PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

On the Relation between Information Technology and Socio-Economic Systems [and Discussion]

G. B. Thompson and E. D. R. Shearman

Phil. Trans. R. Soc. Lond. A 1978 **289**, 207-212
doi: 10.1098/rsta.1978.0057

Phil. Trans. R. Soc. Lond. A. **289**, 207–212 (1978) [207]
Printed in Great Britain

On the relation between information technology and socio-economic systems

By G. B. Thompson
Bell-Northern Research, Ottawa, Canada

The developments over the last decade in digital switching data networks and intelligent signal processing suggest an almost unbounded future in terms of opportunity. But who needs it?

Information technology appears to act upon our socio-economic system in a manner that is quite different from the way other technologies affected earlier socio-economic systems. In those earlier instances a reasonable balance was maintained between the intensive, or extrapolative interactions and the extensive or transformative ones. Today, we can establish a non-trivial hypothesis that states that the extensive or transformative interactions between information technology and our socio-economic system are being somehow constrained and hence denying us considerable economic and social benefits. The hypothesis stands up under the Socratic test, in that the conclusions deduced from the hypothesis match what we see in the real world.

If one takes the hypothesis as given, is there any real potential that is being constrained, what is the value of that potential, and what might be the nature of the constraint? Research suggests that the potential exists, that it may be very significant, and that the constraint is of a fundamental linguistic nature. Some strategies are set forth to avoid or move the constraint.

If the hypothesis is valid and the important benefits of information technology are inhibited from flowering, of what significance is all our fine technology? The prediction is made that unless we address that fundamental constraint, the future for information technology is at the best rather bleak and intensely competitive, for our capacity to produce sophisticated communications will outstrip our needs.

A comparison of the performance of the British economy under the beginnings of the industrial technology and economies today, as information technology becomes rampant, suggests that information technology may not be as powerful as was once presumed. From 1755 to 1805 the cost of living in London rose an average of 1.4% per year. The labour force increased significantly and there was no serious unemployment. Industrial technology, pushed by minor martial activities, produced a remarkably stable era during the transition from the mercantile to the industrial economy. In the U.S. today, half the labour force is engaged in the processing and handling of information or the creation of information-type products. This activity is not regarded in nearly the same way as industrial activity was early as 1813, when, in Britain, with only one third of the labour force engaged in the industrial sector, that activity was recognized for its economic significance.

It is not clear that the mere act of providing today's information worker with more sophisticated 'tooling' would significantly improve the situation. There is a tendency to apply this strategy, because the information worker, in comparison with the industrial worker, seems under-supported in terms of capital tooling. Before we rush off and invest large sums of money on an essentially untested hypothesis, by developing 'integrated service networks' and other

sophisticated communications facilities, we should ask the basic questions and do the research needed to assure that the results will be worth the effort.

A simple model of the interaction between a technology and a socio-economic system consists of classifying these interactions into two sets. In the first set, one places all the interactions that represent intensification, substitution, and extrapolation. This set of interactions between a technology and a socio-economic system can be called the intensive set. The second set, the extensive, involves more transformative interactions between the technology and the socio-economic system.

These intensive interactions between a technology and a socio-economic system involve such notions as cost reduction, productivity, efficiency and labour release. An example of an intensive interaction between steam technology and a socio-economic system can be found in the replacement of the donkey with the steam engine in supplying the motive power for the mine hoist. The steam engine could hoist heavier loads faster and cheaper.

Taking the same steam engine, mounting it on wheels and having it run along rails, produced something different. New cities sprang up along the rails in North America and other parts of the world. Here, the higher order impacts turned out to be more important than the first order impacts. This is the significant characteristic of the extensive set of interactions between a technology and a socio-economic system. These interactions are transforming, labour absorbing, and have higher order impacts that exceed the importance of their direct impacts.

The direct impact of the iron stirrup was not as significant as the chain of events that unfolded as a direct result and which finally culminated in the feudal economic system. The iron stirrup allowed a rider to deliver a blow from horseback that capitalized upon the mass of the horse in intensifying the blow. This meant that wars could be fought by warriors on horseback. Previously, combatants rode their horses to the field of battle, tied them up, and fought on foot. The iron stirrup changed all that. The mounted warrior led to the fully armoured warrior. The investment needed to equip such a warrior was now more than could be supplied by a single peasant. Hence, citizens had to be organized into groups to pool their resources. This was the foundation of the feudal economy. The iron stirrup exemplifies a very extensive interaction between the technology of iron and the socio-economic system of the day.

If we consider the situation in Britain two hundred years ago, recognizing that improvements in health care resulted in a considerable increase in the worker population during the latter part of the eighteenth century and that the economy flourished quite well, we can only conclude that there must have been a reasonable balance between the intensive and extensive interactions. They were not plagued with the double-headed devil of inflation and unemployment. In fact, in Lancashire, real wages increased during the latter half of the eighteenth century while prices also advanced. Elizabeth Gilboy, discussing this point, concludes that increasing real wages may occur simultaneously with advancing prices in periods when extraordinary industrial and technical changes are under way (Gilboy 1972). Perhaps today's problem is that we do not have extraordinary industrial and technical changes happening, in spite of our belief to the contrary.

