In-home computing and information services

A twenty-year analysis of the technology and its impacts

Project NOAH

Alladi Venkatesh

Nicholas P. Vitalari

Professor, Graduate School of Management and
Director, Project NOAH
Center for Research on Information Technology and Organizations (CRITO)
3200 Berkeley Place
University of California
Irvine CA 92697
Tel – 1-949-824-1134
avenkate@uci.edu
www.crito.uci.edu/noah

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ABSTRACT

This article examines the evolution of in-home computing over a period of 20 years, 1980-2000. Although its development in the past five years has not occurred in the precise manner predicted, there are many signals which promise its future growth in different directions. In order to capture these various possibilities realistically, what is needed is an assessment of in-home computing not as an expression of a single product within a single technology but as an outcome of the fusion of computing, communication and information technologies developing over a period of time. The impact of such a multifaceted development extends to the economic, social, political and psychological spheres.

Recent developments in the technologies of personal computers and information networks have generated new products and services for the average citizen. Unknown or infeasible only a few years ago, such services as home banking, electronic shopping, telecommuting and quick access to a variety of data sources are now known and feasible to many. Yet despite the technological promise, the demand for and impact of in-home computing technology and information services (HCIS)[1] is neither well established nor clearly understood.

Most analyses to date focus narrowly upon short-term market developments, single-product strategies (e.g. personal computers or videotex), or specific technological impacts. A comprehensive analysis of HCIS is needed to account for the impending convergence of the technologies, long-term diffusion and use processes, the lags between technological development, infrastructure development and consumer acceptance, and the differential impacts which will occur at each stage of development.

This article presents a comprehensive examination of HCIS and its impacts over the next 20 years. The objective in selecting a relatively long timeframe is to base the analysis on a systematic framework of HCIS diffusion and use. The article will (a) conduct a baseline assessment of the HCIS technologies and its infrastructure, (b) provide a systematic framework for analysing the evolution of HCIS diffusion and use, and (c) explore the economic, social, political and psychological impacts over the next 20 years.

In-home computing and information technology - a baseline assessment

The concept of in-home computing and information services began in the late 1960s and the early 1970s with the idea of computer utilities. Computer utilities were envisioned as large regional and national time-sharing computers providing a range of computing services to businesses and homes.[2] In recent years the fusion of computing, communications and advanced information technologies has inspired renewed interest in HCIS. Long-term adoption and use of HCIS technologies depends on a combination of computing hardware, software, information services and infrastructure. An analysis of the current state of each of these components and their prognosis provides a baseline to understand how in-home computing and information technologies will evolve over the next 20 years.

[1] The terms in-home computing, home computing, in-home computing technology and information services (HCIS) are used interchangeably throughout this article to denote the convergence of computers, communications, computer applications and advanced electronic consumer technologies which will become available to households over the next 20 years.

[2] H. Sackman and B. Boehm, Planning Community Information Utilities, AFIPS Press, Montvale, NJ, USA, 1972.

Computer hardware and software

The early 1980s witnessed the rapid diffusion of personal computing technology into a select subset of US homes.[3] Most offerings fell into two categories: low-cost `home computers' with limited internal and secondary memory, graphics and sound; and high-cost personal computers designed for professional use both at home and the office.[4] Of the latter variety (Apple 11, IBM-PC and TRS-80), an average of 50% of the units found their way into US homes.[5]

Currently, computer systems for the home are limited to three areas: (1) work support applications; (2) child and adult education; and (3) entertainment programs. The next generation of technology is expected to be less expensive, more powerful, easier to use and easily linked to communication devices.[6] At the consumer level it is expected that a number of traditional technologies and media such as the television, VCR, stereo and the telephone will coalesce with computer and information services to produce new products. As advanced technology becomes available and integration among the technologies occurs, synergistic information applications (ie computer and communication applications highly compatible with the unique characteristics of the home) will emerge, making advanced home environments superior to previous traditional home environments. The differential advantages of the new home environments will provide the incentives for consumers to adopt the technology and integrate it into the lifestyle of the household. Some examples of the next generation of computer and information technologies for the home are:

- More powerful and less expensive microcomputers.
- Advanced software, including fourth-generation languages, expert systems, and multi-user operating systems which will reduce the amount of detailed knowledge required to use computers.
- Digital television, eg colour graphics displays, high-definition television (HDTV).
- Local area digital communication networks (several standards have been proposed for the home).
- Intelligent telephonic devices (voice forward and store phones, multiband multiplexed phone links).
- Digitally accessible and controllable video and audio storage technologies (eg, CD-ROM, video cassette recordings).
  Videotex and multifunction information service systems.
  Digital process controllers (eg home security, home energy management, event control).
- Cable television.

[3] Joel Dreyfus, 'What will send computers home?', *Fortune, 2* April 1984, pp 71-74.

[4] A. Venkatesh and N. Vitalari, 'Computing technology for the home: product strategies for the next generation', *Journal of Product Innovation and Management*, December 1986.

[5] Betsy Gilbert, 'Personal computing marketing -a special report', Advertising Age, 7 February 1985, pp 13-34.

[6] J. P. Crecine, 'The next generation of personal computers', *Science, Vol* 231, No 4741, 28 February 1986, pp 935-943; and Robert E. Kahn, 'A new generation in computing', in Edward A. Torreno, ed, Next *Generation of Computers*, IEEE Press, New York, 1985, pp 4-9.

