INTERNET *of* THINGS

Connecting trillions of smart things

Machines connected to each other – and people with implanted microchips – are revolutionising industry and enriching everyday lives

◆ OVERVIEW

● JAMES DEAN

With a flick of his wrist, Hannes Sjoblad throws me his business card. There is no white rectangle of card for me to catch though. Instead, my iPhone lights up. He has just wirelessly transmitted his phone numbers, e-mail address and Twitter handle from a small microchip implanted in his wrist.

Mr Sjoblad is the chief disruption officer of BioNyfiken, a Swedish "bio-hacking" group. Members of BioNyfiken are trying to hook themselves up to the internet. They all have radio-frequency identification chips implanted into the backs of their hands. The chips, no bigger than a grain of rice, store personalised information that can be transmitted over short distances to special receivers.

As well as pinging digital business cards to nearby smartphones, members of BioNyfiken are using their chips to open electronic locks on their front doors and go shopping in Stockholm. They are lobbying for the chips to be accepted on public transport. Soon the chips could be used as personal identification tags, perhaps to identify who is driving a car. A swipe of the wrist across a steering wheel chip reader would tell the car who was sitting in the driver's seat, and adjust the controls and radio station as appropriate.

Members of BioNyfiken want to become part of the internet of things (IoT). This is a concept whereby "smart" devices – essentially objects containing microchips that connect them to the internet – will become ubiquitous. But humans with chips in their wrists, pets with chipped collars, as well as connected electrical appliances, such as toasters, fridges and washing machines,

home thermostats, cars, can also hook up.

Billions, perhaps trillions of things – and people – would be able to communicate with each other. One of the advantages, advocates say, is that we will be able to automate the mundane aspects of our lives.

The same goes for industry. The central promise of an industrial internet of things (IIoT) is that machinery can be made to run more efficiently, increasing productivity. Such machinery contains interlinked environmental sensors that provide real-time feedback about a wide variety of conditions to a central source that may be thousands of miles away at corporate headquarters. Intelligent software algorithms process the data to tweak the conditions and improve efficiency. The software predicts equipment failures long before they happen.

In 2012, companies across the world spent approximately $20 billion on technologies linked to the IIoT. By 2020, this spending is expected to exceed $500 billion. Such is its promise that by 2020 some believe the IIoT could contribute more than $14 trillion to the world economy.

Several pioneering companies are already embracing this new connected world, although there are many more that have not, perhaps hampered by a lack of understanding about the benefits of the IIoT or held back by an outdated regulatory environment.

There is also genuine concern about connecting more of our critical infrastructure and industry to the internet, potentially allowing cyber criminals to steal corporate secrets and extort ransoms, or hostile foreign governments to attack core systems. These concerns are real – it was only five years ago that security researchers discovered Stuxnet, a virus that infected and ultimately helped to destroy uranium centrifuges at an Iranian nuclear facility.

> **Billions, perhaps trillions of things – and people – would be able to communicate with each other**
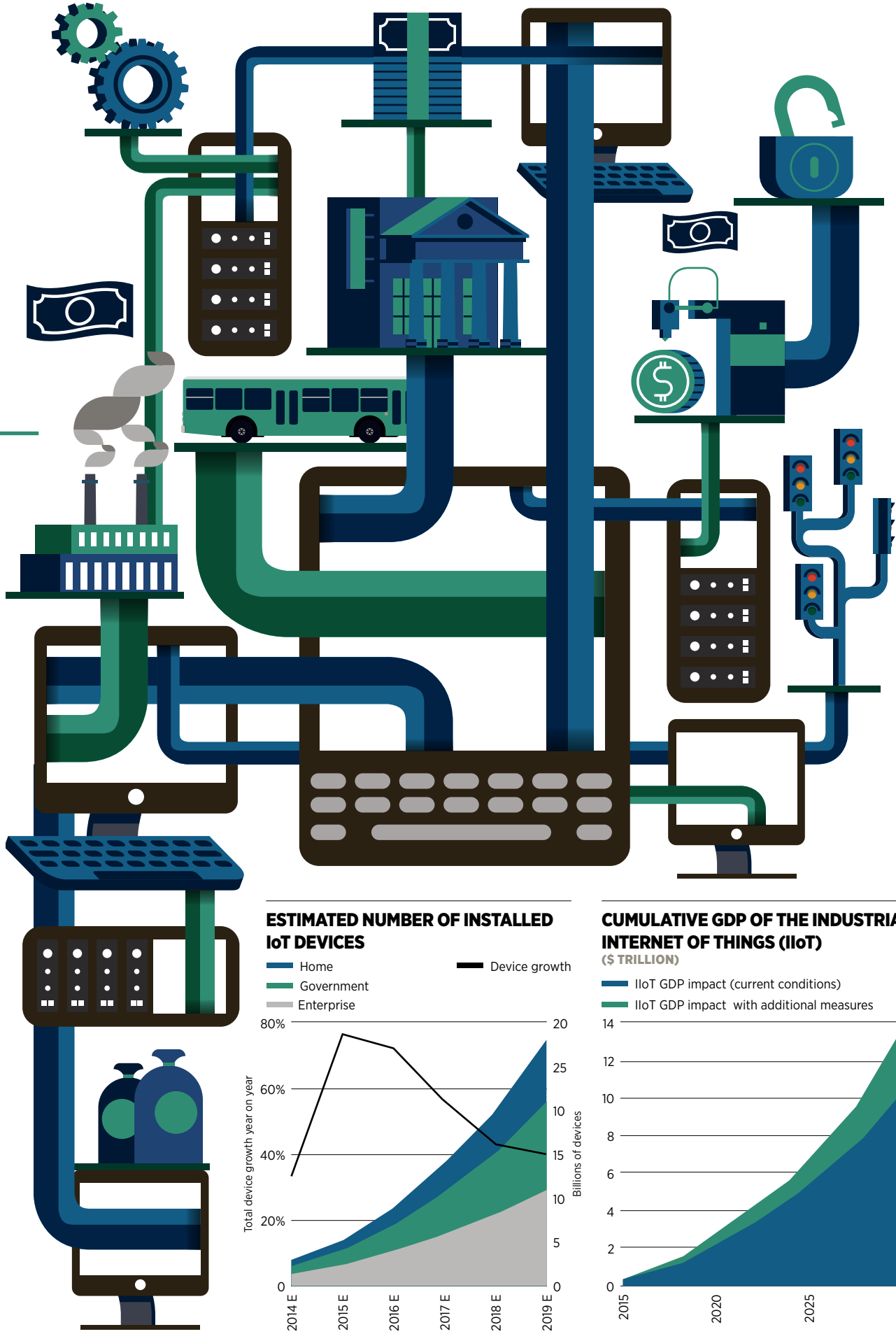
However, there are more good reasons than bad to pick up the IIoT baton. There is also an important defensive play to make. As the digital world creates opportunities for incumbent industry, it also opens the door for new competitors. Google, for example, is a company built up from an internet search engine. Yet now it is testing the most advanced driverless cars in the world, raising high-altitude balloons that beam internet connections to far corners of the globe and conducting a large-scale medical study which aims to predict the onset of terminal diseases.

Companies that embrace the IIoT can channel this sort of entrepreneurial spirit. Say that software engineers at a steel mill create some software that improves the efficiency of the mill by 10 per cent. Why not sell that software to other steel companies, not just in the UK, but across the world? And why not see whether the concepts behind the software can be applied to other industries and develop it accordingly? The IIoT is set to have more than just money-saving applications, opening up new revenue streams for the companies that are prepared to innovate.

The IIoT also reaches into the workforce. If employees are able to receive detailed feedback from customers about how they use the things they sell, they can tweak product design accordingly, based on a wealth of incisive information. It is a technique used widely by big internet and software companies, which receive trillions of gigabytes of automated feedback, transmitted over the internet, from computers and smartphones running their programmes.

The IoT, industrial or otherwise, is no longer a faraway concept. A recent estimate by Gartner suggested that 3.9 billion smart devices were connected to the internet by the end of 2014. This figure will, the technology analyst believes, rise to 25 billion by 2020. Separately, Cisco estimates that 99.5 per cent of the 1.5 trillion connectable devices in the world are currently offline.

Meanwhile, the world's biggest microchip makers are merging with and acquiring each other to better position themselves for a world where cheap, simple chips are inserted into pretty much anything that rolls off a production line. In May, Singaporean chipmaker Avago, which was once the electronic components division of Hewlett-Packard, announced it intended to buy Broadcom, in the United States, for $37 billion (£23.3 billion). It is one of the biggest takeovers the technology industry has ever seen and the latest in a string of big deals in the semiconductor industry.

The power of smart industrial systems will only increase as the artificial intelligence (AI) that runs them becomes cleverer. Machine learning – the process by which software "learns" from past experiences to enable it to predict the future – is becoming increasingly formidable. The longer that industrial AI is exposed to real world conditions, the smarter it gets. As such, getting connected sooner rather than later would appear to be a sensible ambition.

ESTIMATED NUMBER OF INSTALLED IoT DEVICES

- Home
- Government
- Enterprise
- Device growth

Source: BI Intelligence Estimates

CUMULATIVE GDP OF THE INDUSTRIAL INTERNET OF THINGS (IIoT)
($ TRILLION)

- IIoT GDP impact (current conditions)
- IIoT GDP impact with additional measures

Source: Accenture/Frontier Economics

Feeling pulse of health revolution

The internet of things offers a cure for many of the afflictions plaguing the NHS and an opportunity for patients to take control of their health

◆ **HEALTHCARE**

● **DANNY BUCKLAND**

Funereal gloom engulfs modern healthcare with most announcements about its future preceded by four jet-black stallions and trailed by a procession of solemn mourners.

