Digital obsolescence

Edlira Nano

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Edlira Nano[1]

[1]Univ Lyon, UCBL, CNRS, INSA Lyon, Centrale Lyon, Univ Lyon 2, LIRIS, Limites numériques project, UMR5205, F-69622, Villeurbanne, France

Abstract

Within a framework of study of the ecological impact of digital technology, this PhD project aims at understanding and analysing digital obsolescence. It aims to analyse software, hardware and middle-ware obsolescence, its technical aspects and its intertwining with non-technical ones such as economical, psychological, human and environmental obsolescence. The study will first focus on smartphones, whose rapid pace of development and replacement allows a better characterisation of digital obsolescence. The second object of our study is digital obsolescence within Debian, a widespread established operational system based on the Linux kernel, maintained by a large community that organises itself in a non profit organisation, following the principles of open source code, collaboration, free distribution and sharing for everyone. Finally, the study will dive into some alternative community networks that profoundly question existing technologies and are shaped and built with the central idea of care for ourselves, for each-other and for the environment.

Keywords

digital obsolescence, environmental digital impact, smartphones, Debian, community networks, alternative technology, care in technology

In: B. Combemale, G. Mussbacher, S. Betz, A. Friday, I. Hadar, J. Sallou, I. Groher, H. Muccini, O. Le Meur, C. Herglotz, E. Eriksson, B. Penzenstadler, AK. Peters, C. C. Venters. Joint Proceedings of ICT4S 2023 Doctoral Symposium, Demonstrations & Posters Track and Workshops. Co-located with ICT4S 2023. Rennes, France, June 05-09, 2023.

eda@mutu.net (E. Nano)
https://eda.mutu.net (E. Nano)
0000-0003-2166-5231 (E. Nano)

1. Research context and motivation

This PhD thesis began in January 2023 at the Unviversité Lyon 1 in France, department of Computer Science, under the supervision of Aurélien Tabard[1], within the *Limites Numériques*[2] team.

Limites Numériques is a research project on the environmental footprint of digital technologies that explores design choices, uses and functions of digital technology within planetary limits.

My background is in theoretical computer science and program development. Before joining the team, I was an independent free software developer and program coordinator. I am a digital rights and freedoms advocate at the nonprofit organisations La Quadrature du Net[3] and April[4]. As such, I have participated in campaigns and workshops on digital empowerment and protection of fundamental rights in ICT, dealing with issues of repair, reuse and reinstall, as well as digital security, encryption and anti-surveillance ones.

The study of digital obsolescence during this PhD thesis is a continuation of my previous work, but it is above all, an opportunity to take a step back and focus on the ecological and environmental aspects of technology.

2. Background

In her PhD thesis in 2019, called *Obsolescence : the philosophy of technology and economic history regarding the shortening of objects' lifespans*[1][5], Jeanne Guien goes through the history of some common everyday consumer goods such as smartphones, plastic glasses, paper tissues, deodorisers. She shows how, far from having been practised in secret, obsolescence of goods has been publicly promoted, and continues to be, as a source of progress, prosperity, equality or emancipation. For Guien, the systematic renewal of objects has been erected as a sign, a source, and even the essence of their value[3]. To Guien, this helps clarify the role that obsolescence and waste play in Western economies, and allows to question the limits of current sustainability policies.

As for digital technologies, while their environmental impact is steadily growing[4], few studies analyse all the mechanisms at play on their obsolescence through their lifespan. In the scientific research literature obsolescence is often defined and analysed from the point of view of managing obsolescence of information systems in an industrial, military or professional context (see [5] or [6]), focusing on solutions to maintain and not on the reasons behind. In France, debate and public policies on digital obsolescence historically focused on hidden planned obsolescence. A French 2021 parliamentary report on software obsolescence [7], defines digital obsolescence as a special case of technical obsolescence, as the loss of use or value resulting from a purely and solely technical evolution.

