Multi-Agent System for Automation of B2C Processes in the Future Internet

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***Abstract*—The concept of New Generation Network (NGN) will define roles and relationships in the future Internet. The fierce competition among players in the Information and Communication (ICT) industry will just catalyze market redefinition processes, requesting from operators to promptly innovate their business models. The consumer's lifestyle will also change: individual users will be interested only in services that are *intelligent* (i.e., personalized and context-aware), *dynamic* (i.e., innovative and fun) and *mobile* (i.e., provisioned anytime and anywhere). A number of latest research incentives in the ICT domain are focused on automation and coordination of interactions between individual consumers and Internet service providers (ISPs). The research proposed in this paper aims to pursue similar ideas while creating a multi-agent system for automation of Business-to-Consumer (B2C) processes in the environment of the future Internet.**

Keywords-future Internet design; business model; B2C electronic market; service overlay; software agent

I. RESEARCH MOTIVATION

We are entering a period of time when everything is becoming digitized and almost all software and devices are innately network-aware [1]. The amazing advances in the Information and Communication Technology (ICT) industry have enabled the advent of the ubiquitous New Generation Network (NGN). The NGN is an outcome of the natural fusion of three different technologies: *computers*, *the Internet*, and *mobile networks*.

A. Computers

Throughout the history of computing, three main eras can be identified [2][3]. The first era was the era of *mainframe computing*, when large and powerful computers were shared by many people. The second era was the era of *personal computing*, when there was one computer per person. In the upcoming third era, we as humans will interact no longer with just one computer at a time, but rather with a dynamic set of small networked computers, often invisible and embodied in everyday objects in the environment (e.g., locating device weaved into the clothes) [4]. This third era is the era of *ubiquitous computing* (now also called *pervasive computing*), or the age of *calm technology*. The calm technology is a concept describing such technology that, when utilized, retreats into the background of our lives and becomes "invisible" [3]. It is important to note that computers, when observed from the calm technology perspective, are not physically invisible, but as a part of the context of use.

B. The Internet

The Internet did not experience real proliferation until the invention of the World Wide Web (WWW or simply Web 1.0), a service provisioned through the Internet infrastructure [5]. Web 1.0, as a global information medium enabling users to read and write via computers connected to the Internet, became the bearer of the digital revolution in the 1990s which was a major catalyst of globalization and an important driver of economic prosperity. Consequently, all further Internet evolution after the invention of Web 1.0, is characterized as Web X.0, in spite of the fact that the WWW is just one of many Internet services. Web 2.0, also called "the Social Web", is no longer simply about connecting information, but also about connecting people through various forms of social networks (e.g., Facebook[1], MySpace[2] or LinkedIn[3]). The phrase "Web 2.0" was coined a couple years ago when the social networking phenomenon was recognized. Today, Web 2.0 has millions of users world-wide employing it on a daily basis for both personal and businesses uses. Web 3.0, also called "the Semantic Web", is the next stage in the evolution of the Internet in which it will become a platform for connecting knowledge. Web 3.0 is an evolutionary path for the Internet which will enable people and machines to connect, evolve, share, and use knowledge on an unprecedented scale and in many new ways make our experience of the Internet better[4]. Web 3.0 is starting now and will define the Internet over the next decade. One of the most promising Web 3.0 technologies, besides the Semantic Web (SW) [6], are intelligent software agents which can utilize semantically annotated information and reason in a quasi-human fashion. A software agent [7][8][9][10] is a program which autonomously acts on behalf of its principal, while carrying out complex information and communication tasks that have been delegated to it.

