

Unfolding digital materiality

How engineers struggle to shape tangible and fluid objects

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Introduction: grasping a matter-network

In this chapter we address two issues related to the notion of digital materiality. The first one concerns the fluidity: On what rests the fluidity of the digital? And how can we qualify the process leading to the production of objects that can circulate? The second one concerns the *mode of existence* (Souriau 2009 [1954], Latour 2013) of digital artifacts: What does becoming digital imply for an artifact? How to qualify the dynamic of becoming digital? We deal with these questions keeping distance from an understanding of digital as a matter, which can be defined according to an opposition container/content or matter/form. We do not propose a new minimal unit supposed to reduce the composition of a digital matter. On the contrary, we chose to tackle the digital materiality from the more dynamic angle of the material, which we define as the matter mobilized in activity and which is transforming as the interactions between the craftsman and the materials unfold. First, a constantly growing number of people is involved in the production of information and digital craftsmanship: these producing interactions remain to be studied. Second, following the moves of the material at stake will enable to overtake the vain quest to establish the minimal unit of the digital.

STS scholars have given renewed importance to the materiality of information, revealing the machines and invisible workers (Star 1991; Denis and Pontille 2012) that allow them to function – as well as the protocols and organizations which subtend them (Bowker et al. 2010). The

attempt to conceive information materiality in terms of material infrastructure and extended embedded artifacts led to the birth of a subfield that Bowker et al. (2010) call “Information Infrastructure Studies” (IIS). As a major result IIS have gone *behind the screen*, revealing the *invisible infrastructures*¹ (Star and Ruhleder 1996; Star and Strauss 1999) that produce information. In a nutshell, these works have led to think information and the digital as a complex and heterogeneous *assemblage*. These works also question the understanding of information and digital as an intrinsically fluid content that is ontologically distinct from and superior to materiality. In the wake of laboratory ethnographies (Latour and Woolgar 1979; Lynch 1985; Pinch 1986), *IIS* conceptualize information as the result of concrete operations from which it cannot be dissociated. The question “*what is digital information made of?*” can be reformulated into another question: “*how is digital information produced?*”. The answer rests on the study of the sociotechnical networks that participate in shaping information and constitute its eminently material being (Denis and Pontille 2012).

Digital information is indeed difficult to grasp. Understanding it often means understanding the pipes, machines, invisible work, protocols, classifications and standards through which it is produced and flows, with particular attention to collective data shaping. In IIS, the emphasis was put on aggregated entities such as collaborative research systems (Star and Ruhleder 1996), transnational databases (Bowker 2000; Millerand 2012; Heaton and Proul, 2012; Heaton and Millerand 2013; Van Horn et al. 2001), health information systems (Hanseth and Monteiro 1997) and digital library systems (Gal, Yoo and Boland 2004). These very interesting works can lead to the strange impression that everything depends on the infrastructure. IIS already suggested that interactions between operators and the material are important to study but we still lack of close look at the practical way the shaping is engaged.

In order to extend ISS results with a closer look at how information is produced, this chapter draws on the analysis of a process of digitization, that of the concerts recordings of the *Montreux Jazz Festival*. Within this ambitious project of digitization, we focus on a specific activity, that of indexing events (speeches, musical performances, applause, etc.) in the digitized files. To complete this work, operators must “tag” the events that occurred on stage at the time of recording. In order to do so, the lab team is often confronted with the need to remove a number of uncertainties that “primary digitization” (conversion of the analog signal into a digital signal) has not dispelled: what is recorded on the digitalized tapes? In what state are they? What does their video and video signal say? What songs were played that evening on stage?

By working on the case of soft and very light artifacts – the shaping of digital pieces of music from recorded live concerts – we challenge the “hardness/softness” of things and look at specific textures of the digital such as digital spatiality, relations and embedded networks, enabling and constraining. The challenge here is that of working on a seemingly double immateriality: music and digital. Following Hennion (2015b), we propose to consider digital (music) as something that has no proper matter of its own while only manifesting its presence to those who interact concretely with it. It is made of matter in the sense of Latour (2013), that is to say “the set of all the other beings upon which any given entity depends” (Latour, MoE)². This conception of matter as a network of relations allows to free the question “what is digital made of?” from the quest for an essence by providing a relational understanding of materiality. The *matter-network* proposed by Latour relates to a sociotechnical network, that is to say a set of associations between heterogeneous entities, human or not (Callon 1986), *assemblage* (Latour 2005) that makes beings exist. Since a thing is made through movements and the process of associating all the elements that constitute it, there is no reason to seek which of these elements is the most

important or ontologically superior, nor even of what “ingredients” it is composed. Understanding what a thing is made of thus equates to unfolding the operations that shape and maintain the sociotechnical network that underlies the existence of this thing.

The aim of the analysis is then to describe this network of associations, paying attention to all the actions and actors that contribute to the *assemblage* that is the thing. Since the network is not defined nor delimited *a priori*, the concept of matter-network does not provide any limit to the associations that are to be taken into account; this means that we have to *follow the associations* (Latour 1987). This points to the relational dimension of the notion of materiality and to the interactions that are needed for the network-matter to exist. Such an analysis is empirically grounded in the description of observable interactions between the elements of this matter-network.

Through this study, we aim to contribute to theoretical and methodological debates about the ways in which STS can help to think about and engage with digitality. Considering the digital shaping of music recordings helps to theorize the question of materiality and the ways in which it can be taken into account through a variety of practices studied by STS scholars, such as producing knowledge or shaping a theory. Our main question is: what “becoming digital” implies for the digitized artifacts? In fact, following ISS we consider that *doing* digitality takes material work, time and effort by human beings but we also propose to add an analysis of what *making* digital things implies. We consider digital thing as a contingent result of a process of association which is, in the same time, precisely aiming for reducing the contingency of the existence of digital productions. Then the key point is to account for this crucial issue by proposing an analysis of the dynamic of reducing the contingency of digital things.³

An ethnography inside the shaping of cultural digital beings

In this chapter, we describe how digital information is produced through a case study in the field of digitization of cultural heritage. Carrying out ethnographic fieldwork in the lab of Ecole Polytechnique Fédérale de Lausanne (EPFL) in charge of this archive, we follow the process of digitizing the archives of the Montreux Jazz Festival. In this lab, a few dozen researchers, engineers and technicians work daily on the digital files of 10,000 hours of audio-visual recordings. Ethnographic investigation allows us to grasp the process of shaping digital entities and, as participating observers, to take part in it and to understand its phenomenological implications. Through this inquiry, we show how the methodology and results of IIS can be completed and deepened not only by going *behind the screen* (Jaton, forthcoming) but also by taking a closer look at, and account for, the experiences made *inside and with the screen*. In order to do so, we have personally experienced the set of tasks of shaping digital beings. Alongside the lab team for six months, we took part in the digitization process. This experience, together with informal interviews and observations of work situations led over one year, allows us to provide a precise account of the constitution of *digital beings*⁴. Then the work of information is grasped in its materiality: stages operators and tools, some tangible (computers, keyboards and mouse) but also more evanescent ones, such as a signal processing software. This work remains difficult to describe, as undemonstrative as can be a mouse click that positions a cursor on the screen. However, their almost silent action has irreversible consequences on the inherently material destiny of information.

