4. Suspending the “Time Domain”: Technological Tempor(e)alities of Media Infrastructures

Wolfgang Ernst

Abstract

Any media event is a time function of signals. In favor of a diagrammatic definition of technological media, media archaeological investigation is not only concerned with their structural “hardwired” level but with their *operative* unfolding-in-time as well. Such an understanding of techno-temporalities does not focus on phenomenal effects of media on humans but primarily refers to the microregimes *within* technological devices. In that sense, “hardwired temporality” refers to the infrastructuring of time by technologies and to temporal structures which are revealed from within techno-logical knowledge itself. From that arises an epistemology of technical processuality beyond the conventional notion of “time.”

Keywords: Media archaeology, techno-temporality, clocking, synchronization, UNIX-time, time of non-reality

The Nonhuman Temporality of Technological Knowledge

In favor of a diagrammatic definition of technological media, media archaeology is concerned not only with their “hardwired” structure but also with their *operative* unfolding-in-time. This vector places the field close to signal analysis. Any media event is a time function of signals.¹ In addition, the radical media archaeology of the present media-infrastructural condition requires analysis of its mathematical, algorithmic operations.

Such an understanding of techno-temporalities does not focus on phenomenal effects of media on humans but primarily refers to the microregimes

within technological devices. Complementary to discourse analysis, it listens to the implicit epistemic articulations and enunciations of infra-technical operations. In that sense, “hardwired temporality” refers to the infrastructuring of time by technologies and to temporal structures revealed from within techno-logical knowledge itself. From that arises an epistemology of technical processuality beyond the conventional notion of “time.”

Clocking as the Anonymous Time Base of Modernity

The time base of present information society (for which actor–network theory admits nonhuman members) turns out to be a critical focus of analysis. High-frequency trading as data exchange, in the electronic stock market as well as in the communication sphere of the internet, surprisingly recalls late medieval monasteries. A true media archaeology of technically temporalized infrastructures starts here and not in the short memory of the recent present. Benedictine monks who needed periodically exact clocking for prayers according to their monastic rules invented the escapement-driven wheeled clock. Regular oscillation, subdividing movement into equal quanta, is a precondition not only for industrial production but also “social media” communication. Within the von Neuman architecture of current computers, the heartbeat of the time base enables exact synchronization of cycling units in data processing.

The escapement-driven clock, providing occidental culture with its equidistant beats, oscillations, and synchronisms, was invented anonymously.² Such temporality cannot be reduced to the timeline of cultural history but rather finds “itself.” There is a rather nonhuman temporality at work in the infrastructuring of techno-logical knowledge.

According to Martin Heidegger, long before computing in the strict sense, information society already started with the modern *Weltbild*: with the measuring and numerical (scientific) approach to physical nature.³ An archaeology of the contemporary therefore starts with what in German is appropriately called “Neuzeit,” or modern time, and in a double sense, because the new epoch starts with the mechanical clock itself. Marshall McLuhan, in media-epistemological terms, *recedes* even further below the clock technology, to the “technologizing” of the spoken word by the ancient Greek vocal alphabet itself.⁴ It was alphabetic writing that cognitively induced the analysis and synthesis of oral speech flow into discrete, digital units. Only when the letter (reduced to the minimum as a binary information unit) becomes radically meaningless in itself does it enable its full range of

storage, transfer, and symbol manipulation (processing) of meaning. Once more, it is epistemologically remarkable that there is no way to inscribe this cultural technique on the historic timeline because there is neither a precise date nor a known inventor.⁵ Technological culture takes place in anonymous temporality.

Enduring Oscillations versus Transient Phenomena

Both the pulled string of an instrument and articulated speech, by their very fading out, reveal the *endlichkeit* (the temporal limit) of any physical signal event. The moment a string is pulled or a sound is articulated, like a breaking wave, the chord already anticipates and senses its very end, almost instantaneously but strictly temporally. A string of an instrument, once struck, never simply articulates the pure sine tone of its proper frequency but carries with it a fading memory of its violently abrupt, sudden, transient start. In the real—that is, physical—world, the picked string fades out due to mechanical loss of energy (Heidegger's "being-toward-death" in its mechanical sense), like a swinging pendulum, a reverberation in the sonosphere.

