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AlgoRHYTHMS Everywhere - a heuristic approach to everyday technologies

"It is impossible to think a rhythm." Paul Valéry, Cahiers/Notebooks (1931)

Ouverture

Understanding the meaning-creating potential of rhythm in a media archeological, techno-cultural and epistemological sense (Ernst, 31) and defining it as a tool for analyzing cultural objects in a post-digital era, where digital computerized technology is no more a novelty, but already an ubiquitous technology, the purpose of this contributions is to introduce a heuristic concept called "algorhythm", which should not only inspire media theorists, but also all arts and humanities related discourses to think more deeply about the current techno and media cultural situation and its hidden relations with rhythms.

"Algorhythm" is a combination of the words ALGORITHM and RHYTHM. Algorithm is a term crucially used in computer science and means a finite sequence of step-by-step instructions, a procedure for solving a problem, often used in computers as a fundamental principle of software or in everyday life for example as cooking recipes. Rhythm on the other side is defined since the ancient greek philosopher Plato as a time based order of movement, whereas movement should be understood as movements of materials that can be measured by technical, but at the same time epistemological tools[1]. "Algorhythms" are consequently combinations of symbolic and real physical structures. They occur when real matter is controlled by symbolic and logic structures like instructions written as code. "Algorhythms" let us hear that our digital culture is not immaterial, but lively, rhythmical, performative, tactile and physical and the most important, "algorhythms" are not just normal rhythms, their transmissions and storages can nowadays be not only that fast, that our senses can be deceived, but also their manipulative power, namely their speed and quality of calculations became in the last decades faster than our human senses. "Algorhythms" oscillate in-between (Tholen, 53) the symbolic and the real, between codes and real world processes of matter. They become thus a third form besides the real and the symbolic. The "algorhythmic" therefore, not the lacanian imaginary, is the real modus operandi of our information society.

Return - fast rewind

Music has not always been reduced to the realm of sound. Since the time of the ancient greeks to the dawn of Europe during the late middle age, music was together with Arithmetics, Geometry and Astronomy part of the mathematical sciences and was an epistemological model of the world. Platon defines "harmonia" (Cornford 66-68) as the well proportioned structure of the world and was inspired by the pythagorean concept of "music of the spheres," which were grounded in the ratios used to divide lengths of a string. Pythagoreans believed in numerical relationships, which explained the existence of everything on every level, including the seasons, the orbits of planets and human beings. They even argued that the universe was itself a harmonia, constructed as a kind of musical structure. Boethius around 500 AD defines in "De institutione musica" the terms musica mundana, humana and instrumentalis. The first is the music of the universe, the second the music in the human body and the third the music in the musical instruments. Harmonia was regarded to be an important factor for their functioning.

Music, Waves and Technology

The concept of "algorhythms" was inspired by those old transmusical notions, which can be resumed as epistemological tools for understanding the world by musical categories like harmonia, melody or as I may suggest like rhythm. In almost every information technological device you can find integrated circuits, microchips or other semiconductors, which allows one to control the flow of electrons in a very precise way. Changes of electric potentials applied to an electro-mechanical transducer like a loudspeaker produce, if they are periodical and change between twenty and twenty-thousand times a second, hearable musical tones. Even short changes of electrical polarity are hearable as short crackles. This leads to the idea that technologies which store, transmit and manipulate informations can as well be explained by musical terms since most contemporary devices, tools and media using those technologies have at least one part if not the most important, that works electronically.

A lot of equations in electronics and as well in acoustics are based on the model of waves. Acoustic waves are caused by mechanical vibrations, which produce fast movements of air molecules, which are oscillations of pressure transmitted through a solid, liquid, or gas. If the oscillation is periodic you can hear a musical tone, non-periodical, transitional waveform have percussive characteristics, if they are short. Other more longer non-periodical waveforms are summed up with the word noise.

