A Framework for P2P E-Business Collaboration

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Abstract: Business collaboration systems have been based on centralized or client-server architectures. Currently it has also been recognized by the research and industrial community that such systems may also be based on the constantly evolving decentralized P2P architecture. There is however still very limited research activity on the area. In this paper, we analyze requirements of P2P business collaboration systems. Based on rigorous analysis and the recent literature, a framework of P2P based business collaboration is provided finally.

Keywords: peer-to-peer; P2P; business collaboration; multi-party business collaboration; business collaboration monitoring.

1 INTRODUCTION

Business-to-business (B2B), Business-to-Consumer (B2C) and Business-to- Government (B2G) systems have so far been based on a variety of centralized or client-server models. In the recent years, decentralized Peer-to-Peer (P2P) architectures have evolved to provide the infrastructure and non-functional characteristics required for implementing much more demanding and complex tasks. P2P systems, such as Napster, Kazaa and Gnutella have originally only been appropriate for best-effort file sharing and basic collaboration. Currently, it has recognized that business collaboration systems could also be based on the P2P model Schoder (2004), White et al. (2003), Choi and Whinston (2001).

The traditional B2B techniques, including the modern standards such as the ebXML framework, only address the issues of relative large business, even when claiming enabling of B2B infrastructure for Small and Medium Enterprises (SMEs) OASIS (2001). Larger companies have more long-term collaborative relationships which provide also more stable collaboration patterns. SMEs, on the other hand, often trend to do business in a more ad-hoc manner and constantly look for the best trading opportunities for survival and competitiveness. Interactions between SMEs are highly dynamic which is P2P by their natures. The SMEs seek partnership irrespectively. Therefore, P2P architectural framework naturally satisfies SMEs need.

The motivation of using P2P architectures to support business collaborations includes different aspects. First, using P2P architectures can reduce the cost of maintenance of a centralized server and the relevant business data, decrease the risk of a centralized server become a single point of failure and diminish the risk of shutting down the centralized server for unfinished business transactions. Second, P2P architectures provide scalable environments. It is able to deal with transient users. Third, P2P architectures offer a dynamic, ad-hoc communication channel and network organization. Moreover the failure recovery functions of P2P architectures enhance the reliability of business collaboration. Fourth, the P2P system provides a democratic environment, especially regarding to SMEs. Fifth, the P2P architecture supports direct, unmediated and potentially synchronous business collaboration. Besides the P2P architecture improves access of resources.

The P2P provide a highly dynamic business collaboration environment where peers can easily find potential parties and services on demand, provide added value otherwise unavailable, assure flexible fail-over scenarios and increase overall service availability. Although there are many advantages in using P2P for business collaborations, mediation, orchestration and monitoring collaboration processes are the key issues for realizing a reliable, flexible, efficient, realistic and acceptable a P2P based e-business environment. The requirements of P2P based business collaborations are classified into four categories which are

- Generic requirements, such as security and availability.
- Requirements of pre-collaboration, such as support for discovery of services and other peers, merchandise or trading parties, authentication and access control, and negotiating collaboration parameters, etc.
- Requirements of collaboration, such as support for workflow and collaboration orchestration, logging and non-repudiation, etc.
- Requirements of post-collaboration, such as user ranking, reputation management, etc.

Business collaboration need be supported by an appropriate framework. In addressing this particular task certain different aspects of requirements are identified which lead to the development of a generic P2P based Multi-party Business Collaboration (MBC) architectural framework.

The further organization of this paper is as follows: we present definitions of business transaction and collaboration from different aspects and also provide our definitions of multi-party business collaboration in Section . Specific issues of P2P based MBC are depicted in Section . We argue requirements of P2P business collaborations in Section . Section presents a framework of P2P based MBC. Section provides the related work, and the paper concludes with Section .

