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ESSENTIAL SERVICES FOR P2P E-MARKETPLACES

Diogo Ferreira[1], J. J. Pinto Ferreira[1,2]
[1]*INESC Porto,Campus da FEUP, Rua Dr. Roberto Frias 378, 4200-465 Porto, Portugal*
[2]*Faculty of Engineering U. P., Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal*
dmf@inescporto.pt,jjpf@fe.up.pt

Existing e-marketplaces, built on traditional client-server architectures, severely restrict the scope and dynamics of B2B interactions. Peer-to-peer (P2P) architectures will provide far more decentralised infrastructures, while allowing a much wider range of business patterns to take place. The purpose of this paper is twofold: (1) to argue that interaction over a P2P network better resembles the way enterprises perform business with each other, and (2) to point out a set of essential services required to make P2P infrastructures fit for B2B exchanges. An overview of those services is presented, based on one of the leading P2P platforms (JXTA).

1. INTRODUCTION

The rise of a global and ubiquitous infrastructure such as the Internet has brought speed and connectivity to the whole spectrum of B2B exchanges, from simple document delivery to complete and automated trading procedures. E-business possibilities have led to new business-to-business (B2B) models, particularly the *e-marketplace*. However, traditional Web-based, client-server architectures exhibit several limitations mainly because they are a centralised solution for a problem which clearly requires a distributed infrastructure.

On the other hand, the impact and success of completely decentralised, peer-to-peer (P2P) solutions has placed this paradigm as a better alternative to cope with B2B trading requirements. Recently, several P2P infrastructures have been proposed (Gnutella, FreeNet, JXTA, Jabber, etc.). Still, these infrastructures lack essential services allowing companies to use them as business platforms. This text proposes and describes the implementation of those services, which will support B2B exchanges over P2P-based e-marketplaces.

2. THE TRADITIONAL E-MARKETPLACE

A significant part of recent B2B developments has been devoted to *e-marketplaces*, Web portals gathering both buyers and sellers and fostering business transactions among them. Though there are e-marketplaces of all sizes, the typical ones focus on

a particular type of business (for example automotive parts, financial funds or chemicals). They are also *neutral*, i.e., they are set up and run by an independent third party. E-marketplaces usually comprise two main areas: one dedicated to the member suppliers advertising selling offers and another to member buyers where they advertise purchase needs. Additionally, there is usually support for auctions and reverse auctions, with buyers bidding for supplier offers or sellers attempting to fulfil demand at the lowest price, respectively.

Typically, a prospective seller publishes offers while a prospective buyer searches for products or services by looking up offers on the marketplace database. If an interesting offer is found, the entity running the e-marketplace will work as a *broker*, mediating contact between buyer and supplier. Both buyer and supplier will always interact solely through the e-marketplace, and never directly. In the end, the broker will usually charge a service fee taking the form of a transaction value percentage.

Thus, the traditional e-marketplace exhibits the following characteristics:

Centralised repository. An e-marketplace is a centralised information repository where buyers and sellers publish and subscribe information of their interest.

Opaque interfacing. Though buyers can browse offers, the e-marketplace will not reveal trading partners' identity in order to assure its own intermediary role.

Static information. The information on that repository is typically static in nature, declaring what a seller is able to provide for what price, anytime. Because an e-marketplace is opaque, offers cannot be tailored to specific customers.

Bottlenecked structure. The e-marketplace is the single interface for all trading partners, and therefore it must be prepared to handle the simultaneous transactions of all registered users.

Loosely connected. Being a single interface for all business transactions, it is also a potential point of failure. In the case where an e-marketplace ceases operation, its trading community will become unavoidably scattered.

Fixed exchanges. All B2B exchanges obey to a set of predefined rules of what a business partners should provide and expect. These rules may be based on B2B frameworks such as OBI, RosettaNet, or cXML (Shim et al, 2000). Because these rules are imposed by the e-marketplace, it may be quite different from what would happen if partners were to trade directly.

