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THE MAGAZINE OF USENIX & SAGE

February 2001 • volume 26 • number 1

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USENIX & SAGE

The Advanced Computing Systems Association &
The System Administrators Guild

needles in the craystack: when machines get sick

Part 2: A Kind of Magic

by Mark Burgess

Mark is an associate professor at Oslo College, and is the program chair for LISA 2001.

<Mark.Burgess@iu.hioslo.no>

In the 1960s science writer Arthur C. Clarke came up with a maxim – actually he called it a "law." He said that any sufficiently advanced technology would appear to us to be indistinguishable from magic. Back in the 1960s, if one identified with that line of thought at all (which usually meant being a fan of science fiction), one could smile wistfully and admire the wisdom of Clarke's acuity. Today, though, it is almost a platitude. The pace of technological change is so great that what was, for most people, a distant and speculative remark has been transformed into a mundane truism, at least in the developed world. The magic of our own technology is revealed to us on a daily basis.

The magnitude of our accomplishments, however, *is* overwhelming: the years of research and discovery, the gradual refinement of small things, the putting together of many small accomplishments into larger accomplishments. Standing on the shoulders of earlier giants, we are able to reach even higher to build taller giants, and each generation of this evolution carries us forward, as we take for granted the technology of the last generation to build something new. Each step seems small, each advance trivial. It is only when we step back and view the whole coherent effort, from beginning to end, that the process seems overwhelming.

Locked in this web of innovation are the answers to many pertinent questions about the present and future of our information systems. For that reason, it is worth exploring the process of development which brought us here. I am not a historian by nature, but history is nothing if not a data-structure charting the structure of data, or patterns of stuff which brought us to where we are today. Patterns recur and problems manifest themselves repeatedly; our history is a catalog of only a few common themes.

To really appreciate the nature of our development, we have to allow ourselves to be impressed by commonplace things. Take something as simple as a window. Try looking at it, instead of through it, and you will see that a window is a perfect example of the advanced technology which we take for granted. The word "window" originates from the Scandinavian *vind-auga*, meaning "eye for the wind." Windows were originally just knocked-out holes, used to ventilate and perhaps illuminate shelters (this was a pre-IKEA design). This illustrates the fact that even technologies as evolved and perfected as the window can have humble beginnings.

The window has been around for centuries in different forms, but it has also gone through enormous technological changes: the invention of glass; the technology to make large, smooth, flat plates of it; the extraction of the raw materials; the generation of temperatures required to melt those materials; the containers to hold them while hot; the metal in the frames and the handles; sun reflective technology; heat insulating technology; sound insulating technology; the molding of the parts. The list is long. All this does not just apply to windows, of course, but to tables and toasters and CD players and televisions, books, buildings, and computers.

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We switch off feelings of awe and take things for granted most of the time. Without that emotional shield we might be cowering in front of household appliances, perhaps not worshipping them, but perhaps not far from it. But is this what we want? The more we feign the triviality of it all, the more we are in danger of losing control and becoming dependent. This process of technological dependency is well under way.

Computers from Soup

Computers are information systems. We are also information processing systems. We are orders of magnitude more complex, but by looking at our own problems, we are peering into the future of our computer systems. The biological program is the simplest of all imaginable programs (*copy thyself*); there are nonetheless important parallels. Our computers are simply a by-product of our own evolution. Their sicknesses emerge from the same principles that ours do. The fact that humans are the vector by which computer sickness is instigated is neither here nor there: the deeper reason, that sickness can occur at all, is independent of the medium.

In one sense, familiar to Darwinists, all our technology assembled itself. It is the final leg of the well-known process of the evolution of structure. According to the best available evidence, we were once nothing more than chance molecular formations, in a microscopic region of a large puddle: the so-called primeval soup. No one really knows how, but presumably conditions became favorable for some molecules to clump together and replicate, and gradually the statistics of this replication led to inevitable mutation. Mutation is always provided by a complex and unpredictable environment messing with the replication program. Errors occur because the environment intervenes at random in the replicator's task, and these errors get propagated onward in the chain. To cut a long story short, these molecules end up being something like RNA, then later DNA, which have the remarkable property of extremely high-fidelity reproduction.

DNA is only a compressed code for protein manufacture. The real information in biological systems lies in the finished proteins. These fold into complex three-dimensional structures. In fact, DNA is unstable and only ever reproduces inside the protective bubble of cells. No one can be completely sure how cells first formed, but once a single cell had been formed, it allowed for greater refinement of a delicate procedure. Thereafter, DNA copied itself by copying and dividing cells.