Some of the latest technological developments illustrate the convergence and merging of technologies. Pactel's Victoria System utilizes existing phone lines for multiple-line communication and ready connection to personal computers and household utilities.[7] AT&T's video board and Sharp's Integrated Computer Television combine video, data and voice storage, manipulation and transmission. General Electric Company is experimenting with the concept of electronic homes in some test markets.[8] Commodore's Amiga and Atari's ST1040 are examples of low-cost computers with large memories, specialized chips and extended interfaces (eg a musical instrument interface). Finally, most major communication and computer vendors are rapidly moving to Integrated Services Digital Network (ISDN) to provide advanced information services.[9]

The next generation of software will offer more options and provide greater power to the household. To date, most computer software is directed at office environments, children's education and entertainment. Similarly, most computer operating systems (MS-DOSTM), interface architectures (Microsoft WindowsTM, DesqTM), and other utilities have been developed for the office user. HCIS will spur the development of new information applications for the home[10] including new operating systems, application generators and expert systems. New information applications will include electronic mail, animated (dynamic) `books', intelligent phone systems, hybrid entertainment systems integrating several media, and automatic information retrieval systems which scan and retrieve information based on predefined user criteria. Researchers at MIT's Media Laboratory are combining advanced intelligent programs with new media to create new applications such as electronic newspapers, voice-activated data retrieval systems, and automatic electronic mail systems.[11]

Information services

Recently, videotex, teletext, and viewdata have revived the concept of in-home services (for example, GatewayTM, SourceTM, CompuservTM, Dow-JOneSTM). In spite of these selective examples, some analysts believe that the major problem today is that such offerings are not well suited for the typical household and must undergo significant development prior to widespread market acceptance.[12]

Table 1 describes three major categories of in-home services: (1) public supplied in-home services (regulated computer or telephone utility), (2) government in-home services (local, state and federal), and (3) commercial in-home services (for-profit information companies). Most of the in-home services will be offered by commercial organizations for a monthly fee or per access charge. Government involvement in

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[7] T.V. Edrington III, 'Videotechnology and PacTel', a presentation to the Workshop on Technology and the Individual, Los Angeles, November 1985.

[8] Charles Levine, 'Home of the future research at General Electric', presentation to the American Psychological Association Annual Meeting, Los Angeles, August 1985.

[9] 'The Rewiring of America', *Business* Week, 15 September 1986.

[10] Others have also outlined computer applications for the home. For example, see Walter Baer, 'Information technology comes home', *Telecommunications Poli*cy, Vol 9, No 1, March 1985, pp 3-22; Edrington, op *cit*, Ref 7; *IEEE* Spectrum special issue on 'At home with high technology', Vol 22, No 5, May 1985; J. Tydeman, H. Lipinski, R. Adler, M. Nyham and L. Zwimpfer, *Teletext and Videotext in the United States: Market Potential, Technology, Public Policy Issues,* McGraw-Hill, New York, 1982; and A. Venkatesh and N. Vitalari, 'A post adoption analysis of computing in the home', *Journal of Economic Psychology,* in press.

[11] B. Dumaine, 'MIT's far-out computer lab', *Fortune,* 19 August 1985.

[12] The information business', *Business Week,* 25 August 1986, pp 82-90.

in-home services is expected to permit increased access to governmental information and streamline government Costs.[13]

The greatest activity, however, will appear in the commercial in-home services. Commercial offerings can be categorized into seven major groups.[14]

Database services. A wide variety of in-home services will depend primarily on the read-only access and retrieval of information from databases. In certain cases, such as airline reservations, users will be able to update the database. Major growth prospects are in service areas where current forms of information acquisition are inconvenient or time-consuming. Further, the distribution of such services may be through online access or CD-ROM subscriptions.

Financial services. The push towards electronic banking is accelerating while the expansion of financial services and marketing of multiple financial instruments creates a complex information management problem for consumers. With the introduction of electronic banking, many consumers are expected to use machine-readable financial data in conjunction with home computer programs to track, reconcile and analyse their financial needs. Expert systems may play a role in this effort, assessing the financial position of the household given a set of consumer financial goals.

Market services. In-home market services have the potential to revolutionize traditional forms of retailing. Consumers armed with high-powered personal computers with access to product data can assess and pinpoint least-priced options. For example, consider a consumer with access to databases which list the price and characteristics of groceries for each food store. A program could access each database, compare the consumer's shopping list and find the minimum-cost shopping bag- suggesting stores and substitution products. Such computing power and information service could provide the consumer with a significant bargaining position vis-a-vis the retailer.

Home security and management. Home security and management is time consuming. Systems are being designed to enable consumers and energy providers to develop cooperative arrangements for energy regulation, billing and minimization. Increasing sophistication in home security can be made possible by combining computer programs with telecommunications links to public and private security services.

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[13] N. Vitalari and A. Venkatesh, 'Computing in the home: implications for the provision of government services', *Computers, Environments and Urban Systems, Vol* 11, Nos 1 /2, 1986.

[14] The different services identified here are based on several sources including our own research (Project NOAH). A few illustrative examples are: Tydeman *et al, op cit,* Ref 10; 'How to computerize your finances', *Business Week, 30* January 1984, pp 92-94; *IEEE* Spectrum, op cit, Ref 10; Levine, op cit, Ref 8; Scott Mace, 'Entertainment giant's target software', *InfoWorld, Vol* 6, No 22, 1985, pp 62-68; Margrette H. Olson, 'Do you telecommute?', *Datamation, 15* October 1985; 'Working at home', Wall Street *Journal, 13* February 1985; Peggy Watt, 'Home security' *InfoWorld, Vol* 6, No *33,* August 1984; and Robert C. Wood, 'Online shopping: will it replace a trip to the store?', Computer *Update, Vol* 8, No 6, November 1985, pp 62-68.

Table 1. The range of in-home information services.

Public in-home services

Computer network infrastructure
Electronic mail News Local schedules and emergency information Home security network/ 'computer watchdog'

Government in-home services

Government information access communication and retrieval (ordinances, zoning, permits, etc)
Emergency services
Opinion polling and political process facilitation
Automated billing of government service units
Local government bulletin boards

Commercial in-home services

Database services
Expert knowledge reference systems Bibliographic reference systems Airline, train, bus departure and arrival schedules with fare and reservation capabilities Structured news and fact-retrieval capabilities Encyclopaedic reference systems

Financial services
Bank transactions and up-to-date information
Stock and investment information and transactions
Investment tracking and analysis
Structured financial news
Financial education facility (artificially intelligent interfaces)
Electronic funds transfer
Digital financial records
Automated bill settlement
Insurance networks

Market services
Consumer and retail advertising
Electronic shopping
Electronic computer software transfer
Structured consumer advocacy/protection database
Nutrition and health information network
Real estate networks
Used goods networks

Home security and management
Private security systems with advanced monitoring
Home energy and systems management
Do-it-yourself repair, intelligent electronic tutors

Work-at-home support services
Business network interconnects
Specialized vertical market services
Time management programs
Office automation capabilities
Childcare facilities index

Entertainment services
Solitary and multi-player interactive games
Artistic expression
Interactive and generative story development
Interactive cartoons

Miscellaneous services
Private clubs
Opinion research panels
Specialized databases
'Underground' electronic services

Work-at-home support services. Work at home is a major activity for users of home-based personal computers. Given the flexibility offered by work-at-home options, information services to support this activity are emerging, if somewhat in an embryonic form. Companies will specialize in certain vertical market services supporting various work tasks and industries such as desktop publishing and advanced statistical analyses. Other services such as computerized typesetting, sophisticated graphics, and volume duplication will develop to support individuals who work at home.

