Abstract—it won’t be long until our prostheses, ECG personal monitors, subcutaneous insulin infusors, glasses, etc. become devices of the Internet of Things (IoT), always connected for monitoring, maintenance, charging and tracking. This will be the dawn of the Smart Human, not just a user of the IoT but a Thing in the Internet. How long would it then take for hackers to attack us like they have been attacking IoT devices? What would happen if hackers were able to blackmail us threatening our IoT body parts? Smart Humans may become victims of the devastating attack of WannaDie, a new ransomware that could provide the plot-line for a possible future episode of the Black Mirror TV series.

I. THE INTERNET OF THINGS

The Internet of Things (IoT) has proved to be one of the biggest technological and societal revolutions since the “opening” of the ARPANET project. IoT is a network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity that enables these objects to connect and exchange data. It is estimated that by 2020 there will be 30 billion devices, with the global market value of IoT reaching $7.1 trillion.

IoT has been creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. Nowadays, almost each everyday object can become a “Thing” of the IoT when it is connected to the net. However, by providing such possibilities IoT has also been unearthing a huge number of security and privacy problems.

Although it can be questionable whether connecting a kettle, a toaster or a toothbrush to the net is actually really useful, most IoT applications have been welcomed by the community of users (and developers). Think, for instance, of the introduction of smart meters in our homes along with electricity meters, home automation, and the integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions. Nowadays, almost each everyday object can become a “Thing” of the IoT when it is connected to the net. It is estimated that by 2020 there will be 30 billion devices, with the global market value of IoT reaching $7.1 trillion.

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where a system of devices (a monitor, an insulin infusion pump and a blood glucose meter) closely mimic the glucose-regulating function of a healthy pancreas. Low-invasive and highly technological pacemakers are being used for the treatment of arrhythmias and dysfunctions of the heart. Robotic prosthetic arms and legs are being used to restore abilities to patients who were born without limbs or lost them in accidents [33]. Some patients affected by paralysis can now walk again thanks to an implanted invasive and highly technological pacemakers are being reported almost on a daily basis. Philips Hue smart lightbulbs were one of the first IoT devices on the market, and one of the first to be attacked [29], even remotely [28]. Smart homes have also been attacked [24], even using smart phones [32]. Several medical devices were attacked [13, 3], including medical mannequins [13] and pacemakers [15], resulting in a concern also for the former Vice President of the USA Dick Cheney [18].

IoT devices have also been used to empower “classical” attacks. Most notably, in September 2016, the Mirai botnet knocked out a large number of sites including Amazon, Netflix, The New York Times, Reddit, Twitter, Spotify, Playstation, Airbnb, PayPal, and many others using a DDoS attack. The peculiarity of this attack is that the botnet was made up of smart toasters and web-enabled devices [5].

In recent years, security analysts have expanded their focus from cyber-threats to our personal data first to cyber-threats to our devices and then to cyber-threats that may cause direct harm to human beings. For instance, manufacturers are investing considerable resources and launching bug-hunting projects to prevent attacks to autonomous driving systems (cars, trains, etc.), which are tightly connected with the IoT. Since the consequences of such attacks would be catastrophic, putting millions of lives at risk, the security and trustworthiness of autonomous systems is currently one of the hottest topics in both academia and industry. It has also been considered in the Black Mirror TV series, along with other IoT (in)security scenarios. For instance, in Hated in the Nation (S03E06) artificial substitute bees have been developed to counteract a sudden colony collapse disorder in the UK’s bee population... but the robotic bees have been hacked and are being used to kill people.

Some of the dreadful consequences that the IoT could have on our lives are shown in Arkangel (S04E02), in which parents can use the Arkangel system to track their children, monitor their health and emotional states, and censor sights they should not see... with devastating effects for parents and children.

In the special White Christmas, artificial copies of clients’ consciousness, stored into small pods called “cookies”, are used to control smart houses, with the usual Black-Mirror-style disastrous consequences.

The idea of having a copy of oneself as a personal assistant for our houses is a more customized and smarter version of Amazon’s Alexa, Apple’s Siri, Google’s Google Assistant and Microsoft’s Cortana, intelligent personal assistants that recognize natural voice (in many different languages) without the requirement for keyboard input. These personal assistants support a wide range of user commands, ranging from answering questions to providing real-time information (such as news, weather forecast or traffic information), from making phone calls to compiling to-do lists, from setting alarms to playing music or audiobooks or streaming podcasts, and to acting as a home automation system that controls several other smart devices. See our own [8] for a summary of the security risks of such personal assistants, including the possibility of someone hacking one of these assistants to take control of what we usually consider the safest place, our homes [7].

There are two more Black Mirror episodes that are relevant here. In The National Anthem (S01E01), a Princess member of the British royal family has been kidnapped and the kidnapper demands that the country’s Prime Minister has sexual intercourse with a pig on live television, otherwise he will kill her. In Shut up and Dance (S03E03), hackers threaten to leak the blackmail material that they have collected of their victims unless they (the victims) carry out the increasingly despicable tasks that the hackers assign them. These two episodes share the same premise, blackmail, which might soon be relevant for the IoT as well.

A technological way to blackmail someone is to use ransomware. In May 2017, a massive cyber-attack was
launched using the ransomware WannaCry, which infected more than 230,000 computers in 150 countries. Once activated, the virus demanded ransom payments in order to unlock the infected system. IoT devices are, and will, of course not be exempt from ransomware attacks and it is just a matter of time before the situations jokingly depicted in the cartoon in Fig. 1 become reality.

