Everyware everywhere: Overview of the Social Implications of Embedded Systems, Internet and Mobile Technologies

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***Abstract*—**Embedded systems are widely implemented in every aspect of contemporary societies. The scale of usage of embedded systems in everyday lives is so high that people have become so accustomed to the conveniences they provide that they become unaware of their existence. Nevertheless, business processes and procedures, interaction with government institutions and public administration as well as social contacts have dramatically changed due to the implementation of embedded systems.

The goal of the paper is to present changes in contemporary societies that are influenced by the intense use of embedded systems. Current trends in mobile computing and RFID technologies are two main driving forces of embedded systems that will be considered in this paper, as well as the development of web semantics and intelligent agents that characterize the era of Web 2.0 and upcoming era of Web 3.0. The paper will try to analyze and discuss possible interactions and amalgamation of these embedded systems as well as possibilities they may bring in the digital or e-societies in future decades.

A survey will be presented in order to determine user perception of these technologies and estimate potential users interest in the adoption of future services that will become available in the next decade.

***Keywords*—** Customer markets, Embedded systems, Innovation, Internet technologies, Ubiquitous computing, Mobile technologies, Society.

I. Introduction

CONTEMPORARY societies have become highly dependent on various technological advances that have become integral part of life for majority of its citizens. Over the course of using these tools they started to shape peoples' habits and ways of thinking and running their everyday lives.

On the other hand the created demand for improved and more efficient technology started a trend of technological convergence that has finally reached its peak, resulting in overwhelming pool of digital information that brought together various technologies in order to provide novel products and services to deal with increased dynamics in contemporary living and business setting.

Due to these trends most of the devices today have embedded systems as their crucial part, usually allowing most of the devices to interconnect and share this digital information with final goal of offering added value to final user or the consumer.

Unfortunately, social systems that are supposed to follow this rapid technological trend seem to be unable to catchup so that educational system or institutional systems and legislation follow behind these changes. This is why we need to understand the state of customers' perspective on understanding these technological trends and technologies that surround them, and their willingness to use them.

Goal of this paper is to review recent technological developments through the notion of technological convergence. The focus of the paper is given to technologies that make up the significant majority of IT and software industry revenue, mobile technologies, Internet technologies and embedded systems. The aim of this review is to set the context for the customer perspective on these developments. Finally, we will try to estimate the level of customer understanding of these technological trends and their readiness to accept new innovative products and services that are still in research and testing phases. This will allow us to estimate potential of customer market absorption and outlook for novel products and services that are the result of advanced technological convergence.

Further on we can then discuss the relation between the knowledge about technology and readiness of customers to use resulting products and services, which may serve as invaluable indicator for the development of future innovative projects in the underlying industries. We base our discussion on a cluster analysis that was used to group customers into two distinct groups that are most important for understanding customers attitudes and their influence on the adoption of various novel products and services.

The structure of the paper is as follows. In Section II we will give a brief overview of recent technological developments that are primarily characterized by the convergence of mobile,

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Internet and embedded technologies. In Section III research of customer perspective will be given based on the results of conducted survey. In Section IV a discussion of the presented results will be given as well as estimates of market abortion potential and relation between customer understanding of technology and their inclination of consuming resulting products and services. In the last Section a conclusion of the research will be presented.

II. Overview of recent Technological Convergence

Technological convergence is a term describing tendency that as technologies evolve they become capable of solving similar tasks, usually not intended by each technology's initial goals. In this sense various technologies become compatible allowing them to be integrated into one another creating novel intermediate technologies reaping synergic benefits.

First convergence trend began in telecommunication during the early stages of digitalization, as more and more signals and data was transformed into digital formats. This was the main perquisite for the technological convergence to take its place.

One of recent examples of new technological paradigms resulting from technological convergence is pervasive computing.

Pervasive or ubiquitous computing is a general term describing the new conceptual paradigm where most of the devices and their environment have particular computing capabilities. This term is meant to contrast the term desktop computing in the sense that computing is available from any device, any location using any computing aspect or technology.

Goal of pervasive computing is to provide users with proactive and self-tuning environments and devices that can augment personal knowledge and decision making abilities, while requiring as little direct user interaction as possible [1].

Pervasive computing combines networking technologies, mobile technologies and embedded systems, all of which are used in other concepts as well. The innovation is founded on the concept and goals what makes different combination of existing technological solutions different. Well established applications engage in the process of technological convergence.

In order to better understand the processes in converging different technologies in the rest of this section we will describe methodologies that are most susceptible to convergence. Their intertwining has already produced a number of products and services well accepted by the customer markets, but the potential is still not fully recognized or exploited [37, 38, 39].

A. Web and other Internet technologies

Internet technologies have been evolving from the beginning of the Internet in 1960s. As the new communication infrastructure started expanding, various new possibilities became recognized resulting in a variety of new services that were based on the Internet. Half a century later standard ways of using internet evolved into Internet services such as, file transfer services, electronic mail, World Wide Web, UseNet, Internet Relay Chat and their derivates. Over time, many of these services evolved into new forms such as Web 2.0 or even with additional semantics to Web 3.0.