In the first part of the chapter, we briefly present the history of the recordings of the festival concerts. We describe the evolution of the network that supports the conservation of the tapes, i.e. their forced rescue through digitization. We set the context, which explains why an

engineering university takes into its hands the destiny of a segment of cultural heritage. It then becomes possible to understand the switch from conservation to promotion in the process of transforming heritage into raw material for innovation. In the second part, we enter the lab where digital files are monitored, digitized and processed, starting with the investigation initiated by the lab to determine what there is on the digital files corresponding to the tapes. We will see how the team builds objects that can be manipulated and qualified. We describe how they interact with physical media, tools and interfaces, producing *holds*⁵ (Bessy and Chateauraynaud 2003; Hennion 2015a) on the digital files. We show that the existence of the informational material becomes more and more certain as they build its *equipment* (Vinck 2011). We account for the negotiations between these operators and the “pieces of concerts” they manipulate leading to the transformation of the archive into an original artwork. We focus on the process of establishing the boundaries for the musical pieces identified within the concerts. These operations of building *pieces of digital music* often face objects that resist to the definition of their boundaries. In the last section we discuss some of the results of this study in the light of works dealing explicitly with the issue of materiality and of a non-essentialist understanding of materiality.

Part 1: Digitization to rescue concerts

Tapes threatened by an eroding network

Since its foundation, the organizers of the *Montreux Jazz Festival* have recorded concerts. The archive now represents about 5,000 hours of audio and video recordings. Endorsed as Memory of the World by UNESCO in 2013, this unique collection covers 50 years of jazz, blues and funk music. As famous US artists and politicians (i.e. Stevie Wonder, Herbie Hancock, Hilary Clinton) were participating, the Montreux archive is one of the most valuable testimonies of the

American contemporary music. The records were made in the most innovative formats of the time: stereo multitracks since 1975; HDTV since 1991; 3D experiments in the 2010s. According to the leaders of the digitization project, the decision to put together the archive dates back to 1988, when a manager of the festival made a request to national television, supposed to preserve the recordings. He asked them to provide a given recording and discovered that the tape had been reused to record a football match between two small towns. There was no other copy of the recording; the memory of that concert was therefore lost. Worried, the festival's founder decided to retrieve the records and construct a building on his property to house safely the tapes whose number increased year by year.

However, the "bunker," as aficionados call it, was quick to show its limits. Seemingly safe in Compactus storages that housed them for 20 years, the tapes were again threatened, this time by oxidation. In order to be read, some formats required technologies that were becoming scarce (2 inches audio and U-matic for example). Some machines could no longer be found; other machines were very bulky. In addition, the knowledge required to run them was not easily available; it was sometimes concentrated in a few specialized companies, sometimes possessed by only a few people no longer in activity in the field. The 18 different formats used during 50 years for recordings and the rarity of some of them give value to the archive and at the same time make the perennial conservation of the archive difficult. Technology and the knowledge on which the archive depended were endangered.

Other elements that support the existence of the tapes and their contents are stable and constitute good allies in the preservation of the recordings: the bunker of the archive (regularly maintained and built according to the best standards of the time); up-to-date inventories; contracts with artists who rely on the wide network of the copyright; amateurs who continue to listen to edited

or pirate copies; collectors who maintain their collection and sometimes enrich it with tapes acquired when organizations that held copies let them go. All those elements were thereby compensating somewhat for the erosion of the network of organizations and actors supposed to ensure the task of preservation. However, these mediators associated with the archive who converge on "concerts that have taken place" were not enough to ensure the sustainability of their recordings. Gradually, their mediation weakened and the network supporting the recordings crumbled in places.

This threat highlights the network-constitutive mediations of memory and illustrates the relational dimension of maintaining in existence the concerts. If the recorded concerts (their materiality) depend on such a network to exist and not to disappear, the question may arise as to *what is their content?* Thus formulated, the question assumes, however, a dichotomy between material form (media) and content that we believe should be abandoned in order fully to grasp the relational dimension of materiality (Law and Mol 1995; Hennion 2003; Ingold 2011; Latour 2013). Examining the network of associations that constitutes the existence of the "concerts that have taken place" also allows us to understand how this existence is threatened and the dynamics of the interaction between the elements of the network that do and undo the concerts.

From conservation to promotion and exploitation: Rescuing the concerts by making them fluid and able to circulate

The destiny of the concert recordings of Montreux brings together actors whose collaboration may be surprising. People originating from the worlds of culture and technology agree on an operation to rescue the recordings. Because of its concern for preserving this heritage and awareness of the importance of the technical and financial investment required for the sustainability of the archive, the responsible Heritage Foundation has signed a partnership with

the *Ecole Polytechnique Fédérale de Lausanne* (EPFL) which seeks to develop its activity in the field of the digitization of cultural heritage. Access to large digitized corpora and to an already shaped *data territory* (Vinck and Camus, forthcoming) will provide resources for the development of its laboratories.

In 2011, on the basis of these contacts and agreements, an ambitious and large-scale project of digitization of audiovisual archives is born. Over five years, more than 15 million Swiss francs are allocated to digitize 10,000 tapes covering the 50 years of the festival in order to preserve this heritage. But the aim is also to promote the Festival and its archives and to generate of added value (academic publication, design of products and services, creation of start-up). At the time of the survey, although 75% of the tapes were digitized and available on the 5 Peta Bytes storage system hosted in a secure room beside the computing machinery and other sensitive data from the Engineering university, the destiny of the archive remains uncertain. Conservation does not happen by itself; our interlocutors state that there is no permanent solution other than the systematic and regular transfer of the archive from one format to another following their evolution, coupled with a copy in at least three different media and locations. To cope with the uncertainty of conservation, the hypothesis formulated by those responsible for the lab – which was, in fact, created at the occasion of this digitization project – is that the sustainability of the archive will be achieved through its promotion and exploitation, including by offering it as *raw material for innovation* to different laboratories of the university. Thus attached to new socio-technical networks, the risk of its disappearance would be reduced, including the risk of missing out on new computer formats, through the technology watch achieved by researchers from the university for their own needs. The lab thus achieves a translation (Callon 1986) between the preservation of a cultural archive and the scientific life of a state-of-the-art lab network. The

digitization of the festival archive is therefore driven by a goal of promotion of the labs involved and the university that hosts these labs. The association of the archive with this network of labs should also produce a dynamic of innovation from which archive promotion should benefit.

