

A Multi-Agent System for Content Trading in Electronic Telecom Markets Using Multi-Attribute Auctions

Ana Petric

Faculty of Electrical Engineering and
Computing, University of Zagreb
Unska 3, Zagreb, Croatia
ana.petric@fer.hr

ABSTRACT

The advent of the Internet and the development of the New Generation Network (NGN) has enabled, while investments in licenses and the desire to stay competitive in the future has triggered the development of value added services (VAS). Due to high market penetration, the telecommunication industry has been facing income stagnation. Consequently, it has been shifting focus to VAS in order to increase income. When forming VAS, special attention needs to be paid to the purchase of resources (e.g., transport capacity and information resources) needed for the service creation. The fact that information resources (i.e., content) are not commodities, opens the question of what is the best (i.e., efficient) mechanism that should be used for trading. As the number of participants on the B2B telecom market increases, the need for the automation of transactions carried between them is critical. The automation of transactions should lower operational costs and speed up the service provisioning process. In this paper, we try to identify stakeholders on the telecom e-market, establish their roles and relationships and find an appropriate model which captures their transactions. Finally we consider the use of multi-attribute auctions for content trading in telecom markets.

Categories and Subject Descriptors

I.2.11 [Distributed Artificial Intelligence]: Intelligent agents, Multiagent systems. J.4. [Social and Behavioral Sciences]: Economics. I.6.5 [Model Development]: Modeling methodologies

General Terms

Management, Design, Economics.

Keywords

Multi-attribute auctions, Multimedia Content Trading, B2B e-markets, Intelligent Software agents, New Generation Network

1. INTRODUCTION

The advent of the Internet and the development of the New

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

10th Int. Conf. on Electronic Commerce (ICEC) '08 Innsbruck, Austria
Copyright 2008 ACM 978-1-60558-075-3/08/08 ...\$5.00.

Generation Network (NGN) provide connections which enable a particular lifestyle that is aspiring to digital humanism where people's daily activities are becoming more digitalized, convenient and intelligent [27]. Actors on the telecom markets are pursuing innovations and launching new value-added services (VAS) [5] in order to increase revenue. This is due to the fact that provisioning basic telecommunication services (i.e., fixed and mobile communication, data transfer) is no longer enough to keep existing customers, let alone attract new ones, due to high market penetration. Investment regain of licenses and staying competitive in the future are key drivers for the expansion of new VAS on the market. This new market demand and technological development has led to the convergence of different domains (i.e., telecommunications, information technology (IT), the Internet, broadcasting and media) all involved in the telecom service provisioning process. The ability to transfer information embodied in different media into digital form to be deployed across multiple technologies is considered to be the most fundamental enabler of convergence [14]. An important feature of convergence is the composition of services and content derived by combining multiple simpler services or types of content in order to provide more powerful services.

The research problem addressed in this paper concerns the automation of business processes related to the creation of VAS that are traded on the telecommunication electronic markets (e-markets). There are two types of resources needed for the creation of telecom VAS. They are the information resources (i.e., content) the service is based on and the transport capacities needed for service provisioning. The telecom market is divided into two submarkets, the B2B (*Business-to-Business*) market and the B2C (*Business-to-Consumer*) market. Our research is focused on B2B telecom e-market trading with information resources using multi-attribute auctions.

The rest of the paper is structured as follows. Section 2 describes the participants on the telecom e-market. Section 3 describes the phases we need to go through in order to conduct a transaction on the B2B telecom e-market. Section 4 addresses general auction mechanisms and presents multi-attribute auctions. Section 5 states the main questions of this research effort and proposes some answers.