Price-based decisions. Buyers have to make decisions mainly on price. But choosing the supplier with the lowest unit cost may not always yield the best results.

Non-iterated agreements. Because B2B exchanges opaque, fixed and price-based, there is little support for agreements attained by iterated phases of negotiation with proposals and counter-proposals.

Short-termed partnerships. Because the e-marketplace is opaque, it is not possible to establish long-term business partnerships or initiatives.

Service charges. The e-marketplace lives on the premise that it is able to bring together buyers and suppliers, and attain successful business transactions. But imposing a fee based on transaction value may be dissuading for prospective trading partners.

3. DECENTRALIZING B2B EXCHANGES

The services provided by the traditional e-marketplace may be approached from a P2P perspective as well, bringing numerous advantages. On a P2P e-marketplace peer nodes represent both buyers and sellers. Peers may search, connect, and exchange data with other peers. In the P2P network, sellers may publish, advertise, or by other means provide information about their offers. Sellers rely on the P2P infrastructure to convey that information to other peers. Buyers, on the other hand, rely on search capabilities to locate and retrieve offers, and on the network infrastructure itself to connect and interact with sellers.

Up to now, interaction over a P2P network has been usually confined to two phases: (1) the search-and-find phase when one peer contacts several others in order to locate desired information, and (2) the connect-and-retrieve phase when the same peer obtains the intended data from another peer. For the purpose of P2P e-marketplaces this is still limited, because peers must be able to interact in a bi-directional way: first while setting trading conditions, and afterwards when attaining the previously agreed exchanges. Notwithstanding, P2P networking provides one-to-many and (possibly secure) one-to-one communication which, associated with powerful search and transfer capabilities, can significantly improve the development of business relationships on e-marketplaces.

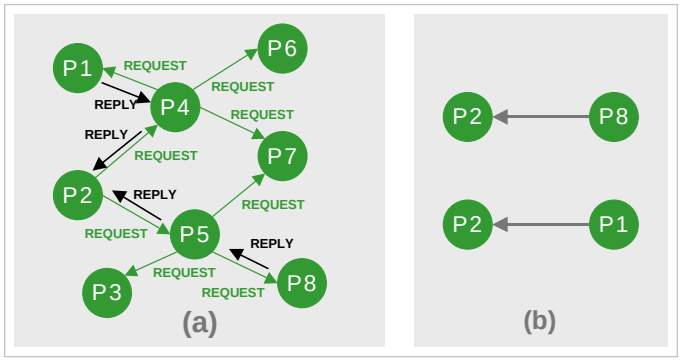

Figure 1 – Search (a) and retrieval (b) over a P2P network

This same behaviour opens a wide range of possibilities for more complex business patterns, such as the ones specified by B2B frameworks (once again like OBI, RosettaNet, cXML and others). Moreover, it allows peers to establish contracts directly, and P2P interaction is only limited by the reach of services that peers are able to deploy on the network. There may be a service for performing transactions according to OBI, and another service to deal with procurement according to cXML. Still, and before that can be done, supporting search and negotiation services must be in place. Equipped with those services, a P2P infrastructure will allow companies to perform flexible and dynamic B2B exchanges on a decentralised, broker-free marketplace.

Without further ado, it can be argued that P2P infrastructures, together with a set of supporting services, can surpass all of the shortcomings of traditional e-marketplaces pointed out in the last section.

4. DISSECTING THE B2B TRADING LIFE-CYCLE

In order to identify the essential services that P2P e-marketplaces should provide one must delve into the individual phases of the B2B trading life cycle. Figure 2 presents those phases, illustrating two distinct business processes which, according to the CIMOSA architecture (AMICE, 1993), may be referred to as denoting the *system life cycle* and the *product life cycle*, the latter being nested in the operational phase of the former one. The product life cycle leads to B2B trading needs. For example, some production steps are to be subcontracted, or a supplier for a sub-component must be contacted, or a funding partner must be found. The system life cycle, which encompasses the whole B2B trading cycle, introduces requirements for the underlying B2B integration infrastructure.

