

The synergy of electronic commerce, agents, and semantic Web services

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Abstract

Advancements in software agents and semantic Web service technologies are generally enhancing the landscape of electronic commerce. Semantic Web service technologies promise the standardisation and discoverability of software capabilities for network-enabled organisations. Moreover, with the addition of the intelligence and autonomy of software agents, transactions may be equally automated for consumer-to-consumer, business-to-consumer, and business-to-business collaborations. The *2003 Workshop on Electronic Commerce, Agents, and Semantic Web Services* was held in conjunction with the *International Conference on Electronic Commerce (ICEC2003)*. The purpose of this workshop was to bring together researchers and practitioners in the areas of electronic commerce, agents, and semantic Web services to discuss the state-of-art in each individual area in addition to the synergies among the areas. This paper contains a summary of the workshop presentations and a discussion of next steps for semantic Web services created in the working sessions concluding the workshop.

1 Introduction

Combining the benefits of software agents and semantic Web services with the field of electronic commerce presents several promising directions. Exploiting semantic Web service capabilities, on-line organisations can advertise their offerings via the description of the provisions of their underlying software services. Using associated technologies, external consumer-based and business-based entities can connect to and execute these services, which may facilitate, or indeed require electronic commerce transactions. Software agents can act as brokers for their human counterparts, and they may facilitate the efficient discovery of pertinent services and the completion of otherwise impossible transactions. Independent usage of these services by consumers is only an initial capability. A further capability is the creation and execution of a sequence or workflow of related services to create more sophisticated, *composed* services. Software agents can play a measurable role in integrating disparate services by resolving syntactic and semantic data discrepancies (W3C, 2004a), and also by decreasing response times while increasing bandwidth and availability in comparison with human users.¹

¹ As an example, consider the way that simple electronic agents can extend human capabilities in online auctions. eBay offers an agent-based service that can be used to monitor the progress of an auction and to place additional bids if the user in question no longer holds the winning bid (up to a specified maximum price). Such an agent monitors the auction continuously, can respond almost instantaneously, and can track the last minute flurry of bids that often occurs in online auctions.

Inter-organisation collaboration may also benefit from this paradigm. In addition to the negotiation of products, multiple organisations may need to negotiate on service usage. Software agents can facilitate the creation of coordination-based contracts that assure delivery obligations and quality of service considerations.

The purpose of the *2003 Workshop on Electronic Commerce, Agents, and Semantic Web Services* was to help understand problems surrounding these areas. The standard electronic commerce domain generally comprises technologies and applications to securely negotiate, auction, and mediate transactions. Electronic commerce issues can be compounded if the transactions must be realised by the discovery and utilisation of semantic Web services. However, the benefits of autonomous agents, such as inference, learning, and adaptability can reduce the barriers to success in the integration of electronic commerce applications with semantic Web service areas. The workshop was split into a set of related presentations and a working session on semantic Web services and electronic commerce. This report proceeds with a section that summarises each of the presented papers, and follows with a section that summarises the discussion in the working session.

2 Research presentations

There were a number of presentations that spanned the focus areas of the workshop. Several accepted papers were, unfortunately, not presented at the workshop. Of the papers presented, the following sections summarise the presentations in the basic areas of electronic commerce, and semantic Web services, and software agent technologies, particularly those addressing service-oriented computing and electronic commerce.

2.1 *Electronic commerce and semantic Web services*

The first presentation was based on the paper ‘Using genetic programming to optimise pricing rules for a double auction market’ by Steve Phelps, Peter McBurney, Elizabeth Sklar, and Simon Parsons. Parsons presented this work in the area of mechanism design, where the central idea is to be able to automatically create new kinds of auction to fit new market scenarios. The presentation described an experimental approach that is a step towards this end. First a learning model of trading behaviour and a mechanism for deciding prices based on offers were introduced. Agents learn how to trade in this market, then the market itself is evaluated against some criteria, such as efficiency or Pareto optimality. Based on the results, the mechanism is changed (using genetic programming) and the simulation repeated. In this work, several scenarios were used to determine the best pricing rule for a particular well-known market, resulting in several reasonable pricing rules. However, for this approach to be useful, the authors must demonstrate that new kinds of auctions can be evolved, and new tools for auction design using these techniques will need to be provided.

