

Following and Accelerating the Design Evolution Curve in Telecommunicated Multi-Media

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Many designers realize they must create and manage design collaborations to achieve the breadth of expertise and perspective necessary to handle all the steps necessary to get technologies into the hands of the public. Managing such collaborations effectively is very challenging, but various useful concepts and techniques are available from the study of deliberate creativity and innovation. These include analytical tools which allow disjoint and conflicting requirements to be understood; group dynamic factors which provide the environment for effective collaboration and co-creativity across national and discipline boundaries; and creativity techniques designed for complex ideas.

The situation

Lovers of technology often laugh bitterly at what they see as the stupidity of humanity, telling stories of "inferior" technologies dominating the market and of "great" ideas getting rejected. It is easy to blame such failures on the stupidity of others, but is a technology truly superior if it has characteristics that make it a market failure? Are designers right to believe that it is impossible to develop technologies that are superior both in technology and in market strength? What do designers have to do differently if they decide to take responsibility for making new technology a total success?

At a recent conference at Illinois Institute of Technology, presenters agreed broadly on the emergence of a new global infrastructure in which Internet Protocol Packet Switched networks of huge bandwidth become widely available. Combined with the continuing advances in compression, many of the most critical constraints and criteria of the communication industry have been transformed, in many ways similar to the impact of the drop in memory cost and increase in processor speeds on the software market. On-demand streamed video may replace cable and broadcast services, the nightly news starts when you request, and standard voice telephone becomes cost-free, even on an international basis. Of course, that huge data bandwidth allows many products currently limited to local systems such as video disk to be available over great distances, blending game technology, video training ware, computer based training, video conferencing, simulation, etc.

The problem is how to use and fill up that bandwidth. When writing was invented, they mostly wrote down the poetry and stories from the existing oral tradition. Many of the early CD-ROM products were labeled "shovelware" as those who had access to and ownership of computer stored print and graphics files simply burned a CD-ROM with the available files, added an access program or two, slapped on a label and started selling them. It has taken time for people to begin exploring the many useful possibilities of the CD-ROM format. The cheapness of memory, storage, and processor speed has led to a generation of software that is labeled as "bloatware" by those who learned to write programs back when these items were critically expensive, and still can't figure out why I need 40 megabytes of software to write a business letter. In the same way, we can expect people to start by simply offering high speed access and transfer of such materials and it may be a while before systems really call upon the capacities of the system to deliver worthwhile benefits to people.

It seems to us that those already positioned in fields of multi-media and telecommunications have an advantage in leading the pack with new and better applications. It is our hope in this paper to give some insights from other technological developments which will help these leaders move the field ahead more quickly and effectively.

We will explore some famous mis-designs, consider their causes and how to avoid them, then explore the current design environment for telecommunicated multimedia and suggest ways to better address the opportunities. Ironically, it can be the very creativity and genius of people who understand a limited part of the problem that leads to some of the biggest problems, a process referred to often in the systems literature as sub-optimization. And the real trick to better design is to truly listen to those who resist your ideas. This is a difficult lesson to learn.

Over time, designs improve in a process often called evolution. Like biological evolution, over time various variations on the original emerge. Where biological success basically is determined by whether you have more grandchildren than others, in products the issue is the marketplace: do people make and buy products and services which include your design features. Some features gain support and become part of the product or service, other features find little support and disappear from the most commonly available products.

The evolutionary perspective gives two important insights. Neither evolution nor the market always picks the survivors you would like. Mosquitoes continue to survive and evolve no matter how irritating they are to other species. And some products which succeed in the market place simply baffle many other people. Also, many species of animals and plants have evolved as interactive systems in which the new features of one enable the new features of another. In the same

ways, one technology change can unleash incredible growth in another by removing a critical constraint.

Basically, products and services are bundles of knowledge accumulated and integrated over time. From the Wright Brother's motorized kites with bicycle controls flown at Kitty Hawk to modern Jumbo Jets, Stealth fighters, and even ultra-light planes, there is a great deal of learning and knowledge and experience embedded in the designs. The speed at which our technologies can learn determines how fast we get new and better benefits. The question we raise is whether technologists in a field such as telecommunicated multimedia can affect the speed at which product effectiveness and efficiency are achieved in the marketplace. And if a technology does not move fast enough, it is bypassed.