Any pleasure of a musical performance by real humans in real time and space (be it oral poetry as sung by Homer or a musical concert) is always already accompanied by a melancholic anticipation (that is, irony) of its ending. On the contrary, audiovisual machine recordings, such as gramophone discs and videotapes, can be replayed with no internal sense of ending. To modify Walter Benjamin's analysis on "The Work of Art in the Age of Its Technological Reproducibility," with technical re-petition, the temporal aura (which is based on the allegorical awareness of ending) is lost.⁶ But the reentry of temporality happens *within* the very signal processing of technological media.

Even electromagnetic waves, such as those calculated by James Clerk Maxwell, propagate very fast but not instantaneously. In 1879 Hermann von Helmholtz initiated a prize by the Berlin Academy of Sciences to answer whether, following Maxwell's mathematical equations, light is in fact part of the electromagnetic wave spectrum and thereby subject to temporality, the literal "speed of light" limit. Radio waves, as turned out by Heinrich Hertz' experiments on the very media-archaeological level (that is, before becoming part of a mass-medium called "radio"), have a *sense of ending* on their very electrophysical-event level; the secondary level is the modulation of such principally timeless carrier waves by the proper radio program, which by

its very program structure introduces a symbolical order of beginning and ending by arbitrary cultural and media-economical decisions.

The out-fading oscillations in early spark-driven telegraphy become transformed into stabilized, equi-dynamic, in principle, “eternal,” oscillations only by the electronic vacuum tube in feedback circuits. Electronics turned electric signals from ephemeral into regenerative, Bergsonian duration. Only this allowed for the radio transmission of carrier-wave-modulated speech and music, resulting in the pulse modulated digital transmission.

The Non-Sense of “Time” for Technological Analysis

Technological media know processual realities but not “time”; therefore, the neographism “tempor(e)alities” is preferred in the subsequent argument, which unfolds such media tempor(e)alities on three levels: first of all, within technologies, when the micro-timing of signal transduction is crucial for the event to succeed at all; next, in the human sense of temporal experience, when media events induce phenomenal affects and irritations; finally, “deep” media temporality (logic and machine), which turns out to be rather autonomous from the cultural imaginary of imaginary time a.k.a. “history.”

In that context, the very notion of *hardwired temporality* is a relief. Its ambition is not deep philosophical questioning of the nature of time; *temporality* is rather a term that names a couple of signal functions, such as the Delta-t, and functions of signal processualities, such as transfer, delay, and even storage. For the close analysis of contemporary media technologies, the *arché* is not in “time,” but a cooriginality where “time” is suspended. Media archaeology is “radical” in the sense that it looks for roots not in “time” but in the technological event. There can be no infrastructuring of temporal orders, only infrastructures triggering notions of “time” as secondary effect. Here, the notion of time as *a priori* condition of perception (as defined by Immanuel Kant) does not count. If time counts here, it is in the precise sense of clocking which generates what Heidegger denounced as “vulgar” technical time. In that sense, technical infrastructures are not “time” based, but “time-basing.” What has been decisive for digital computing in the individual machine counts more interconnected computers. Communication is not only the material infrastructures of cables, antennas, and data-processing devices but also events temporally infra-structured. Synchronization of internet traffic creates an artefactual tempor(e)ality, just as the introduction of a synchronizing master clock was the condition of a universal “time” in the nineteenth century. The master clock, in networked computing and

communication, has imploded into a myriad of local temporal agencies. This temporal pattern is multiple and invites the replacement of transcendent signifiers with a plurality of more precise *termini technici*, practicing a language of analysis that bypasses outdated notions like "time" in the mediasphere.