2. TELECOM E-MARKETS

The appearance of new stakeholders on the B2B telecom market had to be taken into account so new business models were formed. One of the long-term objectives of the NGN is to support business models that open the market to emerging service providers [14]. The volume and dynamic nature of VAS offered

in the NGN place novel demands and challenges on telecom stakeholders. In this newly developed situation it is not enough just to adequately respond on the existing requests but also to intelligently anticipate the development of the future events and adapt to their environment. In order to understand the relationships between stakeholders and the way they interact it is important that their roles are well classified. We use the classification determined in [8] as shown in Figure 1.

Consumers are service users that have at their disposal various devices (e.g., mobile phone, laptop, PDA) and are connected through various access networks (e.g., 3G, WiMax). *Access Provider* ensures telecommunication access for service consumers. *Service Provider* facilitates a variety of basic and integrated services for consumers enabling easy content consumption. *Carriers* provide a transport service for the data traffic and they usually buy bandwidth from *Network Infrastructure Owners* who provide transmission lines. A large number of Carriers are at the same time also Network Infrastructure Owners. *Wholesaler of Capacity* provides lower-cost transmission and storage capacity. *Content Owner* possesses the information in its original format while *Content Enabler* converts this information to a format eligible for the transmission over heterogeneous networks. Content Provider is at the same time Content Owner and Content Enabler. *Wholesaler of Content* provides lower-cost content. *Server Infrastructure Owner* provides storage capacity and server functionality. *Information Enablers* enable information resources while *Transport Enablers* provide transport of information resources through the various networks swiftly and seamlessly.

We are focusing on the B2B e-market since it is widely believed that it will become the primer way of doing business [21]. The assumption is that the telecom B2B e-market will grow with other B2B e-markets. A special intention is paid to the negotiation phase since the outcome (i.e. financial efficiency) is still the premier performance measure for most businesses [16, 17].

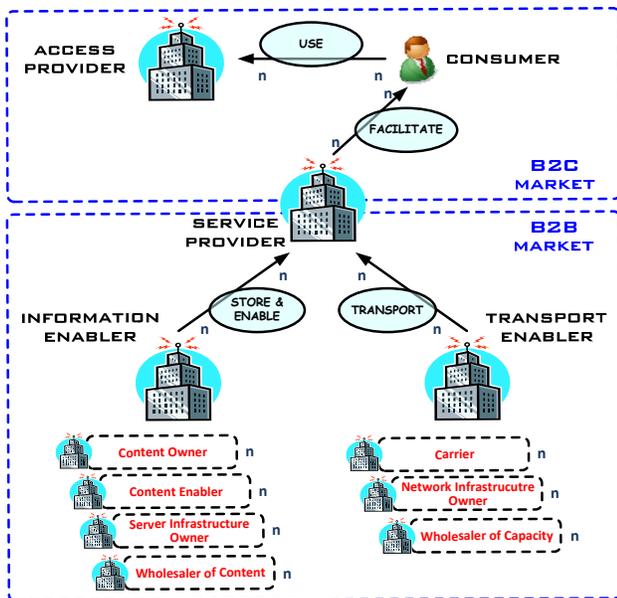


Figure 1. The roles and relationships of stakeholders in the telecom market

3. B2B TELECOM E-MARKET

The BBT (Business-to-Business Transaction) model [15] systematically analyses processes in B2B e-markets. The proliferation of auctions on the Internet, and the dynamic nature of auction interactions, argues for the development of intelligent trading agents which act on behalf of human traders (i.e., buyers and sellers). Intelligent trading agents can also be used to impersonate stakeholders in the environment of the NGN in order to enable automated interactions and business transactions on the telecom markets [20]. Namely, an agent can monitor and participate in the market continuously. Software agents [7, 19] are programs which autonomously act on behalf of their principal while carrying out complex information and communication tasks that have been delegated to them. A software agent is intelligent (its intelligence is grounded on its knowledge base, reasoning mechanisms and learning capabilities), autonomous, reactive, proactive, cooperative, and persistent. Additionally, a software agent can also be mobile.