So bad are the NHS's vital life signs – a £34 billion funding shortage and chronic illness time bombs – that it feels just a matter of time before a sorrowing nation bids farewell to a dear institutional friend.

But there is light. If the ages of medicine have been characterised by such wonders as anaesthetic, antibiotics, robotic operating techniques and biologics, a new era of therapies is upon us and it is one that could breathe fresh life into the creaking body of healthcare. The internet of things (IoT) may not have an august medical profile, but it can be the power behind a health revolution.

The wearable technology of the fitness craze is about to mature into a procession of devices that can monitor a body's vital rhythms and predict illness. Small patches on the skin and even ingested capsules will stream real-time data to clinicians who can keep patients out of hospitals and GP waiting rooms.

Getting connected could save us a fortune and postpone the psalms and eulogies for the NHS.

The opportunity for change – and profit, with Cisco predicting the IoT could generate £48 billion of business over the next decade – is attracting some of the most creative minds in technology including the big players such as IBM and Apple.

Their combined brain and corporate firepower could liberate the NHS's choke-points such as clogged waiting rooms and the sclerotic pathways of care full of delayed and disjointed appointments.

Crucially, it also has the potential to encourage the public to take ownership of their health and make the lifestyle changes that could stem the engulfing tides of diabetes and heart conditions.

The gadgets are ready; the IoT is ready. The number of smartphones in the UK will reach 43.4 million in 2017.

James Norman, former IT director at the Royal Liverpool and Broadgreen University Hospitals NHS Foundation Trust, believes that new data streams from devices linked to the internet will demystify health for the public and provide them with knowledge to live better lives.
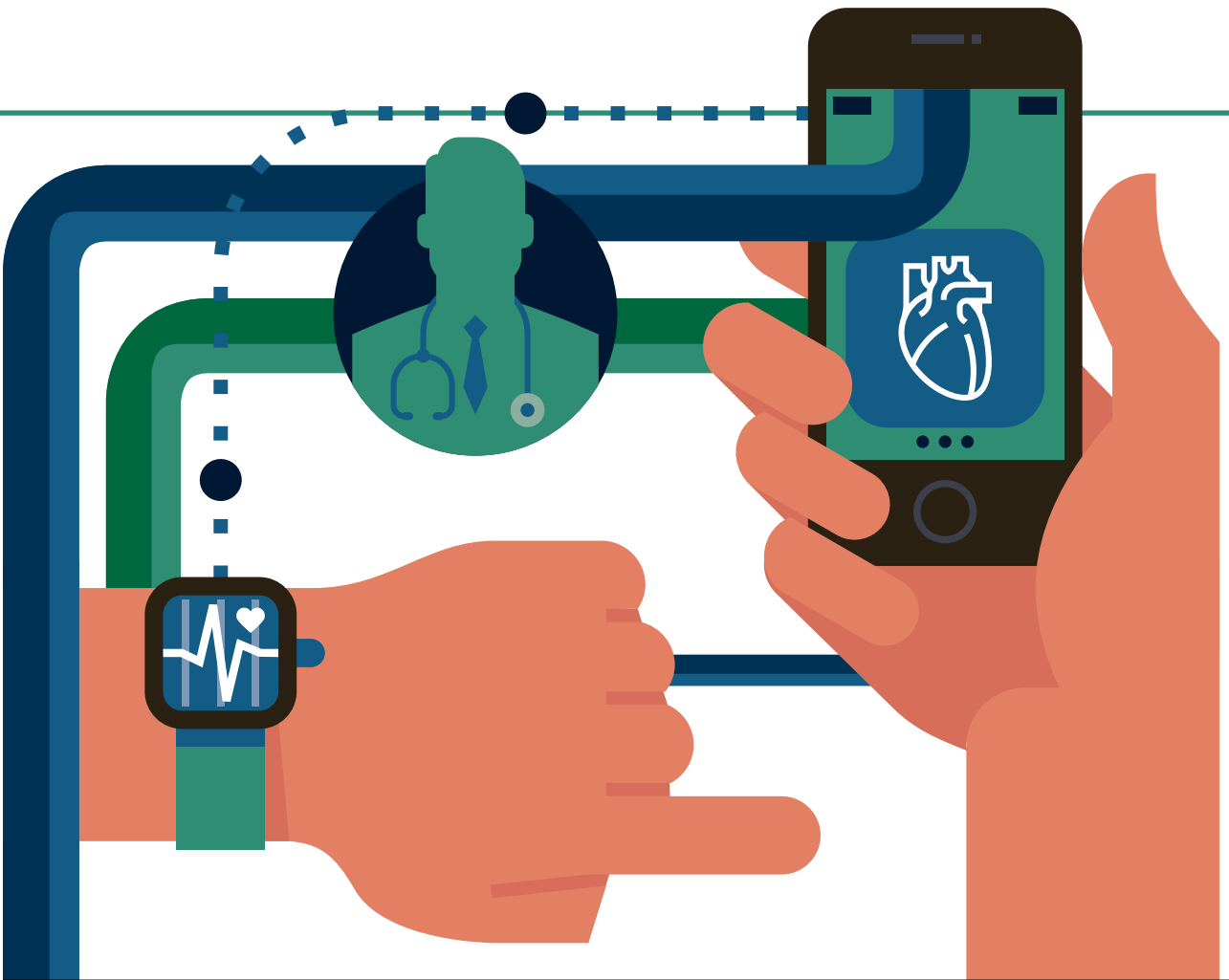
"It is about keeping them out of hospital by keeping them informed. If a patient is involved in their care, evidence shows they have a better chance of a more successful and quicker outcome, and their demand on services is reduced," he says.

Mr Norman, now UK public sector chief information officer for global technology leadership specialists EMC, adds: "We need different models of care with patients being treated at home, and greater use of technology around big data and predictive analytics to find the best care for patients.

"The NHS can change and change quite quickly, but it is all about investing in the right skills. If you don't invest in promoting the skills to analyse the data you might as well put it in a black hole – it is a waste of money."

The use of tele-health systems – e-mail and video links to diagnose and guide patients – is growing, but the pace of change needs to accelerate so the one million patients seen by NHS every 36 hours have easy access to monitors and devices to have a dynamic impact on mortality as well as the systemic choke-points.

"In five years' time, hypertension will not be the silent killer it is now because we will know everyone who is hypertensive – we are at the $50 price per person for the device to monitor this, so it will have a major impact," says Thibault Sevestre, a digital innovation lead for Philips, which is developing devices and systems for heart conditions, diabetes and chronic obstructive pulmonary disease.

"With the IoT and the right technology, we are going to be able to offer diagnosis, risk-profiling and the right support to take action for the masses very quickly. It means you intervene with 10 per cent of patients who need attention rather than those coming in for their scheduled visits yet are actually doing pretty well."

Pilot Philips projects have returned a 30 per cent reduction in both re-admissions to hospitals and to operating costs. Extrapolate that across the NHS landscape and the savings could hit £40 billion.

IoT devices are also predicted to punch a huge hole in the annual £300-million bill for unused medicine by prompting patients to adhere to regimes.

Dr Shahid Ali, a Bradford GP and Professor of Digital Health at the University of Salford, has already proved the benefit of connectivity at his NHS practice where 98 per cent of patients on a tech-supported programme reduced their blood pressure within three months.

"When you empower individuals rather than dictating to them, you begin to see that real change. We need to personalise services and be more proactive and introduce immediacy and they will respond," he says.

"Getting the best from it requires cultural change. We are not at the tipping point yet, but it has to come relatively soon, within the next five years."

Michael Thomas, a healthcare analyst at A. T. Kearney, adds: "There is a real opportunity for a healthcare revolution – it is the chance to engage with patients to tailor treatments and make them more responsible for their health.

"Healthcare is so much cheaper if delivered digitally and it is the best shot we have."

Security of data is still a big concern along with the connectivity of NHS hospitals – one survey suggested only 23 per cent had access to wi-fi.

At the sharp end, Tunstall Healthcare is delivering pioneering technology-based services to more than three million people around the world, employing smart hubs and sensors to help people live independent lives.

A project in Barcelona deploys a smart hub in homes to act as an emergency alarm to detect activity levels and as a medication reminder, wirelessly relaying the data. It has generated a 20 per cent drop in call-outs and residents enjoy an average one year extra at home.

Steve Sadler, the Yorkshire-based company's chief technical officer, believes IoT efficacy will be governed by the quality of the data collected as well as the sophistication of new devices and monitors.

"When it is there, the IoT helps us enrich that data so we can build better services," he says. "The big challenge is for the technology not to work in isolation. It needs context and linking, but get it right and we can replace the fragmented silos of healthcare and the future is very exciting."

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HEALTHCARE INNOVATIONS

BEE INSULIN TRACKER
The world's first smart diabetes and glucose monitoring device that can transmit dosage data via Bluetooth to a smartphone or tablet powered by iOS or Android.
Every dose is recorded, sent from the injection device, and shared with clinicians and family. Made by the Swiss IoT healthcare company Vigilant, it won a prestigious 2015 innovation award.

INGESTIBLE SENSOR
The tiny sensor can be integrated into an inert pill and swallowed to communicate if a patient is sticking to their medication regime and the effect it has on the body. Made by Proteus Digital Health, it emits signals after contact with stomach fluid and relays crucial information to smartphones.

STAR TREK'S TRICORDERS
A $10-million prize from Qualcomm has encouraged the development of non-invasive devices that can test for 15 conditions, including diabetes, stroke and lung diseases, using a range of sensors, portable tests and imaging diagnostics. Ten finalists have spent more than three years crafting a range of handheld devices to make *Star Trek* science fiction a reality. The winner will be announced next year.

CAMERA PILLS
Israeli company Given Imaging has invented a camera in a capsule the size of a large vitamin pill that can be swallowed and transmit images as it travels naturally through the digestive tract. The single-use PillCam houses a tiny battery, radio-frequency transmitter, two image sensors and circuit boards that capture images at up to 36 frames per second.

ELECTRONIC TATTOOS
Ultra-thin technology containing semi-conductors in a patch that sticks to the skin like a tattoo. They monitor expectant mothers through pregnancy, picking up foetal and maternal heart rates as well as other subtle condition changes. The device, from the University of Illinois, is hailed as a vital early warning for premature births.

COMMERCIAL FEATURE

RISE OF THE MACHINES

*Machine-to-machine communication is driving the internet of things and many successful businesses, says **Kristina Hagström, managing director of FältCom Ltd***

FÄLTCOM

With more than 55 per cent of British adults now owning a smartphone, mobile internet has transformed the way we communicate, shop and consume information. But always-on connectivity isn't just for humans. Machines are getting in on the act – and the opportunities for business have never been bigger.

Machine-to-machine (M2M) communication is the driving force behind the so-called internet of things, which allows devices from connected cars to bus stops to send and receive information in real time, without the need for human intervention.

For a business that could mean information about a connected vehicle's location or passenger numbers, tracking the progress of a consignment or on-the-spot reports on maintenance issues. The advantages of M2M extend to businesses in a host of markets, from servicing appliances to smart metering, connected buses to smart electricity grids.

By providing real-time feedback from devices on the ground, M2M can minimise time spent in the field by employees, reducing the environmental impact of a company's activities and limiting the time vehicles,

vending machines or other equipment spend out of action. Crucially, M2M provides companies with valuable information about when and where their products and services are needed most.

It's a trend that's set to explode. With billions of devices connected in a global market worth a predicted $96 billion by 2020, M2M promises to reshape entire industries, and create new and previously unanticipated areas of business.

But the benefits of M2M are more than theoretical. Businesses across the globe are successfully employing the technology right now. Scandinavia has been at the forefront of the M2M revolution, with the market in connected devices there growing at 30per cent year on year – twice the global average. By 2017, an estimated 21 million connected devices will be in use in homes and offices across the Nordic countries, according to recent figures released by analyst Arthur D. Little. This includes as many as 45 per cent of all vehicles, delivering improved safety, boosting reliability and reducing the environmental impact of road transport.

FältCom has been one of the leaders in the Nordic drive toward M2M. Established in 1998, the company was one of the earliest entrants to the M2M market, implementing its first cloud-based solution in Sweden as far back as 2004. Its M2M solutions work across a range of software platforms, and more than 160,000 of FältCom's units are now in service worldwide, delivering data to businesses over 2G, 3G and 4G mobile networks. Applications range from New York City's connected bus stops to a platform for connected vehicles using integrated apps that can be managed and monitored via the cloud.

SMARTER TRANSPORT
Connected transport has been a key component of Scandinavia's M2M boom. Nobina, a large Nordic bus operator, has installed barcode readers in its fleet of buses in Umeå, Sweden. The switch to electronic ticket validation offers major benefits, reducing driver workload and speeding up the boarding process. One less obvious, though equally important, benefit of this ticketing approach, combined with service improvements such as on-board wi-fi, is an

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enhanced customer perception of a modern and efficient transport system.

It's a lead that British operators have been quick to follow. FältCom's UK customers include a UK bus operator on Merseyside, which has been trying out M2M on some of its buses, and Nottingham City Council, which uses the technology to provide up-to-the-minute arrival times at bus stops.

By bringing a range of business-critical data together on a single, scalable, internet-connected platform, transport companies can enjoy closer integration of services across their business. Replacing on-board radios with internet protocol or IP-based systems

enables bus operators to monitor and record communications, as well as adding the ability to leave messages when drivers are busy.

IP-based CCTV on board buses provides footage of incidents as they occur. Combined with readings from a vehicle's tachometer, maintenance diagnostics and GPS location data, this information enables companies to provide valuable evidence to insurers in the result of a claim. And unlike conventional CCTV, video from internet-connected systems can be collected immediately, without the need to physically retrieve recordings from the vehicle. Connected CCTV is also a key enabler for other transport operators, including Transport for London, and emergency services such as ambulances.

Problems with equipment can be identified immediately, avoiding the possibility that faulty cameras will be detected only after footage is required when an accident or passenger incident has occurred. Diagnostics data is transmitted all the time the bus is in service, reducing the cost of engineer call-outs by as much as 98 per cent.

M2M offers substantial benefits for customers too, with additional perks such

as on-board wi-fi that enhance their travel experience. By encouraging users to sign up for free internet access, operators can gain additional information about their users' travel habits, enabling them to deliver targeted offers and tailor services to meet demand.

With access to real-time data on passenger numbers, operators are better placed to allocate transport capacity and ticketing. Journeys can be smoother too, with on-board GPS allowing each vehicle's location to be tracked so that buses can be diverted to avoid delays.

Testament to the power of M2M is the fact that one of Sweden's major transport operators is now set to do away with that cornerstone of conventional transport infrastructure, the humble bus timetable. With accurate GPS tracking of bus routes, old-fashioned schedules could soon be replaced by real-time travel information delivered direct to customers' mobile phones.

Want to know when the next service is due? Soon you can ask the bus itself.

www.faltcom.com

Case study

CONNECTED SOLUTION KEEPS BUS NETWORK TALKING

Regional transport authority Skånetrafiken in FältCom's home country of Sweden has seen big benefits from the company's machine-to-machine (M2M) technology. The organisation, which contracts out transport services in the Skåne region to a number of operators, required a solution that would improve communication across its network.

The solution used to connect up the region's buses and trains offers voice-over-IP communication with drivers and on-board wi-fi to enhance customers' journeys. Location tracking enables Skånetrafiken to pinpoint each vehicle's location at all times, enabling conventional timetables to be replaced by real-time apps.

Skånetrafiken's Björn Wallin is enthusiastic about the organisation's partnership with FältCom.

"We're very satisfied with the communication platform delivered from FältCom. It has opened up flexibility and opportunities to integrate and manage applications from any company we choose in the same device management tool," he says.

Smart things in the city

Future smart cities are unlikely to look that much different, but they are destined to interact differently with their human inhabitants

◆ **SMART CITIES**
● **JIM McCLELLAND**

Urbanisation is a monster. According to United Nations data, the proportion of the 2014 world population living in urban areas was 54 per cent, heading for 66 per cent by 2050.

Urbanisation is also greedy and dirty. Inhabitants consume 75 per cent of the planet's natural resources and contribute to urban activities responsible for 75 per cent of all greenhouse gas emissions.

The numbers are sobering. It is easy to see why technological innovations that promise resource efficiency and mobility would be attractive to city planners, architects and engineers.

Given the scale of the problem, it is no surprise then that the size of the prize for solutions is equally large. Forecasts from Frost & Sullivan suggest the global smart city market will be valued at $1.565 trillion in 2020. Some 1.1 billion connected things are now in use in smart cities, according to Gartner research, rising to an estimated 9.7 billion by 2020.

Public and private money is also already on trend. In the European Union, the Smart Cities and Communities European Innovation Partnership has been backed by €365 million of European Commission funding. In the UK, the 2015 Budget saw chancellor George Osborne allocate £40 million for the internet of things (IoT) in healthcare, social care and smart cities.

Such sums, however, look pretty modest viewed alongside the investment plans of Cisco, for example, which originally set aside $100 million just for "internet of everything" (IoE) startup companies and has followed this up with a further $150 million as part of a $2-billion portfolio in disruptive technology markets.

Cisco has identified six particular cities spearheading the technological leap forward – Barcelona, Bengaluru, Chicago, Hamburg, Nice, San Jose and Songdo, South Korea. It has collaborated to develop Asia's first end-to-end innovation hub in Bengaluru, India. Its E-City Living Lab is home to a cluster of more than 185 companies and emblematic of the company's investment focus in the country. With India's prime minister Narendra Modi's plan to roll out 100 smart cities, Machina Research forecasts India will account for $10-12 billion of the global IoT market by 2020.

All this talk of potential and market speculation sounds exciting, but what is actually happening on the ground?

> ❝
> **The internet of things in smart cities is more a matter of the unseen, unheard creep of covert data collection and real-time response, sneaking up on society**

There are new-build one-offs of note, such as Abu Dhabi's Masdar or Fujisawa, the Panasonic-led smart town in Japan. Otherwise, in established cities, perhaps not as much radical innovation is in evidence as you might expect, argues Andrew Comer, cities director at Buro Happold Engineering.

"There are many cities thinking about opportunities for technology to improve operations and services, but not many really want to be used as a laboratory with the risk of failure. Physical examples are currently limited to incremental advances in areas such as smart grids and networks," he says. With the possible exception of cities such as Singapore, Hong Kong and Copenhagen, Mr Comer sees a cautious and conservative mindset at work.

For Charbel Aoun, senior vice president for smart cities at Schneider Electric, however, the catalytic power of the IoT for smart cities actually lies in the multiplier effect of its somewhat utilitarian functionality. "IoT simplifies smart cities. Cities already understand the process of sensing and actuating to collect and act on data. IoT has been happening for years with traffic light systems, automatic number plate recognition and the like, it's just increasing scale and reach," he says.