Between 2011 and 2014, five labs and over 30 researchers have worked on this digitized archive, resulting for example in the development of a musical suggestion application and automatic playlist generation (*Genezik*) and in an application allowing to browse the festival's archives on iPad (*Archive Discovery Application*). These devices form new socio-technical extensions of the archive and thus extend its existence. They feed on the digitization of the archive and, at the same time, they guide the treatment of the digital archive according to their specific needs. They depend, in particular, on a music content classification system used by contemporary media players: the playlist. To serve these applications, recorded and digitized concerts must be formatted so as to generate a playlist. Through this way of processing digital files, the suggestion algorithm is able to offer a "musical journey" based upon the analysis of the first piece selected by the user. From this first selection, the application developed by researchers in signal processing analyzes the musical content (they call it the "musical DNA") and calculates⁶ the supposed tastes of the user so as to offer songs transition as "soft" as possible according to "audio only" parameters (rhythmic structure, timbre, harmonic progression). The application should thus distinguish itself from its competitors whose algorithmic recommendations depend on metadata (for example, qualification of the "style") – an unreliable criterion according to the researchers of the project. The application is supposed to allow the user to discover pieces he had forgotten and should nevertheless enjoy. However, it assumes that the digital files it handles are equipped with tags transforming concerts into a world of independent musical pieces, i.e. clearly marked with a beginning and an end. For this application, an entire concert is not a suitable

material for deployment; it needs pieces. The lab accordingly shapes digital files, allowing the archive concerts to deploy in new socio-technical networks, at the price of a *musical-material translation* of concerts into playlists. Another application, the *Archive Discovery Application*, offers the user the possibility to navigate the festival concerts on iPad by selecting a year, a concert or a song. The concert as a digital entity is not a problem as long as it is equipped with tags that allow it to be read and translated as if it were a playlist of the concert. This playlist allows the user to switch from one song to another.

Both applications briefly presented here highlight the fact that the rescue of endangered tapes involves the creation of new networks of relations between entities that are themselves also new. The association of the archive with these technological artifacts offers it new conditions for digital existence; however, this association involves a series of transformations of the archive and concerts. The temporality of recordings and concerts does not remain intact; it does not become what it would have been in a classical conservation process of archives where the integrity of the document is an end in itself. Embedded in a dynamic of digitization, the archive is put to the test, put to work and transformed in order to participate in its promotion, which is posed as a condition of its preservation. The renewed vitality of the concerts, through the socio-digital treatment they undergo, suggests that they are on track to be saved. Digitization is the opportunity to decouple threatened concert tapes and to embed them into a new network under construction. The survival of the festival concerts depends on the success of this construction and association with new entities that are, from now on, protective of the henceforth digital existence of the recordings.

Part 2: Multiplying mediators in order to obtain a tangible material

In the following part of this chapter, we continue the investigation of the digital deployment of the music archive by entering the lab in which this digital-musical material, which is intended to circulate in other labs, is prepared. We begin by operating an “infrastructural inversion” (Bowker 1994) to highlight the operations that make and unmake the digital material. We situate our analysis upstream of the circulation outside the lab, at the time when a collection of digitized tapes acquires circulation potential. This preparation for circulation involves manipulations of digitized records and qualification operations of what there is “in” the files.

Getting acquainted with the digital material

In order to create mobile units and tag concert sequences (*songs of playlists*), researchers transform digital files into a material with which interactions become possible. They begin by looking for a way to manipulate the material and “catch the tapes”. Their investigation consists in qualifying what these tapes may *be* and what they might be *made of*.

At its arrival at the lab, the tape is digitized⁷ and copied onto two durable storage media⁸. A unique ID and a digitizing report available in the project database are already associated and link to the magnetic tape data storage. These are the basic handles available for researchers to locate files in the collection under construction. They also provide them with a set of clues concerning their probable state: if the digitization has gone well, the signal is probably in good condition. This is precisely what they will begin to verify. The investigation they initiate shows that digitization does not mean dematerialization but rather materialization, otherwise. The primary digitization has transformed a single magnetic tape into six files stored on two physical supports (LTO cartridges). To each file corresponds a unique ID that takes the formalism of the analog archive inventories to which is added the filename extension (ex: .wav, .avi). These indications

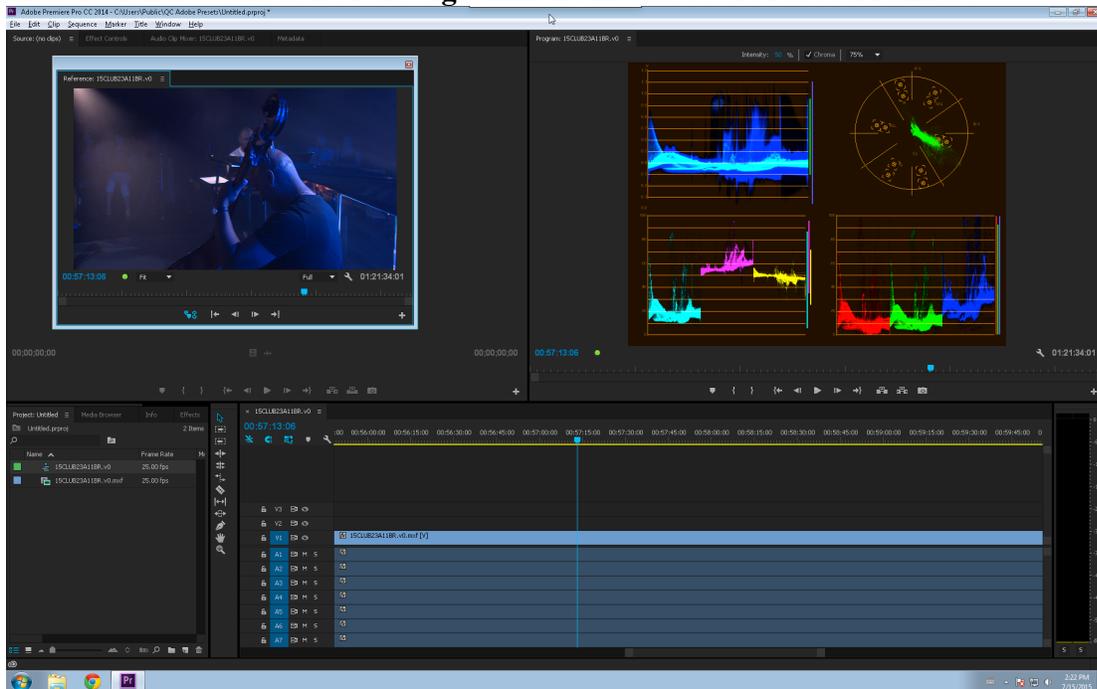
enable them to manage the unloading of the files from one of the LTO cartridges into the storage system. The primary, “pre-digital”, archive is the copy of the original magnetic tape on a new physical support and magnetic tape. This archive is kept as such on its new support, duplicated and stored in a safe, waiting to migrate to the next generation of the support. The secondary (II) and tertiary (III) versions of the digital archive are uploaded into the storage system. The secondary archive will provide the basis for continuing the process due to its good value in relation to weight (about 50 GB per hour of recording) according to the researchers.

On the basis of this version, they transform the files to prepare pieces on which they will run tests. They then undertake a series of tests to learn more about the tapes. The first test concerns the signal. To qualify the audio signal, they use a specialized software (*Adobe Audition™*), which is their main tool for audio signal processing. For the video signal, they use another specialized software (*Adobe Premiere™*) and tools present in the "reference monitors" with advanced signal processing functions.

The tests and inspections of signals constitute an introduction. The signal is then taken as an intermediary through which researchers catch "what there is on the tape". This contact is limited to the most experienced members of the lab. In concrete terms, the researcher opens the file corresponding to the digital copy of the tape in its secondary archive version with the specialized software. Her workstation is equipped with two screens. On the top of the right screen appears the moving image of the video recording under which are displayed the different signal channels: video is represented by a sequence of still *frames* and audio by the graphical representation of the *waveform* corresponding to each stereo channel. Audio can be listened to through headphones but most of the time researchers only see it on the screen.