The replication game chanced upon increasingly bizarre and intricate multicellular structures: plants and animals. Fortune favored our development into intelligent mechanisms (just replicators nonetheless) capable of understanding, abstracting, and manipulating the world to our own advantage. Our motivations changed from mere replication of biological information to the replication of abstract information: art, science, imagination, belief, and other culture. Much of "intelligent" human behavior can be understood in a framework of copying ideas and themes from person to person. These are called memes ("mind genes"). Successful ideas are not necessarily good ideas, but simply those which copy themselves most perniciously: the awful songs that get stuck in our heads, the images which are most seductive. The whole notion of jingles and catchphrases is based upon this idea: involuntary replication inside human minds. Drive us crazy, but survive at any cost. From this billion year evolutionary process come humans and all the rest of it, including our technology. It is a kind of meme, not a kind of magic.

The evolution of the human body and mind is perhaps the most complex "technology" ever to arise on the planet; the most bizarre and wondrous stalactite, deposited and

mutated by the drip of time, sculpted and refined by the whittling away erosion of natural selection. Tracking this complexity through all its mindless jiggling is so far beyond our comprehension that some still prefer to believe in a supernatural explanation for our emergence, but the principles are clear, if not the details. By comparison, today's information systems are almost trivial, yet still so complex that it is difficult to comprehend them in every detail. Probably it is only the blatant smoking gun that convinces us that humans made computers and that no supernatural explanation is required to explain them.

Biology is about complex chemical machinery which often fails to live up to expectations. We observe and accept its diseases from bitter experience, and invest great effort into researching solutions. Computer systems are about electronic machinery, of lesser but still formidable complexity. Our attitudes toward them are mixed, but seldom consistent. There are users and there are menders, and whichever side we are on, we need to understand the price that complexity brings.

The Sheep Look Up

We take our windows for granted. Technology is treated as a kind of magic to which we are entitled, but which many do not feel obliged to understand, or forgive. Some feel that, if only things were made better, they would not go wrong. The reality might well be that, as things become more complex and more refined, the wrongs only change in character. They do not go away, because that all-important interaction with the environment remains.

The declining interest in technology-related subjects at colleges and universities is no accident. Technology has never been more used or more passé than it is today. The mystery is gone, the vision of a better future, which technology used to symbolize, has been diluted by its perceived triviality. It is just another home comfort, which we can buy in the safe abstraction of a shopping mall, another step into the air-conditioned virtual reality of our contemporary Western theme park. Only computer and mobile communication technologies remain interesting on a wide scale. This seems to be mainly due to the social freedoms and multimedia glamour which they offer, rather than the technical challenges they represent.

But how does society hope to better technologies, or even maintain existing ones, if new generations are not inspired to learn something about them? Sure enough, there will always be a few who remain interested (those of you reading this, I expect), but a situation of dependency on a few figures in a society, no matter how well intentioned they might be, is a dangerous position to place oneself in. Power corrupts. It is a sobering fact that the true driving force behind technological development has not been curiosity, or sense of adventure, but the quest for supremacy.

The evidence of our complacency toward technology is everywhere. It began with the best of intentions: to simplify technology for everyday use. Take the development of windowing systems for computers as an example. Windowing systems offer the possibility of no-knowledge execution of a handful of tasks by pushing big buttons. As a form of communication, icons are trivial and hold only limited meaning. There is no grammar for combining primitives into more complex actions, and thus icon users are locked into a rigid framework from which they cannot escape. It is like holding a conversation by semaphore: it is difficult to order a medium-rare steak or complain about the wine with only the flags provided.

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Keeping complex systems in a stable state is an arms race. Nature will find a way.

Command line interfaces represent the "user-unfriendly" side of computing, but they are grammatical languages within which users can express their precise wishes. This is seldom articulated. Even computer science students will press buttons at random for hours rather than taking a few moments to express their wishes in textual form. In other words, they prefer to hit buttons at random, like rats in an experiment, than invest time in learning a form of expression which would empower them on a whole new level. Whether commendable or not, this must be human nature. We should probably fight it.

These are symptoms of a more general malaise: the convenience society. We began a cycle of making things easier for non-experts. This is a downward spiral which ends up in system designers underestimating user abilities. The BBC news service recently had a serious discussion about whether to follow suit in "dumbing down the news" to bring it more into line with other world news stations. In Norway, the process has already begun. Flaunting the attitude that expertise is not for normal folks is disturbing. Normal folks don't waste their time with that kind of expert nonsense.

Information is power, as they say. Security is the opposite of convenience. Since computers are ever more likely to hold the keys to power in our future, computer designers and managers need to be aware of this problem and counteract it. If computer systems are to be protected from users, while giving users what they need, the issues are not only about simplifying things and making everything as easy as possible. They must be understood.

Why do computers get sick? One answer is abuse, neglect, and even ignorance. They will only get sicker if we do not invest a steady effort in researching their weaknesses. Before the existence of medical research, we were slaves to our limited immune systems. Before the discovery of antibiotics, open wounds would often be fatal, broken bones would lead to disability. The story with our computers will be the same, unless we have our wits about us. Fixed defenses might serve in routine cases, but if one stands still, the enemy will gain an advantage. Keeping complex systems in a stable state is an arms race. Nature will find a way.