Mr Aoun can reel off a range of apparently unremarkable applications for the IoT: streetlights that can sense and adjust to
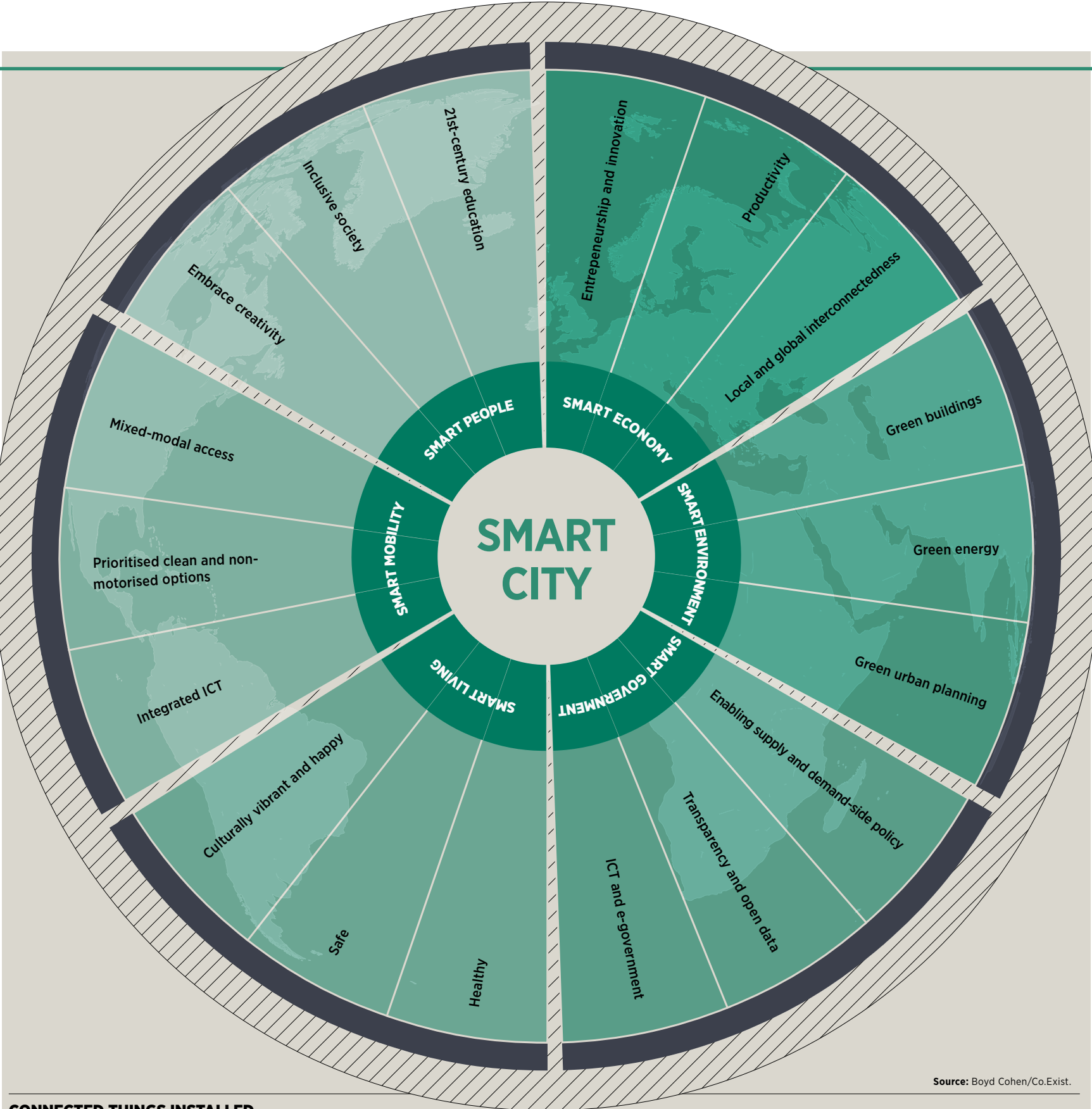
the environment and conditions, whether people or traffic are passing, or notifying if a bulb fails; monitors for water leaks, with the facility to shut off pipes automatically; or simply sensors to detect full rubbish bins.

In reality, resource management issues in energy, water and waste are being tackled in a myriad of small ways, one sensor at a time, with a trillion sensors forecast worldwide for 2030 – more than 100 for every human on Earth.

The effect is both cumulative and potentially transformative, says Mr Comer. "As technology becomes embedded within more and more everyday objects, and parts of objects, so the dynamics of city systems and city lifestyles will change from one of a layered and linear set of data collection, analysis and reaction, to real-time interchange of sensing and response across a very broad spectrum of city operations and activities," he says.

Joined-up sensing calls form a bedrock of commonality, says Bilel Jamoussi, study groups department chief at the Telecommunication Standardization Bureau, International Telecommunication Union (ITU). "The internet of things involves the interlinking of networks, devices and data that have thus far never been linked," says Dr Jamoussi. "It is the collective power of these utterly disparate elements that lies at the heart of the power of IoT and the smart city. International standardisation through public-private co-operation is therefore indispensable to ensure things, devices and processes speak the same language."

In response, ITU members have established a new study group to address standardisation requirements, with an initial focus on the IoT in smart cities. Singapore offered to host the inaugural meeting and, in May, Dubai became the world's first city to assess efficiency and sustainability of operations.

In the UK, backed by the government's Innovate UK programme, the HyperCat-City initiative also looks to use an open and interoperable standard to do away with conflicting systems. The London DataStore official free-access site for the Greater London Authority has "HyperCat-enabled" its data, making it possible for anyone to build applications from it. Pilot programmes are also in place for Milton Keynes and Bristol.
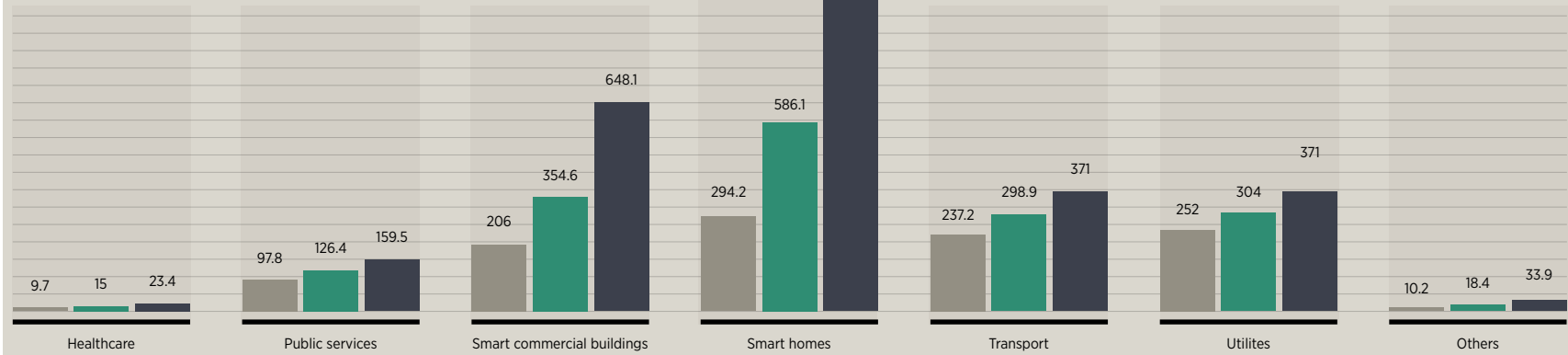
Working towards what the ITU dubs "systems of systems", it might be easy though to lose sight of cities as places for people. Some of the indirect effects of the IoT in cities will revolve around collaborative behaviours among humans, not just things, says Léan Doody, smart cities lead at Arup Digital. She says: "IoT will allow us to connect people, things and places in new ways. This will allow us to build new services combining things and locations to allow for a more responsive city experience – and potentially share resources better than we do now."

We are already seeing ride-sharing, bike hire and electric vehicle rental, for example, being enabled by mobile and digital technology, and having a growing impact on reducing the need for land given over to city-centre parking. IoT-enabled co-ordination with public transport provision and access also serves to ease congestion, reduce pollution and increase mobility. Smart cities are where the sharing economy meets the digital and physical world, simultaneously and sustainably.

In terms of the planning and design of the built environment and physical infrastructure, will IoT-enabled smart cities actually start to look different though? According to Ms Doody, there are some signs of change, but again they are slight and slow. "We are beginning to see examples of how technology is changing use of physical space – for instance, with the implementation of Oyster [travelcard] and contactless payment, we don't need ticket offices."

Such transformations are hardly dramatic, however, leading Mr Comer to predict that future smart cities will actually look very similar in fabric terms, but very different in the way we interact. The truth is, at present, the IoT in smart cities is not all artificial intelligence, robots and driverless cars. It is more a matter of the unseen, unheard creep of covert data collection and real-time response, sneaking up on society, app by app.

SMART CITY

SMART PEOPLE — Embrace creativity / Inclusive society / 21st-century education

SMART ECONOMY — Entrepreneurship and innovation / Productivity / Local and global interconnectedness

SMART ENVIRONMENT — Green buildings / Green energy / Green urban planning

SMART GOVERNMENT — Enabling supply and demand-side policy / Transparency and open data / ICT and e-government

SMART LIVING — Healthy / Safe / Culturally vibrant and happy

SMART MOBILITY — Integrated ICT / Prioritised clean and non-motorised options / Mixed-modal access

Source: Boyd Cohen/Co.Exist.