Entertainment services. The decline of the electronic game market underscores the limitation of toy-like, trendy forms of home entertainment. Nevertheless computers and telecommunications can offer new home entertainment opportunities of greater sophistication. New forms of computerized entertainment include interactive reading and writing, computerized support of musical and artistic composition, and long-distance interactive games.

Miscellaneous services. Once computers and telecommunications networks are available to homes, a number of miscellaneous in-home services are likely to follow. The exact nature of these types of services is difficult to predict. For example, certain types of private electronic clubs may develop with specialized bulletin boards and member networks. Commercial organizations may use in-home services to conduct research surveys permitting new methods of data collection.

The future demand for in-home services depends on several important demographic and social forces. The adoption and usage patterns of in-home services will be heavily influenced by normal generational maturation. Today's 10-year-olds will find computers ubiquitous in their working and childbearing years. To that generation, in-home computing services may well be considered second nature. Many of the productivity aids used in school and work will create a demand for similar functions in the home. In the long term, a wide variety of in-home services could emerge which address many aspects of household life. Such services could become an electronic window to other households, institutions, public agenices, and to the rest of the world through information service gateways.

In the more immediate term, our own research (Project NOAH)[15] suggests that a modest market for in-home services currently exists among highly educated, upper-income, middle-aged individuals. This segment uses personal computers to work at home, access electronic mail networks and introduce their children to computing. The current size of this segment in the USA is approximately 5 million households.[16] Assuming a $20 per month fee for services, a conservative extrapolation suggests a $1.2 billion annual market for in-home services in the near term.

Taken together, the next generation of technologies increases the amount of information processing power available to the household.[17] Given the trends in the

[15] Project NOAH is an acronym for National Outlook for Automation in the Home, and is funded by the National Science Foundation for evaluating the social impacts of in-home computing technology.

[16] Computers: where they go', USA Today, 27 July 1985.

[17] In the early stages of technological diffusion, adoption and use, technological advance precedes informed use. Thus, the hardware technology defines the opportunity horizon for future applications. But the learning curve of the users defines the actual rate of application use and the eventual mix of application choices.

technology, we can expect that an increasing amount of household work such as record keeping, bill paying, maintenance scheduling and written communication will be greatly assisted by the new technology, and in some cases be completely delegated to the machine via intelligent programs. However, a major obstacle to these developments, in the short term, is a well developed infrastructure.

Infrastructure for the information society

Infrastructure is the key to successful computing in the home. Automobiles depend upon highways and service stations, VCRs depend upon video programming and a network of video rental outlets, and computers depend upon standards, programs and computer literacy. Traditionally, computing has been viewed as a tool or an appliance, that is, a piece of equipment much like a hammer, a drill, or a saw which extends and enhances the capabilities of a person in a particular task. However, as Kling and Scacchi[18] have pointed out, the tool model does not fit computer technology, because computer technology does not stand alone. A more appropriate metaphor for computing is the *computing package.*[19] In this metaphor, the computer is useful only with the requisite infrastructure in which to operate, the necessary skills, and the necessary support. If we use the package metaphor in the context of home computing we see that the infrastructure must still develop. Recent analysis[20] indicates that home computer owners are most dissatisfied with the technological infrastructure related to personal computing. For computing in the home, the infrastructure consists of the following elements.

- *Electronic networks.* The electronic equivalents of a regional and national road system. This costly but necessary apparatus will be essential for homes to adopt the idea of computing in the home. Electronic communication creates many more opportunities to support home activities.
- *Maintenance and support.* Organizations which provide reliable and up-to-date service for in-home computing are essential. Current methods of maintenance and support are limited. In the future it may become increasingly difficult to expect consumers to bring their computer into `the shop' for repair. It is likely that we can use computer networks for remote diagnostic purposes.
- *Training and computer literacy.* Because computing is a complex technology it requires a certain level of knowledge to use it effectively. Appropriate levels of training will be required to assist individuals in becoming computer-literate.[21]
- *Security safeguards.* With the proliferation of computers in the home and network services, the computer industry will have to develop sophisticated security systems to protect individual privacy and the integrity of the networks and computer systems.
- *Standards.* The computer industry is characterized by a lack of technological standards. This issue is complex because standards must be developed at different

[18] R. Kling and W. Scacchi, 'The web of computing: computer technology as social organization', in M. Yovits, ed, *Advances* in Computers, Vol 21, Academic Press, New York, 1982.

[19] For a discussion of the package and tool metaphors for understanding complex technology, see *ibid.*

[20] Venkatesh and Vitalari, op cit, Ref 10.

[21] While it is likely that the need for extensive computer literacy will decrease as computer sophistication increases (see Roger Schank and Peter Childers, The Cognitive Computer, Addison-Wesley, Reading, MA, 1984), it is also equally likely that some basic level of computer literacy will be needed similar to the type of literacy which individuals have for use of the telephone or automobile. Currently, this minimum level of computer literacy is only shared by a small segment of society.

levels: for hardware, and for software interfaces. In the case of home computers, the industry cannot expect the average consumer to be fluent in person-machine interfaces of multiple systems. This standardization of interfaces and structures becomes most apparent in the `gateway' concept where a number of electronic networks will be linked together in *ad* hoc configurations depending on the user's request for information.

- *Laws and privacy*. Legal precepts which outline computer crimes and protect the privacy of the individual and the liability of the producer are required. Today there is a virtual vacuum in laws concerning the proper use of computers.

The importance of infrastructure to the successful evolution of HCIS technologies is often underestimated in industry analyses. HCIS will develop gradually over an extended period of time, as has been the case with previous complex technologies such as the telephone, the automobile and the television.[22] Each technology has moved through a diffusion, adoption and use process, where over time developments in the technology, infrastructure and consumer understanding have led to increasing consumer participation and utilization.