From the BBT model perspective [15], we can formally identify six fundamental steps which must be executed in order to successfully complete one transaction in a B2B environment. These steps are as follows (Figure 2): 1) *partnership formation*, 2) *brokering*, 3) *negotiation*, 4) *contract formation*, 5) *contract fulfillment*, and 6) *service and evaluation*. B2B negotiation is complex since it typically involves larger volumes, repeated transactions and more complicated contracts. This is the reason why most researchers have concentrated on the negotiating phase of B2B market transactions.

The *partnership formation* phase usually includes forming of a new virtual enterprise or finding partners to form a supply chain. A virtual enterprise represents a form of cooperation of independent stakeholders which combine their competencies in order to provide a service [6]. On the B2B telecom e-market, *Content Owners*, *Content Enablers*, *Server Infrastructure Owners* and *Wholesalers of Content* can form a *virtual enterprise* in order to successfully place and sell information resources to various service providers. Moreover, *Carriers*, *Network Infrastructure Owners* and *Wholesalers of Capacity* may also form a *Virtual Enterprise* to enhance trading with transport capacity. With the expansion of the e-market, the number of buyers and sellers grows accordingly making it more difficult to find all potential business partners trading a requested service/resource. The main role of the *Brokering* phase is to match service providers with information/transport enablers that sell information resources/transport capacities needed for the creation of a new service or improvements of an old one.

Negotiation is a process which tries to reach an agreement regarding one or more resource attributes (e.g., price, quality, etc.). Each stakeholder in the negotiation process is represented by an intelligent trading agent that negotiates in his behalf (e.g., *Information Agent* trades in behalf of *Information Enabler*). The trading agent uses a negotiation strategy suitable for the type of auction applied (i.e., negotiation protocol) on the market. The negotiation protocol defines the rules of encounter between trading agents. It should ensure that the negotiation's likely outcome satisfies certain social objectives, such as maximizing allocation efficiency (i.e., ensuring that resources are awarded to the participants who value them the most) and achieving market

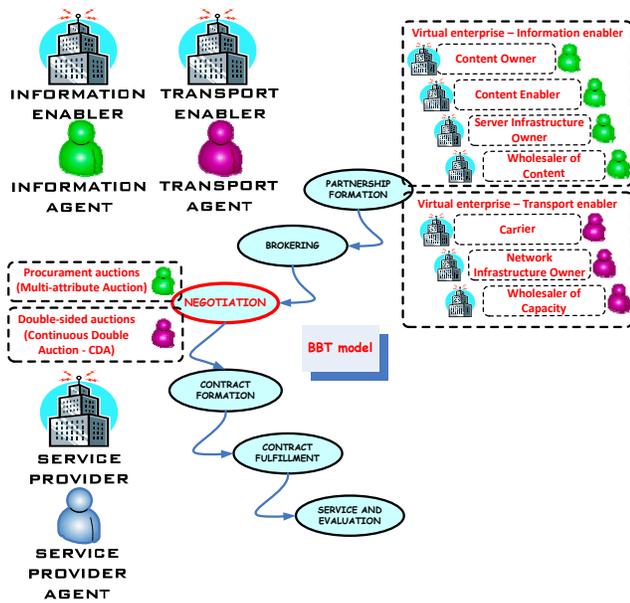


Figure 2. The BBT model for the B2B telecom domain

equilibrium [9]. The negotiation strategy represents a set of rules that determines the behavior of a trading agent.

The negotiation process can be either distributive or integrative [22]. In distributive negotiations, one issue is subject to negotiation while the parties involved have opposing interests. One party tries to minimize loss and the other party tries to maximize gain. Distributive negotiations are also characterized as “win-lose” negotiations. The continuous double auction (CDA), which is suitable for transport capacity trading in a B2B e-market, represents a distributive type of negotiation in a multi-unit auction with multiple buyers and sellers [25].

