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Digital home technologies and transformation of households

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1 Introduction

The basic issue I examine here is whether and how contemporary home life is being transformed with the arrival of new digital technologies.[1] As new technologies diffuse into the home, new terminology has begun to emerge as, for example, in smart homes, home automation, digital home, digital living, networked home, home of the future, smart appliances and so on. To simplify the terminology, in this paper, I will use the term "digital home technologies" and smart home technologies interchangeably to describe all of them. Although digital home technologies have developed in different directions because of the types of industry players involved, some common themes underlie these developments. They all seem to point to a great sense of anticipation that home life as we have understood in the past two or three decades will undergo some fundamental changes. It is claimed that some of the changes may be the result of advances at the technological frontier.

It is generally acknowledged that the digital home idea has been around for at least a decade and people had known about its potential possibility even in the mid-1980s from the prototypes built in the USA, UK and Scandinavia. Embedded in the concept of digital home are smart appliances, multimedia systems, energy devices, sensors, lighting systems, sensors and control systems, and home robots which manifest basic qualities of programmable machine intelligence. However, their implementation has not been very successful and has been a little slow. Recent developments seem to suggest that digital home concepts are closer to reality and must be taken seriously.

To put these developments in a historical perspective, one can trace all such advances to the early 1980s with the introduction of the PC into the home. This was also the period when various electronic gadgets entered the domestic space: VCRs, microwave ovens, answering machines, cable TV to name important few. A lot has happened since then. For example, the technological scene changed dramatically with the arrival of the Internet connecting the household to the external environment in some fundamental ways. The introduction of mobile phones and wireless technologies has further opened up the technological boundaries. The possibilities seem endless. In this ever increasing technological frenzy, some caution must be exercised as new technologies knock on the door to gain acceptance by families. Our previous studies show that families are reluctant to "overtechnologize" their homes, but at the same time are quite open to technologies that fit with their current patterns of behaviors and possibly add value to the family life. It is this balance between too much and too little technology that one must seek and it is also what motivates our thinking in this area.

2 The role of technology in the home: Some theoretical ideas

The basic dynamic with respect to home-based technologies is that technologies play a key role in relation to home life. This can be identified in terms of three possibilities: the enabling role of technology, its mediating role and the transformative role.

[1] The ideas expressed here are based on the work of several researchers since the 1990s, including my own, and space does not permit me to mention all of them.

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In the simplest of the three, the enabling role suggests that technologies make things work faster, better or in some improved fashion. Imagine a family that has recently purchased a new coffee maker as a replacement for an existing one. Let us suppose this new coffee maker can make coffee in less time. It also has a built in grinder and an alarm and some other simple functions. By no means is this considered a radical technology but we grant that it adds efficiency and convenience to the routine activity of preparing coffee. This is an example of an enabling technology.

A mediating technology is one that acts as a facilitator between the user and their living environment. For example, when the cable TV was introduced into the home, it opened up several channels for family viewing and acted as a go between the user and the entertainment world. As a mediating technology, the cable (or satellite) TV connects the family with the world of entertainment. The mediating role of technology is a bit more complex than its enabling role because it adds a higher order dimension to the application of technology for user's benefit not present in its enabling role.

A transformational technology is one which alters family life and activities in some fundamental ways. When the PC entered the home environment, it made it possible for individuals to bring work into their home thus altering their work life. And, it did not stop here. In the ensuing years, or, as we now call it, in the age of the Internet, families do a lot of things using the computer: shopping, email and other forms of communication, online banking, information search, home based learning, telemedicine, home-based business and so on. When we consider the impact of the Internet on family life, one can easily recognize its transformative role. If we now add digital or smart appliances, the possibilities increase dramatically.

Of course, the same technology can perform different roles under different conditions. Thus for a user who never owned a TV set, a new TV can fundamentally alter their viewing habits and transform their life. However, in a family that already has a TV set, a new replacement TV will have a minimal impact. In other words, what role a technology plays is partially dependent on the user and their existing use patterns. The important point is that the various technologies that are now ready to be launched seem to have the potential to change the home life in some major ways. As a large part of this transformation involves the actions of the consumer/user and the overall user environment, one must take them into account seriously.

