9. The Future

”The idea with such multiple scenarios, then, would be to understand what information to gather to better and at an early stage understand what development trends are emerging, and also to prepare — not least mentally — for a larger variety of challenges, decisions, and action.”

Bengt-Arne Vedin

”Since the end of the cold war stalemate, defense projects are no longer always the driving force behind IT breakthroughs, but often entertainment applications instead.”

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Three areas seem very difficult for us to forecast, no matter how much we try — the weather, human behaviour, and the future. All the same, we need to have some idea of what the weather is going to be like, shine or rain; we need to try to understand how IST users are going to react to a new product or service; and we need to have an idea about what the future is going to be like in order to concentrate on the right issues.

Looking back, it is obvious to anyone involved in the IST industries, whether manufacturer or user, that some of us were not thinking far enough ahead when constructing chips, computers, and electronic systems for communications. The idea of the second millenium and its consequences for internal clocks at the very turn of the century, Y2K as the acronym has it, was too far ahead.

Should the problem have been in the mind of the system builders? We have no answer to that question. We can only watch the effects caused by the rather immediate future, the year 2000, upon companies, public administrations, and agencies alike. Some are working energetically to solve their problems. Others are hoping for a godmother that will wave her magic wand to make all problems go away. For a small country like Sweden, where resources are scarce, a problem like this may be more serious than to large countries like the USA. A specific problem, not foreseen, takes all the energy there is to solve, while business as usual is being, if not neglected, at least put out of focus. Those who have questions regarding how the Swedish public administration is solving the Y2K problem, should turn to the specialists at Statskontoret, the public agency for administrative rationalisation.

We are likely to run into similar problems in the future Information Society, there is no doubt about it. Those who want to be a bit better prepared may want to apply the advice in the following article on the future and its many possibilities.

9.1. Scenarios for the Year 2007 — A Do-Them-Yourself Instruction

by Bengt-Arne Vedin

For a long while, it was common wisdom that computer terminals would provide the general access route to computer power and data processing capacity. The personal computer breakthrough came as a genuine surprise. It was fuelled by the necessary, even critically important access to software of high utility, first the VisiCalc spreadsheet.

This little story tells something about the difficulty in forecasting the trajectory and time table of IT developments. To this we must add the experience from the emergence of fax ubiquity. The telefax is older than the telephone, and its breakthrough had been ever so often foreseen in the 1970s and early 80s that eventually people started to believe that it would never happen. Then price and utility concurred to create the final critical mass, and an avalanche of fax diffusion was triggered.

This latter ”avalanche” is an example of something called network economies, where utility shows an increase instead of a decrease with the number of subscribers or network nodes existing. This equals increasing marginal investment returns, not decreasing as in conventional economics. Such effects are difficult to bring into conventional calculations but they are extremely important, a subject we will return to.

Ten years ago, no one would have forecast the network economies and the critical mass now associated with the Internet, possibly triggered by software inventions such as Mosaic and the World Wide Web, eased by further developments such as, e.g., the search engine Alta Vista. Today, we contemplate whether Netscape or some other surfing tool will conquer the market. We discuss the fate of the net computer idea — in a way, a return to the concept of ubiquitous computer terminals. There is furthermore a lot of advocates for applets, the temporary downloading and need based utilization of whatever software modules are currently needed.

Thus an attempt to describe the state of the art of IT ten years into the future would have to be designed a bit differently than extrapolating current statistics. It would rather seem important to describe those developments that have had most impact, including, then, changes in individual, organisational, and societal information behavior. On some points, there seem to exist trends and counter trends simultaneously. Sometimes only one will win, sometimes, however, they may coexist, as we shall see.

The trick with scenarios

A scenario for the year 2008 might read something like this: the experience industry is by far the largest; people have their lives organized in short and long term portfolios, encompassing caring for others, sustenance, knowledge and competence acquisition, and experiencing. The scenario would give the percentages for these categories over the life time of people with cognitive and knowledge based tasks; those dedicated to interaction (possibly emotional also) and services; and those geared to tactile endeavors. It would perhaps describe individual lives of representatives for these different categories.

Instead of providing a fixed though multifaceted version of a future, of one future, of one or perhaps a couple of alternative scenarios, I suggest to provide the reader with a basis for producing her or his own set of pictures of the future. As a starter, however, let us discuss the idea of producing scenarios. Why would it be a worthwhile endeavor?

A scenario is a self-consistent, broad picture of some particular future. Thus it may be surprising and seem unlikely, while it must not be allowed to display any internal contradictions. Instead of focusing on forecasting the evolution of one or two salient features, it attempts to integrate a larger set of interdependent factors, and to interpret them into applications and consequences. Here the scenario builder relies upon various trend extrapolations, Delphi studies, etc. Thus development forecast for speed, capacity, numbers, prices, etc. will be taken into account.

