COMPUTING AND COMMUNICATIONS

By

F. J. LAVER, C.B.E.

Abstract

An after-dinner address to the International Seminar on ‘Computers and Communications’ held at the University of Newcastle upon Tyne, 4th-7th September, 1973. This Seminar was the sixth in an annual series on the teaching of computing science, jointly sponsored by IBM and the University of Newcastle upon Tyne.

The swiftly accelerating convergence of computing and communications will, in my view, be seen as the most significant technological change of this century. However, because its two components have traversed separate evolutionary paths there is a conceptual gap which must be bridged if we are to reap the full benefit of their coming together. Users especially, must strive to express clearly exactly what it is they want, and when, and evaluate specifically and precisely how much they are prepared to pay.

Telecommunications and computing have grown out of quite different disciplines, for quite different reasons and have been nurtured by quite different kinds of people. Thus, telecommunications began as an everyday, domestic art, used by the public at large, and developed by practical electricians: only later did it acquire a respectable theoretical base. Computers began as esoteric scientific apparatus, used by a tiny number of specialists in the mathematical laboratories of universities: but although they served the needs of theoreticians par excellence the vast majority of computing (commercial data processing) is not yet backed by any adequate theory.

Telecommunications endeavours to convey data without changing it; of course, it does not succeed but the inescapable changes are seen as degradations as its signals slip inexorably into the abyss where entropy increases without limit, and information decays into rubbish. Computing has a much more robust attitude to data, which it regards as so much raw material to be converted into finished information. I am sure that Shannon has a law tucked away somewhere that says that no amount of processing can increase the amount of information in a set of data - it merely distils and refines what is already there; but you could say the same of the processing that converts barley mash into whisky, and although the food value may be no higher the result is more readily and cheerfully absorbed.

Traditionally, then, communication transports without transforming, and computing transforms without transporting: but today we see these seemingly diverse aims as complementary sub-goals within a wider synthesis which I will call Information Engineering. Telecommunications has always divided naturally into three parts: terminal apparatus, transmission and switching, and it is now evident that these cover
only one-half of a total picture. The three missing pieces of the jig-saw are, or rather were: data storage, data processing and programmed control; and these are just what computing has provided. Two principal forces are acting to push the pieces together.

First, we have the headlong convergence of the two technologies as digital systems are finding favour for both the transmission and the switching of telecommunication signals, in what I can only describe as the rediscovery of telegraphy -- and it would be profitable for some to read through the history of that subject. To this we must add the developments in large-scale integration: LSI needs digital signals and conversely, which means that positive feedback is driving the whole thing along at an ever faster pace. By the end of the century, voice, vision and data signals and their instrumentation will be indistinguishable whether they are being transmitted, switched, processed or stored. Second, we have the continued fusion of computing and communicating at the functional level: real-time systems rely wholly on adequate communications; telecommunications is coming to rely increasingly on stored-program control for channel and message switching, and for signal processing.

When uses converge, markets merge. When technologies converge, manufacture merges. And when marketing and manufacture each overlap, the corresponding industries tend to flow into one. In this area it is worth emphasising that in the UK we are talking of a marriage between equals, and not as you might suppose a telecommunications giant casually inhaling a computing gnat. Marriage is primarily a matter for the principals, but society has an interest in its fruits. It will be clear to all here that, despite the bridegroom’s great age, the progeny are likely to be numerous and to cover the earth -- or, at least, to permeate every aspect of our industrial, commercial, professional, legal, social and domestic lives. I would like to enlarge on just one aspect which is common to all of these applications, namely the capability that information engineering will give for the design and construction of very large systems.

These large systems will offer virtually unlimited opportunities for extending our understanding of, and enlarging our control over, the world around us. Perhaps we shall be able to handle much more nearly complete eco-systems, and in this way buff up the somewhat tarnished image of technology. We shall only be able to do this last, of course, if the will exists and the money is found to pursue the more expensive ethical approach to the total environment. And also, of course, if we know how to set about doing so, for large systems offer rather large possibilities of getting egg all over our faces should we design them without sufficient foresight or understanding. There is an ancient human temptation to run before we can walk, but in this game an ounce of insight will always outweigh many tons of processing. I would like, therefore, to draw your attention to two fundamental limits each of which was put forward humourously by people who were being serious.

The first is encapsulated in a remark of Lord Bowden’s about an early computer that “it, took the united efforts of the staff to keep it on the verge of operation”. Electronic engineers and system designers will always design systems of increasing complexity up to the ‘Bowden Limit’, which is reached when the system just does not work long enough to establish that it is working properly: more formally, Check-out time $\geq$ M.T.B.F.

The second limit I derive from Hans Alfven’s social-science-fiction essay “The Great Computer”, in which he refers to a Sociological Complexity Theorem. There is, I
believe, a Comprehensibility Limit, and as with improved electronic and software reliability the Bowden Limit rises we may well run up against this second limit when our big systems begin to behave in ways that we did not expect and cannot analyse using the system itself to do so: and then we shall be in the same plight as the psychologist, and may heaven help us! Concealed behind the comprehensibility limit there may be an even more obdurate one: may not some actions and events be inherently acybernetic? For example, the weather. What principle requires that the world’s impact on our sensors should be completely explicable by the human brain’s activity.

System designers will have to take such matters seriously; and when I reflect on the potential impact of their productions on our daily lives I could wish that their work rested on a more firm foundation of theory. Let me illustrate by a comparison with civil engineering in which design rests on an excellent, modest, applied science called “Strength of Materials”, which roams widely over the plains of mathematics but avoids its more arid uplands, and which draws freely from the wells of physics but eschews their more arcane depths, It is a decent, dependable, discipline; and in systems work we desperately need its like.

It has been predicted that information engineering will become one of the three larger industries in the world, and that information will become the principal economic resource. When these thoughts are added to those that have been so apprehensively voiced about such issues as the invasion of individual privacy, it becomes apparent that all concerned in the design and operation of large information engineering projects have very great social responsibilities. The synergy of computing and communications is placing at our disposal the most powerful instrument any man has ever had for increasing his understanding and control of human affairs: but the understanding and control of the instrument itself will (as a matter of fact, and not of law) remain concentrated in the hands of a tiny fraction of the population. In this we have the genesis of some difficult and potentially troublesome political problems, and their satisfactory solution will demand the exercise of great responsibility as well as great skill. It is for this reason, above all others, that I support all efforts to transform ‘computing’ from a mechanic art into a profession - today’s ugly duckling must become tomorrow’s swan.

However, I am optimistic; as they say in the prologue to “Star Trek” we have “to boldly go where no man has gone before”, splitting our infinitives if necessary as we go, but always tempering our logic and our economics with wisdom and compassion.