Walter Benjamin defined the nineteenth century as the antiquity of the "now." Indeed, the "present" can already be seen in 1839 when Karl August Steinheil designed a timekeeping system for the synchronization of electromagnetic external clocks by a mechanical central clock whose pendulum triggers alternating positive and negative poled "time impulses"—an interlacing of timekeeping and telegraphy. Today, the radio time signal transmitter DCF77 (77,6 kHz) at Mainflingen synchronizes radio clocks wirelessly.

In a radically media-archaeological understanding, techno-logical infrastructures extend from material (technical) to mathematical (logical) grids, to the algorithms embedded in ubiquitous microchips. The imaginary unifying time axis is decomposed into a symbolic concatenation of programmed processes, patterned and interrupted by moments of the tempoReal. Aristotle was radically media-archaeological in book IV of his *Physics*, defining "time" as resulting from measuring movement sequentially by numbers. Even etymologically, only from incisive cuts does the notion of a temporal order arise.

Synchronization and Functional Timing

Rigid analysis of technology does not know metaphysical "time" but rather an ensemble of temporal operators. There is no given preexisting "time" but rather an enforced timing, as expressed in the very constructive term of synchronization.

Edmund Husserl once phenomenologically described the mechanism of the inner sense of subjective time.⁷ Such a temporal horizon unfolding as extended present between re- and protention is radically "grounded" and de-metaphysicized when it comes to technological ensembles. Lewis Fry Richardson's once designed a (human) computing "forecast-factory" for real-time calculation of weather, connected to local weather stations in telegraphic "instantaneity." A central official maintains "a uniform speed of progress" for the individual partial calculations, "like the conductor of an orchestra in which the instruments are slide-rules and calculating machines." Panoptically, "he turns a beam of rosy light upon any region

that is running ahead of the rest, and a beam of clue light upon those who are behindhand.”⁸

In the meantime, human synchronization of human “computers” has been replaced by the cybernetic diagram of feedback circuits, replacing the central time control agency by a flexible automation where human monitoring itself becomes integrated into the circuitry. For a moment, technological utopia has become reality: the “Opsroom” for monitoring and control in Stafford Beer’s Cybersyn computing structure in Salvador Allende’s Chile 1971–73 for national feedback and control of economic data from state-owned factories. The data flow was based on a “Cybernet” teletype network, to be calculated by a central mainframe IBM 360 computer, Cyberstride, and monitored by a collective of humans for positive or negative feedback. Human wetware is wired into the symbolic infrastructure for the option to interrupt and correct: suspending the time series generated by data.⁹ The melodic re- and protentional “inner time consciousness” of the human individual (Husserl) is replaced by the radically “discrete” temporality of counting.

The Emancipation of Technical Timing from Natural “Time”

Media culture is not shaped by a transcendent timeline, but technologies themselves “shape” time.¹⁰ In the 1930s, the crystal quartz clock emancipated the time base of technology from the astronomical “natural” reference—an epistemological breaking point. Since 1971, the 555 timer chip has been the most popular integrated circuit for its ability to generate a steady oscillation independent of supply voltage.

Against phenomenological suggestions of endurance, a truly archaeological analysis of temporality is time-discrete. This imperative conditions the rhythmic bias of digital culture. As once expressed by Alan Turing himself, clocking is still the heartbeat of structuring data processing from within.¹¹

Against its meaning at first sight, “real-time” data processing is not about being close in time but its actual negation. It replaces the familiar “live” signal transmission by a re- and protentional microtime window of the present; telepresence (Heideggerian “Ent-fernung”) becomes predictive coding, a mathematical *in-between* of humans and their physical environment.

Since 1970, Unix time has described time for operating systems and file formats in terms of the number of seconds that have elapsed since 00:00:00 Coordinated Universal Time (UTC), Thursday, January 1, 1970. This starting date is appropriately called “The Epoch,” and thus the *epoch* of the computational present starts here. Unix subdivides the day exactly into

86,400 seconds. But this chronotechnical regime does not itself tolerate the interpolation of leap seconds according to atomic clock-generated timekeeping, where a second must be added to the UTC system to coordinate with the variability of the Earth's rotation. Occasionally, when computers have been forced to use the leap-second friendly UTC, such ruptures of the tempoReal have crashed websites and confused airline departures.¹² Similarly, the Millennium Bug was a reminder at the end of the 1990s that time in digital computers is logical and mathematical, not intuitive ("Bergsonian") time.

