What Time Is It?
History and Typology of Time Signals From the Telegraph to the Digital

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Time signals provide a sense of "despatialized simultaneity," a rhythm to the everyday lives of billions of people, and experiences of liveness. This article offers a history of time signals from the 19th to the 21st centuries, identifying three typologies: *scheduled* time signals, sent mainly by radio and TV; *on-demand*, such as those of the speaking clock; and *automatized*, transmitted by the Network Time Protocol for digital devices. The article stresses the importance of time signals in media history and the significance of an infrastructural network of timekeeping/timesharing for the functioning of media themselves.

Keywords: time signals, media history, media and time, media content, infrastructure, telephone, broadcasting, liveness

Time signals play a huge part in our everyday life experience. Whether they are embodied in profound clock chiming, ringing bells, short "beeps," or large numbers on the screen, time signals accompany every aspect of our lives and witness many media changes. Little research, however, has addressed the question of their content and format. Within the last two centuries, time signals have evolved significantly, reflecting both media development and progression in timekeeping. By overlooking time signals, media studies underestimate the significance of an infrastructural network of

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timekeeping/timesharing for the functioning of media themselves and, more broadly, undervalues their contribution to the complex relation between media and time.

This article aims to investigate time signals in their relation to different media in a long-term perspective, from the 19th century to the 21st century, focusing on different communication technologies like electric telegraph, telephone, wireless telegraph, radio and television broadcasting, Internet and mobile phone. Those media have kept the right time also in relation with church bells, cannons, and other nonelectronic or electronic ways to measure and to signal the flow of time, and are actually engaged in a broad intermedia system.

This historical reconstruction of time signals has two main aims. First, to propose a historical overview of this understudied but highly symbolic and often appreciated media content and to classify the different genres of time signals. Second, we aim at contributing new ideas and sources to advance the theoretical understanding of the relations between media and time. This relation has been studied extensively and in different fields (see Adam, 2004; Fornäs, 2016; Morgner, 2017; Pentzold, 2018; Scannell, 1996; Schwarz, 2004), but this article advances an intermedia and intertechnological analysis of time signals, considering different and overlapping infrastructures used in their design.

The research is based on a revision of the secondary literature about time signals and on primary sources from international organizations or national archives (such as legislations, private companies' boards of directors, and technical journals). The first section of this article addresses theoretical and conceptual foundations for approaching time signals, the following sections classify time signals into three different types with specific case studies related to different media. The conclusion sums up the findings and discusses the changes and continuities in evolution of the time signals and their relevance in media studies today.

What Do We Mean by Time Signals?
Theoretical Foundations

Time signals embody a link between two phenomena: media and time. *Time signal*, as a term, became popular especially thanks to radio or television: It is not by chance that in 2010, the *Oxford English Dictionary* defined it as "an audible signal indicating the exact time of day, especially one broadcast by radio at certain times" (Stevenson, Pearsall, & Hanks, 2010, p. 1863). But, in 2019, the meaning of time signal had expanded, and again, the *Oxford English Dictionary* redefined it as "an audible, visible, or (in later use) electronic signal serving to indicate the exact time of day" ("Time Signal," 2019). This broad definition brings attention to the different forms and formats of time signals and to their evolution.

Many scholars have researched the complex relation between media and time. From the spread of telecommunications in the 19th century to the advent of digital and mobile devices today, media developments have been often conceptualized in terms of "time-space compression," "acceleration," and "culture of speed," influencing societies and creating social pressures because of time scarcity (Giddens, 1990; Harvey, 1989; Rosa, 2013; Tomlinson, 2007; Wajcman, 2015). John Thompson points out that electric communication technologies gave rise to "despatialized simultaneity" because media and telecommunications help to experience events "as simultaneous despite the fact that they occurred in locales that were spatially remote" (J. B. Thompson, 1995, p. 32). The mass media, such as broadcasting media, had been acknowledged a great impact on temporal structures of everyday life through scheduling the daily routine. Silverstone (1994) famously asserts that television "provides a framework for the temporal structure of the suburban day" (p. 71). In past centuries, there is consequently an increasing intertwine among media, shared experiences, and beliefs of billions of people, and the rhythms of everyday lives affected by the use of the media themselves.

Radio and TV broadcasting is probably the most studied medium regarding the rhythms of everyday live, and the key issue is the concept of liveness. "Liveness" refers not just to live programs, but also to the way contents, even when recorded, are designed. As Ellis (2000) pointed out, the TV programs adopt the rhetoric of liveness without necessary being live: "They talk of 'now' and 'today,' 'here' and 'we'; they use the present tense, which maintain the illusion of liveness" (p. 33). The language, design, and content of the radio or TV shows are designed to constantly refer to the present, to the current "now," and so to synchronize the audience. Scannell (2004) highlights that this is not just an implication of the technology itself, but in fact the existential phenomenon that deals with "the aliveness of our being" (p. 8).

