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The Digital Divide: An Integrated Approach

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Key words: digital divide, system dynamics, soft systems methodology, systems thinking, modeling and simulation.

Abstract

The term "Digital Divide" refers to the gap between people and communities who have access to the information resources and those who have not. As with any complex issue, there are several approaches to the problem, and several stakeholders trying to design interventions to close the gap. The present paper uses a combination of the conceptualization tools proposed by Soft Systems Methodology and the simulation approach of System Dynamics with two main purposes: to create a rich definition of the Digital Divide, and to explore the impact of some strategies used by the stakeholders in order to evaluate their impact.

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Introduction

Technological development is one of the most important characteristics of our time, and every new technology changes our lives in some extent. One particular development, the Internet, has the potential to create massive discontinuities in both local and global societies.

The number of computers connected to the Internet has doubled every year since its introduction to the scientific community in the early 1980's (Comer, 2000). This expansion of capacity has not been linear, but rather geometric, for as Bob Metcalfe, founder of 3Com has noted, "every computer added to the Internet doubles the [Internet] overall power" (Rayport and Jaworsky, 2000). With respect to related technologies, Gordon Moore, cofounder of Intel Corporation has forecasted that "computer processors will double their power every 18 months" (Rayport and Jaworsky, 2000), and George

Gilder thinks “the network communications capacity will triple every year for the next 25 years” (Rayport and Jaworsky, 2000).

Various stakeholders have different reactions to the Internet’s growth. For educators, it revitalizes the dream of education for everyone. For policy makers, it constitutes a challenge to guarantee equal access for all people. For economists, the Internet has the potential to become a perfect marketplace where supply and demand interact freely to fix prices. In contrast, psychologists and sociologists see it as an instrument that could change our personal and collective interaction patterns. For businessmen, it is an opportunity to grow the business or to start new ventures. And for the skeptical, it is seen as merely a transitory phenomenon that will not promote any change at all.

However, none of the interpretations of the Internet’s impact is feasible without widespread distributed access and utilization of information available via the network. This problem of information distribution has been referred to by many names during the past two decades. It has been called the information gap (Berry, 2000), the gap between information haves and have-nots (Saundra, 2000; Howland, 1998) or the difference between information wealth and poverty (Cawkell, 2001). Since 1996, the term Digital Divide, coined by Al Gore (Conhaim, 200), has been used to refer to the “gap between people and communities who have access to the information technology and who do not” (Carvin, 2000).

Discussions about the divide involve two different foci: the information gap within a specific country (Conhaim, 2000), and the gap among different countries at different levels of development (James, 2001). Within both these focal areas, some visions into the future are optimistic (Chon, 2001), while others look to a future where “a relatively small super-class will have become rich from ideas they have in their heads, … Most of the remainder will be information-poor, competing for badly paid jobs in a world of escalating violence” (Davidson and Rees-Mogg, 1997 in Cawkell, 2001).

Predictions of the Digital Divide have led to various governmental and private efforts to decrease the perceived gap between the information rich and poor. (Jones and Kueppers, 2000; Bishop et al., 2000). However, their potential for success depends both on their ability to develop a realistic problem definition, and identification of policies that can lead to real and sustainable change. Accordingly, the focus of this paper is to create a rich definition of the Digital Divide by exploring several dimensions of the problem, and to search for feasible leverage points that will help develop strategies directed to close the gap.

Method

In order to develop an integrated view of the digital divide, we have followed the approach proposed by Lane and Oliva (1998), which combines the strengths of Soft Systems Methodology (SSM) and System Dynamics Simulation (SDS).

Soft Systems Methodology is a systems approach created by Peter Checkland (1972). The basic philosophical principle of SSM is that reality is socially constructed. Thus, a system is not an element of the real world that needs to be "fixed" by an external actor, but a method for achieving a better understanding of reality. The method consists in the creation of a *rich picture* of the problem to be modeled and an analysis of different views of the problem from the standpoint of all the relevant stakeholders. The end product is a set of feasible transformation processes acceptable to the stakeholders involved.

System dynamics is a methodology for studying and managing complex feedback systems, where feedback is understood as a closed sequence of causal relationships. That is to say, X causes Y, and over time Y r affects X once more. Jay Forrester envisioned the field in 1956 (Richardson, 1995). The main concept of System Dynamics is that a system's dynamic behaviors (performance over time) are closely linked to an underlying structure of endogenous feedback processes. Furthermore, a computer model is needed because humans do not have the capability to independently visualize and manage the behavior of these complex structures (Forrester, 1971). A system dynamics computer model is the result of an iterative process of comparing and contrasting a set of assumptions about the system structure and the known behaviors of it.

According to Lane and Oliva (1998), both methodologies are complementary, given that SSM is an excellent tool to create conceptual understanding of the problem, and SDS is an outstanding tool to analyze and understand system structure and behavior in order to identify policy guidelines and leverage points.

Thus, the model proposed in this paper consists in a *rich picture* of the Digital Divide and a system dynamics model drawn from that picture to explore policy alternatives that help to close the divide.

The Model

The model's focus is an analysis of the Digital Divide in the United States of America. According to the methodology, the model has two main components, a rich picture that describes a conceptual framework of the issues and interests of the main stakeholders involved in the Digital Divide, and a simulation model that reflects the dynamic behavior of the problem.

There is no a simple definition for the Digital Divide, but we can start by thinking about it as "a complex, multifaceted set of issues that encompass information and technology issues as well as social and economic issues" (Saundra, 2000). As such, it describes a gap among people and communities in terms of their access to the information. The general perception is that the gap is widening (Wallys and Conhaim, 2000; Goldsborough, 2000; Carvin, 2000; U.S. Department of Commerce, 2000). Thus, we can initially represent the problem through the picture shown in figure 1. The picture represents the gap in the access and use of the information among a small group of information-rich and a bigger group of

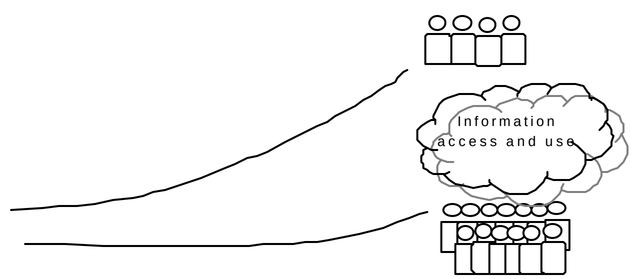


Figure 1. An initial image of the digital divide

information poor. However, it does not include a description of the different variables related with the problem.

First, it is important to note that, though the Digital Divide discussion is related mainly to the Internet in several publications, the problem involves all available telecommunication technologies available at this point. That is to say, telephone access was an important issue in the American discussion of the information divides until some years ago (U.S. Department of Commerce, 1998), and still an issue at the international level. At this moment, the most important technological variables tracked by the Department of Commerce studies are computer and Internet access, but new variables have been added, like broadband Internet access (i.e. DSL or Cable). Given this, a first dimension of the Digital Divide includes the different telecommunication technologies used to access information.