Narrowband Integrated Services Digital Network (NISDN)

The rapid advance of telecommunications technologies provides an excellent example of designs that at one time were considered leading-edge and were quickly relegated to the historical memories of the user community. No technology had such a hype as the development of the Narrowband Integrated Services Digital Network (NISDN). The specifications found their roots in the international standards community, and by 1989 there was an apparent buy-in by virtually all of the major switch vendors, and customer premises equipment (cpe) manufacturers. The National Institute of Standards and Technology (NIST) in the United States took the lead in fostering the finalization of international standards for NISDN. NIST created the North American ISDN Users' Forum (NIUF) with the absolute goal of involving as many representatives of the user community as possible to finalize the standard.

The European Telecommunications Standards Institute (ETSI) formally monitored the progress of this standards development by having several observers attend every meeting of the NIUF. Standards were agreed upon in February 1992, and it was anticipated that NIST would issue a Federal Information Processing Standards (FIPS) document for use by all agencies of the U.S. government in their acquisition of ISDN services and ISDN-conformant cpe gear. In November 1992, a major demonstration of the effectiveness of these NISDN specifications was run globally.

Participating nations included the United States, Canada, the European community, Japan, Hong Kong, and Taiwan. This international event was called the Transcontinental ISDN Project (TRIP92) and demonstrated interoperability of international ISDN circuits. TRIP92 was an overwhelming success ... !!! It was anticipated that NISDN would be an immediate national success in terms of the consumer marketplace.

No such success was ever achieved in the United States. Even today, with NISDN 56 Kbps circuits advertised as the way to get high-speed data into the

individual homes, NISDN cannot be considered a success since the number of NISDN lines subscribed to nationally measure only in the several million while the projected number of such circuits that were to be active as visualized in 1992 was in the 100's of millions. It is worthwhile to recognize what aspects of the evolutionary design curve were not considered by the telecommunications innovators of 1990-1992.

The first aspect was the highly political aspects of the international standardization process. Europe had successfully established NISDN applications and a vast subscriber base in France and West Germany by TRIP92. They did not feel that they had to wait for the U.S.A. Unfortunately without U.S. standards there could be no international circuits which would gracefully interoperate with the U.S. NISDN circuits. NIST refused to publish the specification developed by the NIUF and used in TRIP92. The NIST legal department felt that the specification was too vendor-specific and violated the guidelines of impartiality set down by Congress when it gave NIST the right to issue FIPS. NIST, instead, issued only the CCITT specification for NISDN that was published in 1992. This closed down the motivation by the NISDN provider community to establish a national standard. While the NIUF specification has since been issued first as National ISDN-1 (NI-1), and then as National ISDN-2 (NI-2) several switch manufacturers such as AT&T issued their own proprietary NISDN specifications and continued to market them as the appropriate implementation. Furthermore, telephone related tariffs were set on a state by state basis and were extremely slow in being established and were quite complicated. In a truly amazing turn of events, by summer of 1994, NISDN had missed its window of opportunity in the telecommunications marketplace. While it would remain as a possible product for customers, alternative technologies such as Asymmetric Digital Subscriber Line (ADSL) had emerged to displace NISDN as an attractive solution.

The development of the Internet and the appearance of Internet Service Providers (ISP's) gave NISDN some new life in fall of 1996, but it is not anticipated that it will ever have the market breadth that was visualized for it at the start of the 1990's. If the designers had overtly addressed the issues of an open architecture for multiple vendors and had organized a process to rapidly address the concerns of the various state regulators, NISDN might be in widespread use today.

Examples of Errors

It may be wrong to label these examples as errors, because in many cases, the design was pure genius, given the problem they were focusing on. Its just that other parts of the situation they did not understand prevented complete success, or parts of the situation they did understand changed, and the design become a problem.

Changing Realities and Constraints

Most technology lovers are familiar with the "**QWERTY**" keyboard, standard on English language computers because it was standard on electric typewriters, because it was standard on manual typewriters as a way to slow down the better typists so they wouldn't jam the keys. This was a great creative solution to their biggest problem at that time. It is hard to sell typewriters if your customers spend a lot of time unjamming the keys. As an additional feature for the salesmen, the designers even shifted a few keys so that the word "typewriter" could be typed very fast alternating between two fingers just on the top line so salesmen could make typing look easy and fast. That idea, so useful then, is wasting an incredible amount of time around the planet as we try to type words on a keyboard designed to slow us down.

And of course it was a stroke of genius to use the **YYMMDD** format for dates, even better the Julian date of two digits for the years and three digits for which day of the 365 in the year. When one author was programming for the J. C. Penney catalog in 1978, giving every transaction the full four digit year would have required the spending of millions of dollars for additional disk drives. Of course, now that great efficiency has become the **Y2K Bug**, with inconceivable amounts of money being spent to fix that one field, and a lot of sensible people seriously thinking about taking a vacation from technology around the turn of the millenium--staying out of elevators, off of airplanes, anywhere that an errant computer might do you harm. A tropical beach might be a good location, but make sure you have plenty of local currency and supplies of your favorite foods and beverages in case the automatic teller machines and credit card approval systems stop working.