The second presentation, ‘SemanticWeb Services: description requirements and current technologies’ by Rubén Lara, Holger Lausen, Sinuhée Arroyo, Jos de Bruijn, and Dieter Fensel, was given by Rubén Lara. Lara motivated this work with a background of technologies for enterprise application integration and electronic commerce, particularly semanticWeb services technologies such as the Web Services Modeling Framework (WSMF) (SWSI, 2004), the DARPA Agent Markup Language for Services (DAML-S) (DAML, 2004), the Business Process Execution Language for Web Services (BPEL4WS) (IBM, 2004), and the Business Process Modeling Language (BPML)/Web Services Choreography Interface (WSCI) (W3C, 2004b). He discussed the limitations of each technology, such as the over-generalised scope of WSMF, the lack of ontology for DAML-S, and the limited automation support in both BPEL4WS and BPML. To determine the best approach for intelligent service-oriented computing, Lara suggested a set of requirements to evaluate existing and emerging semantic Web service technologies. The general areas of these requirements are the ability to support discovery/composition, interoperation, invocation, and

error/compensation. Based on this requirements model, several general suggestions were made. The discovery and composition support in DAML-S should be changed and updated with defining generic functionality and refinements. For interoperability, the DAML-S process model should be replaced with either the BPEL4WS or BPML/WSCI model. For invocation, although Lara suggests the DAML-S approach, it should also be extended. Finally, for error/compensation, DAML-S must be enhanced with compensation. DAML-S can be extended with BPEL4WS or BPML. In future work, DAML should be extended with the aforementioned requirements, and use cases should be applied.

2.2 Agents for services and electronic commerce

There were two papers that concentrated on agent technology as it relates to service-oriented computing and electronic commerce. M. Brian Blake presented his paper 'Forming agents for workflow-oriented process orchestration'. Considering the *ad-hoc* construction of business processes composed of Web services or *orchestration* (Peltz, 2003), Blake suggested that agents may be posed with several solutions to realise a specific workflow. In his work, a model was created that can be programmed into agents that evaluates a list of options to determine the most efficient solution. Simulation software was created to implement and evaluate the model. In evaluation, Blake showed results of the simulation that favourably support the creation of efficient *ad-hoc* service compositions.

'B-Cart-based agent system for B2B electronic commerce', by Gyoo Gun Lim and Jae Kyu Lee, described the merits of using agent approaches to manage consumer-based electronic commerce. Lim and Lee suggested that maintaining buyer information during a transaction can be managed on the buyer's side (as in the B-Cart approach proposed in the paper) or on the seller's side. In their work, an agent implementation was constructed that manages functions, such as identification, user dialog, collection, trashing, individual purchase, decision support, organisational purchase decision support, negotiation, ordering, payment, tracking, recording, record transmission, and knowledge maintenance. The main contributions of this work were the conceptualisation of an evolvable system, a framework using agents, and its evaluation.

3 Strategic analysis of semantic Web services

The workshop also included a working session to discuss the future of semantic Web services. The participants initially discussed current barriers to the semantic Web services. The session concluded with a discussion of next steps in the evolution of semantic Web services. The following sections summarise the discussions from the working session.

3.1 Barriers to the current state of semantic Web services

Considering the current state of technologies, the participants raised a number of questions about the implementation of semantic Web services, and then discussed the barriers to providing solutions to the questions. The questions and follow-up discussions are summarised as follows.

- *Purposeful ontology, is it generalisable?* A major problem in providing semantic Web services is describing them in a way that is understandable to all agents that seek to make use of them. This requires the orchestration of existing service ontologies to provide a general purpose ontology for Web services. Participants suggested that in order to scope the problem of orchestration, ontologies should be created for specific domains. This scoping can serve as a first step to understanding low level problems of orchestration that would not normally be uncovered until ontology approaches are more mature. A barrier to this approach would be determining what domains would be appropriate for this scoping. Some participants suggested the creation of an ontology in the general domain of services that could be later augmented with domain-dependent

information. Furthermore, a service oriented ontology could facilitate the act of defining and refining service functionality using their underlying input/output messages and pre/post conditions.

