composing more than one service. In both cases a chain reaction can be started, but solutions are in place in order to make sure that either it converges or that circularities are managed.

The DySCo Infrastructure

Based on the concepts in the DySCo model, in this section we present a brief outline of the prototype developed at HP Labs for an e-service-enabled ecosystem. The prototype infrastructure for DySCo reproduces a real-world scenario, with a number of e-service providers relying on an electronic marketplace for offering their services. Each e-service exposes different types of information (meta-data), ranging from a functional description of the service to availability and pricing models.

E-service description manager and e-service integration manager (Figure 3) have access to specific meta-data information about the service. These meta-data describe both the customer view on the service delivery process, and the partner view on the service implementation processes. This information can be generated automatically, applying a role based projection algorithm to the description of the business processes implemented by the service provider [20]. The algorithm dynamically adapts the definition of the interaction process between customer and service provider based on the roles that the customer accepts to play (e.g. receiver of the service, receiver of the invoice, quality assurance monitor). The interaction with partner service providers is handled in the same way. The interaction process becomes a part of the service contract between customer and service provider. The electronic marketplace mediates the interaction between the parties enforcing the processes specified in the service contract.

Concerning the technology used, the platform for DySCo is based on the HP business process management system Changengine. Changengine [13] is a comprehensive system that covers all aspects of business process lifecycle, from the definition to the enactment. Motivating factors in the choice of Changengine were its high-performance process engine, the web based management interface, and its wide range of adapters to databases and legacy applications. The purpose of DySCo is to define a reference framework to turn business services into e-services; therefore the infrastructure used aims at reproducing a real-word environment. Federation capabilities based on open protocols and programmatic interfaces for access to process instances are also major features of Changengine. The Java API provided with Changengine for process interaction is the main building block for the mediation system we developed for the electronic marketplace.

In DySCo each service provider is equipped with Changengine. Automated process management is a prerequisite for the e-economy. The electronic marketplace is also equipped with Changengine (Figure 5) that, among other activities, manages the interaction processes between customers and service providers.

Service Aggregation in FreightMixer

In this section we present an application scenario for the concepts and technology in DySCo. The business domain is the freight market. The scenario and related prototype was used in an impact study for e-services and e-marketplaces involving a number of British and international operators in the field [5].

For its very nature [6], the freight market is an area where online trading and electronic support to service delivery is receiving a lot of attention from businesses. Two fundamental reasons for this trend are the regulation framework of the market and the structure of the goods traded. The unit of trade is freight space. Containers follow specific routes, and they can usually be loaded with different types of goods. The unit of cost is largely dependent on the space taken by the container, and the main objective for transport providers is to use all the space within each container they send around the world. The information required for service provision revolves around the space occupied by the goods, the pick up and delivery point, time constraints, and level of insurance. The market itself is highly structured, and a consolidated body of rules and regulations is in place so that all the parties involved in a transaction know exactly what are their roles and responsibilities. Information on availability and negotiation speed is crucial for the profitability of the service providers.