Rhythm, Time, Notation and Machines

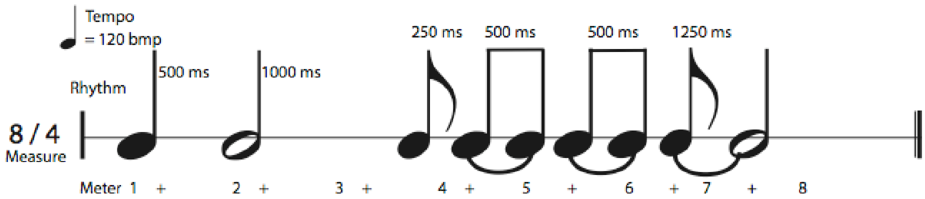
As mentioned previously rhythm is defined by Plato as a time based order of movement. The suggestion here is to define order as a traceable continuous stream of perceivable and measurable physical processes. One example is a sequence of beats of some drum played by a human, another example could be in terms of Bruno Latour also an "actant" like a record player, a tape recorder, a radio or a computer, which all are like humans able to reproduce or synthesize rhythms. There is a temptation to claim that human rhythms are more lively, groovy and emotional, but ultra-small computers and digital technology in general are nowadays able to simulate up to a certain extent human errors, thus artefacts and processes, which are generally perceived as being human or being analog in contrast to the monotonous and cold logic of digital machines. Additionally more and more digital processes manipulated and controlled by algorithms happen in real-time nowadays. In the last decades operations of media technology, thanks to improvements in calculation time, reached such a velocity, that they can process time-critical affairs, where time plays a crucial role that things happen timely. Otherwise human lives are lost, big amounts of money disappear or inter-activity doesn't work at all. Time-critical[2] media technology, a term coined by german media archeologist Wolfgang Ernst, play important roles in computerized - thus in my terms "algorhythmized" - everyday live.

Even though interpreting rhythm as a transmusical concept it is essential to explain some of its musical aspects, namely its fundamental correlation with notation. The word notation etymologically derived from latin "nota", mark or sign. Consequently semiotics comes to mind, when writing about notation, but also the relation of material and sign. Thinking about rhythm and notation leads up to the dichotomy of the real and the symbolic. In traditional musical notation, there is the symbolic musical sign, a sequence of ideal durations, which the musician transforms to real actions of sound production. Rhythm therefore needs both the symbolic, as well as the real to come to existence. Some careful considerations need to follow:

First of all the notion that digital data is another sort of musical notation needs to be introduced. The word "data" etymologically derived from "datus", act of giving, refers it-self to the procedural and both operational and performative nature of digitizing. Considering their sequential form, discreteness, finiteness and their hidden potential for actions, musical notes are similar to data and algorithms. They are, like data, symbolic representations of something from the real world. A sequence of rhythm played by a drum player might be an example for musical notation coming into action, a numerical array retrieved from changes of electric power during a certain time an example of a sequence of data. Second, rhythm is also strongly correlated with a term called meter, which is as well related to notation. Meter has two separate layers of meaning. One is connected with notation, therefore the symbolic and the other is connected with real physical aspects. In this sense it is similar to the term rhythm. Notably the connotations and etymology are slightly different. Meter is associated with the greek word meson, which means "to measure", whereas rhythm derived from the greek word, rhythmos, which refers to a sort of flowing or streaming character of something (Fraisse, XX). Third, it is useful for analysing different computerized processes in our post-digital techno-culture to expand the definition of rhythm and assume that even irregular rhythms or wrong rhythms are still rhythms, when they can be integrated in a time scale of regular small-scale time units. This would then include also hearable outputs of algorithmically controlled stochastic processes like Markov chains. Forth, on the other side exactly those errors or little irregularities make a monotonic rhythm become human, tactile, performative or musical. It is known that minimal delays or offsets make an otherwise monotonous rhythm feel groovy. Fifth, the boundaries of human senses, but also of current status quo of scientific objectivity[3] and measurements must be considered, which is a important point to understand the concept of "algorhythm."

