



The Internet of Things: Are we running quickly into the darkness?

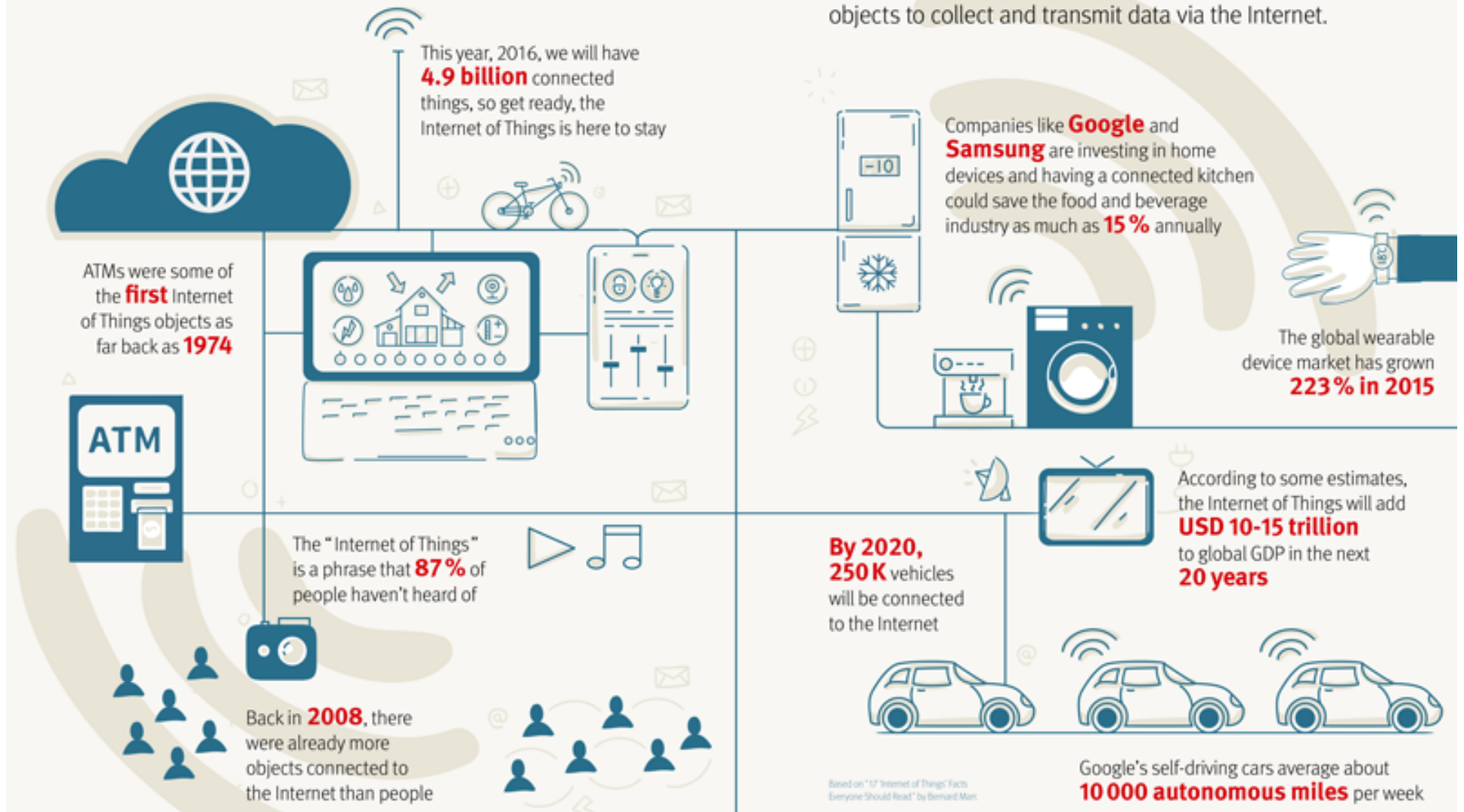
George Weir
george.weir@strath.ac.uk

Summary

- The Internet of Things: Are we running quickly into the darkness?
 - Yes
- Should we be worried?
 - Yes
- Can we mitigate the risks?
 - Yes (partly)

The Internet of Things a very short story

The Internet of Things is the network of physical devices, vehicles, buildings and so on embedded with electronics, software, sensors and network connectivity that enable these objects to collect and transmit data via the Internet.



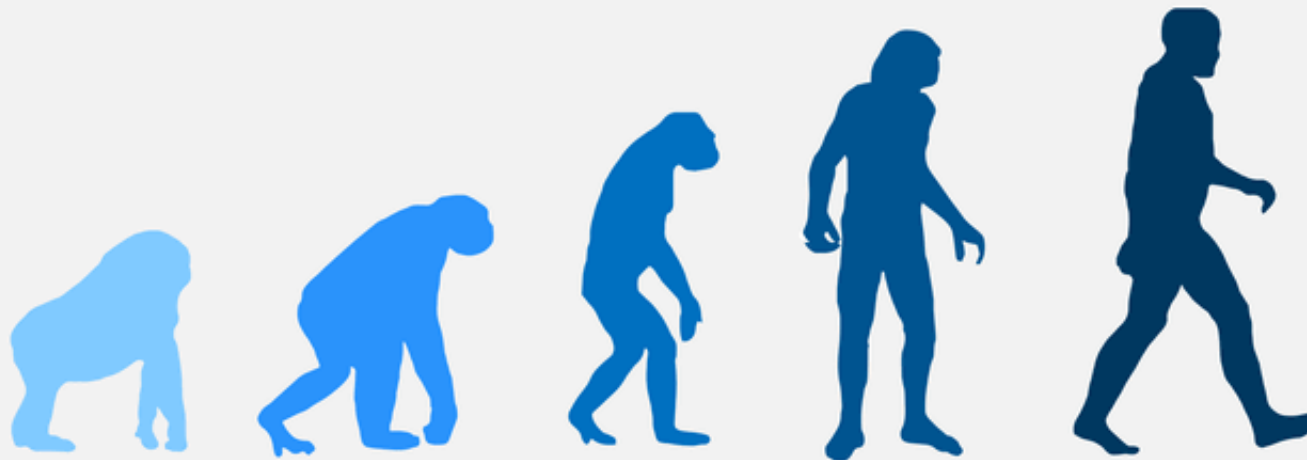
George Weir, 2018

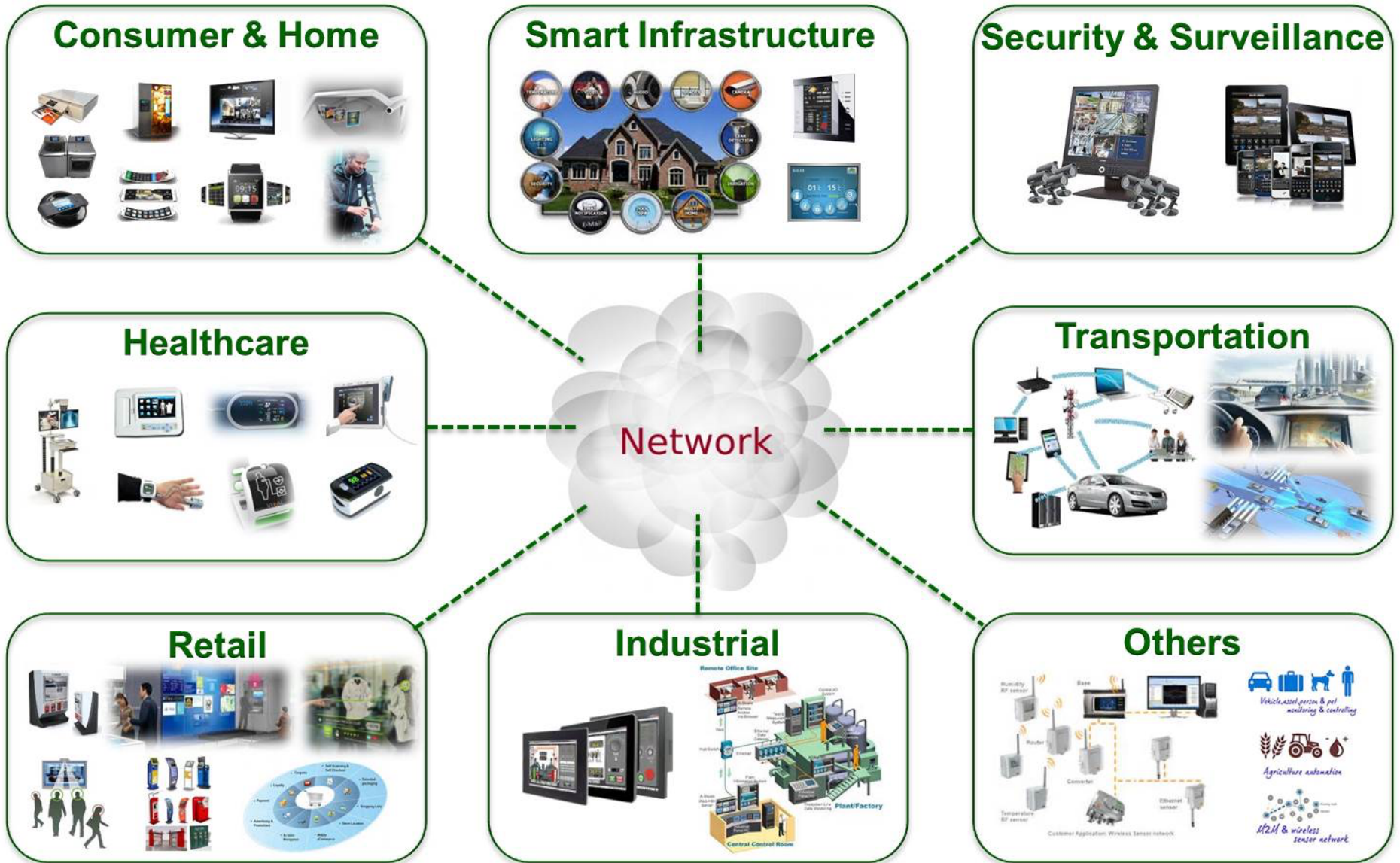
iso.org

A natural progression?