2 TERMINOLOGY

In this section, we provide a traditional definition of transactions, definitions of business transaction from ISO and ebXML perspectives respectively, a definition of business collaboration from ebXML perspective and P2P concept. Finally, we define multi-party business collaboration.

Transactions are a fundamental concept in building reliable distributed applications. A transaction is a mechanism to insure all the participants in an application achieve a mutually agreed outcome. Traditionally, transactions have held the following properties collectively referred to as ACID T. and A. (1983):

- Atomicity: if successful, then all the operations happen, and if unsuccessful, then none of the operations happen.
- Consistency: the application performs valid state transitions at completion.
- Isolation: the effects of the operations are not shared outside the transaction until it completes successfully
- Durability: once a transaction successfully completes, the changes survive failure.

According to the International Organization for Standardization (ISO), a business transaction is "a predefined set of activities or processes of organization to accomplish an explicitly shared business goal" ISO (1997). A business transaction may involve any number of participants, it may be a one time or last for years, and it can have various degrees of complexity.

Following the ebXML Business Process Specification Schema ebXML (2001), the concepts of business transaction and business collaboration are defined as follows,

- a *business transaction* involves two parties, and is an atomic unit of work that can result in either a success or a failure.
- a *business collaboration* can involve any number of parties and is a combination of choreographed business transaction, defining the ordering and transition between them.

Definitions of P2P vary in emphasis depending on the application. Paper Milojicic et al. (2002) define P2P as "a class of systems and applications that employ distributed resources to perform a function in a decentralized manner", and go on to explain that these resources can be anything from computing power to data and network bandwidth.

In the following discussion, we will analyze P2P MBC that involve coordinated actions by multiple peers to achieve the accomplishment of some results. In our definition, we do not imply that collaboration is number of two-party transactions where ebXML does implicate.

For briefly, we analyze only requirements of the collaboration stage, requirements (as outlined in Section) of the general, the pre- and post- collaboration stages will leave to another paper. Therefore, we assume that the peers have found each other and they can communicate with each other properly and securely. They also know what needs to be done for their common interests. In the next section, issues of P2P based MBC are discussed.

3 ISSUES of P2P BASED MBC

P2P business collaboration most of the time is multi-party business collaboration where more than two peers are involved. A distinction between bilateral business process and multi-party business collaboration is the way of interactions. In multi-party collaboration, many business activities which involved different peers can be performed in parallel. The order of interactions is no longer sequential.

To use an absolute order to specify multi-party collaboration is not suitable. Therefore, requirements of MBC automation are different with bilateral collaboration automation. When a bilateral collaboration is executed, it is not so difficult to recognize who does not (or does) do what. In multi-party collaboration, however it is an important concern, because different peers can perform different collaboration activities at the same time.

It is difficult to find all violators responsible for unsatisfying performance or mis-performance in P2P based MBC (as illustrated in Xu et al. (2005), Xu and Jeusfeld (2004)). Monitoring business collaboration and detecting disobedient peers are thus more complicated. Some solid examples and solutions of monitoring MBC and all detecting violators can be found from Xu et al. (2005), Xu and Jeusfeld (2004).

After identified issues of P2P based MBC, executing and monitoring requirements of P2P based MBC are discussed in the next section.

4 REQUIREMENTS for P2P BASED MBC

The following requirements analysis focuses on two aspects of business collaborations. First, we look at requirements of business collaboration automation under P2P architectures. Second, requirements of monitoring business collaboration are discussed.

Supporting P2P business collaborations, first of all, rules of the collaboration need to be pre-defined in pre-collaboration stage. All involved peers need to agree on a collaboration agreement [1] or protocol which specifies when what should be done by which peers in response to which event. The information of the collaboration agreement or protocol includes the scope, time bounds, business information semantics, determination of success or failure, etc. The specification of a collaboration agreement and protocol can use XML (or XML-based languages, such as ebXML BPSS) and logic-based contract languages. In our previous work we have used temporal logic to specify business collaboration. It specifically supports partial orders of business collaboration specifications. Detailed presentations of the various contract languages can be found in Xu (2004b), Xu (2004a), Xu and Jeusfeld (2003), and Xu (2003b).