Rhythm versus Meter

Let us first, imagine a infinite sequence of even, isochronous, periodical beats. This is called meter. Then second, imagine if there are more louder beats than other in one limited section of for example 2 times 3 beats. This sequence of "one, two, three, one, two, three" where there is an emphasis on one, could be called three-quarter bar, when the basic quantity of a note is a so-called quarter. The same sequence can also be called meter or even rhythm. This is were the difficulties start. Both rhythm and meter can denote the same physical and perceptual processes. On the first sight it is very clear. As it is general knowledge, meter functions as a framework for rhythms. A music piece, where the tempo is defined as 120 beats per minute for one quarter, there is the possibility to choose a simple meter or a compound meter. We choose a simple meter like a 8/4. Now one musical measure has eight quarters of a duration of 500 ms, because 6000 ms, which is one minute, divided through 120 equals 500 ms. Now we fill this empty sequence with a rhythm represented by some notes of following lengths: 500 ms, 1000 ms, 250 ms, 500 ms, 500 ms and 1250 ms, which are all together 4000 ms, the length of one musical measure under above defined tempo. In this example is it very easy to adress where the rhythm is and where the meter (see Fig. 1).



(Fig. 1, Rhythm and Meter)

Here the meter is a symbolic, not hearable, mental sequence of eight unhearable notes with a duration of 500 ms, which should be called symbolic meter. If this meter gets hearable by adding for example a second line of musical notes, which should be played simultaneously, then this abstract, unhearable meter gets a physically real hearable meter. It would be a completely monotonous, exact measured sequence of beats, which would be perceived by humans as exact the same. This kind of meter should be called real-world meter. The important point here is that although there are perceived by humans as exact the same, they may not be uniform on a physical micro temporal level. A sequence of short pulses each with durations of 500 ms, could contain little erros resulting in a sequence for example with 499 ms, 500 ms, 501 ms, 499.5 ms, 500.5 ms etc. To be more specific: Imagine a pulse would be played by a mechanical metronome with a pendulum. After a certain time the energy put into the metronome by for example a wind up spring mechanism, gets lost and the metronome gets slower. Similar issues can happen to crystal oscillators, which operate as clocks[4] for transmission and calculations synchronisation in computers and other digitally operating devices. For example a normal 32 kHz tuning fork crystal changes its frequency slightly in relation to the temperature of its environment. In a real-world application, this means that a watch made using a regular 32 kHz tuning fork crystal will keep correct time at room temperature, lose 2 minutes per year at plus or minus 10 degrees Celsius room temperature and lose 8 minutes per year at plus or minus 20 degrees Celsius room temperature due to the instability of the quartz crystal. Consequently a real-world-meter is physically considered, just another form of rhythm, a rhythm, which seems to be very exact, but is not when measured in the scale of micro seconds. It is a kind of measurable irregular rhythm, as I mentioned above. The differences and errors are here just in the time scale of micro or even nano seconds. To come back to the musical and hearable rhythm, the human tolerance level to sense a regular pulse begins at 125 ms (Roads, 17; Fraisse, 156). Everything which is faster is not distinguishable. 50 ms is the next tolerance limit for perceiving individual pulses. Everything which is faster will be perceived as tone.

To come here to a point, it is important to understand that, like the human perception process of rhythm is based on a symbolical framework of an certain meter, digital processes work correct and produce perfect results "as long as the operation of each component only produce fluctuations within its pre-assigned tolerance limits" as early computer pioneer John von Neumann after him the design architecture of many first generations computers were called claims (von Neumann, 294). Electronic processes and operations of digital technology function like rhythms and are erroneous, which means also individual, as long they are kept in some tolerance limits. This is one of many reason of my attempt to suggest the term "algorhythm" as a heuristic term to understand digital media and technology.

