UNIVERSITY
OF TRENTO

DEPARTMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY

38050 Povo – Trento (Italy), Via Sommarive 14
http://www.dit.unitn.it

ToothAgent: Brushing on Your Behalf

Sameh Abdel-Naby and Paolo Giorgini

December 2005

Technical Report # DIT-05-082

ToothAgent: Brushing on Your Behalf

Sameh Abdel-Naby and Paolo Giorgini

Department of Information and Communication technology
University of Trento

{sameh, paolo.giorgini} @ dit.unitn.it

ABSTRACT

Common interests among people in different communities and levels are driving plenty of research groups and industry developers to pay more attention to such a vast zone of opportunities. Nowadays, unifying service architectures and implementations has become achievable, advanced and sophisticated mobile services early-adopters and late-integrators are standing over one tangible concept; trouble-free life throughout hassle-free services, system design flexibility and support is established through superior and refined research methodologies and techniques. In this paper, we introduce a new form of previously implemented architecture: ToothAgent, we perform a simple amplification process that helps concatenating ToothAgent newly proposed schemes. We confirm a possible augmentation then we demonstrate the foreseen architecture possible integrations.

Keywords: Agent Oriented Architectures, Service providers, Mobile sets and services, Delegation systems, Advanced telecommunication methods

1. INTRODUCTION

Nowadays and after the revolutionary hi-tech services that are habitually introduced and embedded in our daily activities with the intention to link sophisticated technology with simple human desires. Friendliness, reliability and smoothness are becoming major characteristics of any at-ease-invention searcher, *early adopter*. In the same time it encourages new-creation bystander, *late integrator* to become fond of such a lifestyle.

Single Function device is a vanishing concept, electronic tools should at least provide multi-tasking technique so it become buyable to consumers. For example, MP3 Players to facilitate video and image showing, PDAs to enable inbound and outbound calls, Cellular Phones to picture capturing integration.

If we look at the software industry, same notion applies. Nowadays, we do not just use a word processing application but it is an image modifier, dictionary as well as marketing instrument. The Internet has done it and reached to the crucial goal by connecting the entire world through online services and portals, but yet the same question remains pending, is it possible to make similar internet services, if not the same ones, smarter, conspicuous and finally portable?.

Software Engineering [2] is the process of combining science, engineering, math and design in order to assist the software deployment process, and software engineers have got the authority to either facilitate or complicate the prequalification process [Jennings, 4], which is consequently reflecting on the entire application implementation process. It is not a coincidence that a complex software was found as much as it is shocking to let this application interface badly with end-users.

According to [3]

> *"agent is an encapsulated computer system that is situated in some environment, and that is capable of flexible, autonomous action in that environment in order to meet its design objectives"*

Solving a problem within the software industry either it is cellular phone relevant or computer concerned, will never be restricted to the usage of single agent [4] nevertheless, multi-agent system approach leaves a large impact on the completion process. The challenge is to compose *Software Engineering* with its *Agent-Oriented programming Techniques* taking advantage of *Multi-agent systems* so we increase the eagerness to use *Advanced Mobile Service*.

Based on Multi-agent system, a previously implemented architecture – ToothAgent [1] is illustrated and as well as a system components demonstration is taking place place along with the illustration. An amplification process is taking place in concatenating ToothAgent concepts with newly proposed ideas, showing the value of each notion and allocating it in the new schema. By this paper, we are conveying the message of having a more reliable system and interactive application that can be delivered to the networked life realistically.

The paper is organized as follows; Section 2 describes the main argument behind the necessity of AO and Advanced Telecom Services fusion, fall back on examples from the past and present in addition to future expectations. Section 3, demonstrates an implemented architecture based on Multi-agent Systems, ToothAgent. In Section 4, we suggest a ToothAgent new implementations by adding on it extra features and capabilities so it can be brushing on your behalf. In Section 5, we justify the advantages and disadvantages of using latest communication standards as messaging method among ToothAgent clients [4, 5, 6]. Section 6 exemplify a business awareness model based on ToothAgent. Finally we conclude and outline our future work in Section 7.