Time signals are exemplary programming content for providing a sense of "despatialized simultaneity" (I set my clock to be on time for my favorite show), a special rhythm to the everyday lives of millions or billions of people (I am synchronized through the exact time), and an experience of liveness (I understand what is "now" thanks to time signals; J. B. Thompson, 1995, p. 32). Just as Scannell (1996) suggests about the press and broadcasting, time signals could be also seen as creating "a frozen immediacy caught in an eternal present that obliterates the past and denies the future" (p. 151). The time signal makes sense of what is "now," and the existence of the time signal makes sense only in the "now."

Apart from this complex relation to media, time signals are an important part of what is being referred to as "exact time." Time kept by clocks is not "natural" time, but always a social construction. Its fragmentation and measurement are designed according to the cultural, economic, and political trends and patterns in society (Adam, 1995; Elias, 1992). As McLuhan (1994) wrote,

> As a piece of technology, a clock is a machine that produces uniform seconds, minutes, and hours on an assembly-line pattern. Processed in this uniform way, time is separated from the rhythms of human experience. The mechanical clock, in short, helps to create the image of a numerically quantified and mechanically powered universe. (p. 146)

Time as a social construction is also a part of an industrial society. As E. P. Thompson (1967) famously noted, industrialization created a specific work discipline, and time signals were quantifiers of economic growth. Moreover, in postindustrial and so-called postmodern societies, the obsession with time persists: The global economy has no respect for daylight and human physiology, and the norms of working nonstop and being synchronous are accepted as legitimate, creating different forms of precariousness (Standing, 2011). Time signals play an important game here: they continuously remind us or to our timekeeping devices our place and our rhythms in everyday life.

In this context, time signals are the essential inner working of logistical media with a priming effect. John Durham Peters (2013, 2015) coined the term "logistical media" (p. 41, p. 176) to refer to the fact that calendars and clocks deeply structure human life and provide the link between nature and culture. Similarly, time signals play the role of a translating mechanism from one clock to another *through the media*. Time signals regulate the rhythm of tools, which, then, regulate the rhythm of our lives. Along with developments in the precision of clocks, which refers to their ability to record the passage of a second consistently, time signals have evolved to improve the accuracy of timekeeping (McCrossen, 2013). As a clock "dragged man out of the world of seasonal rhythms and recurrence" (McLuhan, 1994, p. 155), time signals dragged clocks out of the world of asynchrony and of different records of the passage of seconds. Thanks to time signals, humans learned to track geolocation for navigation at sea, help to maneuver airplanes, register weather changes, predict earthquakes, and calculate longitude, the earth's shape, or the wind direction. In sum, time signals enhance the synchronization of human lives and help to record and reproduce the passage of time.

Despite the undeniable importance of a time signal and its daily persistence, so far, very few studies have addressed this topic in *longue durée*. Many scholars have acknowledged the importance of understanding the evolution of communicative tools as providing not only momentary mediation of time in each instance but also "the historically transforming mediatization of time" (Fornäs, 2016, p. 5221). Time signals are a clear example of a long-term genre and format affecting the mediatization of time. Indeed, they represent specific media content, so to say, a specific program or show, designed to be distributed and shared with audiences. Time signals have presupposed content (communication of the current "now"), and therefore, they can be seen as all sharing the same news. However, they are very different in terms of channels of distribution, accessibility, costs, formats, lengths, and other features. Their design inherits particular traits of the medium on which they appear, and they have changed over time, corresponding to the current timekeeping opportunities.

Time Signals in Media History: A Typology

This article proposes three main types of time signals that persist in media history over the past two centuries. We call the first ones *scheduled* time signals, not to focus on radio and television broadcasting exclusively, as the word "schedule" may suggest, but to underline the fact that there are time signals transmitted by institutions at regular times that can be received regularly by a mass audience. The second type is *on-demand* time signals, transmitted to final users on request. Finally, the third is made of *automatized* time signals, transmitted by digital protocols and picked up automatically by digital devices without any human intervention.

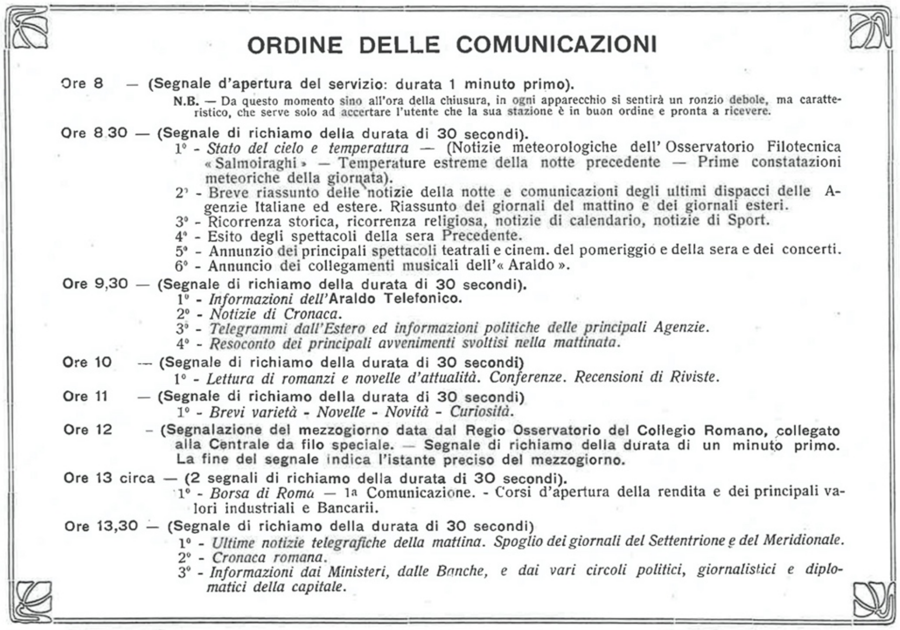
Scheduled Time Signals

Time signals can be transmitted by multi- or broadcasting media, such as electric and wireless telegraph, circular telephone, radio, and television. These types of time signals, descendants of a time ball or church bells, provide a one-to-many transmission of the right time at specific moments. A sender, or a broadcaster, delivers live the right time to many people simultaneously. This means that if people do not listen or watch at that moment, they simply miss the signal. The scheduled time signal imposes that all users receive the signal *at the same time*, which therefore "forces" them to participate in a mass (and powerful) ritual of synchronization.

A scheduled time signal also operates with binary content: Like time balls or cannon shots, it communicates whether the right time has arrived or not. When the time ball is dropped in the port at noon, all surrounding ships receive the coded message: Noon has arrived. The same goes for an audience receiving broadcast time signals: The time has arrived (or not).

This process can occur in small groups of people, larger communities (up to an entire nation), or even globally. Starting from the early 1800s, telegraph offices synchronized their clocks to keep track of all incoming and outgoing correspondence. To synchronize the clocks in every telegraph office, a designated telegraph operator tapped one beat every second, beginning at four minutes before noon. At noon, the operator started to type a pair of dots every second for one minute. The process was mostly designed to synchronize clocks to the exact minute, not the exact second. If the beginning of the string of two dots was missed, the receiving operator was still able to synchronize the clock to within a minute (Bartky, 2000). In this case, the telegraph was a medium sending multicast time signals only transmitted to the offices included in the network. The synchronizing power of telegraphy was also very useful for organizing railway traffic at the beginning of the 19th century, making train travel much safer (Schivelbusch, 2014; Schwoch, 2018). A side effect of this process was the creation of "national time." Telegraph operators had to choose which of the different times within single countries should be transmitted, and typically the time of the country's capital was chosen. In the United States, the telegraph offices predominately worked with reference to Washington, DC, noontime (Dick, 2003), whereas in Russia, the telegraph messages and railroads operated exclusively under Saint Petersburg time, the then capital of the Russian empire (Siefert, 2011).

A second medium transmitting scheduled time signals was the telephone. Between the end of the 19th century and the first decades of the 20th century, in countries like France, the UK, Hungary, the United States, and Italy, the telephone was used not only as a point-to-point telecommunication tool but also as one-to-many technology. The so-called circular telephone allowed information to circulate among subscribers in the form of regular transmissions over the telephone lines. This medium anticipated radio broadcasting, and through the scheduling of its programs, users were able to listen to concerts, readings, stock exchange news, updates on horse races, news programs, and language courses, among others. Among these programs, there were also time signals (Balbi, 2010b; Marvin, 1988). Similar to telegraphy, the programmed time signal reached only those customers who subscribed to the telephone company, and the hour of transmission was announced in advance. However, despite always using multi- and broadcast time signals, the circular telephone did not address professionals, like telegraph operators, in their working spaces, but all kinds of users directly in their houses instead. This can be seen as the first step toward the popularization of time signals we are experiencing today. Again, the most relevant moment for time synchronization was considered to be noon, and, at one minute before noon, the telephone started to ring with a special tone for one minute. It stopped when it was exactly 12:00 p.m (see Figure 1). The time signals transmitted over the circular telephone were mainly audible signals. In Hamburg, Germany, for example, time signals consisted of different sounds, such as beeps, "siren-like tones," and "rattling alarm sounds," to indicate the exact minutes ("Telephonisches Zeitsignal," 1909, p. 811). Those time signals had also been communicated to Copenhagen, Wisbaden, Cologne, Munich, and Paris.



ORDINE DELLE COMUNICAZIONI

Ore 8 — (Segnale d'apertura del servizio: durata 1 minuto primo).
N.B. — Da questo momento sino all'ora della chiusura, in ogni apparecchio si sentirà un ronzio debole, ma caratteristico, che serve solo ad accertare l'utente che la sua stazione è in buon ordine e pronta a ricevere.

Ore 8.30 — (Segnale di richiamo della durata di 30 secondi).
1° - *Stato del cielo e temperatura* — (Notizie meteorologiche dell' Osservatorio Filotecnica « Salmoiraghi » — Temperature estreme della notte precedente — Prime constatazioni meteoriche della giornata).
2° - Breve riassunto delle notizie della notte e comunicazioni degli ultimi dispacci delle Agenzie Italiane ed estere. Riassunto dei giornali del mattino e dei giornali esteri.
3° - Ricorrenza storica, ricorrenza religiosa, notizie di calendario, notizie di Sport.
4° - Esito degli spettacoli della sera Precedente.
5° - Annunzio dei principali spettacoli teatrali e cinem. del pomeriggio e della sera e dei concerti.
6° - Annuncio dei collegamenti musicali dell'« Araldo ».

Ore 9,30 — (Segnale di richiamo della durata di 30 secondi).
1° - *Informazioni dell'*Araldo Telefonico.
2° - *Notizie di Cronaca.*
3° - *Telegrammi dall'Estero ed informazioni politiche delle principali Agenzie.*
4° - *Resoconto dei principali avvenimenti svoltisi nella mattinata.*

Ore 10 — (Segnale di richiamo della durata di 30 secondi)
1° - *Lettura di romanzi e novelle d'attualità. Conferenze. Recensioni di Riviste.*

Ore 11 — (Segnale di richiamo della durata di 30 secondi)
1° - *Brevi varietà - Novelle - Novità - Curiosità.*

Ore 12 – (Segnalazione del mezzogiorno data dal Regio Osservatorio del Collegio Romano, collegato alla Centrale da filo speciale. — Segnale di richiamo della durata di un minuto primo. La fine del segnale indica l'istante preciso del mezzogiorno.

Ore 13 circa — (2 segnali di richiamo della durata di 30 secondi).
1° - *Borsa di Roma* — 1a Comunicazione. - Corsi d'apertura della rendita e dei principali valori industriali e Bancarii.

Ore 13,30 — (Segnale di richiamo della durata di 30 secondi)
1° - *Ultime notizie telegrafiche della mattina. Spoglio dei giornali del Settentrione e del Meridionale.*
2° - *Cronaca romana.*
3° - *Informazioni dai Ministeri, dalle Banche, e dai vari circoli politici, giornalistici e diplomatici della capitale.*

Figure 1. The schedule of the circular telephone with the time signal scheduled at noon. The text says: "12 o'clock. Signaling of the noon given by the Royal Observatory of the Roman College, connected to the Central station by special wire. Signal lasting one minute. The end of the signal indicates the precise instant of noon" ("Che cosa," 1920).

According to a brochure for the Italian circular telephone (called *Araldo Telefonico* [Telephone Herald]), time signals were broadcast thanks to a "special wire" that connected the central station of the company to the observatories, both to the Royal Observatory of Collegio Romano in Rome and the University of Bologna Observatory in Bologna. But later, the program announcer responsible for it claimed that, actually, she adopted a hands-on and less precise practice: She simply listened to the cannon shot on Janiculum Hill to announce noon, and, on the basis of that acoustic signal, made the buzzers resound at subscribers' homes (Balbi, 2010a). This is a living form of coexistence and co-functioning of old and new time signals: cannons and telephone distribution of the right time.

Wireless telegraph networks followed the same pattern and even elaborated it further, taking time signals from a national to an international level. Wireless telegraphy provided the first real broadcasting network of time signals—meaning that any user equipped with a radio set could receive the right time wirelessly. In 1912, the most powerful stations in the world were united in a project of transmitting time signals at a given hour, according to a special timetable of the international organization Bureau International de l'Heure ("Scientific Time Signals," 1913). Each radio station in the network was assigned a specific hour to transmit the signal: For example, Paris would send it at midnight, San Fernando in Brazil at 2 a.m., and Arlington in the United States at 3 a.m. (Rikitianskaia, Balbi, & Lobinger, 2018). The time signals repeated every hour all over the world, which meant mostly once per day by a single station. This project also made time signals uniform globally, because originally, every wireless telegraph station had a different format for the signal (e.g., "crumpling of tissue paper" from the Eiffel Tower in Paris or "the squealing of a rabbit" from Norddeich in Germany; "Time Signals," 1912, p. 312). This project was a great success for scientists and radio amateurs who experimented with receiving the exact time directly at home (Rikitianskaia, 2018, p. 137). The spread of these accessible time signals contributed to what McCrossen (2013) calls the "end of the public clock era" (p. 25) because between the 19th and the 20th century the new technologies of communication made public clocks obsolete. Along with the circular telephone that brought the exact time to several homes simultaneously, wireless telegraphy further advanced time signals by bringing global and uniform time and making possible the reception of precise time signals on the move.