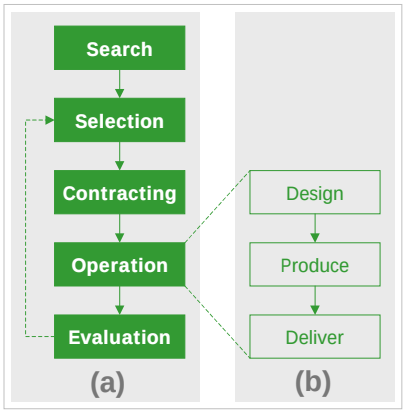

Figure 2 – System (a) and product (b) life cycles

4.1. Search

As illustrated in figure 2, the first phase is partner search. Here, companies use requirements drawn from the product life cycle to search for other key players. The search begins by issuing a search request. Specification of a search request may follow a format such as the *technology request* (TR) used to search for partners on the European Innovation Relay Centre Network (CORDIS, 2000). This format combines both human-readable information and standard business codes that allow automatic indexing of TRs. The counterpart is the *technology offer* (TO), a document following a similar structure but describing a product or service offer. For each TR, some or none matching TOs may be found. Both TRs and TOs are anonymous, specifying a contact point but concealing the identity of the company providing the document.

4.2. Selection

In response to a (one-to-many) search request, a peer will probably receive a set of matching offers, the point when the second phase – selection – begins. The selection phase is comprised of at least two smaller steps. The first step is pre-selection, i.e.,

immediately ruling out offers that seem unrelated or inappropriate. The remainder will be a set of candidates from which a choice cannot be made without further information. The second step is therefore to contact the peers referred to in the remaining TOs and, disclosing the identity of buyer and seller, proceed with further inquiries, on a one-to-one basis. Iterated steps of contact and inquiry – negotiation – may follow until the candidate offering the best conditions is found. These conditions may be based on many factors other than price alone.

4.3. Contracting

Once the business partner is chosen, a legal contract must be established between peers. The contract, called a *trading partner agreement* (TPA), formalises the legal conditions under which the trade will take place. Typical TPAs contain mainly human-readable information stating the rights and duties of each trading party (Taylor, 2001). Recent efforts in devising appropriate TPA formats for B2B exchanges (Dan et al, 2001), (ebXML, 2001) have led to specifications with a strong technological bias, but irrelevant for legal purposes. Research projects such as ECLIP (Cavanillas and Nadal, 1999), eLEGAL (Hassan et al, 2001), and Octane24 (ComNetMedia, 2001) have taken a step towards legal frameworks, but there is still little agreement as to how TPAs should be represented. This is more of a legal issue than a technological one, since the enabling technologies – languages (XML), protocols (S/MIME, HTTPS, TLS) and electronic signatures (digital certificates, X.509) – are all available.

4.4. Operation

The operation phase concerns the assignment of resources to operational business processes, as well as enacting and controlling the entire product life cycle. Some resources are internal to the company – such as employees, machines, and applications – while others are external – precisely the ones having been negotiated in the previous phases. During process execution interaction with resources should be done transparently, whether they are internal or external.

Therefore, the operation phase requires B2B front-ends to be properly integrated with the back-office systems of each company, i.e., real-time back-office integration is required, as opposed to batch-oriented integration approaches (Lamond and Edelheit, 1999). In practice, secure communication channels should be in place, as well as application wrappers or gateways allowing data to be exchanged between endpoint systems across the marketplace.

4.5. Evaluation

The final phase of the system life cycle is an evaluation phase when overall performance and the performance of each contracted partner are registered. These measures, together with a log of all activities will help the selection of future partners in forthcoming trading opportunities. Evaluation, which is a strictly internal process, is also a chance for improving both the operational process and the B2B integration services, which are the focus of the next section.