INTERNET OF THINGS

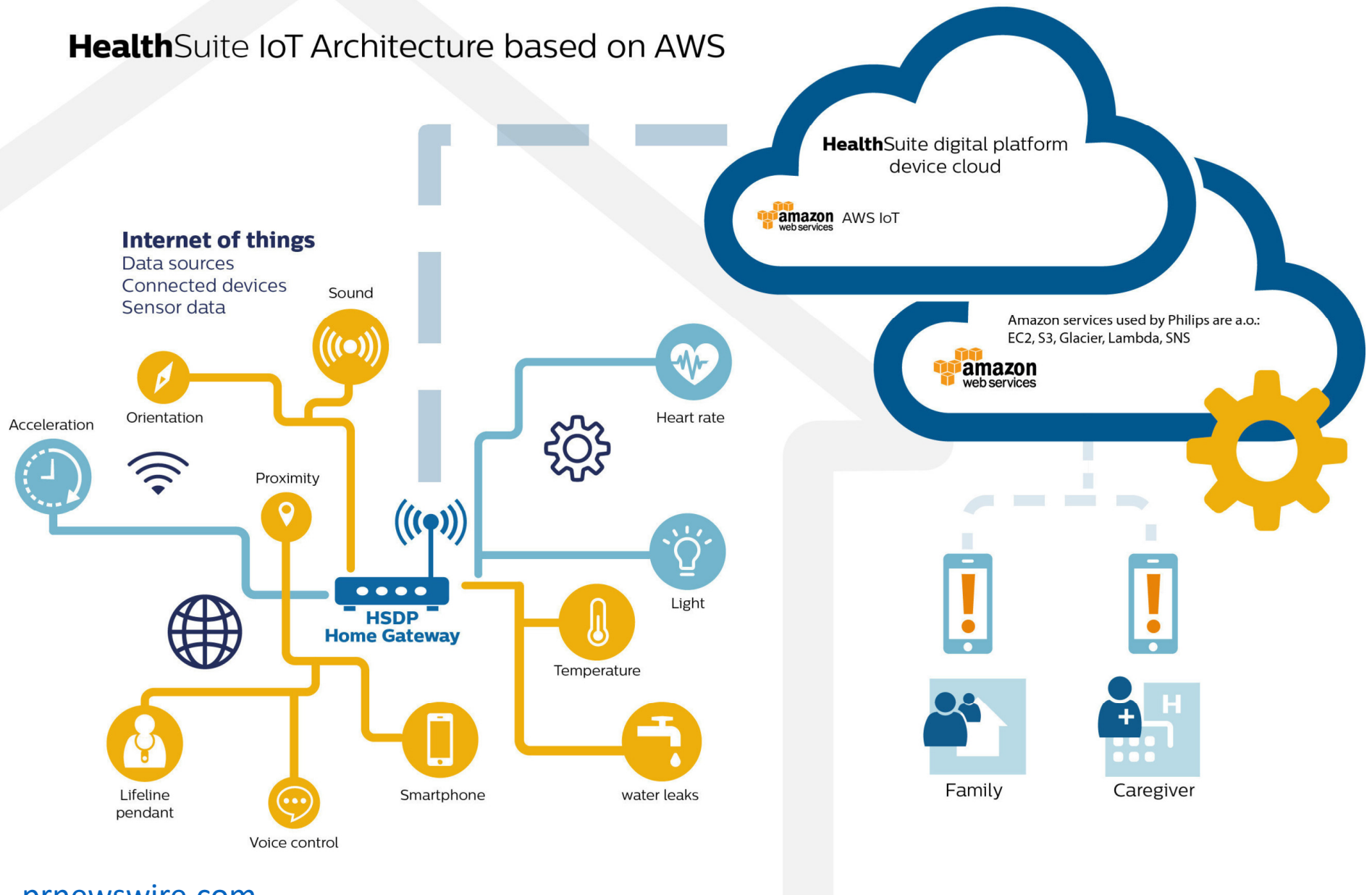
Internet Evolution





Vivante and the Vivante logo are trademarks of Vivante Corporation. All other product, image or service names in this presentation are the property of their respective owners. © 2013 Vivante Corporation

HealthSuite IoT Architecture based on AWS



Are we Running?

- Apparently, everyone is engaging with Cloud-based IoT:

INTERNET OF THINGS LANDSCAPE

Platforms & Enablement (Horizontal)

Connectivity FITT, Symplo, ioBridge, ARRAYENT, haystack, electric imp, sensinode, ThingWorx, NODE, EVERYTHING, BUGSWARM	Open Source Platforms sense, spark, Nimbits, ThingSpeak	Software Platforms sense, SmartThings, Withings, NINJABLOCKS, xively, TWINE, OSITO, zonoff	Sensor Networks MESHSYSTEMS, SAFECAST	Enabling Networks FreedomPop, SocialSign.in, Open Garden, SIGFOX	Corporates IBM, GE, LG, CISCO, Honeywell
---	---	--	---	--	--

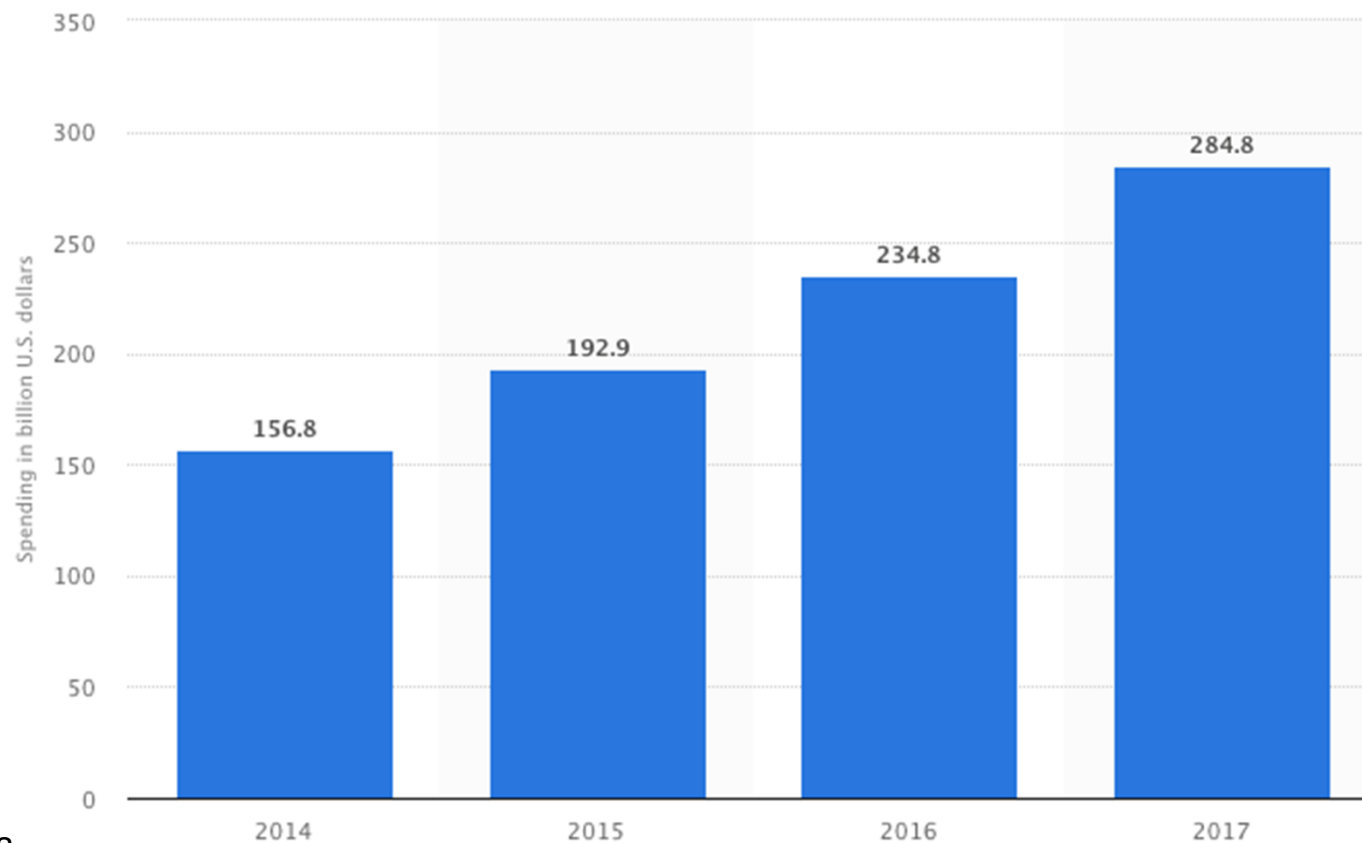
Applications (Verticals)

Quantified Self Wearable Computing: GLASS, Pebble Fitness: Withings, fitbit, JAWBONE, amigo Health: BASIS, Lumo, HAPIfork, wahoo, NuMetrex Family: Lively, Good Night Lamp, Withings, EVADO FILIP	Lifestyle Leisure: blossom, ICA kitchen, remee, Thimble, iGrill, HEXBRIGHT, sobi Pets: gifi, FITBARK Toys: sifteo, MakieLab, KAROTZ, greengoose Music: glar Gardening: BITPONICS, plantlink, Koubachi Home Improv.: Radiator Labs, netatmo	Connected Home Home Automation: SmartThings, NINJABLOCKS, lapka, Ubi, electric imp, Wovyn Energy Efficiency: knut, nest, we mo, tado, ecobee, belkin echo, LIFX, micasaverde Security: Kwikset, ALARM.COM, Lockitron, BESCH, CANARY, HomeMonitor, iSmartAlarm	Industries Retail: Nomi, euclid, placemeter Healthcare: VISI MOBILE, AdhereTech, AliveCor, TELCARE, intelligentM Automotive: Dashlabs, SYNC, OpenXC, moji, venture Smart Buildings: APOGEE, Johnson Controls, Schneider Electric	Industrial Internet Robotics: KIVA Systems, Double Robotics, Airware, ROBOTEX, 3D Robotics, MOMENTUM Greentech: BigBelly, Axeda, enlited, GRIDMOBILITY 3D Printing: Stratasys, MezzoMill, formlabs, shapeways, MakerBot, RepRap
New Interfaces NeuroSky, gestigon, sphero, EQUISO, emotivo, PrimeSense, Interaxon, LEAP				

Building Blocks

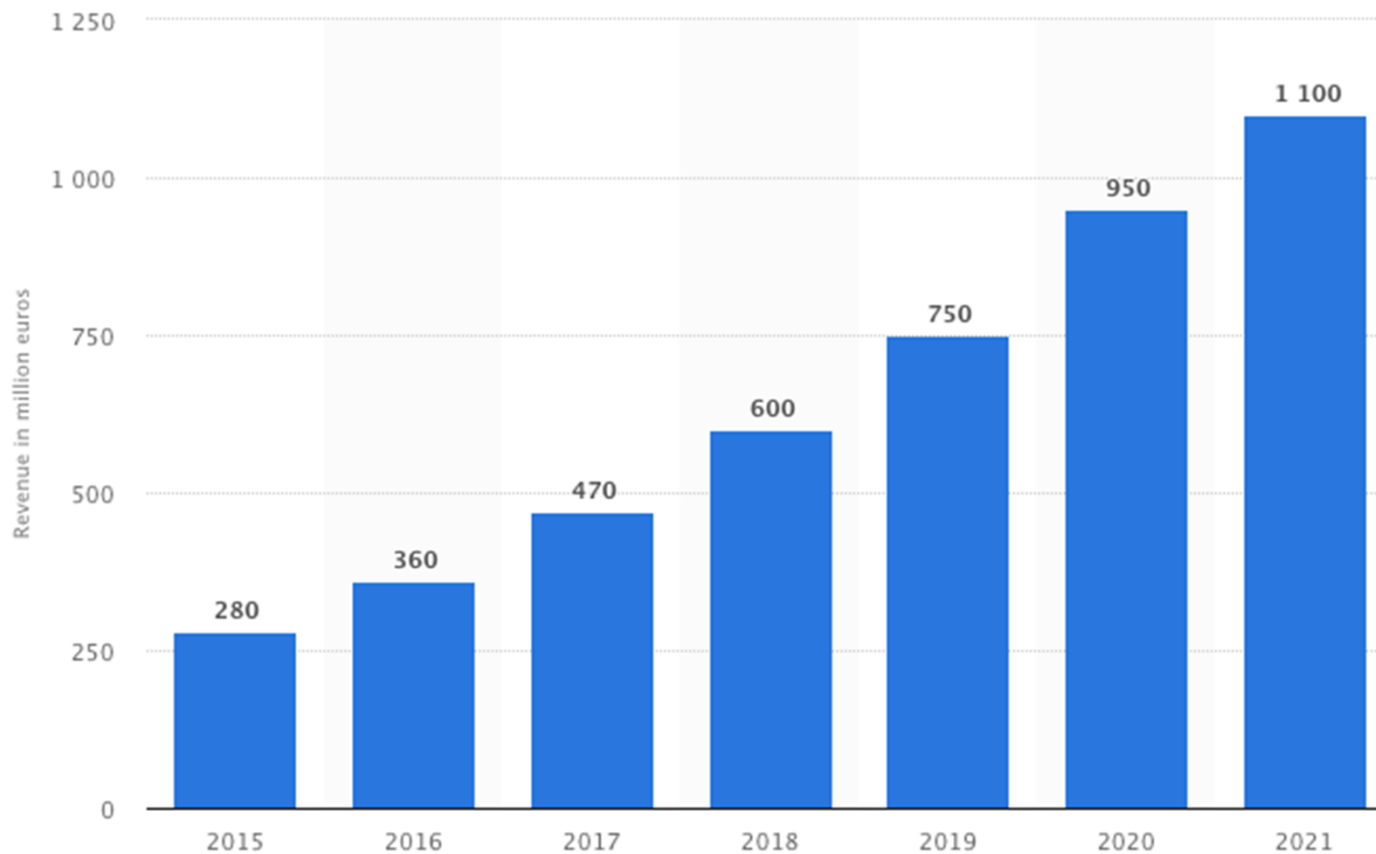
Connection Protocols neul, ZigBee, macheen, RFID, NFC, WiFi, Bluetooth, M-Bus, MQTT, 2G, 3G, 4G	Telecom at&t, verizon, T-Mobile, Virgin mobile, boost	M2M CROSSBRIDGE, gemalto, Jasper, Numorex, Telit, ERICSSON					
Software amazon web services, hadoop	Mobile ios, android, Parse, George Weir, 2018	Hardware pengate, ARDUINO, beagleboard.org, spark	Parts / Kits MAKE, TinkerForge, littleBits, MOSORO, ready mate	Services DRAGON Innovation, makexyz, adafruit, CIRCUIT LAB	Incubators BOLT, LEMNOS Labs, springboard	Funding KICKSTARTER, indiegogo	Distribution Anvil