In integrative negotiations, multiple issues are negotiated while the parties involved have different preferences towards these issues. For example, two information enablers may want to sell multimedia information resources to a portal provider, but one is primarily interested in the sale of news, whereas the other is interested in the sale of movie clips. These variant valuations can be exploited to find an agreement resulting in mutual gain. If their preferences are the same across multiple issues, the negotiation remains integrative until opposing interests are identified. In such a case, both parties can realize gains: consequently, another name for this class of negotiations is “win-win” negotiations. A multi-attribute auction represents an integrative negotiation process which can be used for trading with information resources.

Last three phases include termination of negotiation where negotiated terms are put in a legally binding contract (contract formation), carrying out the transaction agreed in the contract (contract fulfillment) and traders evaluating the received service (service evaluation). Due to legal issues and subjective judgments it is not likely that these phases are going to be automated with the use of intelligent agents.

4. AUCTIONS

Auctions, due to their well defined protocols, are suitable enablers of negotiations in e-markets. The variety and value of goods that

are sold in auctions has grown to tremendous proportions. Auctions are defined as a market institution that acts in pursuit of a set of predefined rules in order to compute the desired economic outcome (i.e., high allocation efficiency) of social interactions [26]. Based on bids and asks placed by market participants, resource allocation and prices are determined. There are two main directions to take when designing auctions, namely we distinguish efficient and optimal auctions. The objective in efficient auctions is to maximize allocative efficiency and deal with dividing the surplus in an auction among the auctioneer and bidders, while optimal auctions concentrate on maximizing revenue or the expected utility of the bid taker [3].

4.1 Multi-attribute auctions

Item characteristics (i.e., attributes) represent an important factor in deciding which auction should be used in the negotiation phase. Negotiation on commodities, such as transport capacities, focuses mainly on the price of the item. These items are mostly sold in conventional single-attribute auctions. On the other hand, complex items such as information resources often require negotiation of several attributes, and not just the price [6]. They are sold in multi-attribute auctions [3] which are a special case of procurement auctions. Procurement auctions are also called reverse auctions since there are multiple sellers (e.g., information enablers) and only one buyer (e.g., service provider) that purchases items (e.g., information resources). Multi-attribute auctions have been attracting more and more attention in B2B markets since the price is not the only important attribute considered in the decision making process¹.

The first step in a multi-attribute auction is for the buyer to specify his preferences regarding the item he wishes to purchase. Preferences are usually defined in the form of a scoring function based on the buyer’s utility function [2]. In order to familiarize sellers with buyer’s valuations of relevant attributes, the buyer usually publicly announces his scoring function. Sellers are not obligated to disclose their private values of an item. The winner of the multi-attribute auction is the seller that provided the highest overall utility for the buyer. The buyer sends a request to all interested sellers which then reply by sending bids. The buyer selects the bid with the highest overall utility. If the auction is one-shot, this bid is declared the winning one, otherwise it is declared as the currently leading bid and the new round of the auction begins. The buyer can also define the bid increment or minimum requirements the bid has to fulfill in order to compete in the next round. Figure 3 shows a multi-attribute auction between a service provider and several information enablers. Information enablers offer multimedia content composed of video and audio streams with different performances. Based on its utility function, the service provider reaches an agreement with the information enabler whose information resource has the highest overall utility.

4.2 Content trading

The term content encompasses movies, songs, news, images and text, in other words data and information within various fields [14, 23]. The NGN brings its own new added value into the market and one of these added values is multimedia content composed of several types of content (e.g., audio, video, data...)