Internet usage is increasing every day because of its huge potential and benefits to the end users [6]. Internet technologies are changing our everyday life and they become ubiquitous in private and business life [19]. Development and adoption of Internet technology has positive impact on competitiveness and social-economic growth of countries, firms and individuals [4]. In 2014 there was 454.2% more Internet users in Europe than in 2000 year and worldwide growth of Internet users from 2000 to 2014 year was 741.0% [16].

B. Mobile technologies

Terms Mobile technologies refers to all the technologies concerned with independent communication canals that rely on wireless transfer of information usually connected to some form of global communication system. This is why this is a form of cellular communication system that may include, pagers, mobile phones, GPS positioning, and similar technologies. This allows the user to use various communication capabilities "on the move", braking the geographical and even time barriers of previous traditional communication technologies while augmenting users perception of reality with additional information and knowledge.

Usage of information and communication technologies is increasing every day in developed countries as well as in developing countries, especially in segment of mobile devices and mobile broadband [34]. The best example is South Africa where 62% of small businesses indicated higher profit because of mobile phones usage [32].

Technological advancement lead to many changes in way people communicate, because of different types of mobile devices which enable people to be connected everywhere and anytime [35, 39]. Mobile broadband subscription was more than a billion in 2011 and there is a prediction for 2016 when more than 80% of broadband access will be through mobile devices. European countries which supply their inhabitants with high quality access to Internet mobile broadband are United Kingdom, Estonia and Austria [36].

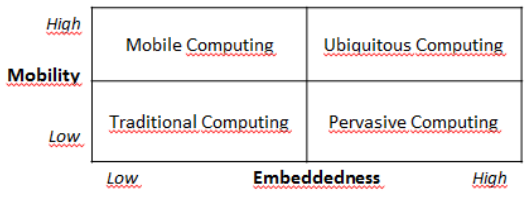


Fig. 1 Characterizing ubiquitous computing

Figure 1 present ubiquitous computing described by high degree mobility and embeddedness, while mobile computing and pervasive computing have low degrees of embeddedness [31].

C. Embedded systems

Embedded systems are computer systems created to perform few very specific tasks. Embedded systems comprise of processing cores which enable access, process, store and control of data [30]. Due to their conceptual dedication to solving a particular set of problems and tasks they are not easy to change. They may include both software and hardware components, but they do not resemble general purpose computer systems. They are mostly added to mechanical or electronic devices as permanent part providing these devices with additional capabilities and improving their initial properties and efficiency. They are used to enable these devices to process information in real-time or process and exchange data with other systems. Embedded systems are used to control most of devices common to contemporaneity. Key part of all embedded systems is software component that cannot be changed once deployed within the device. Some devices though, have gone through a process of evolving from basic embedded systems towards more general purpose devices such as mobile phones and other mobile devices that may periodically update their software components called firmware.

Embedded systems have become commonly used in most application areas, while they present a key factor for innovation in major industries (e.g. manufacturing, distribution and maintenance systems). The fact that 98% of all the microprocessors produced in the world use embedded systems [7] supports the importance of the development and evolution of embedded systems. Embedded systems range in their complexity, from portable devices to large stationary installations. Some areas of embedded system applications are: consumer electronics, household appliances, office automation, business equipments, automobile communications, toys, avionics systems, medical and computer peripherals [30].

Embedded systems are everywhere, and some research showed that in the future, there will be more embedded systems using the Internet than people [29]. Due to their presence and improved capabilities embedded systems provide new solutions in the way that user may not perceive and be aware of them so the gap between the users active understanding and the rate of usage of these systems is increasing. This characteristic is also translated from embedded systems to pervasive computing where providing innovative and convenient new functionality does not require the user to understand the inner working [1]. While this may be an advantage in terms of user interaction and convenience, it may also pose a reasonable threat in terms of security, privacy and device failure scenarios.

D. Trends in related customer markets and industries

Innovation in ICT industry is feasible only if the end user market can absorb newly developed products and services. Same is true for goods and services rooted in pervasive computing. Understanding the current state of customer markets that are related to pervasive computing is of utmost importance. Here, we will take a closer look at the consumer electronic markets and their current states in terms of revenue and structure. Also we will take a closer look at the performance of mobile application distribution platforms that present a key component in distribution of current customized applications of various products and services that originate in embedded systems, mobile technologies or other networking technologies that are the basis of pervasive computing.

Consumer electronic market includes all the markets of electronic equipment used by individuals on daily basis either for personal or official use. Consumer electronic market contains several market segments: (1) digital media boxes, which include home video game consoles, blu-ray video players and recorders and digital media adapters or multimedia gateways; (2) computers, that include desktop computers and laptop computers, but also other sub segments such as netbooks and notebooks; (3) Televisions; (4) Set-top boxes, subdivided according to external signal technology such as cable, satellite, terrestrial or IPTV signal; (5) portable media devices that include sub segments such as smartphones, handheld game consoles and media tablets.

According to World Consumer Electronics Market 2014-2018 Research Report [15] the market is expected to grow further due to favorable conditions. The report further details four most important influences which are active technological innovation cycle, availability of new services and positive response by the end users in adoption of new customer habits. Mobile devices are bestsellers worldwide. There is an increase in the sales of connectable devices, and there is a shift from stationary desktop computer sales towards more mobile technologies and devices such as tablet computers.