The concert – both its sound and image – is thus visually deployed on multiple screens. Two screens are used for this operation described as *quality assessment*. A third screen, known as the “reference screen” is put to use from time to time for some operations. On the right screen, the video is displayed in play mode via the software interface; on the second, left-hand, screen, the researcher varies visualizations of the video signal corresponding to different approaches of the signal (Cf. illustration 1). The lab has previously referred to local experts, who have been for a long time related to the recording of the festival concerts, to help establish acceptance criteria, for example chrominance (part of the signal concerning the color) and luminance (level of light). They have agreed to set the luminance of the video between 0.3 and 0.9-1.1. She explores the "digitized tapes" to value indicators that allow her to estimate the quality of the digitization performed by the subcontractor.

Illustration 1: variation of the signal in the interface of Adobe Premiere



Credits: Metamedia Center , EPFL

Illustration 2: Dropouts (see on the hear)



Credits: Metamedia Center, EPFL

The researcher involved in this process of testing the signal is constantly navigating between the two main screens that combine different approaches of the recordings through specific visualizations, each corresponding to different types of tests. To chrominance and luminance is added the detection of errors and defects, such as *dropouts* (small losses of analog signal due to digitization or originating in the recording itself. Cf. illustration 2).

During this first stage, browsing in the video is done randomly, through trial and error. The mouse cursor moves and clicks on the timeline, which is located on the right screen, allowing circulation in the concert file. The representations of the signal coexist with the video. Moving forward on the *timeline*, the researcher goes ahead in the recording and in the discovery of the

digitized tape, seeking to verify that there is still something that looks like a concert, assessing the state of the signal and detecting possible defects.

If indicators of the video signal delivered on the screen do not show values outside the standards, the read-discovery-analysis continues linearly moving forward in the recording. However, when an anomaly is detected, scrolling is immediately stopped and the researcher goes back. Too high luminance or chrominance leads her to a more detailed examination: Is it sure? By how much? Under what conditions? Which color exactly? The dropouts also interrupt the reading because their perception involves finding the incriminated frames. As a first step, she looks back on her perception and aligns it on a part of the video signal. She identifies the sequence (zone) in which could take place what seemed to be a dropout. Then she zooms inside the frame sequence represented by a series of rods. Finally she changes tools. Leaving the mouse, she moves to the keyboard and uses the arrows, scrolling through the frames one by one until she finds and notes the timecode⁹ (to 1/100 second) that matches the defect. This operation can be tricky because the matching of perception and the sequence that contains the defective images is not easy. Sometimes the perceived dropout is not found and the reading-analysis resumes.

Giving birth to musical-digital intermediary objects

This first meeting between researchers and digitized tapes is an important step in understanding the recordings because *holds* are built in order to qualify them. Knowledge is channeled through the “signal” that translates the digital file into an object that can be handled with clues, indicators and concepts that are known and tested by the specialists of signal processing. The signal appears on the screen and it is “here” or “there”, on its graphical-digital representation, that the researchers identify relevant information, such as a remarkable value of the signal or images containing *dropouts*. The tapes are then recognized as containing content that the researchers can

qualify, at least the small portions that they can qualify and with which they build an object of knowledge. They thus begin to know “what the recordings are made of”.

Approaching the tape through its audio or video signal also allows them to connect "what there is" on the tape with instruments mastered by the researchers. With their conceptual and instrumental equipment, they capture and translate a portion of what there is on the tape and spread it over two or even three 22" screens. Even deployed in this way, the qualification of the signal remains difficult; the material is not fully captive. Some reactions to the signal testing are furtive and sometimes difficult to catch even with a trained eye.

The result of this first encounter is materialized by a report (*quality assessment report*), i.e. another computer file that reports on the meeting with and the behavior of the tape grasped through its video signal. Researchers formalize *the competence deduced from observed performances* (Latour 2004). This process leads to descriptions that increase knowledge while multiplying the elements supposed to be constitutive of digitized records (signal, color, light, frame, timeline and timecode, etc.). These elements appear as *intermediary objects* (Vinck 2012) at the interface level (screens, headphones) and are sometimes *inscriptions* (Latour and Woolgar 1979), due to operations carried out by researchers, their computers and algorithms. This set of successive operations of transforming the recording make it an object of knowledge and a component of the information infrastructure constituted by the digital archive.

Preparing the recorded concert for new encounters: Networking the content with other files

We have just seen a foundational stage of the process that helps dispel initial uncertainty about the state of digitized tapes and their capacity to be grabbed. The trial also involves many researchers, their techniques and their body skills. This first encounter verifies whether it is

possible to go further in relation to the recording. The socio-technical network constitutive of the material has significantly increased by connecting with instruments and scientific skills of the lab that multiply the material properties. However, we still have to consider many operations before the digitized tapes become equipped concerts that will drive music playlists. Now, we shall briefly account for the deployment of the material before stopping at an important moment of interaction between the operators and digital-musical material.

The reconstitution of a concert involves a detailed examination of the recordings on which their existence depends. During this review, the researchers seek to answer questions such as: what happened that night on the stage? What was played? In doing so they "reveal" the concert that is supposed to be "contained" in the tapes. By putting to work these recordings as well as inventories and other traces that have been kept since the days of video recording (labels on the case of the tape and ID), researchers link tapes to concerts and identify objects (such and such piece of music) that are supposed to exist in the file of the digitized concert. Up until this point, the researchers have revealed a signal proving the existence of a concert. The next part of the process is about bringing into existence its content and what this content is made of. To do so, they use archives from the legal files of the festival which, in the negotiation of contracts with the artists, established the song list supposed to have been played that night. So these songs have a script-legal existence. This *setlist* provided by the festival organizers (*Festival-setlist*) introduces in the lab a potential *hold* on the content of the concerts. Considering together the tape IDs attached to the corresponding digital files, the presence of a signal attested by first tests and the *Festival-setlist* leads to the idea that there indeed are pieces of music in the digital file corresponding to the concert, pieces whose list is given *a priori*. This new step then consists in testing this hypothesis, verifying whether what is described on the *setlist* is really to be found in

the digital files and avatars of the tapes received from the subcontractor. The *Festival-setlist* looks like a relatively cursory Excel document; it is, for now, the most accurate description available to researchers and temporary employees (who generally are man engineering students) about the events that may have been preserved in the digitized tapes. This description of the concert does not necessarily correspond to a tape on which these pieces may be because in the world of copyright, the reference unit is not the tape but the concert. The next task is to establish a matching of concerts setlists and tapes (often two tapes for a concert).

The descriptive file of the concert is included in a file directory that gradually gathers a set of files to be investigated in order to determine what concerts are made of. The directory is named after a concert and collects lightened copies of audio files (WAV versions slightly compressed after extracting the audio stream of archive II), video files (highly compressed MP4 versions of the archive II) of each tape related to the concert, the setlist provided by the Legal service of the Festival (*Festival-setlist*), and finally a list of songs to be completed (Indexing-setlist) as and when the *Festival-setlist* is validated by an exploration of audio and video files.

In this exploration of digitized concert, researchers and temporary employees favor the audio file over the video file. The audio signal is said to be lighter; especially the *waveform* visualization and the possibility that it offers to zoom onto the signal make the audio signal an object considered to be manageable and easy to handle. Comparatively, the video signal representation is said to be hard to grasp. So it is on the audio file that temporary employees place markers that distinguish the events constituting the concert. The video file, considered to be peripheral, is there "just in case"; the user guide explains to temporary employees that in general, it will not be used. However, this MP4 version of the archive is that which is included in the iPad and its Archive Discovery App.