It is important to note that the intention in most cases is not to forecast or foresee the future. It may, for example, well be that a scenario that seems not improbable but repelling, generates action to prevent it from coming true. Thus a scenario may be self-defeating — or self-fulfilling, and that may have been the idea behind.

This point of view is further stressed by the strong recommendation that no one produces just one, not just two, but several different scenarios. Aristotle said that ”it is probable that something improbable will happen” and Herman Kahn, who used always to produce a basis scenario for the ”surprise free development”, claimed that of course ”nothing would be more surprising than if this surprise free scenario actually came true”. The idea with such multiple scenarios, then, would be to understand what information to gather to better and at an early stage understand what development trends are emerging, and also to prepare — not least mentally — for a larger variety of challenges, decisions, and action.

A word also on scenario format, on its presentation, apart from underlying documentation. ”Scenario” may induce associations with a written description resulting in a scene or screen production. Often scenarios are written like journalistic reports from the future, sometimes, however, produced in some other written form, e.g., an annual report from the future. But there are also slide and theatre shows as wells as movie and video productions. Theme, creativity, purpose, target group, and, of course, resources are the decisive factors. An informative and provocative way of presenting the scenarios goes a long way towards providing a productive dissemination of underlying facts and stimulating a fruitful discussion. Eventually, one result, apart from mental preparedness, would be a guideline as to important indicators of new developments.

Looking for sea changes ... in international politics

Now to our problem, scenarios for the future of IT, or IT and its consequences in the future. Out of several starting points, we will concentrate on two, which are complementary rather that mutually exclusive. The first is to ask what future developments — likely to happen or not — would have most impact, in this case on the future trajectory of IT (in some other case, perhaps your case, on the future of a particular industry, market, technology, organisation, or individual). The second is to try to define how the subject under study — here IT — might be described, in what dimensions and under what influencing forces.

Adopting, first, the global viewpoint, we pose the question which developments in international politics which might impact drastically on IT development. Since the end of the cold war stalemate, defense projects are no longer always the driving force behind IT breakthroughs, but often entertainment applications instead. Various international confrontations calling for a new arms race thus would reflect upon IT developments.

There is also the concern that new ”wars” might turn into information wars, where false information and especially attacks upon the information infrastructure would be of great importance, conceivably difficult to trace to a particular aggressor or the aggressor not necessarily being a nation but some other type of organisation. The first attacks of this type might then give impetus to entirely new developments with the eventual objective of securing IT systems integrity.

The reader is invited to produce yet other major shifts in international relations. Perhaps only developed countries are vulnerable to ”information wars”? Perhaps there may emerge ”crazy states” (or do they exist already?) that neglect to adhere to the conventions of international diplomacy and ”decent

behavior" between nations. May they play the defector's role in the "prisoner's dilemma", playing on other nations' unwillingness to let international law and order break down? Will we see the emergence of new powerful political doctrines, of religious creeds, or cultural perceptions that energise nations or groups so as to create upheavals of a radical nature? What, then, the consequences for IT?

... in international trade and commerce

One particular arena of international relations is of singular interest: international trade and commerce. A more interdependent world might be less likely to generate armed conflict. But is the development towards trade liberalisation unstoppable? What are the odds for a return to stiff trade and tariffs barriers? How would different outcomes affect IT development, or a particular organisation? Is there a definite shift of economic power to, e.g., South East Asia, and will, e.g., Europe as a consequence of this lose out, not just in relative terms but in absolute as well? With what consequences? An obvious dichotomy would be a real downturn in the economy, like 1929 and after, versus blockbuster growth.

Information has a lot to do with international trade and commerce. The relationship is constantly growing more lopsided, so the figure that the international money flow, on paper, no, in bits, is eighty (yes, 80) times as large as the underlying trade in goods and services may be all too conservative. This figure relates to what is sometimes called speculation but what is rather the market trying to allocate resources as efficiently as possible, i.e., gaining whatever arbitrage there may be in return on government and other bonds, or currencies, or company stock. And it is also insurance instead of speculation — hedging one's bets against currency fluctuations, different markets reacting differently to different changes in the world economy.

... and markets in general

If electronic money contributes to less transaction costs, this huge money flow might increase substantially. Perhaps there will be new services allowing for the proverbial man in the street to do for himself, possibly with new software, and banking services, dedicated to such activity. This further growth in money flow might also imply a still larger increase in a risk that concern a considerable number of money men: there might develop instabilities in the system, because of its complexity, speed, and its tenuous relationship to fundamentals, unleashing a severe crisis just because no one is in control and thus the process might run wild. Clearly, no single nation or corporation or organization has a handle on the process as such, and it is difficult to see how one could emerge. If it did, however, that would imply a major shift.