2. MOTIVATION

In this section we discuss the key arguments and motivation behind the need of implementing a ToothAgent (explained in section 3) like systems, and how to allocate these systems in our normal life structure, summarizing previous and present experiments, results and both AO and regular community reaction.

Rapidly growing technologies and services has strongly influenced our daily life, the adjustment to what so called *Network Life (connected life* is a common term as well*)* has became a must for everyone, duties that used to be easily achieved are becoming easier, although sophisticated technologies and complex processes are used. Moreover, ordinary *portable computers*, PDAs and Cellular phones that people use frequently on daily basis have got advanced communication methods (e.g. Infrared, Wireless and Bluetooth) integrated so it facilitate the establishment of Networked Life, besides the plenty of preinstalled and downloadable applications that interconnect with several communication devices so it achieves rich tasks in a clear resourceful behavior.

Lets imagine a frequent life scenario (*Figure 1*) considering a working place like a **Factory** where professionals dedicate 4 hours (minimum) to office work and computer substances, educational place like a **School** where students are allowed to use the computer labs as well as their cellular phones, goods distribution zone like a **Shopping Mall** where people from different society levels walk for hours in one single place roofed by different mobile serviced coverage plus normal telecom infrastructure, an entertainment district like a **Sports Club** with all of its modern characteristics. The majority of people either they work or study, whenever a spare time is found, they would rather go for shopping or sports in general. Among all these different activities, a cellular phone, PDA, Laptop or desktop computer is usually accessible. consequently, life is connected.

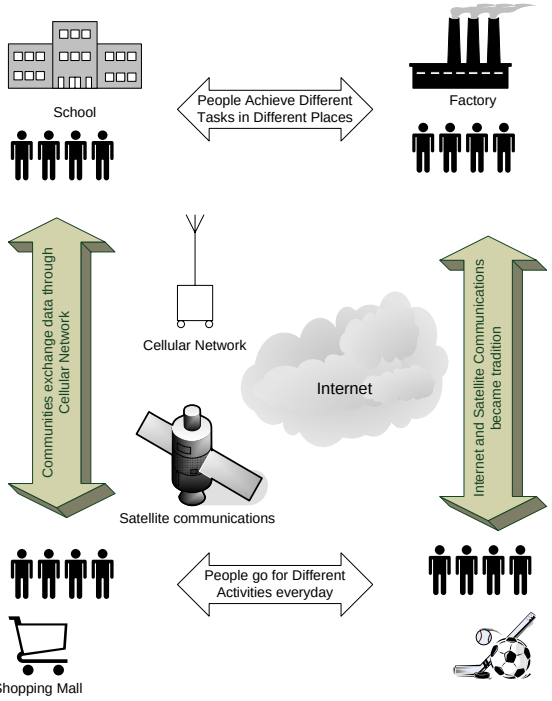

Figure 1: People interests, traditions and obligations are the common factor between different communities in numerous locations.

What drive people to use their electronic devices is their desire to achieve either a duty or maintain a procedure to reach it (e.g. phone call so they can fix an appointment in order to buy a new car). Apparently, people desires, needs and interests are the main motivators to technological adaptation.

From this point on, we can outline our paper main objectives. Does people desires drive software engineering research and development or the vice versa, and how far this construction should last? Is there any crossing point for different people interests and needs, and how should it be maintained? What possible features can be added on top of ToothAgent like, so it create a new desire and show the need for people to use it and rely on?. These questions will be answered along with our paper contents.

In 2001, KSACI [7] was first presented as developing tool that serves the communication infrastructure part among agents operating on a portable devices (handhelds were mentioned). Based on innovative capabilities like storage, location determination and processing time KSACI enables its users to exchange information and data with other embedded agents or with desktop predefined agents. This tool uses Knowledge Query and Manipulation Language (KQML) [8] as agents communications protocol and XML in editing the tool contents.