On the other hand, there is a set of variables that have been identified as critical factors influencing people's access to information sources. The main variables identified by the series of studies of the Department of Commerce (Falling Through the Net) are economic status, race, gender, education, physical ability, geographic location, age and household composition. Economic status has been measured through income. The main racial groups identified in the US have been White-non-Hispanics, Black-non-Hispanics, Asians and Hispanics. Education has been measured in terms of the last level of education reached. Physical ability is related with 22% of Americans with any physical disability (U.S. Department of Commerce). Though some differences among different regions of the country have been found, the geographical location variable is related to community types: urban, rural, or inner cities. Finally, there are identified differences according to household composition, two-parent families with or without children, one-parent families with children, and people who live alone. This set of variables conforms a second dimension of the digital divide.

The third and last dimension (figure 2) includes several issues to be considered when the have and have-nots problem is studied. The most visible issue has to do with access to information, but other important aspects to consider are content, literacy, digital literacy, pedagogy and the community. These aspects will be discussed with more detail in the following paragraphs.

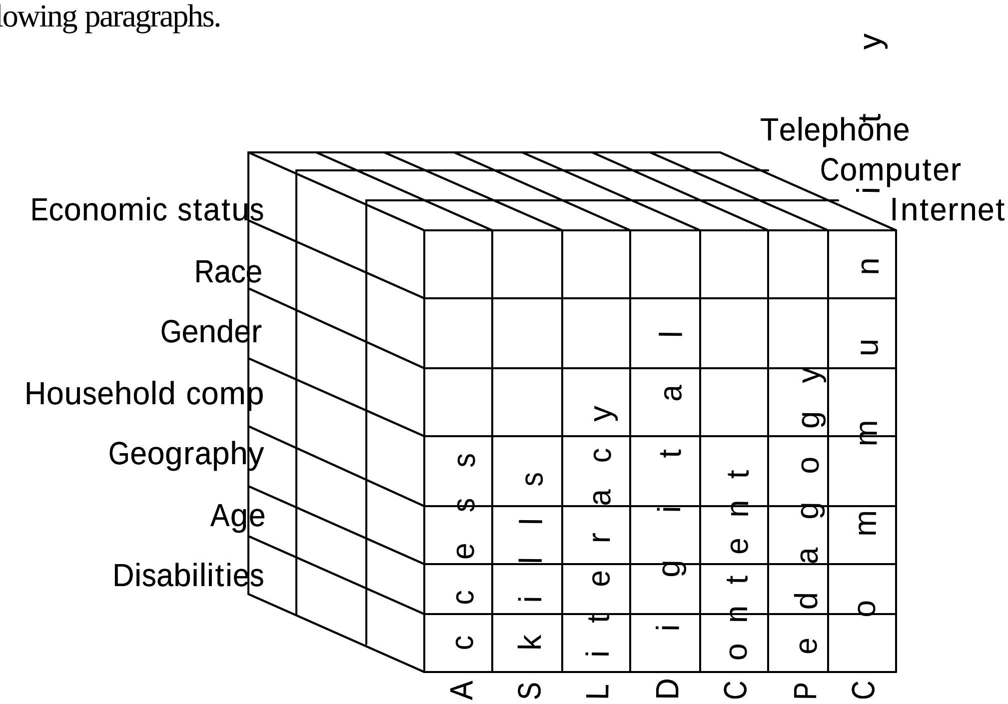


Figure 2. A three-dimensional model of the digital divide issues

The Access Problem

As indicated above, access is the most comprehensively studied factor of the related set of problems listed above. The U.S. Department of Commerce has developed several documents in the series “Falling Through the Net”. The last report, delivered in February 2002, shows a general growth in computer and Internet access penetration in American households. For example, the share of households with Internet rose from 41.5% to 50.5% from August 2000 to September 2001; more than a half of American households (56.5%) have computers (up from 51% in 2000); and the share of individuals using the Internet grew from 44.4% to 54% in the same 13-month period.

According to the report, it is possible to observe that the gap is narrowing in regard with some critical factors like geography, economic status, education, gender, and age. That is to say, rural areas, middle levels of income, people with some college education or high school, women, and individuals older than 50 years are showing relatively faster rates of growth. Other gaps, such as the one related to computer ownership, showed no significant improvements. And finally, there is still a gap in terms of people with disabilities (specially the visually impaired) and ethnic groups (Blacks and Hispanics).

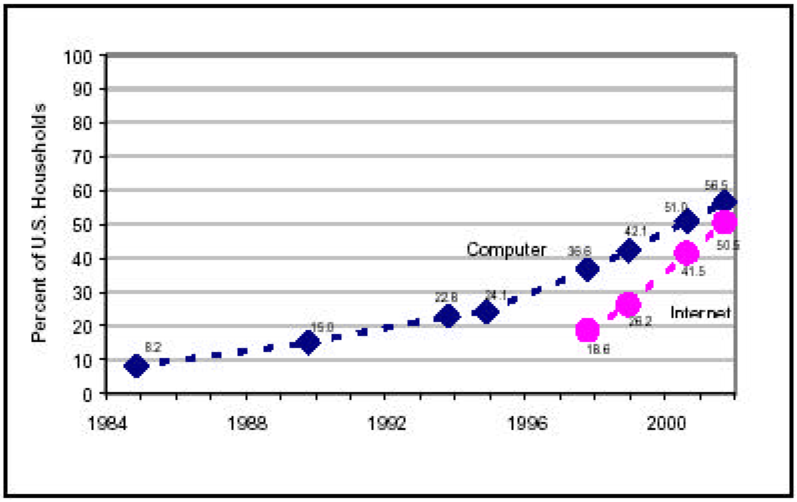


Figure 3. The observed pattern of computer and Internet penetration in the US. *Source: U.S. Department of Commerce, 2002, p. 3*

Figure 3 shows the time series of the observed market penetration of computers and Internet in the US. According to the 2000 Department of Commerce report, it shows the first half of an S-shaped graph similar to the graph of any product life cycle. The adoption rates along these curves are seen as dependent on the awareness of the new technology, the affordability of that technology, and the attraction for people to use the technology.

The Content Problem

An important characteristic of the Internet is the speed of content generation within the Network. Unfortunately, an analysis of website content conducted by Cawkell (2000) reveals that only 6% of the sites analyzed could be useful for low-income users. Some other studies have found that 99% of the information on the Web is of no interest to 99% of the users (Garofalakis et al., 1999). Moreover, the quality of the content has been pointed out as one of the characteristics of the "dark side" of the information revolution (Clarke, 1999). Therefore, even if people get connected to the Internet (access focus) the probability they will remain attached will be less if they cannot find relevant information. More effort is needed to better understand the effects of the content problem on the digital divide.

Literacy and Digital Literacy Problems

44 million Americans are functionally illiterate, and 50 million more have limited literacy (Carvin, 2000; Conhaim, 2000). That is to say, almost 1 out of every 2 Americans will have problems in finding relevant information in the Internet due to their lack of ability to read text. Furthermore, Internet content is mainly in English, and there are 32 million Americans (about 2 out of every 10) whose primary language is different than English (Conhaim, 2000). These problems limit in an important way the Internet's potential to penetrate the U.S. market.