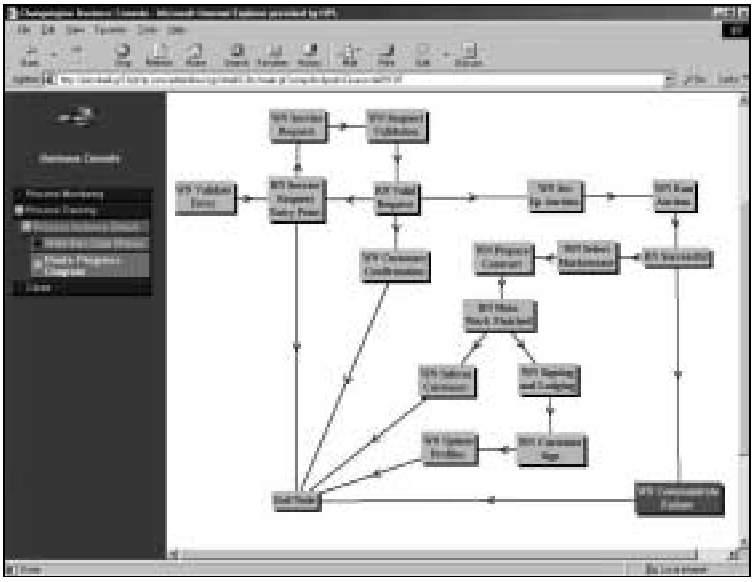

Figure 5: Auction process in an e-marketplace

Assuming a scenario where service provision reflects the e-service model and business interaction is mediated by electronic marketplaces, we developed a prototype for a new generation of freight service providers. Key capability for this new type of service provider is to assemble service solutions more dynamically, by aggregation and composition of existing offers. An end-to-end transport is composed by a number of connected legs, where each leg is acquired by negotiation in multiple electronic marketplaces. The profitability of the overall model depends on the skills of the service aggregator in terms of exploiting existing offers in the market, and composing them with the integrations required to obtain the end-to-end transport service for the end customer. Service aggregation and composition were our main points of investigation, hence the name chosen for our prototype service provider: FreightMixer.
From a logical and architectural implementation standpoint, FreightMixer was layered on top of the DySCo environment. The operational model of FreightMixer revolves around three main points: understanding customer needs, produce effective solution, and offer competitive prices. FreightMixer is constantly monitoring the e-marketplaces in which

the demand for its services is more likely to be generated. It can also subscribe to a wide range of directory services, so that it becomes visible to companies developing horizontal solutions using aggregation and composition models.
When a customer request arises, the core of the operational capabilities of FreightMixer is applied in order to dynamically compose a cost-effective solution (Figure 6). The knowledge that FreightMixer has of the freight market is the main asset for the company. The fact that it is captured electronically drives the automatic design and implementation of end-to-end solutions. Two crucial components of the IT infrastructure used by FreightMixer are the Negotiation Engine and the Service Composition Engine.

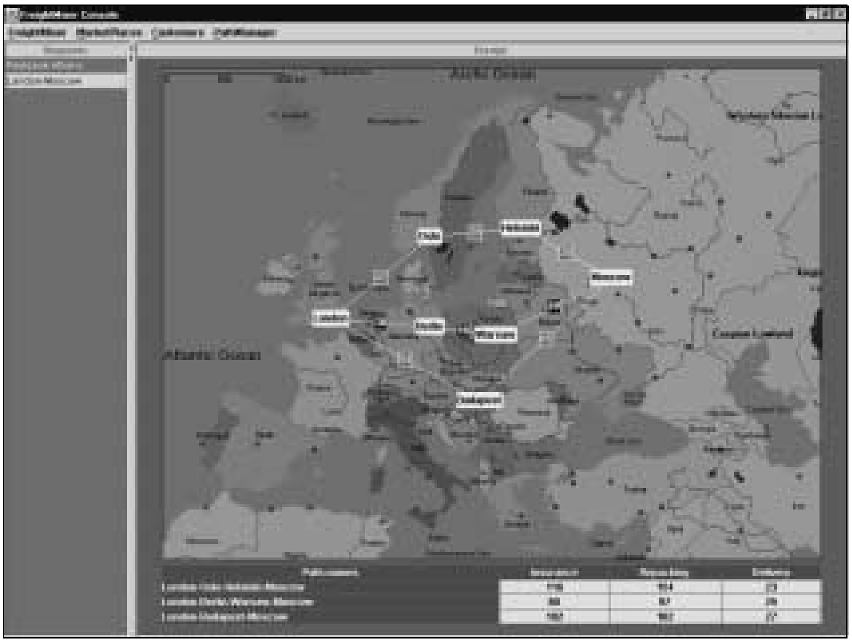

Figure 6: Service aggregation and composition

These two components work in tandem, starting from a set of possible solutions defined by the Service Composition Engine. These solutions will indicate a number of possible routes for the transportation of the goods, as well as the corollary services required (e.g. insurance, re-packaging, temporary storage).
The Negotiation Engine then starts to negotiate in the most appropriate marketplaces for the acquisition of the services. In doing so, specific techniques are applied based on parallel negotiation in multiple marketplaces [21] and the use of different trading mechanisms (e.g. exchanges, auctions, RFQs). The negotiation activity is based on multiple complex parameters, namely: pricing policy, interaction processes, time constraints, and payment procedure.
Some of the services required for a specific solution may not be available, or their acquisition cost may be unattractive. The Service Composition Engine will adapt the initial solution, incorporating the feedback from the Negotiation Engine. Based on the new information, alternative solutions can also be generated. The interaction process between Service Composition Engine and Negotiation Engine is then iterated.

