Design and Planned Obsolescence. Theories and Approaches for Designing Enabling Technologies.

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Abstract: We are currently living in a decade where smart objects and Internet of Things (IoT)-based devices are becoming part of daily life in different contexts. This research seeks to investigate and verify, by using a formal literature review methodology, the most visible aspects of technological development, within the Industry 4.0 and IoT scenario, in relation to the theories of the so called “Planned Obsolescence”.

This study covers a defined number of works on Design theories and practices on how to face the issue of built-in obsolescence of devices in the era of the Connected Devices.

The majority of the works studied are useful to create substrates of essential knowledge that strengthen the concept of premature ageing of technological devices and it has been noticed that the discipline of Design can be used as an incentive to extend life, improve the usability of existing products and empower user abilities.

Keywords: Design Practice, Planned Obsolescence, Assistive Technologies, Internet of Things, Human Factors.

1. Introduction

We are currently living in a decade where technologies, especially smart objects and IoT-based devices, are increasingly used in different contexts of our life and every day new gadgets and tools emerge that make us ever more connected (Norman, 1994). Recently, the Gartner Group has released an impressive study concerning the number of connected devices that will be in use in the next few years. They stated that in 2016 there were as many as 6.4 billion IoT-based objects in use worldwide, 30% more than 2015. The study further predicts that this number will constantly increase, reaching 20.8 billion by 2020 (Van der Meulen, 2015).
The potential of connected devices will certainly bring with it a growth in the world consumer electronic market with a higher expenditure on web-based services and an increased demand for data from the network. This contradictory mechanism is producing mainly two effects:

- As a global society, we are becoming every day more dependent on ICT and Web-based services;
- Devices, in particular IoT-based and smart products are becoming obsolescent in a shorter time than a few years ago, this due to various factors.

It is known that the policy of planning and designing objects with a verifiably limited useful life, is a common practice among different international companies. This Design strategy, called “Planned Obsolescence”, can be defined when a product is directly designed to have a specific short life expectancy, so the customers will have to make repeat purchases (Bulow, 1986). The idea of billions of connected devices becoming obsolescent every year is alarming and market forces notwithstanding, clearly some work needs to be done on how to minimise the impact of this effect.

In recent years, movements like “Degrowth” (Demaria, 2013) have emerged and one of its proponents Serge Latouche, argues that current consumption levels are already unsustainable for the world economic market (Latouche, 2015).

Following these ideas, related research questions can be stated with respect to the growth of the IoT area:

- What are the main impacts of the product’s ageing process on objects with embedded technologies, smart devices, IoT-based appliances?
- What fundamental approaches, models and patterns in research, can be applied to the theme of Planned Obsolescence (PO) in relation to technological devices?
- What is the role of Planned Obsolescence (PO) in designing IoT products, with respect to their intended usage context?
- Could this model drive a new way to develop a design thinking for empowering user abilities?

These are important questions. They can be answered by applying a holistic approach in investigating related topics from different perspectives. In order to address these research questions, this work has embraced the approach used by Webster and Watson with the application of a methodology for performing a comprehensive, integrative literature review to analyse resources within the Planned Obsolescence topic, the implications and related contexts (Webster, 2002).

The aim of the research work is to investigate, by using a formal literature review methodology, the potential and the critical issues of technological development, within Industry 4.0 and Internet of Things scenario, in relation to theories of so called Planned Obsolescence. In the following section, the aim is to define the state of the art of the knowledge within topics related to PO and analyse different design paradigms that could influence the practice of developing devices, objects and services, by using the potential of smart technologies such as Internet of Things, Big Data, Artificial Intelligence and Machine Learning. Some of the final outcomes will identify and clarify approaches and paradigms, that might be useful to develop a sustainable design approach that could impact on future development of add-on objects or adaptable devices that will extend life expectancy of existing products for people with different abilities.
2. Background and domain definition:

The increased use of appliances, objects and the recent wave of connected technologies, such as wearables, smart objects and many more, is helping to drive innovation and the consumer market of connected devices. Software and hardware components of everyday objects, such as smartphones, tablets, laptops, home appliances, cars (especially recently introduced smart-connected cars) have an enormous power in controlling the obsolescence of different products (McKinsey, 2014). Some of the most famous case studies, show how many companies have design strategies that are driven from different aims.

