# REBOOTING ENERGY DEMAND: AUTOMATIC SOFTWARE UPDATES

Kris de Decker, February 2017

When and how we upgrade our computer software used to be in large part our own decision. Today, it's increasingly decided by software vendors themselves, who have automated this process through downloads. Automated software upgrades can increase energy use in different and unexpected ways, without any action from the user. More and more consumer products are controlled by networked software: what does this mean for energy demand, and exactly who is responsible for increasing consumption?

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Data traffic over the internet is growing dramatically, roughly doubling every two to three years. Because the internet infrastructure becomes more energy efficient over time, the electricity use associated with this data traffic is growing a bit slower, doubling roughly every five years. According to the latest estimates, the internet now uses between 5 and 10% of global electricity, and forecasts see further growth for many decades to come. [1] Crucially, the growth of data traffic and energy use is not so much due to an increasing amount of internet users. Rather, it's a consequence of growing data use per internet user. For example, in the UK, average monthly home broadband data traffic rose from 17 gigabyte (GB) in 2011 to 82 GB in 2015, an increase of almost 500%. [2] Over the same period, the number of internet users in the UK grew by only 10%. [3]

Part of the growth in data traffic occurs as the direct result of what people do when using online services, reflecting the presence and significance of media rich communications in everyday practices. [2] We now spend longer online than before: smartphones and tablets have allowed us to be connected throughout the day, and to use more than one connected device at the same time. [4] However, part of the increased data traffic per internet user is disconnected from user activity and from how people spend time online. [2] Firstly, the data intensities of certain services are increasing, for instance through higher definition video content. Secondly, there's an increasing share of automated data traffic between computers. Software upgrades play an important role in both of these trends.

## Meet the New Software Industry

Traditionally, software vendors developed individual operating systems and applications, selling them on discs in cardboard boxes at fixed prices. During the time of its use, this software remained largely unchanged until the user eventually replaced it with a newer generation of the same software, which was again sold at fixed prices, or pre-installed on a newly bought computer. [5] Although the arrival of the internet made it possible to make changes to installed software through downloading a specific update, for many years these online updates were limited to security “patches”, themselves an answer to a problem created by connecting computers to the internet: “malware”, software that compromises a computer system.

During the last ten years, however, the software industry's business model has changed profoundly. Today, software vendors typically offer their products only as downloads. Once installed, this software is then frequently changed through additional downloads. This not only includes security patches, but also features that modify the core functionality of the software and change the user experience. [5] In other words, software updates have become software *upgrades*.

The new approach was pioneered on a large scale by smartphones and tablet computers. In 2007 and 2010, Apple introduced the *iPhone* and the *iPad*, respectively. The operating system of these mobile devices (Apple iOS) and the applications that run on it are regularly upgraded through software downloads. In the last few years, these downloads have been made to happen automatically by default, without the user having to do anything, and often not being aware of them. Google's *Android*, which has become the dominant mobile operating system lately, takes the same approach.

This business model has also become the standard in the more mature field of software for desktop and laptop computers, both for operating systems and for the programs that run on them. In 2013, Microsoft started offering its *Office* software as a subscription-based product, while Adobe did the same for its professional design programs such as *Photoshop* and *InDesign*. Apple began offering downloads of its *MAC OS X* operating system in 2011 ("Lion"), and has enabled automated OS upgrades since 2015. Microsoft switched to online software upgrades for its operating system with the launch of *Windows 10* in July 2015. The games software industry has also adopted downloads.

## Automated Data Traffic

Automated software upgrades increase energy use in several ways. Most direct is the increased energy demand due to the communications networks and data centers involved in the distribution of upgrades. [2] It was estimated that in 2015 software updates and upgrades accounted for at least 6-7% of the downstream internet peak traffic in North America and Europe, and for roughly 10% if upgrades of PC and console games are included. [6] Because data traffic over the internet has doubled every two years, this means that automated software updates and upgrades now generate as much traffic as the entire internet in 2007.