The tempor(e)ality of "online" timing actually escapes the historiographical timeline. Accurate timekeeping systems such as the cesium atomic clock embedded in GPS signal traffic are rather independent. In computing science, so-called "real-time," or the physical clock measuring physical time as hardware, differs from the logical clock as software; this causes the necessity to synchronize, in intervals, the real-time clock in computers with external time, by requesting time from *time servers* and then, by intelligent algorithms, equaling the time delay in the Network Time Protocol, based on the Internet Protocol and time synchronization software.

In October 1998, the Swiss watchmaker Swatch announced "Internet Time," which undoes the familiar differential time zones. Every day is divided into 1,000 "beats," creating a new meridian in Biel, home of Swatch itself: the Biel Mean Time (BMT) as universal reference to Internet Time.¹³ This is "an indifferent time, no longer the vectorial time of chronology."¹⁴ At that point, the familiar historic *timeline* graph fails.

The Fuzzy Present of Internet Communication

Any media archaeological analysis of technological communication infrastructures takes their increasingly time-critical nature into account. If "time" is not understood in a unifying metaphysical sense but in its Aristotelian definition, it turns out as a functional plurality of signifying incisions and intervals. What was once electromagnetic "live" radio or TV signal transmission in telecommunication has been replaced by "real time" computation which dissimulates the belatedness of complex calculations of discrete pulse trains so as to trap human perception of the "present." In digital *online* communication, there is no transmission *in* time but a timing of data packets (datagrams) that are numerically time-stamped to avoid internet traffic congestion.

In 1972, Bob Metcalfe developed a program called PING for testing the interoperability of networked devices on what would come to be called

Ethernet. The program would open a connection through the physical and logical network topology to test whether the addressee actually reacts. From that technical implementation of a time-critical test, Vint Cerf developed the Transmission Control Protocol for the ARPANET in 1975, which preceded the actual Internet. So-called time-to-live and ping-to-death are articulations of internet temporality. The past is not “imperfect” anymore but becomes “historical perfect,” residually enduring within the present. The “residual” is still active, “not at all as an element of the past, but as an effective element of the present.”¹⁵

Metaphors like “streaming media” are misleading in their suggestion of a temporal flow. Even with respect to the signal carrier (the “flow” of electricity), information depends on the digitally coded electrons. Where humans believe themselves to be communicating messages via digital channels, a nonhuman temporality is at work between computers. Any political criticism of the microphysics of power has to focus on time-critical events on the most physical level of the OSI network model.

Network culture is less about modernist clock time than about latencies. The delayed present stems from the “hyperbolic temporalities of digitality.”¹⁶ Speculative media theory asks experimental questions: What if data packets were humans, how (if at all) do they experience time? In Web 2.0 packet switching, before any kind of “social memory” is triggered, intermediary storage is a decisive and integral part of the technical transmission itself. The age-old contradiction between archive and transmission collapses in the delayed present. Before there can be any moments of short-time virtual communities (“crowds,” or even societies), data networks consist of distributed sparks of ultra-short retentions and protentions.

Time-to-Live and Ping-to-Death

In the times of internet protocols McLuhan’s thesis that the pace of electronic media changes the patterns of temporal perception deserves a closer reading. Time-critical processes take place in the most media-archaeological sense, that is, on the basic layer of bit transfer in the internet, the *physical layer*. This layer represents the interface between symbolic transfer and material channel of communication and thus embodies very concretely the interlacing of logi(sti)cs and matter which is already implied in the term “technology.” It is on this layer that the voltage level of what is meant to represent a logic “zero” and a logic “one” is being defined. The function of this bit-transfer layer is to transform signals from the physical channel into information to

be passed on to level two of the OSI system.¹⁷ This identification of signals happens within the time-critical field, such as signal frequency and signal duration, synchronous or asynchronous clocking, and the decision on serial or parallel data transfer.

