Services Based Collaboration/Coalition Networks

Ramana Reddy, Professor and Director
Kankanahalli Srinivas, Research Associate Professor
Sumitra M. Reddy, Research Associate Professor
Lane Department of Computer Science and Electrical Engg.
West Virginia University,USA
{rar, srini, smr @ cerc.wvu.edu}
and
Rao Mikkilineni
enSANET, Inc.
Cupertino, California, USA
rao@ensanet.com

Abstract
We propose a novel framework and a scalable architecture that can be used for rapid formation of coalitions and to perform collaborative transactions. Our framework combines the traditional theory of organizations with the theory of signaling from telephone networks to bring about a unifying theory of collaboration to enable dynamic virtual enterprises formed on-demand. The new framework, overcomes many limitations of the traditional frameworks. Our framework known as the PPP/SST denoting the various components of the framework can be realized on the Internet.

1. Introduction

The term *Collaboration* is defined as the act of "working jointly with others" in the Webster's Collegiate Dictionary. It also defines "Coalition" as a "temporary alliance of distinct parties for joint action." While these two words are often used interchangeably, the word *coalition* brings out an important nuance, that of a "temporary alliance" which takes on a great significance in the light of an emerging business paradigm known as *Virtual Corporation*. Virtual corporations (or enterprises) are based on the notion that different parties can come together (i.e., form a coalition) temporarily to accomplish a "mission" and then move on to form possibly different coalitions to accomplish other missions. In this business paradigm one can envision a universe of freelancers offering specialized services to a variety of coalitions on-demand. For example, a training enterprise can form a temporary coalition of freelancing professors to develop a specialized seminar to meet a demand for a topic that may be in vogue. If the demand is ephemeral, so will be the coalition.

To enable this type of opportunistic, on-demand, and temporary coalitions we need to develop a more natural, holistic group-work paradigm that goes beyond the traditional models of Computer Supported Co-operative Work (CSCW) embodied in such products and technologies as NetMeeting [1], whiteboards (1], application sharing [1], erooms [2], Grove Nets [3] and others. All these focus on bringing together, synchronously or asynchronously different parties to communicate and or share documents on the Net. On the other hand collaborations based on Agent Paradigms [4] rooted in Distributed Artificial Intelligence concepts [5] are based on formal communication languages and the presence of "intelligence" at collaborating nodes. We believe these products/technologies and pure agent paradigms do not allow us to fully realize the business potential of ephemeral collaborations. To address this, we propose a new collaboration paradigm based on the idea that an ephemeral collaboration could be accomplished by bringing together a set of network based services through "signaling" mechanisms that facilitate composition of services. In this paradigm, the Person-Agent continuum makes available a service to a coalition on demand as a result of requests (or signals) initiated by the "owner" of a coalition. In this sense, we can consider our paradigm bridging the gap between traditional CSCW and pure agent based collaboration. We call this the PPP/SST Coalition Paradigm. This paper is organized as follows: section 2 describes the PPP/SST framework together with its signaling and interaction model. Section 3 illustrates the various framework components. Section 4 describes the architecture of our framework. Section 5 outlines the infrastructure trends and assumptions for our framework.

2. The PPP/SST framework

The various components of the framework are autonomous entities that reside on a distributed infrastructure. The sequence of interactions among the various components of the framework is illustrated in Figure 1. The coalition episode *starts* with a virtual enterprise initiator creating and sending a Statement Of Purpose (SOP) message denoted by (1) in the diagram, which describes the intent for the coalition to the service mediator object. The SOP message will use a markup language such as XML and use a dictionary and an ontology that are understood by the various components of the framework. In situations wherein the vocabulary is unclear, a metadata service could be used to disambiguate the markup. In the most rudimentary setup, the person in the person-agent continuum could interpret the message and take the necessary action. The same will be true at all other nodes, which receive messages in pursuit of the proposed coalition.