5. IMPLEMENTING P2P SUPPORT SERVICES

Several services are required in order to support the life cycle just described. First of all, a search service must match technology offers to technology requests. Then, there must be direct exchange mechanisms for peers to exchange TPAs and other documents. Additional services providing support for particular B2B frameworks could also be in place. Finally, B2B interactions must be integrated with each partner's internal business processes. This requires real-time back-office integration between the enterprise system and the P2P network, as well as the deployment of P2P-aware client applications.

While several P2P platforms exist, the JXTA project (Sun, 2001) seems to be the most comprehensive and flexible framework. In a JXTA network, peers communicate through pipes, a protocol-independent abstraction. Pipes may use TCP/IP sockets, IP multicasting or HTTP to establish a connection between two endpoints on the network, no matter how far apart. The connection between endpoints may not be direct and is usually attained through a sequence of JXTA *routers* and *rendezvous* peers that allow traffic to circumvent firewalls.

The powerful feature of JXTA is that peers may create and join peer groups where special-purpose services can be deployed. A service can be any functionality that implements behaviour on the P2P network. Services may be used for searching, interacting, or any other purpose that peer groups may find useful.

The JXTA infrastructure is based on a particular type of XML document called *advertisement*. All JXTA resources (peers, peer groups, pipes and services) are represented by an advertisement. JXTA already provides community services – particularly the Discovery Service – that allows peers to find those resources. For example, peers search for group advertisements, then join the group and search for service advertisements, which in turn may contain pipe advertisements allowing the peer to interact with the service.

Hence, the JXTA platform comprises an architecture that is quite appropriate for the development of P2P e-marketplace services.

5.1. Search services

One of the cornerstones of a P2P infrastructure is the ability to perform distributed searches on available content. It is thus not surprising that JXTA already provides its own search service – JXTA Search (Waterhouse et al, 2002). The JXTA Search service assumes there are three kinds of behaviour a peer may exhibit: information provider, information consumer, and search hub.

Information consumer applications send requests to the nearest search hub, which decides which providers to forward the request to. The search hub also receives replies and sends them back to the consumers. In many applications, a peer will act both as provider and consumer.

Peers will probably connect to different search hubs which, in turn, are connected across the JXTA network. Using JXTA Search requires, therefore, a certain number of search hubs to be running, and requires providers to register themselves on these hubs. Moreover, due to its emphasis on Web content, JXTA Search is built upon the Tomcat servlet container. Also, as of this writing, the search service requires an older JXTA release.

An alternative, lighter solution would be to build a search service based exclusively on the mechanisms provided by the JXTA infrastructure. In fact, and using the concept of peer groups and propagate pipes, it is possible for peers to submit search requests to other peers in their group, without intermediary hubs. Because the purpose of this search service is to find trading partners, it is called *Trading Partner Search Service* (TPSS).

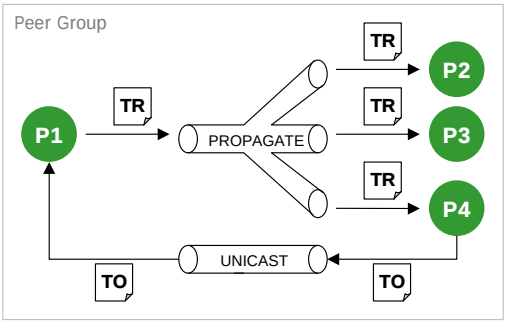

Figure 3 – The Trading Partner Search Service (TPSS)

The service is available under a group called "marketplace", with password-protected membership. When joining the group, a peer looks for a propagate-pipe advertisement that provides a one-to-all communication channel, and submits technology requests (TRs) using this pipe. At the opposite endpoints, the service matches the TR against the local technology offers (TOs) and returns the matching results. Each TR includes a unicast pipe advertisement specifying the input pipe through which the requester receives the matching TOs.