Based on these observations and continuing in the footsteps of the work from Jeanne Guien, this thesis will first try to analyse how obsolescence is situated through the history of the

[1] https://tabard.fr/
[2] https://limitesnumeriques.fr/
[3] https://laquadrature.net/en/
[4] https://april.org/en
[5] Guien has also published a book from her thesis called *Consumerism through its objects[2]*

development and spread of modern digital technology. By choosing to focus on specific objects, and studying their spread and usage historically, the aim is to analyse software, hardware and middleware obsolescence, its technical aspects but also socioeconomic, political, psychological and human factors that are at stake and intertwined in digital obsolescence.

3. Research goals and questions

The study will first focus on two digital objects:

- smartphones on one hand, that hold a rapid growth and significant obsolescence issues, fuelled by economic discourses and marketing policies based on promotion of technology "innovation", of design-related features or trends, accompanied by a strong and rapid change in usage patterns;
- the Debian operating system on the other hand, as a lasting well established operating system since 1993, that seems to address issues of sustainability and longevity in a different way, away from economic and mercantile traditional digital markets, more focused on durability, stability, maintenance, collaboration, sharing of code and knowledge.

Finally, the study will dive into alternative ways of building technologies through examples of community networks that build digital tools based on their exact needs, by questioning problems of present mainstream technologies, taking care not to reproduce them, and instead putting main focus on the care of one-selves, of each-other and of the environment.

3.1. Digital obsolescence through smartphones

As the environmental impact of ICT grows[4], smartphones continue to spread wider, to be used more, and to be renewed very frequently, while being highly tied to digital physical and software infrastructures (networks, data centers, servers, software platforms). In France in 2019, the average age of smartphones in use was estimated at 32 months in 2021[8], while a recent study on European consumers estimates smartphone renewal after 43 months of use[9].

3.1.1. Technical obsolescence and technology promotion narratives

The market of smartphones offers and promotes new model devices at unrivaled frequent rates. At the same time, there is a very rapid release rate of major smartphone operating systems (Apple iOS every one year, Google Android OS every 6 months), while existing devices are rarely updated to the newly released systems (Android's new OS rarely exceeds 35% of device coverage at its most[6]). As a consequence, functioning smartphones quickly and widely carry unmaintained systems with neither important security updates, nor new features, while applications and services are constantly being developed or reshaped to fit the newest operating systems and newest device models with higher hardware performances. This repeated cycle of renewal, is accompanied by an advertising and mercantile staging that promotes innovation, novelty, change, and the need and urge to adopt them. These notions, that have shaped our

[6] see e.g. statistics here, last accessed April 23, 2023

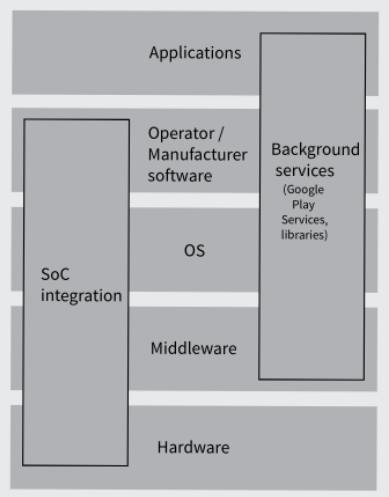

Figure 1: Smartphone layers where obsolescence is observed

digital modern life, hold obsolescence by design: by definition, innovation is temporary, and novelty is an ephemeral quality.

This thesis will try to qualify and quantify the intertwining of hardware and software obsolescence in smartphones, during their historical development, production, promotion, spread and renewal cycle. We will do so by analysing technology promotion narratives, but also technical data gathered on some selected smartphone models. We will interview developers working on hardware and software maintenance issues at manufacturers, application developers, but also online communities building alternative and long-term maintained OSs for older devices, such as LineageOS[7] and LineageOS for microG[8], two free and open source community-developed Android-based OSs.

So far, as represented in Figure 1, we have identified the following smartphone layers in which obsolescence mostly appears: the *hardware* layer, the *middle-ware* layer, the *operational system* (OS) layer, the *manufacturers and operators* layer and the *application* layer. We also identified two layers that seem to interact in an intersectional way with the above ones: the *SoC integration* layer and the *background services* one. During this thesis we will analyse how obsolescence is created and is enhanced in each of these layers.