Time signals were also one of the most prominent radio, and later, television, programs. Radio broadcasting inherited many formats and practices from circular telephone and wireless telegraphy, including time signals (Balbi, 2010a; Lombardi, 2006). In 1924, radio listeners in Italy identified time signals as "their favorite radio program," ahead of the news, sport news, weather forecasts, musical programs, women's hour, children's hour, and readings ("Tabella delle," 1924, p. 369). Time signals were (and still are) the perfect content for broadcasting media like radio and TV. As said, broadcasting brought "simultaneous despatialization" to the highest and most effective level: For the first time in history, radio and TV allowed physically displaced people to listen to the same content at the same time and all together. For this reason, broadcasting is considered a powerful means of synchronization, and time signals are exemplary content, bringing this metaprocess of synchronization to a higher level (Ortoleva, 1986). Time signals provide insights into the very essence of broadcasting, as they create direct relation to the "now" and enhance forms of expectations: Think about the millions of listeners tuning in at a certain hour in anticipation of the exact time signal. This certain hour is announced in advance in the radio schedule, so the listener will know when to tune in. This introduces another consideration of scheduled time signals: They are actually *made of* two messages, the announcement and the signal itself, where the announcement also provides information on the hour and peculiarities of transmission, followed by the signal itself.

Time signals also keep the rhythm of radio and TV programs, and, especially, of the schedule: The schedule itself is an infrastructure and platform of timekeeping, and so time signals can be again considered the perfect-fit message for this structure. Originally, time signals were considered proper programs, and they were also announced separately in the schedule of transmissions. Later, time signals were no longer announced separately, and, even today, they are simply broadcast at a certain time, or are obsessively repeated by radio speakers during the "normal" live programs. Despite being absorbed by other programs, the signaling of the right time is still a key content of radio and TV programming.

Radio broadcasting history also reveals another persistent feature of a time signal: It is composed of "beams" or some particular sounds resembling Morse code, and so, the transmission of time was through telegraphy. In 1924, in the UK, the British Broadcasting Company introduced the Greenwich Time Signal (GTS) transmission, popularly known as the pips, and namely a series of six short tones broadcast at one-second intervals by many BBC radio stations (McIlroy, 1993). On Radio Moscow, as well, in the 1930s, time signals were announced as follows: "The signals of the exact time will be transmitted now: Two long ones, one short. Citizens, check your watch!" (Markevich, 1938, p. 4). Thus, those signals resembled two dashes and one dot. The sound of beams then later passed to TV time signals, and, even if there were not practical reasons for conserving this audible dimension, it can be considered to be a persistent form of a telegraphic practice: Listening to dots and dashes up to the right time and setting the clocks based on them.

Television added a visual dimension to the audial one. In different countries, a moving clock was shown before the beginning of prime time (and so not anymore at noon). Probably the BBC provided one of the most symbolic examples of TV time signals showing Big Ben in London (Crisell, 1997; McKay, 2010). This is another interesting form of the persistence of timekeeping and a form of remediation (Bolter & Grusin, 1999) of what can be considered as the first mass time signals provided by church bells, and it is another example of old and new forms of time signals coexisting. Bells were indeed the main tool for timekeeping in the preelectric era, and it is interesting to note how special tones and sounds of time signals were experimented with for the first time with bells: In several Catholic countries, for example, at 7 a.m. and 7 p.m., church bells still sound differently from at other times.

Scheduled time signals are still relevant today for listening to the radio or watching TV. But today, other forms of time signals have changed the way we synchronize our clocks, and the crisis of linear broadcasting could also be explained by its inability to synchronize the audience anymore.

On-Demand Time Signals

The second type of time signals can be defined as *on-demand*. In the past two centuries, there have been several attempts to implement technical systems to transmit time signals by request of the final users, and the most important experimentations concerned the use of the telephone in its one-to-one traditional form.

Since its invention, the telephone has been used as an alarm clock—for example, when switchboard operators phoned customers' homes directly in the morning or at specific times of the day to wake them up (Balbi, 2013). This special paid service mixed human and mechanic abilities: Human operators had to establish close relations with customers, but their activity was only possible because of the existence of a telephone network.