In communication networks, topological systems are being appropriately expressed by hypertextual links, whereas time-critical processes rarely become apparent. The answer to this is to find a new term that does not nominate a new medium but declares the temporal mode of a mode its decisive media-theoretical criterium. "The real-time web is a set of technologies and practices which enable users to receive information as soon as it is published ... rather than requiring that they or their software check a source periodically for updates."¹⁸ The communicative practice of *instant messaging* belongs to this temporal field; in McLuhan's sense, the message of the medium here is immediacy serving to create the illusion of a pseudo-copresence. This recent form of web economy is being defined by communication within the time-critical realm; *cyberspace* as what Ted Nelsen calls "docuverse" is being replaced by the extreme speeding up of information processing in *cybertime*.¹⁹ The internet thus turns out not to be just a topological extension of a generalized archive, but equally as a chrono-technical expression of time.

The time-critical *message* of the internet requires a close look at the time-critical operations on its physical and logistical levels, such as seen in the "Ping" signal. Each data packet into which a document has been sliced is being observed individually; its transfer happens independent of its preceding or successive packets. This procedure is radically time-critical because it takes place within the so-called "time to live" field that defines the maximal temporal duration in seconds that an IP packet is allowed to exist in the internet. A counter is progressively reduced during this routing; if the TTL-counter reaches zero before the packet has reached its destination, it is annihilated.²⁰ Media time is not endless. In TCP/IP as fundamental network program, techniques of synchronization meet a deadly economy of time. "Time to live" means that each data packet is assigned a given lifespan; "time to die" thus becomes a crucial signature of the information age.

Whereas Husserl's phenomenology expresses neuro-cognitive perception of the present in "time diagrams" between retention and protention, media archaeology tries to precisely identify the rather different operations of micro-technical signal transduction and algorithmic data processing. Humans and machines are different in their operative signal processing, resulting in different tempor(e)alities.

(A)Temporalizing Radio

The present can be analyzed only when it starts to recede into the past. The concept of a prehistory of the present technological condition refers not only to a “before” in its temporally sequential, historical sense but also to its technological preconditions. This prestructuring “before” endures or re(oc)curs in the present in nonlinear modes. Media archaeological analysis, besides its apparent meaning in a search for “origins,” refers to a structural argument: the *arché* which is the insisting, essential features of a technological system. Heuristically, this means analytic reduction to the essential functions, the elementary bits, a rarefication against discursive redundancies.

All of a sudden, the “recent” is not past but a concealed retreat, the hidden, still copresent ground behind the apparent visible. The technological conditions take place in intervals (*epoché*) where an established infrastructure remains valid across all apparent political, historical, and cultural changes, just as analog AM radio has endured for more than 80 years almost technologically unchanged. Such intervals, as Delta-*t*, endure anachronistically (even achronically) when compared with the historical timeline. Public radio, in Germany, dates back to October 1923. As an independent media format, based in autonomous technological implementation, it apparently dies these years in its familiar AM / FM analog technology. A historic “timeline” representation of the heroic radio age is misleading. There is a reentry of “radio” into mobile communication, not as a program format and “broadcasting,” but in its purest form as technical medium: wireless (German “Funk”) electro-magnetic waves, this time digitally modulated, as in mobile telephony and WLAN internet access. In present mobile communication, there is more radio than ever, even if dissimulated as a condition of possibility.

The infrastructure of wired and wireless networks increasingly becomes interlaced. “Rather than wireless cities of wireless networks, it might be more accurate to speak of the rewiring of cities through the highly reconfigurable paths of chipsets.”²¹ In wireless communication, the infrastructure has become mobile itself. McLuhan described the wireless transmission of analog signals as a sphere as “acoustic space” because its inherent message (its implicit “sonicity”) has been the wave as temporal form. “Electric speed is approximately the speed of light, and this constitutes an information environment that has basically an acoustic structure.”²² In digital communication, this almost Heideggerian “Being” of electromagnetic space has been inverted from melodic tuning to pulsed rhythm.²³ Eleni Ikoniadou’s

The Rhythmic Event conceptualizes digital events not as binary sequences of zeros and ones but instead as relational pulsation.²⁴ This correlates with the notion of "algorhythmics"—the rhythmic processes of computational algorithms.²⁵ In that sense, hardwired temporalities can never be reduced to (infra-)structures, but in reverse, they temporalize such structuring conditions (*l'archive*, in the sense given by Foucault) themselves, "posting" infrastructures.²⁶

While data-processing microchips are still hardwired infrastructures in themselves, the wireless signal transfer has become a dynamic infrastructure consisting of extremely volatile temporal objects: multiple radio-frequency waves transduced by devices using digital signal processing (DSP) embedded within mobile phones and other wireless communication devices. To exhaust the available channels for signal transmission in parallel (known from George Antheil and Hedy Lamarr's invention of "frequency hopping"), "the designers of contemporary wireless DSP chipsets usually supply a palette of different hardwired algorithms alongside generic processors."²⁷ Just as in integrated circuits, the integration of hardwired and wireless networks allows for algorithms to operate. Radical mathematization transforms conventional communication engineering into intelligence in its double meaning.²⁸ While most of the physical layer of information networks "is quasi-hardwired into semiconductor chips,"²⁹ in order to facilitate algorithmic intelligence (or "cognitive radio") to unfold its micro-time-critical efficiency, its dynamic intra-structure is not based on "time" anymore in the ontological sense but on an asynchronous grid of operative temporal actions, such as compressing movements into ultra-short slots. Such a mobile network replaces the immobile cables of the internet or telephone lines with a dynamic, in fact temporal grid for time-critical signal processing. Wireless communication is not simply a form of bridging spatial distances by electromagnetic waves between antenna and receiver anymore, but becomes primarily a function of intelligent shaping of signal events in between.

The traditional linear channel becomes itself dynamical and temporalized, composed of algorithms that "generate waveforms that support conjunctive pathways"—that is, a mobile infrastructure, a new kind of ether.³⁰ Although this almost amorphous infrastructure is still grounded in conventional communication engineering and technologies, in its essence it becomes more radically mathematized than even conceived by Shannon.³¹ While the traditional radio wave has been a time signal, in digital processing it becomes decomposed in frequency values in order to be treated computationally. The time axis itself is techno-mathematically suspended when a waveform that varies over time is transubstantiated into a set of

component frequencies by Fourier transform; at the same time it allows for switching back from the frequency domain into the time domain. Such communication infrastructures oscillate between temporal and atemporal moments. Fourier transform is challenged by a structural incertitude either toward temporality or spatiality; in so-called wavelets, temporal linearity itself is suspended. For more efficient transmission streams, digital signals themselves become superimposed and enclosed in a signal envelope that looks like white noise, which is finally filtered back into a data stream. Temporality is just one (itself “ephemeral”) function within such chains of operations. Efficient coding (convolution) has been developed to match signal errors and erroneous signal intrusions: “The stochastic character of the Viterbi algorithm ... alters the terrain on which machine time moves.”³² What once was conceived as moments “in time” becomes a function of irruptions of the tempoReal (an escalation of Norbert Wiener’s notorious term “time of non-reality” for the switching momentum between binary states³³). Far beyond the world of communication engineering, knowledge culture has to acknowledge this nonsymbolic temporal quality, learning from media.

Contemporary “Media Ecology” Identified from within Its Temporal Infrastructures

In media-archaeological terms, computational technologies, in the very essence of both components (*techné* as well as *lógos*), consists of *both* “hard-wired” temporality on the very infrastructural level of microchip circuitry and “soft-wired” temporalities resulting from what drives such machines: source code which concerns time-critical operations in computational languages such as assembly language. Micro-temporal physicality (the “real”) is as much the object of media-archaeological analysis as “the symbolic” ordering of signal series, the algorithmic logic of digital culture—bypassing the imaginary *alias* “history.”