3.1.2. SoC integration obsolescence

In smartphones, hardware components are often materially designed and manufactured as integrated circuits that combine different units in one silicon plate. System-on-chip (SoC) is one of the most widely spread integrated circuit in smartphones, tablets or other IoT. An SoC generally contains the Central Processing Unit (CPU), together with other central processing units (memory, modems, sensors ...), all manufactured together in a single chip soldered onto

[7] https://lineageos.org/
[8] https://lineage.microg.org/

the circuit board. SoCs also include a software component (called firmware) executed on the processing elements to control the peripherals and interfaces.

During the personal computers (PC) era, the use of microprocessors with separate controller chips has been the norm, giving more flexibility in assembling and repairing devices. The drive toward smartphones, tablets and IoT has pushed integration further: putting more elements on a single piece of silicon as happens with SoCs is said to reduce cost and physical size, which helps create smaller, flatter smartphones that use less battery life. The size and thinness aspects have been key selling features in smartphones, playing a significant role in economical cross-brand competition and smartphone designing trends. Lately, SoCs and integrated circuits are being more and more used in PCs, with the same promise of flatter, thinner and easier mobility. By analysing the history of their economical promotion and spread, we can see how SoCs have accompanied the rapid renewal and disposable aspect of smartphone devices.

We think that SoCs are likely to be at the chunter of software and hardware obsolescence in smartphones by reducing hardware flexibility, making repair and parts replacement far more complicated on the hardware side, and on the software side also by being the main reason for the early end of OS versions maintenance and update.

We will focus the analysis on the three major smartphone SoC manufacturers: Apple Silicon SoCs on one hand, Qualcomm and MediaTek in the Android market on the other hand[9]. The impact of SoC integration in OS maintenance will be analysed through the example of the maintenance process of Android OS in Fairphone[10] smartphones. Fairphone development team has been reporting and giving feedback on their OS maintenance issues, much related to SoC integration problems. Fairphone has nevertheless been offering long-term OS maintenance on their old devices, based on work with LineageOs and other alternative free and open-source (FOSS) initiatives. We will try to understand how these FOSS initiatives and Fairphone circumvent no-longer maintained firmware, and develop their own code to offer further OS maintenance for old to very old devices.

3.1.3. Background services that cause obsolescence

At the OS and applications level, smartphones are often equipped with system-like background services, which are often software based cloud-connectivity technologies such as Google Play Services (GPS) or Google's Firebase Cloud Messaging (FCM).

Introduced in 2012, Google Play Services are now widely generalised in all Android devices and applications. Android applications are being developed specifically to interact with them. This dependency has come to the point where many simple-purposed apps like the Clock app, or the Calculator app, that do not fundamentally need them, that used to work historically without them in previous OS versions, now function only when Google Play Services are enabled and trigger panic warnings when not (see figure 2).

The Google Firebase Cloud Messaging is a cross-platform cloud service for messages and push notifications for Android, iOS, and web applications. In Android, FCM is strongly related to Google Play Services. Over the years Google made changes to Android OS, making it harder not to use FCM for push notifications.

[9] see the market study from Counterpoint, last accessed on April 29, 2023
[10] https://www.fairphone.com/

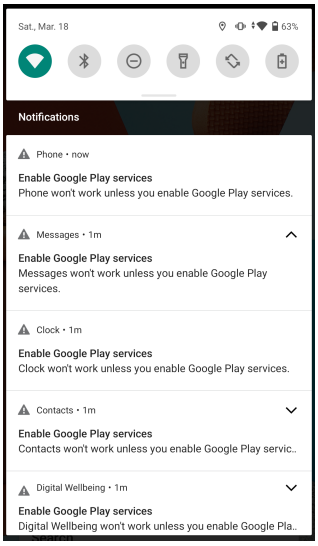

Figure 2: Screenshot of a Fairphone 3 with Google Android 11: after deactivation of Google Play Services, basic applications such as Phone, Messages, Clock or Contacts, warn repeatedly and worryingly that they won't function without GPS. Most of them do seem to work quite normally though.

Both FCM and GPS services are proprietary software, privately owned and developed by Google in a closed manner. They are based on Google's cloud hardware and software infrastructure (data centers, servers...). If the Android system is open-source, its strong dependency to proprietary background services and infrastructure, makes the bare open-source version of Android quite difficult to be used alone, making in practice the Android system dependent on maintenance decisions from Google.