An evolutionary perspective on HCIS developments

The history of the past 40 years of information systems indicates that computing use and computing technology evolve through a complementary cycle of supply and demand.[23] Technology is offered to users, users employ it, learn it, social arrangements adapt and new technology is provided in response to evoked requirements. New offerings of a technology at given points in time expand the technological horizon, but more importantly generate a larger opportunity set to which the technology may be applied. Similarly, the longer the technology is available, the greater is the consumers' awareness, expertise and understanding of its utility. Further, as experience with the technology increases over time, the ability and skill to assimilate the technology into existing social arrangements increases.

To understand the evolution of HCIS and the resultant technological impacts on the home and society, a framework which identifies major processes and variables underlying the evolutionary process for the consumer setting is used. The framework is based on the premise that technological evolution is an interactive as well as iterative process of technological supply and demand (see Figure 1). The framework postulates that three elements - (1) the household penetration level, (2) the available in-home computing and information service technology, and (3) the accumulated experience and infrastructure - interact over time, to produce an evolving mix of computing options and computing behaviour. As computing options and behaviour unfold, technological impacts occur which in turn contribute to a new level of household penetration,

[22] For the telephone, see Ithiel de Sola Pool, 'The social impact of the telephone', MIT Press, Cambridge, MA, 1977; for the automobile, see F.R. Allen, 'The automobile', in F. Allen et *al*, eds, *Technology and Social Change*, Appleton-Century-Crofts, New York, 1957, pp 107-133; for the television, see W.A. Belson, *The Im*pact *of Television*, Archon Books, Hamden CT, 1967.

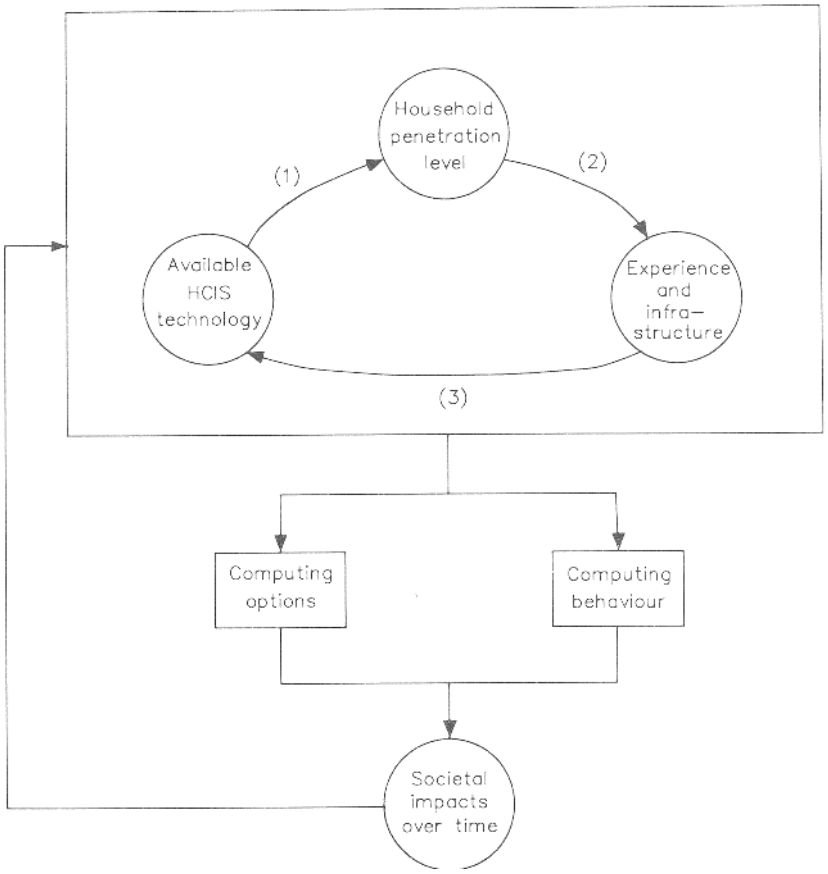
[23] Richard L. Nolan, 'Managing the crises in data processing', *Harvard Business Review*, March-April 1979, pp 115-126; Gary W. Dickson, 'Management information systems: evolution and status', in M. Youts, ed, *Advances in* Computers, Academic Press, New York, 1981; and John L. King and Kenneth L. Kraemer, 'Evolution of organizational information systems: an assessment of Nolan's stage model', Communications of the *ACM, Vol* 27, No 5, 1984, pp 466-475.

technological capability, experience and infrastructure. As the household penetration level in HCIS increases, the capabilities of the technology and the services will increase, thereby advancing the technology and broadening the spectrum of potential impacts.

For example, in 1975 certain households (i.e. hobbyists) decided to purchase personal computer kits. The diffusion process was influenced by the available technology and the unique technical expertise of this small group of households. Societal impacts were modest. By 1978 new technology became available (e.g. TRS-80 and Apple II computers) and permitted more households to adopt the technology. Major societal impacts at this stage were primarily economic, with rapid growth in computer sales, recognition in the popular press, and the first evidence of a computer subculture (computer clubs). At these early stages of evolution, infrastructure was less important than today. However, as penetration levels increase and the technology becomes more sophisticated the infrastructural elements become more important.

In summary, the interactive model asserts that over time, advances in technology, higher levels of household penetration, and a more mature infrastructure lead to greater consumer experience, new evoked computing requirements, additional investment in the infrastructure, and better technology. This interactive process produces new computing options and reinforces patterns of computing behaviour, which begin to exert societal level impacts.

Figure 1. An interactive model of HCIS technology adoption and use.



Stage model for the in-home computing market

For the purposes of this article the evolutionary process discussed above will be partitioned into six stages of development. Each stage designates a dominant theme resulting from given levels in the three components of the interactive model: available technology, household penetration, and infrastructure development accessible to the mass market.[24] For example, stage one is designated the hobbyist stage because it is the stage of the enthusiast or the uncommon individual whose fascination with the technology allowed them to explore it in innovative ways. Stage two, on the other hand, is labelled the entertainment/work-at-home stage because the available technology and its use was oriented towards either home entertainment or working at home. Although the stages are distinct, particular uses and technological applications may overlap from time to time as is the case with all normal diffusion processes. Advanced users anticipate future uses pushing the technology to its limits, while less sophisticated users lag in applying the full capabilities of the available technology. For example, it is certainly true that many hobbyists in the first stage used the computer for entertainment and working at home characteristic of stage two. It is also true that later users (stage two) found the computer a useful hobby. At present (stage three), it is possible to see certain advanced users[25] experimenting with high levels of home automation expected to occur in the 1990s in stages four and five.