In a centralized collaboration approach, the collaborative agreement and the process of collaboration can be monitored in a central server. In P2P approach, the collaborative agreement should deploy in every involved peer and the process of collaboration should be understood by each peer. The process and state of the collaboration must be maintained by all peers. The information of process and state of collaboration should be shared with all involved peers.

In addition, a monitoring mechanism on what is the current state of collaboration must be used throughout all collaboration entities. The monitoring issues are also key issues for P2P business collaborations Xu (2003a). In our previous research, we also provide some monitoring mechanisms for different purposes Xu et al. (2005) and Xu and Jeusfeld (2004).

The peers should be able to detect anomalous events or transactions, to share information, to update collaboration state appropriately, to complete or to fail transactions, and to measure the quality of other peers' performance. Compensation or roll-back function should also be provided for failed transactions.

Besides, there exists different ways to implement the authority or mediator. In a centralize approach, a central service is used as a neutral authority or mediator. It is thus often entrusted the roles of logging, time-stamping and maintaining all transaction information, which may be used to resolve potential disputes or recover from a failure. In the P2P based approach, the peers engaging in same collaboration will usually have conflicting interests, so it is not feasible to assign this task to only one particular peer. Current P2P technologies allow the tamper-resistant cryptographic distribution of data across various other peers, in a secure way that allows immediate recovery upon demand. Actually, the inter-user communication and document exchange that takes place directly between the peers engaging in a collaboration remains to a large degree unaffected in the P2P approach.

While looking at P2P business collaboration, it allows the involved peers using a remedial mechanism which might return business processes to a normal course after occurrence of anomalous behavior. For example when a peer changes business priorities of different business collaboration processes, it first deviates from the prescribed behavior for execution of another higher priority business collaboration; later it compensates this behavior and returns to normal behavior for the first business collaboration. The P2P business collaboration also requires some management flexibility.

In this section, we have elaborated the execution and monitoring requirements. Furthermore, some characteristics of P2P based MBC have discussed. We will provide our architectural framework for P2P based MBC in the next sections.

5 A FRAMEWORK of P2P BBASED MBC

Having explained terminology, issues and the general requirements of P2P based MBC, we summarize our ideas by providing an architectural reference framework (depicted in Figure 1), which can serve as basis for P2P based MBC implementation. The rest of this section provides an explanation of this framework.

Each peer implementation consist of the following components, a collaboration agreement repository, a log file, a performance repository, a collaboration automation module, a monitoring module, and a compensation module. The monitoring module contains tracing process module

[1] A collaboration agreement can also be called as a contract

and violator detection module. These modules and repositories work together to fulfill the overall collaboration maintenance tasks of a peer.

The functions of the three knowledge bases are as follows:

- A *collaboration agreement repository* stores all agreed upon collaboration rules that need to be executed in a business collaboration.
- A *log file* records all operations.
- A optional *performance repository* records the historical status of other peers' fulfillment for long-term collaborations or the use of common financial services (e.g. a bank or a credit card company) as a reputation reference

In a P2P business collaboration, the progress and state of the collaboration must be maintained by all involved peers. For this purpose a collaboration automation module, a monitoring module and an optional compensation module should be included to perform following functions:

- Based on the collaboration agreement, the *collaboration automation module* performs what the peer needs to do and the peer sends information to the monitoring module.
- Based on the collaboration agreement, the collaboration performance state and other monitoring information, the *tracing process module* indicates where the business process is, what needs to be done next, and signals the detecting module after it finds nonconforming transactions.
- The *violator detection module* ensures that any anomalous or non-compliant transactions can be exactly located. It can single out and send detected results to the compensation module. Detecting algorithms can be found from Xu et al. (2005), Xu and Jeusfeld (2004), Xu (2004c). The tracing process and detecting violator modules work together to perform the monitoring collaboration tasks.
- The *compensation module* has the capability to compensate or undo an transaction that should occur, but did not due to failure.

In general, there exist two kinds of business collaborations: high-risk business collaborations and trust-based collaborations Xu (2003a). High-risk business collaborations refer to collaborations among peer business peers who do not know each other so well or simply to high business value collaborations. Trust-based business collaborations refer to collaborations among business parties who trust each other or to low business value collaboration. High business value collaboration need strong monitoring ability, while trust-based collaboration may be less interested in monitoring and instead might want to optimize on bandwidth/speed of network. Therefore, how much the peer wants to be monitored is up to the peer and whether compensation items should be applied also depends on the peer.

On the execution of a business collaboration, every peer shares information, and could attribute all or a part of the transaction messages to other peers or relevant peers for different monitoring abilities. It is up to the agreed collaboration agreement or protocol. Based on these messages, each peer identifies the particular collaboration agreement from its agreement repository, executes and traces the process to identify which obligation remains on the peer and the following expectable transactions. Combining each peer's reputation with the current monitoring result, the peer can send the relative reminder or warning messages, and identify the necessary compensation transaction based on the compensation clause in the collaboration agreement if any violation happened.

6 RELATED WORK

Work on designing P2P systems to support business collaboration has so far centered around generic and rather abstract discussions of ideas, problems that need to be solved and potential system requirements. The JXTA P2P infrastructure and practical suggestions are presented in Gao (2001), JXTA (2003), JXTA (2004). XML-based definitions are used to describe parties' capabilities in order to provide the best candidates to service a client request, using pluggable matchmaking strategies and the data of previous activities. This approach allows maximizing utilization of business parties' resources and increase their competitive advantage. The provided infrastructure and suggestions are simplistic solutions for a very narrow and limited subset of the range of business transactions that should be supported by a complete solution.

We also review some of the main approaches to execute business transactions in multi-agent systems as well as existing e-commerce platforms. In general multi-agent system fault-tolerant approaches analyze an entire business transaction going on in the system to detect state inconsistencies using replication strategies Marin et al. (2001), sentinel approaches Hagg (1996), reassignment resource approaches Kumar and Cohen (2000) and knowledge-based approaches Klein and Dellarocas (1999). Most of research presents relevant centralized approaches supporting various business collaboration through application interconnection.

Two models for ebXML BPSS multi-party collaboration and web services choreography are presented in Dubray (2002a), Webber (2004) respectively. Other research Dubray (2002b), Haugen (2002), Svirskas and Roberts (2004) on multi-party collaboration tries to break down a multi-party collaboration into a number of bilateral relations. A principle cause behind this is that current e-commerce environments only support bilateral executions. In some simple cases, the approach to support multi-party collaboration execution in current e-commerce environ-

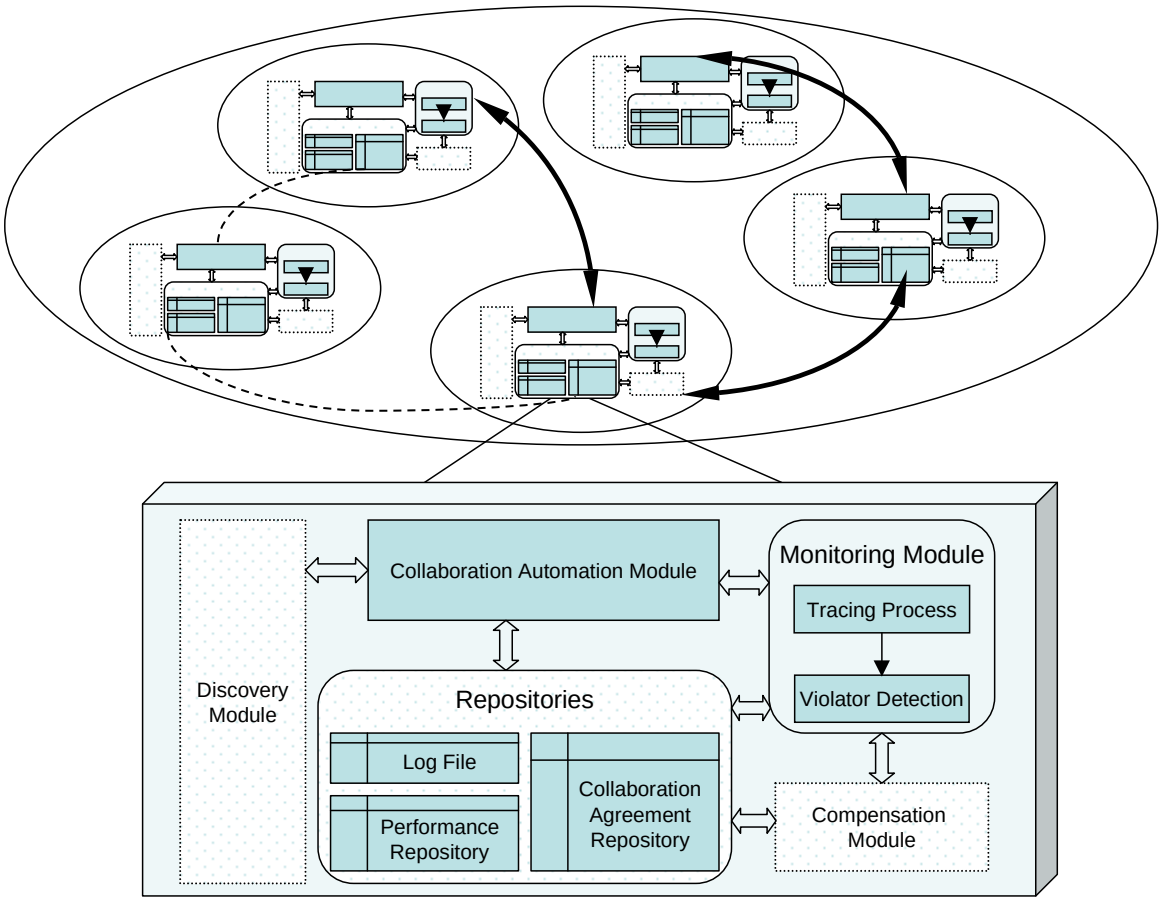

Figure 1: Framework for P2P Based Multi-party Business Collaboration (MBC)

ments is to assume the whole business process runs correctly according to a number of bilateral relations. In complicated multi-party collaborations however this conversion results in information of relations being lost or hidden. Consequently this option to split multi-party collaborations up into several two-party relations will not work for these complex multi-party collaborations. By using P2P architectures, multi-party collaborations can be supported without need to split a multi-party collaboration into a number of bilateral relations.

7 CONCLUSIONS

The P2P architecture is particularly well suited for the design of decentralized business collaboration processing systems, although the current study on P2P business collaborations lacks a detailed and specific requirements definition and analysis. This includes an analysis of desired features, characteristics and properties, and accompanied by an account of whether and how these feature can be supported by existing P2P technologies, and what additional research work is required.

The main issues of P2P based MBCs are business process automation and monitoring. This paper concentrates mainly on providing an insight into what is currently lacking in this direction, a rigorous definition of the potential requirements of such a system, and a view of the degree to which these requirements are satisfied by current "state-of-the-art" P2P technologies.

Our research has made an attempt to innovate using MBC concepts in order to enable added value on-demand concentration. The constraint of breaking a business collaboration into a number of bilateral transactions is not necessary. A real concept of business collaboration is provided.

Our conclusion is that P2P systems have evolved and matured considerably and are capable of providing practical and satisfactory solutions to many of the problems that arise in the conversion from a centralized to a decentralized system design.

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