Changing the properties of the material: Obtaining a reasonably “clickable” material:

The network of entities gathered around the tapes is already dense. New people and machines intervene in the handling of the files that researchers now call “concert files”. As the network grows, the archive corpus becomes a more and more tangible material. The deployment of the network gives thickness to the digitized records by associating inscriptions and accumulating clues used to qualify the material.

At this stage, temporary employees have access to material that is just a click away. The sum of the files gathered in their working directory becomes the ground on which they prepare to take action and draw the outlines of what could be the concert they are in charge of. The recorded concert is from now on a set of *concert files* constituted of various computer files. The co-presence of these files and clues reinforces the thickness of what is now the concert. By their participation in the evidential base (Ginzburg 1984) that make the object, their role as evidence provides them also with a role as mediator. These files are the mediators of an indexed concert in the making, with which temporary employees should be able to interact.

This *proliferation of mediators* (Hennion 2003) ensures a possible and tangible interaction with the corpus of digitized recordings: the concert is distributed and expands into a series of new objects. Its *matter* (Latour 2013) extends and is populated with elements that can be put to work in future interactions. The mediators built by engineers enable them to multiply *holds* for future interactions with the concert that can now be manipulated and modified.

Part 3: The struggle for fluidity: Building mobile pieces

Transforming concerts into collections of small pieces: songs and playlists

The digitized recordings transformed into *concert files* pass through the hands of the engineering students temporary employees who question the files: What happened that night on the stage? What was actually played? The lab team thus progresses in its knowledge of digitized tapes and becomes prepared to index recording files by identification of events in order to be able to find them easily, or even to extract and build them as “songs” which “may be played individually in a music software playlist” (as written into the *Indexing user guide*). This indexing operation adds tags to digital files, allowing for example the *Archive Discovery Application* to explore videos of concerts in the media player *playlist* of an iPad, but also allowing *Genezik* to analyze musical similarity of pieces.

On their arrival at the lab, the dozen new temporary employees are trained for a week and receive a 13-pages guideline that reminds them of the goals and steps to follow:

- Locate transitions between songs and events, placing markers in [the audio edition window] and naming them from the provided concert setlist
- Build the setlist associated to the .WAV file in progress, copying information from the concert setlist. If mismatch is observed compared with the audio, apply the corrections.
- Generally speaking, consider that each song will be isolated and played back alone, or as a part of a playlist, making use of fade out and fade in transitions.

(*Indexing user guide*, lab internal document, p. 9)

They must scrutinize the whole tape in order to describe the content and mark events. To do this, they have a list of typical events:

- Intro: the whole recorded area before the first song, including silence, applause, speeches
- Song
- Interlude: short piece of music, instrument tests
- Applause: includes “thank you“ and song introduction speeches by the artists
- Speech: something more than just simple song introduction, including applause
- Come back: long applause time before come back of an artist, may include speeches
- Silence: rarely used
- To check: in case something does not fit the previous types (*Indexing user guide*, lab internal document, p. 9)

The guidelines for indexing, setlists and the graphical representation of the waveform on the screen are used as support for engineering students temporary employees to guide their work of qualifying file content but always need to be interpreted. This work leads to the emergence of *quasi-objects*, including songs that are not separate entities and detached from the flow of the concert but that anticipate their potential extraction and their establishment as new objects. At this stage, they are temporary objects made for the construction of new objects, which include songs and playlists.

Feeling and touching the sound material before modifying it: the songs as quasi-objects

The first of these supports is the setlist, listing the songs as so many music-digital objects supposed to have been recorded and stored on tape. It orients the work of the temporary employees who, without this support, cannot *a priori* know what to look for in the recording and might put off their investigation by just leaving a note saying "no setlist". Without the *Festival-*

setlist, the investigation stops. If the *Festival-setlist* and the *Indexing-setlist* to be completed appear in the workspace, temporary employees open the file from the audio version (WAV) of the recording. It is with this file that they will interact. The markers they place on it will testify to the fact that an event is recorded at this precise location.

At this point the tape is no longer simply an audio signal; it begins to exist as a concert. With the setlist, it even starts to become a potential playlist. All the temporary employees need, in principle, is to recognize the pieces assumed to be in the recording; then, with a click, they set new tags to delimit the songs. This is a first decisive but sometimes difficult step toward fluidization. Sometimes, they find easily the songs, especially when the song's title words are regularly quoted in the lyrics; they may have more difficulty tracking and identifying others, including instrumentals, which precisely jazz is fond of.

Having opened the audio file, mouse in hand, they move the cursor from a "moment" of the concert to another on the graphical representation of the sound wave displayed on the screen. First, they scan visually the shape of the waveform recording to identify its structure. With their headphones on, they spot graphical wave packets mainly from visual cues on the screen, clicking the mouse for a brief stop at the beginning of each graphical wave packet to check whether it is music or not. With this visual scan of sound, in some way a warm up for the real work of identification that will follow, they seek what they expect to find according to the setlist. They get an idea of what looks like the concert and the way in which the pieces are connected and the transitions done. They count as music tracks the graphical wave packets *a priori* identified, hoping that the setlist displays the same number. This identification of the relevant graphical wave packets does not happen by itself; it takes the engineering students temporary employees a while to learn how to make the difference, at a glance, between a graphical wave packet that

shows a "song" and another packet that represents a "speech". By doing this work for a few weeks, they become apprentices or even experts in music edition, able to distinguish a piece of music from a speech at a single glance.

Interacting with digital recordings, armed with a mouse, a headset and especially a screen, with their eyes and fingertips, they explore the structure of the concert. Doing so, they are already transforming the continuous flow of the concert into a playlist whose labels are those of the *Festival-setlist*. The concert is seen on the screen, mainly on the audio file. The amount of clues and evidence gathered around it grants *thickness* to the audio file (Ginzburg 1984). Through the visualization of the audio file, the recorded concert becomes a space in which it is possible to move freely, in small steps or giant leaps, thus shaping quasi-objects (Lécaille 2003) preparing the installation of a markup. Once these (reversible) bollards are installed, the pieces take on more consistency. They are now defined by boundaries under construction.

Sketching of the piece

Indexing consists in adding tags to digitized files in order to mark the beginning and the end of each identified event on the audio avatar of the tape recording (wav file). The time code of these tags can then be used to guide the extraction of tracks and to facilitate searching in and playing concerts that have become playlists. To reach this goal, the engineering student temporary employees have to build songs. They do this by starting from the *Festival-setlist* and a first visual exploration of the sound file. Then comes the moment to determine the physical limits of these songs.

Having spotted on the audio file the first song corresponding to the setlist, they position the cursor and set a tag at the end of the graphical wave packet. This end point is the exact beginning of the next transition, i.e. an "applause" sequence, whose end is at first fixed temporarily. It

becomes final once the start of the second piece has been clearly identified; for the moment this is somewhere between the possible end of the "applause" and the following graphical wave packet. In this still unclear area, the temporary employee walks the cursor with small touches on the graphical representation of the audio signal; each stop generates the corresponding sound in the headphones. She thus tests some possible beginnings until she marks one provisionally; automatically opening a new time range she extends to the end of the graphical wave packet that is about to become the second piece. The end marker is positioned roughly towards the end of the graphical wave packet. She then moves the cursor within the package that could be the second piece, with some hops in order to proceed through a quick listening. This ensures her that the piece does not contain anything unexpected that she could not otherwise "see".