¹ <http://www.cindywaxer.com/viewArticle.aspx?artID=149> (Business 2.0 magazine)

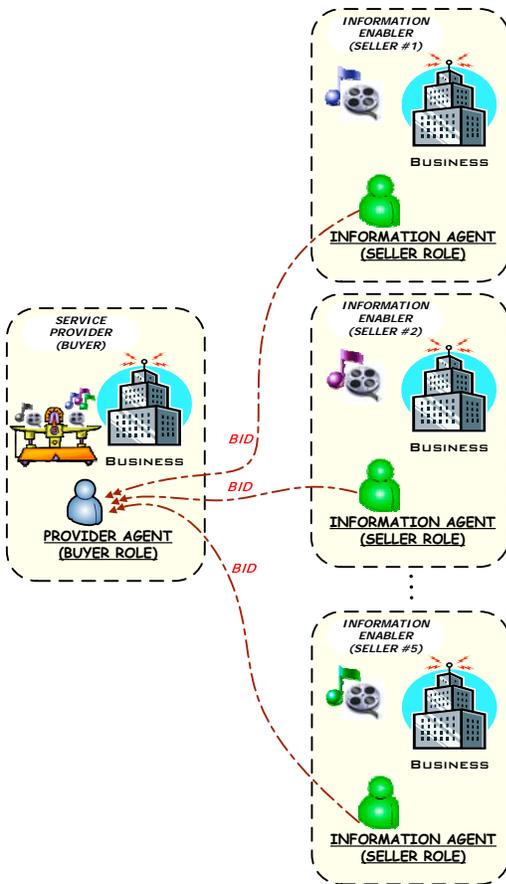


Figure 3. An agent mediated e-market for content trading

[11]. When trading with multimedia content there are several attributes that are negotiated on; the quality of the audio and video content (i.e., audio bit rate, resolution of the video), type of the information provided (i.e., music, video clips, games, news, sports, weather...), time of origin of the content (e.g., two days old weather forecast is of no use, one minute old stock market news could be worth a lot), reusability of the content (i.e., using the content in forming various services), potential number of users interested in this content, and the price. An example of trading with multimedia content by using multi-attribute auctions is shown in Figure 3 where several agents posing as sellers offer different multimedia (i.e., audio and video) content while the agent posing as a buyer must decide which content holds the highest utility for him and then buy the content in order to resell it further on the B2C e-market [18].

5. PROPOSAL OF THE RESEARCH PLAN

The research plan consists of four stages². The aim of the first phase is to explore the telecom market, identify participants on the market, establish their roles and relationships, and, finally establish with what goods and services are being traded on the market. This phase is completed and is described in Section 2. We can see that a service provider actually manages a supply chain by buying information and transport capacities on the B2B telecom

e-market, forming value added services from purchased goods and then selling those services to consumers on the B2C telecom e-market.

Due to the lack of research related to B2B telecom e-markets [13] (i.e., most research is related to the B2C telecom e-market [5, 10, 12, 18]) and the expected growth of B2B e-markets in general, the second phase is oriented to finding an appropriate model which captures all stages related to transactions carried out on the B2B telecom e-market. As shown in Section 3, the BBT model was used to describe B2B telecom transactions, while intelligent agents were used to impersonate stakeholders on the market. Since the B2B e-market includes repeated transactions with existing and/or new business partners, a new phase should be introduced into the BBT model. This phase will be in charge of collecting knowledge regarding the state of the e-market, processing information collected in the service evaluation phase, and deciding on the changes that need to be applied in the next round of negotiations.

The third phase is dedicated to the negotiation phase of the BBT telecom model. Well defined and widely researched CDA is used for trading with transport capacities. Consequently, we decided to focus on multi-attribute auctions for trading with information resources (i.e., content). In order to trade with content, the first step is to define relevant attributes and form an ontology which adequately represents multimedia content. The next step is to study existing models of multi-attribute auctions using different approaches (i.e., defining utility functions [2, 3], fuzzy multi-attribute decision making algorithms [24], introducing pricing functions and preference relations for determining acceptable offers [1], defining reserved and aspiration levels of attributes and distinguishing negotiable and non-negotiable attributes [4]). After studying the existing models, we plan to choose the best features from each approach and try to incorporate them into a new unified model most suitable for content trading. The new approach will be incorporated into the multi-attribute auction mechanism based on the English auction. Due to the specifics of the B2B telecom e-market (e.g., larger values of single transactions, repeated transactions, and a smaller number of participants than on B2C e-markets) the goal is to create a balance between maximizing the allocative efficiency of the B2B market and maximizing revenue or the expected utility of bid takers characteristic for multi-attribute auctions.

