JUDGE_____ FINAL ADJUSTED SCORE_____

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DAVID SCHWEIZER - YALE UNIVERSITY

COMPUTERS Booklet Number 00645

The computer revolution is upon us. In the next 25 years, all aspects of computing — from input to output — will change radically. The greatest change will occur in the way computers are put together: there will be three fundamental modifications to our thoughts on how we compute. One change will involve neither new hardware nor new philosophy, but will come about simply through the realization of the potential of existing technology. Another change will be made through the development of new hardware, more powerful than anything currently constructed, but will remain within our philosophical paradigm of computing. The third change will be a completely new approach to artificial intelligence, and will require the abandonment of many current "truths."

The least radical of the three new approaches will make computers ubiquitous. Microcomputers with the power of current minicomputers can be made easily and cheaply. The basis will be a distributed multiprocessor architecture. As soon as computer designers realize that for many tasks it is already cheaper to use a dedicated microprocessor than it is to use special purpose hardware and a central processor, we will see a new breed of machine. Imagine a microcomputer based on a 16-bit central processor with dedicated 8-bit processors for input-output control, printer control, mass storage control, and tele communications. Such a machine would have the full power of the CPU available for computing, would not be tremendously expensive, and could, with good software, rival many minicomputers. If this design philosophy is used, and is coupled with software designed on the principle of maximizing computer productivity, we will soon see many very powerful, cheap computers. By 2008, these machines will be everywhere.

We will also overcome the 11.8" barrier. Supercomputing has almost reached the point where the speed of light (11.8" per nano second) is a serious design limitation. The next 25 years will see the creation of new machines able to circumvent the problem through parallel processing. The gradual development of the technology of vector and array architectures, and the

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COMPUTERS (continued)

concurrent development of the techniques and algorithms needed to program such computers, will provide the basis for scientific calculation in the future. These machines will supplant current mainframes, and will provide more power for the tasks computers already perform. Some problems which are computationally infeasible (astrophysical and weather models, for example, or any any other problem based on partial differential equations) will become tractable. But the basic idea of computers as number-crunchers will remain.

The advances in artificial intelligence will be based on one simple fact: that while digital computers can perform millions of calculations in a flash, the hallmark of intelligence is precisely the opposite. The difference between a human being and a computer is that the human seeks to avoid solving problems by repetitive methods. As an example, consider the game of chess. If chessmen are placed on a chessboard in a completely random fashion and the layout shown to a novice and a Grand Master, they will each be able to remember the positions of only a few pieces. But if the pieces are placed in a position which could arise in play, the Grand Master will be able to recreate the setup almost perfectly. A human being understands the game as a "gestalt" rather than simply as an arrangement of figurines. While chess-playing computers are gradually getting better, their approach is still the simple one. In the next 25 years, artificial intelligence researchers will realize that you don't mimic the brain by doing ever better what the brain does badly to begin with. The result will be the creation of new theories. The computers which will be built will be unlike anything ever imagined. They may be non-deterministic, they will probably not be based on boolean logic, they may even be biolectronic. But by 2008, they will think.

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ELECTRONIC COMMUNICATION Booklet Number 00645

In the next 25 years, there will be no significant advances in the technologies of electronic communication. This is not to say that the face of information transfer will not be completely transfigured, for it will; but simply to emphasize the fact that the changes will involve the development and dissemination of existing technology rather than the creation ab initio of new concepts in communication.

The potential of electronic communication is inherently limited: human beings have only five senses, and three of the five are not used in normal message transfer. The senses of smell and taste require chemical stimulation. And although "reach out and touch someone" is a famous slogan, it is only a metaphor. The technology already exists for the two senses we rely upon for communication, and that is the technology we will be using in 2008.

There will, however, be a massive transformation of our communications systems. Within the next 25 years, we will see a comprehensive interconnected system of two-way audio, video, and electronic data communication. Everything will be wired.