Relationships between subscribers and switchboard operators continued into the early 20th century, when the customers would actually call the operator to inquire about the exact time. This practice became so popular that it contributed to congestion of the telephone lines in some countries, and some telephone companies prohibited their operators from providing the right time. For example, in 1918, the magazine of the New England Telephone & Telegraph Company issued the announcement that the operators would not be providing time information anymore, to increase the efficiency of telephone services and to relieve operators form "unnecessary burdens" (New England Telephone & Telegraph Company, 1918, p. 12).

The perfect solution to the management of time signals on the telephone lines was found in the speaking clock, whose "invention" was a long and difficult process because of a very mechanical issue: The breakage of the film from the continuous rotation on the disks, with it being a sort of gramophone in continuous operation. The first experiments with the automatic speaking clocks over telephone lines were held in France in the 1930s, and in 1937, a similar service was offered in Hamburg, replacing the previous use of the circular telephone (Wolfschmidt, 2008, p. 91). The speaking clock immediately became popular. As a Russian newspaper noted in the 1930s, the telephone lines in Moscow were frequently busy in the morning *because of* the speaking clock: Calling for the exact time became a routine practice for Soviet citizens before going to work ("Novyj Komplekt," 1938). Clearly, the habit of phoning for the right time, and so blocking the telephone network, passed from manual operators to the speaking clocks, and telephone subscribers kept on appreciating it.

A crucial innovation of the speaking clock was its automatization in transmission. The time signal was reproduced on demand: The customer dialed a special number, and a prerecorded voice announced the exact hour. Beams also persisted in this on-demand service, as the cartoon (see Figure 2) from the *Indianapolis Star* shows: The dog in the telephone box is instructed to "hear the tone" to know the exact time.

Figure 2. A comic appeared in the* Indianapolis Star *reflecting on the spread of the speaking clock (Greenwood, 1969).

This service became more and more relevant in the second half of the 20th century, and especially from the 1960s and 1970s, when telephone companies in Europe tried to expand their markets by providing new services. Telephone companies identified new sectors and services like data exchange over telephone lines (the ancestor of the contemporary Internet), the transmission of TV over telephone lines, picture-phone, and on-demand services like the speaking clock.

For a long time, there was no alternative to the speaking clock for getting the signal of the exact time on demand. The only choice that developed in the 1980s was Teletext that supplied an on-demand time signal on TV. In Flanders, for example, Teletext was even considered a competitor to the speaking clock, a direct threat to the service of the national telephone and telegraph operator RTT (Van den Bulck, 2016, p. 83). Moreover, Teletext provided a visual format of on-demand time signals instead of audial ones.

Around the 1990s, the mechanical system of providing the tone was replaced with a digital system. The service migrated from observatories to time standards labs and to the informatics domain. Thus, the Web has become a medium where time signals can be delivered on demand. Websites, like the French *Horloge Parlante*, provide not only the visual time signal but also resemble the practices of the speaking clock ("Horloge Parlante," 2021), combining the audible tones inherited from telegraphy and the speaking clock with the precision of the Network Time Protocol (NTP; see below).

In conclusion, these various experiments with using telephone for transmitting the signals of the exact time demonstrate the growing demand of subscribers for the on-demand service of timekeeping, and, at the same time, the persistence of “old” and telegraphic formats of time signals, such as tones. Finally, the speaking clock set the road toward automation of the transmission of the time signal, which is discussed in further detail in the next section.

Automatized Time Signals

The development of the atomic clock in the 1950s, capable of generating a very accurate pulse per second, has been a revolution and a milestone in timekeeping history (Mulvin, 2017). However, its introduction did not immediately affect the distribution of time. The majority of the world’s countries continued operating standard time and frequency broadcast stations as they did before the invention of the atomic clock. The distribution process changed only with the spread of personal computers in the 1980s and the Internet in the second half of the 1990s, as the existing signals were not suitable for computer use. Consequently, a new type of time signals appeared, solely transmitted by Internet-based digital devices, and designed as a number of seconds elapsed from a particular reference point (see below).

The ways in which digital devices keep time today is quite elaborate. First of all, digital devices have two clocks responsible for timekeeping, called the hardware and the system clocks. The hardware clock is usually powered by a battery, so the clock also runs when the device does not have electricity; while the system clock keeps track of time, time zone, and daylight saving time. Typically, most operating systems keep track of time in three steps: The hardware clock sets the signal in the system clock on boot, the system clock keeps the accurate passage of time, and finally, the system clock sets the hardware clock on shutdown. There is, however, a problem in this process: The quartz-based hardware clocks of our devices are incapable of keeping the time as accurately as the atomic clock does.