5.2. Negotiation services

Since TOs and TRs are anonymous documents, peers must have a way to exchange additional information, should a particular TO turn out to be interesting. That information is conveyed through a *Trading Partner Information Service* (TPIS). The TPIS works through a secure unicast pipe, on a request-reply basis. Each TO the search service (TPSS) returns includes a pipe advertisement for accessing the TPIS on the corresponding peer. Through the TPIS, peers exchange information such as company profile, available infrastructure, and preferred partners. Because the TPIS is a generic information exchange service there is no mandatory format for the information exchanged. Its purpose is to serve as a decision-support service during the selection phase.

Every message exchanged through TPIS should, however, include a pipe advertisement, this time for interacting with a contracting-support service, the *Trading Partner Agreement Service* (TPAS). This way, and after the selection phase is concluded, the chosen partner can be contacted in order to establish a TPA. The TPAS requires a secure unicast pipe just like the TPIS but, in contrast with the request-reply behaviour of TPIS, the TPAS allows iterated exchanges until a (digitally signed) TPA has been achieved.

5.3. Operation services

A TPA includes the pipe advertisements needed for the operation phase. Through these pipes, local applications at each peer can communicate directly, sending from or bringing messages to the local information system. This is achieved through the *Trading Partner Exchange Service* (TPES) that supports exchanges according to one or more B2B frameworks. A similar service interface is provided by the *Trading Partner Task Service* (TPTS) allowing interaction with the local resources that are accommodated in the P2P infrastructure as well.

6. CONCLUSION

Available P2P platforms are still not mature enough to support B2B exchanges such as the ones that take place on e-marketplaces. But once the proper services are in place, P2P architectures will probably surpass every other architecture by providing an infrastructure that better resembles the distributed nature of B2B trading.

This paper has pointed out some services for that infrastructure, that current P2P platforms still lack, assuming a particular B2B exchange life cycle. Clearly, though, more developments are needed in this field in order to achieve a comprehensive B2B framework of its own and, ultimately, to show the feasibility and suitability of the P2P approach.

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7. REFERENCES

1. AMICE, ESPRIT Consortium. CIMOSA: Open System Architecture for CIM. 2nd ed, Springer-Verlag, 1993
2. Cavanillas S, Nadal AM. Deliverable 2.1.7: Contract Law. http://www.eclip.org/documents/deliverable_2_1_7_contract_law.pdf, 1999
3. ComNetMedia AG. OCTANE e-contracting service concept. http://www.octane24.com/oct_home/oct_project/pro_background/chart/chart2, 2001
4. CORDIS. IRC Public Website. http://irc.cordis.lu/, 2000
5. Dan A, Dias DM, Kearney R, Lau TC, Nguyen TN, Parr FN, Sachs MW, Shaikh HH. Business-to-business integration with tpaML and a business-to-business protocol framework. IBM Systems Journal, vol.40, no.1, 2001
6. ebXML Trading-Partners Team. Collaboration-Protocol Profile and Agreement Specification. Version 1.0. http://www.ebxml.org/specs/ebCCP.pdf, 2001
7. Hassan TM, Carter C, Hannus M, Hyvärinen J. "eLEGAL: Defining a Framework for Legally Admissible Use of ICT in Virtual Enterprises". In Proceedings of the 7th International Conference on Concurrent Enterprising (ICE2001), Bremen, 2001
8. Lamond K, Edelheit JA. "Electronic commerce back-office integration". BT Technology Journal, vol.17, no.3, July 1999
9. Shim SSY, Pendyala VS, Sundaram M, Gao JZ. "Business-to-Business E-Commerce Frameworks". IEEE Computer, vol.33, no.10, October 2000
10. Sun Microsystems Inc. Project JXTA, http://www.jxta.org/, 2001
11. Taylor ML. Trading Partner Agreement Sample. http://www.mltweb.com/ec/tpa.htm, 2001
12. Waterhouse S, Doolin DM, Kan G, Faybishenko Y. "Distributed Search in P2P Networks". IEEE Internet Computing, vol.6, no.1, January/February 2002