The enormous money flows, the lack of control, and the risks implied have generated a number of ideas for restraining ”the system”. One is to tax money transfers, possibly having the UN receiving the proceeds. Another is to have some type of ”border control”, like the customs. Such suggestions seem to assume a true global consensus and application. But it is hard to see how the flow of bits might be controlled and taxed. Again, our message for the scenario builder would be to say: important if... so: be on the lookout.

With this, we have touched upon an issue which may be termed the functioning of markets. Currently, it contains two major aspects, digital money and new ways of selling information, liberating it as it were. Digital money would possibly reduce transaction costs radically, making transactions at the nanodollar (one billionth of a dollar, or tens of millionths of cents) level feasible. Since money serves the double purpose of being the voucher for exchange and the representation of underlying value — though most central banks no longer promise any underlying gold value as a backup — digital money offers the opportunity for just about everyone to generate digital monetary instruments. To the extent that the market doubts that full backup exists, they may command a discount.

Apart from such expressions of intangibles, the Internet would turn into an enormous shopping mall, dedicated, of course, to such goods and services that lend themselves to marketing this way, possibly calling forward new distribution means. Digital money would require the solution of a number of difficult problems related to IT integrity. The shopping mall would, however, be more quid-pro-quo between seller and buyer in the sense that buyers with similar interests might get together easily, swiftly and also temporarily, to negotiate a rebate, to join forces in knowledge development, or to press the seller on a warranty issue.

Before buying, there is marketing and selling, basically information activities, affected by multimedia and IT developments in general, but of course depending upon the particular goods or services being marketed. Then there is the transaction, followed by some kind of transfer of what has been sold. There may also be after sales service and support, possibly including teaching on the one side, learning on the other, often with instructions built into the product.

... new types of organizations

Early on, book and gramophone record (CD) selling turned out to be efficiently handled on the Internet, with new brokers establishing themselves, relying directly on networking with producers and publishers. Book shops instead offered contacts with live authors, and agreeable coffee corners. Music distribution now seems to be turning into downloading directly from the Net, copyright issues obviously the critical, and difficult, obstacle to negotiate.

The one studying IT is prone to look at the software business as a bellwether for tomorrow. Though important and still growing rapidly, software is something fairly particular. With this caution, we again see the opportunity for downloading directly from the Internet, with the added idea of giving the basic version away for free, money made instead on support and later or extended versions of the application. This is the general business formula pursued by the enthusiasts for ”information wants to be free”: music, software, newsletters are provided without any cost, profit generated instead through live concerts or seminars, or consulting.

We may regard the international community as well as ”the market” as partly self-organising super-organisations. On the next level, we have nation and corporation, all types of large corporations, not just business firms. So we have smaller groups with a personal acquaintance, and finally individuals. All the way, we see lesser importance allocated to the legal entity, the business corporation, networks and virtual corporations complementing and sometimes substituting it — possibly with a new broker function at work.

... new conditions for decision making power to emerge

Markets are only partly self-organising, because there are various restrictions. We may also distinguish between market decisions, legal and administrative procedures, abiding by formal rules, negotiations between different parties, and democratic procedures, of which there are many constitutional variants.

Having dealt with possible changes in market mechanisms, we shall return to what seems to be shifts in information behavior, impacting upon most of these different mechanisms. Let us just note that while currently there are concerns about IT playing too large a role in electoral campaigns, there are also ideas in progress on how to develop and improve democracy with new information and feedback tools. Could possibly major changes of this type impact on the fate of the organisational or functional unit under consideration?

A fairly large number of experiments with digital democracy are under way in different parts of the world. Voting directly, substituting parliamentarians, is not the highest priority. But establishing the agenda, allowing citizen access to decision making, and to nominating candidates belong to facets that meet with enthusiasm among the people — and concern among party hierarchies.

There are systems allowing participants to play out their relationships as community members in a digital community that they themselves create (e.g., Habitat). It turns out that certain rules for human interaction emerge spontaneously, because without those, people vote with their feet, i.e., opt out of the community. One might note that this is a community where membership is voluntary which is less the case with real, not virtual villages. But could it be that such spontaneous rules will prove efficient enough to be translated back into real community?

The technology issue

Before going into the tricky field of human information behavior, let us discuss something that has been conspicuously absent until now: technology. Apart from a rapid development in general, foreseeable at its technology roots, two more radical deviations will be considered here.

The first is a very speculative and vague one. Telecommunications networks are complex organisations, bordering to biological organisms in several ways, something demonstrated by applying the emerging science of complexity. Complex systems sometimes display a completely surprising behavior, not easily understood just by looking at the system as the sum of its parts. Life is the prime example: we have just four basic components, oxygen, hydrogen, nitrogen, and coal — but there are many, many of them! — and the forces governing their interactions are comparatively simple also. Yet we have the astonishing phenomenon of — life!