Errors, Materiality and Individuality

Humans are machines with very low frequency bandwidths, to paraphrase a notion by Friedrich Kittler, who was inspired by Joseph C. R. Licklider's famous text "Man-Computer Symbiosis (1960)". But fortunately there are media technologies and "epistemic things", a term coined by Hans-Jörg Rheinberger, which enable knowledge production, expand our senses and let us measure the world. Nevertheless measurements are just approximations, if a symbolic and logic structure like an algorithm takes action in the real-world as this is crucial during processes of media technology and if these actions change some measurable physical properties, then it is more accurate to explain the whole process with the term rhythm than with the words clock, meter or regular pulse. To formulate it from the opposite perspective: Even if we want to call it a regular pulse, an exact meter or a correct clock, it is in physical terms not correct. Because exact measurements are in any case not possible, as physicist John Robert Taylor notes in the introduction section of "An

Introduction to Error Analysis" (Taylor, XV).

An intensified media archeology as I would suggest here to understand our current media and techno culture, must stay always on the physical side of things, but nevertheless still be able to analyse cultural processes epistemologically, if not philosophically. The knowledge of digital or computer forensic sciences may help here a lot. They form a corrective of our naive view on technology, when this new disciplin learns us, that even mass produced hard disks, microchips and CPUs and also digital data like emails, digital photographies, etc., have individual traceable measurable characteristics. Digital Forensics became a mainstream tool in criminal investigations lately and made understandable to a broader audience for example by a publication called "Cybercrime" by Debra Shinder (2001). Matthew Kirschenbaum described in "Mechanism: New Media and the Forensic Imagination" digital forensics in my interpretation as a further media archeological method to examine machinic individualities on the micro level of the parts (Kirschenbaum, 9-20). He interestingly distinguished between forensic materiality and formal materiality (Kirschenbaum, 10), which I would expand and combine with the media theoretical distinction between the symbolic and the real, which was developed from Jacque Lacan's "Three Orders" the real, symbolic and imaginary by german media theorists like Georg Christoph Tholen or Friedrich Kittler in the late nineteen-eighties. The real physical properties are constituent for forensic materiality, whereas formal materiality is a symbolic representation of the so-called zeros and ones, the absent and the present, which can be retrieved from the real physical signals wandering trough the CPU and Busses to the RAM etc. A formal materiality is for example a table of hexadecimal values of a sound file (.wav or .aiff) read with a hex editor, which can reveal some hidden meta data of a file. Accordingly to this distinction I would differentiate between rhythm and meter, where rhythms refers to the physical, tactile, erroneous qualities, which have individual traceable characteristics, whereas meter builds the symbolic framework, which is needed to keep everything approximately in order. Investigations methods of computer forensics provide accurate methods to understand those individualities on the micro-level both in time and space. Another helpful distinction is the ubiquitous hard/software dichotomy. Forensic materiality is closer to the hardware side of digital technology, whereas formal materiality is more a concept on the software, thus the symbolic, not the real-world side. Analyzers of hard disk data or network traffic data can only reveal informations of artificially naturalized "real" numbers and structures of a data packet, but cannot go further to the actual physical constitutive signals of data traffic.[5] For this you need to directly measure the electronic signals from the circuits.

Rhythm versus Melody

There is still one important distinction for rhythm, which needs to be defined before conducting a media archeological cut into current everyday "algorhythms": The difference of rhythm and melody: As explained earlier changes of electric potentials applied to an electro-mechanical transducer like a loudspeaker produce musical pitches, if they are periodical and have a frequency from 20 to 20000 Hz. Change of musical pitch within time is widely defined as melody. In spite of the fact that musical pitch is a temporal phenomenon, it has still some static component due to its periodical nature. They are two arguments that I can proffer, who are against the use of the term melody for describing realtime signals of digital technology. First, it is restricted to periodical signals and second, melody is just a very fast sort of perceived real-world meter, which I defined above as a subset of rhythm.