The sales of these products are mainly determined by the technology used in these products, the pricing, availability of different variants, and the level of after-sales support given to customers. In addition, global economic conditions also influence the sales of consumer electronics because they directly affect the purchasing power of customers.

During the recent years of global economic recession most of the segments of consumer markets showed high resilience to economic fluctuations, counteracting negative trends through technological innovation cycle that has been active since 2009.

This means that availability of innovative information devices has not decreased and that through everyday use individuals have already accepted new habit of everyday use which is also a positive indication for further innovations such as pervasive computing.

Closely related to customer electronics markets is the software market. Global software sales have not experienced a significant drop in revenues during the recent global economic crises [23]. Software industry trends are showing an increasing share of mobile application products being distributed to customer markets. The importance of this segment is also recognized by software developers and new software development methodologies are being employed in the development processes, e.g. Mobile-D [2, 18].

Mobile application distribution platforms play a major role

in providing availability and accessibility of new mobile applications. Additionally they are a readily available distribution channel for after-sales support for customers that strongly influence the creation of new customer habits and expectations.

The revenue shares of products and services in mobile computing are steadily increasing since its first appearance. Recent study estimates that in the EU region revenues from mobile applications have reached over 10 billion euros in 2013, while creating over half a million jobs in 28 EU countries [24]. This segment has gained in economic significance as the market shares have risen, not only by the revenue attained through the realization of products and services but also by creating jobs, and establishing new service industries with related supporting service industries. This is why this market segment, taken as a whole, both the customer side and supplier side, is being referred to as the App Economy. The role of App Economy will be crucial in further development of products and services of the pervasive computing paradigm.

Taking into account the positive market trends in accepting new product and services and the fact that pervasive computing is eliminating the need to understand the underlying technologies in these products and services we will present a research that tries to explain if there is the lack of understanding of technologies used today and how this may affect future trends from customer perspective.

III. Research on Users' Perspective on Technological Convergence

Pervasive computing through embedded systems and internet technologies is developing every day and its usage is growing constantly. However, there is still lack of research and studies dealing with this topic especially regarding users. In this article we want to estimate the level of understanding of using internet technologies by the individuals and to investigate the interest of individuals to new and innovative Internet technology services. In order to achieve these two goals a simple close-ended questionnaire was conducted.

A. Our research

In May 2013 the empirical research on usage of ubiquitous computing supported by embedded systems and internet technologies was conducted among the third year students from the Faculty of Economics and Business - Zagreb. Students were engaged in the course Business Information Systems. There were 384 students who participated in the survey.

The survey consists of four parts. The first part of the survey is about demographic characteristics of the respondents. They have to indicate their gender, age, study year and graduate study they would like to attend. The second part of the survey is about embedded systems and students' knowledge and understanding about them. In the third part of the survey students indicate are they familiar with embedded system usage and which services they used on a daily base. The last, the fourth part of the survey deals with further usage of embedded systems and possible services preferred by students. While fulfilling the survey, the respondents can choose one or more offered answers, but some questions were organized through 5-point Liker scale. The questionnaire was made in Google docs and put online through Google sites. The questionnaire was analyzed using frequency analysis descriptive statistics methods and techniques with the Statistica software.

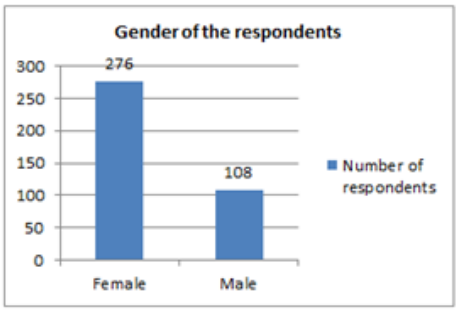
For the purpose of better understanding customer behavior a cluster analysis using k-means *apriori* algorithm was conducted.

Cluster analysis, also called segmentation analysis or taxonomy analysis, is used to identify homogeneous subgroups of cases in data set. These groups, also known as clusters, are formed so that they both minimize within-group variation and maximize between-group variation. For each cluster a typical value across predictor variables is identified called centroid. Centroid is the value that has the minimal average distance for all members of each cluster, but that has maximum distance to centorids of other clusters [33]. By comparing centroids and statistics of different clusters differences can be determined between clusters and stereotypes can be created. For each stereotype a number of measures can be taken into account in order to customize final course design to targeted students.

Through our analysis we want to identify respondents' perceptions, knowledge and their attitude toward usage of different, but innovative internet technologies. We also try to evaluate customers' readiness to accept new and innovative products and services that are still in research and testing phases. We decided to conduct our research on students' population, who are the best indicator of using new IT products and services.

B. Research results

Demographic characteristics of the respondents show that



Source: Authors' analysis

Fig. 2 Demographic characteristics of the respondents

most of the students are female who are 21 years old (Figure 2).

Actually, most of the students at the Faculty of Economics and Business - Zagreb are female, which is the reason for higher number of female respondents. They are attending course Business Information Systems, which is obligatory course at the 3rd year at the Faculty of Economics and Business Zagreb.