If we go back to the early Twentieth century, the famous “Phoebus Cartel” was one of the first examples of a declaration, between different light bulb producers, to control the manufacture and sales of their products. The so called “Cartel” stated a reduction of the durability of the light bulbs and at the same time it established a non-competition scheme among subscriber’s companies, in order to increase the demand for new light bulbs from users and consequently guarantee a prosperous market for the adherent companies (Krajewski, 2014).

One of the most famous examples of the early-on decline of technological devices is the Apple iPod, introduced in 2001 (Strausz, 2006). The iPod was at that time, the best-selling MP3 player within the consumer electronic market. In 2003 Apple acknowledges that the iPod’s battery had a limited lifetime and is irreplaceable. After battery failure, consumers needed to buy a new device, or use Apple’s out-of-warranty battery replacement program for an amount of $99. The company defended its high fee by explaining that, by design, it is cheaper to exchange the physical device than to replace only the battery.

Another more recent example concerns the battery packs of contemporary smartphones. Many of them are not easily removable, so this leads to qualitative obsolescence when the battery degrades and economical obsolescence when the replacement of the battery becomes very costly as it cannot be carried out by the average user (Proske, et al, 2016). It is unclear whether early obsolescence of devices due to reduced lifetime of integrated batteries is an intention of manufacturers. For example, industry associations argue that non-removable batteries can allow a different product design (e.g. 25% thinner as additional housing of the battery can be avoided) which is considered as one of the main buying decision of the consumer (Institut für Demoskopie Allensbach, 2014). Whether it is intentional or not it has the same effect. Many of these examples can be easily related to the theories of Consumerism and Planned Obsolescence.

According to Mahajan, “Consumerism is a social and economic order and ideology that encourages the acquisition of goods and services in ever-increasing amounts” (Mahajan, 2015). According to Bugas, the term Consumerism “would pin the tag where it actually belongs, on Mr. Consumer, the real boss and beneficiary of the American system” (Bugas, 1955). Consumerism, cording to these definitions, can be considered as a prelude to obsolescence. So if there is a need to consume more, to produce more and to increase the number of sales, consumerism leads inevitably to the presence of obsolescence in the consumer market.

In order to define the domain of the research, to identify the keywords used for performing the literature review and explore the state of the art of identified cases, a number of definitions have been combined with literature findings and information from accredited websites.
Planned Obsolescence or Built-in Obsolescence, according to the William Collins English Dictionary, can be defined as “the policy of deliberately limiting the life of a product in order to encourage the purchaser to replace it” (Collins English Dictionary, 2016).

The term Planned Obsolescence, first was mentioned in a famous script from Bernard London, in 1932. “People everywhere are today disobeying the law of obsolescence... when a person continues to possess and use old clothing, automobiles and buildings, after they have passed their obsolescence date... he should be taxed for such continued use of what is legally dead” (London, 1932). This is one of the first mention of the theories of the PO, where the aim of a certain design and engineering strategy in developing goods and services is extremely clear.

Sloan, in order to keep a high level of car sales in the Twenties of the 20th century, suggested what we usually call “restyling”, a design change to convince car owners that they needed to buy a new replacement each year. The term coined was the “Dynamic Obsolescence” as a strategy had far-reaching effects on the automotive business, the field of product design and eventually the American economy (Babaian, 1998).

A similar definition is the one called Progressive Obsolescence. At the end of the Nineteen Twenties J. F. George wrote a lead article in which he explained the theories related to obsolescence and consumerism: “We must induce people...to buy a greater variety of goods... buying goods not to wear out, but to trade in or discard after a short time... the Progressive Obsolescence principle...” (George, 1928). Progressive Obsolescence, as mentioned by Slade, was George’s attempt to reshape America’s thinking about the social role of advertising and design following the obsolescence of the Model T and the introduction of the Model A by Ford (Slade, 2009).

Some years later, in one of the most important scripts concerning the origin of Planned Obsolescence, Packard defined three different levels of deepness of obsolescence. The Obsolescence of Function, Obsolescence of Quality, Obsolescence of Desirability (Packard, 1960).

Finally, Psychological Obsolescence, named by Newman in the late Fifties, could be seen as a strategy to persuade the public that style is an important element in the desirability of one's product. The older style is obsolete because it no longer satisfies the physical needs of the consumer (Newman, 1957).