3 Digital homes and smart appliances

Digital (or smart homes), then, are homes which utilize information appliances and a home-based network to connect household appliances to each other and to the outside Internet world. Because of the integral nature of the home-based network into the digital home, the discussion of it should be inclusive of the discussion of the networked home.

There have been several high-profile digital home projects undertaken by private citizens over the last few years. The most well-known of these has been Microsoft founder Bill Gates' residence on Mercer Island, east of Seattle. The home includes art frames which can display different "paintings" on demand, as well as identification badges that are handed out to guests that can then tailor the music played in a particular room based on the guest's preferences.

Digital home technologies are also beginning to find their ways into homes *not* necessarily owned by the world's richest but middle-income families. However, they do seem to be owned by the employees of technology-savvy companies. Some members of the information appliance industry are looking to improve the prospects for in-home shopping. In sum, digital homes are expected to develop some very useful properties. Among suggested benefits that could be offered by digital homes are improved energy efficiency (and lower electrical bills), improved security, "upgradeable" home appliances, on-demand video programming, and safety mechanisms to allow the elderly to continue living at home.

4 Some key problems

There are several key problems to the proliferation and advancement of IA technologies or digital Home technologies. *Consumers are unaware of the benefits of the networked or smart home.* At this point in time, most home networks are used to connect PCs for tasks such as printing and shared Internet connectivity. Consumers are just beginning to see the other potential benefits, such as on-demand video, enhanced voice communications, and remote security control. As this awareness grows, the demand for home networking products will rise.

- *Technology is too complex for most household users.* Unlike other home electronics, the technology behind home networking is not intuitive and requires more technological expertise than the average household possesses. With the complex array of products that manufacturers are currently using to take aim at the Smart Home market of the near future, the potential for confusion could be daunting.
- *Lack of incentive for Internet providers to push networking technology.* In-home providers of broadband Internet (i.e., cable Internet providers and DSL providers) are currently surviving well enough on the strength of their connectivity service sales and do not

need to push additional products. In addition, these communications carriers are too busy building network infrastructures and too swamped with customers demanding their high-speed access to spend time worrying about home networking.

- *Potential privacy issues.* Because the networked home would enable information to flow out of the home in ways that households are not accustomed to, privacy could be compromised. Additionally, the new technology behind information appliances and digital homes could introduce new security holes not encountered before.
- *Interface issues*. In digital home test beds, control interfaces have ranged from touch-screen devices to PDAs. Data on the effectiveness of the various interfaces seem scarce.

5 Digital home is a collection of activity centers

The living space can be viewed organically in terms of what we call centers. In a recent survey of American households, we asked families how computers were used in the home (see Fig. 1). Based on our findings, we were able to identify eight centers where home life is possible: the home management center, the entertainment center, the work center, the shopping/financial center, the family interaction center, the information center, the communication center, and the learning center. From a technology point of view, in the 1950s, the concept of the home was in terms of the *home management center*. Most early technologies into the home were targeted toward specific household activities relating to cleaning, meal preparation, washing clothes, and other various household activities. These technologies were primarily labor or time-saving devices. With the introduction of the television in the late 1950s and early 1960s, the home became an *entertainment center*. In the 1980s, with the arrival of computers in the home, it became possible for people to work at home and we see the beginnings of the *work center*. In the 1990s, new media and information technologies and in particular, the Internet has begun to transform the home even more dramatically. The home is now viewed as a *shopping center* as in home shopping, the *communication center*, *the information center* and *learning center*. It is these new developments that have contributed significantly to reconfiguring the home in terms of digital networks.

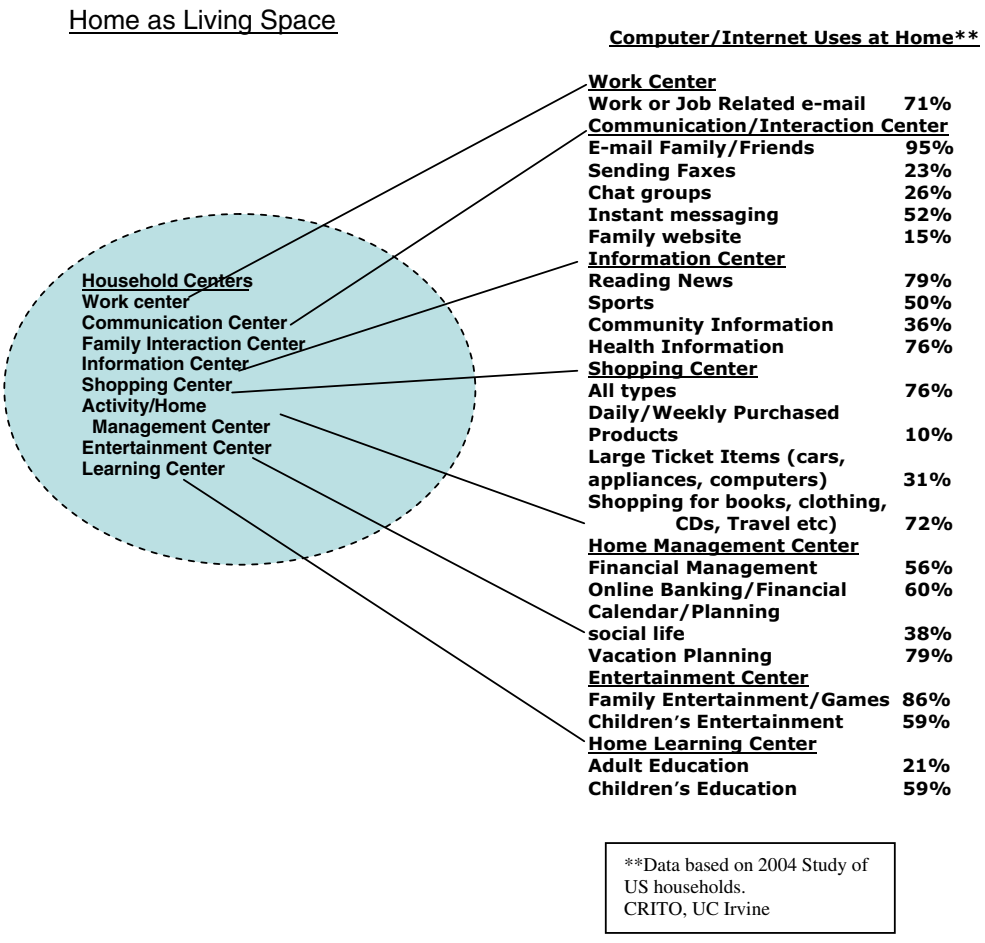

Fig. 1 Home as living space

6 Household Information/Communication System (HIACC)

I envision the center concepts in terms of a unifying theme, the household activity/information/communication system or HIACC. There are two aspects to HIACC paradigm, the activity/*information/communication* aspect and a system-based *device* aspect. At the device level in the practitioner world, all the three are combined and one can call it the smart home system for home applications. Of course, there is already a lot of prototyping and testing of devices in progress that combine the mechanical and intelligent (information) functions into home-based systems. Ultimately, the goal is to combine the time saving and the labor saving aspects with information and communication capabilities. Based on our recent work on home networking, we feel that the focal point of these devices can be the household as a collection of activity centers as described above. This means that: (a) they assist the family in performing various household tasks according to some fundamentals of domestic life; and (b) they are also imbued with strong "information" (digital) content.

These new possibilities create a new opportunity both for the user (i.e. the household) of the technology and the producer of the technology. In order to fully understand all the relevant possibilities, what is needed is a systematic exploration and development of HIACC that families can adopt for internal home based activities and external networking. For example, we can envision it as a centralizing point for maintaining family records that contain financial, shopping, medical, dietary, child-oriented, and other types of domestic information. It can also be a center for communication with family, friends and outside agencies. In order to develop such a system we need to understand family life and family information needs in a methodical fashion.

Table 1 provides a comparison of the different technologies and their social character as revealed through our empirical analysis.

7 Related trends

We have also observed some related trends from our ongoing research. The five trends worthy of note are computer orientation of the household, computer integration, domestication of the computers, feminization of computing, and changing perceptions toward computers. Computer orientation suggests that families are developing appropriate computer related skills, achieving higher levels of expertise and literacy and are putting technology to continuous use. In terms of computer integration, we observe that computer use has become part of daily routines. The domestication of

Table 1 Summary of communication technologies and their social dimensions

	Relationships	Distant/local	In urgent situations	Social/informative	Intimacy	Engaged/terse dialogue	Personal/casual	Fast/slow	Convenience	Vulnerability
Telephone	Strong	Mainly local	High	Social	High	Engaged	Personal	Fast feedback, sometimes slow	Medium–high	High
E-mail	Strong and weak	Both	Low	Informative	Low and high	Terse	Both	Fast to send, slow feedback	High	Low
Cellular phone	Strong	Local		Both	Medium	Seemingly terse	Personal	Seemingly fast	High	High
Instant messenger		Both			Low	Both		Slow	High	Low
Paper notes	Strong	Very local	Low	Informative	Low	Terse		Fast	Low	Very low
Face-to-face	Strong	Local		Social	High	Engaged		Slow	Low	Highest

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Table 2 Computer/internet use over 20 years

	Chi-Sq	1984	2001	2004
E-mail family or friends	1132.423***	18.2%	72.4%	94.8%
Job related work	37.344***	84.6	73.7	71.8
School related work	33.099***	47.9	59.0	47.0
Shopping	801.149***	5.8	50.8	76.2
Financial management	9.806**	53.4	61.2	59.6
Chat/IM	596.491***		27.6	56.4
Games/entertainment/ hobbies	317.697***	53.9	85.7	87.9
Family records and health information	840.849***	4.1	45.6	76.0
Travel and vacation planning	953.800***	5.5	54.7	81.9
F stat				
Hours of use per week	366.420***	4.49[a]	9.59[b]	19.9[c]

***p<.01, **p<.05

computer suggests that households are accepting the computer as any other home-based technologies and appliances and thus computers are no longer perceived as alien machines but essential to home life. We are also witnessing a greater use of computers by female heads of household for home management and financial management and therefore describe this trend as the feminization of computing in the household context. Finally, perceptions towards computers are positive and there is a feeling of indispensability. Computers are here to stay are being used in multiple ways as communication and information tools, to maintain family calendar, as a shopping tool, as a learning tool, and a home management tool.

8 Changing patterns of use over time

Table 2 shows how computer use has changed over 20 years. Of course the changes from 1984 and 2001 can be clearly explained in terms of the absence of the Internet in 1984. But the changes from 2001 to 2004 are also quite significant. It is clear from the table that dramatic increases have occurred along three major dimensions, information seeking, communications and home management

9 Conclusions

Much has happened in the last 25 years since the PC entered the home front. We can safely divide the last quarter century into three distinct periods, the pre-Internet period (from the early 1980s to mid-1990s), the transition to the Internet period (the second half of the 1990s) and the Internet period. Projecting into the future, we can confidently state that we are entering the transformational period. On the social side, we are witnessing the emergence of social-networking sites and the net-generation. On the home front, the digital technologies prompting us to reconfigure them home as living space. It is our hope that all these changes augur well.

It is, of course, up to scientists to continue our quest for deeper understanding of the important phenomenon of technology in households.

Alladi Venkatesh is Professor of Management and Associate Director of CRITO (Center for Research on Information Technology and Organizations) at the University of California, Irvine. His research focus is on the impact of new media and information technologies on consumers/households. He is also the principal investigator of Project Noah and Co-PI on Project POINT. In the 1980s he directed a major study for the National Science Foundation looking at how American families are adapting to the presence of computers at home. This study was the first of its kind in the USA. Since then he received two other grants from the National Science Foundation to study the impact of media and information technologies on households. His current work involves Electronic Commerce and the Consumer Sector, and the future of the Networked Home. Professor Venkatesh has given several invited presentations at major universities and also at Intel, Ericsson, Microsoft, Philips, HP, Electrolux, on new media technologies and consumers/households. Professor Venkatesh's scholarly publications have appeared in various journals, including, *Journal of Consumer Research, Management Science, Communications of the ACM, Journal of Product Innovation and Management, International Journal of Research in Marketing, Telecommunications Policy.* Professor Venkatesh is a co-editor-in chief of, *Consumption, Markets and Culture* (CMC). He is a co-editor of a recent book, titled, *ICT for the Next Billion*, published by Springer in 2007, based on a conference (HOIT 2007) held at the Indian Institute of Technology, Chennai, India.