Operating time is considered a deficiency in KSACI. Briefly this tool was built on top of Simple Agent Communication Infrastructure SACI [9] that make units communicate with each other using Remote Method Invocation (RMI), then messages are exchangeable within a SACI proxy unit inside a HTTP server on desktop, and these server is considered a special agent that function as a TCP/IP listener and messages redirector. In order to pick the right message recipient, KSACI system will be constantly checking proxy MBox (messages box) for new retrieves, which we consider it as absolute network trafficker and power consuming.

March 2005 witnesses the reveal of MoPiDiG [10], *mobile profile based distributed grouping*, it is a mobile ad hoc application where each mobile host is supplied with a user-profile, and each user profile cope with a person (object). Special constraints are given to each user profile so it help configuring each user customized application and finally similar profiles have to be found.

This technique was applied the best within organizations that users grouping and categorization is needed. A museum example was mentioned [Seitz, 9] as previously implemented agent based system for guiding museum tours but without differentiating between visitor characteristics and interests, and here comes MoPiDiG with its innovative technique so same groups are allocated and museum personalized guided tours are organized.

We observe some imperfections in such a system, GROUP definition was not clearly maintained so it gave the application the possibility to look at a single user as a group even if it is more feasible to merge these user with her different interests into a bigger group with different profiles (cost and organization wise). Profile measurements and grouping criteria, for example, if our interests conflict with our family ones yet we would prefer to not make a museum tour individually, relations between profiles are significant in grouping. The dynamicity of the ad hoc mobile network was considered generally without specifying different scenarios for different communication methods (e.g. logging in and out process duration based on Bluetooth doesn't shape the same as Wi-Fi and WiMAX)

Different AOSE research groups in various locations and shapes are all concerned with the main concept of easing the interactions between societies, services and communication devices based on innovative telecommunication standards and protocols, *Figure 1* shows how people are layered under a fully connected architecture that walks along with them wherever and whenever they go.

AO community role should not be restricted with facilitating the reliable and automatic engineering attainment of people daily desires, needs and requirements. Being on hold up till a new human ambition is discovered is not the ultimate paradigm that Software engineers are considering. Forecasting future services, invoking new human needs and early realizing for certain combination of services and engineering concepts, is the foreseen trend for AOSE and in specific the MAS – Multi-Agent Systems researchers that are concerned with mobile integrations. Reflecting AO footprints strongly on the industrial mirror will leave a great impact on the merging process between research and development. A similar initiative was implemented and proposed by University of Trento MAS research group joint with ARSLOGICA R&D lab, ITALY (for more info: www.sesaspa.it) [1] and we are about to explain and un and re Lego it further on.

3. ToothAgent

Portal multi-agent platforms [11] is remote agent executing approach that is recognized by AO community in solving agent based applications processing on the server side of the architecture instead of the client side. The ToothAgent [1] architecture is portal multi-agent platforms based that can be installed on server where Multi-agent techniques are enabled, each server handles a specific data service area, and system users can contact their personal agents using their Bluetooth integrated devices, and on top of the previous features, ToothAgent is domain and technology independent, so specific services provided by a server does not affect the system, and different technologies can be used in different sights.

These system allows users to express their interests and customize their accessible services according to location through basic interactions, categories and keywords (Figure 2). Application interactions are maintained through an user-friendly interface that requires the user to insert variable parameters. A transmission process between the mobile device and the system is executed after finishing the configuration process, and again re-executed whenever a proper server is allocated, this happens after the searching process that offered by the system and within the mobile Bluetooth coverage range.