Speculation, then, would suggest that telecommunications systems develop not life of their own but behavior that will first seem odd and make for problems, possibly also opportunities. They certainly fulfil the requirement of consisting of a great many components, which furthermore may be regarded as of few and simple types, linked together through simple relationships. One suggestion would be that networks became susceptible to infectious diseases — not, of course, in the literal sense but through some phenomenon approximately resembling infection. It is important to note that this would have nothing to do with computer viruses but be a property generated by the network itself.

Here an example. It is not ideal because emergent properties are surprises and if we could forecast them, they would be no surprises. But a major telephone exchange on the American West Coast suffered a severe breakdown that was extremely hard to spot. It turned out that instead of signalling a greater switching delay under heavier load, which is the way to tell other exchanges to take over some of the job, it inverted the sign and signalled an impossible over capacity, which other nodes were more than eager to exploit. Thus it would be the task of the scenario producer to try to dream up such possible improbabilities.

The second major technological change has been discussed a lot and implies the slowdown from fast to less drastic development. From around 1950, Moore’s Law has prevailed, implying a reduction by half in computer power cost every eighteen months. Every decade the end to this rapid cost reduction has been in sight, mostly because of problems with miniaturisation, reaching noise or photographic resolution limitations of a physical kind. These problems have, time and again, been resolved in ingenious ways.

When Gordon Moore himself now foresees the end to his law, it is because of something else: cost. Concomitant with cost reduction, chip factories have grown in complexity, eventually creating such demands on investments that they will be insurmountable by the year 2005 or so.

The spectacular cost reduction has been an important driving force. Is Moore right, and, if so, have we arrived at the end of history? Of course, engineers have come up with ideas to ease the demand for capital forecast by Moore and underpinned by trends so far. Another argument, which is more than somewhat true, is that since computer power has increased so swiftly, we have been less concerned with harnessing it to its potential or using it very efficiently. Thus if development came to an end, there would still be another ten years to go before the potential of technology already existing had been fully utilized. And the same might be said for application programs, and for information organisation.

With this reasoning, it would take another twenty years after Moore's last super-factory before innovation ground, not to a halt but to the small improvements of a mature technology. The question looms large, however.

The closer to the sources of IT, microchips, the more concern for the scenario writer, however. And from this story, and the hypothesis that underlie it, we may discern a number of changes in emphasis.

But are microchips still the sources of IT? The growing emphasis on telecommunications stems from breakthrough developments also in optics and transmission technology. Furthermore, it stems from great strides in applied mathematics, allowing computer power to be harnessed to allow for radical signal compression.

May we, when producing our scenarios, suggest other such mathematical breakthroughs (think of public-private key, pretty good privacy, and others)? Is it true that such ”soft” innovation, including computer software innovation, is characterised by something different from the ordinary laws of nature: human logic? And is it true that this implies different rules governing innovation activity and the achievement of innovative results?

Here developments have not been so orderly as they seem to have been in microelectronics — seem to have been, because here too there are steep curves indicating drastic cost reductions and capacity increases. Thus we may come to understand that the underlying forces are not really depending on engineering efforts as such but rather market forces inducing such efforts.

The power of investments

Here, then, forces are of two types, or two categories of one factor — investments. Traditional infrastructural investments is one category, though some may not be entirely traditional, as we will see. The other is anonymous, discrete, individual small investments, as much, perhaps in time and effort as in hardware — what eventually creates critical mass.

Looking ten years into the future, we may identify at least one possible new huge investment in infrastructure, and that is an airborne (or spaceborne?) mobile telephone system. Motorola came out first, with Iridium, comprehending some seventy satellites. Next a consortium with Microsoft as one prominent participant claimed to be going for lower orbit satellites but then some eight hundred of them. But there are several more contenders, including a scheme with stationary high altitude balloons. Anyhow, these are systems that cannot be launched piecemeal but need a (near) full scale launch.

There are, to be sure, infrastructural investments that are moderate, such as Mosaic and the World Wide Web, tools that needed to be developed and which generated the run-away success of the Internet. Possibly, future such general tools and interfaces, available to all may become instrumental in the break-through of this or that development.

The fax breakthrough of the 80s was not something caused by massive investments into fax networks or fax servers. It was just the arrival, finally, of critical mass: a sufficient number of faxes ”out there” to justify the acquisition of, not investment in, another fax. Certainly prices had come down, something which happened partly because of general cost cutting in IT, partly because of larger production volumes.

The Internet, like the telephone almost a century ago, is the same story. Critical mass makes for higher utility attracting more adherents which increases utility even further, attracting... And making for a larger increase in traffic than the simple addition of new members or nodes would indicate.