In respect to these definitions, from the latest Century, it is possible to underline that the general term of Planned or Built-in Obsolescence is mostly referred to business and economic fields, to the psychological and social context and the design and engineering aspects. As mentioned in the example of the light bulbs or the Apple iPod, the reducing functions of the devices makes it appears that designers have been requested to find a way to make the goods less easy to repair or to last a shorter time.

3. A formal literature review on product obsolescence

3.1 Search strategy

In order to have a comprehensive and wider scenario for the literature review, different factors have to be taken into account when deciding the domain, source and search criteria to follow. The search strategy should be un-restrictive as possible, including a wide range of information sources (Lluch, 2011). As mentioned by Anthopoulos, the analysis on the literature based topics, attempts to
identify authors, schools, approaches, case studies, classifies research projects and products and generates a taxonomy that can clarify this complex domain. A rigorous literature study requires defining the domain (the disciplinary field in which the literature search is conducted), the search strategy (search terms applied to extract relevant articles) and the sources (publication outlets from that domain to be included in the search) (Anthopoulos, 2015). According to Koo Et al., while descriptive reviews focus on the methodology, findings, and interpretation of each reviewed study, integrative reviews attempt to find common ideas and concepts from the reviewed material (Khoo, et al, 2011). The topic of Planned Obsolescence or Built-in Obsolescence is widely disseminated in various digital formats such as journal articles, conference proceedings, research papers and largely in the consumer market within online blogs, interviews, books and not peer-reviewed articles. In order to focus on these aspects, especially on the domain of the usage and the development of objects and devices in the design and engineering area, a group of keywords associated with the term PO has been researched in different resources such as books, articles and dictionaries. 

According to London, Sloan, George, Packard and Newman many different terms could be associated with the theme of premature ageing of objects and devices and more in general to the practice of reducing the lifetime of a product. Some of the terms investigated and indexed to compose the search strategy are: “Planned Obsolescence, Built-in Obsolescence, Dynamic Obsolescence, Progressive Obsolescence, Obsolescence of Function, Obsolescence of Quality, Obsolescence of Desirability or Style Obsolescence and Psychological Obsolescence”. All of these terms have been used for structuring an initial search query within various research platforms, academic databases and search engines. The chosen databases each included a large number of peer-reviewed publications and tools for advanced research queries such as summarizing the domain area of the work published, the possibility to include multiple terms and search sources. In the first stage of the literature review search, the type of study was not considered restrictive and a wide range of information sources have accordingly been considered: scientific articles, journal articles, editorials or other short reports, research reports, conference documents, presentations and conference publications and media articles.

3.2 The selection criteria

The research was carried out during the period of October and November 2016 and additional research reviews and updates have been carried out during the following months, until the final version of the study was formed. According to the previous definitions of the topic PO and being aware of the multidisciplinary nature of the theme, the first stage of research was performed by searching within the most important publications repositories: SCOPUS, IEEE Xplore Digital Library, ACM Digital Library (Full Text Collection and Guide to Computing Literature) and Science Direct. It was noticed that a large number of works matched different disciplines and research areas such as: Engineering, Computer Science, Social Sciences, Business, Management and Accounting, Economics, Econometrics and Finance and many others. 

It is clear that, by finding a so various and large number of works in many different disciplines, one of the main issues in performing this study was to keep the literature review focused on the main disciplinary field. It was also necessary to find a multidisciplinary connection between the design paradigms and the utilitarian and functional features of devices. It is possible to see in Table 1 the number of publications and works related to each keyword identified within different publications repositories.
In order to conduct the formal literature review, a total of 5 databases were examined. Despite the deliberate intention to look only in technical and scientific databases, the first search originally showed a total of 1820 references and works within 26 different domains. These were divided into 910 in SCOPUS, 232 in IEEE Xplore Digital Library, 130 in ACM Digital Library – Full Text collection, 298 in ACM Digital Library – Guide to Computing Literature and 250 in Science Direct. The search was performed including title, keywords, abstracts, metadata and it was repeated two times. The search terms were reused within the same database, with the connection query “or” as an internal repetition and “and not” for the second research repetition. The selected time-frame of this stage of research was limited between 1921 to 2016, in order to identify the amount of academic publications dealing with the defined topic as time elapsed.