The often debated “technological determinism” in media-archaeological analysis refers to infrastructures by necessity: a reconnaissance of both hard-wired (materially embedded) and softwired (algorithmic) structures which govern media temporalities from within. Media archaeology is a consciously *anachronistic* identification of contemporary predefining states and layers of electronic media culture. The technological infrastructure of AM radio, for instance, endured for almost the whole twentieth century, notwithstanding the political and cultural catastrophes occurring within that century. The endurance of insisting hardwired and softcoded technologicistics creates a

temporal interval of its own. As long as such an *epoché* is still in operation, its media are excepted from the transience of the historical event. Such a theory of media time not only concerns emphatic "deep temporality" on a grand scale but also inversely re(oc)curs within the microscale of technological timing in the concrete circuitry of electronics itself.

Current "speculative design" theory registers a shift from progressive modernity to an *epoché* of contemporaneity where time is not an empty duration unaffected by the processes that happen within its technologies. On the extensive and microlevel of technological infrastructures, there is no homogeneous "time" but multiple and asynchronous tempor(e)alities, reminiscent of Ernst Bloch's notion of "non-contemporaneous contemporaneities" ("die Gleichzeitigkeit des Ungleichzeitigen"). The infrastructures of technological contemporaneity are not a coming together of data in time but a coming together of functional timings. Technological machine times challenge historicist notions of accumulative continuity. The concept of "media ecology" in that sense refers to temporal environments, to being in a clocked world, Heidegger's "Zeit des Weltbilds" taken literally.

Notes

1. "Zeitfunktionen der Signale": Karl Küpfmüller, *Die Systemtheorie der elektrischen Nachrichtenübertragung* (Stuttgart: Hirzel, 1974), 393.
2. See Gerhard Dohrn-van Rossum, *History of the Hour* (Chicago: University of Chicago Press, 1996).
3. Martin Heidegger, "The Age of the World Picture," in *The Question Concerning Technology*, trans. William Lovitt (New York: Harper & Row, 1977), 115–154.
4. Walter Ong, *The Technologizing of the Word* (London: Methuen & Co., 1982).
5. See Barry Powell, *Homer and the Origin of the Greek Alphabet* (Cambridge: Cambridge UP, 1991).
6. Walter Benjamin, *The Work of Art in the Age of Its Technological Reproducibility and Other Writings on Media*, ed. Michael William Jennings, Brigid Doherty, and Thomas Y. Levin (Cambridge, MA: Harvard University Press, 2008).
7. Edmund Husserl, *On the Phenomenology of the Consciousness of Internal Time (1983–1917)*, ed. and trans. J. B. Brough (Dordrecht: Kluwer Academic Publishers, 1991).
8. Lewis Fry Richardson, "A Forecast-Factory," in *Collected Papers of Lewis Fry Richardson*, vol. 1, *Meteorology and Numerical Analysis*, ed. P. G. Drazin (Cambridge and New York: Cambridge University Press, 1993), 219.