CONNECTED THINGS INSTALLED IN SMART CITIES (MILLIONS)

Legend: 2015 / 2016 / 2017

Category	2015	2016	2017
Healthcare	9.7	15	23.4
Public services	97.8	126.4	159.5
Smart commercial buildings	206	354.6	648.1
Smart homes	294.2	586.1	1067
Transport	237.2	298.9	371
Utilites	252	304	371
Others	10.2	18.4	33.9

Source: Gartner 2015

SMART CITY MARKETS WORLDWIDE 2012-20

- 14.6% Smart healthcare
- 9.7% Smart building
- 24.6% Smart governance and smart education
- 13.5% Smart security
- 15.8% Smart energy
- 13.1% Smart infrastructure
- 8.7% Smart mobility
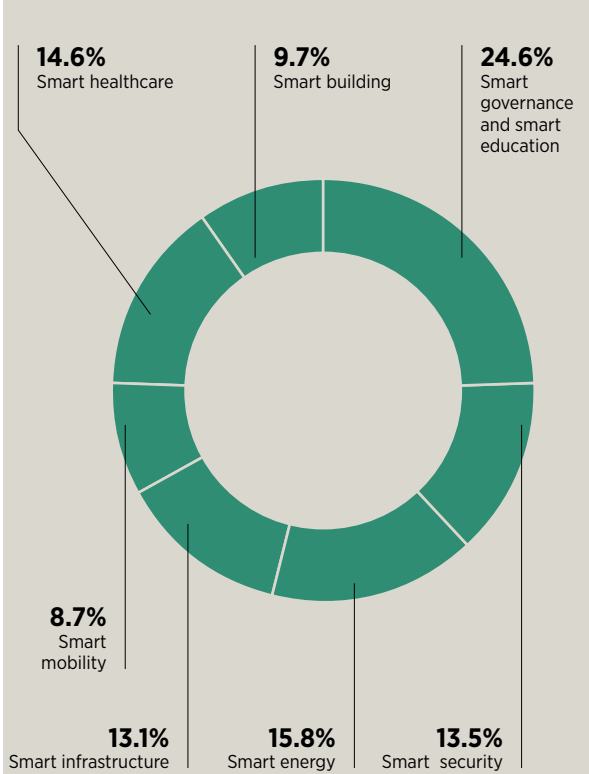
Source: Frost and Sullivan

SMARTEST MEDIUM-SIZED EUROPEAN CITIES

Eskilstuna — Smart people

Luxembourg — Smart economy and total smart city

Umeå — Smart environment

Jyväskylä — Smart governance

Eindhoven — Smart mobility

Salzburg — Smart living
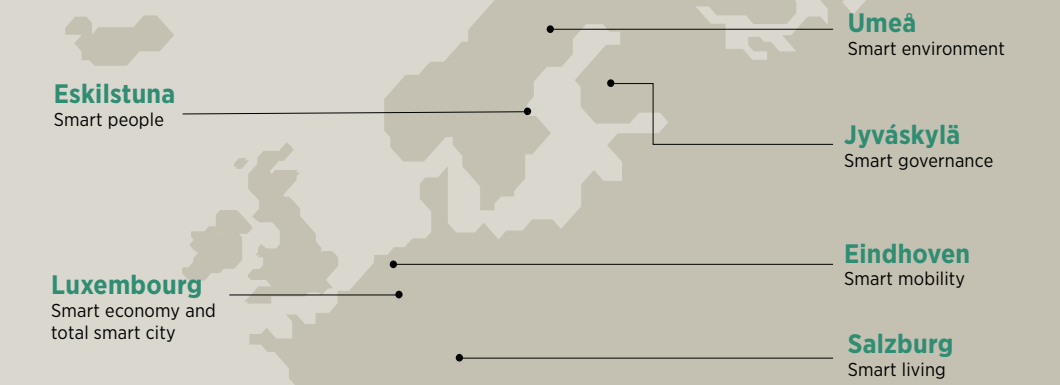
	Smart economy	Smart people	Smart governance	Smart mobility	Smart environment	Smart living	Total smart city
1	Luxembourg Luxembourg	Eskilstuna Sweden	Jyväskylä Finland	Eindhoven Netherlands	Umeå Sweden	Salzburg Austria	Luxembourg Luxembourg
2	Aarhus Denmark	Tampere Finland	Umeå Sweden	Salzburg Austria	Jönköping Sweden	Graz Austria	Aarhus Denmark
3	Cork Ireland	Aarhus Denmark	Jönköping Sweden	Aarhus Denmark	Eskilstuna Sweden	Innsbruk Austria	Umeå Sweden
4	Regensburg Germany	Oulu Finland	Odense Denmark	Luxembourg Luxembourg	Montpelier France	Luxembourg Luxembourg	Eskilstuna Sweden
5	Eindhoven Netherlands	Umeå Sweden	Aalborg Denmark	Leicester UK	Jyväskylä Finland	Brügge Belgium	Aalborg Denmark

Source: Technical University Vienna, European Smart Cities 2014

PALO ALTO: CALIFORNIA DRIVIN'

Home to Hewlett Packard and Tesla Motors, next door to Stanford University and down the road from Apple and Google, the city of Palo Alto is located in the heart of Silicon Valley.

Also newly opened in the California city is the Research & Innovation Center of the Ford Motor Company, leading the vehicle manufacturer's work on driverless cars, connecting autonomous vehicles to smart homes and the Nest thermostat.

Not surprisingly, then, given its proximity to such world-leading technology providers, the city of Palo Alto is also now equipped with one of the first traffic management systems in the United States to address the IoT driving connected vehicle initiative.

The ATMS 2.0 system from Trafficware incorporates SynchroGreen, which will update signal timings in real time based on current traffic demand, and help alleviate congestion and reduce delays. A web-based driver information system allows the public to view real-time traffic conditions, video feeds and obtain current traffic data using a web browser, smartphone or tablet.

The system will integrate with the city's future parking management system and includes real-time occupancy data in downtown Palo Alto.

"As we looked for a partner for traffic management for the next decade, it became important to consider capabilities for connected vehicles," says Jaime Rodriguez, Palo Alto's chief transportation official at the time the initiative was announced.

"The city is expanding functionality of the traffic management system to meet the data-sharing demands that we anticipate within our market. Trafficware has demonstrated the ability to provide data to smart vehicles through previous projects with European automobile companies. It is the city's intent to build on these partnerships and data-sharing capabilities to make automobiles more fuel efficient and empower motorists in Palo Alto with more information."

Connected services typically include safety information with severe weather warnings and alerts about road conditions, plus entertainment features, such as music-streaming and social media networking.

According to Business Insider Intelligence, by 2020 some 75 per cent of all cars worldwide will be equipped with internet access and associated software, with global revenues from connected services expected to top $152 billion.

Research by KPMG has forecast full highway pilot features by 2017, with vehicle autonomy from 2025. It estimates connected and autonomous vehicles could provide a £51-billion boost to the UK economy and reduce serious road traffic accidents by more than 25,000 a year by 2030.

HELPING TO BRING THINGS TOGETHER

The internet has revolutionised the world around us, in our homes and professional lives – yet this may be nothing compared to the next technological revolution, the so-called internet of things

JABIL

The internet of things or IoT will allow devices to communicate and send data to each other, wirelessly and immediately. Technology giant Cisco predicts some 50 billion devices will be connected to the internet by 2020, having ten times the impact on society the internet has had to date.

"The fact that the technology has become so cost effective is driving the adoption of it in more mainstream applications. It's now both feasible and relatively affordable for cameras and sensors, among other devices, to be attached to someone or something and to transmit data and valuable information that can be used for mutual benefits," says Joanne Moretti, senior vice president, marketing and sales enablement at Jabil.

The potential for the IoT has been loosely divided into industrial and human, with the former incorporating new applications into existing infrastructure in areas such as mechanical, electrical and digital systems, and the latter focusing on new devices interacting with individuals.

Both require the development of infrastructure along the way. "In the short term, the people side of things has been faster to adopt the IoT," says Scott Gebicke, leader of emerging markets at Jabil. "But by far the largest impact will be in industrial, in sectors such as manufacturing, healthcare and utilities, around issues such as energy and water management, transportation and logistics. That's what will drive the economic value."

Ms Moretti adds: "The race is on to innovate, differentiate and connect. For example, with an ageing population, we see remote health monitoring as a trend. By 2020, the number of connected devices will be up threefold."

Before this happens, though, there are a number of challenges which must be overcome. Skills is a particular issue. Research conducted by Jabil earlier this year, which involved surveying more than 300 supply chain professionals from around the globe at electronic goods manufacturers, found that while 75 per cent are planning to develop or produce IoT-related devices, 77 per cent admitted they lacked the necessary in-house expertise in order to do so.

Another issue is the lack of an ecosystem which can bring together the various constituent parts of the process, such as sensors, communication technology, gateway analytics, security and the user interface. This is a significant point as we think about the dimensions of an ecosystem as layers of complexity in a connectivity sphere.

We have sensors and devices that communicate within the confines of their own purposes, such as radio-frequency identification or Bluetooth signals, for essentially finite purposes, such as inventory or headphones and speakers, as well as interactions for health and fitness to your smartphone that utilises an extended layer of the ecosystem into the internet, and so on.

"The biggest barrier is the integration of these devices into a wider system that is completely seamless to the end-user," says Mr Gebicke. "Right now things are so disparate that it's really difficult for people to adopt a single standard and that's what the Industrial Internet Consortium is driving towards. But until that is solved, either through consensus or the emergence of a clear winner, it will be very difficult to capture the potential value in this market."

Jabil is helping to create such an ecosystem and remove the complexities through its role as a design and manufacturing partner for virtually every industry which could benefit from the IoT, bringing together the various disparate players. "There are a lot of companies offering things in siloes," says Ms Moretti. "There's no one company you can go to and that's an issue for municipalities, retailers, hospitality companies – a lot of companies that historically haven't got electronic hardware. Having someone to weave this together and offer a full service solution with a number of partners already in place can add a tremendous amount of value."

So Jabil manufactures everything from the sensors that gather and communicate data, to the end-products which use the sensors and the data they generate, including smartphones, wearables, clothing and medical devices. It also designs and builds the infrastructure that supports the IoT, such as smart grids, servers, cloud infrastructure and communication systems.
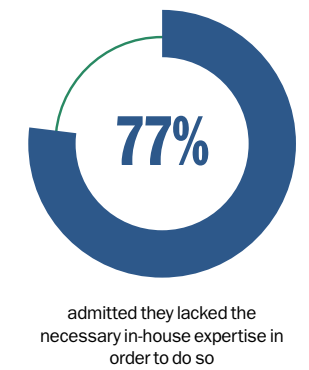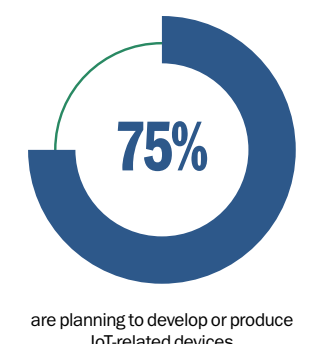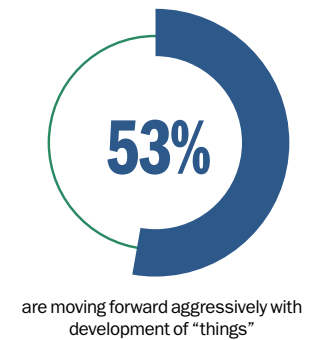
"We're the biggest company that nobody has ever heard of," says Ms Moretti. "We work with industry leaders in 16 distinct sectors in concept, design, engineering, manufacturing and advanced services around the world." The business has strong links with Cisco, she adds, and works closely with Intel, AT&T, GE and IBM as part of the Industrial Internet Consortium, giving it a unique place in the market.

Jabil has recently opened its Blue Sky Center for Innovation in Silicon Valley, where it displays the latest manufacturing and design technologies in the IoT, and its ability to connect sensors, devices, data and people together to enable IoT on a global scale, across industries including consumer wearables, packing and healthcare applications. This has received the backing of the UPnP Forum-certified cloud platform ConnectingYourThings, which will enable Jabil's customers to design and verify new devices on a live cloud platform before production.

Already it is positioning itself to get new products out to market quickly. Earlier this year, it entered into an innovative partnership with the MIT Media Lab and Mass Challenge in Boston, which will give startups unprecedented access to the advanced electronics and prototyping capabilities, as well as the training they need to bring new products to life.

It also recently acquired San Jose-based Wolfe Engineering, a well-respected design and engineering firm which specialises in new product introductions for companies in the semiconductor capital equipment market, to help expand its ability to take advantage of new innovations and roll them out as quickly as possible.

"Companies need to identify the specific end-to-end solutions they want to play in. Once they've done that, it's a case of working out where they want to play in that ecosystem and who their partners will be because no one company is going to be able to provide the entire solution," says Mr Gebicke. "The adoption of connected devices in the industrial sector, given the cost-point and emergence of new technology, will enter into a geometric curve in the next couple of years."

How to ride that curve and capture value is now the real challenge.

> **The biggest barrier is the integration of devices into a wider system that is completely seamless to the end-user**

To find out more about how Jabil could help your business take advantage of the internet of things, visit www.jabil.com and follow us on Twitter @jabil www.blueskycenter.com

2015 DISCOVERY RESEARCH SURVEY TARGETING 300+ RESPONDENTS

53% are moving forward aggressively with development of "things"

75% are planning to develop or produce IoT-related devices

77% admitted they lacked the necessary in-house expertise in order to do so

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Saving resources and the planet

Connected devices not only save consumers money, they can generate customer loyalty and help in the move to a low-carbon economy

◆ **ENERGY AND UTILITIES**
● **TOM IDLE**

Modern-day utility companies face a host of challenges. The industrialised electricity markets in Europe and North America are currently supported by ageing infrastructure tha t requires significant investment to combat potential energy losses across grids. Theft of power remains a big issue. According to Accenture, around $6-billion-worth of electricity is stolen in the United States each year.

The continued opening up of energy markets, particularly across Europe, is increasing the churn of customers which, in turn, is putting pressure on utility companies' ability to find operational efficiencies or to innovate.

These challenges are compounded by tough decarbonisation targets. At least 67 countries around the world now have renewable energy policy targets – a government-imposed legislative requirement on electricity retailers to source specific proportions of total energy sales from clean energy sources within a fixed time-frame. The European Union has set a goal to generate 20 per cent of energy from renewables by 2020, for example.

As a result, more and more distributed and intermittent green energy is being plugged into national grids. By 2025, more than 10 per cent of electricity will be micro-generated by consumers, according to Verizon. That's good news for target-setters. But it adds layers of complexity for utilities getting to grips with supply and demand in a fast-changing sector.

The development of a smarter grid, which uses information and communications technology to gather data, such as energy consumption information, and to act on it in an automated way to improve efficiency and reliability of supply, has long been cited as a panacea for the future success of utility supply and distribution.

Aided by policy intervention, the roll-out of smart-grid technology is happening across Europe and North America. According to Navigate Research, 94 million smart meters were shipped worldwide last year and the total number installed is set to reach 1.1 billion by 2022. In the UK, GB Smart Grid estimates £19 billion of savings might be achieved in the energy sector by upgrading the network to a smart grid.

Today, smart meters are being used to gather data largely for billing purposes. However, this data contains a wealth of information that can help utilities and their consumers in many ways. And it is the advent of the internet of things (IoT) that could really spark life into smart-grid potential.

By connecting physical devices over the internet, technologies such as smart meters and sensors can "talk" to each other – and communicate both with utilities and their consumers.

In the homes of the future, light switches, televisions, power sockets and air conditioning units will be linked up to the internet. Sensor and actuation systems will be integrated into the same systems, connected to the same internet, making it easier for utilities to balance power generation with energy usage by turning things on and off based on occupants' behaviour.

According to Nest, makers of "learning" thermostats, domestic energy consumers in the UK are currently wasting up to 20 per cent on their heating and cooling bills due to inefficient scheduling. British Gas estimates that 7.8 million empty homes are being heated every year. Better connected systems can help to alleviate this problem by putting greater power into the hands of residents, who will be able to control their heating appliances or washing machines remotely via cloud-based internet programmes, or by creating their own schedules to determine when certain devices are turned on and off. Some devices even have the ability to "learn" consumer behaviour and build personalised schedules.

Many of these devices, such as the British Gas Hive, RWE SmartHome and Google Nest, have already been launched. And the market potential for utilities is clearly huge. According to IDC's *Worldwide Internet of Things Spending* forecast, the global revenue opportunity presented by the IoT for the utilities industry is around $201 billion by 2018. In the UK alone, the 26.4 million households represent a £1-billion market, assuming that 20 per cent of households opt to buy a British Gas Hive device at around £200.

By investing in technologies that give consumers more control over how they save money, utilities are improving customer relationships and protecting brand loyalty, something that is becoming more valuable in liberalised utility markets. Around 30 per cent of the 50,000 British Gas Hive customers are using 10 per cent less energy or heating thanks to the technology. What more incentive do they need to stick with their supplier rather than switch in search of money-savings? The growth in small-scale home energy generation and the use of electric vehicles is likely to further fuel the market by the end of the decade.

Dealing with larger-scale commercial energy use is also being tackled by smarter connectivity. Companies such as Kiwi Power and Open Energi are helping business customers realise the benefits of having access to more data. When the UK's National Grid requires extra capacity, its internet-connected systems "talk" to these two energy aggregators to find out which of their clients has some spare energy that can be used, rather than powering up another power plant and giving utilities another supply-and-demand headache.

Similarly, the cloud-based platform Tradenergy controls entire business sites, determining how and when certain industrial refrigerators, air conditioning units or heating systems are using energy, and taking full advantage of market price fluctuations.

However, it is not just about helping consumers save energy and money. Utilities also have an opportunity to solve some of their large-scale operational, maintenance and distribution challenges. For example, sensor data and advanced analytics can be used to predict when critical components might fail, helping to avoid costly breakdowns, and interrupted energy and water supply. In addition, heightened monitoring and control will make it easier to detect, and act upon, energy loss or theft.

Of course, challenges will remain. Connected technology that carries consumer data possesses a certain amount of risk and, should security be breached, any brand loyalty a supplier has garnered will be firmly eradicated. Companies will also need to create a positive user experience if they are to gain ground and not undermine consumer confidence.

The good news for utilities is that the cost of interconnecting devices is falling. By 2020, some 30 billion smart, wirelessly connected devices will be in operation in homes and the utilities industry worldwide, accounting for 67 per cent of all machine-to-machine connections worldwide by 2023, according to Analysis Mason. In turn, it will create a wealth of opportunities for the sector to reduce risk within the supply chain, improve operational efficiencies and develop a truly smart grid fit for the future.

And by getting closer to their customers, the industry has a chance to increase revenues by helping consumers save on their utility bills. Who would have thought that?

> **By connecting physical devices over the internet, technologies such as smart meters and sensors can 'talk' to each other – and communicate both with utilities and their consumers**

Hive Home heating and hot water control

Nest Labs thermostat

RWE home automation

30bn
smart, wirelessly connected devices will be in operation in homes and the utilities industry worldwide by 2020
Source: Analysis Mason

$201bn
global revenue opportunity presented by the IoT for the utilities industry by 2018
Source: IDC

94m
smart meters were shipped worldwide last year and the total number installed is set to reach 1.1bn by 2022
Source: Navigate Research

Beware household gadgets that can take control and 'spy' on you

Makers of connected devices for the internet of things must focus on security to protect consumers' privacy

◆ **SECURITY**

● **CHARLES ORTON-JONES**

The Samsung TV incident was a massive wake-up call. An investigation in February revealed some Samsung smart TVs could be "spying on customers". A clause in the privacy policy advised buyers that spoken words could be "captured and transmitted to a third party". The media exploded with indignation. Orwell's *1984* was cited in which telescreens track to citizens' every move and word. Will your TV report you if you mention your tax affairs? Or sell leads to marketing companies if you mention product names?

When the story broke, Samsung admitted it was logging users' activity and voice commands, but claimed users agreed to in the terms and conditions, and had enabled the function when setting up their TV. The option could be turned off.

In truth, Samsung was engaging in what many companies do, which is to learn from voice commands in order to improve the service. Use Siri on an iPhone and something similar is taking place. But the episode publicised just how dangerous it could be to install internet-connected devices.

Even in the industry right now you'll find a unanimous verdict: internet of things (IoT) security is a red-hot issue.

Security testing firm Pen Test Partners loves exposing flaws in IoT devices. It's hacked a wi-fi kettle, bathroom scales and got a children's doll called My Friend Cayla to "to swear like a docker, a very sweary docker at that". The security flaws ranged from mild to serious. The IoT kettle could be hacked to keep it continuously warm to consumer electricity. That's a two out of ten nuisance. The bathroom scales could be used to seize control of an entire wi-fi network. That's far more serious.

A recent study by HP found "70 per cent of the most commonly used internet of things devices contain serious vulnerabil-

ities". On average there were 25 vulnerabilities per device.

These flaws mean hackers can use IoT devices to spy on you with a webcam, to take control of your network, make your lights flash on and off, steal account data, and listen to your conversations. And what other devices with IoT capability? It is speculated that car engines could be shut off in the middle of the M1. Airbags deployed. As for medical devices and airlines... how gruesome is your imagination.

Should we be panicking? There are two schools – optimists and pessimists. Both admit the security situation right now is poor. But the former believe patching things up will deal with the threats, just as online banking keeps the hackers at bay despite the odd glitch.

In order to assess the situation, it is worth reflecting on who might pose a threat. Hackers, obviously. Malevolent folk may want to steal your money, spy on you or simply make mischief. Ordinary hackers already spy on people at home by taking control of webcams, known as "ratting", after the remote administration tool which gives them access. A BBC investigation cited a 20-year-old student who realised she was being observed while watching a DVD in the bath.

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> Try and turn off your lights using an IoT mobile app and you might find you plunge a family in another country into darkness

Legally permissible intrusions are more subtle. The device-makers may wish to learn more about you. Google, Apple and Facebook already do all they can to observe consumer behaviour to improve their products. Unscrupulous device makers may use terms and conditions to be even nosier.

Governments may demand covert control of your devices. Rogue agent Edward Snowden revealed the US National Security Agency (NSA) was using backdoors provided by umpteen technology giants to spy on e-mails, pictures and the location of unsuspecting people.

Some of the NSA cases were pretty creepy. Agents engaged in LOVEINT – spying on persons of love interest. Spouses, partners

or just member of the public they found attractive could be monitored. One agent admitted spying on six e-mail addresses belonging to his ex-girlfriend. Not great to know the government may also be doing it.

We can add to our list of potential malefactors – rival device manufacturers who wish to sabotage or learn from other devices, viruses that don't care what they get access to, corporate raiders looking for business information, as well as accidental intrusions. Try and turn off your lights using an IoT mobile app and you might find you plunge a family in another country into darkness.

The onus is on IoT makers to up their game. Scott Cairns, chief technical officer at T-Systems, says the appetite to be first to market is undermining security. "An inherent problem is that the engineers inventing and adding nodes to the IoT on a daily basis are not security experts and more often are not implementing comprehensive security measures.

The pace of expansion of the IoT is far outstripping the required security being employed," he says. This needs to change.

Consumers need to do their bit. If consumers blindly agree to all terms and conditions they are poorly placed to complain about

legal intrusion. The trouble is the "small print" can be impossible to read. This needs remedying says AVG anti-virus senior security evangelist Tony Anscombe.

"The industry needs to make everything clearer. They have a responsibility to make sure consumers know what they are agreeing to and right now the documentation isn't helping. Perhaps a simple, graphical format would be best," he says. The website TLDRLegal.com is attempting to provide an easy-to-read summary of end-user licence agreements. It is a work in progress.

Keeping software up to date is vital. Sadly, many consumers can't even keep

their main PC protected. A survey by security firm Secunia shows 11.5 per cent of private PCs in the UK are unprotected. Almost half are using Java Oracle 7 rather than 8, with three-quarters not updating in a year despite more than 100 known vulnerabilities.

Can we really expect the same consumers to update the firmware on their IoT kettle?

One solution is to add barriers to the IoT system. The new Bitdefender Box claims to be a one-stop-shop for IoT security. It installs software updates, identifies vulnerabilities and blocks unauthorised traffic.

Bitdefender's chief security strategist Catalin Cosoi is under no illusions of how big the security challenge is for IoT. Even "harmless" devices, such as thermostats, pose a risk. "In the much anticipated smart city of the future, smart metering will improve energy consciousness and efficiency, but it's not difficult to imagine a scenario where energy meter data could be used track our location," he says.

Should we be pessimists about IoT? Hongwen Zhang, co-chairman of OpenCloud Connect, the industry alliance of cloud and IoT makers, says even if doubters are right, consumers will still enjoy using IoT devices. "Your above items of threat are all valid. However, the benefits of IoT overweigh all these fears. We have passed the point of no return in our evolution path with IoT," he says.

He warns the real danger isn't nosy governments or teenage hackers. But something more sinister – artificial intelligence.

Dr Zhang admits this: "On the speculation spectrum, the irony is that we will soon able to build terminators before we figure out how to do time travel. The evil actors may not be humans but 'superintelligence' as described by Professor Nick Bostrom of Oxford University in his book *Superintelligence: Paths, Dangers, Strategies.* Let's hope humanity avoids those bad paths that lead to extinction."

He adds sensibly: "We are good at finding cures." If he's wrong, dodgy kettles and sweary dolls would be the least of our worries.

COMMERCIAL FEATURE

LAUNCH PLATFORM FOR BATTLESHIPS AND IOT STARTUPS

From the powerful United States military and top corporations to small startups, **Red Hat Enterprise Linux** *has it covered*

Jim Totton
Vice president & general manager

redhat.

The USS Zumwalt is the most technically advanced warship in the US Navy. Launched two-years ago, it is a guided-missile destroyer armed with Tomahawk and anti-submarine rockets. It looks jaw-dropping. The hull slopes inward to deflect enemy radar signals, so it shows up no bigger than a fishing vessel. An exhaust suppressor makes sure there's no tell-tale white foam trail dragging behind.

The inside is equally astonishing. There are touch-screens offering a new level of computer automation. The guns can be moved and fired from within the central ops room, which looks more like a financial trading centre than anything found on the ocean.

Military analysts call the USS Zumwalt the next-generation of vessel for head-to-head enemy combat. In press briefings, the US Navy revealed something else about the warship – that it runs Red Hat Enterprise Linux.

The use of Linux in the most demanding security scenario is proof of how trusted the operating system has become. Advocates have long claimed the open source nature of the code brings significant security advantages over closed-code rivals. Open source means there are no hidden nasties and no secret backdoors to worry about.

Security protocols can be examined by anyone who wants to take a look. There is complete transparency.

Perhaps the most significant thing about the USS Zumwalt deployment is that it is using completely standard Linux. It's not a special version or limited edition. The Navy is using the same version found in enterprises from Fortune 500 companies through to startups.

This point is resonating in the world of the internet of things (IoT). Developers are realising they can use standard Linux in a wide variety of situations. It is suitable for companies of all sizes, from Fortune 500 enterprises to cost-sensitive startups. And standard Linux is suitable for the full spectrum of IoT requirements, too.

We know that Linux is hugely popular for servers, both at the analytics level and at the gateway level connecting IoT devices. But now that the processing power of the IoT sensors themselves has increased, with many running on standard x86 chips, Linux is becoming a mainstream choice for IoT devices. From weather sensors to baby monitors, the IoT device can run on standard bootable Linux. Yes, the very same version found on board the USS Zumwalt. The implications for the IoT industry will be profound.

WHY LINUX IS IDEAL FOR IoT
The leap to Linux brings a long list of advantages. Yes, there's security. There is also familiarity. The current IoT world is a patchwork of proprietary platforms and licences. Developers moan about needing to learn new technologies when they move from the sensor to the gateway server. New hires may have no understanding of the technologies being used. It's a headache.

When Linux is the operating system, there are none of these problems. Developers will be already familiar with Linux. They'll have used it in their professional life, and maybe their person life, for years. There's nothing new to learn.

As Linux can be used for IoT sensors, for the gateway servers and the enterprise-level analytics servers, there is continuity across the entire eco-system. This avoids developers getting stuck in one niche, unable to work with colleagues on another part of the project.

Cost is reduced. By using Linux at each tier of the IoT chain there is no need to

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> Internet of things developers are realising they can use standard Linux in a wide variety of situations

accumulate proprietary licences. Training costs are slashed. The fact that developers already know how to use Linux means the time to market is faster.

Furthermore, developers can make use of a suite of middleware tools. Red Hat is the biggest name in enterprise Linux, with a 65 per cent share of the paid market. Its middleware tools cover the full gamut of needs, including messaging, data virtualisation and business logic rules management.

Red Hat general manager of business platforms Jim Totton says IoT developers appreciate being able to deploy standard, existing tools with a proven track record. "Our middleware suite is called Red Hat JBoss Middleware. It is used by the world's biggest financial institutions and stock exchanges. It is routinely used across the enterprise world. The same technologies used by these companies are now being used by internet of things developers, who appreciate they can use enterprise-grade middleware in their own projects," he says.

For IoT propositions, which require a high degree of connectivity between mobile devices and enterprise servers, such as streaming and other cloud-based services, developers can use a platform such as Feed Henry. It is a popular mobile application development platform, which works perfectly with the Linux operating system. Mobiles and tablets are now a core part of the IoT world. Platforms such as Feed Henry ensure it is easier than ever to produce mobile and tablet-based IoT services.

Some IoT services have specific requirements. For example, some applications require low latency and strongly "deterministic" behaviour. Again, Linux offers an off-the-shelf solution.

Red Hat Enterprise Linux for Realtime is a low-latency, deterministic platform, designed for real-time applications. Other platforms would require specific development to address these issues. Linux offers standard tools.