The wave packet is now becoming a song. The temporary employee then returns to its borders to define them more accurately. She retrieves the start marker and zooms in on this provisional start. The software then produces a detailed representation of the waves in order to sort out the sounds. She moves around and tests two or three plausible places, working on a different scale from the one used at the time of the provisional setting. She now targets a small portion, i.e. a sample, defined at a 48,000th of a second (sampling rate of 48 kHz) on the audio file. Her eye guides the operation, as a slowed listening would distort the sound too much; the temporary employees act on the audio signal through its visualization and the mouse controlling the cursor position¹⁰. Decisions on sound are thus taken visually.

On the way to the first note: boundary work struggle

How do engineering students temporary employees determine the most appropriate sample to materialize the beginning of the song? The *Indexing user guide*, of which they always have a handy copy, insists on the fact that a good song beginning should be located in the first half-

second before the first note. This rule refers explicitly to the music industry and particularly to the edition of live CDs. In this interval, they must take the decision to define the small piece of waveform on which to fix the tag. At the scale of the sample $1 / 48,000$ th of a second, half a second is actually very large and contains a mixture of various noises: audience applause, whistles, shouts, etc., with which the words of an artist can overlap (thanks or announcements of the next song). Cases of relative silence are rare; there is no *tabula rasa* on which they can fix the tag arbitrarily. This is nearly always applause that articulates two pieces. Zooming becomes strategic for indexers, in order to choose the sample that will host the tag of the beginning of the song; a second, stretched by the zoom, then spreads on a quarter of the 22'' screen.

Described as such because it hinders action, noise is also a resource for indexers. They treat it as a buffer zone, a material martyr in which they can cut without mercy. This buffer zone forces them to zoom in and turn the time lapse of noise into a subsequence with many possibilities. They scrutinize it to know its composition and detail one by one the sounds that could interfere with the beginning of the first note. For example, they wait for a cry or whistle to fade and place the marker then, to avoid giving the impression of starting on something that is ending. It is therefore not straightforward work to get closer and closer to the first note. Indexers use many tricks, knowledge of editing software, their sharpened ear and body control that ensures fine coordination between hand, mouse, cursor, graphical-numerical representation and sight. This work also puts to use their acoustic knowledge learned on the job about the behavior of the signal: the velocity of each sound, the need to wait for a sound to finish in order to be able to isolate it without disturbing listening. This indexing work, in fact, opens a new set of uncertainties. The division into distinct sequences does not impose by themselves as evident. The indexers must negotiate with the sound stream and dynamics of the concert. Nothing is obvious; the sound must

be very finely qualified in order for the indexer to be able to decide where to put its click markup.

Once the cursor has almost found its final place after a series of trials and hesitations, the indexer checks once again, listening to what happens by mimicking the start of the song as if it were in a playlist. She then repeats listening once or twice by pressing the buttons on the built-in player of the editing software. Sometimes dissatisfied, she shifts again slightly the cursor to skip a tiny passage finally judged to be bad. She starts listening again in the manner of the player until she is satisfied with the result; the piece has therefore a beginning and an end, at least temporarily. This work will be taken up later in the file biography, during a step called "quality control" consisting in verifying the quality of boundaries, particularly to ensure nobody has missed notes before the start of the song, that they have left enough, but not too much, applause at the end of the song, and have not forgotten real "silences" in the song.

Shaping the object, equipping its boundaries

Transforming heavy musical events like a concert into more fluid materials like songs goes through boundary work consisting of identifying what a song is and what its boundaries are. But it also goes through an equipping work (Vinck, 2011) of these boundaries. In order to give more consistency to these boundaries, they are associated with new elements which give them more weight and paradoxically contribute to the fluidization of the concerts. So, once the sequence has precise limits, indexers describe it in the *Indexing-setlist*. They assign a name using the generic formalism of *Festival-setlist* (when the song actually exists in the recording). They also include parentage with respect to the concert of songs that are on their way to become autonomous entities.

Ex : artist -x- title -x- Album -x- year -x- track number -x- ID

B.B King -x- Strung Out -x- The Jazz Festival archive -x- 2015 -x- 1 -x- 173

From the Indexing-setlist, which is destined to replace the Festival-setlist, the temporary employees copy the corresponding line in the list of events which is built using the editing software (*Audition*); the "piece" that is shaped by the work of boundary markers had no name yet but only timecodes (the two samples hosting the start and end of a sequence). These timecodes are embedded in *Audition* and in the indexed audio file it produces. They are then extracted from the indexed audio file with another software, a freeware that structures into a text file (.TXT), a description that reproduces the formalism of the example and adds timecodes. The sound file is not attached to this timecode.txt file, which is designed to serve as a basis for playing audio and video files¹¹ and to provide time stamps that will be transformed into reading marks in the player of the *Archive Discovery Application*. The indexing operation ends with file saving. The *Indexing-setlist* is saved in two formats including *XML*, which "dialogues" more easily with the general database. This *Indexing-setlist* may now replace the list provided by the festival, which was the reference so far. However, indexing does not end here. The songs now constituted as tagged entities are still embedded in the recording of the concert. The issue is then to extract them and add another set of equipment to them in order to ensure their new and autonomous life. With the indexed audio file still open, a new directory named "SONGS" is created and placed in the same directory as the other files being processed. The engineering student temporary employee selects musical events she has just indexed via the interface of editing software, more precisely in its descriptive list on the left of the waveform representation. With a right-click, she selects "export", sets the format (WAV 24bits 48kHz, the same as the one with which she just tagged pieces of concert) and introduces the destination file: "SONGS". She repeats the operation by changing the format for copying songs to MP3. She then reduces the editing software window

and goes to the "SONGS" directory where she sorts out what she will keep. *Audition* automatically generates a third set of files in .PKF format. This proprietary format saves an image of the graphical representation of the signal. It is an image of wave images that evolves according to signal processing; it is always up-to-date because it is produced in the background; it thus avoids having to generate a graphical representation each time the file is opened. These files, however, are the first to be deleted, indicating that the lab has no plans to reopen the tracks in the editing software. To do this, the "SONGS" files are sorted by "type"; all PKF files are selected and then deleted. Then, WAV and MP3 are sorted by name. Events that are not songs, such as *speech*, *applause* and others are also deleted in order to leave only songs in the SONGS folder.

Then the temporary employees structure song metadata using the *Tag & Rename* program. In concrete terms, they take all the songs in MP3 version, drag and drop them into the program, click on "edit tag" and the metadata that was in the name of the file itself is structured in columns. Continuing the example from BB KING:

ARTIST -X- TITLE -X- ALBUM -X- YEAR -X- TRACK NUMBER -X- ID

**B.B KING -X- STRUNG OUT -X- THE MONTREUX JAZZ FESTIVAL ARCHIVE -X- 2011 -X-
1 -X- 173**

The term "-x-" separates the variables. Artist, Title, Album, Year, Track-Number now constitute 'columns' of metadata that media players are supposed to recognize and read. Engineering students temporary employees then add to each piece the poster of the year of the concert. The pieces, whose parentage remains attached in the metadata, are now recognizable by any media player that will "play" them as any other MP3 song. In order to become autonomous, the song

files are equipped with data that keeps track of their parentage and refers to documents confirming their origin and copyrights associated with the concert.