Here is where the NTP intervenes, helping to communicate the right time from the (extraordinarily precise) atomic clocks to the (not accurate enough) quartz-based electronic clocks of our digital devices. The NTP, designed in 1985, is one of the oldest protocols that lies in the foundation of the Internet. Its specific type of time signal also became more and more prominent with the spread of computers, smartphones, and other devices, synchronizing through this protocol. Today, it remains the most important protocol for time synchronization, and, thanks to it, our digital devices receive information about timing continuously, mandatorily, and automatically. The latter two adverbs are crucial for this third type of the time signal, which is fully *automatic*—from transmission to reception—and therefore, no longer depends on a particular person adjusting the clock hand. It is designed to minimize or to exclude human intervention, not only having transmission automatized as with the speaking clock but also excluding the manual reception of the signal. Automatic time signals are also *mandatory* both for users to receive and for media systems to transmit. Our devices cannot avoid this time signal; they have to adapt and adjust to its message. The automatic reception and transmission also make these time signals a necessity for the functioning of digital media systems. Therefore, humans passed from searching and longing for time signals to being subjected to them automatically, with no escape.

The time signal of the NTP is the time stamp. Just as the post office stamped letters with the current date or time, computers stamp the files and any actions with "electronic time stamps" to record their sequence, using different coding and systems. The NTP time stamps provide the number of seconds that have passed since a particular date, so our digital machines can convert it to the local clock. This means that the structure of time signaling is designed in a very different way: It refers not to the synchronicity of all the machines, but to the calculation of the number of seconds passed since a certain point in the past. To illustrate the case, it is helpful to consider the selection of historical NTP dates in the description of the most recent NTP version released in 2012. In Figure 3, the first column in the table refers to our calendar. The column "NTP Timestamp Era Offset" presents respective time stamps, as the number of seconds elapsed since the start of an era. The current era was set on January 1, 1900. As the column "NTP Era" suggests, we currently live in Era 0, and everything before that date should be considered as Era −1, −2, and so forth. On February 8, 2036, Era 1 will start.

Date	MJD	NTP Era	NTP Timestamp Era Offset	Epoch
1 Jan -4712	-2,400,001	-49	1,795,583,104	1st day Julian
1 Jan -1	-679,306	-14	139,775,744	2 BCE
1 Jan 0	-678,491	-14	171,311,744	1 BCE
1 Jan 1	-678,575	-14	202,939,144	1 CE
4 Oct 1582	-100,851	-3	2,873,647,488	Last day Julian
15 Oct 1582	-100,840	-3	2,874,597,888	First day Gregorian
31 Dec 1899	15019	-1	4,294,880,896	Last day NTP Era -1
1 Jan 1900	15020	0	0	First day NTP Era 0
1 Jan 1970	40,587	0	2,208,988,800	First day UNIX
1 Jan 1972	41,317	0	2,272,060,800	First day UTC
31 Dec 1999	51,543	0	3,155,587,200	Last day 20th Century
8 Feb 2036	64,731	1	63,104	First day NTP Era 1

Figure 3. Selection of historical NTP dates as presented in the NTP Version 4 specification (Mills, Dellaware, & Martin, 2010).

Thanks to the time stamp format, every time signal transmitted is unique. The same hour, minute, and second of different days have different time stamps. The noon of today is a different time signal from the noon of tomorrow. Moreover, the fact that the NTP operates with the number of seconds passed since the reference point, rather than attempting to spread the same signal simultaneously, is the key to its replicability and reliability. The NTP uses a hierarchical system of primary and secondary time servers, clients, and interconnecting transmission paths, divided by strata. This hierarchical configuration means that the accuracy of the time signal may decrease with the distance of the stratum from the reference clocks (Mills, 1991). However, the accuracy in synchronization is achieved by implementing not only hierarchical client-server model but also horizontal peer-to-peer connections. This means that computers are able to calculate the speed and errors in the transmission of the messages, therefore calculating the passage of time in relation to the traveling speed of the time signal. Time signals today are also accurate *because of* the users, as a form of participation from below.

Just as with scheduled and on-demand time signals, automatized ones require a supplementary infrastructure to work properly, and, specifically, a shared knowledge of the reference point (read it the year zero). In 1991, the NTP was described as "symmetric architecture in which a distributed subnet of time servers operating in a self-organizing, hierarchical configuration synchronizes local clocks within the subnet and to national time standards via wire, radio, or calibrated atomic clock" (Mills, 1991, p. 1482). Therefore, the NTP design itself emphasized the importance of bridging different media infrastructures, or, in other words, it stressed the relevance of intermediality. The automated time signal is indeed not only continuous, mandatory, and automatized, but also inherently intermedia.