[1] http://www.facebook.com
[2] http://www.myspace.com
[3] http://www.linkedin.com
[4] Project10X's Semantic Wave 2008 Report (http://www.project10x.com)

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C. Mobile networks

The first and second generation (1G and 2G) of mobile networks have enabled circuit-switched voice services to go wireless. As the Internet grew, it became necessary to ensure mobile Internet access. The 2G GSM (*Global System for Mobile communications*) system was enhanced to 2.5G by introducing data communication and packet-switched services into the GSM network. The technologies of 2.5G, GPRS (*General Packet Radio Service*) and EDGE (*Enhanced Data Rate for GSM Evolution*) were the first step towards creating a mobile Internet. The third generation (3G) system, known as UMTS (*Universal Mobile Telecommunications System*), has introduced higher data rates which enable multimedia communications. The development of mobile networks has continued in both access and core networks. The UMTS access network has been improved by HSPA (*High Speed Packet Access*) technology which enables very high throughput focusing on streaming and interactive services. The core network incorporates IMS (*IP Multimedia Subsystem*) [11] which integrates mobile communications and the Internet at the core network level. The LTE (*Long Term Evolution*) is working on the evolution of mobile communication systems beyond GSM-UMTS-HSPA systems (B3G). The LTE should introduce higher levels of capacity, bit rates and performance, and support new services and features.

D. New Generation Network

Tremendous developments in wireless technologies and mobile telecommunication systems, as well as rapid proliferation of various types of portable devices, have significantly amended computing lifestyle, thus advancing the vision of ubiquitous computing toward technical and economic viability [12]. This vision is becoming a reality with the new generation of communication systems: the NGN [13].

The NGN will enable the transformation of physical spaces into computationally active and intelligent environments [14], characterized with ambient intelligence where devices embedded in the environment provide seamless connectivity and services all the time. This is aimed at improving the human experience and quality of life without explicit awareness of the underlying communication and computing technologies.

The NGN concept introduces the multi-dimensional convergence in the rapidly evolving ICT industry:

- *network convergence*, describing the integration of wireline and wireless access technologies;
- *terminal convergence*, describing the introduction of adaptive services that can be delivered anytime, anywhere, and to any device the consumer prefers;
- *content convergence*, describing the ever-growing tendency of digitizing various forms of information;
- *business convergence*, describing the fusion of the ICT industry and the media industry.

II. THE FUTURE INTERNET

The vision of *future Internet* is that of a ubiquitous platform that enables goal-directed applications that intelligibly and adaptively coordinate information exchanges and actions [15][16]. Such a vision provokes dynamic and extensive research aimed at developing efficient electronic market (e-market) models [7][10][17]. E-markets function as digital intermediaries that create value by bringing consumers and providers together in order to create transactional immediacy and supply liquidity, as well as the reduction of transaction costs. A model we use for systematic analysis of processes in B2C (*Business-to-Consumer*) e-markets is based on the Consumer Buying Behavior (CBB) model [8], adapted for the B2C Internet domain. Our model identifies six fundamental steps (Fig. 1), which need to be executed in order to successfully complete a transaction in the B2C environment of the future Internet. A brief description of these steps follows.

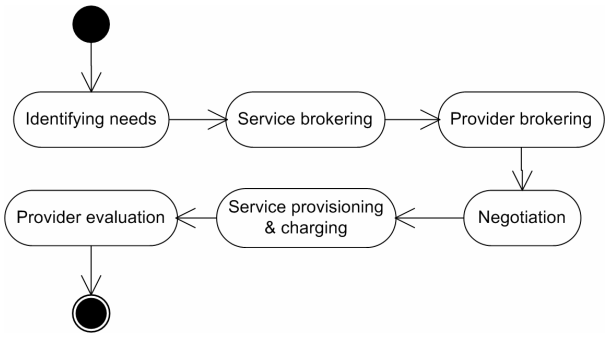

Figure 1. The CBB model adapted for the B2C Internet domain

1) Identifying needs: Prior to service utilization, the consumer must become aware of existence of a service which conforms to his/her needs.

2) Service brokering: The step responsible for determining what (i.e., which service) to buy, which encompasses an evaluation of service alternatives based on consumer-provided criteria. The output of this stage is called the *consideration set* of services.

3) Provider brokering: This step combines the derived *consideration set* with provider-specific information to help determine from which Internet Service Provider (ISP) to buy the service. This includes the evaluation of ISP alternatives based on consumer-selected criteria (e.g., price, reputation).

4) Negotiation: After the consumer has selected the ISP which offers the desired service, (s)he must negotiate conditions (e.g., price, QoS) for utilizing the service.

5) Service provisioning & charging: Once the service utilization is arranged, the ISP provisions the service with agreed QoS level, while the consumer is being charged for it.

6) Provider evaluation: Evaluation of consumer's level of satisfaction with the service provided by the selected ISP and its conformance to the agreed QoS level.

III. STATEMENT OF THE RESEARCH PROBLEM

Today, the number of Internet service consumers rises rapidly. Moreover, the competition among stakeholders on the market, as well as the NGN concept which introduces the whole spectrum of new services, enables consumers to be very picky. Consequently, realization of the full potential of the future Internet will make it necessary for ISPs to offer *intelligent* (i.e., personalized and context-aware), *dynamic* (i.e., innovative and fun) and *mobile* (i.e., provisioned anytime and anywhere) services [18]. Providing such services transparently to consumers is challenging from technical, business and social points of view.

The ultimate goal of the proposed research is to answer whether the combination of the market-based approach, the agent paradigm and the calm technology concept is the viable solution to the automation of B2C processes in the environment of the future Internet.

During the proposed research the special focus will be put on the automation and coordination of interactions between individual consumers and ISPs during introductory stages of the CBB model (namely, *identifying needs* phase, *service brokering* phase, and *provider brokering* phase).

IV. RESEARCH METHODOLOGY

The research plan consists of four research stages. The artifact of the first research stage is the model of future Internet environment. In the second stage mechanisms for all CBB phases should be designed, as well as incorporated into the model from the first stage. Furthermore, the third stage of research should deal with the implementation of designed CBB mechanisms. In the fourth, and final, research stage the implemented system will be evaluated. More details about the proposed research methodology follow.

A. Research stage 1

Identify all stakeholders in the future Internet environment. Assign them adequate roles and define possible relationships between them. This step resulted with a specification of the future Internet domain (presented in Fig. 2).

Dynamic and distributed nature of services in the future Internet requires stakeholders not only to respond to requests but also to intelligently anticipate and adapt to their environment. Software agents as the computing paradigm and the calm technology as the utilization concept are able to conform to requirements set forth. Fig. 2 presents the introduction of software agents into the B2C Internet environment. Entities shown as *Consumer Agent (CA)*, *Broker Agent (BA)* and *Provider Agent (PA)* impersonate consumers, service brokers, and ISPs, respectively.

B. Research stage 2

Isolate the B2C e-market (from Fig. 2) and propose mechanism for all CBB phases. When creating a solution for automation of processes in B2C Internet environment, the following important phenomenon of ICT supply chains should be considered:

- in classical supply chains a factory cannot use the same purchased component in more than one product;
- in service supply chains a service provider can reuse some of the purchased components in more than one service: for instance, when ISP purchases a movie clip from a content provider, the ISP can reuse the same movie clip in several different services, whereas every service can be provisioned to unlimited number of consumers.

Additionally, the characteristic of B2C Internet environment is a huge number of players on the consumer side, but just a few service providers on the business side.