Moreover, reading the hyper-linked texts that could be found in the Internet requires a new set of literacy skills that have been called "digital literacy" (Conhaim, 2000). Digital literacy includes the computer-use skills needed to access the Internet, and has been characterized as a "second-level" digital divide (Hargittai, 2002). According to studies conducted by Children's Partnership, about 20% of those who are connected cannot find the information they need. There are several efforts to improve search engines and Internet user interfaces that can help to solve this problem (Shneiderman, 2001), but efforts to define and experiment educational programs to build information literacy skills are also needed. (Webber and Johnston, 2000).

Pedagogy Problem

One of the main achievements of American governmental efforts is that over 50% of all American classrooms are connected to the Internet (Carvin, 2000). However, the connection rate is far faster than teachers' adoption rates of computers inside classrooms.

Teachers still need to learn how computers will change the actual curriculum, teaching methods and the role of teachers inside the classroom.

Community Problem

The Falling Through the Net series has revealed that the most important use of the Internet by the Americans is e-mail that enables people to stay in contact with others. In addition, businessmen have realized the importance of using the community creation potential of the Internet to create businesses with a better probability of success.

In summary, our initial picture could be enriched by including the three-dimensional definition of the Digital Divide explaining why the gap is widening and showing, at the same time, possible intervention points (figure 4).

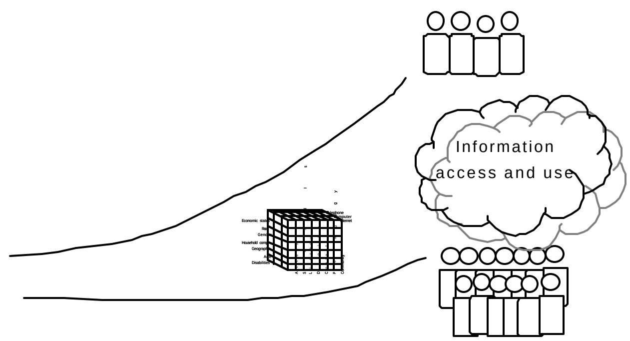


Figure 4. A richer picture of the Digital Divide

However, the complete picture involves the activity of several stakeholders who have different points of view about the problem, and who are devoting efforts to improve information access. The main stakeholders included in the model are the Government, computer vendors and Internet service providers, non-profit organizations and foundations, schools, universities and public libraries (figure 5).

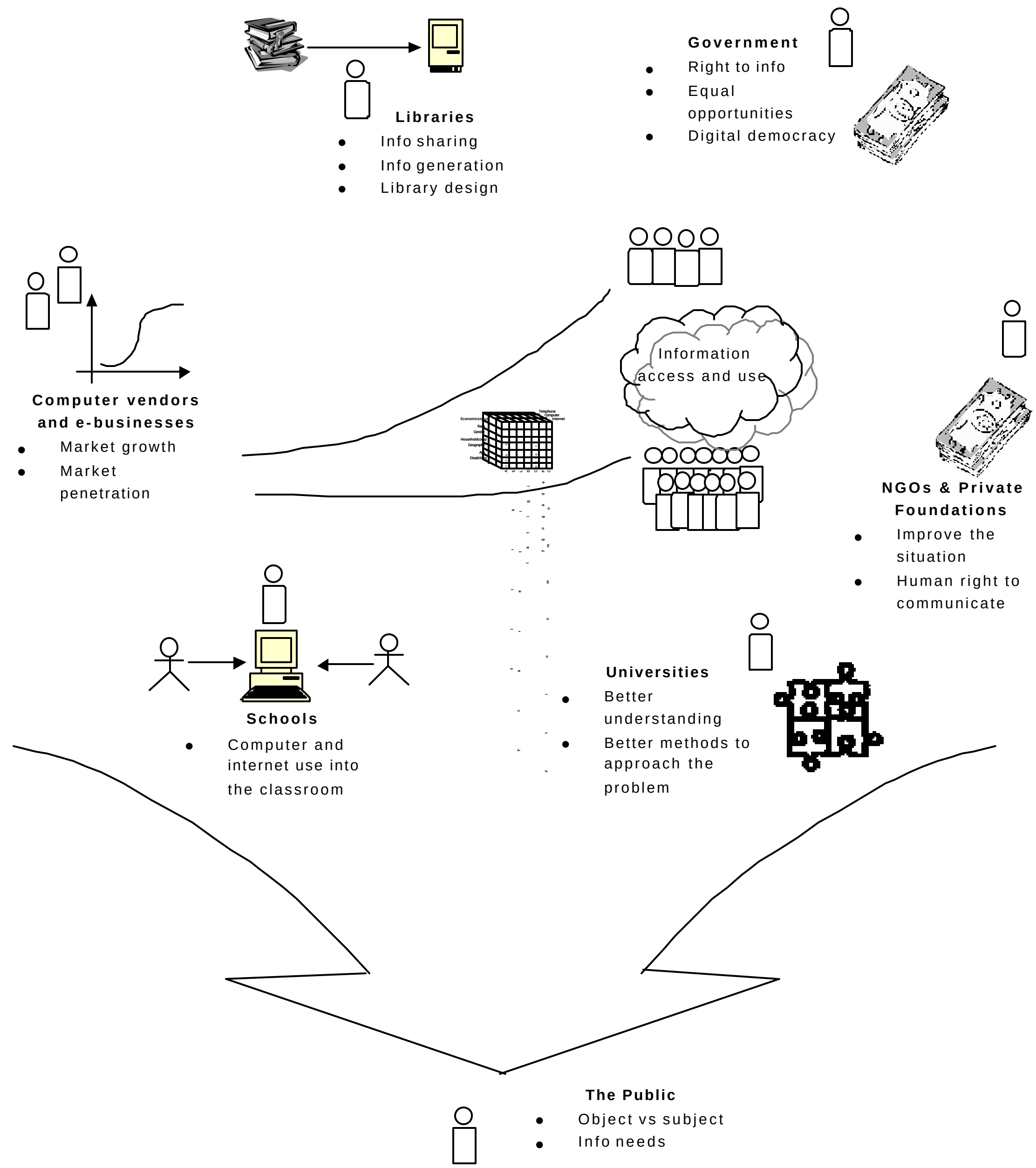


Figure 5. The rich picture of the Digital Divide.

For computer vendors and Internet service providers, the Digital Divide is mainly a problem of market growth and market penetration. In their world, technology improvements of computer equipment and other Internet access devices are impacting price, and making technology more accessible to the lower income strata (Goldsborough, 2000). Looking at their future markets, several companies like Apple or Compaq have developed partnerships with educational networks for several years, providing computer access and training (Conhaim, 2000).

Schools are dealing with the introduction of a “new animal” into the classroom. The first natural step to follow is to train teachers in effective ways to use computers as educational partners (Santos, 1999). However, deep reflection on the value of computers and the impact of the Internet on the overall curriculum is still in its infancy.

Universities are working in several different ways to close the divide. Some of them are developing partnerships with technical schools and non-profits in order to give access to computer literacy to people in training (Jones and Kueppers, 2000). However, a lot of them are actively participating in the development of a deep understanding of the phenomenon and in efforts to create better ways to close the information gap, by getting a better understanding of the personal information-seeking processes, by developing better search engines, by creating content, and by improving user interfaces (Shneiderman, 2001).