Projected Internet of Things services spending worldwide from 2014 to 2017 (in billion U.S. dollars)



Statista 2018

Third-party Internet of Things platform connectivity revenue worldwide from 2015 to 2021 (in million euros)

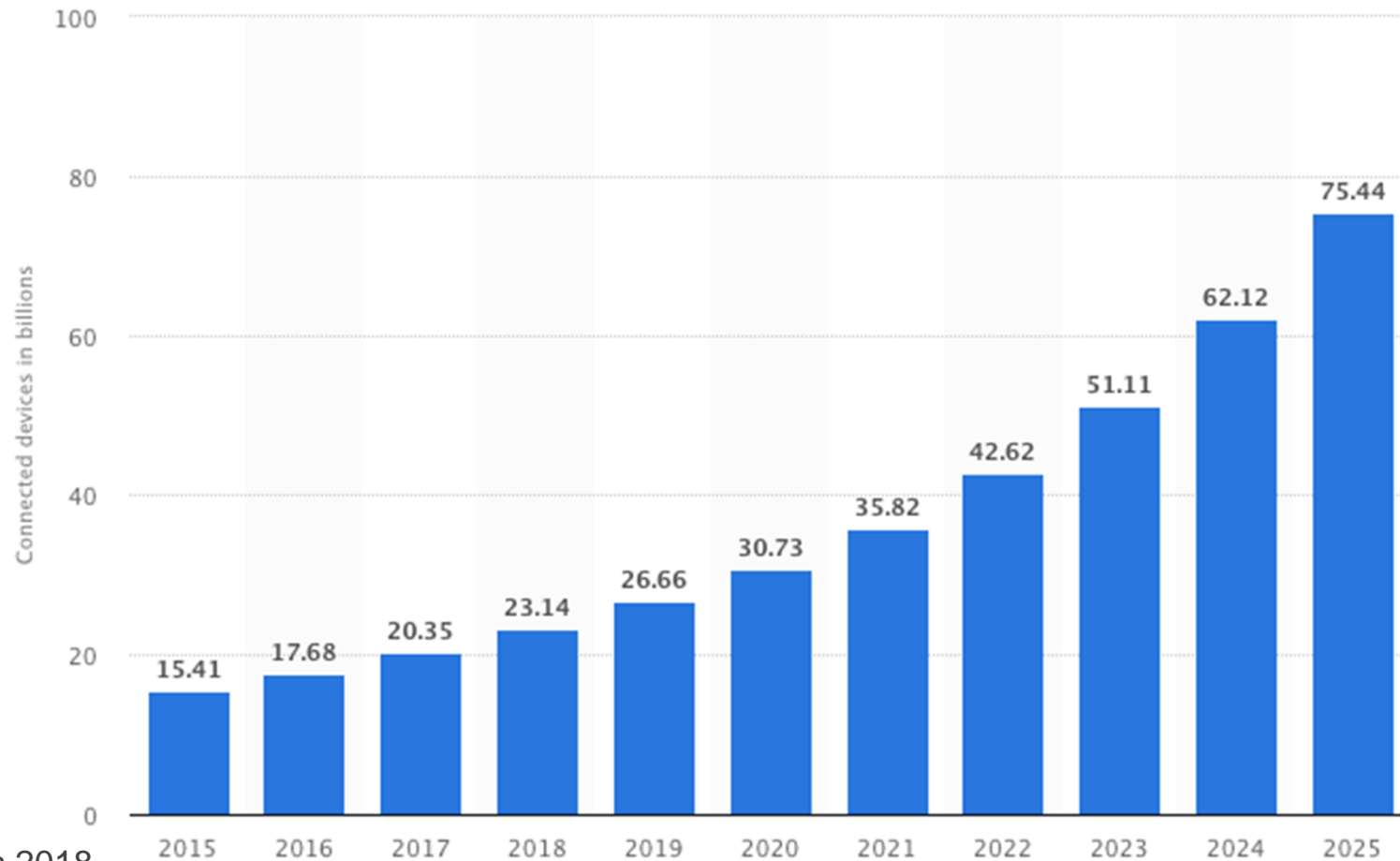


Statista 2018

George Weir, 2018

Third-party connectivity platform revenue is forecast to reach 1.1 billion euros in 2021

Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)



Statista 2018

George Weir, 2018

Media prediction

- “A typical home will soon contain a network of gadgets designed to make life easier.”
(Sunday Times, 11.01.15)



George Weir, 2018



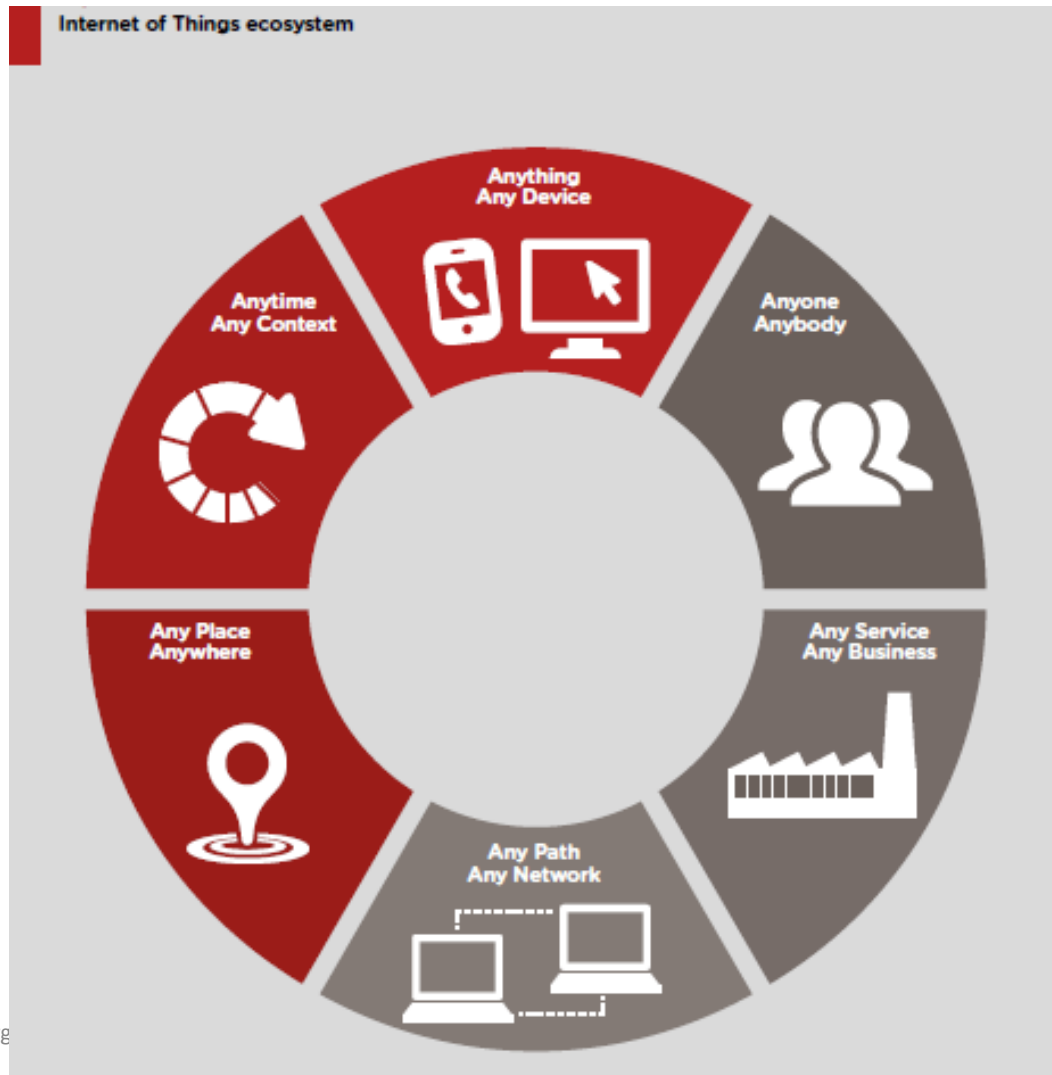
Government initiative?



The Internet of Things: making the most of the Second Digital Revolution

A report by the UK Government Chief Scientific Adviser

Large-scale Ecosystem



Report perspective: *we should engage quickly with these developments for the welfare of the population and the economic benefit of the country.*

Key ingredients

- **Communication**

- Wireless technology
 - Wlan
 - Bluetooth
 - GPRS (GSM)
 - New communication standards

- **Integration**

- Local systems talking together and to 'upper level' systems

- **Data analysis**

- Widely distributed data gathering
- Centralised synthesis and analysis

Likely applications

- Home automation
 - Building management systems
- Energy
 - Smart meters
- Healthcare
 - Telehealth: delivery of remote health-related services
- Transport
 - Self-adjusting vehicles
- Agriculture
 - Sensor-based yield management



Example devices

- Smart thermostat with remote control



Apps on Your Fridge?

- ‘Upgrade your life with a Wi-Fi enabled refrigerator
- Featuring a brilliant 8” touchscreen that puts access to apps at your fingertips
- Check the morning weather, browse the web for recipes, explore your social networks or leave notes for your family—all from the refrigerator door’

Samsung advert



Smart toothbrush



- Bluetooth smartphone interaction
- No internet connection (yet!)