Most of the students indicate that they have plans to be

enrolled on the 5th study year - graduate programme (Table 1). The most popular graduate study programme is Finance (24,5%). There is approximately the same interest of students for graduate programme in Marketing (13,8%), Management (15,1%) and Accounting and Revision (15,6%). Only 6,0% of students are interested in graduate study programme of Managerial informatics. The same number of students (6,3%)

Plans for future graduate study programme	Number of respondents	%
Analyse and Business Planning	36	9,4
Finance	94	24,5
Managerial Informatics	23	6,0
Marketing	53	13,8
Management	58	15,1
Nothing	24	6,3
Accounting and Revision	60	15,6
Trade	16	4,2
Tourism	20	5,2
TOTAL	**384**	**100**

Source: authors' analysis

Table 1 Future study plans of the respondents

have different plans and would like to find a job without continuing studying at the 5th year.

In Table 2 are presented differences (price, functions and size) which respondents consider important regarding smart phones and mobile devices. Most of the respondents highlighted that functions are the main difference between smart phones and mobile devices (92,2%). Size does not present important difference among smart phones and mobile

Features	Number of respondents	%
Price	24	6,3
Functions	354	92,2
Size	6	1,6
TOTAL	384	100,0

Source: authors' analysis

Table 2 Differences between smart phones and mobile devices

devices. Only 6,3% respondents believe that price is important difference between smart phones and mobile devices.

In Table 3 research results regarding estimation of respondents usage of mobile services from 1 (do not use it at all) to 5 (using service several times a day) are presented. Calls, SMS and Internet search are the most used mobile services with average grade 4,51 for Calls, 4,65 for SMS and 4,56 for Internet search. Mobile services, e.g. sharing photos, music listening, video and looking for the address in the city, have average grade above three, which means that respondents use these services several times a week. Average grade below 2 means that respondents do not use mobile services for QR codes sensing and Games playing based on real locations in the city (e.g. Ingress) and possible explanation could be that they do not understand what is QR codes sensing and Games playing based on real locations in the city (e.g. Ingress).

Table 4 presents types of mobile devices that respondents mostly use. The respondents have the possibility to choose between three possible mobile devices they possess. Results showed that more than a half respondents have only smart phone (67,4%). Only 1,6% of respondents possess mobile

Plans for future graduate	Mean	Std. Dev.	Variance
Calls	4,51	0,934	0,872
SMS	4,65	0,835	0,697
MMS	2,53	1,272	1,618
Internet search	4,56	1,010	1,020
E-mail	4,20	1,107	1,226
SNs	4,46	1,128	1,272
Sharing photos	3,84	1,128	1,272
Music listening	3,80	1,239	1,536
Video	3,60	1,228	1,509
Looking for address in the city	3,31	1,096	1,200
Navigation	2,85	1,147	1,316
QR codes sensing	1,97	1,086	1,179
Games playing based on real locations in the city (e.g. Ingress)	1,69	1,029	1,059

Source: authors' analysis

Table 3 Mobile services usage

Features	Number of respondents	%
Mobile device	81	21,1
Mobile device, smart phone	4	1,0
Mobile device, smart phone, tablet	6	1,6
Mobile device, tablet	4	1,0
Smart phone	259	67,4
Smart phone, tablet	27	7,0
Tablet	2	0,5
Nothing mentioned	1	0,3
TOTAL	384	100,0

Source: authors' analysis

Table 4 Mobile devices that respondents use

Features	Number of respondents	%
Using just existing applications	52	13,5
Rarely – once a year	57	14,8
Sometimes	111	28,9
Very often – once a month	146	38,0
Testing new applications as soon as they are available	18	4,7
TOTAL	**384**	**100,0**

Source: authors' analysis

Table 5 Mobile devices that respondents use

device, smart phone and tablet.

Table 5 outlines the frequency of installation of new mobile applications. More than third of the respondents (38,0%) install new mobile application very often – once a month. Approximately 15% of respondents stated that they install new mobile applications rarely – once a year (14,8%) and that they mostly use existing applications (13,5%). The lowest percentage of respondents, who present the population of those who are very interested in new technology achievements, indicate that they test new mobile applications as soon as they are available (4,7%).

Table 6 shows what respondents consider an embedded system is. They could choose more than one answer, e.g. POS devices, Smartphone, Data base, ATM, Personal computers, Safe alarms, Peacemaker, SIM cards, eBooks, Traffic lights, Video games, MP3, Console for playing video games, Presentation pointer and Dishwasher machine. The highest

percentage of respondents consider that POS device (48,57%), Smartphone (45,19%) and Data base (42,08%) present embedded systems. One quarter of the respondents believe that Personal computers (25,19%) and Safe alarms (24,16%) present embedded systems. The lowest percentage of respondents choose MP3, Console for playing video games, Presentation pointer and Dish machine as devices with embedded systems.

In your opinion, what present embedded system?	Number of respondents	%
POS devices	187	48,57%
Smartphone	174	45,19%
Data base	162	42,08%
ATM	141	36,62%
Personal computers	97	25,19%
Safe alarms	93	24,16%
Peacemaker	84	21,82%
SIM cards	84	21,82%
eBooks	64	16,62%
Traffic lights	63	16,36%
Video games	59	15,32%
MP3	49	12,73%
Console for playing video games	46	11,95%
Presentation pointer	46	11,95%
Dish machine	35	9,09%

Source: Authors' analysis

Table 6 Devices that present embedded systems

Table 7 presents different usage of GPS technology for the city sightseeing. The respondents could choose more than one answer while answering the questionnaire, e.g. Defining route between two addresses in the city; Discovering city sights close to your location; Monitoring and forecasting dense traffic and View of all restaurants on selected city area. Most of the respondents (83,12%) stated that defining route between two addresses in the city is one of the most important usage of the GPS technology for the city sightseeing. Half of the respondents excerpt that usage of the GPS technology is important in discovering city sights close to your location (47,01%). The lowest percentage of respondents named that usage of GPS technology can be useful for monitoring and forecasting dense traffic (23,12%) and finding restaurants on selected city (21,82%).