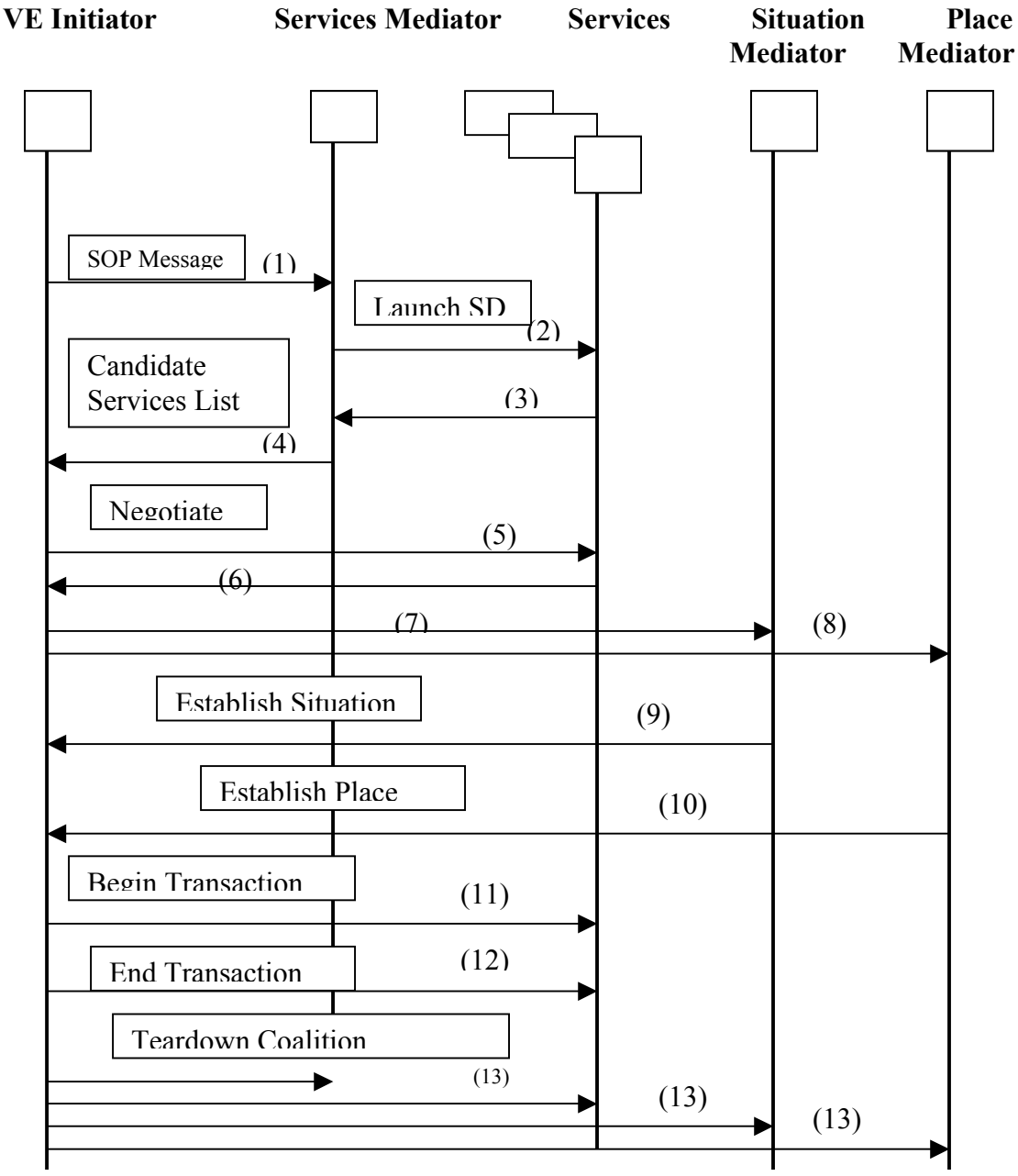

Figure 1. A Logical Message Sequence for Virtual Enterprise Transactions

The assumption here is that the services are described by a service description language such as Web Services Description Language (WSDL) [6]. After the service description is complete, the service registration is performed with a service registry, which is a logical conglomeration of services. The service registration infrastructure is assumed to also consist of proxy agents for services, redirect services (which can redirect requests to appropriate services) and other related services. Upon receipt of

the SOP message, the Service Mediator initiates the service discovery process indicated by message labeled (2) in Figure 1. The service discovery process can have multiple bidding and negotiation phases and eventually should result in a set of possible candidate services, which constitute a set of possible coalition partners denoted by message(3) in Figure 1.

After the discovery of candidate services and their availability a negotiated agreement is reached among the coalition partners indicated by messages (5) and (6). Upon completion of the negotiation, a place and a situation are determined similarly by sending appropriate messages to the place and situation mediators denoted by messages (7) and (8). The messages (7) and (8) will contain the preferences and constraints that are imposed by the coalition partners. Messages (9) and (10) are used to establish the situation and place for the coalition, which satisfy the preferences and constraints imposed by the coalition partners as specified in messages (7) and (8). The business process potentially could move from situation to situation, and also from place to place during its lifetime. In a given situation and/or a place a series of transactions take place. These transactions are designed to fulfill the goals described in the SOP message. These transactions are denoted by message (11). Once the halting criteria such as meeting the goal or reaching the end of time allotted for the coalition task are reached, the transactions are ended as denoted by message labeled (12) and a series of teardown messages, labeled (13), are broadcast or multicast to all the members of the coalition. The coalition may be owned by one or more members of the group depending on the nature of the coalition. The entire process is under the control of the coalition owner(s) generating the events that move the coalition forward. This control mechanism could be modeled in a manner very similar to the control mechanism used in Discrete Event Simulation [7] or the control plane in communication networks.

Communication among persons (hereafter we use person to represent the person-agent continuum) is accomplished through message passing. Each situation results in a transcript that is linked with the transcripts of other situations through hyper-linking to form a longitudinal (or episodic) document. This document will be very similar to the Electronic Design Notebooks [8], [9] used in design enterprises. It is clear from this description of the proposed coalition framework, that there is a need to define a number of protocols to deal with description of services, signaling and organization of the transcript, which we assume can be a part of the underlying distributed infrastructure. We believe that extant standards such as BIZTALK [10], WSDL[6], SOAP [11]for services description, and SIP [12] for signaling can be successfully used in realizing implementations of this framework. However, we do not propose to develop yet another collection of standards as we do not feel they are absolutely necessary to realize the potential of this framework. Ad hoc coalitions could be built using agreed upon protocols among partners rather than striving for universal standards.

In the rest of this section we briefly describe the various components of this framework with examples where appropriate. Object descriptions are to be viewed

only as representative and not as standard descriptions. To promote clarity of the key concepts we will use the following hypothetical example:

SpeedWay Software Company (SSC) advertises itself as a virtual enterprise which can undertake turnkey software development assignments. It has neither software professionals nor a significant computer infrastructure. It has a small executive staff with the necessary skills to undertake any complex software project. SSC's success is predicated on the discovery and composition of appropriate services from sources anywhere in the world and executing them somewhere in the cyberspace (i.e. the Place), (in fact places such as Sourceforge [13] which has some of the characteristics already exists on the Internet today) according to a script which itself may have been designed by some person serving as a coalition partner through the net. Under this framework, SSC's management is concerned with a series of tasks involving discovery of services, entering into contracts, and generating signaling events to apply previously contracted services until the halting criteria are met. A person providing a service may be modeled as a real person who receives messages in the form of emails or short messages that are understood by humans or could be modeled as an agent who can interpret these messages received according to an agreed upon protocol. In actual operation, we can envision a person as a continuum between a real person and an agent. Further, the agent could be a pure instruction executor or could be endowed with "intelligence" to decide on the action that should be executed autonomously or with the assistance of the agent's owner – a real person. Thus, SSC's operation could be summarized as a series of discoveries, contracts and signaling operations to appropriate persons or agents. This is the essential concept of our framework that bridges the gap between CSCW and pure agent based collaborations.

*3. PPP/SST Com*ponents

We will now describe briefly the general nature of various components of this framework. We do not define actual formats as they could be specified only in actual implementations of this framework.

3.1 Person/Agent

An agent in this framework may be described as an object, which is capable of providing a service and responds to different types of messages listed below:

(a) Registration Messages: This class of messages is intended for the agent to publish its service in a format that is based on a known markup language and a discernable ontology.
(b) Discovery Messages - This class of messages is designed to enable a VE to discover prospective agents that can become coalition partners. Since a universal description of services may not be available in some situations, these messages may likely be handled by a person.

(c) Contract Messages – This class of messages is intended to discover the availability of an agent, and determine the terms of contract and the method of providing services.
(d) Execution Messages – This class of messages is designed to enable a service provider to execute operations that result in the provision of services. These could also be viewed as transactions of the coalition corresponding to messages (11) and (12) in figure 1.

In the case of SSC, we can envision a number of agents such as problem analysts, system designers, programmers, testers, documentation experts and support providers. All of these agents could be drawn from different sources and "assembled" for a particular coalition episode. From an implementation point of view the agent could be totally subsumed by the application layer of the standard TCP/IP stack.

3.2 Purpose

Purpose could be modeled as a goal of the particular coalition episode, which also specifies when the coalition episode will be terminated using a termination or completion clause. The purpose should specify the goals using appropriate markup language and ontology, such that the goals may be easily mapped to services by the service mediator. For example, in the case of SSC, the purpose of an episode could be the creation of a fully documented and tested program artifact that accomplishes a certain goal. The episode comes to an end when the last task (say, acceptance testing) takes place.

3.3 Place

Place could be modeled as a workspace in cyberspace where artifacts created by various agents could be saved and or archived for use by other agents. The concept of eroom [2] is a good example of Place, though it provides primarily project management capabilities. In the general case we could view this as a workspace on a server that is organized as a collection of hyper linked documents. These could be perused, modified, transferred and otherwise manipulated by coalition partners – subjected, to the constraints imposed by the coalition owner(s).

3.4 Situation

Situation could be modeled as a state corresponding to a subtask that is part of a coalition episode. In this model we can think of the coalition episode moving from Situation to Situation as a result of completion of tasks by different agents. This is somewhat analogous to different elements in a process plan that describes a manufacturing operation.

3.5 Signaling

Signaling is an important aspect of telecommunication networks, wherein protocols such as SS7 [14] are ubiquitous. It is an important component of this framework, to bring together coalitions rapidly and to teardown the coalition after the goals of the

coalition are reached. This is similar to signaling in the telecommunication world, which is used primarily to set up and teardown calls. Services get executed when the owner of the service is "signaled".

3.6 Transcript

Transcript is a document linking all the situations that are part of a coalition episode. The actual transcript could be created by a transcription service, which is a part of the coalition. The transcript can be used as a basis for management by the agent charged with management as well as a record that may be needed for legal and /or corporate reasons. In addition the transcript could serve to document "corporate memory" [8] as in the case of the Electronic Design Notebooks.

4. The PPP/SST Architecture

Figure 2 shows the basic underlying P2P computational model of the PPP/SST coalition paradigm. All services needed by a coalition are available on the network edge and can act as clients or servers (depending on the role played by the service in the coalition). Services can also provide a place in the cyberspace for a particular transaction. Figure 3 shows the relationship among different components of the framework. These components are coupled through the networking infrastructure on which message exchange (i.e., signaling) takes place. Because of the inherent flexibility of the P2P computing paradigm, the location of the "place" where a particular task is being executed can be shifted around at will – thus ensuring continuation of the coalition activity in the presence of node failures. In addition, the distributed infrastructure and the protocols should support service-based collaboration in a robust and a secure manner. This is realized by supporting end-to-end Service Level Agreements (SLA) ,Quality of Service (QOS), in addition to new and novel mechanisms for service discovery .Our proposed PPP/SST framework assumes that the underlying networks support the discovery, mediation and compos ability of services. This can be easily achieved in IP(Internet Protocol) based networks such as the Internet.

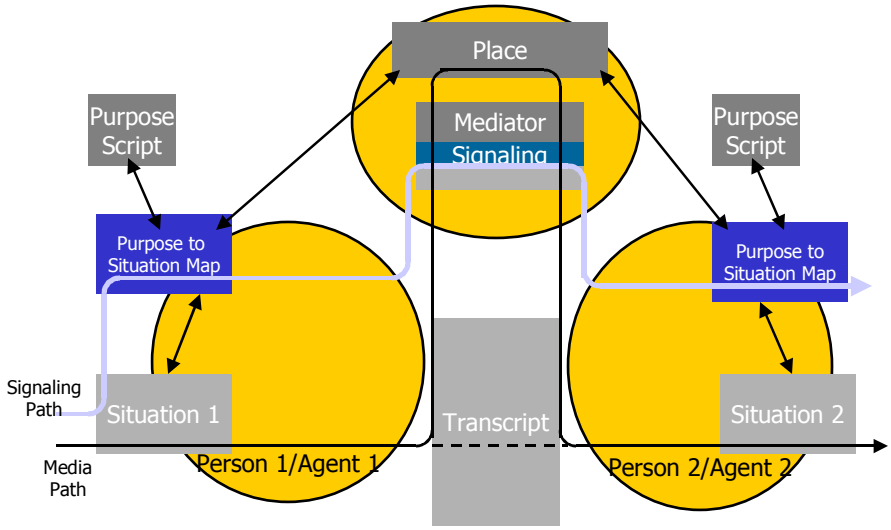

Figure 2. Architecture of PPP/SST

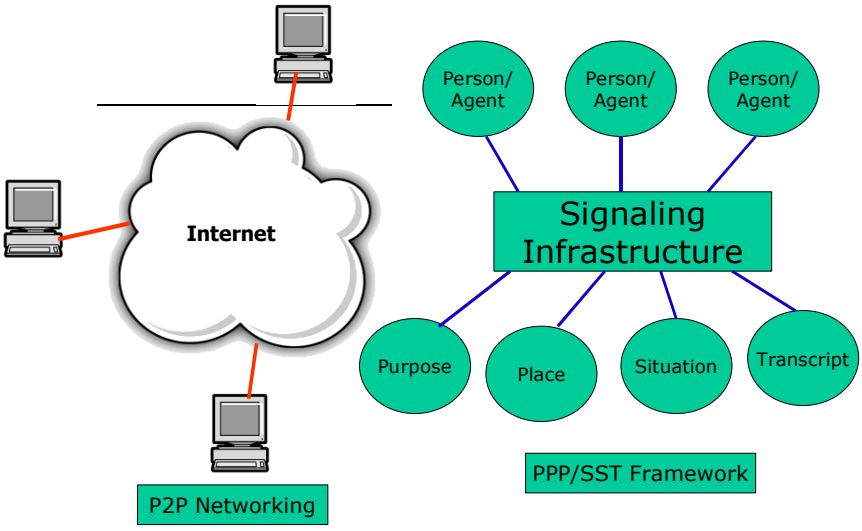

Figure 3. Architecture of PPP/SST

Figure 3 depicts the signaling and media paths in this architecture. Each Situation is attached to a situation map that connects a Situation with a Place where the transaction is being executed. Multiple Situations may be connected to the same Place through their respective mappings. Coordination between Situations is accomplished by executing signaling events that flow through the common place connecting the Situations. Each Place also includes a signaling mediator that ensures mutually contradictory signals are not executed. The transcript that results from this coordinated activity is created and associated with the Place of execution. As the coalition activity continues, these transcripts get hyper linked and periodically consolidated. The disposition of the transcript at the end of the coalition is determined by the agreements reached among partners at the outset.