The fourth phase will be devoted to implementing the multi-attribute auction with agents as representatives of telecom stakeholders using the JADE (Java Agent DEvelopment Framework) agent platform and evaluating the designed mechanism with the existing mechanisms mentioned in the previous paragraph.

6. ACKNOWLEDGMENTS

The work presented in this paper was carried out within research projects 036-0362027-1639 "Content Delivery and Mobility of Users and Services in New Generation Networks", supported by the Ministry of Science, Education and Sports of the Republic of Croatia, and "Agent-based Service & Telecom Operations Management", supported by Ericsson Nikola Tesla, Croatia.

² I am a 3rd year PhD student.

7. REFERENCES

- [1] Bellosta, M.-J., Kornman, S., and Vanderpooten, D. 2006. An Agent-Based Mechanism for autonomous multiple criteria auctions. In Proceedings of the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (Hong Kong, December 18-22, 2006). IAT'06. IEEE Computer Society, Washington, DC, USA, 587-594.
- [2] Bichler, M. 2000. An Experimental Analysis of Multi-attribute Auctions. *Decision Support Systems*. 29, 3 (Oct. 2000), 249-268.
- [3] Bichler, M., and Kalagnanam, J. 2005. Configurable Offers and Winner Determination in Multi-attribute Auctions. *European Journal of Operational Research*. 16, 2 (Jan. 2005), 380-394.
- [4] Bui, T., Yen, J., Hu, J., and Sankaran, S. 2001. A Multi-Attribute Negotiation Support System with Market Signaling for Electronic Markets. *Group Decision and Negotiation*. 10, 6 (Nov. 2001), 515-537.
- [5] Damsgaard, J., and Marchegiani, L. 2004. Like Rome a mobile operator's empire wasn't built in a day - a journey through the rise and fall of mobile network operators. In Proceedings of the Sixth Conference on Electronic Commerce (Vancouver, Canada, June 5-8, 2005) ICEC'04. ACM Press, New York, NY, 639-648. DOI=<http://doi.acm.org/10.1145/1052220.1052301>
- [6] Do, V., Halatchev, M., and Neumann, D. 2000. A Context-based Approach to Support Virtual Enterprises. In Proceedings of the 33rd Hawaii International Conference on System Sciences (Maui, Hawaii, January 4-7, 2000). HICSS 2000). IEEE Computer Society, Island of Maui, 6005.
- [7] Fasli, M. 2007. *Agent Technology for E-Commerce*. Chichester: Wiley & Sons.
- [8] Fischer & Lorenz (European Telecommunications Consultants). 2000. *Internet and the Future Policy Framework for Telecommunications*. Report for the European Commission
- [9] Friedman, D., and Rust, J. 1993. *The Double Auction Market: Institutions, Theories, and Evidence*. Perseus Publishing, Cambridge.
- [10] Furregoni, E., Rangone, A., Renga, F. M., and Valsecchi, M. 2007. The Mobile Digital Contents Distribution Scenario. In Proc. of the Sixth Int. Conference on the Management of Mobile Business (Toronto, Canada, July 9-11, 2007). IEEE Computer Society, Washington, DC, USA, 32.
- [11] Ghys, F., Mampaey, M., Smouts, M., and Vaaraniemi, A. 2003. *3G Multimedia Network services, Accounting, and user profiles*. Artech House, Inc. Norwood, MA, USA