Building on the model of interactions between a socio-economic system and a technology consisting of an intensive class and an extensive class, one can hypothesize that there is some kind of constraint inhibiting the extensive interactions between information technology and our socio-economic systems.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

For some one hundred years, we in the telecommunications industry have been working very hard at producing services that are efficient, reliable, inexpensive, and widely available. We have been very good at innovations involving the intensive interactions between information technology and our socio-economic system. Perhaps we have been singularly lacking in either conceiving or developing those innovations that are truly transformative, wealth creating and labour absorbing, and so are members of the extensive set of interactions between information technology and our socio-economic system. A list of the new services proposed for integrated service networks reveals that these services are substitutions for what already happens today, and so are likely members of the intensive class of interactions between information technology and our socio-economic system. It is difficult to find in suggestions for new services anything that is likely to have higher order impacts of sufficient significance to classify that service as a member of the extensive set. To be particularly horrified, one only has to look at the proposal for systems that 'aid the office worker'. Here, the motion of intensification is rampant. Only in the most futuristic projections does one see any seeds of transformation.

If we accept the premise that there is some constraint acting to inhibit the extensive set of interactions between information technology and our socio-economic system, and so withholding from us the significant benefits of this technology, what might be the nature of the constraint? At the moment, there appear to be two candidates for this rôle. The first is economic, and the second linguistic.

Edwin Parker (1976) has pointed out that our classical economic system is unsuited for many of the transactions involving information. To force information to live by the economic rules that have been developed for the regulation of a world where the ownership of things, and rights, and scarcity were the principal factors, seems inconsistent. Information is a very strange good, in terms of our past experience with goods. Information is self-replicating. It is not scarce, and in fact may have problems that are special to it because of this fact. Given this economic inconsistency, which is extremely basic, the flowerings of extensive interactions between information technology and our society can be expected to be discouraged rather than encouraged. An economic system that is designed to accommodate the exchange of singular, non-replicating goods, can hardly cope with so recalcitrant a good as information. If the first halting steps cannot receive economic encouragement, how likely is it that bigger steps can be achieved? Fortunately, the industrial revolution did not face this kind of problem. It is not at all clear that the communications systems that develop under a classical economy tuned to conventional goods transfers, etc., would, in the long run, necessarily serve the best interests of a society at large.

The industrial revolution can be characterized as the replacement of muscle with machine. The intelligence that directed this process was outside the process itself. Today, the situation is different. Information technology relates to the augmentation or replacement of intellect. The intelligence guiding this process is involved in the process itself. Intelligence communicates through language and we really do not understand fully this whole process. This lack of knowledge is a constraint on our ability to build machines that intelligently process ordinary language.

Our written language today has its roots in the technology of a stick scratching in sand. Even today's typewriter still strikes the medium with blows, very reminiscent of the early forms of writing. Our technology today offers us the opportunity to develop new language forms beyond the one we now have. Besides communicating mouth-to-ear, we have the opportunity to

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

develop new forms of graphical communication involving fingers, eyes and the new technologies. In fact, unless such a development occurs, we can assume that the technology was somewhat trivial.

These two constraints, the economic and the linguistic, are somewhat different in nature in that the economic one represents an artificial measure being somewhat misapplied and so constraining the early recognition of utility, while the linguistic one represents a frustration of real utility, regardless of how it is measured. In combination, these two constraints could be very significant in frustrating our realization of worthwhile benefits from our use of information technology.

By constraining the interactions between information technology and our socio-economic system to the intensive class of interactions, we could well exacerbate the difficulties. Consider again the application of information technology in the office area. Much of the activity in this area represents an attempt to use the computer to aid in the preparation of documents. The underlying theme here is to improve the productivity of document preparation. Surely this can result in nothing but more documents being prepared, with a strong tendency towards a lowering of the quality of those documents. Like the Xerox machine, this technology merely increases the need for larger 'in' baskets and waste paper baskets. It is not clear how this increase in lower quality information can really help.

The combination of an implicit faith in the value of information technology and the almost complete confinement of this activity to the intensive class of interactions can produce a level of competitive activity that would not necessarily benefit the key actors or the society at large. This is all the more the case in view of the misalignment between conventional economics and that that might be more suitable for an information society. The return on investment that the society might get under such situations, for its efforts in the area of information technology could be one of diminishing returns. It is difficult to develop alternative arguments that do not involve faith, hand-waving and other such emotion-laden techniques.

Appealing again to British history, there is a model that may be of some use: the solution to the problem of determining longitude at sea. The experts of the day were incapable of providing a suitable solution to the problem, and a solution was only forthcoming after the British parliament made a prize of £20 000 available to the person who solved the problem. You will recall that John Harrison, a carpenter's son, came up with a successful chronometer design that met the criteria. The public prize greatly increased the pluralism with which the problem was attacked. The solution did come from an unlikely source. Perhaps we need to sufficiently demystify information technology so that ordinary people can contribute to the learning that seems required before the society can fully benefit from its use of this new information technology.