As I pointed out earlier there is a threshold of about 50 ms for the human auditory senses, where rhythm and melody are divided. All uniformly structured rhythms, which are faster than this, sound like musical tones, although they are structurally and physically considered rhythms. As media archeology is not only about human senses, but also about machinic materialities, physical properties and forensic scientific individualities and to cover up the most possible wide range of fluctuating phenomena, I would like to call them also rhythms and not melodies.

Inter-modalities of Rhythms

Rhythm is an inter-modal model to understand all kind of processes, operations of our current information technology and its correlation with humans. It is reasonable to speak about visual, bodily, social, neuronal or chemical rhythms. Indeed there is a alternative scientific approach called sonification or auditory displaying, where rhythm is a important concept to understand all kind of processes. A leading conference and annual meeting is organized by ICAD (International Community for Auditory Display), which is a forum for presenting scientific results on the use of sound to display data or monitor systems. One convincing realm of study is human brain activity during epileptic attacks pioneered by Gerold Baier and Thomas Hermann.

Finally, a Media Archeological Cut

After this preliminary considerations I define "algorhythm" as a term, which denotes the crucial, dynamic, time critical, real-time manipulative processes, which happen when digital technology operate in ulta high speed operation rates: In this medial in-betweenness, real physical, dynamic and noisy, erroneous RHYTHMS are produced by discreet step-by-step formalistic, static and abstract symbolic instructions written and coded as ALGORITHMS.

If it comes to offer some exemplification of the concept of "algorhythm" I need to choose from a vast range of possibilities, which go from current mobile communication systems like UMTS or GSM to so-called computer bus[6] systems like USB or Firewire and other system of data storing, transmitting and manipulating. Therefore I narrow the object of study for the present case to ethernet, which is a broadly used computer networking technology for local area networks (LANs). Most wired local internet network systems are based on ethernet, which are then usually connected via DLS (Digital subscriber line) to the telephone network. In that case, there is a DLS-Modem, a modulator and de-modulator, and a Router, where one or several computers are connected.

Initially the OSI-Reference Model (Open Systems Interconnection Reference Model), with seven different layers starting at the lowest with the "physical layer" and then "data link layer", "network layer", "transport layer", "session layer", "presentation layer" and on the top the "application layer" is an important key concept for understanding "algorhythmics". The idea of this layered reference model of network architecture started in 1977 and then later the International Organization for Standardization (ISO) began to develop its OSI framework architecture. The "Physical Layer" consists of the basic hardware transmission technologies of a network. It is underlying the logical and symbolic data structures of the higher level functions in a network, thus it is in-visible from the software side of computer system analysis tools.

Further the terms "algorithm", "data" and "protocol" used in communication and information sciences must be (re-)defined for my media archeological approach. Observed and measured in the level of the physical circuit all three concepts are "algorhythms" when their static stored codes become computational run time. Nevertheless it is important to make precise distinctions between those three terms.

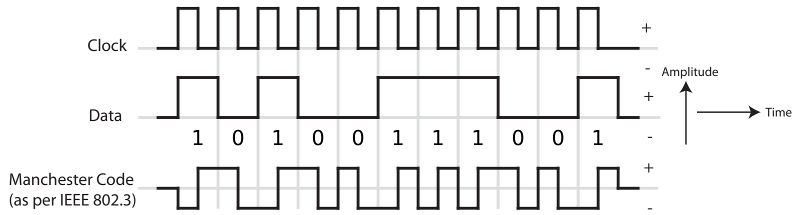
First, Algorithms are abstract, symbolized step-by-step instructions normally written in pseudocode or drawn in flow-chart-diagrams. When writing or thinking about new software programs, a professional programmer usually rewords the pseudocode into a proper software programming language. Often he or she skips the first step to write a pseudocode and writes directly in his/her favorite programming language. A compiler then encodes in several complicated processes the algorithmic instructions from a higher programming language level to the most lowest level called machine code, which will be then executed by the computer architecture (CPU, busses, RAM etc.) as a electronic stream of basic computer instructions.

