

## E-optimism on a tide of red ink

**Telecommunications and semiconductor companies are suffering from a precipitous downturn. But researchers can be sure that a healthy, handy electronic future is on the way.**

The author J. P. Donleavy once wrote that electronic books are a bad thing because they cannot be accumulated on shelves: to remind you of your past, to impress your neighbours and colleagues, and to help prevent divorces thanks to the sheer bother of arguing over who owns what. But despite these and other reasons for paper manufacturers' optimism, electronic media have too much going for them not to displace conventional ink on paper for some purposes, at least. The key questions are: how and when?

How, for example, can the portable and visual convenience of printed *Nature* be emulated electronically? Candidate display technologies — electronic ink and paper, organic light-emitting diodes — are already under development, although combining high resolution, high contrast and stability remains a major challenge. Moore's law, still consistent with foreseeable semiconductor technologies, is set to deliver ever-increasing memory and processing power in handy and affordable forms. Hand-held computers and the Wireless Application Protocol are harbingers of the third-generation (3G) technologies that will allow megabits-per-second data transmission and digital media convergence over the air. Thus, a very powerful combination of readability, functionality and portability is coming into sight.

The Internet's infrastructure is also developing apace. Its brute carrying capacity, with fibre optics, optical interconnections and amplifiers and multiple-wavelength transmission, is huge compared with foreseeable needs. Bottlenecks arise, but engineers are developing switches and routers that are faster and more responsive. Beware of those who advocate an intelligent network, however. Far better to have a dumb but flexible network that allows increasingly sophisticated machines, not to mention people, to interact with each other, rather than rely on network operators to (fail to) anticipate our needs.

### Value of richness

But even in the absence of friendlier hardware, people are being driven to read clunky screens because of the increasing richness of the medium. The web pages and links that were the very point of Tim Berners-Lee's original vision of hypertext are now easy enough to generate, and fast enough to link to, to be a compelling addition to everyday communication. Streaming technologies allow users to listen to radio stations as they work or, more purposefully, communicate dynamic images and data. For the complex, high-throughput data of some sciences — particle physics, gene-expression arrays, neural imaging and suchlike — electronic media are increasingly the only practical means of communication.

Web applications and services will soon become much easier to access. Several software companies are developing the ability to provide Internet users with unique identities or electronic passports. Online suppliers can agree to recognize those identities just as they can a credit card — and an online purchase will be correspondingly easier as well. Gone, then, will be the days of multiple usernames and passwords. For researchers, this freedom, combined with increasing collaboration between publishers in developing links and specialized searching, will make it ever easier to pursue research strands across the literature.

Web applications are also set to become more computationally powerful. In an initiative known as the Semantic Web, the Internet itself is hoped, within a decade, to become an everyday vehicle for communication between technologies as well as people. Meanwhile, supercomputer centres are turning themselves into nodes of the Grid — the computational equivalent of the Internet, using the Internet itself, in which computer algorithms are automatically redistributed around the network as, from one instant to another, demand and local capacity fluctuate. Companies, such as IBM, national funding agencies and the European Union are all developing Grid initiatives.

### Beating the strain

The social aspects should not be forgotten either. Although the global free-for-all spirit is still prevalent among Internet users, a corresponding threat of a tragedy of the commons, in which the resource ultimately collapses under the strain, is likely to be circumvented by regulations and privatization. Less contentiously, Internet investment is rapid in many developing countries, which are generally free of the necessity to pay off previous investments in slower infrastructure, and the Internet's availability is beginning to stimulate a significantly more generous distribution of information.

All very exciting, except that much of this might seem like an increasingly distant and naïve pipe-dream, given the news in recent months. Embarrassing for enthusiasts, geeks and salespeople is the fact that the telecommunications, IT and semiconductor industrial sectors have seen a swathe of cancelled orders, inventories that greatly exceed demand, redundancies and closures. Sales of mobile telephone handsets are in freefall in the West. Telecommunications companies and their suppliers are suffering from the impact of huge debt burdens from 3G licence auctions. This has limited their ability to raise investment and repay loans; as share values have tumbled, dividends have been cancelled and credit ratings reduced to junk.

Nevertheless, and despite the further collapse of the dotcom e-commerce bubble, the underlying picture is positive. Infrastructure continues to develop as governments, businesses and consumers continue to pay for improved network and online services. The convenience, security and value of the more resilient sectors of online commerce — both in retail and business-to-business transactions — continue to grow. Many troubled companies believe it is important to maintain R&D programmes to secure eventual recovery from market downturns. History also suggests that unforeseeable convergence of technologies will lead to new sources of growth and market opportunities. At most, therefore, and barring catastrophes, the arrival of the technologies heralded above should be delayed by the few years of an economic cycle.

For its part, *Nature* will remain committed to the quiescent joys of paper for years to come. But most researchers are literature scavengers as well as grazers, and therefore demand a highly linked and functional electronic literature. *Nature* is committed to their needs too. We, like them, look forward to navigating the waves of hardware and software to come, and damn the stock market's torpedoes. ■