If neither good research nor other more pluralistic learning strategies produce a lessening of our dependence on the intensive class of interactions between information technology and our socio-economic system, there is a high probability that George Orwell's *Nineteen eighty-four* will be our fate, if institutions in which humans are used only where information processing machines cannot deal with the particular information problems involved. Surely the postal worker, reading postal codes from envelopes and keying these data into a machine that prints, in machine-readable format, instructions for the subsequent sorting machines, typifies this abysmal use of human potential. If this is what the information society really is, then let us choose some other alternative.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

There may be, however, some strategies that we can invoke to release some of the extensive potential of information technology. The rapidly evolving computer graphics field is spawning the study of graphical communication as a basic means of communication. Were this technology to become ubiquitous it is fairly reasonable to expect the development of a form of iconic writing in the Western World. Given the computer and such displays, it would be a relatively simple matter to educate the young to have great facility in such a language. This language should be based on a limited number of visual 'phonemes' that would be combined dynamically by the computer to create complete thoughts. Earlier iconic languages were quite static, and could not make use of the time-varying capabilities that our present technology has. It would be a relatively simple matter to create a short audio-visual sequence using such a medium to express one's ideas on a particular subject. Key-frame techniques and other animation aides would make this process relatively easy. The Bliss symbols (Bliss 1965) now used in Ontario schools for handicapped children do form an iconic language, but its syntax is similar to our spoken language. We have the opportunity to develop a visual language based on time varying icons and using an alternative syntax to our spoken language.

Such a possibility is exciting and has the potential of producing impacts far beyond that of merely easing our communication. Such a proposal may not be practical to you and me, but could be very significant for those who follow. Such a development could increase the rate at which information is processed in people's heads and so produce some exciting developments. It is a bit difficult to see how an entrepreneur, in today's economy, could justify the research and development efforts required to produce systems and products aimed at achieving this kind of objective. Our current economic discount analysis techniques make such dreams unreal. But these kinds of dreams may be the only ones that make a tomorrow for our world real.

References (Thompson)

Bliss, C. K. 1965 *A logical writing for an illogical world*, Second enlarged edition. Semantography (Blissymbolics) Publications (non-profit), 2 Vicar Street, Coogee, Sydney, Australia.

Gilboy, E. W. 1972 The cost of living and real wages in eighteenth century England. In *Europe and the Industrial Revolution* (ed. S. Lieberman), pp. 193–208. Cambridge, Massachusetts: Schenkman.

Parker, E. B. 1976 The assessment, control and management of developments in telecommunications and information systems. *Telecomm. Policy* **1**, (1), 3–20.

Discussion

E. D. R. Shearman (*Department of Electronic and Electrical Engineering, The University, Birmingham, U.K.*). I should first like to add a comment to the discussion on Mr Thompson's paper. This is that rather a caricature has been made of the contribution (or rather lack of contribution) made to the economy by telecommunications. I was left with an image of a home facsimile machine pouring out unread newspaper into a waste-paper basket for pulping into more paper for re-use by the machine, certainly an unproductive process. But telecommunication can in fact give more power to a worker's elbow just as the steam engine did to the coal-miners and mill-workers of the industrial revolution. To see a foreman controlling a construction project with his mobile radio, or a dispatcher controlling a lorry fleet, is to convince one of this. Perhaps it is for the telecommunication planners to put their priorities into services like these which work for us rather than contributing to all this intolerable graffiti.

My second comment is a criticism of the balance of this Conference, which, though I have enjoyed and learnt much from it, does not live up to its title. It has in fact covered only common carrier communications as provided by Post and Telephone Administration; it has mentioned only in passing the whole field of mobile radio, land, sea and air, and has omitted completely h.f. communication. As I go round the firms of the Electronic Engineering Association I see a great deal of equipment in production in these categories, over half of it for export. It is forecast that the free-world market in mobile radio alone will be about £9000 M at current prices in the year 2000 with a likely U.K. export share of nearly £300 M. We therefore ignore this field at our peril.

I should not like an outsider to leave the Conference thinking that he has heard a balanced review of the field of telecommunications.

G. B. Thompson. If I managed to cause Professor Shearman to perceive the 'Sorcerer's Apprentice' electronic newspaper machine as being totally unproductive, then I have achieved one of my goals. It is, after all, merely a new way of doing something old. As such, a member of the Intensive class of innovations.

The two other examples cited are also members of the Intensive class of innovative interactions between Information Technology and our socio-economic system. This pair illustrates the importance of doing this class of innovation well. It is not the Intensive class of innovation I am decrying, but rather the lack of significant members of the Extensive class.

Josiah Wedgwood was a superb industrial engineer, and introduced many Intensive class innovations into the manufacturing of pottery, some of which are still used today. He was, in addition, a marketing and research genius, and transformed the pottery business from a moribund craft industry into a full-blown labour-absorbing one that had impacts extending even into the health of the population by mass producing inexpensive pottery that could be properly cleansed. In his activities, we see a balance between the Intensive and Extensive class of innovations. This is not the case with our present use of Information Technology, there being a very heavy bias towards the Intensive class with the other class being virtually absent. I suggest that the real peril is the continuation of this imbalance.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES