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The History of Communication Media

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Introduction

What follows is on attempt to discuss the history of communication technologies - as far as this is humanly possible - in general terms. The objective is ultimately the outline of a scientific history of the media - an outline for the simple reason that media sciences is a new field of research which would not exist had it not been for the triumphal advance of modern information technologies. This is why such a history comes up against methodological and practical problems.

One practical problem is that communications technologies themselves are documented to a far lesser extent or are far less accessible than their contents vide the manner in which the intelligence services have remained, despite their frequently decisive role in wars (to quote the last head of the Wehrmacht intelligence service, "the Cinderella of military-historical research" [1]

Then there is the methodological problem posed by the conundrum of whether the now so self-evident term "communication" can properly be used in connection with times and locations which manifestly were characterised by other terminology (drawn from mythology or religion). At any rate its enthronement in philosophy was based in John Locke's "Essay on Human Understanding" on the scarcely generalisable assumption that communication means the rendering into speech of perceived ideas and consequently the linking of isolated individuals through "bonds of language".[2] The only trouble is that philosophy omits to enquire how, without language, people are supposed to have arrived at their ideas and conceptions in the first place. Liberation from this unfathomable confusion came only with a technical concept of information which, since Shannon's "Mathematical Theory of Communication", avoids any reference to ideas or meanings and thus to people.

Information systems in the narrowest sense of the word are, it is true, optimised in terms of the storage, processing and transmission of messages. Communication systems on the other hand because in addition to messages they also control the traffic of persons and goods [3] comprise all kinds of media (in McLuhan's analysis) from road systems to language.[4] There is nonetheless good reason to analyse communication systems in the same way as information systems. Ultimately, communication too depends on control signals, the more so the more complex its working; even the triad of "things communicated" - information, persons, goods - can be reformulated in terms of information theory:

- Firstly, messages are essentially commands to which persons are expected to react [this definition in the original German is based on the etymology of the German word "Nachrichten" - Tr.].

- Secondly, as systems theory teaches, persons are not objects but addresses which "make possible the assessment of further communications".[5]
- Thirdly, as ethnology since Mauss and Levi-Strauss has taught, goods represent data in an order of exchange between said persons.

However if data make possible the operation of storage, addresses that of transmission and commands that of data processing, then every communication system, as the alliance of these three operations, is an information system. It depends solely on whether the three operations are implemented in physical reality to what extent such a system becomes an independent communication technology. In other words the history of these technologies comes to an end when machines not only handle the transmission of addresses and data storage, but are also able, via mathematical algorithms, to control the processing of commands. It is thus no coincidence that not until the start of the computer age, that is, when all operations of communication systems had been mechanised, was Shannon able to describe a formal model of information. This model comprises, as we know, five connected stages [6]:

- Firstly there is an information source which selects one message per unit of time from the either enumerable-discrete or innumerable-continuous quantity of possible messages.
- Secondly this source supplies one or more transmitters which process the message via suitable coding into a technical signal (something which is quite impossible in the discrete case without intermediate data storage).
- Thirdly these transmitters feed a channel which safeguards the transmission of the signal in space and/or time from physical noise and/or hostile interference.
- Fourthly these channels lead to one or more receivers which reconstitute the message from the signal by subjecting it to a decoding algorithm inverse to that of the transmitter, so that finally,
- Fifthly, the retranslated message arrives at the address of an information drain.[7]

This elegant model, however, cannot simply be applied to the factual history of communication technology, not least because it lays no claim whatever to historicity. Instead of simply accepting Shannon's five black boxes, as has become customary in linguistics and the humanities too, it seems more important and more rewarding to trace back through history how their evolution must have proceeded in the first place. Taking Luhmann's premise that communication technologies provide a "first-rate demarcation of epochs magnetising all else" [8], it is reasonable to conclude that the historical transition from orality to the written word equated to a decoupling of interaction and communication, and the transition from writing to the technical media indeed to a decoupling of communication and information. What we have here, therefore, is a process of evolution which has come to a conclusion only in the theory and practice of an information which corresponds to the exact opposite of the energetic concept of entropy.[9]

This evolutionary process gives us the possibility of dividing the history of communication media into two main blocks. The first block deals with the history of writing and itself divides into a section on scripts and one on printing. The second block on technical media will take us from the basic invention of telegraphy via the analog media to, finally, the digital medium of the computer.

A. Writing

1. Script

The history of the literate cultures, whose "medium" customarily also divides history from prehistory [10], is determined by two series of variables. The first series stands in relation to what philosophy since the Stoics has recognised, or failed to recognise, as a reference: To the extent that the content of a medium is always another medium [11] and that of writing (even for Aristotle [12]) is speech, scripts can be classified according to whether they process everyday languages into pictographs or syllabic or phonemic signs.[13] However to the extent that the medium of writing, probably for the first time, also couples storage and transmission, inscription and post, then physical variables relating to writing implements and writing surface decide as to the space and time frame of the communication. These variables dictate the time needed for transmitting and receiving, the permanence or erasability of what is written and, not least, whether the information is transportable or not.

The first series of variables controls developments between speech and writing: degrees of memory performance, degrees of grammatical analysability, the possibilities of coupling speech with other media. As an independent field of anthropological media research it can, for our purposes, be left to one side.

The second series of variables has received considerably less attention, possibly because it is so material in nature. And yet it is such simple things as writing implements and writing surfaces that determine the gain in power in which the introduction of scripts always results. If priests were interested in the storage of addresses, that is, of gods or the dead, for a maximum length of time; if merchants were interested in the storage of goods over a maximum length of time and in the transportation of goods over maximum distances and finally warriors in the transmission of commands over maximum distances in the shortest possible time, then the oldest scripts which were produced some 3000 years BC in Sumeria and Egypt had economic and religious functions. In warrior circles however, that which military historians call the oral "stone age of the command flow" ended only with Napoleon.[14] Apart from commands passed from mouth to ear there were only the semiotic use of fire for signaling purposes and fast but equally oral messengers, whose record was probably held by Genghis Khan.[15]

The first manifestations of script are of course inscriptions without a writing surface in the accepted sense. Two-dimensional rolls of seals or stamps in the medium of clay enabled goods to be given addresses indicating their owner or their contents. Stone inscriptions named the deceased occupants of tombs.[16] As signals in the absence of the source of information, in other words through the decoupling of communication and interaction, inscriptions opened up, according to Jan Assmann, the possibility in principle of literature.[17]

By contrast an administration of those great river irrigation systems in which cities and high cultures blossomed presupposed the transition from inscribed tablets to skillfully crafted and optimised transportable writing surfaces: bamboo and mulberry in China, unfired clay or clay fired for storage purposes in Mesopotamia, papyrus as the monopoly of the Nile delta. Thus the same rivers on which the traffic of slave labour and goods flowed simultaneously carried (on the basis of a calendar or goniometric mathematics) the commands of water allocation and the harvesting of products.[18] The same cities that translated the anthropological schema of head, hand and torso into the architectonic schema of palaces, streets and storehouses [19] needed scripts for the processing transmission and storage of their data. This establishment of a unified area is reflected in the texts themselves as a spatialisation of speech: since its very beginnings writing has yielded lists without context which bear no traces of oral or written communication networks, but for this precise reason no longer have any equivalent in everyday situations.[20]

By contrast, outreachings beyond the unified area - the founding of empires in other words - only became possible when states in both the ancient world and the modern took over control of the warrior messengers and additionally, in the ancient world since 1200 BC, after the crossing of two breeds of horse, made messengers and warriors mobile.[21] In classical times, "There was," in the immortal words of Herodotus, "nothing swifter on earth" than the alliance of media which, under the Achaemenides, combined Persia's Royal Way with a mounted staging messenger service to carry "urgent messages at a fast trot, in the face of all natural adversities, from rider to rider, from stage to stage.[22] Angareion, the Persian name of this military mail, is the root of the Greek word for messenger and consequently of all Christian angels.

The Greek polis had but one script to set against a communications empire such as the Persian, but in contrast to oriental bureaucracies it was entirely susceptible *of orality. Firstly the Greek alphabet (from Indo-European necessities and because it developed in the course of commercial and translation intercourse with semitic consonant scripts) turned redundant consonants into vowels, thus performing the first total analysis of a spoken language - and in principle of all such.[23] The fact that vowel signs for the first time encoded prosodic-musical elements of speech permitted of a musical notation, and in the Pythagorean school for the simple reason that Greek letters also possessed numerical values [24], a mathematisation of music, to the extent that this remained a matter of abstract intervals.

Secondly, the triumphal progress of the vocalic alphabet seems less to be the result of an overestimated degree of innovation rather than of the unambiguity of its phoneme allocation. This minimised the effort required for literacy and thus transferred palace and temple secrets to the public domain.[25] It became possible for literature firstly to incorporate oral mnemonics (such as airs or rhapsodies) and later also prose.[26] Athenian tyrants founded the first public library; the bookworm Euripides became the "first great reader" among writers.[27]

These ancient scrolls got their Biblical name from a papyrus-exporting city in Phoenicia whose place was taken as of 5O0 BC by the Nile delta. The Imperium Romanum too, after the conquest of Egypt, based its command network - which is what the empire was - on a combination of mounted staging messengers, madeup military roads and easily transportable papyrus. The empire, in other words, combined despotic transmission mechanisms with a democratic alphabet. The cursus publicus which Augustus set up, with overnight stations at distances of 40 kilometres and staging posts at around 12 kilometres, exclusively for officials and legions [28] became, despite this, or perhaps precisely because of it, the crystallisation point for European towns. In combination with beacon telegraphy at sensitive frontiers, a state postal service, which was faster than the fastest ships and was not excelled until Napoleon, transmitted imperial power as such: "Caesarum est per arbem terrae litteras missitare" [29], as a late Roman writer has it - "It is the office of emperors to send written commands across the world." In comparison with this perfect transmission medium for said world and Caesar's news-sheet distribution in the city of Rome, data storage - even if there was an imperial *officium sacrae memoriae* since Hadrian - remained technically retarded.

Papyrus may be light, but it is fragile and impermanent. It could only be stored in rolls and read with two hands. In the opinion of Alan Turing, the first computer theorist, "it must have taken some time to look up references in such volumes".[30] It was not until the arrival of the codex in parchment, used first by the library of Persimmon for circumventing the Egyptian papyrus monopoly, and by Christians since 140 AD, that indexing by location, sheets and finally sides, became possible. Books, which were durable, erasable (as in the palimpsest) and addressable with special pages (indices) were worth their extra weight and extra cost. They decoupled increasingly cursory reading from the laboriousness and slowness of orality. When Bishop Ambrose of Milan (according to the testimony of his best-known disciple) read a codex "his eyes swept over the pages extracting the essence of the meaning while he himself remained silent".[31] In the codex, the transportable, addressable and interpretable scripts of former nomads, the Jews and Arabs, vanquished the immobility of statues and temples of the gods.

The decline of the *cursus publicus* and the Islamic incorporation of Egypt, which also led to the destruction of the great ancient library, cut off Western Europe from papyrus imports. What was left was the agricultural product, parchment, on which monks were constrained to copy the censored Christian version of what was contained on papyrus, while in the Byzantine Empire the flaw of written commands from all past emperors coagulated into the legislation of the Codex. Through such bridgings or compressions of time a *translatio studii* was enabled to take place; but the *translatio imperii* presupposed new orders of distance and thus more accessible writing surfaces.

In the 13th century, paper, imported from China via Baghdad, arrived in Europe, where it was further developed by cities of the linen trade and the new windmills and watermills into rag-paper. This writing surface was central to the rise of the universities which, with their incorporated book-copying departments and postal networks broke the storage monopoly of the monasteries. And at the same time it was central, in combination with the Indian numerical system imported via Arabia, to the rise of trading cities.[32] The important thing in this context was not simply the well known invention of double-entry bookkeeping but, above all, a mathematical notation which for the first time brought independence from the numerous workaday languages.

Greeks, when adding two numbers together, had said *kai*, and Romans *et*; since the 15th century however we have had plus and minus, as mute as they are international, as signs for mathematical operators.

2. Printing

Gutenberg's invention of printing using movable letters developed from book-spine stamps which, in contrast to their predecessors in China and Korea, functioned both alphabetically and (after the disappearance of ligatures) discretely, may not have been a revolution of the magnitude of the codex - but it met the demand awakened by paper. As "the first assembly line in the history of technology" [33], printing potentiated the data processing capacity of books. Because all copies of an edition, in contrast to manual copies, had the same texts, woodcuts and engravings in the same places, they could be accessed via unified and for the first time alphabetical indexes. This addressing using page numbers, titles and, since Leibniz, alphabetical library catalogues [34], put the communication system which is science on its reference basis, while book illustrations free of copying errors formed the basis of engineering.[35] Not without reason could Vasari boast that Italy had discovered perspective, as enabling the production of technically accurate drawings, in the same year as Gutenberg invented typography.

New media do not make old media obsolete; they assign them other places in the system. Thus because printing now reproduced the rhetorical-musical performances at tournaments as literature and fictions of the authors, the physical techniques of these tournaments appear (according to Gumbrecht's thesis) to have been transmuted into silent, measurable disciplines.[36] Equally, it was only as a development within typography that the intrinsic value of handwriting emerged, the individuality of the hand taking the place of seals on letters and documents and which became the domain of a state system of post and police. The first state postal systems of early modernity were, after the fashion of the Roman imperial system, still reserved for military and diplomatic networks and protected from interception by a cryptography whose rise began with Vieta's algebraic encoding of alphabetical and numerical signs.[37] On the other hand, the territorial states, controlled extensively by post and firearms, opened up their networks to a private traffic which they also monopolised through their sovereign right of posts. When commercial correspondents were included in the public postal network after 1600, newspapers and journals came into being; when the transport of persons was also included after 1650, the post-coach networks were established as a scheduled service.[38] However the oft-quoted structural transformation from the aristocratic to the middle-class publicness, whose travels and letters, printed pamphlets and newspaper critiques are supposed to have undermined the old power system of Europe, never took place.[39] Even without its consistent control through secret cabinets and print censorship the middle-class publicness remained an artefact of mercantile states, whose new post office provided half the budget and half the war chest.[40] Only in the intimacy of family circles did the "addiction to reading" of the so-called public [41] promote a record rise in national-language belles-lettres which compensated for the "loss of sensuality" [42] with virtual effects on readers' senses, thus presaging future media technologies.[43]

This mediatisation of the printed word presumably had its basis in a routine light reading which was no longer a privilege of the elite, as in Saint Ambrose's time, but which paved the way for democracy through compulsory schooling and general literacy. But precisely this effortless reading triggered a new systemic problem. Because, unlike parchment codices, printed books are storage devices having no possibility of erasure, there was, around 1800, (to quote Fichte) "no branch of knowledge on which a surfeit of books is not available".[44] As a result literature and science had to revamp their transmission and receiving techniques: away from the literalness of quotes from the scholarly elite, and rhetorical mnemonics, towards an interpretative approach which reduced the quantity of printed data to its essence, in other words to a smaller quantity of data. The consequence for the communication system that is science, since Humboldt's reform, was lectures without textbooks, seminars as exercises in interpretation and the rise at universities of a philosophy whose absolute "spirit" preserved only the "remembrance" of all previous forms of knowledge and of its own textbook, thus becoming the hermeneutic "silhouette" of the totality of books.[45]

In the real world this mediatisation of writing amounted to its industrial revolution. In place of Gutenberg's enumerable combinations came, in practical terms too, a calculus of infinites: endless paper machines replaced, as of 1800, the discrete formats and moulded sheets; pulp papers from America's seemingly inexhaustible forests, this material basis of all mass print material since 1850, took the place of rag. And finally the typewriter and have, since 1880, levelled out the difference between writing and printing [46], thus opening up the floodgates of modern literature.[47] It was Mallarme who first offered the solution of reducing literature to its lexical meaning, the twenty-six letters, and thus not competing with other media at all.

B. Technical Media

Unlike writing, technical media do not utilise the code of a workaday language. They make use of physical processes which are faster than human perception and are only at all susceptible of formulation in the code of modern mathematics.

1. Telegraphy and Analog Technology

Self-evidently there must always have been technical media, because any sending of signals using acoustic or visual means is in itself technical. However in preindustrial times channels such as smoke signals or fire telegraphy which exploited the speed of light, or bush telegraphs and calling chains making use of the speed of sound were only subsystems of an everyday language. The beacon signal from Troy to Mycenae with which Aeschylus introduces the literary genre of tragedy announced in one single bit the fall of the besieged fortress although that depended on prior arrangement.[48] On the other hand it remains questionable whether a form of telegraphy which according to Polybios was capable of encoding the Greek alphabet into five times five light signals and thus transmitting random sets ever saw service.[49]

Information rates which exceeded all performance limits of writing were first achieved as a result of the necessity for command flow in conscripted mass armies and wars waged with standardised weaponry. It was one and the same to Lakanai, the politician who presented the revolutionary France of 1793 with an elementary school system and a literary copyright law who one year later persuaded the national assembly to build optical telegraphy lines. As the official reason for this revolution the argument was pressed into service that, in large nation-states, only Chappe's optical telegraph could make possible that democratic election process which Rousseau had, as we know, picked up from the city-state of Geneva. With Napoleon however, a less public but exclusive use of the optical telegraph network gave rise to a strategy which finally released wars from the stone age of command flow. Independently-operating divisions were able to fight on several fronts at the same time because newly-created general staffs imposed their cartographic knowledge by telegraph on the actual ground.[50]

Telegraphy thus separated literary publicness and military secrecy at the same historic moment, since publicness was transferred from elites to entire populations. A new elite of engineering schools and general staffs finally discovered in the 1809 war their new, to all intents and purposes, secret medium of electricity. With the move of telegraphy from optics to direct current, not only did the human and therefore unreliable, relay stations disappear, but also Claude Chappe's grand total of 98 signs. The Morse code with its dots and dashes and pauses put an economy of signs into practice which Leibniz had previously come up with in expressly typographical theory in the form of his binary code.[51] The electric telegraph, optimised on the basis of letter frequency and charged by the number of words, was the first step on the road to information technology.

In terms of organisation and technology too, telegraphy had world-wide repercussions. For absolutely the first time, information was decoupled, in the form of a massless flow of electromagnetic waves, from communication. Remote telegraphic control via landline made possible a systematic railway network.[52] Railways made possible an accelerated traffic in goods and persons [53] which, from the time of the American Civil War onward, was also subject, for military purposes, to telegraphic command.[54] However, in the form of goods and people traffic, the post lost two of its traditional functions. It was forced to become a pure information technology based on the principles of house numbers and letterboxes, prepayment with stamps and the world postal union.[55]

This detachment from the ground whose distances (as in synchronous mathematical topography) are, in contrast to all pre-modern postal systems, no longer calculated because only absolute speed counts, brought internationality: from the stock exchange reports of world trade and the telegraph agencies of the world press, to colonial empires which, like the British Empire, were founded on a "fleet in being" and consequently on a global undersea cable monopoly.[56]

Technical repercussions of telegraphy as information time made discrete, were consequential inventions which paradoxically also processed precisely the continuous signal sources. Of these I shall pass over the analog medium of photography which requires a treatment of its own and mention only the telephone, gramophone record and film.

Bell's telephone, the most lucrative single patent of all time, came about in 1876 not by any means in its familiar function, but in the course of an attempt to transmit several messages over a single telegraph cable at the same time. In exactly the same way only a year later Edison's phonograph emerged as a spin-off from an attempt to increase the throughput rate of telegraph cables. And finally Muybridge's scientific serial photographs which, in 1895, after the invention of Maltese cross and celluloid paved the way for cinema, were triggered by electric telegraph relays.

Film and gramophone, these mass-reproducible competitors to Edison's phonographs, made it possible to store optical and acoustical data as such. Because analog media underbid, first mechanically and subsequently electrically, the perceptual thresholds determined by Fechner, they can recognise in speech phonemes and musical intervals - which is where the Greek analysis as their being the final alphabetical elements stopped - complex frequency mixtures which are open to a further, and since Fourier, mathematical, analysis. The modern fundamental concept of frequency [57], which since Euler governs probability calculation, music and optics alike, has replaced the arts with technical media. This physics in the simulation process of the real is no longer partnered in the reception process by a language-based mnemonics or pedagogy, but by a sensory physiology which has guaranteed the media their world-wide and, thanks to Shannon's measure of information, calculable success.[58] At the same, time a knowledge gap between unconscious media effects on the one hand, and the innovatory thrusts on the other, (which since Edison's first laboratory are also plannable) has emerged which, despite the participation of women in telegraph, telephone and typewriter operations [59] is inimical to the general development of literacy and absolutely rules out communication on communication.

A prominent role in this turning-point, whose significance is probably equalled only by the invention of writing [60], was taken by Maxwell's electromagnetic field equations and their experimental substantiation by Heinrich Hertz. Since Christmas 1906, when Fessenden's radio transmitter broadcast low-frequency random events as they occur as amplitude or frequency modulation of a high frequency, there exist non-material channels. Since 1906, when de Forest developed, from Edison's light bulb, the controllable valve, information is open to any kind of amplification and manipulation. The valve radio, developed as wireless telephony for breaking the imperial cable monopoly, first of all made the new weapons systems of the first World War, the aeroplane and the tank, both mobile and dirigible by remote control [61], and after the end of the war, was applied to the civilian populations.[62]

In the guise of a "secondary orality" [63], bypassing the written word, radio had the effect of standardising unwritten languages, primarily through world-wide short-wave broadcasting [64],thus transforming colonised tribal associations into independent nations.[65] In the same way the telephone, in its progress from the direct dialling system via frequency multiplex to satellite links, has made possible the non-hierarchical networking firstly of cities and ultimately of the "global village".[66] Yet the publicly accessible wavebands remain, despite their critical overcrowding [67], only fractions of a frequency spectrum which, from long-wave broadcasting to the decimetre radar, exercises governmental or military control functions and taps all public wavebands for the secret services.[68]

The electrification of sensory input data through transducers and sensors enabled the entertainments industry to couple analog storage media firstly with one another and secondly with transmission media. The sound film combined optical and acoustic memories; radio, before the introduction of the tape-recorder, largely transmitted gramophone records; the first television systems, prior to the development of electronic cameras, scanned feature films. Thus the content of entertainment media always remains another medium which, in this way, they serve to promote.

But all these couplings of technologies which are already individually standardised, even though they gave birth to aesthetic forms from the radio play and electronic music to the videoclip, have one decisive deficiency: there is no general standard which regulates their control and reciprocal translation. This is precisely the point at which the heroes and heroines of Benjamin's theory of media came to the rescue in the form of editors in film studios and sound engineers for tape with their celebrated but strictly manual montage techniques.[69] The rendering obsolete of this human intervention and the automation of a general standard was reserved for digital technology.

2. Digital Technology

Digital technology functions like an alphabet but on a numerical basis. It replaces the continuous functions into which the analog media transform input data, which are generally also continuous, with discrete scannings at points in time as equidistant as possible, in the same way that the 24 film exposures per second, or at a much higher frequency since the Nipkow screen television did before. This measurement, followed by evaluation in the binary number system, is the precondition for a general media standard.

According to the scanning theorem of Nyquist and Shannon, any and every form of signal, provided it is frequency-range-limited intrinsically or through filtering, can be bi-univocally reconstructed from scanned values of at least twice the frequency.[70] The quantisation noise which necessarily arises in the process can also, in contrast to the physically-determined noise of analog systems, be minimised to any degree simply because it obeys the laws of a digital system.[71]

It was in 1936 that Turing's universal discrete machine stated the principle of all digital technology. Extrapolating or reducing the equally discrete typewriter [72], it consisted simply of an endless paper tape, the idea of which goes back to 1800. On this "paper machine" for data storage, a write/read/erase head for data processing could write the binary signs 0 and 1 while a transport device for data addressing made it possible to access the neighbouring signs right and left. Turing proved however that this elementary machine, because by contrast to the noisy Laplace universe it knows a finite number of states, is equal not only to any mathematician but solves all (in Hilbert's sense) decidable problems of mathematics through simulation of any other correctly-programmed machine.[73]

Thus the Turing machine concluded in its universality all developments for the storing, indexing and processing of both alphabetical and numerical data. In the alphabetical field these developments had led from lists and catalogues, via the card indexes from which around 1800 Jean Paul's literature and Hegel's philosophy had sprung [74], to the Hollerith machine of the American census of 1890.[75] In the numeric field a parallel development had led from Schickart's calculator for the four basic types of calculation, via Jacquard's programmable looms [76], to the pioneer of computers, Babbage, whose differential engine of 1822 reduced the time-consuming developments of series in trigonometry and ballistics to recurrent difference equations while his later planned analytical engine was intended to make the whole of analysis calculable with conditional jump commands.[77] To achieve the alphanumeric universality of Turing machines, alias computers, however, the two development strands had to be brought together by Boole's logical algebra and Goedel's theorem of incompleteness, making statements and axioms as manipulable as figures.

The Turing machine of 1936 was infinitely slow, its paper tape infinitely long and therefore inexistent. By contrast the computer, its technical successor, is a miracle of economy of time and space called forth by the exigencies of the second World War. At the same time that Shannon was demonstrating that simple relays connected in series or in parallel can automate all operations of Boole's algebra [78], Zuse was building the first computers for Luftwaffe research from telegraph relays while the cryptography department of the Wehrmacht rejected his offers of automation.[79] At the end of 1943, by contrast, the British secret service came up with computers based on overmodulated tubes for Turing's war-deciding cryptoanalysis of precisely that secret VHF radio traffic which had made the German blitzkrieg possible.[80] Finally, in 1945, John von Neumann designed the now customary architecture of sequential but microsecond-fast computers for the planned American uranium bomb whose rate of explosion set new standards in the measurement of time.[81]

Von Neumann's design postulated the following three system elements:

- Firstly a central processing unit for command-controlled processing of alphanumeric data by either mathematical or logical rules;
- Secondly a write-read memory for variable data and a read-only memory for programmed commands;
- Thirdly a bus system for sequential transmission of all these data and commands as bi-univocally indicated through binary addresses by pages and columns.

