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BEFORE COMPUTERS

On Information Technology from
Writing to the Age of
Digital Data



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3. Sending messages: electricity

A new medium

The ideal method of sending messages over a distance would not involve the physical transfer of an object at all. The use of bonfire beacons is an old method suitable for a limited number of tasks; slightly more sophisticated is the smoke signal. Both of these have a venerable history. A more recent (eighteenth-century) idea was semaphore, sometimes used for Naval signalling, using hand-held flags or mechanical arms, involving a simple alphabetic code. But major developments in this direction arose from the evolving understanding of electricity. The idea of using electricity for point-to-point communication is almost as old as the serious investigation of electricity as a physical phenomenon. It is certainly older than the notions of using electricity for power, heat or light.

Various systems of signaling using electrical methods were proposed in the early nineteenth century, but the one that had the greatest impact was the system of telegraphy devised by Samuel Morse. This, unlike the earlier proposals, used just one wire, but had a distinct electrical code for each letter of the alphabet. This is the famous Morse Code, consisting of dots and dashes (short and long signals), still occasionally in use today. (At the time of writing this paragraph, one particular brand of mobile phone has, as its default audible signal for the arrival of a text—that is, an SMS—message, the letters SMS in Morse code.)

Morse's electrical system, transmitting codes down a wire, takes us one small step further from visual signals, which is nevertheless a giant leap towards the huge developments of the late twentieth century.

We might also notice how the invention of the alphabet, some three millennia earlier, paved the way. Given that we can construct any message using only the letters of the alphabet (perhaps with a few extra characters such as

digits and some punctuation), the notion of using a similar small number of codes, which may be manipulated by some physical mechanism, is simple but revolutionary. Now we can transmit *any* message in our language, via writing and the alphabet, using on-off electrical pulses sent along a single wire. It's enough to blow the mind.

The telegraph

As Tom Standage's book *The Victorian Internet* shows us, Morse's telegraph became, around the middle of the nineteenth century, a huge success—not just commercially, but in revolutionising our view of the world in general and communication in particular. Suddenly the speed of physical communication, messengers carrying messages, was no longer the limiting factor in long-distance communication. The achievements of the *Cursus Publicus* and Thurn und Taxis no longer mattered. Provided you had a wire running from A to B, messages could be delivered to all intents and purposes instantly. And wires there were. Networks of telegraph wires spread like wildfire across the developed (and sometimes the less developed) portions of the globe.

But what is most extraordinary about this process is the way in which people suddenly discovered the *necessity* for fast communication, and embraced the medium. Just as the far cheaper and easier penny post was at the same time inviting vast numbers of people to enter the letter-writing age, other groups were discovering the wonders of instant communication. Governments, military authorities, businessmen and news organisations all found it was a medium that they could not do without.

There was never any serious competition between the postal system and the telegraph. The needs for communication expanded to such an extent that both media could simultaneously grow at a prodigious rate. We have not yet reached the heyday of post; the telegraph will in the end turn out to be a rather short-lived medium, because of real competition from the telephone and other media.

Printing telegraph

We are now well into the period of Victorian invention, and many challenges were quickly recognised and taken up by the inventors of the time. Morse telegraphy required a human operator at each end, to make the conversion both ways between the written letters and the dot-dash code. How much easier it would be, people realised, to have machines do these conversions.

Although the eventually successful printing telegraph service, the telex, was a twentieth-century development (actually later than the telephone), there were several nineteenth-century precursors that achieved some degree of success. One of these was due to David Hughes. In the tradition of inventors of the time, he was a polymath; he was eventually honoured as a physicist, and has a Royal Society medal named after him. But in 1855, when he was a professor of music at a college in the United States, he devised a system with a keyboard and a printing wheel. The sender would type out the message letter by letter on marked keys, and the receiving machine would print the message on a sort of ticker tape.

The image that comes to mind from this description is probably the typewriter-like keyboard with which we are now so familiar. I will be talking about the QWERTY keyboard later, but the modern typewriter had not yet been invented in 1855. However, Hughes took his inspiration from the much older keyboard tradition with which he personally was particularly familiar. His keyboard, with alternate black and white keys, looks like nothing so much as that of a piano.

In fact he was not the only, nor even the first, person to consider using something like a piano keyboard for keying alphabetic messages. A slightly earlier device in the vein of printing telegraph was developed by Royal Earl House—his keyboard too was piano-like. In truth, until the invention of the QWERTY keyboard late in the nineteenth century, the piano and its predecessors defined the canonical idea of keyboard control.

Telephony

Even better than writing a message out on a keyboard and then reading a printed version at the other end, would be to speak and hear it. Again, this was a challenge to which the Victorians rose with enthusiasm. In 1876,

Alexander Graham Bell won that particular race by a short head over Elisha Gray. David Hughes was not involved in this race, but he did, within two years of Bell's patent, invent the carbon microphone. The era of the telephone had begun.

But quite quickly, a new dimension was added. The telegraph was a specialist point-to-point messaging system rather like the postal system, with wires strung between offices that acted as gateways for the messages. With telephones, everyone wanted a piece of the action.

The wires had to go to people's homes, and the gateway became the switchboard or exchange, operated by a human being. Directing calls involved connecting one bit of wire to another, via a plugboard. Although manual exchanges continued for a long time, and are familiar to us through films, already in the nineteenth century people were devising automatic exchanges.