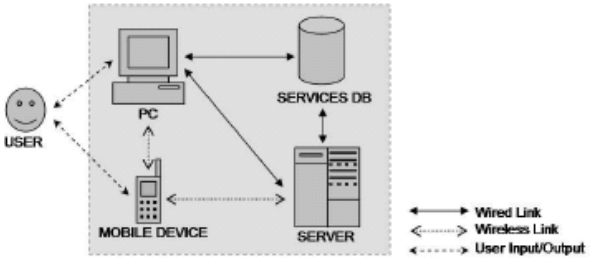

Figure 2: Interactions of System's Components [1]

Showed in Figure 2, the ToothAgent architecture interactive part. Through an Input/output relationship, The user will be taking over 2 authorities, the PC part, where user will configure his ToothAgent based application for desired services and details, and the mobile device part, where user will be enabling his device to function through the Bluetooth harbor and retrieve relevant data from the PC (wireless relationship). In the same time, this PC will be communicating with ToothAgent services server throughout a wired link requiring list of servers locations and services places.

Another pioneering feature in ToothAgent architecture that it enables its users to recover queued results throughout granting system clients the accessibility to check predefined demand results, whether user is within the Bluetooth range of the server or not.

PC operating software make users capable to search and identify servers and services that are listed in the ToothAgent architecture database (Figure 2). According to the service that has been selected by users, a relevant information should be given from their side so it facilitate the service customization process.

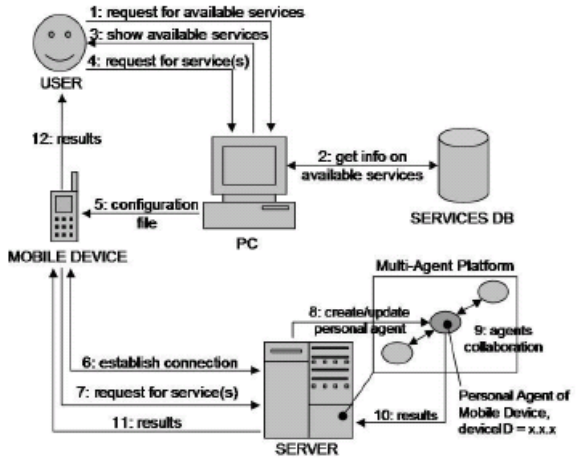

Figure 3: ToothAgent Technique in getting access to service [1]

Figure 3 shows ToothAgent service accessing architecture, in steps 1-3 the user outline servers and services registered to the ToothAgent Database. In step 4, the user chooses the more desirable services and provide the system with relevant information. In step 5, using a Bluetooth the configuration file where all previous data and configurations were saved are retrieved by the mobile device. In steps 6-7, the user is approaching a architecture related server, so device software is connecting to it and sending service requests upon the available ones. In steps 8-12, a prequalification process is initiated to confirm the user interests matching with server services and then results are sent back to user, and finally, the mobile device is storing server addresses to record previously interacted servers.

When a mobile device holder gets closer to one of the servers (Figure 3), the preinstalled software on the device set up a connection with these server and accordingly it broadcasts requests related to the accessible services. These requests were built on top of the previously communicated file between user mobile device and PC, at the end, results are sent back to the user and a list of all visited servers that cooperated with certain service is saved to be reviewed by user later on.

Each of the allocated servers is operating throughout a Multi-agent platform, consequently, agents and mobile devices are communicating among themselves based on one-to-one communication protocol, in a way that make possible receiving and processing requests obtained by users. Distinction between agents is achieved through the unique Bluetooth address of the corresponding address [1].

To access the service (Figure 4), platform users will be asked to function the Bluetooth based application installed in the mobile device. These application has been developed using Java and uses JSR-82 [12] – *Bluetooth API for Java*. Whenever a server is found and it matches a demanded service, a message is initiated through the mobile device and broadcasted toward the server direction. Consequently, agents are trying to broadcast their requests in the network searching for other agents that carry same interests or matching criteria requests, once searching mission was achieved successfully (fulfilling agent was found), the results are stored locally in the ToothAgent database server. Later on, results are sent to the user and await for reaction.

The initiative version of ToothAgent has been implemented and tested in university of Trento taking the case of students interests in buying used books. For more details about ToothAgent you can visit http://www.dit.unitn.it/~pgiorgio/ToothAgent (a demo of the system is also available).