This is an example of network economies, mentioned initially, which run counter to ordinary economies. Instead of diminishing marginal returns as new members are added to the network, we see increasing returns. The utility for the individual member or subscriber is approximately proportional to the number of members or subscribers. Critical mass has arrived when it is just too costly to stay outside this profitable system. There is one important provision, though. New nodes must not cause the system to choke, so the information volume of future messages (live pictures, 3D virtual realities...) and bandwidth and switching availability will have something to do with future trade-offs.

Increasing returns

Network economies, in turn, provide one example of knowledge economies, and this is just one group of economic phenomena sharing the characteristic that they display increasing marginal returns. The return on the first amount of investment is Q; normally the return on the next equal amount of investment would be less than Q, but here it is larger instead. Thus there is an incentive to rush forward with new increments of investments even faster.

Seldom one actor is alone in this, and if knowledge grows in sharing, it is a collaborative undertaking. Thus we claimed that the first successful personal computer, Apple II, actually became a success only after the introduction of the VisiCalc spreadsheet. With sufficient numbers of computers available, other software producers started developing their own products. They competed, but they also collaborated in that they were all instrumental in creating a new market, a market needing both hardware and software.

Sometimes the win-win process coalesces around one standard, making losers out of those not adhering to that standard. The new industry as a whole still displays increasing returns, but there are some losers, those left out of the standard, by their own design or by various types of barriers having been erected. Sony Beta versus JVC is typical for the first type of battle, with the pioneering (and technically somewhat better) Beta turning out to be the eventual loser. The IBM PC became the industry standard, IBM supporting a win-win process by laying the standard open to all interested players — too open for its own good, some observers claim. And the MS-DOS, later Windows, became the dominant standard for operating systems. The current attempts by Microsoft to retake the lead from Netscape in Net-surfing tools must be seen in this perspective, as Bill Gates makes evident in his book, *”The Road Ahead”*.

Consequently, the identification of such run away processes, and future standards, are crucial for successful scenarios. Many fax producers had given up on any breakthrough ever happening, after so many false starts, and as we have concluded, PCs and the Internet were hardly foreseen, especially not the exact timing. Therefore, our scenarios should not concentrate on the timing of such events but rather on different outcomes and indicators as to their imminence.

To reiterate: it would be all too ambitious to try to generate some kind of all-encompassing IT scenario for the future, including, technology, applications, and social and societal effects. Instead, the idea is to provide the reader with some tools and inputs to make it possible for him or her to produce a set of scenarios pertaining to a particular situation. We have already mentioned a number of salient features to take into account, but when we now approach the individual level, what should we look for in suggesting important shifts in information behavior?

What individual communications behavior?

A few scattered examples of changes in information behavior might serve better to color the abstract term. The advent of the copying machine led to a surprising proliferation of copies. One way of describing this phenomenon might be to say that now a lot of copies of copies were made — in fact, the great majority. Or you might point to the fact that when people lining up to wait for making copies called forward the installation of another copying machine, this led to a step increase in copies made. One study showed that of all the documents arriving in an ordinary individual office, one half of them had any business there, the other half was superfluous. And of the half that was relevant, one half found its appropriate place in the waste paper basket after being studied.

A completely different discovery was that electronic mail caused people to be much less restrained in personal communication in this medium than in letters or on the telephone — rude, insulting. On the other hand, in serious decision meetings, where normally in the US white male participants would dominate, digital meetings made for equal opportunity also for women and minorities. And it turned out that such meetings handling of collective attitudes to risky projects changed in a tangible way.

In retrospect, we may say that such effects are obvious: the medium may not quite be the message, but it is well known that media temper our communication and thus can affect the dynamics of it. The point for us as producers of scenarios is of course to try to suggest such future shifts in behavior.

The change in work patterns related to the advent of photocopying make important points about convenience, human convenience, as a governing concern when people develop their information behavior. Thus it would be too limited just to take into consideration available economic resources when looking at our information future. Time and convenience, including propensity to learn, to find motivation and concentration to learn how to use various future possibilities will be decisive. Must learning be painful — can it become more rewarding in itself?

People are different, and producers of services especially are often reminded that they are operating on a mass market of one individual at a time. The service, or the goods combined with services, may be described as consisting of a combination of offers requiring producer efforts involving hand, head, and heart. Or we might, as mentioned initially, look at producers in general as working with cognition and knowledge; interaction and services; or tactile — those hands. How will various activities incorporate these factors, and what role will IT play? Again, one has to decide what is the theme of the scenario.