Second, data is a kind of material, which can be transformed by different algorithms. Nevertheless at the lowest physical level of machine code, data and instructions are not distinguishable. Hence, I would suggest that they should be called "algorhythms."

Third, a protocol is a set of rules which is used by computers to communicate with each other across a certain network. It is a convention, standard or specification that controls and enables the connection, communication and data transfer between computing hardware. Protocols may be implemented by hardware and/or software. At the lowest physical level, a protocol defines the behavior of a hardware connection and defines when and how smaller algorithms, which for example are securing the flawless transmission of data, should operate on which kind of data. A protocol is thus a sort of meta-algorithm.

Coming back to the Ethernet protocol, which is standardized in IEEE 802.3[7], it is important to know that it deals exactly within above mentioned physical layer. Basic principles of the Ethernet protocol were developed at Xerox Parc (Palo Alto Research Center) in California during the early ninety-seventies by Robert Metcalfe and David Boggs, who were inspired by earlier works especially those of the ALOHA-Project, which were one of the first data packet radio transmission systems, developed at University of Hawaii. In 1976 Metcalfe and Boggs publish a scientific paper called "Ethernet: Distributed Packet Switching for Local Computer Networks", where the principles of IEEE 802.3 were already declared. In 1980 the work group 802 of IEEE (Institute of Electrical and Electronics Engineers) declares then in February, which is denoted by the two of 802, the rest of the still in-use Ethernet protocol.

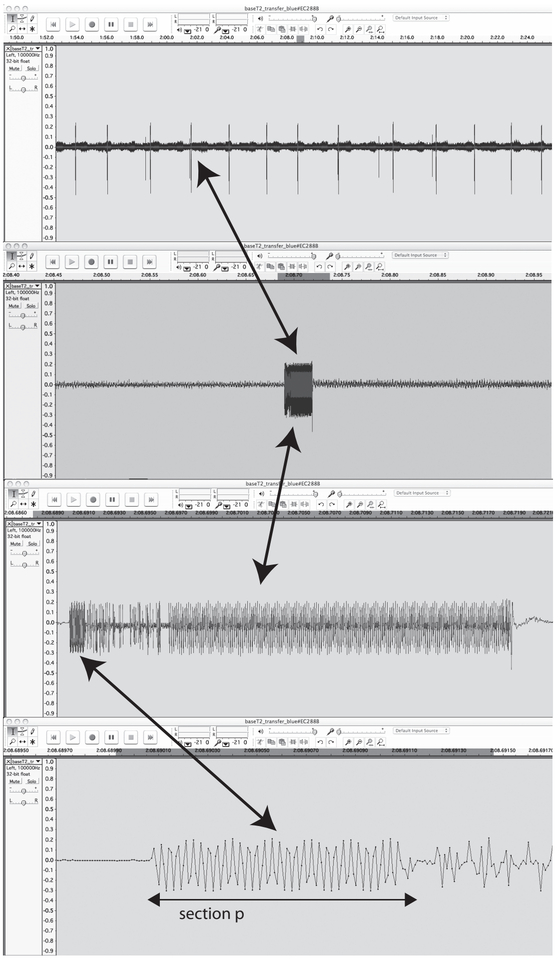
Interesting for my exemplification is a standard called Ethernet 10Base-T, which was used mainly between the early-nineteen-nineties and until around the turn of the millenium. It has a bandwidth of 10 Mbits per second. The word "Base" implies a digital base-band transmission, which means that there are no modulations or demodulations happening at this stage. Still it is important to know that there is a line code (sometimes called digital base-band modulation), which encodes the pure bit stream to a more stable coded stream for a more secure transmission. The line code used in 10Base-T is called manchester code, which produces a self-clocking signal. Manchester Coding was used for the first time at the University of Manchester in the context of early computer Manchester Mark 1 in the early-nineteen-fifties (see Fig. 2). The T of 10Base-T means twisted pair cable, which is a method to reduce electromagnetic disturbances or in my terms "wrong algorhythms" to a minimum.