Not only are these background services forcing strong, sometimes unnecessary network connectivity and cloud infrastructure use, but they also reduce development flexibility and long lasting software possibilities. Indeed, an application developer will more likely implement Google private background services, and not bother duplicate code for smaller use markets. Nevertheless, more recently, was developed UnifiedPush[11], a set of free and open-source specifications and tools for push services that follows a standard protocol. If implemented, UnifiedPush allows an application developer to use the push services that the phone offers, be it Google Firebase or others.

In our study we will analyse the history of the creation and spread of major non-standardised background services, and of the way they control the software ecosystem in smartphones, forcing dependencies and creating obsolescence. We will also be exploring some community-driven and alternative circumventing solutions such as e.g. LineageOs for MicroG - which adds a free and open source implementation of Google Play Services to LineageOs -, or UnifiedPush that standardises use of push notifications.

[11] https://unifiedpush.org/

3.1.4. Connectivity obsolescence

Smartphones are highly connected devices whose usage is permanently connected.

First, there is a permanent connectivity to the Internet in smartphones, that is assumed by design in the OSs - as we can see with the Google Play Services example -, and in most of applications, which offer very little offline use possibilities. This permanently-connected use of smartphones has been democratised little by little, from the first phones that were not or very little connected, until appearing today as a preponderant, mandatory or inevitable use. Cutting the connectivity of a smartphone today means breaking a large number of services, both at the system and at the application level, making the device quite difficult to be used.

Moreover, there is almost no way to turn off all connectivity on a smartphone. Around 2010 smartphone devices began to have non removable batteries and sealed covers. Before this, cutting the connectivity was still possible by ultimately removing the battery and thus switching off the phone in a hardware-based way. With the arrival of non-removable batteries in almost all smartphones, not only has repairability been affected, but also connectivity. A software-based powering-off does not mean that the phone is actually off: in recent devices, services like Google Android's or Apple's remote tracking, designed to be used to locate the phone in case of loss or theft, always remain on, even after the so called "powering-off".

As data continuously flows in and out of modern smartphones, invisible and invisibilised digital infrastructure is used to ensure constant connectivity and data flow. At the same time, phone internet providers offer unlimited or large data consumption subscriptions, also transforming our use habits and pushing towards perpetual connectivity. The arrival of the 5G connectivity technology in recent years, promising bigger and faster data transfer, is presented as a necessary technical adaptation to modern uses, but in reality the path towards unlimited data flows and perpetual smartphone connectivity was already traced for users before the advent and spread of 5G technology.

This thesis will try to analyse the obsolescence behind the historically induced connectivity in smartphones.

3.1.5. The experience of obsolescence: human and social obsolescence

The experience of obsolescence has already been a focus in the *Limites numériques* team where this thesis is taking place, in particular through the work of our team member Léa Mosesso on obsolescence paths[10]. In the footsteps of Lea's work, during this thesis we will organise workshops to question and analyse smartphone experiences of obsolescence.

During this study we will consider the links between digital obsolescence and the new digital human oppression on workers. First, the difficult work and human conditions in the Global South factories that manufacture smartphones and components, for example at Foxconn factories in Asia, where most of Apple smartphones are produced and where there is a big worker suicidal rate[11]. But also, the work of subcontracted developers, such as the so-called "click workers"[12].

Moreover, some digital uses such as digital surveillance, digital violence, discrimination or oppression, are all new forms of violence enhanced by an increasing digital usage in our societies, that seriously deteriorate living and working conditions and violate fundamental human rights.

This thesis will consider these human factors as an important part of the ecological footprint of digital technologies and will analyse the related digital obsolescence at stake.