9.2. The New Technologies

The Evolution of Communications and Computing Technology 1950 — 2000

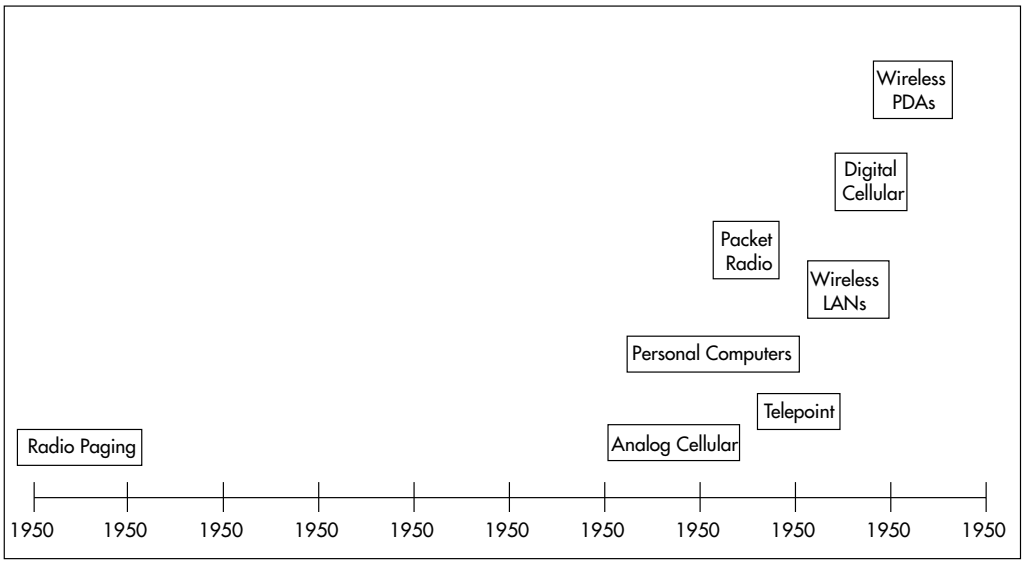

Fig. Feb. F The diagram shows the development of the wireless communications that we see exploding today. Although radio paging was used already in the 1950ies, it took until the early 1980ies for mobile communications to take off. Several books tell the fascinating story of the technological developments in the area. As can be noted from many diagrams in this book, fixed communications are rapidly being overtaken by mobile ones, whatever terminals we use — telephones, computers, fax, etc.
Source: EITO: European Information Technology Observatory 94

Micro Machines on the Chip

”The electronics industry relies on its ability to double the number of transistors on a microchip every 18 month, a trend that drives the dramatic revolution in electronics. Manufacturing millions of microscopic elements in an area no larger than a postage stamp has now begun to inspire technology that reaches beyond the field that produced the pocket telephone and the personal computer.

Using the materials and processes of microelectronics, researchers have fashioned microscopic beams, pits, gears, membranes and even motors that can be deployed to move atoms or to open and close valves that pump microliters of liquid. The size of these mechanical elements is measured in microns — a

fraction of the width of a human hair. And like transistors, millions of them can be fabricated at one time.

In the next 50 years, this structural engineering of silicon may have as profound an impact on society as did the miniaturization of electronics in preceding decades.

Micromechanical devices will supply electronic systems with a much needed window to the physical world, allowing them to sense and control motion, light, sound, heat and other physical forces."

Souce: Scientific American, September 1995, p. 118 ff. "Engineering Microscopic Machines" by Kaigham J. Gabriel