Conclusion

This article provides a historical overview of the role, relevance, and functioning of time signals in different media, such as electric telegraph, telephone, wireless telegraph, radio and television broadcasting, and digital media. By examining the design and format of time signals, this article analyzes the broad relation between media and time, focusing on understudied media content developed specifically to transmit time.

We propose three types of time signals that have emerged over the past two centuries: scheduled, on-demand, and automatized. They imply different relationships between media and time: The scheduled time signals are supposed to be picked up at a particular hour, the on-demand ones always remain available, and the automatized ones are constantly being received and transmitted in the background of our digital media systems.

Time signals refer to the current "now" in all their formats and forms. This means that they bridge liveness, rhythm, and simultaneity. Time signals shape the present moment, and they *are* the present moment. They exist only in the "now," highlighting the immediacy and accessibility of the communication system. They embody present time.

Our research highlights that transmitting information about time for different users over long distances was a great challenge for a long time. Hence, time signals are technologically complex and shape different behaviors of users and different visions of synchronization. The scheduled time signal requires the transmission of a particular tone from one sender to several receivers at a given moment. This time message is binary: It signals whether the moment has arrived or not, and the audience has to know in advance when to pick it up. The on-demand time signals, such as the speaking clock or Teletext, provide the exact hour, minute, and second. It is a one-to-one message by request of the receiver, who should know which number to dial or which Teletext page to access. The automatized time signal goes even further, compressing information about the date into one message, and, by doing this, it follows the principle of time stamps. This third type of time signals is easily understandable and convertible by digital devices, but it works quite differently from the way humans used to track time. It is also a "mandatory" time signal because receivers using digital devices cannot avoid being synchronized by them.

This article has also underlined some forms of changes and continuities in the use and evolution of time signals.

There are two most relevant changes. First, time signals have evolved from a manual to an exclusively automatic service, communicated between machines without human intervention. This automatization happened gradually. As early as 1915, there were suggestions to automatize the service, to not rely on the human ear, as the wireless time signal was already that clear and understandable (Hinks, 1915). It took, however, many decades to implement this idea on a large scale: from the automatization of the transmission with recordings of the speaking clock, to the automatization of reception starting with the radio clocks to the digital media.

Second, time signals gradually changed their role in the media ecologies, becoming more and more invisible. From being highly appreciated, sought-after, and engaging content, they now blend into media, becoming a taken-for-granted and "inevitable" media component. Again, this evolution can be understood only with a long-term perspective: from the slow disappearance from radio and TV schedules to their now hidden nature in the code of Internet protocols.

The article has also revealed some unexpected continuities in the evolution of time signals. First, many time signals inherit the ways of transmission from their previous forms, and, for instance, incorporate "beams" and tones of the Morse code into the Web. Then, time signals, themselves, make up an essential part of the existence of the media. The telegraph networks transmitted time signals to synchronize offices. The radio time signals help to adjust the clock to pick up a particular radio program later on. The NTP time stamps help computers record the sequence of events correctly. The media convey time signals, and, simultaneously, depend on time signal transmission themselves.

Even though the development of time signals reflects the evolution of various technologies, communication systems, and overall human capability to transmit messages, it is necessary to stress the fact that different types of time signals coexist. With every new way of transmitting time signals, the old ways are seen as endangered. The invention of the NTP, for example, was considered to provoke a fast decline of the speaking clock. In the United States, already, in 2008, journalists noted that there was no more reason to dial the speaking clock unless one was suffering from some visual disability or needing to pretend to be on the phone, while AT&T Inc. calculated that about 300,000 phone numbers were freed up with the change in southern California alone (Donkin, 2008). In some countries, such as the UK, Australia, and New Zealand, the speaking clock lines were shut down. However, in other countries, the speaking clock experienced an incredible persistence: According to the main Italian telephone operator TIM, for example, the speaking clock remains open and used by subscribers despite being a costly service (two euros per minute) ("42.161 Ora esatta. Per essere sempre in perfetto orario [Exact time. To be always on time]," 2021).

Overall, this historical overview of time signals brings to the scope of media studies new perspectives on the relations between media and time. Reflecting on the precision and accuracy of modern time discipline, Michael Sauter (2016) points out that "only after people stopped disciplining clocks could clocks discipline people" (p. 709). The means of this time discipline, as presented in this article, deals with synchronization, social habits, and needs (being on time); private and public timekeeping; and several everyday sociocultural practices that tend to be invisible. The history of time signals also sheds light on the history of media themselves. Nowadays, taken for granted and almost blending into other media contents, time signals persist in nearly every communication infrastructure, and their existence is both important for the users, as well as indispensable for the media functioning. They are not only logistical media, but also infrastructural ones.

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