Usage of GPS technology	Number of respondents	%
Defining route between two addresses in the city	320	83,12%
Discovering city sights close to your location	181	47,01%
Monitoring and forecasting dense traffic	89	23,12%
View of all restaurants on selected city area	84	21,82%

Source: Authors' analysis

Table 7 Usage of GPS technology

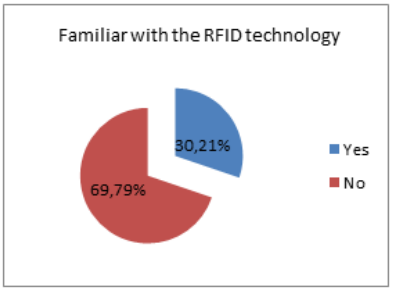
In Table 8 Possession and usage of different devices is described. Respondents could choose more than one offered answer, e.g. Smartphone, Laptop, WIFI device, MP3, GPRS, Tablet, Playing console, SmartTV, Cyclocomputer and eReader. Almost all respondents (94,03%) have smartphone. Laptop (78,96%) and WIFI device (72,21%) are also used by high percentage of students. Half of respondents have MP3 device (52,47%). GPRS, Tablet and Playing console are devices that around 20% of respondents possess and use. Cyclocomputers (6,23%) and eReaders (3,90%) are really rarely used.

Possession and usage of different devices	Number of respondents	%
Smartphone	362	94,03%
Laptop	304	78,96%
WIFI device	278	72,21%
MP3	202	52,47%
GPRS	90	23,38%
Tablet	79	20,52%
Playing console	74	19,22%
SmartTV	54	14,03%
Computer for the bicycle	24	6,23%
eReader	15	3,90%
Nothing	6	1,56%

Source: Authors' analysis

Table 8 Possession and usage of different devices

Figure 3 shows results about students' knowledge regarding RFID technology. Most of them stated that they are not familiar with RFID technology (69,79%). Only 30,21% respondents know what is RFID technology.



Source: Authors' analysis

Fig. 3 Respondents' knowledge about RFID technology

Although, respondents do not know what RFID technology is, most of them estimate that RFID is mostly used in Logistics and transport industry (66,23%) (Table 9). Just 18,44% of respondents consider that RFID is widely used in Tourism industry. The lowest percentage of respondents believe that RFID technology is primarily used in Construction industry (5,71) and in Textile industry (2,34%).

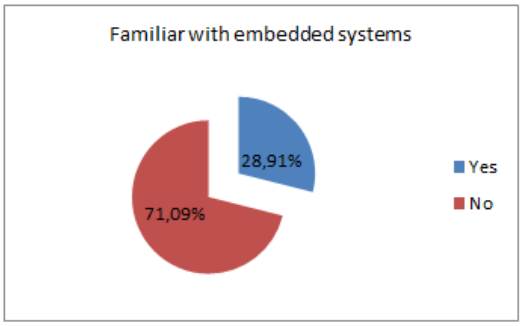
Industries	Number of respondents	%
Logistics and transport industry	255	66,23%
Tourism industry	71	18,44%
Food industry	27	7,01%
Construction industry	22	5,71%
Textile industry	9	2,34%
TOTAL	**384**	**100%**

Source: Authors' analysis

Table 9 Respondents' knowledge about RFID technology

Figure 4 shows results about students' knowledge regarding

embedded systems. Most of them stated that they are not



Source: Authors' analysis

Fig. 4 Respondents' knowledge about embedded systems

familiar with embedded systems (71,09%). Only 28,91% respondents know what embedded systems are.

In Table 10, data about usage of embedded systems by individuals is presented. The respondents could choose more than one offered answer, e.g. Digital thermometer, Parking sensors, eReader, Blood Glucose Monitoring Device, Peacemaker, 3D printer and Robot vacuum cleaner. The highest percentage of respondents use digital thermometer (60,00%) and parking sensors (47,79). Quarter of all respondents use also eReader (27,53%) and Blood Glucose Monitoring Device (23,38%). The lowest percentage of respondents indicates that they use 3D printer (11,95%) and Robot vacuum cleaner (11,69%).