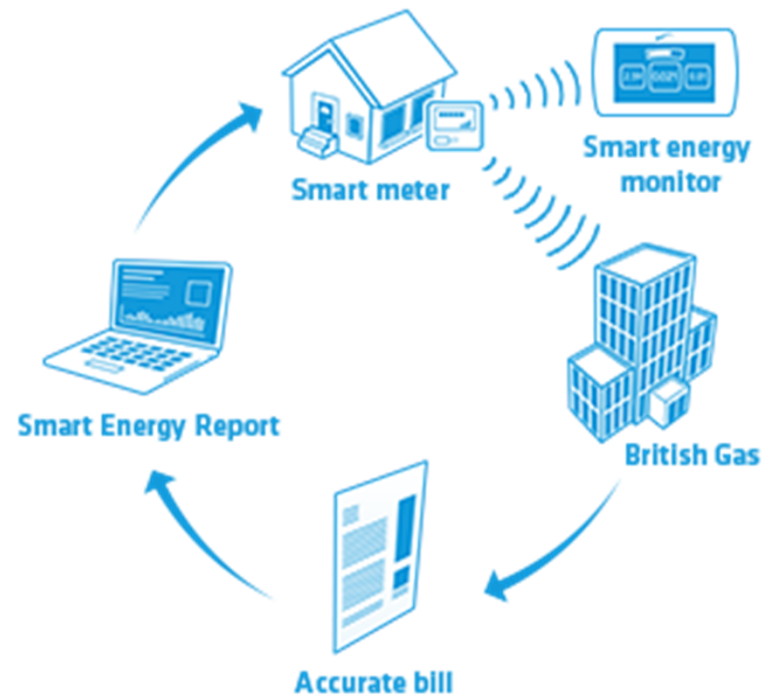
Smart energy meters

- Consumers with smart meters can have an in-home display (IHD) that lets them see how much energy they are using and what it will cost.
- This will let them have more control over their energy use and help them save energy and money.



How smart meters work

- Smart meters take accurate readings of your energy
- Readings are automatically sent to the supplier using wireless technology
- You can view usage online with an in-house display
- You receive an accurate energy bill without having to submit meter readings



Wearable technology

- Smart watches with sensors
 - Health and fitness applications
- Smart clothing is predicted to overtake the sale of fitness trackers by 2017



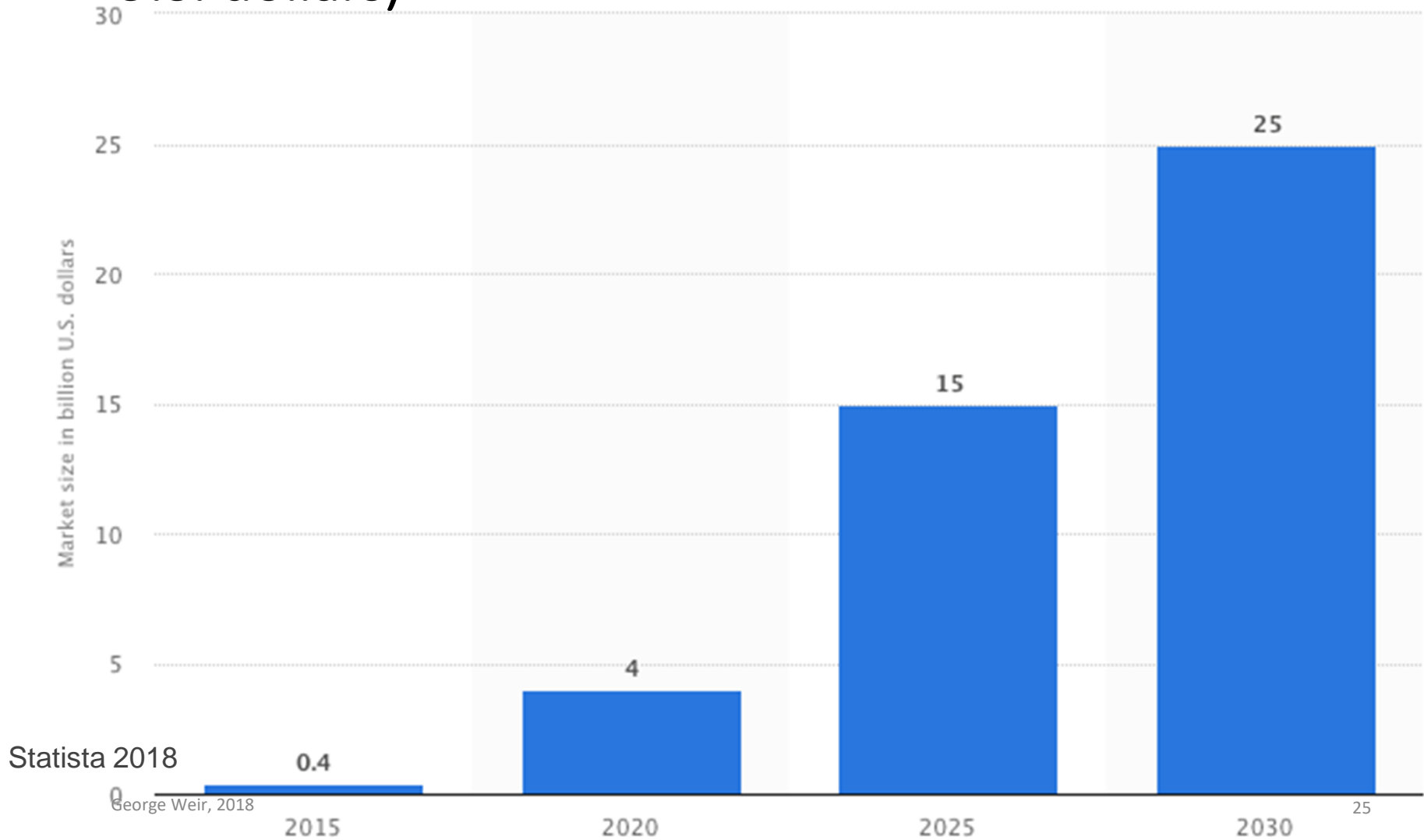
The Polo Tech smart shirt by Ralph Lauren, can measure heart rate and respiration connecting to a smartphone via Bluetooth

Wearable technology (2)

- The Polo Tech smart shirt by Ralph Lauren
- Can measure heart rate and respiration, distance travelled and calories burned
- Connects to smartphone or tablet via Bluetooth



Projected global market for autonomous driving sensor components from 2015 to 2030 (in billion U.S. dollars)



Intelligent Transport System Corridor

- Cooperative ITS Corridor
- EU project to manage cars from Rotterdam via Munich, Frankfurt, and on to Vienna
 - warning drivers of upcoming roadwork and other obstacles
 - aims to harmonize smart-road standards among different countries



Cooperative ITS Corridor

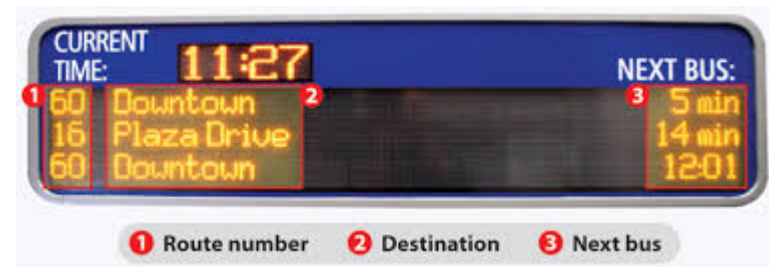
- Cameras every 100 metres
- Wi-Fi antennas every 500 metres
 - Short-range 'car to road' communication
- Measuring exact position of vehicles 10 times per second
 - within 1 metre accuracy
- Improved flow management
 - claims to address the 'braking shockwave' problem

Cars Will Talk, Then Collaborate

- Initial stage is 'car to roadside' communication
- Later stage extends this to 'car to car'

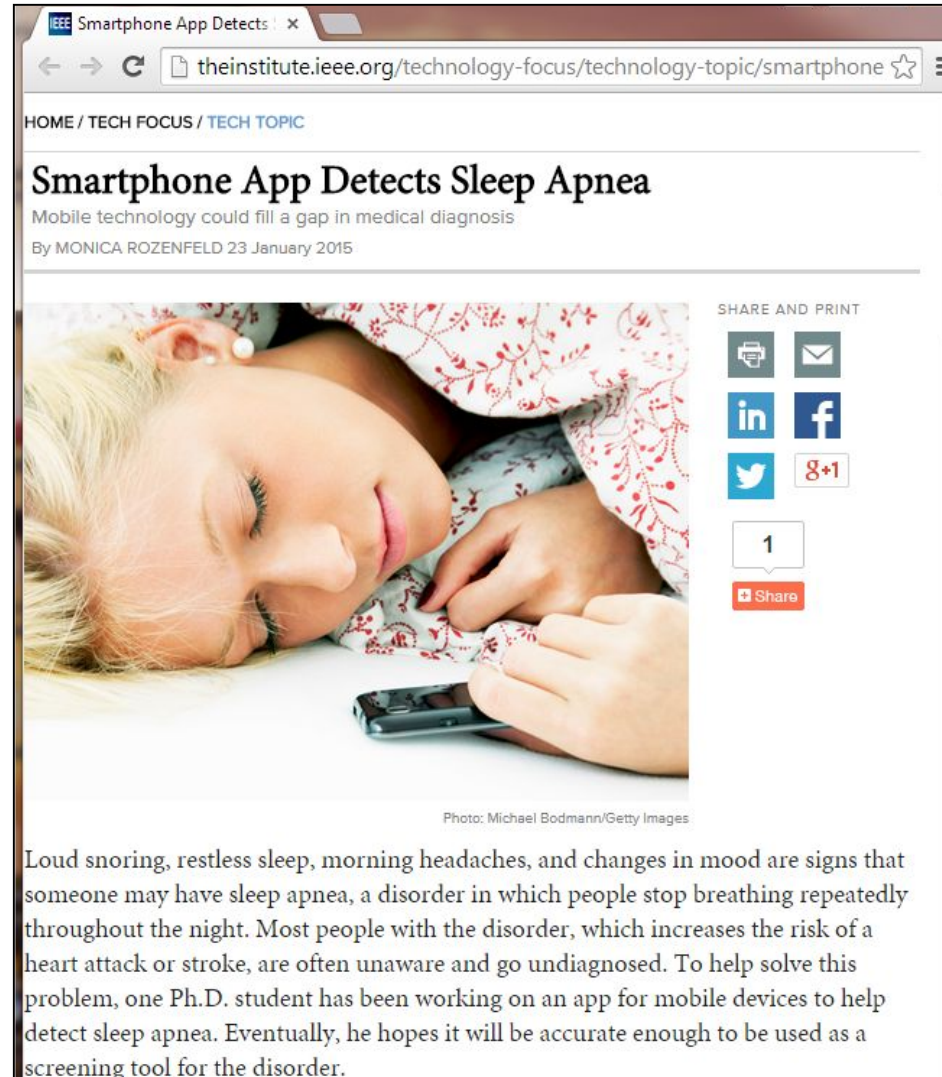
Where we are

- Green wave system implemented in Glasgow City Centre (~2010)
 - Allows emergency vehicles to receive green waves to allow for safe and speedy journeys across the city
 - Vehicles tracked using GPRS transmission
- Bus stops showing expected arrivals