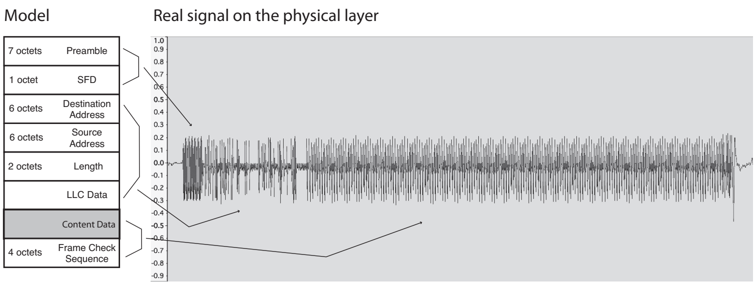
(Fig. 2, Manchester Code)

The first and easiest method to hear "algoryhthms" of Ethernet is, when you merely hook up one pair of the 10Base-T cable into a audio mixing device with preamplifiers and adjust the volume to a certain level, that you can hear, when there is transmission activity between two computers, a stream of sounds similar to a geiger counter. If we inspect the structure of the transmitted data packets (also called frames), which means that we need to measure, digitalize and record the electric signals in the ethernet-cable fluctuating between -2.5 Volt and +2.5 Volt, with a ultra-fast digital-analog converter[8], we will find on a macroscopic level, some little ultra-short high-bandwidth bursts, which have a very high pitch, when they are made audible by adjusting the playback-rate of the digital data recording to the standard playback rate for a Compact Disc (CD) namely 44100 Hz (see Fig. 3). On a closer look and if we slow down the playback-rate we can see and hear the structure of one data frame on the physical layer (Fig. 3) and compare it to the model defined by the specifications in IEEE 802.3 (Fig. 4). As it is observable the content of both diagrams, namely the graphical plot of the real physical signal and the model of a data frame defined by IEEE 802.3 more or less match. We can easily recognize the different sections of data. One special issue we were confronted with, when conducting this experiment in physical measurement was the capacity of our semi-professional equipment. The sampling frequency of our USRP (Universal Software Radio Peripheral) was a bit too slow for the complete reconstruction of a 10 Mbit per second signal. Nevertheless we were able to recognize clearly all data sections, especially the start preamble, which was rhythmized-in to synchronize sender and receiver. The preamble consists of 7 octets of alternating zeros and ones, which looks like this:

10101010 10101010 10101010 10101010 10101010 10101010 10101010 and an octet called SFD (Start Frame Delimiter) like 10101011, which I marked as section P on the graphical plot of the digitally measured and reconstructed signal (Fig. 3). As Data becomes a stream of signals, it becomes a operational process and it can be understood as an "algorhythm" and special meta-algorithms called protocols define for each individual case of transmission the framework of those data streams, which changes slightly from protocol to protocol. Other Algorithms work with the data or produce the data, which should be transmitted. All are either implemented in a special hardware or are programmed in the "application layer". In the case of Ethernet 10Base-T, there are algorithms for protecting data collision, when several computers are connected together or there is a little algorithm called "checksum algorithm", which is used to detect if the data packets has been transmitted successfully. Sometimes the whole data is encrypted. Then some complex encryption algorithm is operating.



(Fig. 3, One data packet of IEEE 802.3 (Ethernet), digitalized with USRP (Hardware) and gnuradio (Software) and visualized with Audacity by the Author with help by Martin Howse (_____-micro_research, berlin). Data packets were synthesized with a software called Scapy.)



(Fig. 4, Comparison of IEEE 802.3 Data Packet Model and real measured signal.)