In Table 11 are presented preferred services for usage. Respondents could choose between similar services, and one of them could be used through embedded systems. The first example is dealing with navigation and more than 80% of respondents (85,16%) indicated that they would rather use

Usage of other embedded systems	Number of respondents	%
Digital thermometer	231	60,00%
Parking sensors	184	47,79%
eReader	106	27,53%
Blood Glucose Monitoring Device	90	23,38%
Peacemaker	62	16,10%
3D printer	46	11,95%
Robot vacuum cleaner	45	11,69%

Source: Authors' analysis

Table 10 Usage of embedded systems

Preferred service for usage	Number of respondents	%
A1.GPRS	327	85,16%
A2. Map	57	14,84%
B1. Car parking paying by automat	79	20,57%
B2. Car parking paying by mobile phone	305	79,43%
C1. Printed government documents	67	17,45%
C2. eGovernment	317	82,55%
D1. Voting at elected sights	120	31,25%
D2. eVoting	264	68,75%
E1. Cash register	217	56,51%
E2. Self-service cash register	167	43,49%
F1. Cash	196	51,04%
F2. Debit card	188	48,96%

Source: Authors' analysis

Table 11 Preferred services for usage

GPRS then a map. The second example is about car parking and almost 80% of respondents (79,43%) prefer paying car parking by mobile phone then by using automat. The third example is about public services and more than 80% of respondents (82,55%) would rather use eGovernment services then going to the institutions and waiting for printed documents. In the fourth example, more people are ready to use eVoting (68,75%) than to go to elected sights (31,25%). In the fifth and in the sixth example the situation is a little bit different and there is almost no difference between offered services. There is almost the same number of respondents who would use cash register (56,51%) and self-service cash register

Interest for the new services and usage of embedded systems	1 – I am not interested in this service because I think that its usage it is not safe (f_{is} / %)	2 – I am not interesting in using this service (f_{is} / %)	3 – I am interested in this service although I am concerned with the safety (f_{is} / %)	4-I would like to try this service and use it if it showed to be useful (f_{is} / %)	5 – I am interested in this service and I would definitely use it (f_{is} / %)	TOTAL (f_{is} / %)
Paying by credit card with embedded RFID chip using the sensor without added authorization	45 (12%)	65 (17%)	71 (18%)	152 (40%)	51 (13%)	384 (100%)
Paying by mobile phone using the sensor without added authorization (engl. Near Field Communication)	47 (12%)	56 (15%)	88 (23%)	143 (37%)	50 (13%)	384 (100%)
Possibility of connection house devices and mobile phones and exchange of useful information	40 (10%)	72 (19%)	67 (17%)	120 (31%)	85 (22%)	384 (100%)
System for automatically car parking	27 (7%)	52 (14%)	84 (22%)	114 (30%)	107 (28%)	384 (100%)
System for tracking vital signs and predicting possibility of attack with automated alarm annunciation of your current address to ER	24 (6%)	50 (13%)	84 (22%)	106 (28%)	120 (31%)	384 (100%)
Managing ATM using mobile phone instead of embedded keyboard with the goal to increase the safety of transactions	32 (8%)	38 (10%)	85 (22%)	141 (37%)	88 (23%)	384 (100%)
Service of automated connection among cars in order to avoid car crash and incidents	36 (9%)	40 (10%)	89 (23%)	133 (35%)	86 (22%)	384 (100%)
Service of smart carts in a store which automatically register price of the products and form a bill	35 (9%)	35 (9%)	69 (18%)	120 (31%)	125 (33%)	384 (100%)

Source: Authors' analysis

Table 12 Interest for the new services and usage of embedded systems

(43,49%) and between those who would use cash (51,04%) and debit card (48,96%). One of the reasons is that most of the students dispose with cash and they do not possess credit cards. For the another example, self-service cash register are still not in a large use and most of the people and students as well rather use cash register.

Table 12 show results about interest for the new services and usage of embedded systems. Respondents could choose from 1 (I am not interested in this service because I think that its usage it is not safe) to 5 (I am interested in this service and I would definitely use it) if they are interested in new services based on embedded systems. In most of the cases, more than a third of respondents indicated that they would like to try service and use it if it showed to be useful (Paying by credit card with embedded RFID chip using the sensor without added authorization; Paying by mobile phone using the sensor without added authorization (engl. Near Field Communication); Possibility of connection house devices and mobile phones and exchange of useful information; System for automatically car parking; Managing ATM using mobile phone instead of embedded keyboard with the goal to increase the safety of transactions and Service of automated connection among cars in order to avoid car crash and incidents). It is important to highlight that approximately 30% of respondents are interested in two mentioned services and would definitely use it (System for tracking vital signs and predicting possibility of attack with automated alarm annunciation of your current address to ER and Service of smart carts in a store which automatically register price of the products and form a bill).

Based on this data a cluster analysis was conducted. Two clusters were detected in the sample data. Most important cluster centroids are shown in table 13.

As we can see from Table 13a cluster 1 and cluster 2 are very similar to knowledge about embedded systems, RFID technologies, mobile devices and GPS technology since they both have same centroid values. First significant differences are encountered for the questions about types of uses for their mobile devices i.e. phones where cluster 1 uses more advanced services such as Internet access, e-mail, file sharing such as photos, music and videos, even navigation capabilities. Cluster 1 has much lower preference and habit of engaging to these services measured on the scale from 1 to 5 (Table 13b). It is not surprising that cluster 1 also installs new apps for they mobile phones very often while cluster 2 only very rarely installs new apps.

Finally, cluster 1 will usually choose digital or technically more advanced methods of achieving services such as navigation, payments, parking or voting than cluster 2 (Table 13c). Also cluster 1 shows higher interest in possible new services and products than cluster 2 as seen in table 13d where inclination to using various possible services is measured on a scale from 1 to 5 where 1 means that they would not try to use this service, while 5 means high interest and readiness to use the service immediately upon availability.