With these three parts, von Neumann machines articulated the fundamental structure of information technology as a functional interrelationship of hardware elements. No matter whether their environment supplies alphabetic or numerical data, that is, writing or media-generated values, the commands, data and addresses are all represented internally by binary numbers. The classic distinction between functions and arguments, operators and numerical values has become permeable. However it is precisely this breakdown of the alphabet which also permits operations to be applied to operations, and ramifications to be automated. Which is why computers in principle comprehend all other media and can subject their data to the mathematical procedures of signal processing.[82]

Data throughput and access time depend solely on physical parameters. Since 1948, when the transistor replaced the tubes/printed circuits of the second World War, and 1968 when integrated circuits replaced the single transistor, in each case reducing the space and time requirement by a factor of ten, real time analyses and real time syntheses of one-dimensional data flows (of speech or music for example) are no longer any problem.[83] So the sound engineer can go home. However, for multi-dimensional signal processing in real time, such as is required for television pictures or computer animations, the von Neumann architecture becomes a bottleneck. For this reason large numbers of parallel computers are already in use, and biological and optical circuitry such as is required above all for the simulation of brain functions, is already under development. The day is not far off when signal processing will reach the physical limits of feasibility.[84]

This absolute limit is where the history of communication technologies will literally come to an end. Theoretically there remains only the question as to what logic this completion will have obeyed. From Freud [85] to McLuhan the classic answer to this was a generic subject - humanity which before of an indifferent or interferent natural world would have externalised first its motor and sensory interface, and finally its intelligence, in technical prosthetics. However if Shannon's mathematisation of information rested on his "fundamental idea" of inferring, through a conceptual transfer, the "information efficiency of a jammed transmission" from its cryptoanalytical efficiency [86], interference will only be understandable as the interventions of a hostile intelligence, and the history of communication technologies as a series of strategic escalations. Without reference to the individual or to mankind, communication technologies will have overhauled each other until finally an artificial intelligence proceeds to the interception of possible intelligences in space.[87]

Notes

1. Praun 1970 137
2. Peters 1 9B9
3. Knies 1857, 6
4. McLuhan I 968
5. Luhmann 1988, 901
6. vgl. Hagemeyer 1979,422-39
7. Shannon 1949a, 10f
8. Luhmann 1985, 21
9. Bell 1955, 35
10. Schiller 1904, XIII 17
11. McLuhan 1968
12. Aristoteles, Herm. 1 6a 3-7
13. Derrida 1974
14. Van Creveld 1985
15. Voigt 1965-73, 11/2 830f
16. Schenkel 1983, 53-59
17. Assmann 1983, 80-88
18. Witfagel 1962
19. Leroi-Gourhon 1980, 228
20. Gaady 1977, 86f
21. Innis 1950, 71
22. Herodot, Hist. VIII 98
23. Lohmann 1980, 168-74
24. Dornseiff 1922,13
25. Vernant 1962, 1-3
26. Havelack 1962, 32
27. Nietzsche 1922 28, V 218
28. Sueton, Augustus, 49
29. Fronio, zit. Riepl 1913, 241
30. Turing 1987, 187
31. Augushn, Conf. VI 3
32. Innis 1950, 126-140
33. Ong 1987, 1 19
34. Vorstius/Joost 1977, 30-46
35. Eisenstein 1979, 153
36. Gumbrecht 1988, 42f
37. Kahn 1967
38. Beyrer 1985, 54
39. Habermas 1971, 28-61
40. Voigt 1965-73, II/ 848
41. Schenda 1970
42. Schon 1987

43. Kittler 1987
44. Fichte 1845, Vlll 98
45. Hegel 1952, 564 and 27
46. McLuhan 1968, 283
47. Kenner 1987
48. Aischylos, Agamemnon, V 281-316
49. Riepl 1913, 91-106
50. Oberliesen 1982, 44-62
51. Cajori, 1928-29, 11 182-85
52. Schivelbusch 1977, 32-34
53. Knies 1857, 16 19
54. Blum 1939, 73
55. vgl. Derrida, 1982
56. Kennedy, 1979, 75-97
57. Hacking 1975
58. Beck 1974, 37f
59. Faulstich-Wieland/Horstkemper, 1987
60. Leroi-Gourhan, 1980, 265-70
61. Virillo 1986
62. Lerg 1970
63. Ong 1987, 136
64. Schwipps 1971, 29
65. Innis 1950, 169
66. McLuhan 1968
67. Beck 1974, 38-42
68. Bamford 1986
69. Benjamin 1972-B5, 1/2 495f
70. Shannon 1949a, 11 f
71. von Neumann 1967, 146f
72. Hodges 19B3, 96
73. Turing 1987, 17-60 and 157f
74. Rosenkranz 1844, 15
75. Oberliesen 182, 212-48
76. Coy 1985, 43-48
77. Hyman 1986, 191-279
78. Shannan 1938, 713-23
79. Zuse 1984, 51 f
80. Hadges 1983, 267-88
81. Hagen 1989
82. Rabiner/Gold 1975
83. Sickert 1983, 1 17 220
84. Cambers 1985
85. Freud 1940 68, XIV 449f
86. Hagemeyer 1979, 434
87. Posner 1984, 198-202

Words Cited

Assmann, Jan, Schrift Tod und Identitaet. Das Grab als Vorschule der Literatur im alten Agypten. In: Assmann, Aleida und Jan/Hardmeier, Christof (Hrsg.) Schrift und Gedaechtnis. Beitraege zur Archaeologie der literarischen Kommunikation 1. Muenchen 1983 64-93

Bamford, James NSA. Amerikas geheimster Nachrichtendienst Zurich/Wiesbaden 1986

Beck Arnod H. Worte und Welen. Geschichte und Technik der Nachrichtenubermiitung Frankfurt/M 1974

Bell, D.A. Information theory and its engineering applications 3 Aufl. New York/Toronto/London 1955

Benjamin, Walter Das Kunswerk im Zeitalter seiner technischen Reproduzierbarkeit Zweite Fassung In: Gesammelte Schriften hrsg. v. Tiedemann Rolf/Schwepphaeuser Hermann. Frankfurt/M. 1972-85 Bd 1 2 471-508

Beyrer, Klaus, Die Postkutschenreise. Tuebingen 1985. (Untersuchungen des Ludwig-Uhland-Instituts der Universitaet Tuebingen im Auhrag der Tubinger Vereinigung fur Volkskunde hrsg. v Hermann Bausinbert Bd 66)

Blake, George G., History of radio telegraphy and telephony. London 1928.