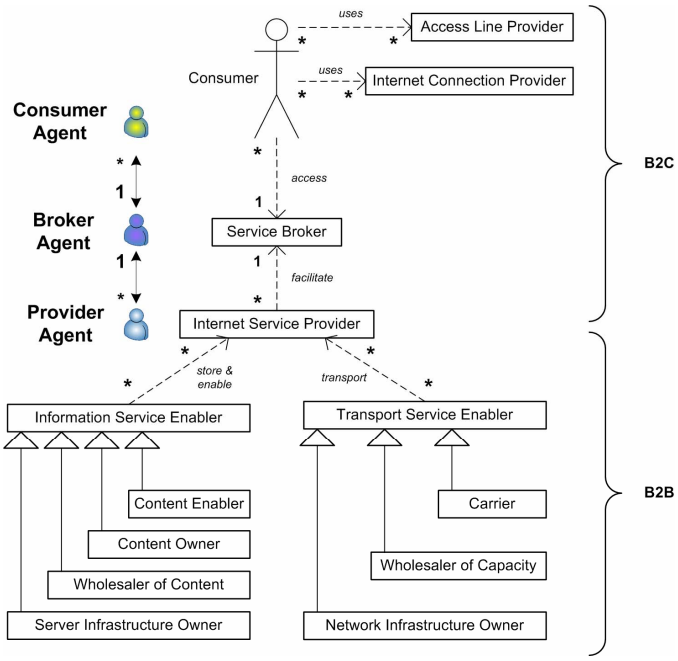

Figure 2. Roles and relationships of stakeholders in the Internet environment

The special focus should be put on designing mechanisms for the three introductory phases of CBB model. A brief description of possible mechanisms, for each CBB phase, follows.

1) Identifying needs: CAs, according to the profiles of its owners and the current state of the owners' environment, dynamically create social groups. The method for discovering groups of consumers that are all closely related is *data clustering* [19]. The input in data clustering algorithm is the matrix describing mutual closeness of every pair of individual consumers. The traditional tools for measuring closeness are *Euclidean distance* and *Pearson correlation*. The fact that the SW technology (i.e., OWL (*Web Ontology Language*)) will be applied when creating consumer profiles disqualifies traditional tools from resolving how similar two consumers are. Instead, a novel mechanism for automated matchmaking of consumer profiles will be designed. This mechanism should benefit from expressiveness of OWL and calculate consumer closeness more accurately than traditional methods. The implementation

should be based on the combination of Sesame framework, Sesame RDF Query Language (SeRQL) querying[5] and OWL.

2) Service brokering: CA, according to the profile of its owner and the current state of the owner's environment, finds the available services which are the "most similar" to the desired service [10][15][16]. This matchmaking is enabled by BA and should be completely automated by using SW mechanisms. The implementation should be based on the combination of Sesame framework, Sesame RDF Query Language (SeRQL) querying and OWL.

3) Provider brokering: CA, according to the profile of its owner, chooses "the best" ISP for a particular service. The presentation of ISPs (i.e., Internet marketing), which can be facilitated through BA, is of key importance here. For example, in our previous work, we have implemented a provider brokering mechanism based on semantically enriched Pay-per-Click (PPC) auction mechanism [10]. Furthermore, based on consumer clustering from the first CBB phase (i.e., *identifying needs*), we plan to do experiments with the idea of viral marketing [20].

4) Negotiation: The protocol should be designed that enables efficient interaction between consumers (i.e., CAs) and ISPs (i.e., PAs), through an intermediary entity (i.e., BA). Possible implementation can be based on the JCAT system [21], which is a Java-based server platform for TAC[6] (*Trading Agent Competition*) Market Design Competition.

5) Service provisioning & charging: A possible payment mechanism for B2C Internet environments is based on "one server wallet per person" concept, which allows the consumer to "deposit" a certain amount of money into his/her "server wallet", while his/her software agent is authorized to dispose of that money.

6) Provider evaluation: Consumer's evaluation, i.e., his/her satisfaction with a particular ISP is a subjective category, and the software agent serves to mediate the agent owner's evaluation to a repository where it remains available as a reference for future requests.

C. Research stage 3

Implement the designed mechanisms of the CBB model as a multi-agent system (MAS), by using the JADE[7] (*Java Agent DEvelopment Framework*) agent platform.

D. Research stage 4

Evaluate the implemented MAS from the viewpoints of designed mechanisms' functionality and efficiency, as well as the performance of the MAS as a whole.

V. PURPOSE OF THE RESEARCH

The proposed research aims to design, implement and evaluate the multi-agent system (MAS) which would demonstrate the processes in the B2C environment of the future Internet. Moreover, the created system should not just confirm the technical feasibility, but also take into account social and economic perspectives through proposing an efficient business model.

[5] http://www.openrdf.org
[6] http://www.sics.se/tac
[7] http://jade.tilab.com

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