IV. Smart Humans

In the rest of this paper, we will discuss a plot-line for a possible future episode of Black Mirror. Following the formula that we stated above, it won’t be long until prostheses, ECG personal monitors, subcutaneous insulin infusers, glasses, etc. become IoT devices, always connected for monitoring, maintenance, charging, tracking but also, why not?, simply because it is cool to control them with a smartphone. This is the advent of the Smart Human, not just a user of the IoT but a Thing in the Internet.

Pros and cons of the IoT will be inherited and to some extent amplified, and new ones will surface, leading to several social, economical, political and ethical implications, including issues related not only to health but also to security and privacy. Smart humans are coming and we wonder whether this time we will get it right, designing security in from the start. It might not be too late in the game to do so, but we confess that we are quite skeptical and believe that the security and privacy issues will be massive. So massive, that they have inspired us to conceive of the following Black-Mirror-style scenario:

What would happen if the Smart in the Human was subject to ransom?

V. WannaDie and other security issues

IoT devices are everywhere. They are around us. They are part of us. We are IoT devices. How far are we from discovering that hackers are able to hack and control these devices? What if someone were able to blackmail us threatening our IoT body parts? This may be the devastating attack of a new ransomware that we have called WannaDie. WannaDie’s victims might receive a message like the one on the left of Fig. 2 announcing that their fully-IoT-connected pacemaker has been locked, or it could be their legs as shown on the right of that figure.

As we observed above, for Smart Humans to be secure, it will be necessary to build in security from the start. Devices should be developed by applying security-by-design principles to avoid inheriting typical IoT weaknesses such as diversity of devices, standards and environments. As security-by-design is most often wishful thinking, let us briefly discuss some contingency security procedures that could be put in place.

WannaCry spread widely and rapidly thanks to the slowness of systems around the world in applying security patches: the exploit used (a Windows’ Server Message Block protocol flaw) was already patched about two months earlier. For the security of Smart Humans, we will need to create an infrastructure that allows software updates to be applied rapidly and thereby prevent an infection. In parallel to that, it would be wise to allow humans to intervene once the infection has started. This could be achieved by means of an “off/on” button to bypass normal functioning, but of course this would require some form of strong authentication (e.g., biometric, via the voice of the human) to access the button in “root mode”. Note, however, that resetting or rebooting a pacemaker might be dangerous.

Hackers could also try to ransom money by capitalizing on the reputation of a previous attack, as it happened recently with WannaCry itself. While most of us who received such “phishing” emails ignored them safely, in the case of WannaDie people might not want to take that chance worrying that their life might be at risk.

So far, humans got sick with diseases, not malware. However, removing the separation between devices and humans, as is in fact the case when the human becomes

1In (to be presented at “Re-coding Black Mirror 2019” as well), we propose the forthcoming widely-deployed of the Internet of Neurons, a new Internet paradigm in which humans will be able to connect bi-directionally to the net using only their brain. Smart humans will be a significant step towards the Internet of Neurons, especially in the first configuration that we consider in in which humans will be implanted a device able to connect their brain to the Internet bi-directionally.

2While we don’t really care whether WannaCry’s authors will mind that we have taken their message and adapted it to WannaDie, we hope that Nitrozac & Snaggy won’t mind that we have taken their comic as inspiration for our drawing shown on the right of the figure (which we modified from the original to include the balloons of the legs speaking).
a Thing, opens scenarios for new kinds of cyber-health threats. This requires revising and broadening the notions of security and privacy. Location privacy, for instance, will be difficult to achieve if a human has an implanted device that is always connected. Humans might also want to keep an implant, a property that we could call smart privacy.

All these security and privacy issues could be exploited to enrich the plot of a new Black Mirror episode. But also the practical problems of Smart Humanity will contribute to making it interesting, and frightful. Solutions to problems like connectivity and power will be crucial. Will the devices use WiFi to be connected? Yes, as long as a WiFi connection is available. However, devices could also take advantage of 5G connectivity (or 6G, by then), but this won’t be without creating new risks for security and health issues due to the close exposure to electromagnetic fields. To keep their functionalities and the connectivity always on, such devices will need to be recharged often, if not constantly, due to the batteries’ life and size. A solution could be to use a wireless power transmission as in [7], but would it still be feasible if the device is inside our body?

Finally, one could envision also a number of psychological issues[1][8]Nowadays humans sometimes reject implants. This is mainly due to their body rejecting the “alien component” but in some cases due to the psychological challenge of accepting the implant and the change it requires both in the personal and in the social sphere; this could be exacerbated by an IoT implant up to the point that some people might prefer not to have it at all, even when they need it. There could even be anti-smarter movements.

It is time to take stock. Like every momentous change, the advent of Smart Humans will go through different phases. It will initially encounter resistance and people will be reluctant to get on board. A slow acceptance phase will follow, in which people will begin to embrace the idea of Smart Humans, thus leading to trust and diffusion of the technology for the geeks, the curious and the wealthy. It is unclear to us if the technology will ever be available to everybody, and if so, if it will be free. History teaches us that this is typically not the case, so we also expect that a new area of social studies will be born to investigate the social implications of Smart Humans interacting with each other but especially with those who are still “smart-less”, which will cause discrimination and division.

Smart humans will not just produce the premise of another disconcerting and scary Black Mirror episode, but it will also force us to reconsider the term “humanity”, trying to identify what may be the line that separates humanity from its possible technological evolution(s).

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