But as you look back at these two cases, could those designers have understood the potential problems from their creative ideas and developed new ideas which worked in their situation and the future? And more importantly, can you avoid being the genius who contributes the next QWERTY or Y2K Bug to the future of technology?

Missing Part of the Problem

Petroski (1994) tells of the marvelous Britannia Tubular Bridge built in 1850 over the Menai Strait on the Northwest coast of Wales to carry passengers to the port for a Dublin bound ferry. A wrought-iron tube with the train running on the inside, it was a technological marvel of design and construction, a work of true engineering genius. Only after construction was it discovered that the bridge was unusable. Imagine a black, wrought-iron tube sitting in the hot sun of a summer day, with more sunlight reflected off of the water. Imagine the temperature inside as this wonderful solar collector stores heat. Now, take a wood-fired engine pulling a trainload of passengers through this tube with no ventilation.

Imagine the heat, the smoke, the sparks flying from the engine. It could easily be described as hell on earth. Examination of the design notes and specifications shows not a single bit of attention paid to the realities of passenger trains, only wind loads and ocean storms and spans. It was a remarkable solution to the problem as understood, but missed one of the most important parts of the problem.

Avoiding and Overcoming "Errors"

A proactive designer has to design an approach that will not only best meet the needs of customers at a good production cost, but also generate a stream of cash of development that will help keep the design evolution funded. Otherwise, progress waits for the entrepreneur who spots the potential for a market in a technology and arranges to get the product out and marketed, then takes the stream of cash as profits for other ventures (or away from luxury spending), paying relatively little to the technologist.

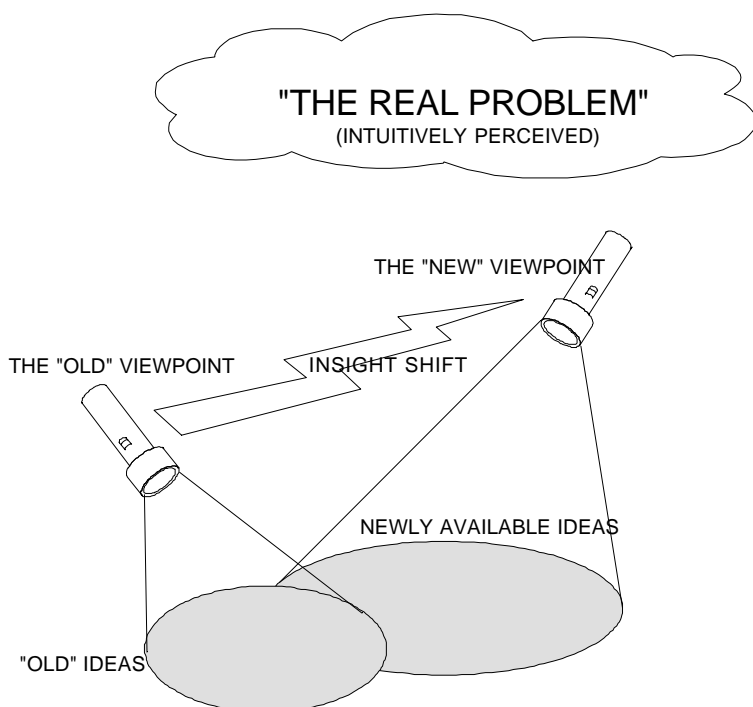
Very few individuals have the breadth of background, knowledge, and relationships to pull off a well designed technological development. So the trick is in assembling a collaboration which is capable of seeing all the issues and all the possibilities. Lets introduce some key ideas from the field of deliberate creativity.

Relevant AHA

So many different people and events are involved in the development and implementation of any innovation, our old concept of inventors getting great ideas and implementing them seems to miss much of what is happening. Barlow (1998) proposes that understanding collaborative creativity is facilitated by focusing the definition of creativity on the changed perspective of the creator rather than on ideas. This "shifted insight" model has its roots in that most subjective and individualistic phenomenon of all, the "AHA" or "Eureka!" experience. Throughout history, various individuals have described this reaction a person has to getting an idea (Koestler, 1978). This intensely physical, emotional, and intellectual experience seems to mark our fundamental recognition that a profoundly advantageous change has taken place in our thinking. The image below attempts to explain this model.

1. A flashlight has been chosen for the model as an analogy for our perception of a problem. The surface below represents all the things anyone could ever do. The area of the surface illuminated by a flashlight signifies the set of ideas that fit the problem statement. If the flashlight represents a problem statement or intention like "raise the bridge" the illuminated circle represents all the various actions that might raise the bridge.
2. A second flashlight represents a new formulation of the problem, such as "increase the gap between the bridge and the water" or "get tall boats past the

bridge." The surface area that its pool of light illuminates includes all the ways to accomplish that goal. In successful creativity, some of the alternatives illuminated or made obvious by this new viewpoint are better than the best of the ideas made obvious by the old perspective. This shifted perspective can be a simple assumption about the situation or as profound as a basic paradigm of a discipline or culture.



3. The lightning bolt labeled "insight shift" represents the shift to the new definition. Although getting such an insight might take years, when it happens, it seems as fast as that lightning bolt.

4. The cloud above represents the "real" problem, the complex interaction of wants, wishes, and reality that is only approximated by our viewpoints and problem statements. Locating the second flashlight of the new viewpoint closer to that cloud represents our perception of the closer fit of the new perception to the total problem.

Lets discuss some of the implications of this model:

1. The strength of the AHA or Eureka experience is directly related to the perceiver's image of the problem, not the broad quality of the idea. The better the fit of the perceiver's knowledge to the breadth of issues involved, the more relevant the AHA response. For example, if we are having a casual conversation with a new acquaintance, and we mention a problem we are facing, that person may get a great AHA reaction to an idea about what we should do, an idea that proves the acquaintance really does not understand the problem. On the other

hand, if their comment or idea triggers a shift in our perception to a point that better fits our perception of the problem and makes obvious some new and useful alternatives, our AHA reaction is relevant, especially since we are the ones to act on the new perception.

2. Our AHA response to someone else's idea or suggestion, an "Appreciative AHA", is a measure of the value of that idea or perspective as to the problem as we see it. It is entirely possible for a non-expert to trigger such a response in an expert, a relevant AHA which indicates the potential of an idea, but the relevance of the response depends on the breadth of understanding of the perceiver.

3. It is important to note that the problem as perceived, the context of our AHA reaction, includes our values and wishes as well as our knowledge and experiences. So, for example, if there is a person at work that has really irritated you, and a new perspective or idea occurs to you which not only seems to fit the problem, but also really punishes your opponent, your AHA will have more energy. The same is true of your good wishes for others. So if you hate or disrespect your customers, the ideas that really light your fire will be those that punish your customers.

4. Satisficing is another important aspect of this creative process. Simon (1946) used the term to describe our tendency to decide to accept less than optimum solutions because the improvement to optimum was not worth the effort to gather and analyze additional data. One of the things which happens to a person who participates in an AHA experience is that their expectations and perceptions of the situation changes. We often talk of the "Not Invented Here" syndrome because it seems that organizations and departments refuse to accept ideas developed by outsiders, but would accept it if they developed it themselves. Note that after you shift to the new perception the new ideas seem obvious, but if you are still back at the old perspective, the new ideas are ridiculous. A good example of this phenomenon would be planning a family vacation. If you sat down, gathered all relevant data, and effectively planned the absolutely best possible vacation for your family given the conditions, they would all complain and be dissatisfied, because your plan is pretty poor in their individual perspectives. On the other hand, if they had been in on the planning, the process would have had an effect on their understanding and expectations, and they would have shifted to a perspective in which your plan is quite good.

So we can see that the knowledge background, beliefs, intentions, and other mental processes all impact an individual's creativity and their reactions to the creativity of others.

Humor

A good analogy for this is humor. In the same way that it is difficult for non-techies to get techie jokes, it is often difficult for technology lovers to design systems usable by the technology reluctant, because their creative AHA's are

unrelated to the problems that real users face. It is also rare for technology experts to understand the dynamics and constraints potential users face. For most customers, there is no intrinsic value to new technology, but for most designers, the technology itself has a high intrinsic reward. So a techie has a great excitement about a new feature that uses a new capacity, even if that feature has little use to a person facing the problems of working in the real world.

Yet it is the ability of the technology to help the user in their real world, with their real world abilities that is the true test of the value of a technology or product.

The Curse of Mental Success

One problem faced by many people who have been successful in technical fields is that they always got high grades in school when they took a test, they rarely made an error. As a result, they have had the consistent experience that every time they felt really good about an idea, the idea was right. Of course, the point they missed was that the tests they took were deliberately designed to be single domain problems with correct answers. Unfortunately, the real work is full of messy, multiple domain problems with no single clear answer. With such real world problems the poor students have a definite advantage. Throughout their academic career, whenever they felt good about an answer, they were wrong about 35% of the time. So they never trust their own judgment and instincts, they check with other people to make sure they understand the full problem and its possible solutions.

One of the best descriptions for the problem of complete design is the old story of the blind men and the elephant, in which each of the blind men encountered a different part of the elephant, then argued about the true nature of the elephant. What is interesting to note is that each blind man is right about their part, yet wrong in their total perception. Each has had a powerful AHA experience which explains what they know about the elephant. Until they can let go of their conclusions, share their information, and experiment with different perspectives and models, they cannot understand the elephant.

A great example of dealing with this issue was the design project for the Ford Taurus. Lew Veraldi, leading the project, mapped out every organization and type of individual who had an interest in the final design of the car, whether repair shop mechanics, legislative bodies, or production workers. Each stakeholder group was approached and a list of their "demands" was created. Each demand was dealt with, although often in a way different than the suggestion. For example, assembly workers demanded that they get rid of plastic bumpers. Instead of accepting the idea, which would have caused real problems in their fuel efficiency, they asked why. It turned out that the original implementation of plastic bumpers had endcaps to go around the corners of the

car which were almost impossible to align. To solve the real problem more completely, they found that they could mold plastic bumpers that would go around the corners, thus keeping the weight down, eliminating the alignment problems, and improving the appearance. They went through all the requests of all the stakeholders and dealt with them in a similar fashion. The resulting design won many awards and captured a very large market share.

The Knowledge Creating Company

Several other cases of team design are given by Nonaka and Takeuchi (1995) such as the Canon personal copier, bread making machines, and automobiles. Interestingly, in a time when middle managers are being eliminated from companies and replaced with macros in distributed databases, Nonaka argues that only middle managers are equipped to lead and manage the collaboration among functional departments which is the knowledge creating engine of organizations. Unfortunately, most of these managers have only been trained to act as individual data processing links, and, like most engineers, have little preparation for the kinds of leadership and management necessary to make team collaboration effective.

For example, one of the key questions in establishing a collaborative design process is how to increase the probability of "relevant AHA's". How do we make sure that every part of the "elephant" is included in the discussion. One aspect is selection of participants, the other is the guidance of a process in which each can both affect the discussion with their knowledge and be affected by the discussion, reformulating their own perspective on the problem. It is important to note that for most problems, the players do not all belong to the same department, and often not even to the same corporate organization. It may be useful to partner with customers, suppliers, even competitors and regulators to build a more effective collaboration. Of course, getting them into the room is the easy part. Helping the interaction flourish is quite difficult. Because each participant has different perspectives and goals, as well as a history of conflict and interaction, creative conversation is often difficult, beyond the skills of most managers. For example, since most have been trained in rational decision-making with well-structured problems, they think that all problems are like that. Classic decision making starts with clear agreement upon and consensus about the problem, the facts, and the criteria. But real design problems are ill-structured, with constraints and criteria in so many conflicting domains that a clear decision is impossible. And most are actually of the type called "wicked": even when we clearly understand the problem, the players disagree about the ultimate goals and values. Even when the most successful, complex, diverse team has designed and accepted a course of action, there are still strong disagreements about the goals, facts, and criteria. The trick is to work together in relative disagreement, seeking

out all the clarifications and simplifications possible, but accepting that consensual clarity is impossible.

Barlow (1998) discovered that some techniques seemed to have very strong contribution to these multi-perspective design efforts. In this analysis ideas are seen as more creative when they involve more disciplines or require so much of a shift in the problem definition that the problem must be re-explained to management. One surprise of the research was that ideas which are more creative in this sense are more likely to be accepted by the organization, leading to the possible conclusion that many ideas are rejected simply because they are not creative enough. The strategy of separating the benefits from the attributes and realizing that attributes cost money, but customers pay for benefits is extremely powerful. This strategy is often referred to in systems design as "black box" thinking, and is called "function analysis" in the field of Value Engineering (Miles, 1971; Mudge, 1971; Fowler, 1990). Even more powerful is a technique where a team analyzes the cost for each increment of benefit the customer is buying, as well as the price the customer is willing and able to pay for that increment. (Snodgrass and Kasi, 1986)

A second technique which strongly related to creative team success was the use of the criteria decision matrix in which each alternative is evaluated against each criteria. Although these techniques would be seen by many as too confining and analytical to allow creativity, they seemed to lead to a deeper, more complex understanding of the situation, allowing more complexly creative ideas to emerge.

As logical as these approaches seem, it is difficult for most people to shift their perceptions from the tried and true, especially when interacting with others. Building a climate and culture of interaction in a team which allows and encourages people to move away from these more acceptable perceptions can be a very difficult process, but it is possible. There are many resources on teamwork and facilitation which can be helpful here, but it is often possible to find someone trained and experienced in this area to help a team or interaction. Basically, it involves building a culture of trust in which exercising flexibility of thinking is seen as success, not deviance. And the best indicator of the success of such a culture is laughter and good humor as the team plays with various outrageous concepts.

The critical point is that while most engineers and managers are poorly prepared to lead or work in such multi-perspective creative teams, it is possible to get more people involved more effectively in design discussions, developing designs which normally might have taken several market cycles to correct. The question for those looking at the opportunity for telecommunicated multimedia is the selection of trends and strategies for the fields it is currently exploring.

Creating Knowledge from Experience

Of course, even a failed technology is often the basis for further development. The lessons learned and the people trained by the endeavor creates the ability to do the next design. Engineers and programmers at Xerox's Palo Alto Research Center tried to invent a paperless document system and produced no profitable products. Apple took the ideas and the people and invented the Lisa computer, another market failure. Taking the best talents from that project and the lessons learned allowed the development of the Apple Macintosh. Copying the best features and strategies resulted in the Windows operating system which is today's market leader and the de facto standard.

Knowledge Evolution From NISDN - Frame Relay and ATM

It is extremely interesting to compare the evolutionary development of several other telecommunications technologies that had their roots in the NISDN effort that has seemed to miss the market. NISDN used X.25 as the packet switching protocol for data. X.25 is a point-to-point protocol which requires each packet to be checked after it traverses an individual link and not be forwarded until it has been correctly received at the current node. Frame Relay technology and standards emerged, as the circuit designers of NISDN recognized that the fiber optic networks then being deployed would have an almost zero error rate and did not need individual packets checked on a point-to-point basis, but rather only on an end-to-end basis when the message is received at the destination site. The concept of using variable length "frames" instead of packets, and immediately forwarding the frames as they arrived at the intermediate nodes, established a new transmission methodology which has taken extensive hold both within the United States, as well as, internationally. Frame Relay (FR) technology is considered a viable transmission choice independent of NISDN and has an enormous user community which employs it. FR standards are in place, and all major telecommunications providers offer Frame Relay networks to rapidly transport data at reasonably cost-effective rates. In this sense, the evolutionary choice of going from NISDN to a Frame Relay transport environment was a major innovation. It simply required the network designers to look at data transmission in a slightly different manner. This shifted perspective may have been a more significant output of the NISDN effort than the standard.

Another innovative step forward from NISDN was the development of Switched Multimegabit Data Services (SMDS) by Bellcore. SMDS was a proprietary solution developed by Bellcore and intended for wide deployment in the United States. It was a metropolitan area network (MAN) solution that was not marketed well in the U.S. On the other hand, in Europe SMDS became a major success and exists today as a viable and cost-effective transport mechanism within the European Union. SMDS has achieved the fate of NISDN in the United

States. It is hard to believe that it will be successful in the explosive growth of modern networking in the U.S.A. where the technology of Asynchronous Transfer Mode (ATM), xDSL, and IP Networking are now rapidly emerging.

The ATM Forum formed in 1990-1992, and immediately became the fastest coalescing standards activity ever organized. ATM, as is SMDS and FR, is based on the concepts of fast packet switching which requires that a “packet” or “frame” or “cell” be error checked only on an end-to-end basis. This allows for such an information “bundle” to be forwarded rapidly through the network, and for a wide selection of virtual circuits to be established simultaneously across the currently active user community. The ATM Forum has now successfully achieved the establishment of international standards for ATM, with ATM being recognized as the best solution for high-bandwidth wide area networking. The Internet backbones in the United States are made up of ATM hubs. One such hub is the Metropolitan Research and Education Network (MREN) established within Chicago which is acting as the backbone for Internet-2.

NISDN was considered to be the answer to multi-media communications once standards were put in place in 1992. What was not fully realized was that bandwidth and real-time video would become extraordinarily important by Spring 1995. NISDN simply did not provide the user with the bandwidth he desired unless he subscribed to the Primary Rate Access Interface (PRI) which offered 1.544 Mbps. By 1995, Bell Atlantic, USWest and Pacific Telesis (now SBC,Inc.) were testing innovative signaling mechanisms to bring bandwidth to the home of up to 6.34 Mbps. These signaling mechanisms are now known as xDSL for a variable bit rate Digital Subscriber Line. It should be understood that this local loop technology offers a remarkable alternative to NISDN which should be cost-effective as soon as the tariff structure is stabilized within the United States. NISDN was simply a victim of the rapid introduction of evolutionary technology. It offered little, and was never timely in its availability on a national scale. Broadband ISDN (BISDN) which makes use of ATM technology, will be effective because it moves with the emerging successful technology and will be deployed as ATM establishes a wide physical presence in the United States.