Two advantages accrue from segmenting the evolutionary process into stages. First, each stage specifies a level of technological progress and household penetration permitting a reasonable dating of the stage, based on normal technological development times and adoption rates.

Second, the stage approach provides a method of postulating societal impacts based on a dominant technological theme present at a definable point several years hence. Each stage delineates an interval of time when it is estimated that certain technological, infrastructural and experience levels will emerge, leading to increased levels of household penetration, computing options, computing behaviour and societal impacts.[26]

The stage model is based on several crucial assumptions.

- Developments in semiconductor, telecommunications and robotic control technology will continue at current rates.
- Growth of the marketplace will largely be dependent on the ability of vendors and systems integrators to define the real needs of the household for in-home computing and information services.

[24] Each stage represents a level of HCIS achievement assuming reductions in the cost of the technology, increasing levels of consumer acceptance and sophistication, levels of household penetration, and infrastructure development. We have anchored each stage to a five-year time interval to indicate the general time frame for the appearance of different levels of HCIS achievement, assuming such trends as five-year technology development times, advances in memory, processor and operating system technologies, and levels of investment try technology vendors.

[25] See *IEEE* Spectrum, op cit, Ref 10.

[26] We are aware of the problems in developing scenarios of future states such as the effects of transitory phenomena, equifinality, and subjective value positions. The rationale underlying the model assumes that technology is incorporated gradually into a social system and is modified through successive stages. The approach avoids assuming one single future world since each stage represents a given social context, technological state and level of social learning.

- The number of computer shipments to the home will continue to be approximately 50% of the total personal computer shipments per year.
- The real growth in this marketplace depends upon the development of a rich infrastructure of services and capabilities.
- The market will be dependent upon the successful development of high quality, easy-to-use software.
- Each stage of growth represents a snapshot or characterization of the evolutionary process which is a product of the household penetration level, the available technology and level of experience and infrastructure development.

Table 2 provides estimates of the level of household penetration at each stage. The estimates are based on a modest growth in use of HCIS technologies in the home and assume a penetration level of about 60% in the year 2000.[27]

A descriptive title for each stage is given to characterize the dominant technological developments and themes. Each stage is characterized as follows:[28]

1. *The hobby/expert stage (1975-79).* Stage one reflects the initial deployment of microcomputer technology into the home. These systems required a significant degree of expertise in electrical engineering, computer science, or a related technical discipline. Many of the prototypic applications for home computers were visible in these early years, such as home control, data communications and computer games. The household penetration level at this stage was less than 1 % .
2. *The entertainment/work-at-home stage (1980-84).* Stage two is characterized by many vendors offering home entertainment and office applications. The home computer was defined as either an entertainment/educational home appliance or a professional work station for the individual who wants to work at home. As a result, by the end of *1984* it was clear that the current concept of the home computer was woefully inadequate to satisfy the complex demands of the marketplace. The household penetration level at this stage was approximately 10%.

[27] The estimates of household penetration are based on a combination of industry sources: International Data Corporation, The Yankee Group, Future Computing, Dataquest Inc and our own experience with Project NOAH. Generally we assume a much more conservative rate for household penetration than do most industry analyses, even considering the real growth in the number of households over the next 20 years. The household penetration level is assumed to be primarily a function of household income level and education. Most current home adopters of HCIS technologies have a median income of approximately $45 000 - slightly less than 30% of all US households (cf USA *Today,* op cit, Ref 16; and N. Vitalari, A. Venkatesh and K. Gronhaug, 'Computing in the home: shifts in the time allocation patterns of households', Communications of the ACM, May 1985). Penetration rates beyond the 30% level require significant price reductions, advances in software interface design, and normal generational maturation. Conservatively, the former should reasonably occur within the next eight to ten years. Estimates by the Yankee Group (A. Zernik, 'Future bright in low end market', *Random* Access, Vol 3, No 4, August 1986, p 12) suggested a resurgence in home computing sales in late 1986 due to price reductions, increased technological capabilities and international competition.

[28] The information gap is likely to be significantly different from previous so called gaps in the diffusion and use of the automobile, telephone and television. These technologies were different because use of automobiles only required basic motor skills and use of the television and telephone is passive. HCIS technologies, on the other hand, require basic reading literacy, knowledge and certain cultural backgrounds, to be used effectively and employed beyond the level of simple entertainment. The information gap is not likely to be solved by easier-to-use interfaces, better ergonomic designs, or artifically intelligent programs. Also, experts have estimated the US functional illiteracy rate at currently 27 million and increasing, further complicating efforts to increase computer literacy. See 'It's at home where language is in distress', US *News and* World *Report, 18* February 1985; and J. *Kozol, Illiterate America,* Anchor Press/ Doubleday, New York, 1985.

Table 2. Projected growth rate in household penetration level for HCIS technologies.

Stage of evolution	Household penetration level (percent) (cumulative)*	Number of household
1. Hobby/expert (1975-79)	< 1	100 000-1 000 000
2. Entertainment/work-at-home (1980-84)	10	8 000 000
3. Multifunction(1985-89)	20	16 000 000
4, Service/information utility (1990-94)	30	24 000 000
5. Robotic/home control (1995-99)	40	32 000 000
6, Household appliance (2000+)	60	48 000 000

'Based on 1981 census estimates of approximately 80 million households. For the purpose of this analysis, real growth in the number of households is not considered.

3. *The multifunction stage (1985-89).* In stage three vendors realize that the computers for the home must be functionally different than computers for the business environment. Home computer hardware and software begins to address the diversity of household requirements (entertainment, working at home, home education, data communications, music, graphical arts, and simplified home finance). Multitasking operating systems make their debut in the later years of stage three. The household penetration level at this stage will reach approximately 20%.
4. *The service/information utility (SIU) stage (1990-94).* Stage four begins as private and public organizations begin to invest and implement the necessary infrastructure to support computers in the home. This will initially include electronic mail and later develop into simple home information services and government services. The household penetration level at this stage will reach approximately *30%.*
5. *The robotic/home control stage (1995-99).* Stage five indicates the convergence of robotic and process control (ie servo controlled) devices possible with ultra fast array processors and enormous semiconductor memories with other HCIS technologies. Movement to stage five requires significant price decreases in analog-to-digital conversion circuits, local area networks, and pattern recognition and signal-processing technologies. During this period, homes will become increasingly automated through new `built in' devices and remodelling of existing structures. The household penetration level at this stage will reach approximately *40%* .
6. *The household appliance stage (2000+).* Stage six indicates a level of maturity in the marketplace. Demand should stabilize and grow moderately thereafter, with further advancements resulting from improvements in product quality, features and service. At this point approximately *40-60%* of US households will own some type of HCIS technology. Assuming an average entry price of $1000, the total market could be worth over *$50* billion in *1984* dollars.

Development of the social impacts of HCIS

Different social impacts are expected to emerge in each of the six stages described above. To construct a scenario of the developmental impacts, four basic perspectives are used (see Table 3):

1. The economic perspective
2. The social perspective
3. The political perspective
4. The psychological perspective

The economic perspective

The economic transformation wrought by the diffusion, adoption and use of HCIS technologies could be significant because they transform a basic social unit - the home -and change some basic modes of information processing and interchange.

From a temporal perspective economic impacts will become more pervasive as the industry matures. Since 1981, most economic issues concern unit cost and unit sales as an indicator of the health of the market. In stage three (1985-89), however, market economics force vendors to provide products and market segmentation strategies which correspond to the realities of the household setting. Increases in the number of individuals working at home spur corporations to investigate the implications for productivity and cost reduction. Trade unions attempt to introduce legislation to protect workers' rights, benefits and compensation.

In stage four (7990-95), the introduction and proliferation of information services and electronic networks creates new information products, bringing growth in revenue. State and federal agencies will investigate the tax revenue opportunities from information taxation the taxing of information flows to and from a commercial information service. Governmental agencies will also examine the potential for revenue tracking from electronic banking transactions to reduce tax evasion by the underground economy. Increases in the number of individuals working at home could spur a work-at-home industry, providing specialized information services and HCIS technologies to support this segment.

Certain segments of the population may be excluded from important financial and market services because of low income levels or severe computer illiteracy. There is also a fear that information services may offer the privileged greater purchasing power, better financial information, job opportunities and greater returns on savings. Stage four could bring an increased polarization between the information-privileged and the information-deprived.[29]

Use of electronic mail and financial transaction systems may have a significant economic impact on traditional mail delivery organizations and their labour force.

[29] H. Nowotny, 'The information society: its impacts on the home, local community and marginal groups', in N. Bjorn-Anderson *et* al, eds, Information *Society for Richer* and *Poorer*, North-Holland, Amsterdam, 1982. John G. Kemeney, 'The case for computer literacy', *Daedalus, Vol* 112, No 2, Spring 1983, pp 211-230; and Bjorn-Anderson, 1982.

Table 3. Summary of societal impacts for HCIS.

	Stage one Hobby/ Expert 1975-79	Stage two Entertainment/ work-at-home, 1980-84	Stage three Multifunction, 1985-89	Stage four Service/ information utility 1990-94	Stage five Robotic/home control, 1995-99	Stage six Household appliance, 2000+
Economic impacts		Growing sales of personal computers	Vendor assess value of in-home services and demand Market segmentation	Information subcultures information taxation Work-at-home industry Emergence of information poor	Information import and export Automated monitoring systems impact service Intellectual property rights Worldwide electronic trade	Information industry becomes largest US industry sector
Social impacts	Computers and the rise of hobbyists	The beginning of computer subculture	Computers as instruments for social advancement Minor problems with juvenile crime	Work-at-home facilities White-collar international crime Social impact of informational gap		Reinstitutionalization of household Information subcultures
Political impacts				Electronic opinion and political polling National information security policy	New political constituencies Legislative monitoring systems	
Psychological impacts		Computer as an alien machine	`Computers as Rorschach' Computers as status symbols	Computing as an entertainment Psychological rejection of electronic information	Intelligent information monitoring and management Demise of broadcast presentation modes Information overload and stress and computing	

By stage five (1995-99), the market will have advanced considerably; optimistic estimates believe that at least 30-40% of US households will have some type of computing technology and information service. International trade in information could become lucrative. Banks and financial institutions which developed large-scale financial networks in the 1980s will expand these services to the home sector. Since information services transcend space and time, households in most developed nations will comprise an information and computing marketplace. Individual households will be able to order products directly from their place of origin anywhere in the world, creating greater international competition.

The emergence of home robotic and control devices will assist consumers in monitoring machine maintenance for automobiles, home appliances and garden care. It is likely that public utilities, service organizations (e.g. automobile dealers, appliance repairers, etc), and police and fire services will experience both positive and negative economic impacts from these developments. For example, if economically feasible, robotics, intelligent programs and data communications may permit maintenance organizations to diagnose remotely household appliance failures and to route appropriate service or provide step-by-step instructions to the consumer for self-repair. Highly

automated service organizations may reduce the need for menial labour in landscape maintenance and reduce the demand for unskilled labour.

In stage six (2000+), the growth rate of the information service industry will have stabilized in terms of new households added, but the support services industry will continue to develop and begin to restructure the labour force. The information service industry will become the largest sector in the economy and will have a synergistic effect on how the other sectors -agriculture, service and industry- operate. The information sector will become a sophisticated support system for the other productive sectors in the economy. Tables 4 and 5 provide illustrative examples of the economic impacts of mature in-home financial and consumer information services, respectively.

In summary, as the market matures, economic issues of national and international significance will emerge which will require policy decisions and legislative debate. New organizational forms may emerge which will permit remote work arrangements and the re-institutionalization of households, which in turn will create change in the consumer services and household product markets. As international trade in information products develops, nations will begin to debate the role of information as a productive asset in national identity and international economies.

Table 4. The range of in-home financial services.

Type of service	Economic impacts	Social impacts	Political impacts	Psychological impacts
Bank transactions and account status information	Reduction of float	More purchases on credit terms	Move to build in float Privacy vs better surveillance	Inflationary expectations Feeling of less control
Stock and investment tracking and analysis	Better portfolio management	Nil	Control over transaction data	Feeling of more control over assets
Structured financial news	Indeterminate	Nil	Nil	Nil
Financial computer-aided analysis	More small investors in market	Small investor networks	Movement to brokerless marketplace	Nil
Electronic funds transfer	Reduction in float Efficient provision of financial services Better predictors: economic activity and money supply	Underground economies Increase in white-collar crime Increase in commodity trade	Privacy legislation Consumer protection and liability	Stress from lack of tangible medium of exchange Stress from EFT errors
Digital financial records	Nil	Nil	Consumer protection	Increased feeling of control over finances
Automated bill settlement	Decrease in age of accounts receivable	Nil	Nil	Less worry over bill paying
Insurance services	Reduction in cost of policy maintenance	Nil	Consumer protection	Nil

Table 5. Expected impacts of in-home consumer services.

Type of service	Economic impacts	Social impacts	Political impacts	Psychological impacts
Expert knowledge person-machine	New industry growth	In-home training	Ownership of expertise	Problems in interaction
Reference systems	Demand for knowledge engineering skills			
Information retrieval And structured news	Decline in broadcast offerings Information tax	Selective control of information	Regulation	Management of information overload Management and control over world view and ideology
Solitary and multi-player games	Nil	New social networks	Nil	Increased sense of connection with world
Artistic expression	Nil	Renaissance in the arts New art forms	Support for the arts	Self-expression Interest in arts
Interactive and Generative story Development	New market	Training in ethics and simulation of real-life situations	Nil	Active involvement in creative leads to reduction (counter to TV syndrome)

The social perspective

The social impacts of HCIS became evident in stage three. Two different research teams[30] found that time spent on watching television decreased in a significant number of households with computers. Vitalari *et a1*[31] also found that time spent alone increased and time spent with family members decreased. As households used the technology, time was allocated away from traditional activities and altered the mix of activities in the household unit.

The Rogers et al study discovered characteristics concerning the diffusion network developed by computer users. Most users were actively involved in telling others about their home computing experience and motivated them to form new social networks and new interests.

Our continuing longitudinal study of computer use among 600 households in the USA[32] indicates an extensive use of computers for work-related activities and a dominant use of word processing systems. The results suggest a move to perform more work in the home. The computer appears to transform a standard home into a useful work setting.

The latter years of stage two and the early years of stage three witnessed minor problems with juvenile computer crime due to the rapid diffusion of personal computers and a less rapid implementation of computer security safeguards. The manifestation of juvenile computer crime indicates that HCIS technologies, like other technologies, will be used for the expression of human social or antisocial behaviour.

The increasing use of electronic networks in stage four raises computing in the home to a new level of activity and generates additional social impacts (see Table 3). Electronic social networks could form through the use of electronic mail and selective consumer information interests. The availability in the home of powerful computing,

[30] E. Rogers, H. Daley and T.D. Wu, `The diffusion of home computers', paper presented at the Association for Consumer Research Conference, Chicago, 1983; and Vitalari et al, op cit, Ref 27.

[31] Vitalari et al, op cit, Ref 27.

[32] Vitalari and Venkatesh, op cit, Ref 13.

coupled with reliable networks, will reduce the investment required for individuals to work at home. As working at home becomes easier, changes will occur in the structure of work organizations, work schedules and the social arrangements in the home. This adaptation may change a number of traditional relationships, such as the division of labour within the home and the location of work among homes, schools, and offices. Organizations will have to deal with the issues of managerial control and new forms of work monitoring which will emerge from increased work at home.[33]

On the negative side, stage four may lead to the development of a cadre of computer criminals, sociopaths and psychopaths which will attempt to profit, disrupt and introduce chaos into HCIS transactions.[34] It is likely that the pathological criminal will find the computer a tempting medium in which to operate. Law enforcement agencies will have a difficult task of tracking electronic signals.

The `information gap', the gap between those who are information privileged and those who are information-underprivileged, was discussed earlier as an economic problem. It is also a social problem, and could become significant in stage five. The information gap is a social problem because it affects three elemental issues underlying social structures and relationships.

- Computer literacy. Will certain groups be isolated and unable to participate in society because they have not developed the skill to interact and successfully cope with computer systems?
- *Knowledge deficiency. Will* certain groups, due to culturally deprived conditions, be unable to use the rich sources of information which will be available? For example, are there developmental experiences which inhibit or do not provide individuals with the proper cognitive information processing behaviours effectively to live in an electronic information world?
- *Access barriers. Will* certain groups, because of their income levels and regional location, be implicitly restricted from participation in electronic networks and services?

Stage six will see the appearance of information subcultures: groups of individuals who share a common understanding of the world due to the way in which they have selectively filtered and coded electronic information. We may see the formation of new belief systems and `world views' formed by their own selective editing of information sources. We can also expect that these filtering activities will be augmented by `artificially intelligent' systems which select information elements based on a set of user preferences.[35]

The political perspective

The political implications of HCIS were foreshadowed in the use of sophisticated computer systems to influence and develop support among voters for the 1984

[33] M H. Olson and S.B. Primps, 'Work at home with computers: work and non-work issues', Journal of Social Issues, Vol 40, No 3, 1984, pp 97-112; Baer, op cit, Ref 10; and R. Schneiderman, 'The time is now for corporate MIS to consider telecommuting', Computer World, 8 September 1986.

[34] Eric Sand berg-Diment, 'The safeguarding of electronic records', *New York* Times, 24 February 1985.

[35] Schank and Childers, op cit, Ref 10.

presidential election in the USA.[36] At least one political campaign will use HCIS technologies in a highly targeted and efficient manner in the next 20 years.

In the first three stages, political impacts have been virtually absent and only minimally present in early teletext and videotex offerings (ie CUBE), in the form of opinion polling and trade unions attempting to limit working at home. Although it is unlikely that electronic systems will dramatically increase voter participation, voter exposure to the democratic process, among those who participate, will be more immediate and intense.

Major political impacts will emerge in stage four. Sophisticated opinion and political polling systems will gather information by permitting citizens increased control over the information they receive and the information they want about the political process. Campaign organizers may develop interactive response systems which answer questions about a candidate and then implicitly gather important respondent opinions based on the way questions were asked (such as elicitation of important issues).

With a properly programmed computer, citizens or citizen watch groups could regularly monitor the legislative behaviour of their elected officials. Citizens could also exercise selective control over the type and number of political messages they choose to view and receive.

HCIS technologies could also simplify citizen access to the complex myriad of government services.[37] In-home services with intelligent programs could provide directed searches for the proper government unit and assist citizens in gaining access to pertinent information.

The increased use of information services and increased exposure to computer crime will raise political issues concerning the effect of electronic information systems on national information security. Will private encryption of data jeopardize national security and law enforcement? Or will it enhance it? Will the government allow individuals to maintain private encrypted databases on transaction data, or will the government require certain electronic data to be registered in central databases or accessible upon demand?

The issue of information security and access will lead to a re-examination of information ownership. How does one verify that the information has been used? Who owns the data in the database or the knowledge in an expert system knowledge base? Does the provider, developer, or distributor own the data? Should royalties be provided to people whose personal data are used for sale? These are political questions because they must be decided at the congressional level.

Stages five and six could witness the establishment of new political constituencies. Users of HCIS technology may share common characteristics and exert political influence as a result of being better informed about their representatives' actions and having more efficient access to appropriate government channels. Thus, informed individuals and organizations may employ HCIS technologies as an effective form of political influence. HCIS technologies can either increase the political power of individuals and their role in democratic government or reduce their role. The outcome depends upon the design of the systems and the level of interest of the users.

The psychological perspective

[36] Peggy Watt, 'Democrats computerize politics', *InfoWorld, Vol 6, No 30, 23 July* 1984.
[37] Vitalari and Venkatesh, op cit, Ref *13.*

The psychological impacts of HCIS are perhaps the most difficult to forecast. However, over time we can expect both positive and negative, latent and manifest psychological ramifications from HCIS evolution. Most likely HCIS technologies will affect attitude formation, information processing behaviour, and self concept.

The best known analysis of the psychological dimension of personal computer use is by Turkle[38] and reflects the impresssions of computer users in stages one, two and three of the model.

Earlier, Turkle[39] suggested that some computer users viewed their computers as more than simple machines. She labelled this behaviour the `Computer as Rorschach', similar to the famous psychological projective test. She found evidence of users projecting subjective psychological meanings that went beyond the intrinsic characteristics of the machine. It is possible that as HCIS becomes more available and prevalent in stages four, five and six, we may find some individuals developing complex psychological attitudes towards computing subtly influencing their attitudes and perception of everyday life. Certainly, the automobile, telephone and television have changed our sense of space and time. HCIS technologies may permit greater isolation and fantasy for those who wish to withdraw from the world, or conversely provide greater exposure to more of the world for those desire higher levels of interaction.

From a cognitive perspective, new information processing skills will be developed, augmented by sophisticated information filtering and retrieval programs. In stages four, five and six, individuals will be able to embed personal preferences, attitudes and affect into computer programs which will scan, monitor and report on data and events according to pre-established criteria. Individuals could develop new cognitive schemata to organize information about the world based on the merging of text, video and audio into a common medium. If basic changes occur at this level, individual attitudes and perceptions about reality may change due to time and space compression in information sources and transmission. On the other hand, some may resist change, preferring traditional media to HCIS.

On an emotive level, we can expect to find individuals who experience more stress and anxiety in the information-rich environment, as well as individuals who will experience a marked decrease in stress and anxiety by reason of increased information filtering. Much of the psychological adaptation and coping ability will depend upon individual knowledge and skill in using the information source. For example, traditional broadcast modes of information transmission, characteristic of the television and the telephone, are declining markedly due to the proliferation of efficient digital and analog memory systems. A selective mode of data acquisition provides the individual with a method by which to manage the flow of information into the household, which can reduce stress.

Some individuals could become information addicts, with a high level of activation resulting in personal psychological problems from social isolation and unrealistic world views. Weizenbaum[40] has already documented the problem of the artificial worlds of pathological hackers. Such individuals may also be viewed as misfits by others in society leading to further isolation and later requiring psychological treatment.

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[38] Sherry Turkle, *The Second Self: Computers and the Human Spirit,* Simon & Schuster, New York, 1984.

[39] S. Turkle, 'Computers as Rorschach', *Society, Vol* 17, No 2, 1980, pp 15-24.

[40] Joseph Weizenbaum, Computer Power *and Human Reason, W.*H. Freeman, San Francisco, 1976.

Many of the psychological responses will be due to effective or defective HCIS designs. The past 25 years of computing experience in complex organizations have indicated the importance of human factors in computer system design. Poorly engineered systems increase frustration and stress. Well designed systems can enhance productivity and the quality of life. In the future, proper design will become more important as the technology becomes widely adopted.

Certain non-ambulatory segments of the society may benefit psychologically from the increased access to information. The handicapped, aged, and other isolated individuals may feel more connected and in touch with what is happening in society, especially if a large portion of society is participating in these systems. Some clinical psychologists have also found the computer useful in treating autistic children,[41] and in family therapy.[42]

Conclusions

This article has presented an evolutionary perspective on the societal impacts of HCIS technology for the next 20 years. HCIS technology has the potential to affect many features of personal, household and organizational life. It is likely that the convergence of this technology, together with a well developed infrastructure, will create new social forms, new values, new belief systems and new perspectives on world trade and commerce.

The analysis also explored the importance of integrating the concepts of technological supply and demand with the successive impacts of higher levels of technological utilization. The interaction of technological push, consumer use, and the gradual emergence of technological requirements will drive new societal behaviours and new options.

From a policy perspective, the analysis indicates the importance for policy makers of understanding (1) the forces driving the convergence of HCIS technologies, (2) the impact of the HCIS technologies, and (3) the implications of the societal impacts for the economy, the legal system, and international competition and relations.

Finally, a great deal of research is needed to understand the nature of the societal impacts. In the final analysis, only well-designed, systematic empirical research will tell the story.

[41] Jacob Palme, 'Interactive software for humans', *Management Datamatics*, Vol 5, No 4, 1976, pp 1-19.
[42] C R. Figley, ed, Computers *and Family* Therapy, The Halworth Press, New York, 1985.