3.1.6. Environmental obsolescence

Environmental impact of digital obsolescence can be observed in all three life phases of smartphones:

- the extraction and manufacturing phase, where we have energy, water and material consumption, land and water pollution, diswatering, biodiversity changes, human population impacts and geopolitical conflicts, all of these being mostly located in Global South countries or indigenous land;
- during marketing and usage phase, mostly located on rich territories but more and more worldwide spread, we have device obsolescence but also infrastructure-caused obsolescence: territorial impact of data center spread, production of carbonated energy needed for powering up, advertisement campaigns impact (energy consumption, induced device renewal, mental and visual pollution for humans);
- and finally, during the end-of-life phase, we encounter insufficient digital waste management (on Lithium-Ion batteries, on precious metals and rare-earth elements, on plastic) and pollution caused by waste being buried, burned, spread out on land or transferred in Global South countries.

This thesis will present state of the art research and analysis on these issues, without analysing them in detail, but considering them throughout the course of our study.

3.2. The case of a lasting operational system, Debian

The Debian Operational System (OS) is one of the oldest and most widespread OS. Based on the open source Linux kernel, composed of free and open source software, Debian is known to be a very stable and reliable OS, serving as a basis for many other Linux OS distributions[12], most notably Ubuntu, Linux, Mint, Tails, Yunohost, Raspberry Pi OS, etc. It began development in 1993 and is nowadays quite widespread among web-servers worldwide[13], embedded systems, microcontrollers, etc.

Debian supports a wide variety of hardware architectures, and can be installed in quite old computers offering a good experience of usability, where other OS are not able to install, or perform poorly and slowly. It is also one of the OSs that offers the longest support time through its Debian Long Term Support (LTS) and Very Long Term Support (VLTS) programs shown on figure 3.

Since its founding, Debian has been developed openly and distributed freely. The project is coordinated by a team of more than a thousand volunteers worldwide, that meet online and regularly in real person gatherings. The team is guided by a Debian Project Leader elected every two years, and three foundational documents: the Debian Social Contract, the Debian Constitution, and the Debian Free Software Guidelines.

[12] 118 as of today according to Distrowatch, last accessed on March 16th, 2023
[13] Debian and Ubuntu were used on 48,5% of all web-servers in 2023 according to w3cook

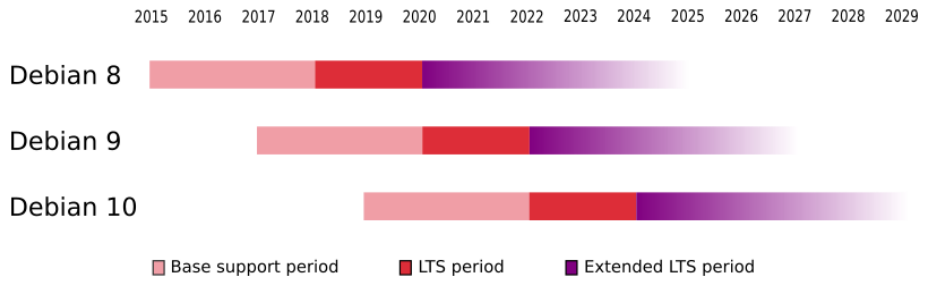

Figure 3: Support periods in Debian (source Freexian, last accessed on April 24, 2023)

The Debian project and its community have been analysed in a quite large number of research papers from the engineering point of view[13], the economical point of view[14] or anthropological and social ones[15][16]. By exploring state of the art on Debian, followed by field research in the community, this thesis will analyse how Debian deals with obsolescence issues such as maintenance and long term support, stability, durability or retro-compatibility.

3.3. Alternative technologies: building community networks based on care

Lastly, during this PhD thesis I would like to study some community networks across the world, usually in areas lacking network infrastructure, or where the existing one does not match community criteria. Let us take some examples:

3.3.1. The *Nós por Nós*, *Nodes that bond* project

The *Nodes that bond* project is a rural women community project in Brazil. Created in 2019, the project *"sprouts from the need to occupy the virtual territory with feminist narratives. During circular meetings allied to basic technology tutorials we began to weave collective knowledge through the creation of common ground. Knowledge is never generic, it only ever exists applied to territory and context. This understanding is very important to help us generate and manage our autonomous network in the best way. Beyond the virtual connection, we seek to keep women connected to each other, learn more about the territory we inhabit and manifest technology as a practice."*[14]

During the first year, the community organised women circles of relating, learning and tutoring together (see examples in figures 4), summarized in the *Nodes for bond workbook*[17]. In the second year in 2020, the community created a collective local monthly podcast and an audio novella.