Market Dominance

In his whole life, Vincent Van Gogh is said to have sold one painting, basically relying upon funds from his brother to buy bread and paint. But few modern creators have the same luxury (or are willing to live in such poverty). So our efforts must not only be great creativity, they must trigger a flow of funds from the market economy which allow us to indulge our passion for design and creativity.

In art, there is an advantage to uniqueness, but in products and technology there is often a strong advantage to being the same as everyone else, thus sharing the

costs of support services. Therefore, most technological marketing is either about becoming the market dominator or fitting your product to the market dominator. QWERTY is the market dominator. Kids in school are taught the keyboard. Anyone who has ever taken typing classes knows that keyboard. When you hire a temporary worker, they know that keyboard. It is hard to imagine any of the technically superior keyboards which have been developed ever gathering enough usage to justify investment in support and training.

In a flat out technical competition between the IOMEGA 100 megabyte Zip drive and the Imation 120 megabyte drive, which can also access the standard 3 1/2" floppy disks, the Imation is the obvious technical winner, especially if you are a computer manufacturer. But Zip entered the marketplace first, got quickly and conveniently onto the systems of many individual users. So, if you want to be able to exchange data with others, the odds are much more in your favor if you are using a Zip drive. If Imation had its drive ready and in the market as soon, it would have won, hands down.

Even less of a delay can be fatal. Some have heard of Elisha Grey, an inventor of the telephone who filed his patent later in the same day as Alexander Graham Bell, and ended up missing out on the money and the fame.

Delivering More than the Market Will Buy

Management of the approach to the market can be critical. Sony's Betamax and Apple's Macintosh are two technologies with a lot of lonely fans, frustrated as technologies they consider inferior dominate their marketplaces. It may be as simple as these two firms overestimating the premium they could charge in the market, a little too confident of their technical advantage. For example, while Betamax gave superior visual quality, most people were taking family films or converting various 8mm films to video to play through their older, lower quality televisions, places where Betamax's video fidelity gave little or no added benefit, so the customers simply would not pay the premium. On the other hand, while lacking visual fidelity, the VHS design had a robust simplicity that might be more tolerant of consumer errors as well as a length which could hold a whole movie. If first run movies had been made available more quickly to the video market, and if people's home televisions had larger and clearer screens, Betamax probably could have gotten away with the premium. If they had better understood their market position, they might have "given away" their technical advantage to customers and competed on equal price with VHS, obliterating that technology and funding the development and improvement of many video products.

Apple charged a similar premium price for the Macintosh because of its quality of graphics and ease of use. This was great for artists and teachers, but there were so many people who only needed word processing and spreadsheets, and who felt empowered, not frustrated by the openness of the DOS based systems, that

the volume went to the IBM compatible market. As hardware costs plummeted in a large (and growing), available DOS marketplace, Microsoft could afford to develop Windows to match many of the benefits of the Macintosh, and at lower cost per machine. Microsoft's market dominance now makes it easy to generate additional cash with various upgrades and new releases, cash which can fund new developments.

It is often dangerous to count on your own employees or the earliest adopters of technology to guide development of products for the masses. Intel's Andy Grove recently pointed out in a speech that they finally decided that they needed to ignore the reactions of the technology lovers and realize that there were a whole bunch of people who had no use for the full capacities of the Pentium II, but wanted some improvement, so they developed the Celeron chip which is currently generating lots of cash for them.

In the early 1950's at General Electric, management began to realize they had problems in the design of kitchen appliances for the consumers. For example, they noticed that to the well educated electrical engineers they had hired to design electric ranges and cooking stoves, a superior design was one which most efficiently converted electricity to heat, which was not the concern highest in the consumer's mind. So they hired a chef to come in and teach the engineers to cook on those ranges. After this experience they began to make improvements to design which actually helped the homemaker. Of course, it never occurred to them to hire some housewives to be designers. And if you have ever owned one of those General Electric ranges from the late 50's and early 60's, it is obvious that the engineers never had to clean a stove, especially after several years of use.

This can all sound cynical and complaining, but success requires either incredible luck or careful attention to all the details, including how the product development and production will be funded. Thomas Edison was an inventor of this type. He set up an invention factory with various successful products funding the effort to develop new and better products. But he knew that without the ability for someone to make a successful business of his products, the products would never be made available. He not only supervised the invention of the incandescent light bulb, he worked diligently to provide everything an electric utility would need to operate from generators to watt-meters which allowed utilities to bill users for actual usage. It is easy to ignore such details, or wait until some other inventor or entrepreneur finds the answer, but progress will move more quickly if the inventor accepts the need to invent a device that not only works for the customer, but for the marketplace that will deliver the product.