IV. Discussion

A. Understanding principles of various technologies and awareness of technological convergence potential

Results regarding demographic characteristics indicate that students are familiar with the features of the latest internet technologies and their usage no matter of their study interests. Although, most of the students would like to continue their study in the area of Marketing and Management, they know which features and characteristics of mobile devices are the best. However, there is still lack of knowledge and interest regarding technology itself.

The conducted research was aimed at young highly educated demographic so when interpreting the presented results we

cluster ID	Have you hear of term embedded system?	Are familiar with the term RFID and its meaning?	What do you consider to be the most important difference between smartphone and mobile phone?	Which of the following services highly depends on GPS technology?	age	Number of cases	Percentage(%)
1	no	no	device functionalities	Route planning between two addresses.	26	325	84,63542
2	no	no	device functionalities	Route planning between two addresses.	21	59	15,36458

a) familiarity with embedded systems, mobile, RFID and GPS technology

cluster ID	Type of mobile device you use:	Telephoning	SMS	MMS	Internet Search	e-mail	Facebook and social networks	Photographs and sharing	Music and sharing	Video and sharing	navigation	route planning	QR codes	augmented reality entertainment (Ingress)	How often do you install new apps on your mobile device?
1	smarphone	5	5	3	5	5	5	5	5	4	4	3	1	1	very often
2	basic mobile phone	5	5	1	5	4	5	3	1	1	1	1	1	1	very rarely

b) on using mobile devices and mobile services

cluster ID	1 - GPRS navigation 2 - navigation using printed map	1 - Using mobile payement for parking 2 - Parking automat / parkingmeter	1 -Residency certificate online 2 - Resitency certificate OTC	1 - voting online 2 - voting booths	1 - self-service checkout in stores 2 - regular cash desk in stores	1 - debit cards payements 2 - cash payements
1	1	1	1	1	2	1
2	1	2	2	2	2	2

c) service type preferences

cluster ID	Non-contact card payements using RFID	Non-contact payements using mobile phone and NFC	Connecting home appliances to mobile devices and data interchange	Automonous parking system	Health monitoring devices	Cashmachine operation through mobile phone	Autonomous connection of vehicle to local vehicle network for safer driving	Smart shopping carts	Number of cases	Percentage(%)
1	4	4	4	4	5	4	4	5	325	84,63542
2	1	1	1	1	1	1	1	1	59	15,36458

d) interest and acceptance of possible new products and services

Table 13 Cluster centroids for most important dimensions

should take into account that the targeted demographics had better access to information about the current state of the art in economics, business and partially to IT and consumer electronics. From table 3 we can also conclude that this targeted demographic is well involved in the trends in electronics since 94,03% of them own and use smartphones. It is safe to presume that due to these characteristics the targeted segment of users are in better position than most of the other demographics that have somewhat lesser access to information through academic channels. This is why we presumed that the results will show adequate understanding and knowledge about technology, and at least some knowledge about various technologies used for pervasive computing.

This is the reason why the first part of the survey resembled an examination test where some of the possible answers were correct and others incorrect. This is why in Table 1 there are correct and incorrect options to choose an answer from to the question what is considered an embedded system. The correct devices that contain or present themselves as embedded systems are POS devices, smartphones, ATMs, safe alarms, pacemakers, SIM cards, traffic lights, video games consoles, presenter pointers and dishwashers. Unfortunately, none of these devices was recognized by majority of respondents as embedded systems. Best scores for POS devices and smartphones are below 50%. It is encouraging, though, that most of the incorrect answers were recognized as incorrect in much greater extent, except from databases that had the highest score of 25% as misidentified embedded system. This means term embedded systems is not overly familiar to the surveyed demographics as they are not able to recognize its real world implementations. Further evidence for this is given in Figure 3 where less than a third of responses claim that they are familiar with embedded systems. Similar results are found for presented RFID technology shown in Figure 2.

If we take a look at more factographic questions that are being taught at various courses during their studies, results are much better as expected. An example is the question of where RFID technology is mostly used with results shown in table 4. This is a piece of information taken from the obligatory undergraduate course Business information systems that all of the respondents took part in that same year. Two thirds of respondents have recognized the most typical industry RFID technology is used in. Usage of GPS technology yielded similar results, where over 80% of students recognized one typical applications of this technology, while other correct uses (discovering city sights in vicinity and traffic density maps) were less recognized. Finally viewing static data on a map that does not require GPS technology was recognized as non GPS application by similar number of students.

Overall, we may conclude that students have some overall declarative knowledge about the mentioned technologies but do not have enough understanding to recognize their usage in real world applications, which may also indicate the lack of awareness of their availability, advantages and disadvantages and potentials.

B. Customer involvement in using novel products and services founded on pervasive computing

Finally, in order to estimate the level of usage of products and services that rely on pervasive computing technologies and principles we focused on what devices students possess and use (shown in Table 3) and what other devices they use or know how to operate (shown in Table 5).

If we take a look at the devices and consumer electronics that respondents own we can see that all of the market segments discussed in Section III are represented. This means that there is a good foundation for development of additional services related to any of the customer electronic devices present on the market which is one of the bases of pervasive computing. Even lesser used devices with very particular purposes are represented as we can see in Table 5. Most important is the use of smartphones and laptops with over 90% and almost 80% of respondents use them, respectively.