Software upgrades can have substantial bandwidth requirements. For example, the release of Apple's mobile operating system iOS 9 in September 2015 was a 1 gigabyte (GB) download, followed by two additional upgrades in the two following weeks, at 800 MB each. Taken together, these downloads cause as much data traffic as the download of an HD movie. iOS receives a major upgrade every year as well as smaller upgrades throughout the year, sent out to at least 500 million active devices around the world, mostly iPhones and iPads. *Android* receives major upgrades every six to nine months and runs on approximately 1.5 billion devices. Its latest release was a 1.1 GB download. Every upgrade to an operating system also triggers additional upgrades for the applications that run on them.

Upgrading laptop and desktop computers, a process that has only recently begun, involves even larger files. Apple's latest upgrade to its operating system, *macOS Sierra*, is a 4.78 GB download, while *Windows 10* is a 3.5 GB download. Once all Microsoft users have switched to *Windows 10* – for many of them this will happen when they buy a new computer with the operating system pre-installed – the software maker will be sending out several gigabytes of data per year to an estimated 1.5 billion machines. The first big upgrade to *Windows 10* was about 3 GB in size. In fact, sending out such large files to such an enormous user base is so challenging that Microsoft now uses a torrent-style approach to conduct software upgrades, allowing *Windows 10* users to download upgrades from other users. [7]

Because most software makers send their software upgrades to all their customers at the same time, the consequent data traffic can cause significant peaks across their networks. For example, when iOS8 was released on 17 September 2014, the UK's internet provider Virgin Media saw its daily data traffic increase by 10%. [8] Because so many people have mobile phones and tablet computers with them everywhere they go, simultaneous upgrades of mobile devices' operating systems cause

bandwidth spikes that can overwhelm local networks if not properly prepared for – either by extending the network, or by installing caching services. In businesses and other organisations such as campus universities, data traffic can surge by 70% per day during iOS upgrades. [9] [10]

## Raising Energy Demand in Unexpected Ways

Shipping software on discs in cardboard boxes also uses energy, but automating software upgrades greatly increases the number of them. In the traditional software business model, many users chose to keep older versions of software running on their computers, even if newer releases were available. With automatic software upgrades, all users are upgraded to the latest version when it becomes available, whether they want to do so or not.

In addition to the network energy required for the update itself, automatic software upgrades can also increase energy use in less direct ways. While software upgrades are not as demanding on infrastructures as audio and video streaming, they are a key mechanism enabling the distribution of internet-based communication and services, including audio and video streaming. [6] Upgrades can change the data consumption of these applications, and thus the energy demand for the data traffic of these services. For example, in 2013, *Netflix* sent out a software upgrade that allowed users to view content in “super HD” resolution, which generates up to 50% more data traffic than the previous HD video resolution. In one stroke, this automatic software upgrade substantially increased energy use by all Netflix customers. Similarly, Facebook's “autoplay” feature, which causes videos to play automatically while users scroll through their newsfeeds, caused Facebook-related online data traffic to increase by at least 50%. [6]

Less obvious but perhaps even more important, automated software upgrades can increase energy use by reconfiguring devices in such a way that the upgrade influences the social practices that depend on these devices. Because digital devices are increasingly central to a large variety of social practices, such as communication, entertainment, shopping, cooking, or dating, automatic software updates can create subtle yet significant changes in the materiality of digital devices, sometimes steering practices in different, more energy-intensive directions. [6] For example, Facebook's “autoplay” feature mentioned above, or the introduction of YouTube's “post-play”, which automatically begins playing the next video right after the first has finished are designed to modify online practices and encourage more viewing.

Finally, the connection between the software industry and its clients causes a data stream in the other direction, too. Software is not only downloaded but also generates routine and often invisible uploads, representing yet more data traffic. For example, *Windows 10* records basically everything that the user does on a computer, and sends back this data to Microsoft. [11] [12]

## Upgrading Computers on Wheels

As more and more consumer products become digitalised and networked, a trend that is known as the *Internet of Things*, automatic software upgrades will become a part of almost any electricity using device, with similar consequences for data traffic and energy use. Market predictions suggest that there will be 26 billion connected devices by 2020, or roughly three connected devices for every person on earth. [13] Examples are household appliances and consumer products (refrigerators, ovens, thermostats, light bulbs, bathroom scales, vacuum cleaners, video surveillance, even mattresses and diapers), health devices (insulin pumps, medicine dispensers, first-responder connectivity, telemedicine), and cars.