- [12] Griffin, D., and Pesch, D. 2006. Service Provision for Next Generation Mobile Communication Systems – The Telecommunications Service Exchange. *IEEE Transactions on Network and Service Management*. 3, 2. (Second Quarter 2006), 2-12.
- [13] Griffin, D., and Pesch, D. 2007. A service oriented marketplace for next generation networks. In Proceedings of the 6th international joint conference on Autonomous agents and multiagent systems (Honolulu, Hawaii, May 14-18, 2007). AAMAS'07. ACM Press, New York, NY, 735-737. DOI=<http://doi.acm.org/10.1145/1329125.1329259>
- [14] Hanrahan, H. 2007. *Network Convergence: Services, Applications, Transport, and Operations Support*. John Wiley & Sons, Inc.
- [15] He, M., Jennings, N.R., and Leung, H. 2003. On Agent-Mediated Electronic Commerce. *IEEE Transactions on Knowledge and Data Engineering*. 15, 4 (Jul./Aug. 2003), 985-1003.
- [16] He, S., Cattelan, R., and Kirovski, D. 2008. Modeling Viral Economies for Digital Media. In Proceedings of the 3rd ACM SIGOPS/EuroSys European Conference on Computer Systems 2008 (Glasgow, Scotland, UK, April 1-4, 2008). EuroSys'08. ACM Press, New York, NY, 149-162. DOI=<http://doi.acm.org/10.1145/1352592.1352609>
- [17] Maes, P., Guttman, R., and Moukas, A. 1999. Agents that buy and sell. *Communications of the ACM*. 42, 3 (March 1999), 81-91. DOI=<http://doi.acm.org/10.1145/295685.295716>
- [18] V. Podobnik, I. Lovrek, "Multi-Agent System for Automation of B2C Processes in the Future Internet", Student Workshop @ 27th IEEE Infocom, Phoenix, USA, in Press.
- [19] Podobnik, V., Petric, A., and Jezic, G. 2008. An Agent-Based Solution for Dynamic Supply Chain Management. *Journal of Universal Computer Science*. 14, 7 (Apr. 2008), 1080-1104.
- [20] Podobnik, V., Trzec, K., Jezic, G., and Lovrek, I. 2007. Agent-Based Discovery of Data Resources in Next-Generation Internet: An Auction Approach. In Proceedings of the 2007 Networking and Electronic Commerce Research Conference (Riva Del Garda, Italy, October 18-21, 2007). NAEC 2007. ASTMA, Riva del Garda, 28-51.
- [21] Shaw, M. 2000. Electronic commerce: state of the art. In *Handbook on Electronic Commerce*, M. Shaw, R. Blanning, T. Strader, A. Whinston, Eds. Springer, Berlin, 3-24.
- [22] Ströbel, M. 2003. *Engineering Electronic Negotiations*. Kluwer Academic/Plenum, New York
- [23] Subramanya, S.R., and Yi, B.K. 2005. Utility Model for On-Demand Digital Content. *Computer Magazine*. 38, 6 (Jun. 2005), 95-98.
- [24] Tong, H., and Zhang, S. 2006. A Fuzzy Multi-Attribute Decision Making Algorithm for Web Services Selection Based on QoS. In Proceedings of the 2006 IEEE Asia-Pacific Conference on Services Computing (GuangZhou, China, December 12-15, 2006). APSCC'06. IEEE Computer Society, Washington, DC, USA, 51-57.
- [25] Trzec, K., Lovrek, I., and Mikac, B. 2006. Agent Behaviour in Double Auction Electronic Market for Communication Resources. In: KES 2006. LNCS. 4251. Gabrys, B., Howlett, R.J., Jain, L.C., Eds. pp. Springer, Heidelberg, 318-325.
- [26] Wurman, P.; Wellman, M.; and Walsh, W. 2002. Specifying Rules for Electronic Auctions. *AI Magazine*. 23, 3 (Fall 2002), 15-23.
- [27] Yoon, J.-L. 2007. Telco 2.0: A new role and business model. *IEEE Communications Magazine*. 45, 1 (Jan. 2007), 10 -12.