Since smartphones present an intermediary form between embedded systems and general-purpose devices [26] it is safe to presume that potential for further use of pervasive computing is significant. Earlier studies [27, 28] have shown that student use various mobile applications and innovative mobile services. This is why better understanding of underlying technologies is called for, or in the case of pervasive computing, implementations that will minimize the risks of technologies used thus increasing further the use of applications and services.

Our results have shown that there is a great potential for new IT products and services especially in mobile industry. More than 70% of respondents (74%) are using smartphones that can offer them high quality mobile service which can be used to facilitate their everyday communication with colleagues. Respondents are ready to test and evaluate innovate mobile services which are easy to understand and use. Thus, quick response time is also benefit which students prefer.

Unfortunately, respondents are not aware of the technology in the devices which is a ground base for services they are using. Actually, they do not understand and they do not want to understand how these technologies work. Features, like processor, software, and guarantee are not important for them. However, memory capacity, social networks, camera, sound are features which students consider while buying mobile devices. Large IT companies have to understand customer needs and consider it when creating products and services in order to be successfully accepted by users.

It is important to highlight that research results are limited only to highly educate young adults (3rd year students) who are following trends and who are under pressure of society. They want to be popular and do not want to be different, which is the reason why most of them have similar mobile devices with similar features.

There is a huge potential of mobile devices which has been confirmed through research results, which can be topic and research question in some future studies. The findings of future

research could help to understand and to exploit benefits for the customers, which will improve users' experience and overall quality of services within a particular segment of economy as well as of society.

C. Innovators and cautious users

As we have described earlier, cluster analysis was conducted where two distinct clusters were detected in sample data. Based on centroids and statistics for these clusters we can conclude that there are two groups of users in the observed demographics.

First group can be called "innovators". They represent users that are highly involved with most technological development and are not shy to embrace new products and services that become readily available. Nevertheless, they do not have deeper understanding for the technologies used in the products and services that they use which immediately make them susceptible to a variety of risks. Security risks, privacy risks just to name a few. This is also bigger group of the two. Taking this into account product and service provider should be aware that this population of their users is susceptible to various IT risks and that they do not have required skills and knowledge to effectively counter these risks. This is why these product and service providers should supply the users with incorporated tools and prevention capabilities in order to promote customer satisfaction and safety. This is also an argument for governments to proscribe regulations that will enhance customer safety while regulating respective customer markets.

Second cluster can be called cluster of cautious users. These customers will be more aware of the risks that using products and services may cause them, while still not fully understanding the technologies that these products and services are based on. It may seem prudent to be aware of the lack of understanding but, this also means that novel products and services may be rejected form the customer market even if there is a well-established mechanism for its safety. This group of customers' needs additional assurance to engage with novel products and services. They tend to follow trends more, so they represent the second wave of market demand after initial acceptation of product and services by the innovators have been successfully accepted.

Either way it is important that product and services providers take full responsibility for technological risks even if this will be achieved by additional intervention of government institutions into legislative regulation. Additional effort is required in informing and educating about technological trends and development. Otherwise, negative consequences may cause losses for customers and businesses as well as overall drop in national technological advancement.

V. Conclusions

In this paper we took a closer look into recent technological trends in information and communication technologies and industries. The main focus of the paper was on the phenomenon of technological convergence that is one of most important trends and sources of innovation in the area of information and communication technology, software and consumer electronics. Recent global economic crisis has further indicated the importance of this industry segment for the global markets and its resilience to market dynamics.

In order to better understand how innovative cycle initiated by the economic crisis creates novel products and services, we have analyzed most important technologies that have created novel approaches and services in the recent years, such as pervasive computing, ambient intelligence and other convergent digital phenomena.

The fundamental areas of research that serve as basis for technological amalgamation are embedded systems technology, Internet technologies and Web and mobile technologies. While acknowledging technical feasibility of resulting novel technologies we analyzed what were the economic limitation or more generally speaking, social limitation from the customers' point of view. In this way we were able to outline the context for the customer perspective on accepting novel products and service, their potential, and finally forces that influence the market absorption capacity.

After conducting research of customer perspective, results have indicated that the level of customer understanding of technologies that are contained in advanced novel products and services in customer electronics market is at a very low level. Despite this fact, the level of use of these products and services as well as the interest in using additional products and services in the near future is still high. This may present a number of different technological risks that customer may be subjected to.

In order to better understand what the possible influence is, we have conducted a cluster analysis where two main groups of customers were detected. *Innovators* are very much involved with most recent trends in electronics and IT. Their interest is one of the main driving forces that motivate businesses to offer new products and services. *Cautious users* are second segment of customers that do not accept new products and services as it becomes available, because they are more aware of the risks and possibly their own lack of understanding of the underlying technologies.

If we respect the fact of increasing dynamics in current living and business environment, customers will eventually fail to cover all the possible risks in terms of security, privacy and trustworthiness, so the businesses should provide their products and services with all the required tools to counter these risks as much as technically and legislatively possible. There may be situations where governments will have to update and adjust current legislation in order to ensure that despite increased dynamics and high percentage of knowledge incorporated into new products and services, customers remain adequately covered from the potential risks.

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