9. See Manuela Garretón and Diego Gómez Venegas, "Towards an Archaeology of Media and Visual Languages," in *The Counterculture Room: Pavillion of Chile at the London Design Biennale 2016*, ed. FabLab Santiago (Barcelona: Ediciones Polígrafa, 2016), 108–127.
10. George Kubler, *The Shape of Time: Remarks on the History of Things* (New Haven, CT: Yale University Press, 1962).
11. Alan Turing, "Lecture to the Mathematical Society on 20 February 1947," in *A. M. Turing's ACE Report of 1946 and Other Papers*, ed. B. E. Carpenter and R. W. Doran (Cambridge, MA: MIT Press, 1986), 111.
12. However, Linus Torvald himself argued in favor of such time-critical synoptic interpolations. See Robert McMillan, "Linux's Creator Wants Us All to Chill Out about the Leap Second," *Wired*, January 9, 2015, http://www.wired.com/2015/01/torvalds_leapsecond/.
13. Geert Lovink, *Dark Fiber: Tracking Critical Internet Culture* (Cambridge, MA: MIT Press, 2002), 152. For more, see the chapter "Net.Times, Not Swatch Time: 21st-Century Global Time Wars," 142–159.
14. Lovink, *Dark Fiber*, 143.
15. Raymond Williams, *Marxism and Literature* (New York and Oxford: Oxford University Press, 1977), 122. See Shannon Mattern, "Deep Time of Media Infrastructure," in *Signal Traffic: Critical Studies of Media Infrastructures* (Urbana, Chicago, Springfield: University of Illinois Press, 2015), 71–93.
16. As stated in a lecture by Jussi Parikka, "Of Queues and Traffic: Network Microtemporalities," on occasion of the symposium *Digital/Social Media and Memory*, University of Glasgow, April 17, 2013.
17. Christoph Neubert, "Elektronische Adressenordnung," in *Die Adresse des Mediums*, ed. Stefan Andriopoulos, Gabriele Schabacher, and Eckhard Schumacher (Köln: DuMont, 2001), 34–63, 41.
18. Wikipedia, s.v. "Real-Time Web," accessed January 20, 2010, http://en.wikipedia.org/wiki/Real-time_web.
19. "Früher ging es um die Schaffung von Räumen ... heute geht es um die Zeit selbst, um Chronos, um die Kunst der *longue durée*." Geert Lovink, "Was uns wirklich krank macht," *Frankfurter Allgemeine Zeitung*, June 21, 2010, 27.
20. Othmar Kyas, *Internet: Zugang, Utilities, Nutzung* (Bergheim: Datacom, 1994), 65.
21. Adrian Mackenzie, *Wirelessness: Radical Empiricism in Network Cultures* (Cambridge, MA: MIT Press, 2010), 65.
22. Letter to Barbara Ward, February 9, 1973, in *Letters of Marshall McLuhan*, ed. Matie Molinaro, Corinne McLuhan, and William Töye (Oxford: Oxford University Press, 1987), 466.
23. See Rainer Bayreuther, "Phänomenologische Grundlegung," in *Heidegger-Handbuch: Leben, Werk, Wirkung*, ed. Dieter Thomä, Katrin Meyer, and Hans Bernhard Schmid (Stuttgart and Weimar: Metzler, 2013), 509–512.
24. Eleni Ikoniadou, *The Rhythmic Event: Art, Media, and the Sonic* (Cambridge, MA: MIT Press, 2014).

25. Shintaro Miyazaki, "Algorithmics: Understanding Micro-Temporality in Computational Cultures," *Computational Culture* 2 (2012).
26. Michel Foucault, *The Archaeology of Knowledge*, trans. A. M. Sheridan Smith (New York: Pantheon, 1972).
27. Mackenzie, *Wirelessness*, 72.
28. This becomes apparent from topics like "Algorithms and Modeling for Tracking and Locating Mobile Users" in the call for papers to the 10th International Conference on Wireless and Mobile Network (WiMo 2018), May 26–27, 2018, Vienna.
29. Mackenzie, *Wirelessness*, 70.
30. Mackenzie, *Wirelessness*, 66.
31. Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).
32. Mackenzie, *Wirelessness*, 80.
33. See Claus Pias, "Time of Non-Reality: Miszellen zum Thema Zeit und Auflösung," in *Zeitkritische Medien*, ed. Axel Volmar (Berlin: Kadmos, 2009), 267–279.

About the Author

Wolfgang Ernst is Full Professor for Media Theories at the Institute for Musicology and Media Science at Humboldt University in Berlin. Having been academically trained as a historian and classicist (Latin Philology and Classical Archaeology) with an ongoing interest in cultural temporalities, Ernst grew into the emergent technology-oriented "German school" of media science. His academic focus has been on archival theory and museology, before attending to media materialities. His current research covers "radical" media archaeology as method, the epistemology of *technológos*, the theory of technical storage, the technologies of cultural transmission, micro-temporal media aesthetics and their chronopoetic potentials, and sound analytics ("sonicity") from a media-epistemological point of view. Ernst's latest booklet in English is entitled *Technológos in Being. Radical Media Archaeology and the Computational Machine* (2021).