3.3.2. *Red del viento* in Columbia

Red del viento is a community network providing internet and intranet access, created in Columbia in 2020 and formed by Indigenous communities of the Nasa people, FARC ex-

[14] https://portalsemporteiras.github.io/en/nos-por-nos

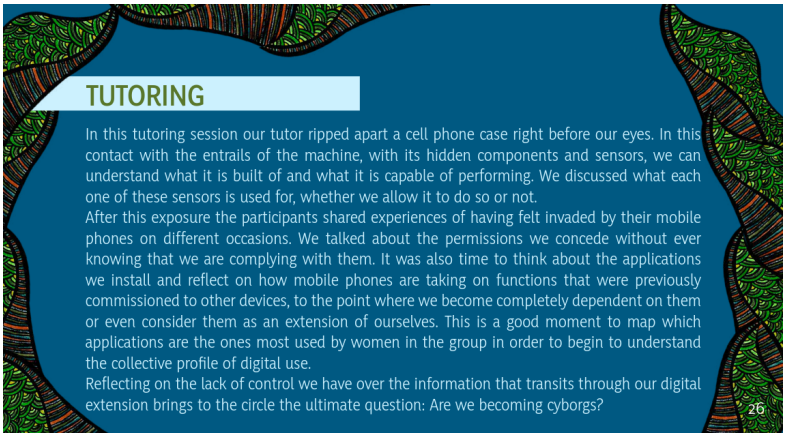

Figure 4: Extract from the Nós por Nós workbook: tutoring on sensors of smartphones

Figure 5: Extract from the Nós por Nós workbook: class on computer components

combatants and peasant local communities, so that they could have their own means of communication[15]. This project allowed the creation of a WiFi network in the region, but above all brought different people together in an auto-organised community and self-educational process.

By studying community networks during a period of 9 to 12 months in the middle of the thesis, I hope to find new perspectives on digital obsolescence, and on how to shape alternative digital tools that focus on care for ourselves, for each-other and for the environment.

4. Research approach and methods

The first approach of this PhD thesis will be a literature study of the history of digital technology and of state of the art literature on obsolescence and environmental impact of ICT.

A parallel approach, will be that of inquiries and field surveys. In my team there is a strong

[15] https://www.apc.org/en/news/community-networks-latin-america-weaving-dreams-together

experience in inquiries, which I think will be of great benefit to me. I believe that most of my inquiries will be semi-directive interviews, and field survey will consist of real-life or online immersions whenever it is possible into the communities events and meetings. I will follow the meetings of the Debian community, and conduct personal or collective interviews with its members following my research goals, and revisiting them during the process.

I would also like to organise smartphone workshops, where we gather and talk about our experiences with our smartphones, and help each other understand obsolescence issues and maybe try technical or non technical solutions.

Finally, I hope to be able to spend several months between my second and third year of PhD, in at least one community network such as those mentioned above, by the mean of a fellowship within the Association for Progressive Communications[16], an international nonprofit organisation that helps and funds community networks, or other similar host organisations.

5. Results, dissertation status and next steps

In the first months of this PhD, I have began the literature study of the subject, and structured the analysis that I am going to conduct on smartphones. I have prepared some first interviews (Fairphone), and have contacted the Debian community. My next steps would be to perform the interviews and to finish a first round of analysis on smartphone data. Next year, I would like to dive more precisely into the Debian community and to centre my study around key issues related to obsolescence and Debian. At the beginning of the 2nd year, I will also actively search for financing my deep dive period of 9 to 12 months into community networks, and prepare this study that would take place between my 2nd and 3rd year. In my 3rd year I am planning on analysing all my data, and organising my results and thoughts while writing the thesis.

By discussing this plan of work within the ICT for sustainability community, I hope to benefit from the critiques and suggestions around my research questions. I would also very much appreciate feedback and advise on interview conducting and survey methods, in particular on survey or interview biases and ways to avoid them. I would also appreciate external feedback on the choices of my three study objects.

Last but not least, I very much welcome any feedback, warning and advise on conducting a PhD thesis.

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