Blum, Prof. Dr. Ing. e.h., Das neuzeitliche Verkehrswesen im Dienste der Kriegsfuhrung. In: Jahrbuch fur Wehrpolitik und Wehrwissenschahen 1939 73 92.

Cajori, Florian, A History of mathematica notations. I. Chicago 1928 II. Chicago 1929.

Chambers, William G., Basics of communication and coding Oxford 1985

Coy, Wolfgong, Industrieroboter. Zur Archaologie der zweiten Schopfung. Berlin 1985

Derrida, Jacques, Die Postkarte von Sokrates bis an Freud und jenseits. l. Berlin 1982.

Dornseiff, Franz, Das Alphabet in Mystik und Magie. 1 Auf Leipzig 1922

Eisenstein, Elizabeth, The printing press as an agent of change. Communications and cultural transformations in early-modern Europe 2 Bde. New York 1979.

Foulstich-Wieland, Hannelore/Horstkemper, Marianne, Der Weg zur modernen Buerokommunikation. Historische Aspekte des Verhaltnisses von Frauen und neuen Technologien BieleFeld 1987.(Materialien zur Frauenforschung Bd.4)

Fichte, Johann Gotlieb, Deducierter Plan einer zu Berlin zu errichtenden hoheren Lehranstalt. (1817) In: Samtliche Werke hrsg. v. Immanuel Hermann Fichte. Berlin t845 Bd Vlll 97-203

Freud, Siegmund, Das Unbehagen in der Kultur. In:Gesammelte Werke chronologisch geordnet. London/Frankfurt/M. 194068 Bd.XIV 419-506.

Goody, Jack, The domestication of the savage mind. Cambridge 1977

Gumbrecht, Hans Ulrich, Beginn von 'Literatur'/Abschied vom Korper? In: Smolka-Koerdt Giesela/Spangenberg, Peter M /Tillmann- Barylla, Dagmar (Hrsg), Der Ursprung von Literatur Medien Rollen und Kommunikationssituationen zwischen 1450 und 1650. Muenchen1988 15-50.

Habermas, Juergen, Strukturwandel der Oeffentlichkeit. Untersuchungen zu einer Kategorie der burgerlichen Gesellschaft 5. Aufl. Neuwied/Berlin 1971

Hacking, Ian, The emergence of probobiliy. A philosophica study of eary ideas about probability induction and statistical inference Cambridge/London/New York/New Rochelle/Melbourne/Sidney 1975

Hagemeyer, Friedrich-Wilhelm, Die Entstehung van Informationskonzepten in der Nachrichtentechnik. Eine Fallstudie zur Theoriebildung in der Technik in Industrie- und Kriegsforschung. Diss. (mosch.) FU Berlin 1979.

Hagen, Wolfgang, Die verlorene Schrift. Ueber digitales Schreiben an Computern. Erscheint in: Kittler, Friedrich A /Tholen, Georg Christoph (Hrsg. Arsenale der Seele. Literatur und Medienanalyse seit 1870 Muenchen1989.

Havelock, Eric A., The literate revoluton in Greece and its cultural consequences. Princeton 1982.
Hegel, Georg Wilhelm Friedrich, Phonomenologie des Geistes (1807) hrsg. v. Johannes Hofmeister 6 Aufl. Hamburg 1952.

Hodges, Andrew, Allan Turing. The enigma. New York 1983.

Holmberg, Erik J., ZurGeschichtedescursuspubicus Diss. Uppsala 1933

Hyman, Anthony, Charles Babbage, 1791-1871 Philosoph Mathematiker Computerpionier Stuttgart 1987.

Innis, Harold Adams, Empire and Communications Oxford 1950.

Kahn, David, The codebrakers. The story of secret writing. London 1967.

Kennedy, Paul M., Imperial Cable Communications and Strategy 1870 1914. In: Kennedy, Paul M. (Hrsg.) The war plans of the great powers 1880-1914. London 1979 75-79.

Kenner, Hugh, The mechanic muse NewYork/Oxford 1987

Kittler, Friedrich A., Grammophon Film Typewriter. Berlin 1986

Kittler, Friedrich A., Aufschreibesysteme 1800/1900 2 Aufl Muenchen1987

Knies, Korl, Der Telegraph as Verkehrsmitel. Tubingen 1857.

Lerg, Winfried B., Die Entstehung des Rundfunks in Deutschland. Herkunft und Entwicklung eines publizistischen Mittels. 2 Auf Frankfurt/M. 1970 (Beitraege zur Geschichte des deutschen Rundfunks Bd.1)

Lerai-Gourhan, Andre, Hand und Wort. Die Evolution von Technik, Sprache und Kunst. Frankfurt/M 1980.

Lohmann, Johannes, Die Geburt der Tragoedie aus dem Geiste der Musik In: Archiv fur Musikwissenschaft 37 1980 167- 186.

Luhmann, Niklas, Das Problem der Epochenbildung und die Evolutionstheorie. In: Gumbrecht, Hans Ulrich/Link-Heer, Ursula (Hrsg.) Epochenschwellen und Epochenstrukturen im Diskurs der Literatur- und Sprachhistorie. Fronkfurt/M. 1985 11-33.