The connected car is perhaps the most dramatic example of the effects of automated software upgrades on energy use. Today's cars have 25 to 50 central processing units and hundreds of sensors on-board. [14] Dashboard functions, steering, suspension, brakes, motor management and others are increasingly controlled by computers instead of mechanical linkages. The digitalisation of the automobile has caused a significant increase in the recall of cars, which need to be driven to the dealership or repairshops in order to fix software bugs. With connected cars, these software bugs could be solved through an over-the-air update, using a cellular or WiFi network. Networked cars also need security patches, just like networked computers. In December, cybersecurity advocates took over the control of a connected vehicle from 12 miles away, adjusting the driver's seat, activating the windshield wipers, and slamming on the brakes. [15]

Several car manufacturers are already updating and upgrading on-board navigation and entertainment systems over the internet, using either cellular networks, WiFi, or a satellite connection. The overall number of vehicles with built-in internet connectivity is estimated to increase from 10% of the overall market today to 90% by 2020. [16] Some car manufacturers have already gone beyond infotainment upgrades. Since 2012, Tesla Motors has been offering automatic software upgrades to its electric cars that solve software problems, add new features and functionality, or improve the performance of the car – basically as if it was a smartphone. For example, in 2013, following some incidents in which batteries caught fire after driving over a metal object on the road, Tesla sent out an over-the-air upgrade that gave its Model S more ground clearance at high speeds. [17][18]

As is the case with computers, automated software upgrades for cars will increase data traffic and energy use in the network. For now, there is little reliable information available on the size of these downloads, but what we do know is that there are roughly 1.2 billion cars on the roads today, a number that is estimated to rise to 2 billion in 2035. [19] Furthermore, connected cars are sending back a wealth of data to the car manufacturer about where the car is, how it's being driven and even contact details, synced from mobile phones. This upload data traffic promises to be much more frequent and comprehensive as in the case of computers. For example, the Mercedes Benz B-series transmits the vehicle's mileage, fuel level, coolant level and tyre pressure every two minutes. [20] According to some reports, connected cars will upload 25 GB of data to the cloud every hour. [21]

The move towards connected cars is encouraged by legislation. From April 2018, it will be impossible for car buyers to purchase non-connected vehicles in Europe, as all new vehicles must include support for a system that requires a mobile data connection to automatically communicate its exact location to emergency services in case of accident. [22] One of the technical challenges for connected cars is the lack of cellular coverage in many areas where cars are driven. Therefore, network operators need to extend coverage in these areas for connected car services to evolve. [16] Although connected cars are often presented as a sustainable solution, such claims – already poorly substantiated – ignore the extra energy use added in the network infrastructure.

## Who or What Demands Energy?

Before the advance of networked devices and automated software updates, the energy use of an appliance was rather predictable, because the features of such devices were static. However, with networked devices and automated software updates, manufacturers can unilaterally decide to send out an update that increases data and also energy use for all devices, without any input from consumers. Although this increased energy demand will be attributed to consumers, in fact they have little control over it.

In conclusion, automatic software updates and upgrades will put an increasing strain on communications networks and raise energy demand in several other ways, not just for computers and smartphones, but for a whole range of other products as well. Such machine-to-machine traffic will happen regardless of what people do.

Energy policy makers have yet to envisage a world in which escalating demand is automated, or in which campaigns and incentives to persuade people to reduce energy consumption are entirely beside the point – as they are with upgrades which go on behind the scenes. There is as yet no attempt to anticipate or restrain what are becoming self-perpetuating engines of demand, and no clear idea of where to begin. Instead, in the UK and in countries around the world, governments are committed to enabling super-fast broadband, laying down an infrastructure on which these forms of escalation depend.

In the face of trends like these, the challenge is to reboot ways of thinking about the 'drivers' of energy demand, and think again where responsibilities and opportunities for demand reduction might lie.

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