Health applications

- Mainly monitoring and data capture
- Some remote access to consultations



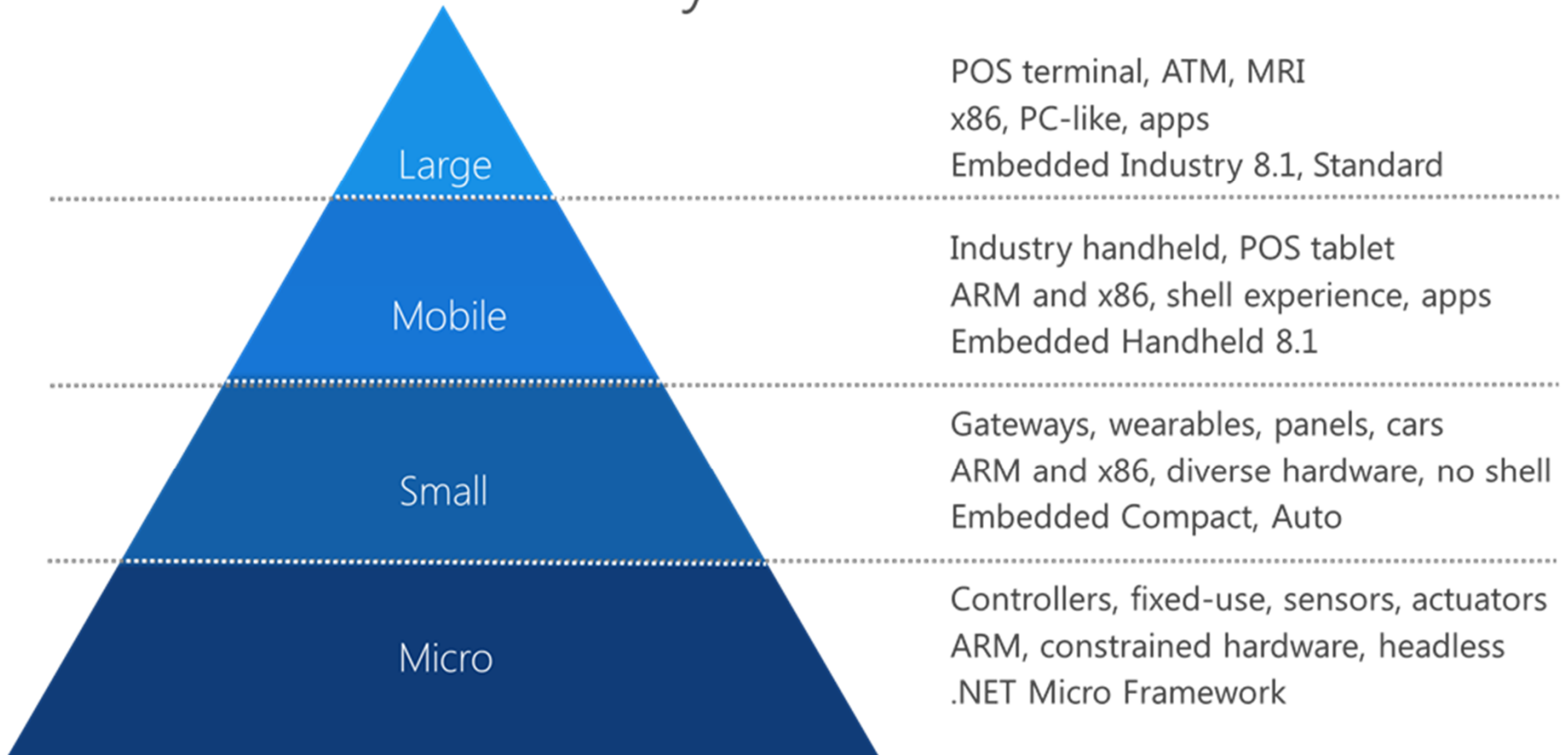
The screenshot shows a web browser window with the URL theinstitute.ieee.org/technology-focus/technology-topic/smartphone. The article title is "Smartphone App Detects Sleep Apnea" with the subtitle "Mobile technology could fill a gap in medical diagnosis" and author "By MONICA ROZENFELD 23 January 2015". The main image shows a woman sleeping with a smartphone on her chest. To the right of the image are social media sharing icons for print, email, LinkedIn, Facebook, Twitter, and Google+, along with a "Share" button and a counter showing "1". Below the image is the photo credit: "Photo: Michael Bodmann/Getty Images".

Loud snoring, restless sleep, morning headaches, and changes in mood are signs that someone may have sleep apnea, a disorder in which people stop breathing repeatedly throughout the night. Most people with the disorder, which increases the risk of a heart attack or stroke, are often unaware and go undiagnosed. To help solve this problem, one Ph.D. student has been working on an app for mobile devices to help detect sleep apnea. Eventually, he hopes it will be accurate enough to be used as a screening tool for the disorder.

Ecosystem requirements

- Varieties of device
- Networking models
- Communication models

IoT Device Taxonomy



Varieties of device

- Three varieties of 'device'
 - Inert (with location markers)
 - Data gathering and relay
 - Sensor-based with data transfer
 - Decision making
 - Action based upon detected conditions

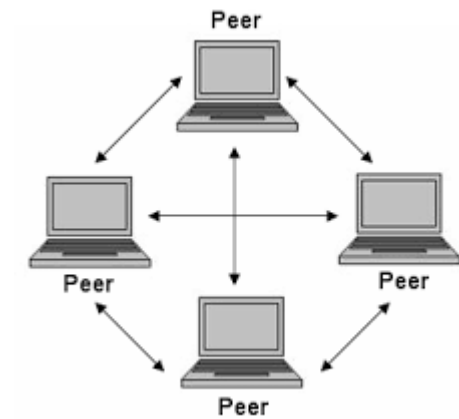
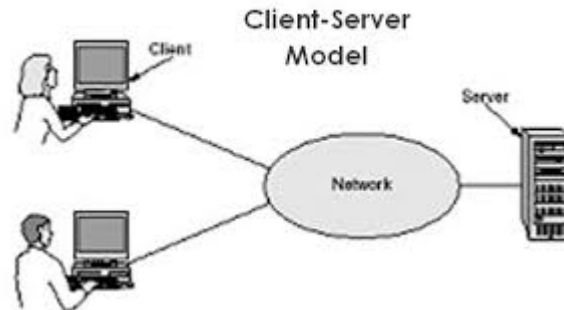
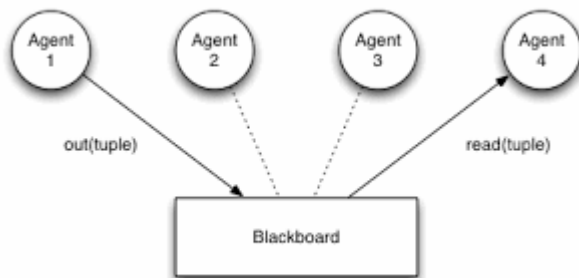
networking models

- Two networking models
 - Mobile device to local network
 - As we have presently
 - Close proximity, ad hoc networking
 - Device to device
 - Peer to peer
- These models will interact



Communication models

- Three communication models
 - Blackboard (e.g., cloud-based)
 - Client-server
 - Peer to peer



Home ecosystem

- Devices register presence and status with central management system
- Domestic sensor network
 - tracks and monitors internal systems, devices and other 'objects'
 - including people
- Extended to 'inert' objects
 - e.g. through RFID tags
 - no more lost items

Home ecosystem (2)

- Domestic objects outside the home can also be tracked/monitored
 - Children
 - Pets
 - Vehicles
 - Mobile phones, ...
- Smart inventory, commercial and domestic
- Regulated service reports
 - Ease of data production for insurance
 - Home reports when selling property

Where we might be

- Highly integrated monitoring and control
 - domestic, district, regional and national
- Device self-monitoring for fault tolerance and timely repair
 - e.g., engine status monitor
- Environment monitoring for smart control
 - e.g., weather forecast affecting thermostat settings
- Significant cost benefits through better insight on system demand
 - e.g., cheaper health service
- Better guarantees of system performance
 - Quality of service enhancements through optimised production

We should be worried about

- Reliability/robustness
- Locus of control
- Privacy
- Integrity
- Accountability
- Security
- Digital Forensics
- Availability

Reliability and robustness

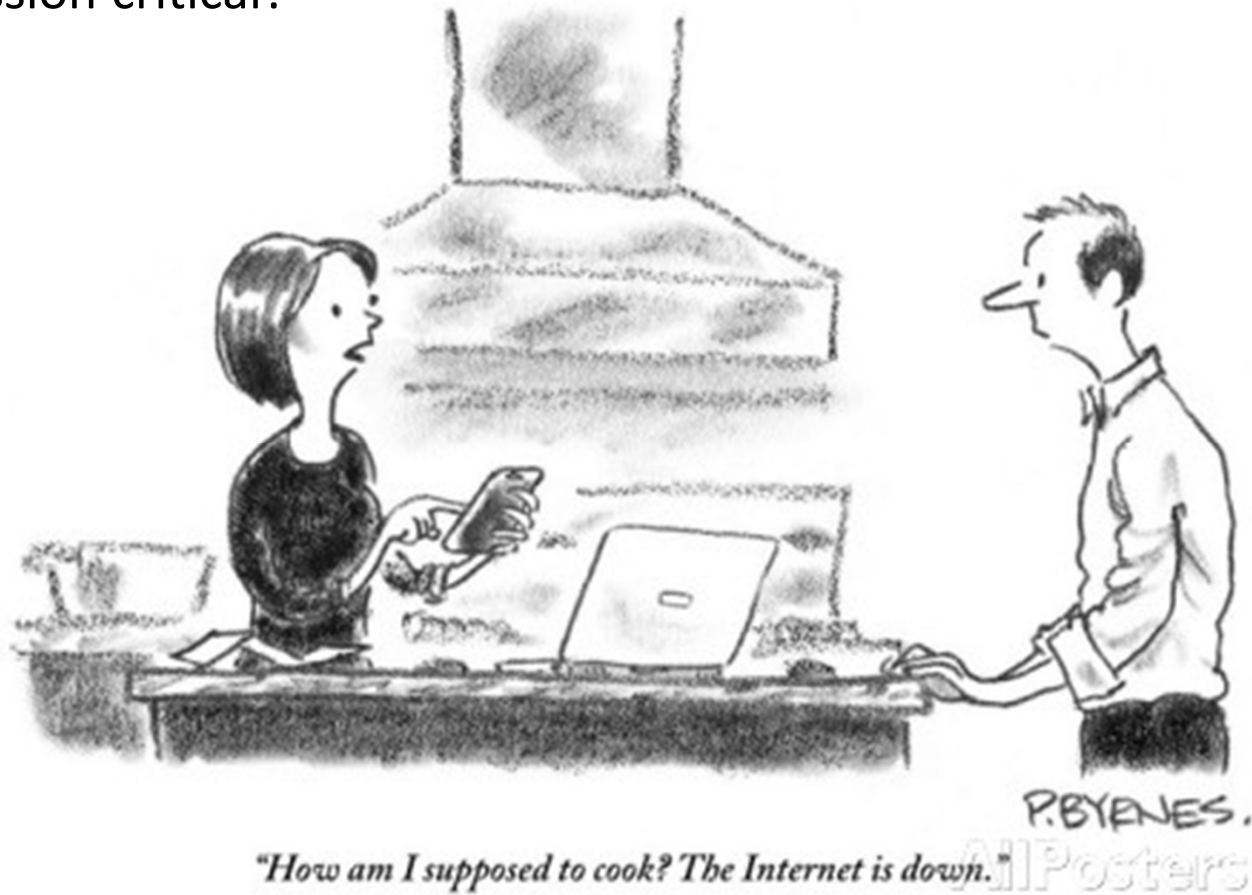
- Integrated systems could become mission or life critical
- Must have minimum failure rate
- issue of performance and capacity
- priority and contention management

Reliability and robustness (2)