Pricing Free Services

What can really surprise you here is the disconnect between price and benefit. Back when IBM sold mostly punch card sorters, their sorter came in two speeds,

with the higher speed machine quite a bit more expensive. However, if you bought the lower speed machine you could purchase a service upgrade to convert your machine to the higher speed, for a price greater than the differential if you had originally bought the faster machine, but less than the cost of a second slow machine. As the story goes, if you purchased the upgrade the service technician showed up with all kinds of tools and spare parts, then locked the customer out of the room while doing the long, tedious upgrade. Once the door was locked, the technician opened the toolbox, spread out the tools and spare parts, took out a thermos of coffee, a magazine, and maybe some snacks and read for a couple of hours. Then he put the magazine and coffee away, opened a panel and moved a drive belt from one drive wheel to another, ran a test on the machine speed, and invited the customer in for a demonstration. Some would complain that it was unfair, or even immoral, to sell a \$25 adjustment for several thousand dollars, but the added function was certainly worth the price to the customer.

This customer value per cost is the main issue in technological success. The majority of telephone switches operated by the local telephone companies in the United States have the built in capacity for services such as three way calling, caller ID, Speed Dialing, etc. In fact you cannot buy a switch today without these services. The added cost of providing these services to customers is basically zero. Yet the phone company is able to charge \$3-\$5 per month for each of these services. As long as this market lasts, the most valuable resource of a telephone company is gullible customers with no alternatives. This is why the road to corporate success in America's telephone systems today is to get a lot more of these gullible customers, thus leading to buying the other regional telephone companies as the fastest route to greater income.

This may seem unfair, but **if** these companies are legally able and willing to use that cash flow to accelerate the design evolution of the global telecommunication systems, it is a great process.

This high cost for free stuff also applies to software. Once a software package is written, the cost for each additional copy delivered can be as low as zero for downloaded software or \$3 for a CD version. The ability to price such free goods in such a way as to fund the further development of products you are interested in is the real name of the game in managing technology.

Conclusions

So what is a designer to do in the current global bandwidth explosion? One option is to just relax and enjoy the ride, but for those who want to be players, it is important to become more broadly aware of the business, strategy, technology, and political issues relevant to the field. More importantly, to develop relationships and collaborations which allow you to mobilize conversations which

are capable of having a relevant AHA. Who do you need to know, what projects do you need to work on to be ready to develop worthwhile products.

The basic trick is humility, to recognize that you really do not understand the whole situation, and that working alone you probably never will understand it well enough to make all the decisions. It also seems important to recognize that you might not be equipped by background, experience, and values to have AHA's about your technology which are relevant to the needs of the consumer whose money you want to pay your expenses while you play with the next generation of the technology.

We would recommend close attention to something we might call "cognitive bandwidth", the amount of information, knowledge, and wisdom transferred, not the amount of data. A live picture of a desert sunset at 1200 by 1200 would be a huge bandwidth transmission with relatively low cognitive bandwidth. The Gettysburgh address went through the telegraph system in Morse code pretty well, but had a tremendous amount of meaning, of cognitive bandwidth. One expert to turn to for more ideas in this area is Tufte (1990, 1992, 1997) whose several books give excellent ideas about how to provide maximum usable information.

Obviously, it is also important to give serious consideration to the realities faced by the majority of those to whom you would like to deliver benefits. It may give great artistic joy to convert your company's phone number list to some incredibly animated "dancing baloney" Java-scripted routine, but when many of your customers are running browsers on 386 machines under Windows 3.1, you may chase away some great customers--leaving less cash available for your salary and your development tools.

Designing successful technologies takes both focused work on key technical issues and broad understanding of the complex realities of the users, the distributors, the producers, and all others involved in the network of activities to deliver value to the end user. The broad understanding of issues generally requires a creative collaborative interaction among those who know different parts of "the elephant". Such interaction requires the sharing of goals, strategies, and beliefs among the collaborators to develop an fuzzy mess of understanding of the complex dynamics of the problem situation. Such interaction can benefit from techniques developed by other designers, such as costed function analysis, decision criteria matrix, creative problem solving, brainstorming, and various team building activities. Even covert usage of these guiding principles by participants in the collaboration can accelerate the synergy and co-creativity of collaborations, thus accelerating the design evolution, bringing more effective and efficient technologies into use sooner. The techniques and concepts are available, for those who have the will to make it happen.

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