To sum up the rhythm-analysis[9] of "Ethernet", a still ubiquitous infrastructure of our telematic society,[10] it is important to remark that the analysis of the object of study was conducted from three different perspectives, which could be categorized as micro-, meso- and macro levels. In the present study case of Ethernet 10Base-T, there was a micro-rhythmic geiger-counter-like sound on the macro level, a more rhythmical sequence of ultra-high pitches short bursts on the meso level and on the micro-level, there was a more or less melodic, but in strict physical sense still rhythmic, noise-like sound motiv. With a intermodal and trans-musical definition of the term rhythm, it is possible to link it with different time scales from nano seconds up to several years. But not only time scales, but also proper scales not in real, but symbolic space are possible as the OSI-layered model illustrates. Different algorithms work together from different symbolically networked locations. This implicates that an analysis on "algorhythms" must also deal with symbolic and logically complex mathematical processes controlled by algorithms, which produce at the end "algorhythmical" sequences of oscillating matter.

The next step of an analysis on "algorhythms", which are operating almost all the time in our little digital gadgets should be the realm of real-time applications. Due to the still accelerating operating rate of digital technology and the miniaturisation of processor technology, which once was called Moore's Law, we are able now with the aid of digital technology to do thing or, more precise, let do things, seemingly instantaneously. Time-critical real time information technologies are the result of an escalation of algorhythmic technologies. Basic principle of such time-critical processes are algorithms, which are calculated and then transmitted as algorhythms over a physical channel that fast, that our humans senses are deceived and can not perceive the delay, which is needed to calculate and transmit those "algorhythms." A real-time video communication system is a example for that kind of time-critical networked system of algorhythms, were real time compression algorithm are needed to reduce the required data transfer amount per seconds called bandwidth to a reasonable number. To make a final point "algorhythms" become more and more crucial building blocks or in musical terms leitmotifs of our current post-digital society, where "the digital" itself is whether perceivable nor visible anymore. To disclose those hidden realties of our culture we need critical methods like media archeology. Technologies, and this implies also media technologies, don't wait to be analysed by the humanities, yet they influence massively our way of thinking, seeing, hearing, acting and living.

Endnotes:

1 These measurements of materiality allow us to hear, see or feel represented informations about changing physical properties and are therefore pre-forms of media technology.

2 For further readings: Axel Volmar (Ed.). Zeitkritische Medien. Berlin: Kadmos 2009

3 Objectivity is always constructed as Lorraine Daston, Director of "Max Planck Institute for the History of Science" in Berlin defines in her publication with Peter Galison called "Objectivity".

4 Engineers speak of clocks rates for CPUs or Busses, which are called interestingly enough "takt rate" in german. Takt, which is derived from latin "tactus" and stands for sense of feeling or touch and is the german expression for meter.

5 This notions is in principles again by courtesy of Friedrich Kittler, who once wrote an wonderful text called "There is no software" published in 1992.

6 In computer architecture, a bus is a subsystem that transfers "algorhythmic" data between computer components inside a computer and/or between computers.

7 See http://standards.ieee.org/getieee802/802.3.html (Retrieved July 2009)

8 For the measurements and digitalisation of the ethernet 10Base-T signal, we used a software and hardware environment called GNU Radio (Software) and USRP (Universal Software Radio Peripheral). See also gnuradio.org (Retrieved July 2009). Thanks to Martin Howse (_____-micro_research, berlin).

9 The term rhythm-analysis was coined by Henri Lefebvre, Rhythmanalysis: Space, Time and Everyday Life. London: Continuum, 2004 (Orig. 1992 posthum).

10 Other algorhythms can be detected in: Morse code, ASCII-Code, USB, Firewire, Wifi (W-LAN), Bluetooth, GSM, DECT (a standard for home-use wireless phones), UMTS, but also everywhere inside the electronic circuit architecture of digital technologies.

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