The architecture presented in this section should be viewed only as representative and not definitive. The paradigm itself could be implemented in a variety of candidate architectures, depending on the capabilities of the enabling technologies. Regardless of the actual architecture, the paradigm ensures that the resulting system is highly adaptive and scalable. In the next section we present trends in the distributed infrastructures for service networks that will have a high degree of impact on the realizability of this framework.

5. Trends in Distributed Infrastructure of Service Networks

In the design of any distributed framework, such as the one proposed here, careful consideration should be given to infrastructure trends and issues, without which the framework will not be realizable. Traditionally, distributed infrastructure, such as the Internet and the telephone networks, have been designed with the intelligence in the core. The intelligence is usually embodied in the routers and switches. Due to the need to support switching and routing at optical speeds, the core is becoming "dumb" and the intelligence is being pushed to the periphery.

One of the benefits of pushing the intelligence to the edge is that it eases the deployment of new value-added services. The emergence of peer-to-peer architectures indicates that many new collaboration architectures will be based on the fact that the intelligence will reside on the edge of the network. The edge intelligence eases the deployment and management of these value-added services to the infrastructure provider such as the Internet Service Provider (ISP), a Network Operating center (NOC) and others.

An important issue in the design and implementation of a framework, such as the one described here is ensuring *trust* among the parties in the coalition and also to ensure the *security of the transactions* that take place in the coalition. To ensure trust mechanisms such as Public Key Infrastructure (PKI), biometric authentication and kerberos like technologies may be part of the underlying infrastructure. The Distributed Denial of Service (DDOS) attack prevention will be one of the crucial assumptions required for coalitions to work.

6. Conclusion

Rapid advances in computational paradigms, protocols, enabling technologies, infrastructures and precipitous drop in the cost and size of computing equipment are giving rise to the dawn of a new era in enterprise theory and practice. Advances in P2P computing, Remote Desktops, Short Messaging Systems, Intelligent Agent frameworks, mark-up languages like XML, Web Services Description Language (WSDL), Simple Object Access protocol (SOAP) and signaling protocols like SIP are some of the key drivers of this trend. The ease with which a person who has a service to offer without being employed by a conventional enterprise is going to rapidly make the employee-enterprise relationship obsolete in a number of disciplines. For example, in the healthcare domain, many radiologists already operate in this mode of service by making themselves available via the Net. Distance education enterprises are beginning to offer the services of *best professors* to students around the world – often through coalitions.

The authors strongly believe this trend towards enterprises, as opportunistic coalitions as opposed to conventional enterprises will gain acceptance rapidly – at least in certain disciplines where information exchange is the key transaction.

7. References

[1] Microsoft NetMeeting http://www.microsoft.com/windows/netmeeting/

[2] erooms http://www.eroom.com/

[3] Grove Networks www.grove.net

[4] Prasannaa Thati, Po-Hao Chang, Gul Agha: Crawlets: Agents for High Performance Web Search Engines. Mobile Agents 2001: 119-134

[5] Readings in Distributed Artificial Intelligence A.H. Bond & L. Gasser (Editors), Morgan Kaufmann, San Mateo, CA, 1988.

[6] WSDL Web Services Description Language http://www.w3.org/TR/wsdl

[7] Discrete Event Simulation Control http://protodesigninc.com/SGmanuals/sansgui_simulation_control.htm

[8] Uejio, Wayne et a l An Electronic Project Notebook from the Electronic Design Notebook (EDN), *In Proceedings of the Third National Symposium on Concurrent Engineering, CALS and CE, Washington DC 1991, pp. 527-535.*

[9] Toye, G. et al. "SHARE: A Methodology and Environment for Collaborative Product Development. In IEEE Proc. Of Second Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises. 1993

[10] http://www.vbxml.com/b2b/articles/biztalk_unleashed/3_whatisbiztalk.asp

[11] Simple Object Access Protocol SOAP http://www.w3.org/TR/SOAP/

[12] Session Initiation Protocol http://www.cs.columbia.edu/sip/

[13] SourceForge www.sourceforge.net

[14] G. Christensen, *SS7 Technology and Applications*, Mobile Streams Publishers, Feb 2000, ISBN 244933 44344.