Luhmann, Niklas, Wie ist Bewusstsein an Kommunikation beteiligt? In: Gumbrecht, Hans Ulrich/Pfeiher, K. Ludwig (Hrsg) Materialitaet der Kommunikation. Fronkfurt/M.1988 884-905.

McLuhan, Marshall, Die magischen Kanaele, Understandig Media, Duesseldorf/Wien 1968.

Metropolis, Nicholas Constantine/Howlet, Jack/Rota, Gian Carlo (Hrsg.) A history of computing in the twentieth century, A collection of essays. New York/London/Toronto/Sydney/San Francisco 1980.

Neumann, John von, AIlgemeine und logische Theorie der Automaten. In: Kursbuch 8 1967 139-175.

Nietzsche, Friedrich, Geschichte der griechischen Literatur. (Vorlesung Basel 1874-76) In: Samtliche Werke. Muenchen1922 29 Bd V 67 284

Oberliesen, Rolf, Information Boten und Signale. Geschichte technischer Informationsverorbeitung Reinbeck 1982

Ong, WalterJ., Oralitaet und Literalitaet. Die Technologisierung des Wortes Oploden 1987

Peters, John Durhom, John Locke the individual and the origin of communication. In: Quarterly journal of speech, August 1989.

Posner, Roland, Mitteilungen an die ferne Zukunft. Hintergrund Anlass Problemstellung und Resultate einer Umfroge. In: Zeitschrift fur Semiotik 6 1984 195-227.

Praun, Albert, Vernachlaessigte Faktoren in der Kriegsgeschichtsschreibung. Das Nachrichtenverbindungswesen im 2. Weltkrieg ein Stiefkind der militaerischen Forschung. Wehrwissenschaftliche Rundschou H.3 1970 137-145.

Rabiner, Lawrence R./Gold, Bernhard, Theory and application of digital signal processing Englewood Cliffs 1975

Riep, Wolfgang, Das Nachrichtenwesen des Altertums Mit besanderer Rucksicht ouf die Roemer Leipzig/Berlin 1913

Rasenkronz Kar Gearg Wilhelm Friedrich Hegels Leben Berin 1844

Schenda, Rudolf. Volk ohne Buch. Studien zur Sozialgeschichte der populaeren Lesestoffe l770-

1910. Fronkfurt/M. 1970

Schenkel, Wolfgang, Wozu die Agypter eine Schrift brauchten. In: Assmann, Aleida und Jan/Hardmeier, Christof (Hrsg.) Schrift und Gedachinis. Zur Archaologie der literarischen Kommunikation 1. Muenchen1983 45-63.

Schiller, Friedrich, Was heisst und zu welchem Ende studiert man Universalgeschichte? Eine akademische Antritsrede (Jena 1789) In: Samtliche Werke hrsg v. Eduard von der Helen Stutgar/Berin 1904 Bd. XIll 3-24

Schivelbusch, Wolfgang, Geschichte der Eisenbahnreise. Zur Industrialisierung von Raum und Zeit im 19. Jahrhundert Muenchen1977.

Schoen, Erich, Der Verlust der Sinnlichkeit oder die Verwandlung des Lesers. Stuttgart 1987.

Schwipps, Werner, Wortschlacht im AEther In: Deutsche Welle (Hrsg.) Wortschlacht im AEther Der deutsche Auslandsrundfunk im Zweiten Weltkrieg Berin 1971 11-97

Shannon, Claude Elwood, A symbolic analysis of relay and switching circuits. In: Transactions of the American institute of electrical engineers 57 1938 713-723.

Shannon, Claude Elwood, Communication in the presence of noise In: Proceeding of the institute of radio engineers, 37, 1 949a, 10-21

Shannon, Claude Elwood, Communicatian theory of secrecy systems. In: Bell system technical journal 1949b, 656-715

Sickert, Klaus (Hrsg.), Automatische Spracheingabe und Sprachausgabe. Analyse, Synthese und Erkennung menschlicher Sprache mit digitalen Systemen. Haar 1983.

Stephan, Heinrich von/Sater, Karl, Geschichte der deutschen Post. I. Berlin 1928 II. Berlin III. 1935.111 Frankfurt/M 1951

Turing, Allan M, Intelligence Sevice. Ausgewahlte Schriften, hrsg v. Datzler, Bernhard/Kittler, Friedrich. Berlin 1 9B7.

Von Creved, Martin L., Cammand in War Cambridge Mass.l/London 19B5

Vernani, Jean-Pierre, Les origines de la pensee grecque. Paris 1962.

Virilio, Paul, Krieg und Kino Logistik der Wahrnehmung. Muenchen1 9B6

Voigt, Fritz, Verkehr. I Berlin 1973 11. Berlin 1965.

Vorstius, Joris/Joost, Siegfried, Grundzuge der Bibliotheksgeschichte. 7 Aufl. Wiesbaden 1977.

Witfogel, Karl, Die Orientalische Despotie. Eine vergleichende Untersuchung totaler Macht. Koln/Berlin 1962

Yates, Frances A., The Art of Memory. London 1966

Zglinicki, Friedrich von, Der Weg des Films. Die Geschichte der Kinematagraphie und ihrer Varlaufer Berlin 1956.

Zuse, Konrad, Der Computer. Mein Lebenswerk. 2 Aufl. Berlin/Heidelberg/New York/Tokyo 1984.

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