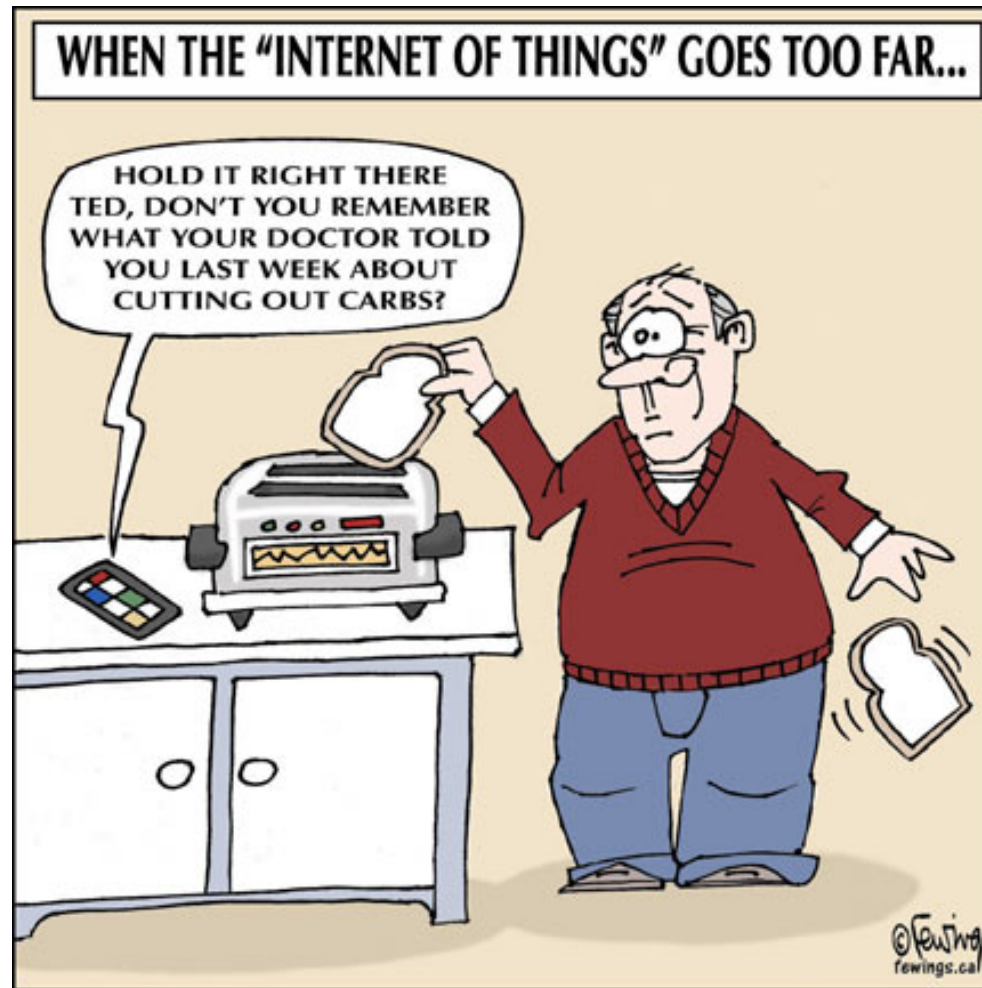
- Multiple points of failure?
 - Individual devices
 - Communication links
 - Centralised services

Reliability and robustness (3)

- Mission critical?



Locus of control



Locus of control (2)

- Who is in control?

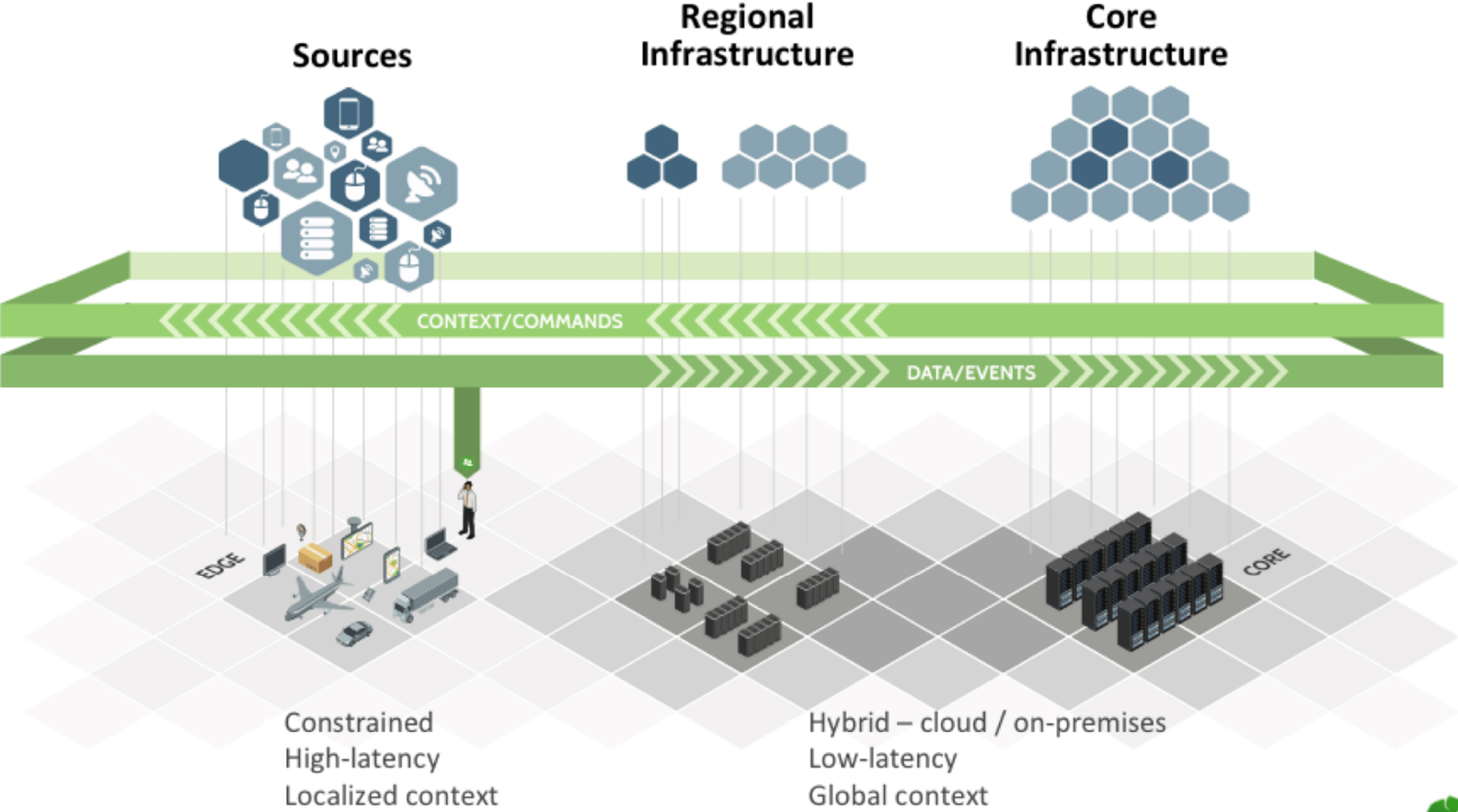


*“Bad news - the scale is threatening to cut off
our access to the fridge...”*

privacy

- Centralised data collection?
- The rise of 'big data' and data analytics
- Who owns the information?
- How can it be used?
 - Timely intervention (e.g., health care)
 - Targeted advertising
 - Product development
- Nowhere to hide?
- Tracking via our portable devices

Big Data and IoT



Buckhacker

A website created by anonymous hackers has been launched that allows anyone to search for unsecured sensitive data stored in the cloud.

Buckhacker is a tool that trawls servers at Amazon Web Services (AWS), a popular cloud computing platform.

AWS provides data storage to private firms, governments and universities, among others.

Exposed data has been found on it before, but Buckhacker makes searching for it much easier.

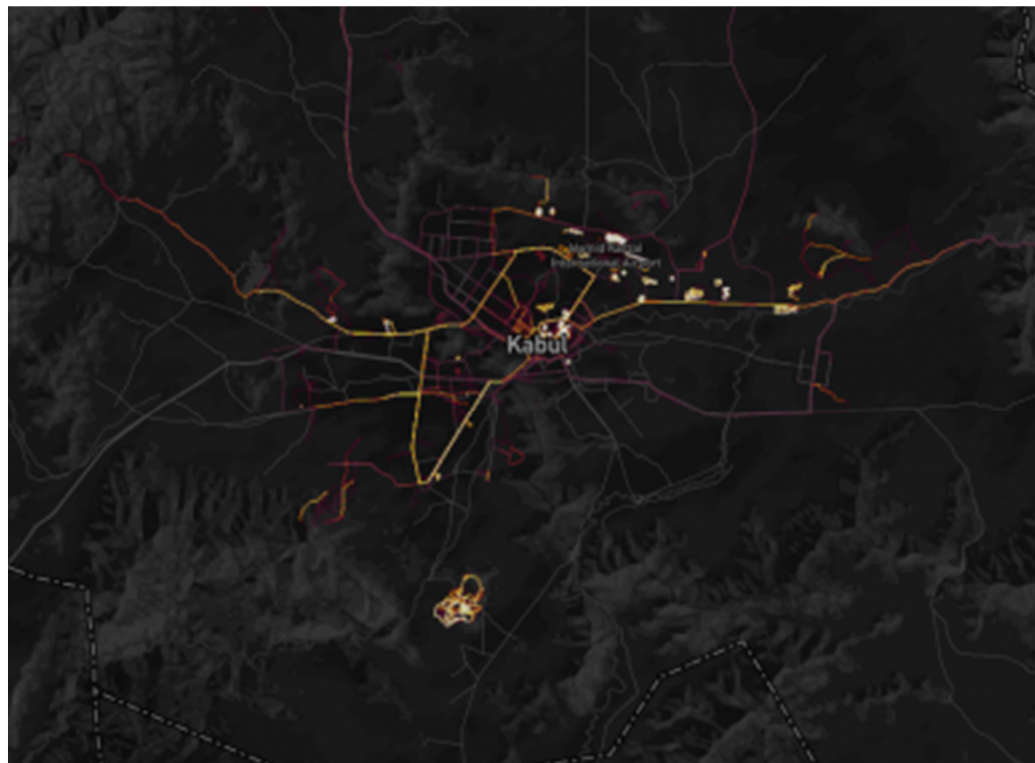
The name comes from the fact that AWS Simple Storage Servers (S3) are known as "buckets" - this is the part of AWS that Buckhacker accesses.

<http://www.bbc.com/news/technology-43057681>

Strava

Fitness tracking app gives away location of secret US military bases

The app, made by Strava Labs, shows the movements of its app users around the world.



George Weir, 2018

Kabul, Afghanistan on the Strava heat map

Integrity/Accountability

- Can you trust the results of data analysis?
- How could you verify?
- Who can be held to account?
 - Distributed responsibility means more complex accountability

security

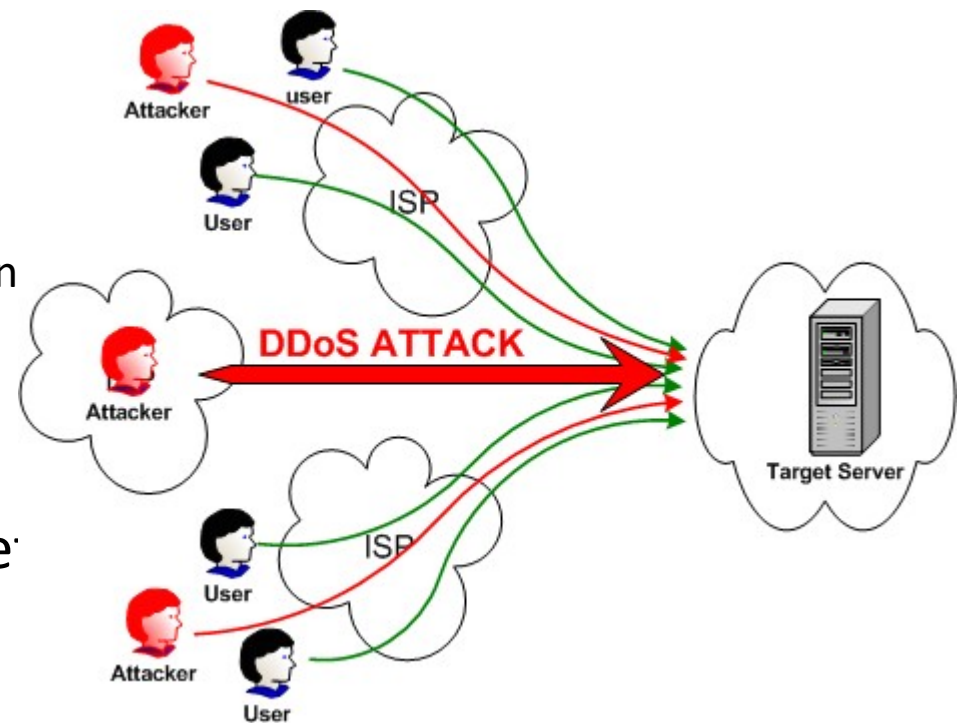
- Internet of Insecure Things
- 'Anything that can be hacked will be hacked'
- Shodan - the world's first search engine for Internet-connected devices
- Recent DDoS attacks employing IoT devices
- Malware (originating in China) has been found on US SCADA systems

Recognising the risks?