Figure 4: ToothAgent Application running on a mobile device [1]

4. ToothAgent (Foreseen adaptation)

In this part we will be zooming in on recently applied realizations in different research areas, and how this implementations can be integrated with ToothAgent [1] to better shape it. We demonstrate a creative and challenging ideas that help ToothAgent to fulfill consumer expectations and market satisfaction, and contribute the most in facilitating ToothAgent integrations with more advanced platforms.

4.1 Possible Enhancements

Using ToothAgent prepare its users to expect service uniqueness, in the sense of having different preferences and needs according to different locations and environments, then remarking this users with a unique ID will be taken as their desires path. ToothAgent has implemented similar thing based on Bluetooth Unique ID, however we see it insufficient in case of different communication methods integrations (Explained further on). Users are registering to a system in a specific time and date, a combination between both adding on it the user family name first 3 characters (optional) will create a specific exclusive ID that recognizes its user profile. Embedding a logging in technique on parallel with this idea into the ToothAgent mobile based application and make it automatically establishing a connection within the available network (circumventing user manual sign in and out), will avoid relying on Bluetooth unique ID and will make it possible to build useful consequences on top of that suggested enhancement idea (Explained further on).

Offline messaging capabilities integrated with Time-to-live (TTL) data packet tags, after obliging clients to select a main server to be acting like their service main faucet. This procedures will offer users the possibility to look at agents based systems from completely different and more reliable perspective. Lets imagine a scenario where users are out of the Bluetooth coverage range, so implementing a function that replaces Bluetooth messaging with mobile small messages services (SMS) will be feasible. However, user might still be out of mobile network coverage, then a message should be initiated and saved in the Faucet-Service-Server (as we call it) and then to be sent to the user whenever he is available in the server communication range. Otherwise the message should be killed according to its TTL tag. Faucet Service Server can be selected by location (e.g. the nearest one to user home or office address), or by checking the visited servers list (already implemented in ToothAgent) and get the most visited one and assign it to the user ID.

Enabling different communication types and models will help service smoothness to increase, a user can be out of the system recognized communications range, but yet he is using his computer for work or connected to the internet one way or another. So enabling the PC ToothAgent application to recognize its owner availability and converting the structure workflow into a chatting (or similar) service will make user reach goes to more realistic edges, especially if other users are using their computers as well (e.g. in a university or working place). System should not wait for users to be available, system should run after them. Moreover, the significance of integrating some value added services that facilitates the requests exchange and delivery, for example, from chatting window to mobile SMS or the vice versa. Auction style service implemented technically will be fulfilling little gaps between buyer and sellers (in case of trade service, *used books*) and will increase system usability.

Preferred Meeting Spots Definition. If 2 users agreed on accomplishing a specific action (e.g. buyer and seller to meet and finalize the agreement), a call or any external communication method should be taken in order to define a meeting point. If the system database was implemented in a way that recognizes the users location and suggests a meeting points according to predefined spots listed in the database, and send this suggestions along with the initiative messages (e.g. this book will cost 20$ and suggested place to meet is by the reception). Avoiding extra communications hassles will be achieved, linking people on different scales and locations will be feasible, taking decisions from the client side will be faster.

Reputation Handling. Using a unique ID and interests, the system can implement a grouping action, where categorizing people will be according to their interests and needs or working fields and locations. The fundamental concern is to have users in groups, but acting and exchanging requests individually, so the maintainability of system group reputation will be achievable, and controlling participants behaviors will be monitored by all of the group members. This will help the service improvement and security. If a user will be informed that he is linked to a specific group (e.g. his friends) and any malicious transaction will influence the entire group reputation among others, the system will never have false operations and the traffic utilization will be purified.

Matching interests with similarities, common concept became a fundamental habit between major online eCommerce portals and service providers, for example, if you are looking for a *thinking in java* book, and some one else is offering *thinking in java live presentation* for the book author in a videocassette, matching this 2 queries as a system suggestion will increase the number of successful transactions.

4.2 Integrations

The integration between Wi-Fi and ToothAgent will give the entire architecture more reliability. Usually, users are by passing servers, rarely hanging there for more than 5 minutes, which will give Wi-Fi technology

with its coverage techniques and fast data transimission possibilities an advantage over Bluetooth (Explained along with the paper). After we demonstrated previously the alternative solution of Bluetooth unique ID and explained its consequences, no other obligations will drive us to limit our coverage to Bluetooth range.

The integration between ToothAgent mobile based application and already existing advanced mobile services platforms and portals (e.g. WAP) will enlarge the variety of system options and facilitate ToothAgent services accessibility. For example, if a user has suddenly noticed that he/she is getting many requests with high prices in reference to her *The Chamber* book selling request, that might lead the user to check the book availability online so it influences her proposed price. Unless ToothAgent is connected to updated product list that work as a measurement balancer among system users and gives advises accordingly.

The integration between ToothAgent and another similar implementations that focus more on localizations and long distances communications, will give ToothAgent the possibility to cover long distance requests and organize far trades and transactions.

4.3 Expectations

We are expecting that ToothAgent after enhancing its connectivity and adding to it extra features and transactions conditions, along with its mobile based application modifications. The system will be able to cover large areas, big amount of transactions, several services types and finally, bigger number of users.

We are expecting ToothAgent to be clearly integrating with our daily life rhythm, as life is becoming faster and people are willing to handle their duties on the fly rather than wasting 1 day looking for used book buyer, lets let agents do it.

5. TECHNOLGY MERGER

Advanced Telecommunication methods (e.g. Bluetooth, Wi-Fi and WiMAX) are widespread among group of people localized in specific zone, which refers to their commonality. In this part we will be showing different advanced possible communication methods that can be easily integrated with ToothAgent like systems or in general, Agent-oriented based messaging architectures.

5.1 Bluetooth

Bluetooth technology [4] provides its users with 10-meter personal communication surround supporting a concurrent transmission for Voice and data between 2 point. 8 devices (e.g. Cellular phones with Bluetooth enabled) can be connected to each other transmitting data among themselves in a single group of nodes (with the ability to exchange voice as well but for maximum number of concurrent 3 sessions). Connection between nodes and within groups are secured because Bluetooth technology uses up to 128-bit public/private key encryption model. Moreover, speed is achieved due to its high actual data rates, 432 Kbps for full duplex transmission.

Relying on Bluetooth to operate messaging service within Multi-Agent oriented architecture will cause a vital problem to raise. Usually, Bluetooth enabled users are dynamically entering into a certain communication ring, for instance, along with people walk in a shopping mall, frequent logging and shutting for the connection are obvious due to the limitation of the coverage distance.

Bluetooth radios operate in the unlicensed 2.4-GHz band that leads to the utilizations of large number of irrelevant devices in the same network. The crossing point arrives rapidly and devices interfere with one another, then devices will have to wait in order to achieve successful transmission which is considered a network slowdown. Network slowdown plus network small coverage distance will cause whatever backoffice application or architecture to lose its credibility. (according to [7] the presence of microwave oven for instance, will cut the transmission rate with 75%, imagine the situation in a shopping mall with plenty of restaurants and fast food corners).

5.2 Wi-Fi

Wi-Fi - *Wireless Fidelity* solutions presented in [5] are almost trustworthy in handling Agent-oriented based messaging platforms. Large-area coverage in the same time with communication speed are both major preferences that put Wi-Fi up to the usage of big number of nowadays organizations. It uses IEEE 802.11 standard and it has got 2 common approaches:

- **Directional Antenna based**: that sends/receives radio frequency waves in single direction stronger than sending to others, dedicated and predefined directional like antennas. It is sufficient for large distances in a constricted areas.

- **Mesh-network topology based**: it helps in enlarging the coverage of traditional WLANs, as all nodes are connected and communication protocols stretched among them all. Wi-Fi mesh topology based architecture is found when group of nodes with different Wi-Fi standards are associated throughout wireless 802.11 link.