Discussion: Digitalization as rematerialization

A produced fluidity

During digitization, the material of the recordings has greatly deployed through multiple mediators and associations established by the lab team. In a first step, the digitized tapes are literally multiplied in different places: a safe for the two conservation cartridges with the uncompressed files, then a storage system containing the uncompressed files and the lower quality version that will be used for the rest of the process. Then their general condition is checked before they are engaged in a space of action in which they are grasped via the mediation of several objects, supposed to help unravel the mystery of their condition and their constitution. In fact, these mediators increase the number of elements on which the existence of the digitized concert rely. They became related as constitutive elements of the matter-network. It is not a unique *essence*, which irrigates a network in construction, but rather a *material*, which is constantly transforming as its existence is deploying.

Researchers and temporary employees interact with digital recordings, sometimes very closely, for example in negotiating the marks these artifacts can accept. These artifacts are worked on a process through which researchers and temporary employees get to know their materiality and composition (including the sequences that make up the concerts). Conversely, progressively built objects lead researchers and temporary employees to act with caution, taking the materiality of these artifacts into account. While this digital-musical material has become tangible (reasonably clickable), this does not mean the material has become docile. Even the transitions that should

help extract the "musical content" are negotiated and inscribed with difficulty. Researchers and temporary employees go through a wrestle which results in an acceptable compromise at some point on samples of 1 / 48,000th of a second. They negotiate those object boundaries piece by piece. The result, written, described and re-copied in several places, unfolds into multiple traces, all of which are certificates and containers of what has just been built and is still attached to the digitized tapes.

The indexing process we described is the most complete attempt to find and reveal what there is "on the tapes". Through indexing, knowledge of the concert is crystallized into a number of entities (inscriptions, equipment, intermediary objects that become material mediators of a matter-network) that are associated with the object (i.e. part of the audio file) that has been built through these operations. This produced object becomes a known object (e.g. a song); the materiality of the produced object (e.g. the piece of file) is considerably extended with respect to that of the object to be built (i.e. songs and playlists). In this sense, our account for indexing process is an attempt to reveal the distribution of being digital. Think of what one should do to move a very small marker materializing the beginning of one song. The number of elements related to the markers – the matter of the marker – could reveal discouraging. The whole chain of mediators must be activated once again and the intermediary objects (timecodes, up-to-date setlists, indexed audio files, independent songs, etc.) have to be re-written and re-produced. While the process of digitization aims at producing and shaping *digital facts*, questioning them would require a new inquiry. Our original question on the destiny of the matter of recordings when it is confronted with a dynamic of digitization leads us to show that the deployment of matter and the dynamic of multiplication of mediators come with enhanced vitality of the *musical fact*. The new life of festival concerts materializes in two ways: on the one hand,

concerts can be yet again read with contemporary devices. New means of navigation are made possible thanks to the reading tags on pieces. On the other hand, bits of concerts, the “songs”, are equipped in order to become autonomous and to circulate in a new socio-technical network, that of *media players*.

The fluidity that has been acquired through the digitization process is grounded in new associations on which, from now on, the recordings of the festival concerts depend. In this sense, this new potential for circulation depends on the capacity of the constitutive elements of the new matter-network to become active in order to allow interactions when necessary. This emphasizes the amount of work accomplished to build a potential of fluidity that can rely on the media readers that are widely available around the world. The fluidity, or potential for circulation, results from the building of a material with which transformation and thus gain of fluidity is possible. The material which is at stake had to become tangible and modifiable in order to become fluid. This is a crucial point that our ethnography can enlighten. On the way to become tangible, i.e. a material one can work with, these very hybrid digital pieces (signal, music, bit, waveform, sample, timecodes, songs, etc.) modified their constitution. These transformations are particularly visible when operators are building for themselves a set of *holds* in order to stabilize a material with which they will be able to interact. These *holds* are forged in interaction with the material and modify its properties by becoming a constitutive part of it. These both practical and conceptual elements show with accuracy that tangibility and contingency reducing are at the heart of the becoming digital process. In our understanding, this is also a key point for the conceptualization of the digital materiality where equipping work (Vinck 2011) is playing a central role.

Following on material properties, the example of copyrights is revealing. While becoming digital, concerts have become richer and have received constitutive elements from the elements used to construct them. While concerts benefit from the emergence of pieces, their existence previous to songs is modified and enhanced by this new presence, which is tested and testified on the indexed recording. The copyright information that has been transformed as one of the prior holds in order to produce “surfable” concerts fosters the emergence of entities that have strong mobility potential. The “same” list of legal objects change the status of the pieces once they have been created. There is no longer the possibility to pretend these objects don’t exist and are not the subject of a contract. Concerts are weighed down by the presence of new pieces and copyright turns back on an absolute and ubiquitous conception of digital fluidity. Law is used as a way to handle the tapes and is inscribed in the objects it refers to. It limits circulation when it has taken part in building the conditions for possible circulation. This composite matter contains elements that may tend to conflicting paths. The pieces that have been built in order to become autonomous may well not be able to exit the servers that host them because of copyright issues. This point encourages avoiding presuming matter is univocal: the apparently “same” constitutive ingredient can shape and reshape the destiny of the material.

Rescuing materiality: the STS contribution

Looking briefly at the history of the notion of materiality in the humanities and social sciences, we can trace back to the original temptation of reducing digital to a matter of pure semantics. For example, the fields of anthropology and archeology, while traditionally sensitive to cultural artifacts and the materiality of the social world, these fields have long contributed to conceptualize a sort of materiality they think of as material culture or material traces of social

activity in which, ultimately, the material dimension is secondary. If analyzing materiality means understanding what there is *in* artifacts, this equates to constructing them as social objects that lose their material properties to become objects of meaning and interpretation. Thus, the literature explicitly dealing with the materiality of things in the social world (Godelier 1986; Miller 1998; Toren 1999; Graves-Brown 2000) has given material objects the status of *tabulae rasae*, unimportant foundations on which the social world and culture are built. Material objects are thus understood to participate passively in social life by providing their material form for the construction of a semantic layer, the higher activity specific to human societies (Godelier 1986). This conception of materiality is based on a generally obvious and implicit hierarchy between humans (who are superior through their use of intentionality and meaning for example) and nonhumans (taken to be inert or transparent). This *Great Divide* (Latour 1993) supports the idea of materiality taken in an essentially semantic sense and leads to a conceptual impasse where materiality and materials are opposed (Ingold 2007).

STS have played an important role in rescuing materiality from the dead end of the absolute exteriority of material things with regard to human beings and what they do. In this respect, we have made extensive use of foundational notions such as inscriptions, instruments, intermediary objects and mediations in our analysis, which could also have been called an analysis of the *construction of a digital fact*, a distortion of the title of the famous 1979 book by Latour and Woolgar. STS have been particularly productive in describing and building concepts around the materiality of scientific facts and technical artefacts, whose analysis became more relevant once it was freed from the mental sphere (Godelier's "*idéal*" sphere) where it was locked up by positivist epistemology. Facts are stabilized by a set of operations from which they cannot be fundamentally dissociated.