Security: risks

- Forms of attack
 - Target devices
 - Target infrastructure
 - Unauthorised access (to data or con
 - Denial of service
- Most attacks use standard protocols to overwhelm target
- If you are connected, you are vulnerable



Security: Internet of Insecure Things

- Recent issues with remote surveillance cameras

MICROSOFT SUBNET An independent Microsoft community [View more](#)

Home > Microsoft Subnet



PRIVACY AND SECURITY FANATIC
By Ms. Smith | Follow

About

Ms. Smith (not her real name) is a freelance writer and programmer with a special and somewhat personal interest in IT privacy and security issues.

Hacks to turn your wireless IP surveillance cameras against you

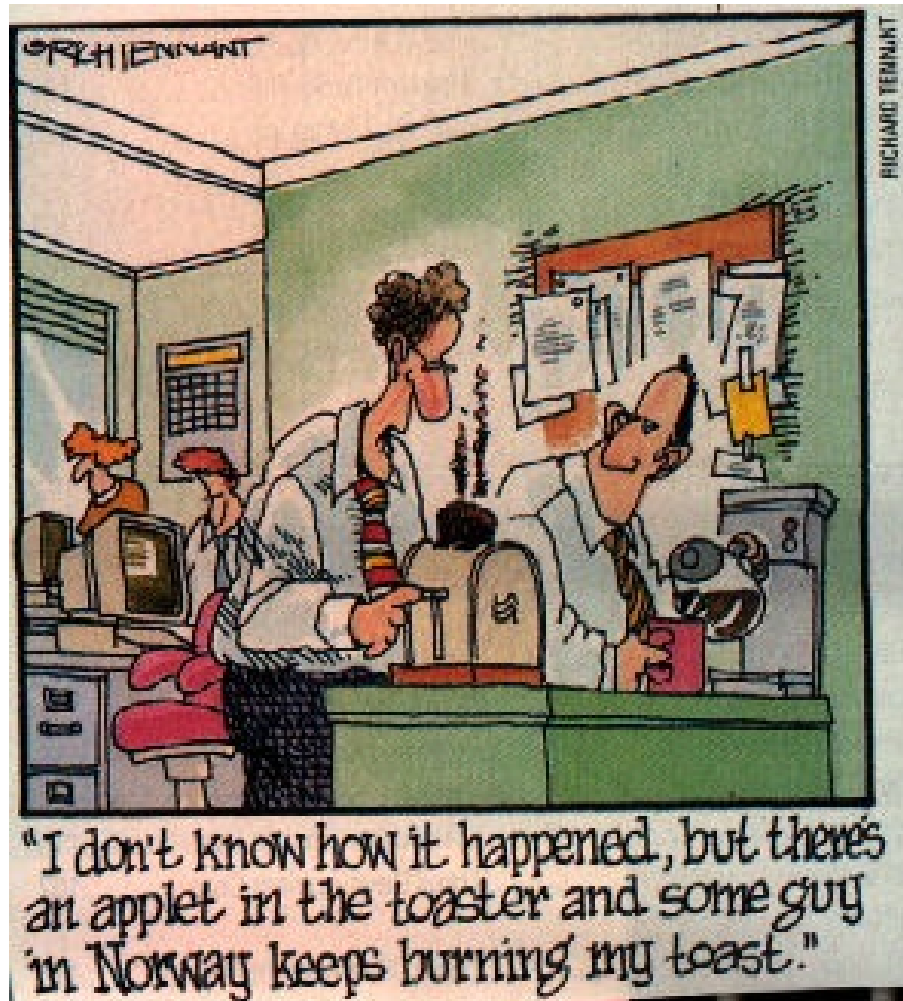
Thousands of wireless IP cameras are vulnerable to remote attacks. At Hack in the Box security conference, researchers showed how to exploit the devices in "To Watch or Be Watched: Turning Your Surveillance Camera Against You" and released a tool to automate attacks.

Network World | Apr 14, 2013 10:18 AM PT

SHODAN Microsoft Sergey Shekyan and Artem Harutyunyan, researchers from the

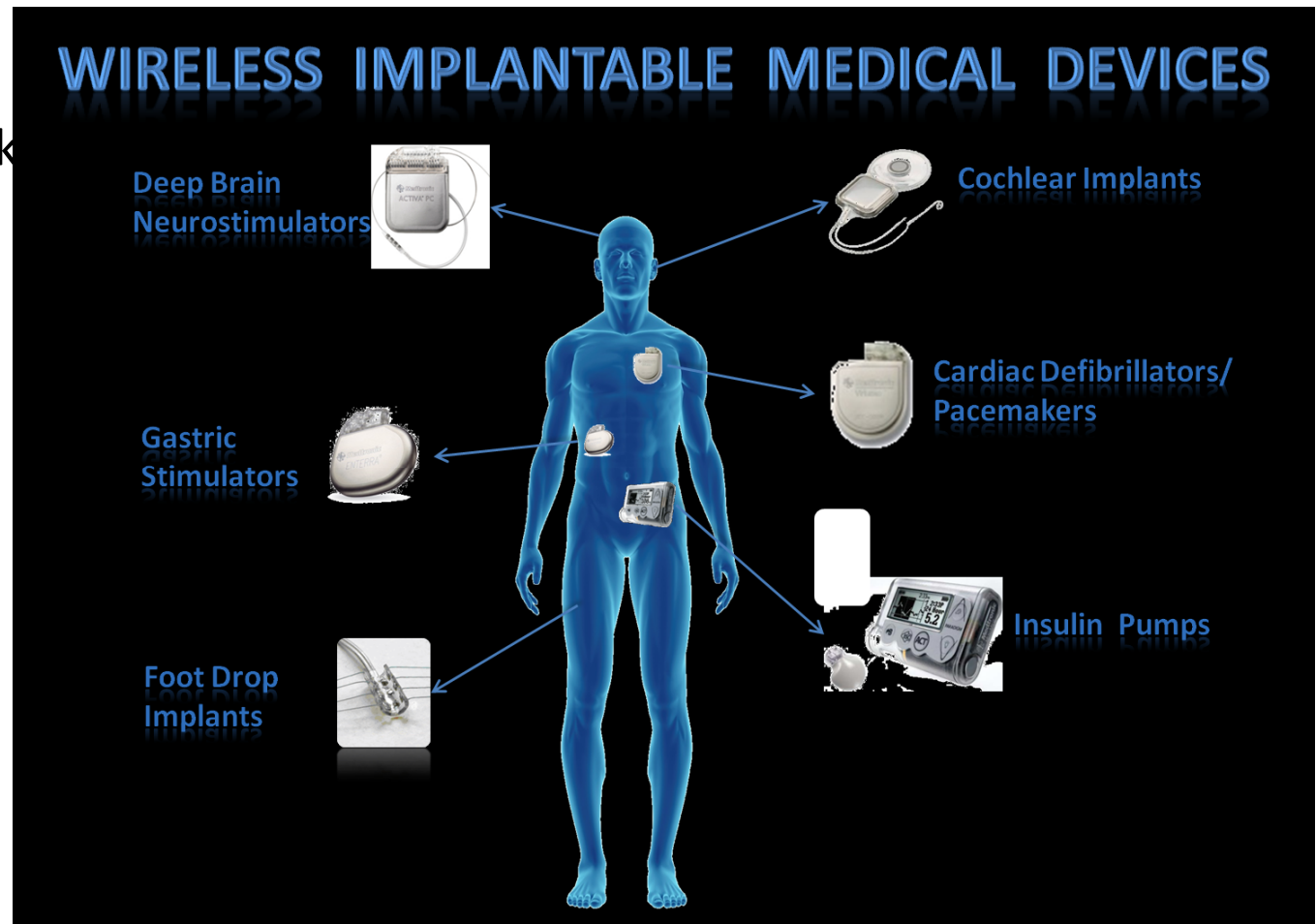
George Weir, 2018

Security: Unauthorised access



Security: Health risks?

- Implanted network medical devices

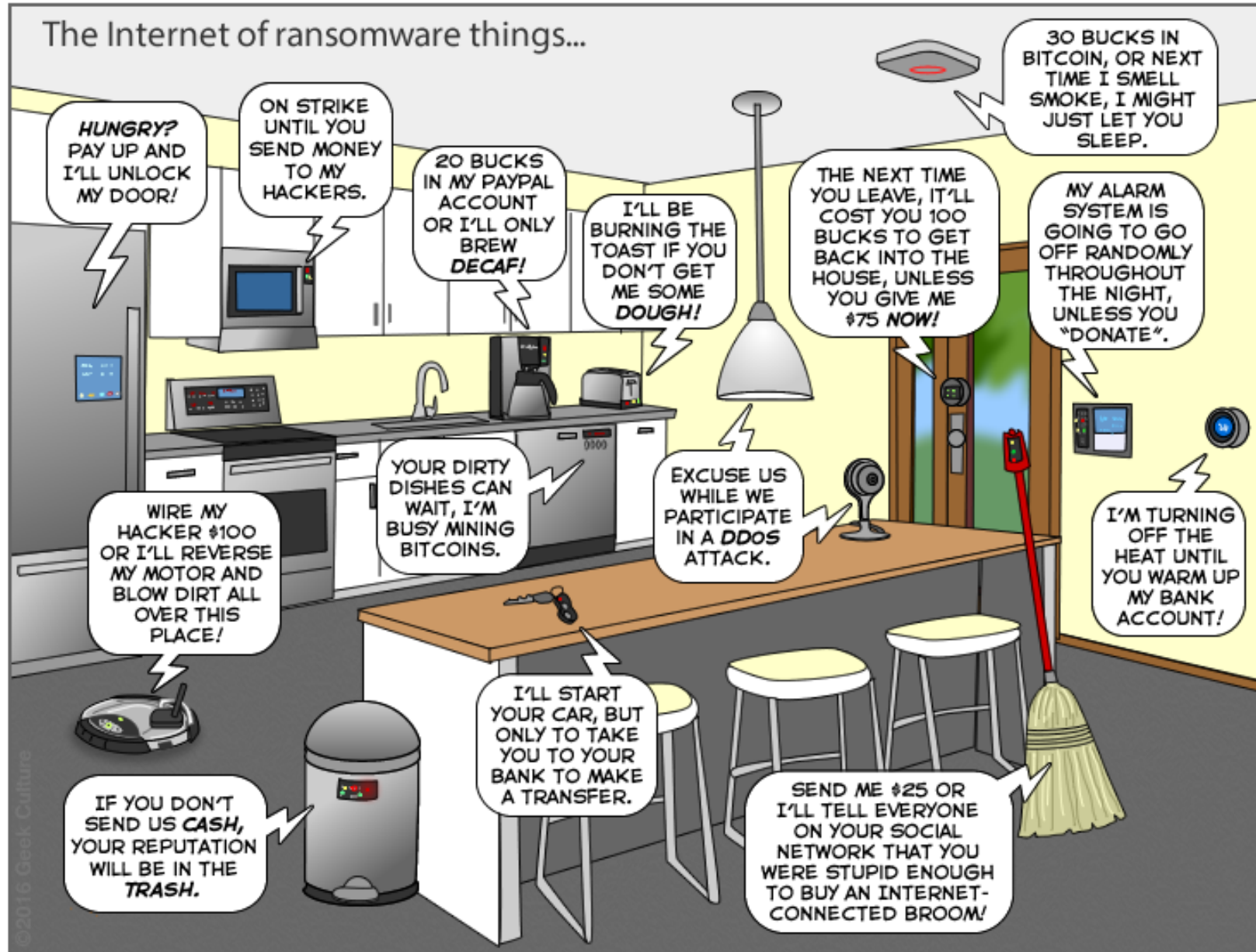


Security: Health risks?