Trends in microelectromechanical systems

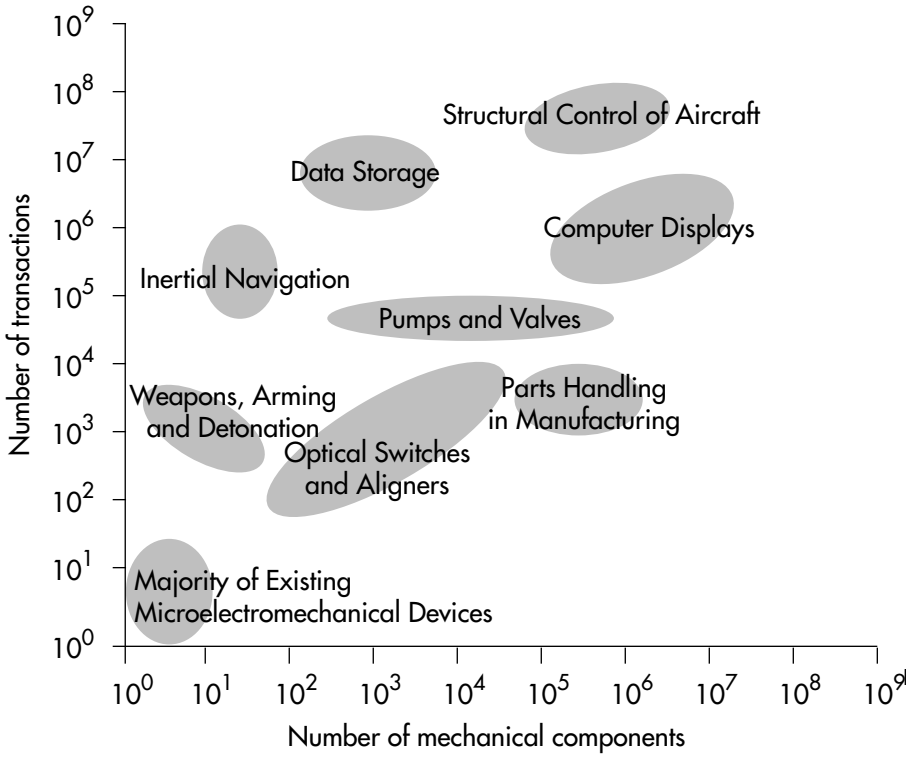

Fig. 14.2.1.: The integration of small machines and sensors with electronic circuits will make it possible for electronic systems to sense and control motion, light, sound, heat and other physical forces. The area at the bottom to the far left represents devices that have already been developed.

Souce: Scientific American, September 1995, p. 118 ff. "Engineering Microscopic Machines" by Kaigham J. Gabriel

All-Optical Networks

A lot of effort goes into solving the most important development problem in optical communications — that of building the optimal optical amplifier. Until such a device exists, the optical transmission technology is realising only a small fraction of the promise of the technology. So far, all the hair-thin optical fibers do are transmitting voice, video and data at speeds 10 to 100 times faster than standard copper wires. With all-optical networks (and no need to convert to slow copper) a single fiber could transport 25 terabits per second, which is sufficient to carry simultaneously all the telephone calls in the U.S. on Mother's Day!

Souce: Scientific American, September 1995

Quantum Components

Four generations of quantum components, i.e. electronic components based on quantum physics, are presently considered in semiconductor research and production. The present methods used for the production of quantum semiconductors are called MBE, Molecular Beam Epitaxy, and MOCVD, Metal-Organic-Chemical-Vapour-Deposition. The generations can be described as follows:

* The first generation includes a number of high volume components, for instance HEMT, High Electron Mobility Transistor, QWL, Quantum Well Lasers, and HBT, Heterojunction Bipolar Transistors. They are used in the following applications:
  - HEMT for high-speed digital signal switching and low-noise amplification in, for instance direct broadcasting via satellite;
  - QWL for semiconductor lasers;
  - HBT for power-device applications in, for instance, portable telephones and computers.
* The second generation is represented by more sophisticaded developments of the first generation technologies, operating at a scale of less than 10 nanometers.
* The third and fourth generations are still in the research fields. But there are clear ideas about their applications, which can be seen from the following diagram.

Examples of the Four Quantum Electronic Component Generations

Generation	Physics	Device Types	Feature Exploited	Operational/ Production Timescale
1st	Quantum confinement, 2D Dos, blue shift	QW laser	Low threshold current density, structure-tunable wavelength	In production
	Quantum confinement, spatial separation of carriers	HEMT	Low-noise, higher speed, less dependent on temperature	In production
2nd	Greater quantum confinement	P-HEMT	Lower noise, even higher speed	In production
	Hot electron injection	Heterojunction Gunn diode	Higher efficiency, lower noise, less dependent on temperature	In production
3rd	Tunnelling	ASPAT	Less dependent on temperature	Prototyping 1 year to market
	Resonant tunnelling	Diode as source/mixer low power	Very high speed, high efficiency	Highly special applications so far. Bandwidth links in space/ on earth > 10 years
4th	Ballistic motion, quantum reflection	Split-gate transistor as terahertz source/mixer	Ultra-high speed, very low power	Possible high bandwidth links in space/on earth > 10 years

Fig. Feb. E: This diagram shows an overview of the emerging quantum electronic components. These represent the future for mainstream electronics. Molecular electronics and all-optical computing are alternatives in the strategic research fields.

Sources: EC DG III/EITO: European Information Technology Observatory 94

Flat Screens

Flat screens, or flat displays, are one of the most strategically important products in the IT industry, according to the OECD (OECD: Information Technology Outlook 1995). They are regarded as key components in some of the fastest growing markets in the IT field, for instance in notebooks and other portable personal computers, in cellular telephones, which rapidly are becoming multifunction terminals, and in digital assistants.