Well-known security problems are recently discussed among these technology specialized communities, which will lead us to a complete recommendation of this expertise integration in any Agent-Oriented application once security defects were taking care of.

5.3 WiMAX

Worldwide Interoperability for Microwave access WiMAX [6] is 802.16/HiperMAN standard based communication protocol for 2-11 GHz wireless metropolitan area network (MAN) that provides broadband wireless connection for different positions users. It covers up to 50-Kilometers of service area. Its QoS – *quality of service* is assumed to be optimum for voice/video streaming with high data transmission rate, up to 280 Mbps / station.

Security issue is yet a hot zone to focus on. Moreover, the latest studies and market researched that confirmed the replacement of WiMAX to Cellular networks once it spreads uncontrollably in the market (understandable due to its large coverage range and nowadays Internet based telephony services).

6. Business Awareness

Agents negotiate one another to gain access to other resources and possibilities, even though, a business agent is an autonomous entity [13]. A common demanding problem is for agents to logically and straightforwardly communicate business and organization aspects and then merge these into a meaningful application or implementation [13] and that what let agents reach to the *self-representation abilities* within a business structure.

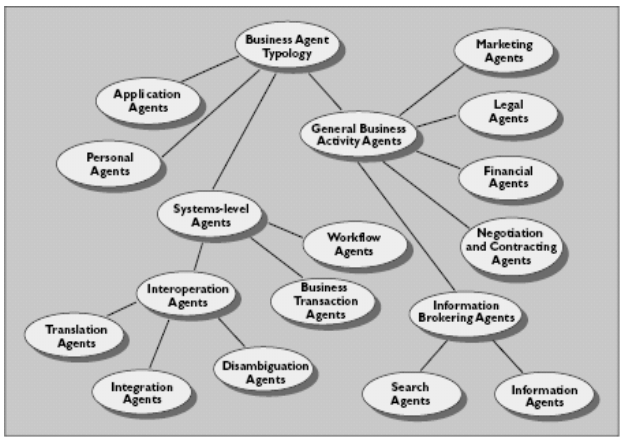

Figure 5: Agent-Oriented Business Construction.[13]

M. P. Papazoglou [13] has defined a multi-agent e-business environement allocating agents into a different layers depending on the business process requirement (Figure 5). The four basic forms of can be summarized as follow;

Application agents: agents are functioning vertically and individually according to their experiences in a single area within a business structure or domain (e.g. e-commerce), it helps other agents among the network by supplying them with information accessibility and knowledge distribution sources, therefore, complex problems are solved through a information clustering approach handled by agents within a business domain.

We see ToothAgent architecture about to fulfill that layer, as ToothAgent agents do interact among themselves so can solve problems but not a complex ones. For example, two buying agents are sending requests in the same time to a selling agent with different prices but both within the predefined average price which request should be selected to be communicated with user, rather than sending them both.

Personal agents: it works directly with users to support the agent based business architecture with the presentation, organization and management of users profile, other agents requests and information collection. A monitoring system is achieved by each user agent so it records the actions taken by the user within the application interface and accordingly it suggests better ways to achieve the specified task.

ToothAgent is not accomplishing these part, as no application monitoring system is implemented within the configuration process through the PC based application.

General Business Activity Agents: where search agents are located, this search agents are concerned mainly with commerce and trade issue, they operate certain processes that enable network surfing and navigation until information and service requests are achieved. So activity partner is outlined and successful connection between both sides is initiated.

ToothAgent is allocated sufficiently in such a business based layer. The Multi-agent system based architecture that ToothAgent utilize within its structural design, is mainly concerned with finding trade partners and negotiating similar interests and needs. Which will carry ToothAgent ahead with its notion, to finally reach users minds and encourage them to delegate straightforwardly such a system to be brushing on their behalf.