On a parallel front, the foundational works of what were to become the Infrastructure Information Studies led by Star and Bowker showed that study of information and its production were not contained in its semantic dimension. Information was thus successfully displaced from being reduced to its semantic content to become a collective act, itself constituted of actions, movements, power, organizations, etc. In a nutshell, thanks to this work, the notion of information has gained thickness and intelligibility. If we want to understand how it is made, we can bring in the notion of infrastructure. The matter of information is made of all the relations that partake in its production, between human beings or with artifacts.

Conclusion: Towards a non-essentialist materiality

The attempt to qualify digital materiality in terms of material infrastructure and extended embedded artifacts has given extremely interesting results, e.g. the deployment of numerous artefacts involved conditioning the digital. However, digital material remains hard to grasp; furthermore, emphasizing digital embeddedness might appear to paradoxically posit digital as escaping materiality, as something non-material flowing inside the cables and processed by humans and machines. But, at the same time, catching digital through the computational infrastructure, which is definitely part of its matter-network, helped also to reintroduce a fundamental possibility to understand digital materiality, avoiding any dualism between digital and material. In the fight against digital essentialism inherited from the late 1990's claim for a "digital world"¹², one of the seminal STS pieces had addressed a now famous question: "If bits are not made of atoms, what could they possibly be made of?" (Blanchette 2011). This statement might give to the atoms a material reality, which reflects only some types of interaction with them and conduces to a definitely materialist understanding of information turned into what we

propose to call a *hard materialism* with unexpected consequences as it seems to oppose one essentialism to another. This hard materialism leads to looking for a canonical element to understand digital materiality and still contribute to the old quest of *essence*, even if we conclude to a material one. Another representation of the atoms, depending of other types of interaction, would show them as vacuum, distributed presence, wave, and fuzzy entities with moving boundaries. With this quantic representation of the atoms, they are material in the sense of hard and weak interactions, which means a materiality not so different of the bits. This relational understanding opens up another materialism coherent with the approach we developed in this chapter.

In recent years, the question of materiality has acquired new relevance as scholars have grappled with the issue of the materiality of the social world, with the result that debates have extended to several subfields of human and social sciences: organizational studies (Orlikowski 2007; Carlile et al. 2013), situated action (Suchman 2007, 2011; Hutchins 1995, 1999) or gender studies (Braidotti 2011a, 2001b; Frost 2011). STS play a special role in this debate. During the 1980s, ANT was central in reviving the debate on materiality and offered new pathways to rescue matter from centuries of philosophical (and theological) essentialism. In this chapter, we have tried to demonstrate the relevance of the notion of matter as recently formulated by Latour as “the set of all the other beings upon which any given entity depends” (2013). This concept seems particularly relevant to account for the unfolding process that is characteristic of the digital becoming.

In other fields closely related to STS exemplified by works on *Care* (Mol 2008; Mol et al. 2010; Puig de la Bellacasa 2010) and *Repair and Maintenance studies* (Henke 2000; Dant 2010; Gregson et al. 2009; Edensor 2011; Denis and Pontille 2015), in-depth dialogue with the studies

gathered under the plural name of *New Materialisms* (Barad 2003; Bennett 2004; DeLanda 2006; Pels et al. 2002) has taken place. This ongoing fruitful discussion builds an increasingly relational understanding of matter and materiality, and rejects any kind of exteriority of matter. In this movement towards taking into account *posthumanist performativity* (Barad 2003), matter can be considered as:

“[...] an active participant in the iterative process of the world’s becoming. Matter is neither a given resource, nor a mere effect of human action. Rather, materials move, transform, damage, mutate, form alliances in a more or less durable way and are constitutive parts of animated things called humans, made of water, bones, blood, hair... As protein source of being » and « energetic forces » (Bennett, 2004), they are essential features of human agency.” (Denis and Pontille 2015)

In complement to these studies, we have shown that issues relative to materiality and material ecologies are not issues that can be restricted to the field of metaphysics. Our aim here was not so much to speculate on the composition of matter, but to account for the dynamic composition of the world, following the unfolding of the existence of few digital beings. Our ethnography of the work of digital material has allowed us to ground in practice the issue of digital materiality, considering the material in the sense of the matter of interaction, accounting for engaged mediations both material and corporeal.

Following the transformation of the material during the shaping process largely overflows the material infrastructure. For example, the scenes we described stage the bodily commitment of the operators. The crucial digital fluidity is conditioned by the abilities of the digital craftsmen to build a material to work with and all the negotiations between operators and the material to become are mediated through perceptions. When aligning the material to bodily perceptions is at stake, the uncertainty of the result overflows material determinism. These digital artifacts in the making bear the marks of all those negotiation results that can be considered as *compromises*

with the material. Tracking the moves of the material in interaction seems to be an effective mean to qualify digital materiality. This probably relies on the close ethnography and the experimenting of the work of this particular material. This text is the account of our encounter with this material for which the fluidity is not given but a hardly satisfied condition of existence, and maybe its only viable mode of existence. This kind of engaged investigation should be reiterated in order to fulfill our knowledge of the digital beings that are constantly deploying around us.

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Notes

¹ “The daily work of one person is the infrastructure of another” (Star & Ruhleder, 1996).

² <http://www.modesofexistence.org/inquiry/?lang=en#a=SEARCH&s=0&q=matter>

³ For a synthetic presentation of different approaches of digital materiality see Ribes (this volume), especially on the « additive approach ».

⁴ We use the term “digital being” to refer to a variety of entities such as data, files, algorithms, databases, digital pieces of music, visualizations, graphical-numerical objects (Lécaille 2003).

⁵ A hold or take (in the climbing vocabulary) is a detail into an object, which detail receives its relevance only into the interaction with this object. The hold allows an actor to grasp the object in order to integrate it into its action. The hold can be created intentionally into the object in

prevision of the action but it could also be an accident, which receives its relevance at the moment of the action and through the interaction (e.g. the hand of the climber looking for an accident into the rock which could become a hold for him).

⁶ Using a method of clustering by similarity pieces according to the audio variables.

⁷ The “primary digitization” consisting in the conversion of the analog signal to a digital one is outsourced to one of the few specialized firms in Europe.

⁸ I.e. Linear Tape Open (LTO) cartridges – a technology that stores a digital signal on a magnetic tape. The life expectancy of these tapes is estimated by experts to range between 15 and 30 years. This is the most-used long-term storage system since the beginning of the 2000s.

⁹ “A timecode is a sequence of numeric codes generated at regular intervals by a timing synchronization system. » (<https://en.wikipedia.org/wiki/Timecode>).

¹⁰ The manipulation of the video signal, which is split into frames that can be scrolled through by using the arrow keys of the keyboard, is very different because the arrows impose a different sequence of cursor movement than the manipulation of the mouse.

¹¹ The videos are not sampled at the same time scale as audio files. A sample in kHz must be translated into the target frame, which means that the marked sample must be converted to correspond to a frame of the sequence of 25-30 frames per second video.

¹¹ For a canonical example of this claim see Negroponte, Nicholas. 1995 *Being Digital*. New York : Alfred A. Knopf

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