Non-profits and private foundations are developing partnerships and funding projects oriented to get a better understanding of the human right to communicate and people’s information needs (Conhaim, 2000; Bishop et al, 1999).

Government is concerned mainly with the access problem and the implications of it in a digital government and digital democracy. Through funding programs like E-rate, government is promoting technological programs in libraries, schools and communities in order to improve access and digital literacy (Howland, 1998; Conhaim, 2000). In addition, there is an important government effort to create content through development of Government-to-Citizen applications designed to provide information and services to the public.

All the stakeholder efforts are grounded in the intention of benefiting the public interest. However, there is a growing group of researchers who think that in order to make all this efforts more productive, a deeper reflection on people’s information needs is needed.

Though it is not the intention to diminish this discussion, it goes beyond the scope of this paper.

Finally, the library community is concerned with the reinvention of libraries, by rethinking their role in content creation, community development and information access (Saundra, 2000). One of the better examples of this work has taken place in the Urbana-Champaign region, where an action-research intervention involving African-American women, has focused on group-specific content creation (Bishop et al, 1999; Bishop et al, 2001).

The stakeholders depicted above have a diverse set of interests. Some of their interests overlaps and promote partnership development, and others represent isolated efforts to improve information distribution. The main efforts are focused in improving access, but there are several efforts to solve other problems depicted in the three-dimensional model (content, literacy, digital literacy, pedagogy and community). However, it is difficult to decide which efforts could produce better results in the long term. In order to explore which kind of interventions could have a more important impact on the information gap, a four-sector system dynamics model was developed (figure 6 on next page).

In the model, the computer penetration and Internet penetration sectors reflect a market structure of computer and Internet users. This structure includes the reinforcing processes that help people to acquire equipment or connect to the Internet through word-of-mouth effects. In addition, as the market saturates, there is a set of limiting factors that reduce the growth rate until the potential user population is fully covered. These structures produce an S-shaped behavior like the one described in the *Falling Through the Net 2000* report. The main factors determining the market penetration trend in the model are the total population, the fraction of literate people, the fraction of people who are digitally literate, computer prices, household income, and, in the case of the Internet, the fraction of people with computer access.

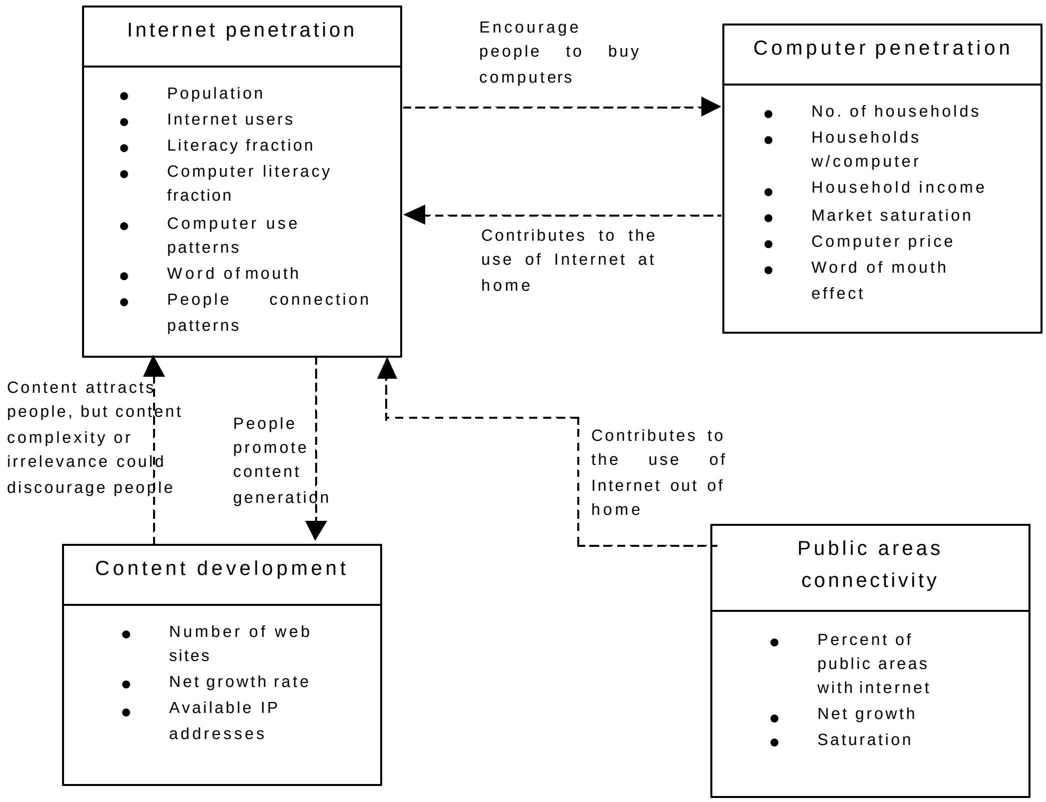


Figure 6. Sector diagram of the System Dynamics Model Divide 1.0

These sectors interact, reflecting the idea that the more people who have computers at home, the more potential market the Internet will have. Alternatively, people connected to the Internet could be motivated to buy their own computer to "surf" at home.

The Public Areas connectivity sector represents non-home access points, including libraries, schools and workplaces. The penetration speed of these places is assumed to be related to government, computer vendor and Internet service provider spending. In this sector, more effort expended will speed up availability. The existence of new access points increases the potential market size of Internet users.

The content generation sector consists of a growing structure associated with the number of Internet users as content creators. Content generation itself has a double effect on the Internet users sector. The amount of content creates a beneficial effect on people's probability of joining the Internet, because of the potential of finding useful information. However, the amount of content also creates a problem, because of the difficulty of finding any particular piece of relevant information.

Taken together, these interactions provide the structure of the system dynamics model used to study the Digital Divide issue. A full listing of model equations could be found in the appendix.

Simulation Results

Figure 7 shows the basic behavior of the system dynamics model described in the previous section. In order to determine the impacts of different policy interventions on the potential for closing the Digital Divide, the variables chosen to be analyzed are *Market Saturation* and *Probability to contact a connected person*. *Market Saturation* represents the fraction of households with a computer, and the *Probability to contact a connected person* represents the fraction of Internet penetration achieved.