Imagine that it is 2008, and allow me to guide you through my day. A few keystrokes at my bedside not only silence my alarm, but also reprogram a small kitchen appliance to brew tea instead of coffee. By the time I am dressed, my home computer has not only successfully guided the electronic appliances in preparing my breakfast, but has also prepared the morning mail for viewing. After responding quickly to some of it, and storing the rest for later consideration, I catch the bus to work. On the way, I browse through the latest issue of my favorite newsmagazine. Electronically, of course. I read a very favorable review of a new recording of Beethoven's Sixth, and decide to get a copy. My order is immediately (the bus has a short-range transmitter; receivers linked to the communications network are located under the street) sent to the local distributor. The digital recording is sent directly to my

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ELECTRONIC COMMUNICATION (continued)

home, where the computer stores it away, and the cost is deducted from my bank account. After finishing my magazine, I send off an order for groceries, shut down my terminal, and chat with the person sitting next to me.

I am interrupted by a videophone call from an associate in another location. She sends me a copy of the report I need. After browsing through it, I send it to my office to be printed. I then decide to go visit a friend in another city. Before getting off the bus, I buy my train ticket.

Once on the train, I reconnect to the data network. I call my office and announce that I will be joining the afternoon meeting via video. Then, just to be safe, I reprogram the emergency call utility on my home computer with my destination instead of my office. Since I have a fairly long train ride, I take the time to catch up on a session of my computer repair class which I missed. For amusement, I download a copy of the latest video game (again, the bank gets electronic authorization to pay the manufacturer). When I get tired of playing, I send the game home for storage.

After visiting my friend, I glance through the afternoon mail, and then join the meeting at my office. On the way home, I answer the letters I had stored at breakfast and note the reminder I left myself to pick up the groceries.

At home, after preparing dinner and watching the evening news, I reprogram the emergency caller with the number of the friends I will be visiting this evening. And now, if you and they will excuse me, I have just been called by my dishwasher. It appears to have sprung a leak, and is busy flooding the kitchen.

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SOCIETAL IMPACT Booklet Number 00645

Information makes the world go round. The truth in that statement has been growing since the beginning of the Industrial Revolution, and will go on doing so for at least the next 25 years. Between now and 2008, the amount of human labor required to produce the material goods needed by the society will decrease. We will undergo a transition to an information economy, an age offering more opportunities for the full development of human potential than any before.

The standard of education will increase. The need of the electronic society for skilled citizens will be coupled with the increased availability of information and will produce better education. Although the resources may not be dedicated to the task immediately, by 2008 the change will have occurred. As the society becomes aware that it has passed the age of manual labor, it will begin to train its members for the age of mental work. This task will be greatly eased by the existence of a full-scale information distribution system. It may not be possible to pinpoint the moment of change, but the child of 2008 will have a greater opportunity to attain its intellectual capacities than does the child of today.

The move to an information economy will not be all for the good. Increasingly many people will be divorced from the soil: most of the society will have no idea of how basic survival works. While children will be taught that milk comes not from a cardboard box, but from a cow, their understanding may be limited by never meeting a cow. There are some who would argue that this will mean greater disregard for the environment. Nothing could be further from the truth. First, the belief that subsistence societies have any greater respect for the land than do industrialized societies has no basis in fact. The difference is that technology allows the same attitudes to do far greater damage. Second, as the electronic age becomes a greater part of our daily lives, we will come to cherish wilderness more. The roots of this attitude could already be found ten years ago, today, the attitude is quite apparent, by 2008, the ecological ethic will be an

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SOCIETAL IMPACT (continued)

Integral part of the information age. And third, we may even find a move back to the country. A comprehensive electronic communication system in a computer age could make cities obsolete.

Privacy may also become obsolete. There is a great threat to personal freedom hidden in the coming electronic era. For example, the potential price of being able to buy anything, anywhere by electronic funds transfer is that someone, somewhere can know when, where, and what you bought. The disadvantage of electronic mail is the ease with which it may be read... By 2008, however, society will have adapted. Some of the problems related to the increased availability of personal information will be fixed by technical means: seemingly unbreakable digital cryptosystems already exist, for example, and fiber optic communication lines are much harder to "tap" than electrical ones. Some of the problems will be removed by social and political means: we may find legal means to prevent unauthorized access to private information, and we may simply change our notion of private. By 2008, we may not expect true privacy while connected to the electronic society, but only when we remove ourselves, and we will find our freedom in the great outdoors.

The next 25 years will be a period of transition. We will have to adapt to the electronic age. We will see the systems we are creating abused by lawmaker and lawbreaker alike. The computer criminals who will become as much a part of American mythology as the outlaws of the Wild West will come and go as we cross the frontier to the 21st century. But as the technology and the society develop and grow together, the good will gradually overtake the bad. Westward ho!