Estimation of the Global Market for Flat Displays 1995 and 2001

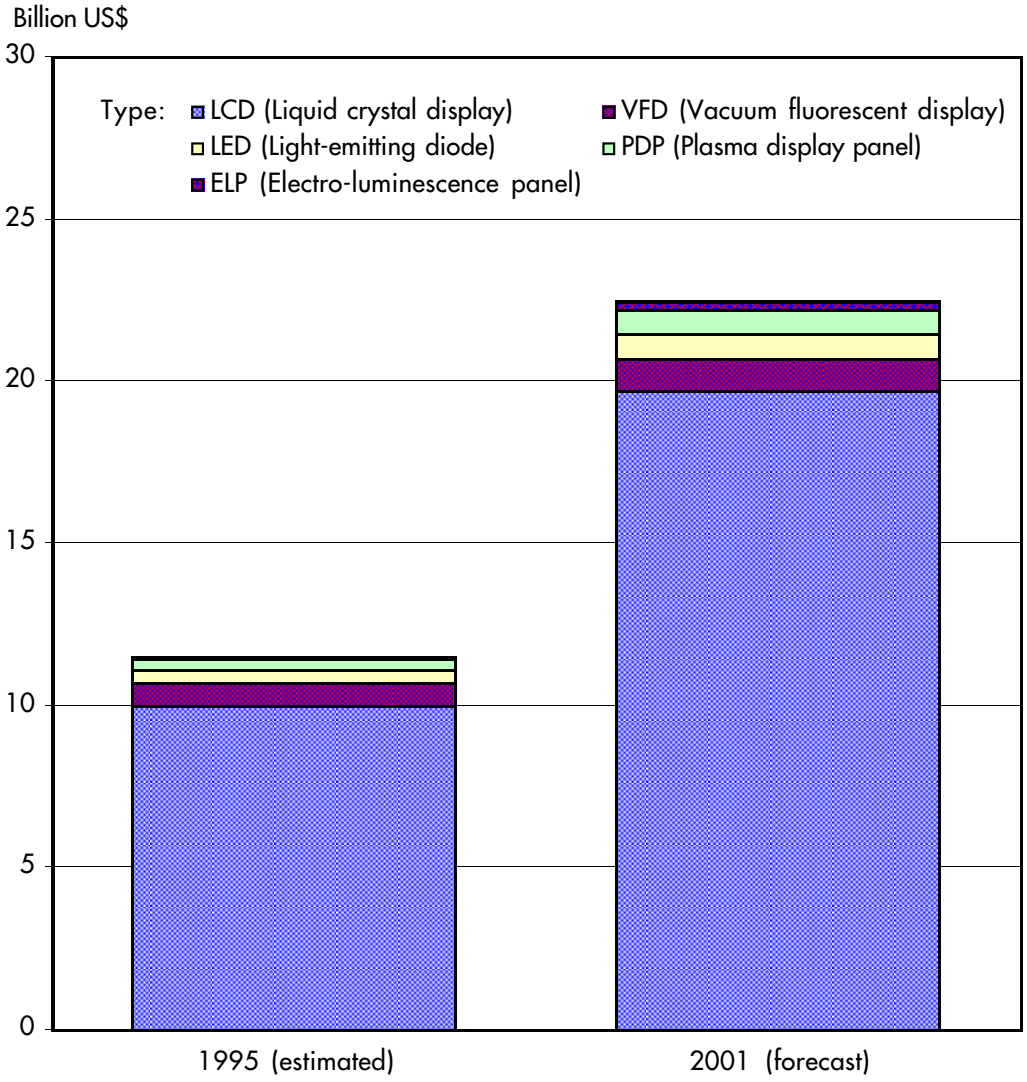

Fig. 25 Feb 18: Several technologies are underway for flat screens. For the time being, LCD displays are dominating the market. PDP is regarded as a strong candidate for large flat sceens.

Sources: Stanford Resources/OECD: Information Technology Outlook 1995 ©OECD, reproduced with permission of the OECD

After 2020?

New production technology for microprocessors and electronic circuits will most likely replace current photolithographic methods, about to reach their limits. Researchers are looking into new ideas, which they hope will take miniaturization down to molecular levels. Some of the ideas worked at are — according to **David A. Patterson** in **Scientific America, September 1995,** are:

* **Quantum dots and other single-electron devices**, i.e. molocular arrays allowing researchers to trap individual electrons and monitor their movements. The possibilities to develop quantum computing techniques are being studied at MIT, the Massachusetts Institute of Technology;

* **Molecular computing**: At the Syracuse University, USA, investigators are trying to develop data storage systems using biological molecules instead of making components out of silicon;

* **Nanomechanical logic gates**: Beams or filaments, only one atom wide are moved to carry out logical operations;

* **Reversible logic gates**: These gates will recapture some of the energy expended in the components of ever more densly populated chips and in this way generate less waste heat. This will solve some of the problems caused by the heat generated by computations.

Paying for peace of mind?

Will we have to pay not to be disturbed by e-mail messages, Internet, fax, mobile telephones and computers, paging systems, and whatever else there is of communication gear? It may well be that personal peace and quiet will be quite expensive in the future. So far, Swedes have to pay Telia for **not** having their telephone number in the directory.

* Is **artificial intelligence** (AI) finally coming of age? At least it seems as if some programming techniques have been developed that can emulate human logic reasoning and learning. Such programs are already helping out in maintenance and service of complex telecommunication networks and traffic control. But we are still at the very beginning of this technology, part of the problem still being our lack of understanding of human cognitive skills.