- *Semantics of the semantic Web, are they rich enough?* A consensus of the group was that semantics of semantic Web technologies perhaps may not be sufficiently rich to support difficult domains and, furthermore, even establishing what deficiencies exist in the current semantics remains an open problem. The first question that needs to be answered is ‘What else do we need in order to specify Web services besides what is included in terms of input/output messages and post/preconditions?’. In answering this question, an additional problem may be that a service defined properly still may not sufficiently represent what the service is *meant* to do. Furthermore, what if ontologies cannot be totally autonomous, particularly if orchestration must be constrained by contracts or commitments? A suggested solution was perhaps to attempt to make the application protocol itself more intelligent to assist in the shortcomings of the semantics of individual Web services. In addition, the semantics need to be augmented to allow real-time problem diagnosis during composition. A starting point may be exploiting monitoring composition using the DAML-S execution modelling and developing the proper exception-handling services.
- *With many different concepts of ontologies and many mechanisms for mapping a variety of ontologies, how can the tough problems be solved?* The participants agreed that there was a need for advanced approaches for mapping disparate ontologies, sometimes referred to as consensus or upper ontologies. Regardless, the methodology of modelling service-oriented artefacts with ontologies must be the first step even if there is no agreed upon ontology.
- *What is the practicality of embedding the semantics within the Web services?* The participants suggested constructing a reflective capability within the Web services by leveraging the capability in DAML-S to keep both service descriptions coupled with process descriptions. A perceived barrier to this approach is that incorporating process information may expose potential problematic information that can cause conflicts with concepts of encapsulation. This barrier might require the construction of a taxonomy that specifies what information should be exposed and what internal information should be hidden.
- *If heterogeneous service composition is a reality, then what are the additional barriers?* The participants agreed that it is only once it is possible to carry out service composition that the most interesting problems in service composition will be exposed. Additionally, there is a need for more maturity in the development of the heterogeneous service composition before the next steps can be achieved or even understood completely. However, the participants suggested a list of additional requirements and issues. One requirement is the need for specific contracts to guarantee service requirements, such as availability at some time in the future in addition to other quality of service requirements. However, this maturity may be hindered by a fear, in the general population, of advancement in this area. As such, assuring privacy is a major requirement and an area that requires more research. Other open issues in this area are as follows.
 1. What are the ethical issues to exposing knowledge that can be potentially dangerous?
 2. Which composition of services should release specific privacy protections and which should be enforced?
 3. Is heterogeneous composition opportunistic or decompositional?
 4. What are the human factors that must be considered in service composition?

3.2 Next steps in advancing semantic Web services

The working sessions concluded by constructing a list of advancements that can be made in the near-term in moving from the *as-is* to the *to-be* architectures. This section summarises those discussions.

- *The development of tools and libraries of software for general compositional capabilities and infrastructure mechanisms, such as discovery.* The participants agreed that the ontology servers

such as OntoWeb (2004), compositional prototypes, such as MindSwap Composer (MindSwap, 2004a, b) and Web Services Call Composer (Stylus Studio, 2004), and prototypes of planning tools for composition (Madhusudan & Uttamsingh 2004) are technologies that can form the basis for general tools for service composition.

- *A competition to evaluate the expressiveness of specific compositional languages.* A competition following the model of the Trading Agent Competition (SICS, 2004) would help to standardise the understanding of existing compositional languages and tools and drive the development of new languages and tools. Of course, organising such a competition is a major undertaking, and an alternative exercise would be to simply compare the expressiveness of existing compositional languages on a specific problem (preferably a problem that is beyond the scope of any one language), rather in the spirit of Sombe (1990).
- *The mediation of the communication between industry and academic standards, such as BPEL4WS and DAML-S.* Initiatives such as the addition of semantics (DAML-S) to the concrete nature of industrial Web services (BPML/WSCI) would help to solidify the connection of industry and research standards. Is it reasonable to expect that the gap between concrete BPEL and DAML-S can be shortened? Investigations in this area might also clarify the direction for mediation.
- *The most effective domain for composition should be investigated.* Although the electronic commerce domain is generally chosen for service composition, is it the right initial domain? Maybe the use of electronic-commerce applications is potentially the incorrect market for service competition. The semantic Grid or others may be more pertinent domains. Investigating domains may be the most useful first step. Domain investigations can be helpful in setting fruitful directions, and are a good means of identifying concrete problems with existing technologies, even when the domain in question is very limited.
- *There needs to be a compromise between expressiveness and the ability to reason on the semantics. Time will be an issue.* There should be investigation into tools that can satisfy the solution or at least an estimate of the time that is needed. Such tools may be able to satisfy the sub-optimal solution and determine what is good enough or *just-in-time*. A specific method of reasoning needs to be determined that fits a specific domain or class of problems. These methods may include fuzzy logic and situational calculus.

4 Conclusions

The 2003 Workshop on Electronic Commerce, Agents, and Semantic Web Services set the background with discussions in general technologies in each of the workshop areas. The closing working session helped to elaborate on the issues surrounding the synergy of the three areas. There are currently several significant barriers to advancement in semantic Web services technologies, and these were elaborated on during the workshop, along with some suggestions for overcoming them. An overarching conclusion from the papers and from the discussion was the need for investigations that will solidify the existing approaches, which are nebulous in places, and to assess the feasibility of some of the directions for future research that were suggested during the workshop. In addition, the participants generally agreed that there needs to be a consolidation of efforts between researchers in the area if significant. The organisers will be involved in the 2004 International Conference on Electronic Commerce in Delft, The Netherlands, and we hope to see work there that reports on solutions to some of the problems that have been identified in this paper.

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