As a result, one of the first technical paper that faces the issue of the Obsolescence in design and engineering was from Guernsey, concerning the attempt of truck builders to build a high-quality product that will operate over a period of years with the minimum of maintenance expense (Guernsey, 1921).

After refining the search settings and defining a specific query in SCOPUS database, it has been possible to underline an important factor. Until 1996 the quantity of published works on the theme of the Planned Obsolescence and related, were below the threshold of 20 per year. In 1996 the results show that the number of works published was 26 and the trend of the following years increased up to 57 works in 2010 then the quantity remained variable between 43 and 47 until 2015 where the number of publications reached the number of 60. The same results have been seen within the IEEE Xplore Digital Library, where the majority of publications has been published after the year 1998, as in the ACM Digital Library and Science Direct where it has been registered a peak of literature production on these topics after 1996. The increased quantity of works published in the last 20 years is a clear symptom of the sensitivity of different academics and researchers to the area and could be seen as an important aspect to take account for developing the second phase of literature review research.

A further interesting approach that was applied in order to identify the results was to perform different cross-referenced searches within the different databases by using separately search keywords. The most frequently-used obsolescence-related term found in academic publications is

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**Table 1 – Analysis table of the research works searched within five databases.**

*Total number of works researched by using the eight identified search keywords.*

| SEARCH WORDS          | SCOPUS | IEEE Xplore Digital Library | ACM Digital Library - Full text collection | ACM Digital Library - Guide to Computing Literature | SCIENCE DIRECT | TOTAL NUMBER OF WORKS |
|-----------------------|--------|-----------------------------|--------------------------------------------|--------------------------------------------------|----------------|------------------------|
| Planned Obsolescence   | 131    | 81                          | 9                                          | 47                                               | 60             | 328                    |
| Built-in Obsolescence  | 42     | 7                           | 79                                         | 17                                               | 51             | 196                    |
| Dynamic Obsolescence   | 113    | 20                          | 8                                          | 63                                               | 32             | 236                    |
| Progressive Obsolescence | 41   | 4                           | 4                                          | 19                                               | 7              | 75                     |
| Obsolescence of Function | 254   | 67                          | 18                                         | 80                                               | 48             | 467                    |
| Obsolescence of Quality | 297   | 49                          | 8                                          | 43                                               | 45             | 442                    |
| Style Obsolescence     | 30     | 2                           | 1                                          | 22                                               | 5              | 60                     |
| Psychological Obsolescence | 2       | 2                           | 3                                          | 7                                                | 2              | 16                     |
| Group of keywords in each database * | 910 | 232                         | 130                                        | 298                                              | 250            | 1820                   |

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Keywords. The most frequently
“Obsolescence of Function” with an amount of 467 related works, followed by “Obsolescence of Quality” with an amount of 442 related works, then “Planned Obsolescence” with an amount of 328 related works, then “Dynamic Obsolescence” with an amount of 236 works, followed by “Built-in Obsolescence” with an amount of 196 works and finally “Progressive Obsolescence”, “Style Obsolescence” and “Psychological Obsolescence” with respectively 75, 60 and 16 works. This aspect was important to consider in order to define a new search terms for the second phase of data collecting and analysis (Image 1).

![Infographic of the most frequently used term identified in academic publications.](Image 1)

In order to restrict the field of research to only academic and peer reviewed works, from the resulting set, articles and papers irrelevant to the main domain, were excluded from the review.

### 4. A theoretical study on Obsolescence and Design practice.

#### 4.1 Data collection and Analysis

The second phase of search has been identified by narrowing down the domains from a number of 26, to mainly 3: the disciplines related to product engineering, product design and industrial design, by restricting the publication year from 1996 to 2016 and by using the most frequent search terms identified in the first study.

The terms *Obsolescence of Function, Obsolescence of Quality* and *Planned Obsolescence*, as a result showed in the image 1, represent the most used within the aforementioned disciplines. The systematic application of the inclusion and exclusion criteria to titles, keywords and abstracts screening, produced a decreased number from 1820 to 688 articles to be analysed and studied (table 2).
Among 688 selected works, a number of them were successively excluded because they were not meeting the inclusion criteria such as: relevance to research question, socio-technical approach and implication in product design and industrial design and the specific domain where they have been published. One of the aspects that lead us to make this decision was the missing match between many works investigated and the technology/IoT scenario that composed the main domain of the research.