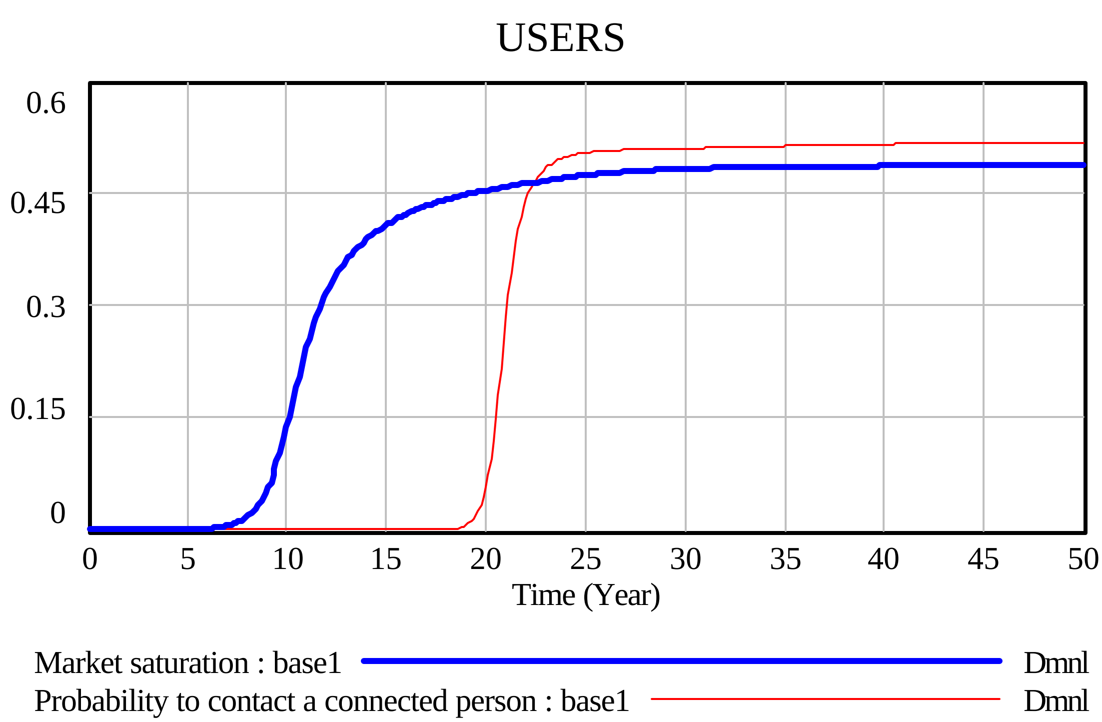


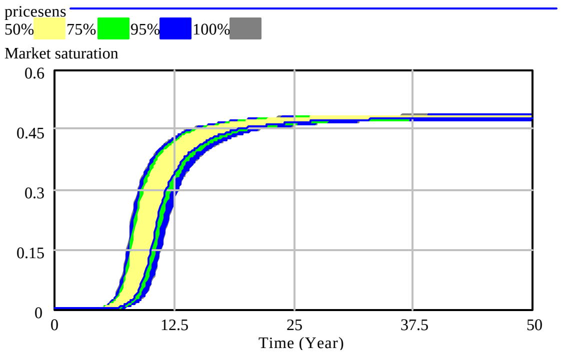
Figure 7. Basic behavior of market penetration of the SD model.

The time frame for the simulation begins in the early 1980's (represented as time zero).

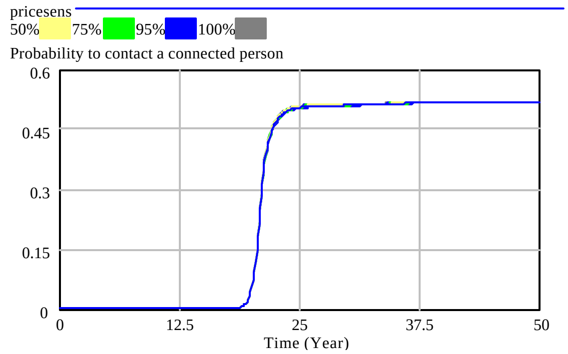
Both graphs show an S-shaped behavior. The model shows, similar to the US reality, a slower penetration timeframe for computers than for the Internet. The model reflects too a different starting point for computer and Internet growth explosion, given that the Internet started its main growth around 1994. Both the Internet penetration fraction and the computer penetration fraction are similar than those found in reality. Though the model behavior would seem to indicate that computer penetration is near its growth limit, it could be a mistake to consider that this is what will happen in reality. SD models like the one described in this paper are more suited for policy analysis than forecasting.

In order to explore the impact of several kinds of interventions that are taking place in the American society, a series of sensitivity analyses were developed using parameters inside the model. The parameters tested were price, average household income, literate and digital literacy fractions, resources devoted to create infrastructure in public places, the fraction of people using internet in public places, and content effect. The first two tests were designed to build confidence in model results. The other parameters were deemed important for policy analysis purposes.

Technology trends have promoted a decrease in the price of computers. However, this change in computer prices does not appear to be a critical factor in computer and Internet penetration trends. To illustrate, figures 8a and 8b show the sensitivity graphs for computer price variations from $700 to $3,000. The main impact of this parameter is during the growth phase of computer penetration, but there is a very small impact on the final penetration level. These results are consistent with the phenomenon in the real world, and help us to build confidence in the model.



(a)

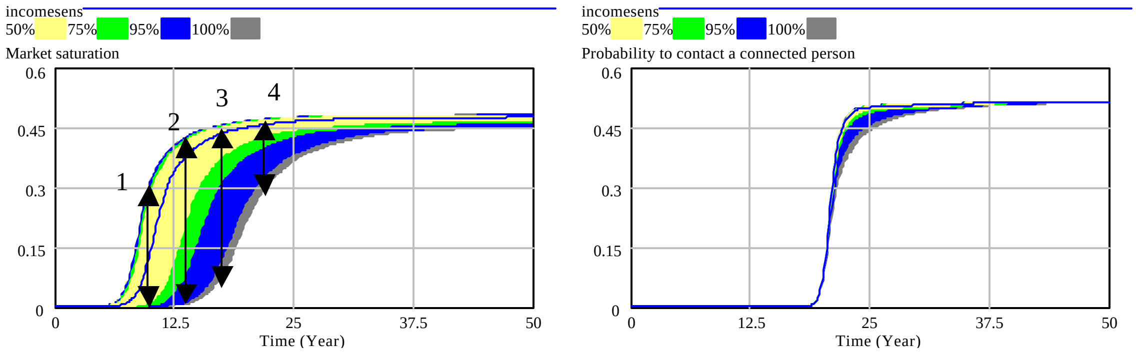


(b)

Figure 8. Sensitivity analysis for computer price.

On the other hand, computer and Internet penetration have been shown to be more sensitive to different income levels. Accordingly, the second sensitivity analysis was undertaken to observe the model behavior with different household incomes (from $15,000 to $70,000 per year). Figures 9a and 9b shows the sensitivity graphs for variation in household income. The model shows a different pattern of variation than that produced with computer price variation, and the model appears to be more sensitive to this variable. This conforms to the realistic behavior, especially in the area of computer market penetration. However, like computer pricing, the observed behavior is more sensitive during in the growth stage, and remains relatively insensitive at the end.