- Moving toward implanted devices
- Risk of illicit device access



The screenshot shows a web browser window displaying a Politico article. The URL is www.politico.com/story/2013/10/dick-cheney-feared-assassinatic. The article title is "Dick Cheney feared assassination by heart-device hack". Below the title are social media sharing buttons for Facebook (2k likes), Twitter (362 tweets), LinkedIn (0 shares), and YouTube (70 shares). There are also 361 comments and a print icon. The main image is a close-up of Dick Cheney wearing glasses, with a caption that reads "Cheney has suffered five heart attacks since the age of 37. | AP Photo". Below the image, the author is identified as "By NICK GASS | 10/18/13 8:14 PM EDT". The article text begins with "Dick Cheney's heart problems are well known." and continues with "What isn't widely known is that the former vice president had the wireless feature of his implanted defibrillator disabled so nobody could attempt to assassinate him by hacking into the device."



©2016 Geek Culture

You can help us keep the comics coming by becoming a patron!
www.patreon/joyoftech

joyoftech.com

INTERNET OF THINGS OR INTERNET OF THREATS?

KASPERSKY

What risks does the IoT brings to your life and how do you use new connected devices wisely

USB-dongle for video streaming

Using the vulnerability in USB-dongle, the attacker could show false error messages to the user and urge them to reset their Wi-Fi network password.

Coffee maker

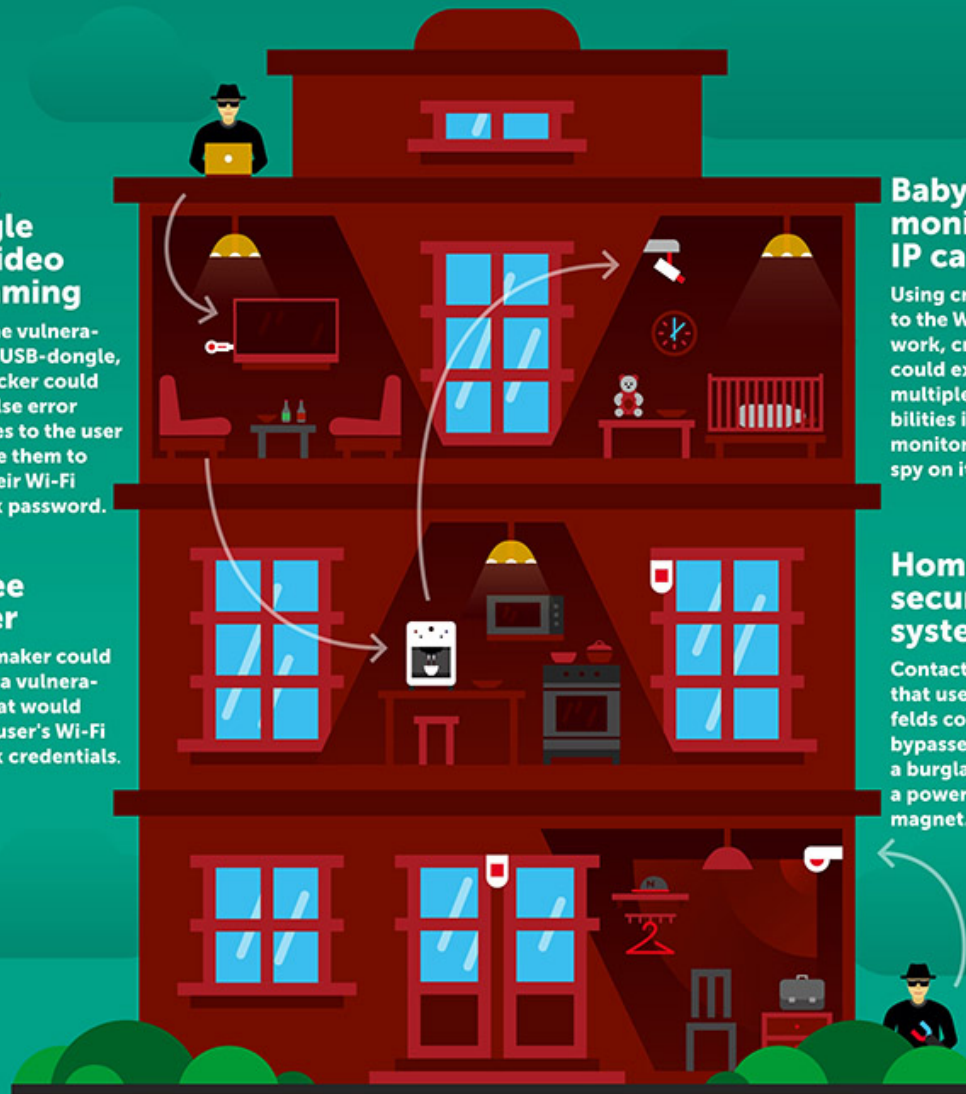
Coffee maker could contain a vulnerability that would expose user's Wi-Fi network credentials.

Baby monitor IP camera

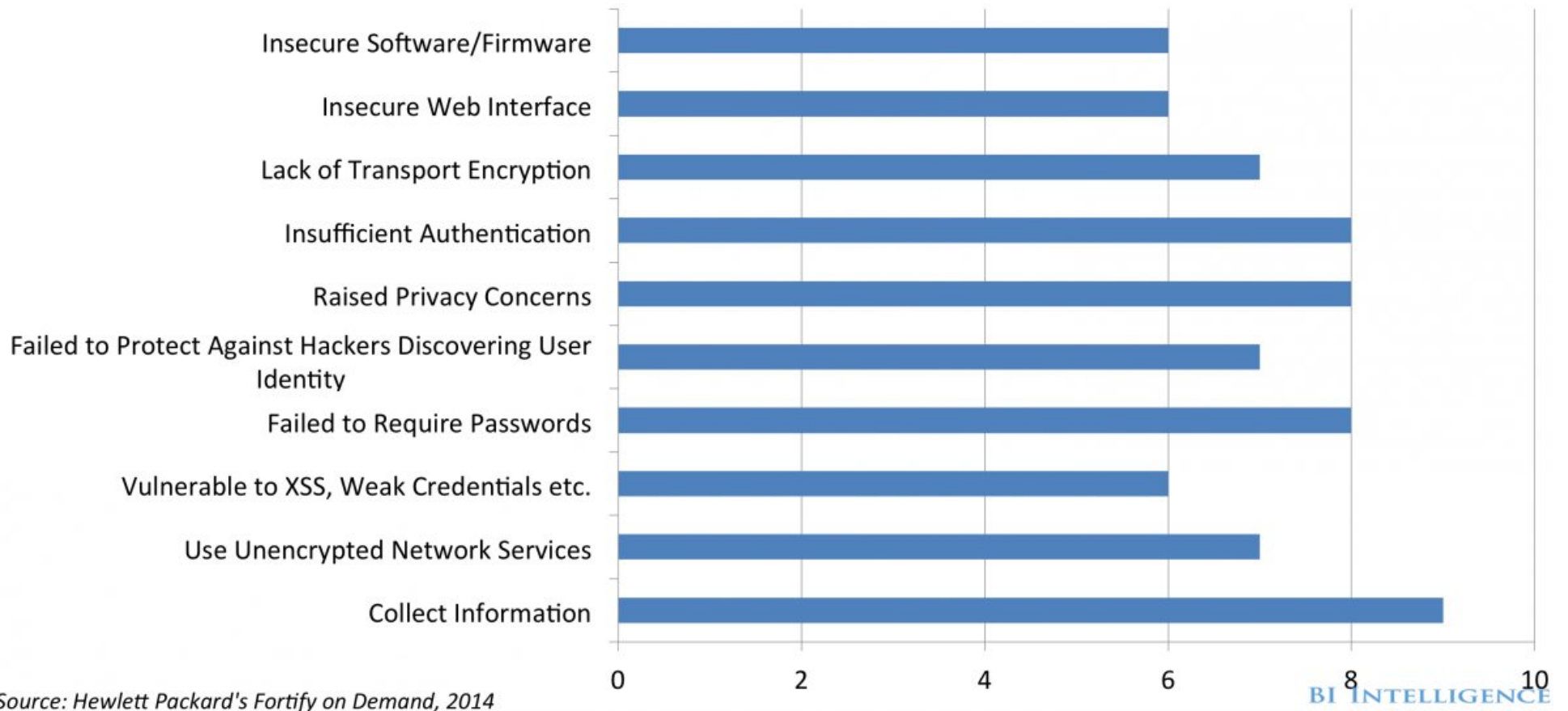
Using credentials to the Wi-Fi network, criminal could exploit multiple vulnerabilities in Baby monitors and spy on its owners.

Home security system

Contact sensors that use magnetic fields could be bypassed by a burglar with a powerful enough magnet.



Top Ten IoT Security Flaws



Digital forensics

- Where does the data reside?
- Who has authority to access logs or centrally stored data?
- Can we keep up with the proliferation of different devices?



Google Home



Amazon Echo

Example

- A recent criminal case involving an Amazon Echo:
- In November 2015, James Bates was charged with first-degree murder of another man, who was found dead in Bates' hot tub
- Police in Arkansas seized Bates' Alexa-enabled Echo smart speaker from his home, and asked Amazon to hand over any pertinent information regarding the device's communication with Alexa
- Amazon denied the request in the absence of a valid and binding legal demand

Amazon Echo

- Forensic investigation in the context of Amazon Echo (and similar, Cloud-based systems) is complex
 - According to Chung et al (2017)*, this requires “a new digital forensic approach for the Amazon Alexa ecosystem combining cloud-side and client-side forensics”
-
- *Digital forensic approaches for Amazon Alexa ecosystem, Digital Investigation, Volume 22, Supplement, August 2017, Pages S15-S25.

Availability: services

- How do we spread the benefits?
- We don't all have the necessary infrastructure
 - High speed broadband
 - Domestic networks
 - Centralised monitoring and control systems
 - New era of 'haves and have nots'?

Availability: quality of service

- Differing service options at different costs?
- Two tier health service with two access modes:
 - personal contact and on-line
- Latter will initially be cheaper option
- May evolve into more specialised service
 - e.g., advice and input from world leading medics, at a premium cost

Availability: data

- Who gets access to the data?
- At what cost?
- New scope for data brokers?
- New avenues for personalised adverts...

Availability: A new digital divide?

- Integrating old and new?
- Accommodating rich and poor?
- New education required?



Conclusion (1)

- The Internet of Things: Are we running quickly into the darkness?
 - Yes
- Should we be worried?
 - Yes
- Can we mitigate the risks?
 - Yes (partly)

Conclusion (2)

- What can we do?



Walk forward (with a flashlight)



George Weir – george.weir@strath.ac.uk