The earliest automatic exchanges were of the rotary type. The rotary telephone dial in effect controlled a rotary switch, which moved in synchronisation with the dial. In this system, the number dialled was not held in the exchange (except implicitly in the position of the dials), and not used in any other way. However, already by the 1930s there were exchanges that remembered the dialled digits in a register (like the register in a calculator) and had embedded decision rules about how to route different numbers. This is a form of information processing to which I will return.

Over the course of a century of development of the telephone system, we eventually reached a universal addressing system—a system of numbers defining not only the line on the local exchange, but the exchange itself, then the city or wider area, then the country—so that by the late twentieth-century, a full telephone number represents a single household on the planet. This is comparable to a postal address, somewhat less transparent to a human reader but more amenable to mechanical manipulation.

Radio

By this time, of course, we also had radio: wireless electrical messages. Radio broadcasting will be discussed further below, but it was also used for direct one-to-one communication from very early. Point-to-point radio, radio telephones, international telephone calls routed via satellite, and mobile

cellphones, all make use of this medium.

This is a slightly curious development, because radio is naturally a broadcasting medium. That is, a message transmitted by radio can be received by anyone within range and with a suitable receiver. Basically, in order to use it for point-to-point communication, we have to subvert its primary nature. Later, we will see other examples of subverting media to serve other purposes than their nature would suggest.

The technicalities of constructing a temporary link between two telephones for the purpose of making a call (now more like a virtual link than a physical wire) have of course become somewhat more complex, and depend heavily on other late-twentieth-century developments in information technology. The addressing system in the form of telephone numbers has been pushed a little further—now, in the mobile phone age, it designates a unique individual on the globe. Well, that is a slight exaggeration—really it designates a unique phone, but given the present-day spread and use of mobile phones, it's coming close.

Email and text messaging

Perhaps the medium that has provided the closest rival to the postal service is electronic mail. Email systems followed the development of computer networks in the last third of the twentieth century, but really took off with the Internet in the 1990s.

Email is also similar to post in that a one-way message is self-contained—a package with an address on the outside. It does not matter much to the sender or recipient what route it takes; it may go through any number of switches, and some delay at some of the switches is not generally critical. Nevertheless, it took email some time to learn the lessons that the postal services had learnt in the previous century, namely that what was required was a universal addressing system and transparent interfaces between the networks. If you wanted to send a long-distance or international email in the 1970s, you would have had to specify the route to be taken, or at least the main staging-posts along the way. One system used the so-called 'bang notation', leading to an address like this:

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utzoo!decvax!harpo!eagle!mhtsa!ihnss!ihuxp!grg
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This means that I want to reach a user called *grg*, whose mail account lives on a machine called *ihuxp*—but my machine does not know about *ihuxp*. Instead, I tell my mail system to send it to a machine called *utzoo*, which should forward it to *decvax*, which should send it on to *harpo*—with three more intermediate machines before it reaches its destination. In order to send the email, I have to know the route. Furthermore, each staging-post would add another address wrapper around my message, so that even a short message would arrive encased in several layers of headers.

But the Internet and the universal addressing system eventually arrived, and the niche occupied by email in the assembly of communication methods open to us has expanded vastly. For all its similarities to conventional mail, it turns out to have some substantial differences also, and its usage reflects these differences. For example, while it is possible to write the kinds of letters one used to send by post, it is also possible to use email in a much more informal and immediate way—to hold conversations by email that have at least some of the characteristics of spoken conversation.

Another medium that has emerged in the last few years is text messaging. This is a most interesting development, because it has no obvious precursor. As a result, the niche that it has now come to occupy was practically invisible until texting started to become popular (although the informal end of the email spectrum provides some clues). But it shows clearly that despite the huge and obvious advantages of speech, written communication has some distinct advantages of its own. It might be hard for generations not brought up with it to recognise texting as a written form of communication; nevertheless, that is what it is.

A note on electricity

In this chapter, I have regarded electricity purely as a ‘medium’ for communication. Although we have known tiny bits about electricity for millenia, the serious scientific study of the phenomenon did not begin until around the seventeenth century. But in the nineteenth, we began to discover some of its uses. And our love affair has proceeded at pace. By the end of the nineteenth century, we have made serious inroads into electrical engineering, and have begun to think of it as a resource with many functions. In the twentieth century, it will come to be seen as a vital service to which everyone

should have access, with a status almost comparable to the supply of fresh water. Nowadays I have a plethora of electrical devices, and the expectation (even if I am occasionally disappointed) that I can get the electricity needed to run them anywhere in the world, in a standardised form.

And then in the twentieth century our understanding of electricity spawns a monstrous offspring—electronics. Already by 1883 we have photosensors; then the thermionic valve (1904), the flip-flop circuit (the original electronic form of a single-bit memory, 1918), the transistor (1947), integrated circuits (1958), a whole variety of sensors, and so on. In the electronics era, the uses of electricity multiply a thousandfold, leading up to and including the entire digital world.

A full exploration of this aspect of our history would take me too far away from the main themes of this book—though it certainly counts as one of the necessary precursors of the digital age.

The connected world

Now, at the beginning of the third millennium CE, we have a range of methods of communicating with others, which is unparalleled in history. Whether the person we wish to communicate with is in the next office, across the street, across town, the other side of the country, or half way round the world, we have ways to make our messages heard. With a variety of media, at least three global addressing systems, and transparent routing, we are spoilt for choice. In this sense at least, it's a small world.

In the next chapter, we go back again in time, in order to consider the idea of *broadcasting*.