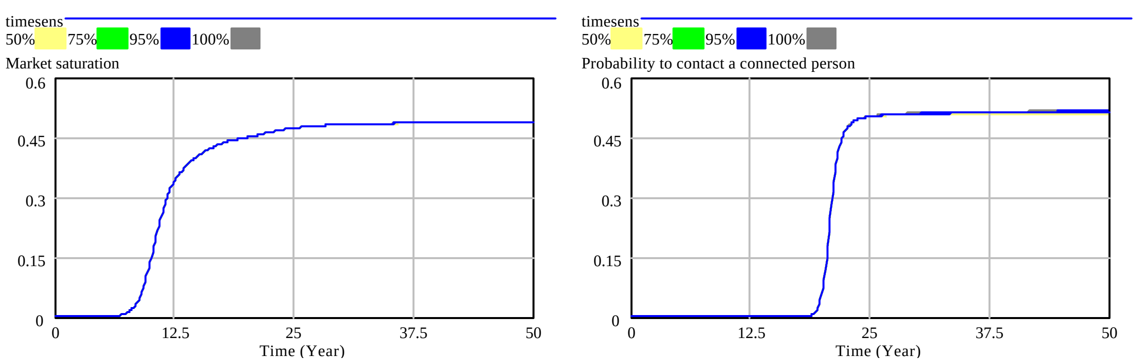
If we think of the shaded area as the actual Digital Divide, that is to say, the upper side part of the shaded area as computer or internet penetration for people with high income level and the lower end as the penetration pattern for the low income levels, it is possible to develop a dynamic explanation for the narrowing and widening of several gaps reported in the *Falling through the Net* reports. The difference in the speed of penetration at different income levels will promote a phase of gap widening (from arrows 1 to 2) and a phase of gap shortening (from arrows 2 to 3 to 4). *In* this way, it is possible to think of the changes observed in the report as caused by internal dynamics of the problem, and not by the money invested in computers to schools and libraries.



(a) (b)

Figure 9. Sensitivity analysis for household income.

Other policy interventions have also been undertaken. For instance, important efforts and resources have been devoted to the creation of public places to facilitate people's access to computers and the Internet. This has been a joint effort of government and computer vendors during the last years. To test the likely impact of this policy initiative, the model's sensitivity to changes in the effort to build public access infrastructure was tested. The parameter used to reflect this was the change in the time needed to build infrastructure. The time needed is thought to be inversely proportional to the amount of resources invested in the problem. Sensitivity graphs shown in figures 10a and 10b show the model response to variations from 2 to 15 years to build the infrastructure. The model indicates very insensitive behavior, which probably means that this is not a good way to invest resources in order to reduce the information gap.



(a) (b)

Figure 10. Sensitivity analysis for the amount of resources directed to build infrastructure in Public places.

Similarly, members of the library community are concerned with the redesign of libraries, to make them a more attractive place to visit and access Internet services. This was operationalized in the model by testing model sensitivity to the fraction of people that gain access to the Internet in places other than home (from 50% to 100%). Figures 11a and 11b show the sensitivity graphs for this test. Unfortunately, the model was not sensitive to changes in this parameter.

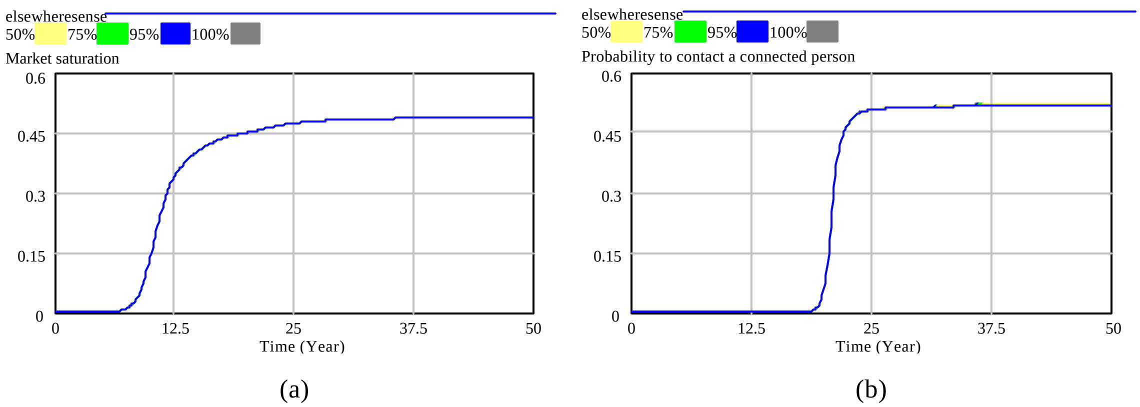


Figure 11. Sensitivity analysis for fraction of people using Internet on public places

Alternatively, some other members of the information science community have focused on content creation. Therefore, different levels of content effects were tested in the model. This experiment showed that the fraction of people connected to the Internet during the equilibrium phase will be greater with better tools for finding relevant content and with increases in the amount of relevant content itself. However, the impact generated by this variation of the model was not very significant with respect to Internet penetration (figure 12b), and did not make a difference in computer penetration (figure 12a).

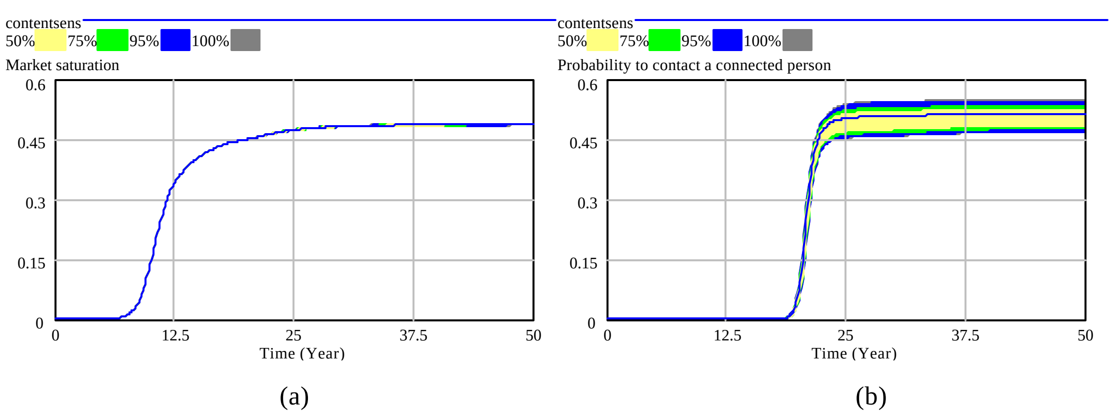
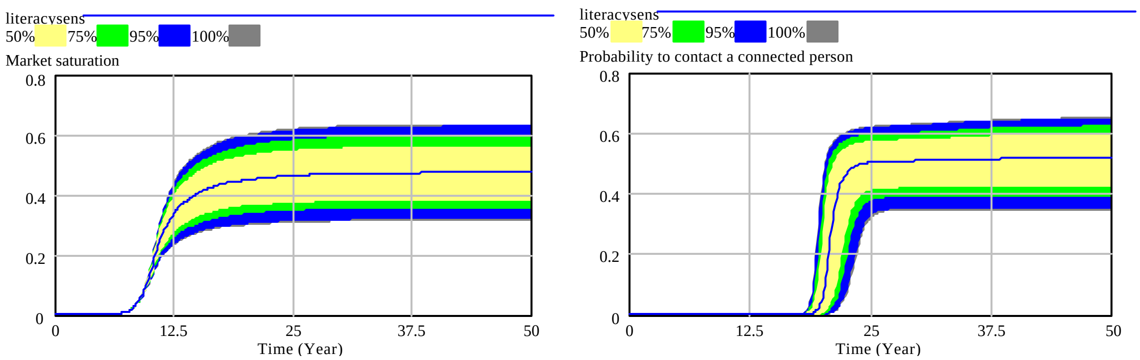


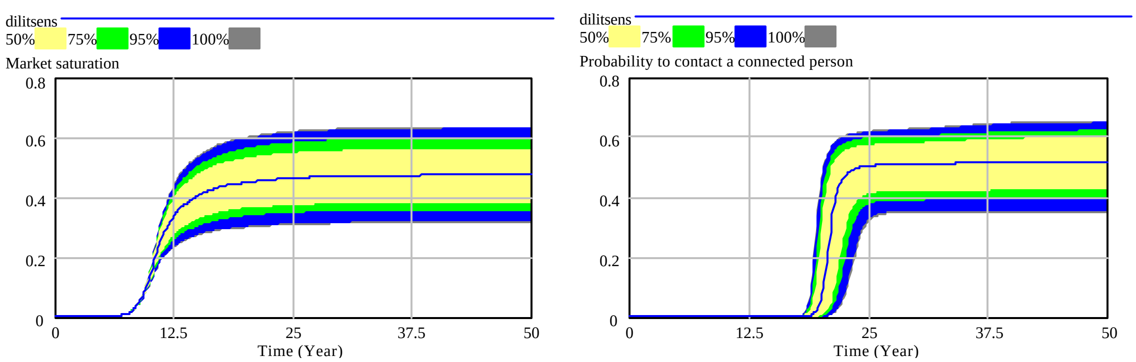
Figure 12. Sensitivity analysis for content effect.

The last two sensitivity tests completed with the model consisted of changes to the fraction of literate and digitally literate people. Both variables observed appeared to be very sensitive to changes in these fractions, particularly during the equilibrium stage of the simulation (figures 13 and 14). However, it is important to consider that these fractions, though easy to model, will require a large amount of time and resources to implement effectively. Therefore, it is very feasible that directing efforts to improve the performance in these areas will show no result in the short term, while being far more beneficial in the long term.



(a) (b)

Figure 13. Sensitivity analysis for literate fraction



(a) (b)

Figure 14. Sensitivity analysis for digital literate fraction

Conclusion

The model used in this paper has an underlying structure identified as a system archetype by Peter Senge (1990), and commonly understood by the system dynamics community since Forrester's book *World Dynamics*. This system archetype (figure 15) is known as the *Limits to growth* structure and consists of reinforcing and balancing structures working together to create S-shaped behavior. From a structural perspective, this archetype indicates that there are several phenomena in which it is possible to observe a kind of virtuous cycle, like the word of mouth effect in the Digital Divide model. This virtuous cycle is the responsible of the first phase of increasing growth in the s-shaped graph. However, as the population with information access approaches the maximum potential population, the saturation structure slows the growing speed until stagnation is reached.

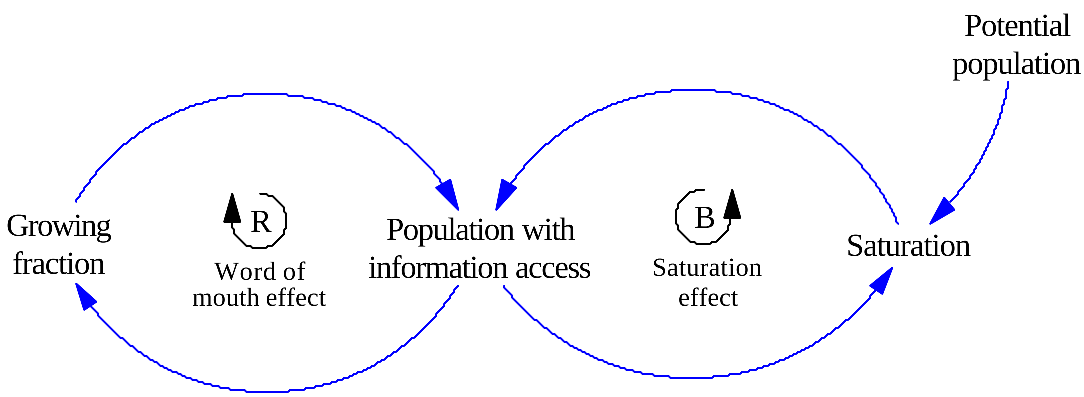


Figure 15. Limits-to-growth archetype.

The limits-to-growth structure offers policy-makers two options for intervention. In the first, it is possible to push the system in order to accelerate initial growth. In the second, it is possible to partially eliminate the limit that constrains potential growth. A set of policies (e.g. infrastructure development and price decreases) tested in the paper that were designed to increase the speed of growth achieved a temporary narrowing of the Digital Divide. The second set (e.g. changes in literacy, information literacy, and content relevance) tended not to speed up the narrowing of access between information haves and have-nots, but instead acted to change the growth limit. Unfortunately, in general policy practice, there is a tendency to choose intervention strategies to accelerate growth, because these provide quicker short-term results.

In contrast, it is possible to conclude that it is very important to direct at least a part of the resources devoted to the Digital Divide to projects and efforts such as:

1. Literacy improvement
2. Digital literacy improvement
3. Content development
    a. Understanding information needs
    b. Understanding and improving information seeking patterns
    c. Improving search engines
4. Developing special devices for people with disabilities

Finally, the model developed for this paper did not explore in any way the effects of teaching methods or the creation of communities. Further development of this initial model is needed in order to increase our understanding of the Digital Divide.

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Appendix – Model Equations

(01) Access to computer fraction=
Probability to contact a person with a computer+Probability of using a computer elsewhere
-Probability of using a computer elsewhere*Probability to contact a person with a computer
Units: Dmnl

(02) Average contacts per year=
100
Units: People/People/Year

(03) Average contacts with connected people=
Average contacts per year*Probability to contact a connected person
Units: People/People/Year

(04) Average contacts with people with computer=
Average contacts per year*Probability to contact a person with a computer
Units: People/People/Year

(05) Average discarding rate=
SMOOTH(Discarding computer,Averaging time)
Units: Households/Year

(06) Average household income=
40000
Units: Dollars/Year

(07) Averaging time=
1
Units: Year

(08) Avg time to change computer=
4
Units: Year

(09) Buying a Computer=
Households without computer*Average contacts with people with computer*Buying a computer probability
*Effect of mkt saturation+Average discarding rate
*Fraction replacing
Units: Households/Year

(10) Buying a computer probability=
Buying probability Normal*Effect of price in buying probability*Effect of the internet users on the buying probability
Units: Dmnl

(11) Buying probability Normal=
0.02
Units: Dmnl

(12) Computer price=
2500
Units: Dollars

(13) Connecting=
IF THEN ELSE(Time<15, 0 , Non internet users*Average contacts with connected people
*Connection probability)
Units: People/Year

(14) Connection probability=
Connection probability Normal*Effect of saturation on connection probability
*Effect of content on connection prob
Units: Dmnl

(15) Connection probability Normal=
0.05
Units: Dmnl

(16) Discarding computer=
"Households w/Computer"/Avg time to change computer
Units: Households/Year

(17) Disconnecting=
IF THEN ELSE(Time<15, 0 , Internet users*Fraction of people discarding the service
*Effect of content on people disconnecting)
Units: People/Year

(18) Domain names available=
3.72018e+009
Units: Website

(19) ECC f(
[(0,0)-(1,3)],(0,1),(0.1,1.02),(0.2,1.1),(0.3,1.3),(0.4,1.7),(0.5,2.3),(0.6,2.8),(0.7,2.9),(0.8,2.95),(0.9,2.99),(1,3))
Units: Dmnl

(20) ECPD f(
[(0,0)-(1,3)],(0,1),(0.1,1.02),(0.2,1.1),(0.3,1.3),(0.4,1.7),(0.5,2.3),(0.6,2.8),(0.7,2.9),(0.8,2.95),(0.9,2.99),(1,3))
Units: Dmnl

(21) Effect of content on connection prob=
ECC f(Web site saturation)
Units: Dmnl

(22) Effect of content on people disconnecting=
ECPD f(Web site saturation)*Sens factor
Units: Dmnl

(23) Effect of mkt saturation=
EHIMS f(Susceptible Market saturation)
Units: Dmnl

(24) Effect of People connected on website addition=
EPCOW f(Probability to contact a connected person)
Units: Dmnl

(25) Effect of price in buying probability=
EOPOB f(Years of salary to buy a computer)
Units: Dmnl

(26) Effect of Sat on addition=
EWS f(Web site saturation)
Units: Dmnl

(27) Effect of saturation on connection probability=
EOSOP1 f(Internet saturation ratio)
Units: Dmnl

(28) Effect of the internet users on the buying probability=
EIUBP f(Probability to contact a connected person)
Units: Dmnl

(29) EHIMS f(
[(0,0)-(1,1)],(0,1),(0.1,0.98),(0.2,0.9),(0.3,0.8),(0.4,0.67),(0.5,0.5),(0.6,0.33),(0.7,0.2),(0.8,0.1),(0.9,0.02),(1,0))
Units: Dmnl

(30) EIUBP f(
[(0,0)-(1,2)],(0,1),(0.1,1.02),(0.2,1.1),(0.3,1.2),(0.4,1.33),(0.5,1.5),(0.6,1.67),(0.7,1.8),(0.8,1.9),(0.9,1.98),(1,2))
Units: Dmnl

(31) EOPOB f(
[(0,0)-
(2,1)],(0,1),(0.1,0.5),(0.2,0.3),(0.3,0.15),(0.4,0.05),(0.5,0.01),
(0.6,0.01),(0.7,0),(0.8,0),(0.9,0),(1,0),(1.2,0),(1.4,0),(1.6,0),(1.8,
0),(
2,0))
Units: Dmnl

(32) EOSOP1 f(
[(0,0)-
(1,1)],(0,1),(0.1,0.95),(0.2,0.87),(0.3,0.75),(0.4,0.6),(0.5,0.45)
,(0.6,0.3),(0.7,0.17),(0.8,0.08),(0.9,0.01),(1,0))
Units: Dmnl

(33) EPCOW f(
[(0,0)-
(1,3)],(0,1),(0.1,1.02),(0.2,1.1),(0.3,1.3),(0.4,1.7),(0.5,2.3),(0.6
,2.8),(0.7,2.9),(0.8,2.95),(0.9,2.99),(1,3))
Units: Dmnl

(34) EWS f(
[(0,0)-
(1,1)],(0,1),(0.1,0.98),(0.2,0.9),(0.3,0.8),(0.4,0.67),(0.5,0.5),(
0.6,0.33),(0.7,0.2),(0.8,0.1),(0.9,0.02),(1,0))
Units: Dmnl

(35) FINAL TIME = 50
Units: Year

(36) Fraction of literated people with computer literacy=
0.75
Units: Dmnl

(37) Fraction of people connecting elsewhere=
0.5
Units: Dmnl

(38) Fraction of people discarding the service=
0.02
Units: 1/Year

(39) Fraction of people with literacy=
0.75
Units: Dmnl

(40) Fraction replacing=
0.95
Units: Dmnl

(41) Goal=
1
Units: Dmnl

(42) Household size=
4
Units: People/Household

(43) "Households w/Computer"= INTEG (
Buying a Computer-Discarding computer,
100)
Units: Households

(44) Households without computer=
Susceptible Households-"Households w/Computer"
Units: Households

(45) INITIAL TIME = 0
Units: Year

(46) Internet saturation ratio=
Probability to contact a connected person/Access to computer fraction
Units: Dmnl

(47) Internet users= INTEG (
Connecting-Disconnecting,
100)
Units: People

(48) Market saturation=
"Households w/Computer"/Total Households
Units: Dmnl

(49) Non internet users=
Susceptible Population-Internet users
Units: People

(50) Percent of other places with a internet access= INTEG (
Wiring places,
0.001)
Units: Dmnl

(51) Probability of using a computer elsewhere=
Fraction of people connecting elsewhere*Percent of other places with a internet access
Units: Dmnl

(52) Probability to contact a connected person=
Internet users/Total Population
Units: Dmnl

(53) Probability to contact a person with a computer=
("Households w/Computer"*Household size)/Susceptible Population
Units: Dmnl

(54) Saturation=
Percent of other places with a internet access/Goal
Units: Dmnl

(55) saturation effect=
SE f(Saturation)
Units: Dmnl

(56) SAVEPER =
TIME STEP
Units: Year

(57) SE f(
[(0,0)-
(1,1)],(0,1),(0.1,0.98),(0.2,0.9),(0.3,0.8),(0.4,0.67),(0.5,0.5),(
0.6,0.33),(0.7,0.2),(0.8,0.1),(0.9,0.02),(1,0))
Units: Dmnl

(58) Sens factor=
4
Units: Dmnl

(59) Susceptible Households=
Susceptible Population/Household size
Units: Households

(60) Susceptible Market saturation=
"Households w/Computer"/Susceptible Households
Units: Dmnl

(61) Susceptible Population=
Total Population*Fraction of literated people with computer literacy*Fraction of people with literacy
Units: People

(62) TIME STEP = 0.125
Units: Year

(63) Time to wire places=
3
Units: Year

(64) Total Households=
Total Population/Household size
Units: Households

(65) Total Population=
2e+008
Units: People

(66) Web site saturation=
Web Sites/Domain names available
Units: Dmnl

(67) Web Sites= INTEG (
Web sites addition,
1)
Units: Website

(68) Web sites addition=
IF THEN ELSE(Time<15, 0, Web Sites*Webs growth fraction*Effect of Sat on addition
*Effect of People connected on website addition)
Units: Website/Year

(69) Webs growth fraction=
0.2
Units: 1/Year

(70) Wiring places=
IF THEN ELSE(Time>15, Percent of other places with a internet access*saturation effect
/Time to wire places, 0)
Units: 1/Year

(71) Years of salary to buy a computer=
Computer price/Average household income
Units: Year

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