Information Brokering Agents: agents in these layer are concerned with determining information path contained by a network or solving ordinary problems that are happening frequently. Brokering agents are capable to preserve, enter and update distributed directory services [13]. Another name has been given to these layer, Matchmaking agents.

Also ToothAgent, are allocated within these layer, since agents which are implemented in this architecture have the possibility to access the users network searching for demanding information, sort it, and finally return it to the system users with expecting results.

ToothAgent is using a Distributed Facilitator Agent based Technique (DF), and that is partially plays a

similar role as Broker Agents one in finding other requests achievers agents within the network. But its usage is limited, as we consider it critical and significant due to the responsibility delegation of platform to provide specific services.

In reference to figure 5, and according to ToothAgent research team keenness to implement something that adjust to industrial needs and accordingly to end-users hands, the e-Business agents based construction is expected to be fitting within ToothAgent development process. By that concept, ToothAgent will be fully achieving simultaneously, both, Private Sector and Research laboratories finest results.

CONCLUSIONS

In this paper we explained the general motive behind implementing an Multi-agent based architectures, we demonstrated some previously achieved work in the same research area. We showed the transforming intersection between technological implementations, basic life needs, and advanced communications methods.

We discussed ToothAget, a Multi-agent approach toward the integrations between advanced mobile services and human desires and interests. We proposed some creative and innovative helping notions so these architecture better integrate with daily life duties. And what do we expect after the achievement of this enhancements.

We explained the emergent communication technologies with ToothAgent like systems, and gave some recommendations in each standard usage. Then we allocated ToothAgent within a predefined Agent based business architecture so we cam up with a conclusion that ToothAgent has missed the personal agents business implementation concept and was acceptable from the application agents prespective. And as future work, we planned to test integration of ToothAgent based architecture with University of Trento Wi-Fi network, and then to bigger coverage.

ACKNOWLEDGEMENTS

We first thank the ToothAgent research team and ArsLogica s.r.l. for the usual collaboration and the support to this project.

REFERENCES

[1] Bryl, Volha and Giorgini, Paolo and Fante, Stefano (2005) Toothagent: a Multi-Agent System for Virtual Communities Support. Technical Report DIT-05-064, Informatica e Telecomunicazioni, University of Trento.

[2] A. Finkelstein and J. Kramer, "Software Engineering: a roadmap," in The Future of Software Engineering, A. Finkelstein, Ed.: ACM Press, 2000, pp. 3--24.

[3] F. P. Brooks (1995) “The mythical man-month” Addison Wesley.

[4] HP. Bluetooth Technology Overview. White Paper.

[5] Intel. Understanding Wi-Fi and WiMAX as Metro-Access Solutionss. White Paper.

[6] alvarion. Introducing WiMAX. The next broadband wireless revolution.

[7] Ryan L. Albuquerque, Jomi F. Hübner, Gustavo E. de Paula, Jaime S. Sichman, Geber L. Ramalho. “KSACI: A Handheld Device Infrastructure for Agents Communication”.

[8] Yannis Labrou and Tim Finin, “*A Proposal for a new KQML Specification KQML*”,. UMBC, Baltimore, 1997.

[9] Jomi Fred Hübner and Jaime Simão Sichman, “*SACI Programming Guide*”

[10] Seitz, C., Berger, M., Bauer B. “MoPiDiG” , Proceedings of the First International Workshop on Mobile Peer-to-Peer Computing, Orlando, Florida, USA, März 2004

[11] C. Carabelea and O. Boissier. Multi-agent platforms on smart devices : Dream or reality? In *Proceedings of the Smart Objects Conference (SOC03), Grenoble, France*, pages 126{129, 2003.

[12] JSR-82: Java APIs for Bluetooth. http://www.jcp.org/en/jsr/detail?id=82.

[13] Mike P. Papazoglou, Agent-oriented technology in support of e-business, Communications of the ACM, v.44 n.4, p.71-77, April 2001

[14] Klusch, M., Ed. *Intelligent Information Agents.* Springer-Verlag, 1999.