This applies to papers not directly related to the industrial design and product design/engineering area, for instance, on “Military Engineering”, “Nuclear Engineering”, “Satellite Communications and Networking”, “Aerospace and Electronic Systems”, “Optical Engineering”.

4.2 Results and discussion

The manual screening on a chosen number of publications produced a number of 24 studies that met the fore mentioned inclusion criteria. In details it is possible to summarize some different design approaches, methods and paradigms on how to face the issue of objects early obsolescence.

Many of the works analysed, as shown in table 3, were developed by following a theoretical research method, in order to get a deep picture of the field of study. For example, Thimbleby reviews Moore’s Law and the usability of everyday things by showing that professional computer science can improve usability with ease. “The poor quality of the computer science of everyday things is eclipsed by the hope for fixing today’s problems with tomorrow’s consumption.” (Thimbleby, 2001). A different approach, more based on the lifecycle of products can be seen in Harmer’s work. He evaluated how the premature Obsolescence of Technology, the Obsolescence of Quality and the Obsolescence of Desire can be mitigated by using the theory of Design for Disassembly (DFD). Instead of using Computer Science theories, the customization of products, enabled through DFD, create a unique and satisfying material culture that promotes product attachment and the management of Obsolescence of Desire (Harmer, 2005).

A smaller number of works considered in the review were conducted using a mixed method, where for instance the first part of the research was a survey, a literature review, or a case study analysis and the second part tried to give a solution or a design strategy on how to address the topic of Planned Obsolescence. An interesting view on how to face this issue, was given by Rai, et al. They analysed how to deal with Obsolescence through the “piggybacking”; a strategy that enables renewed functionality of a technologically obsolete product through the integration or add-on of a secondary device or component (Rai, et al, 2007). This attractive design approach could be seen as a complement of usability aspects managed in the Computer Science area and at the same time by the product design aspects with the Design for Disassembly. A similar work produced by Lemer, characterized obsolescence as a concern for facility design and management. He outlined a strategy...
for mitigating obsolescence by: planning and designing to provide the flexibility of objects and devices; assure that the facility does not fall short of the required characteristics of performance anticipated; monitor change during operations and maintenance; refurbish and retrofit early to accommodate change (Lemer, 1996). Van Nes, et al. and Sun, et al. investigated through a literature study and case study analysis the possibility of influencing product lifetime through product design. The results of the literature study on consumer behaviour showed that people want a well-functioning and up to date product that meets their changing needs. This requires the development of dynamic and flexible products, which implies designing for variability and preparing the product for future repair or upgrading (Van Nes, et al., 2005). In the work of Sun, the case study was based on the analysis of the design of the Ricoh R digital camera. The study develops a theory that embrace the flexibility of the design process, that will gradually upgrade the product in order to extend its life cycle and then help enterprise and society to create more wealth (Sun, et al., 2008).

Within this group of works, Morais, et al., investigated through surveys and case studies analysis how consumers throw away their garment due to a failed relationship between them and the product. Their theory is developed as an idea, which plans to reduce the fashion product obsolescence, valuing and maximizing each individual's wardrobe and showing how human factors can be helpful in all processes. Designing for changing shapes allows designers to acquire knowledge of radical clothing construction at the same time he has to recognize the creative abilities and limits (physical and psychological) of the end wearer (Morais, et al., 2015).

Finally, a reduced number of works analysed, can be classified as applied research useful to develop a design strategy, based on previous theories, or principles for designing against obsolescence. In particular Meyer, et al., proposed a model, to develop an obsolescence mitigation timeline for the life support of complex electronics or long life systems. They noted that an approach to obsolescence management that covers all aspects of the product life cycle from Design, production to in-service operational support and end of life phase out, is essential to ensure the lowest-cost solution for customers, suppliers and OEMs (Meyer, et al., 2004). In a similar way Cuculoski focused on the obsolescence management strategy, which must be flexible, versatile and be able to offer multiple paths to achieve the ultimate goal. It has been identified some design key points such as: cost effective sustenance of an asset without compromising the asset capability, availability and reliability and has to be flexible enough to accommodate for possible future changes in the capability requirements (Cuculoski, 2013).