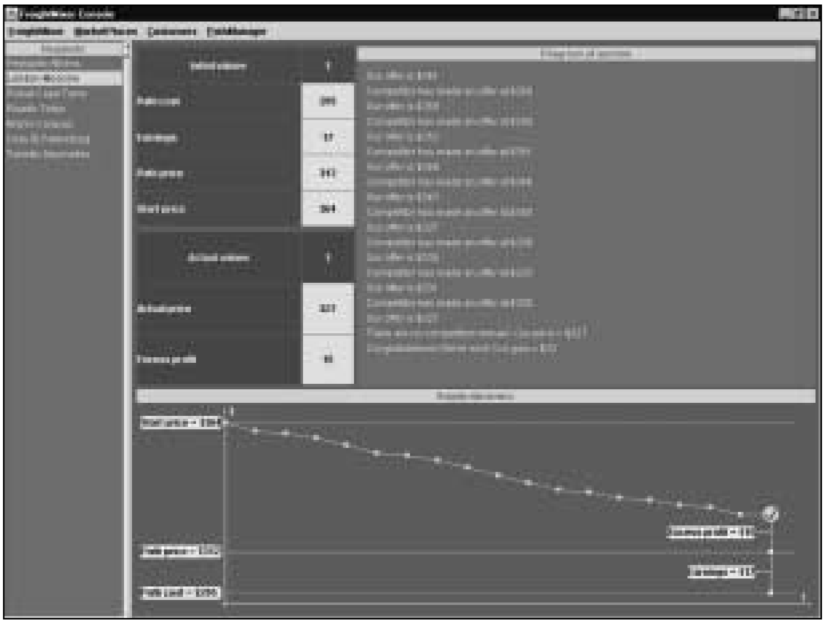

Figure 7: Automatic bidding in an auction

When a viable solution is found, FreightMixer (Figure 7) enters the competition with other potential suppliers in order to secure the contract with the customer. Again the Negotiation Engine manages the negotiation process behind the offer, balancing profit optimisation with successful acquisition of the contract.

Value of the Service Composition Engine

The precise design for the solution is crucial for customer satisfaction, but it also impacts dramatically on the costs of its actual execution. Given the volatility of the business network created, it is important that operational compatibility is verified. In the case of stable cooperation networks, the cost of mutual adjustments is spread over a number of transactions. In the case of the business network that FreightMixer dynamically pulls together for a specific service offer, the cost of overcoming points of incompatibility will fall almost entirely on one single transaction. Dealing with service providers that are e-service enabled is fundamental for the work of the Service Composition Engine.

Value of the Negotiation Engine

Time constraints and the type of trading mechanism involved are crucial in the various negotiation activities. The actual commitment to buy something may be confirmed at different stages for different mechanisms, and the same holds true for the certainty of the acquisition of a service. For example, placing a bid in an auction for a service doesn't automatically imply the acquisition of the service. At the same time, placing the bid implies a certain level of commitment. If not outbid, the bidder is forced to buy/sell in accordance with the bid it placed.

In the case of FreightMixer, the balance is among a number of dramatically conflicting forces; namely: time and acquisition risks. If the offer arrives late to the customer, the delay can compromise its likelihood of favourable acceptance. The problem is that rushing the offer may compromise the optimisation of its cost-effectiveness. Then there is the acquisition risk. On the one side, FreightMixer may need to commit itself to buy some of the services it needs in order to secure a certain price. If the bid to the potential customer is not successful, it may have to bear their cost entirely. On the other side, FreightMixer may place the bid to the customer before having secured some of the necessary services at a specific price. This means that if the bid to the customer is successful, FreightMixer will be bound to deliver at the price promised in the bid. If the cost of acquiring the services is higher than expected, the profit margin could be eroded.

Conclusions

In this paper we focus on the possibility for e-services to be dynamically aggregated, composed with, and integrated into other e-services and more traditional systems for supply-chain management. Based on the concepts of service incompleteness, multi-party orchestration, and dynamic service composition, we propose DySCo (Dynamic Service Composer) as a reference framework for the development of e-service-oriented ecosystems. A reference infrastructure based on the DySCo model is presented, together with its use in an application scenario related to the freight market. The scenario gives us the opportunity to discuss the interdependencies between e-services, electronic marketplaces, and new business models.

Electronic marketplaces may represent yet another channel for some companies, but they are becoming a key element for the operational model of others. Electronic marketplaces create a new dimension in terms of speed, aggregation power, and market opportunities. The combination of the intermediation properties of electronic marketplaces with the delivery capabilities of e-services makes the existence of companies like FreightMixer feasible.

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