### Table 3. Classification criteria of the selected works. Applied Research, Theoretical Research, Mixed Research.
Moreover, the majority of the works studied are useful to create the substrates of essential knowledge that strengthen the concept of premature ageing of products and in particular of the technological devices and appliances.

5. The Design practice for enabling technologies.

The obsolescence of products, is largely known and addressed within many different fields of study and application. Almost the majority of disciplines, as outlined in paragraph 3.2, are involved within this topic, from different perspectives. One of the direct effects of product obsolescence is the large amount of waste it generates and Technological Obsolescence is one of the primary reasons for product ageing (Rai, et al, (2007). According to the formal literature review analysis processed with this work, the majority of academic studies related to the main topic refers to theoretical research methodologies. It has been noticed that objects are usually subjected to obsolescence by the action of two domains: hard domain and soft domain. With a particular focus on recent appliances and technological devices, the manipulation of software, firmware and hardware systems (such as type of material, shape of the objects and quality of production), give opportunities to companies and sellers to control in different way the purchasing power of the users and customers. Software could be also seen as a service for the user as many companies like for example Apple or Virgin Media can update the software or firmware of a system in order to keep it updated and “fresh”. These aspects would obviously impact on commercial and industrial related markets all over the world and it affects system availability, maintainability and supportability (Meyer, et al, 2004).

In order to face these issues for the future generations and for designing in a responsible and efficient way, the literature review has been useful to summarize different approaches and theories in the field of product and industrial design. Despite the fact that majority of the works studied contribute the substrates of essential knowledge that strengthen the concept of premature ageing of products and in particular of technological devices, the discipline of sustainable design can be used as an incentive to extend life and improve the usability of existing products.

Following this analysis, it is possible to affirm that Planned Obsolescence has been, since the beginning of the current century, a common practice in manufacturer and industrial production. Engineers and designers played a fundamental role in creating products with high levels of specifications but that were downgraded in some cases in order to be competitive in a market where the consumerism was one of the main aims. In the past two decades, this process dramatically increased, mostly caused by the birth of new disruptive technologies and services, such as Internet of Things, Industry 4.0, Smart devices, Artificial Intelligence and many more. In the same way the requests from the market (if they are driven from the market or from the industry) for new products, new technologies and new solutions has brought a change in how a designer must think in order to develop an idea. These aspects have led to an increase in the academic literature production of theories, approaches and design principles that could face the problem from different angles. Based on these reflections, this work has sought to underline that the role of Planned Obsolescence within the design context is now a relatively constant aspect of the industrial production and design creativity. As new professions in the design area born, and acknowledging “peak resources”, a new design thinking is needed. This must be based on sustainability and flexibility of a dynamic approach in upgrading existing solutions, on the integration of different devices for increasing the inner performance and quality rate and predict the life cycle of products for increase the usability especially in a later stage of life, should be learned from the students of today that will be designers of tomorrow.
It's clear that it is quite difficult to stop the evolution of technology and design, especially in a world where more and more people can access to Internet, services and data. However, it is possible to positively evaluate the use and reuse of objects, thanks to small upgrades, unobtrusive plug-in & smart adds-on that could increase the life expectancy of our existing devices and enable people with different abilities to use them for a longer period. One example can be given by Apple company, which provided the Apple Genius (technicians in every Apple store) with a small device for increasing and automating the purchasing experience of customers. The small device is simply an old iPod or iPhone that has been taken off from the consumer market, but still well usable as a personal tablet, with limited computational demand. Every device has been upgraded with a bigger protective case, which embeds a day-long lasting battery, a credit card terminal, an RFID sensor and a simple software that could manage selling, calendar and tasks. As the research states, a sustainable design approach, could be to aim for solutions that bring an innovation in the market of new devices by rediscovering the pleasure of a highly durable and high quality product, through high industrial design quality. In addition, there is a need for further research providing new theories and practices as the potential of new technologies is every day rapidly increasing. In a further stage of investigation, there will be faced new design issues with empirical case studies already developed within the tPOT research group, from the Dublin Institute of Technology, to address issues related to usability, affordability and user acceptance of not up-to-date devices.

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