Naturally, security will remain a big selling point for Linux. Mr Totton at Red Hat explains that it's a prime reason developers work with his company. "Red Hat has a world-leading tradition of providing security fixes faster than almost any other technology provider.

We make sure any security patch is applied before any exploit takes place," he says.

Security, like all areas of Linux R&D, is developed by the entire community. By contrast, other platforms are developed by lone operators or small consortia. Linux offers the collective strength of a global community of developers, academics and enterprises.

When working on an IoT project, it helps to have the right partner. One reason Red Hat is prospering in the IoT world is its size and reputation. A $1.8-billion revenue company, with 7,300 employees and more than two decades of working with enterprises from the Fortune 500 through to startups, Red Hat has a credibility and scale many IoT niche rivals fail to match. When an IoT device marker or service provider grows, it needs to know it's using a platform which won't disappear or stagnate. Red Hat Enterprise Linux gives that reassurance.

IoT developers are waking up to the idea that the tools they need already exist and on a platform they know well. Security is at US-military grade. When IoT booms, Linux will be playing a very big role.

redhat.com

Speeding towards retail like an asteroid

Retailers' attitudes to the internet of things are set to change rapidly as the benefits of "connected retail" begin to be felt

◆ **RETAIL**

● **DAVID BENADY**

Fitness trackers are flying off the shelves at Currys, while other connected devices such as Parrot camera drones, Nest thermostats and Philips Hue lighting systems are also strong sellers.

"Hardware is cool again. It's an incredible time for consumers. Who would have thought 25 years ago you could turn off your lights from your phone?" says Dave Ward, head of new technology and innovation at Currys' owner Dixons Carphone.

He believes the explosion in sales of connected consumer electronics, which can be controlled via a mobile phone app, is just the start of a retailing revolution that will be brought about by the internet of things (IoT).

Dixons Carphone has created a series of smart tech areas in its Currys, PC World and Carphone stores selling connected devices, with staff on hand to explain how the gadgets work. But the current crop of smart devices, such as thermostats and lighting systems, which can be controlled via smartphone, are just the start.

The real revolution will come about when connected devices collect data about the way their owners are using them, and feed it back to manufacturers and retailers. This will help manufacturers to make improved goods and guide consumers when they choose replacement products. For instance, a connected washing machine would be able to tell its owner how much electricity it uses each year, indicating that the owner should buy an energy efficient replacement.

"This is about trying to create products that 'talk' to each other in more of a holistic way," says Mr Ward. And he adds: "What people want to do over time is to control multiple devices from one place."

The smartphone is expected to become the central hub for monitoring connected devices. In the United States, smartphone apps such as Wink act as home hubs that control and collect data from a number of connected domestic devices. If users opt in, such apps will give retailers and manufacturers reams of information, which they will be able to use to help consumers plan their lives, perhaps enabling them to close down home functions, such as heating and lighting, from their mobiles with a single command when they go on holiday.

Although these innovations in connected devices are starting to hit the mainstream, the retail revolution brought about by the IoT is only just beginning. But retailers are gearing up for a change to the way they do business that could be as big as the arrival of e-commerce over a decade ago.

According to research by US firm Zebra Technologies, most retailers think the IoT will be the biggest technological change to the industry this decade. Nearly 96 per cent of retail decision-makers say they are ready to make changes needed to adopt the IoT,

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> **The real revolution will come about when connected devices collect data about the way their owners are using them, and feed it back to manufacturers and retailers**

have been predictions that there could be a connected fridge that automatically re-orders milk, cheese or any other item that is running low. Mr Ward is sceptical that this will be a reality anytime soon, but he believes there could be a smartphone app which activates a camera in your fridge allowing you to see how much food is left.

Replenishment technology has been boosted recently with the trial of the Amazon Dash Button in the US, which you simply push to re-order a particular brand. There's a Dash Button for Gillette, another for Huggies and buttons for various grocery brands. Press the button and another consignment of the brand will be dispatched to your home.

Andrew Long, UK retail technology lead at consultancy Accenture, points to the Poppy home system, which monitors a coffee maker, a smart infant formula machine and a pet food dispenser. These connected objects automatically order refills through Amazon when they detect stocks are running low.

"It becomes a more seamless experience. Retailers are almost locking customers into a pattern of purchase so they don't need to think about it," he says. "The convenience is there as there is less effort. But the customers would have to continue to check they are getting value for money and check it is not an inferior product."

One result could be that the retailer gets cut out of the relationship if the manufacturer, or a rival such as Amazon, delivers replacement products directly. Once the relationship is established through a buy button, it could be difficult to encourage the consumer to change their preferences.

Meanwhile, another innovation could be connected goods that contain their own diagnostic services, which alert the manufacturer to any faults. There may eventually be ways of getting the devices to fix themselves or allowing the manufacturer to do so remotely, rather than having to take them back to the store or send them back to the factory.

This will transform the relationship between retailers and customers. Andy Hobsbawm, founder of Evrythng, a system for allowing devices to "talk" to each other, believes customer service will be greatly enhanced once products can interact. "We will have data to make sure the customer service relationship helps us get more out of the product," says Mr Hobsbawm.

He believes we will move to a world of "product relationship marketing" where we will consider the relationships between products and how they can communicate with each other.

The IoT also promises to transform the back-of-house operations of retail. Many retailers are already using radio-frequency identification (RFID) tags, which are chips put into products to allow accurate tracking of stock. The chips emit a code which can be understood by an electronic reader. The tags are mostly used on pallets or cases of goods, though Marks & Spencer is putting RFID tags on all its clothing and many other items it sells.

Dominic Regan, Europe, Middle East and Africa director of supply chain applications at Oracle, says that with sensors collecting relevant data at many points along the supply chain, retailers will be able to improve their stock management.

"For example, tracking to what extent a shipment of apples might be subject to vibration, temperature and humidity fluctuations throughout its journey will allow a grocery store chain to pinpoint where the greatest risk to degradation is, and adjust its shipping strategy accordingly," he says.

Data from individual items or pallets of goods will also help retailers if they have an oversupply or undersupply of goods, allowing them to run promotions when they know they have lots of a certain products in the supply chain.

In addition, RFID tags could be used to transform the in-store experience. Burberry's flagship store on Regent Street already points the way. Many of the clothes contain RFID tags, so when you take them into a changing room, a digital mirror might respond by showing how they are worn on the catwalk.

Apple iBeacons, which can be installed by retailers to communicate with customers' mobile phones when they enter a store, are ushering in new connectivity between retailer and customer. The iBeacons enable retailers to send coupons and promotions to customers in the store and also get data about their in-store behaviour. As with all developments in the IoT, this depends on customers opting in to the technology and allowing their smartphones to receive and transmit data.

Mr Ward at Dixons Carphone predicts the IoT could take off fast and, when it does, retailers will need to be ready. He concludes: "People's expectations in this space will change very quickly. Uber has changed the taxi market almost overnight and we can see that happening in retail. Where retailers aren't ready, it will hit them like an asteroid."

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IN-STORE EXPERIENCE OF TOMORROW

● Customer benefits
● Operational benefits

Smart thermostats/lighting that improves energy use

Smart shelves in-store that detect when inventory is low

Smart mirrors that allow customers to "try on" different clothing virtually

Contactless checkout by automatic scanning of product as customer walks out of store

Radio-frequency identification solutions to track inventory as it moves across the supply chain

Customers can use their smartphone or a wearable device to quickly scan an item and call up product information, reviews or social media commentary

Robots with touch screens for browsing inventory that can lead customers to desired products

Smart shopping carts can help customers navigate the aisles of a store based on their digital shopping lists

Smart price tags that can be changed in real time based on demand or other trends

Customers can call for assistance or check inventory availability via their mobile device or wearable

Beacons serve up information on frequent store visitors, such as purchase histories and personal preferences, to help a sales associate deliver high-touch service to their most valuable customers

Personalised digital coupon delivered to a VIP customer upon entering the store

IoT-connected digital signage that pushes content to stores in real time, customised for specific stores, cities or regions

Smart packaging that monitors freshness or age of perishable goods

Source: Accenture, *The Internet of Things: Revolutionizing the Retail Industry*

'Miracle' cure for business ills

Affordable technologies developed to monitor machines and track goods have opened up the so-called internet of things to small as well as big businesses

◆ MANUFACTURING

● MICHAEL DEMPSEY

When the Americas Cup comes to Portsmouth next month, British hopes rest with Sir Ben Ainslie's racing team. It will spring into action from a former boat-stacking area that has been emptied of its normal occupants. But the owner of this displaced business has no objection. Its vessels will all be securely shelved in three-storey-high steel racks tailor-made for small boat storage.

The company that came up with this innovative approach to dry-docking is Wickens Engineering, a family-owned Worcester firm that produces industrial

> Technology is sometimes most fruitful when it is applied with a light touch and used to solve very basic questions

racking for a range of uses. Wickens is expanding into new sectors, while squeezing the maximum efficiency out of its factory, and a big technology trend is helping it do this.

The internet of things (IoT) has been touted as a miracle cure for multiple business ailments. Just attaching a computer chip to every item that passes through an assembly line is somehow supposed to transform manufacturing. But the incessant hype conceals a basic truth. Technol-

ogy is sometimes most fruitful when it is applied with a light touch and used to solve very basic questions. Wickens Engineering is a great example of this.

Putting heavy-duty racking together involves a series of expensive machines, including top-of-the-range industrial robots. But this process can still be undermined by bottlenecks that appear when one single machine is not working at high capacity. Enter the Warwick Manufacturing Group (WMG), which works out of Warwick University and intervenes to boost businesses with its specialist skills.

Using an ultrasound scanner, working on the same principle as a pregnancy monitor, WMG is able to measure precisely when a cutting machine is busy or idle. This in turn
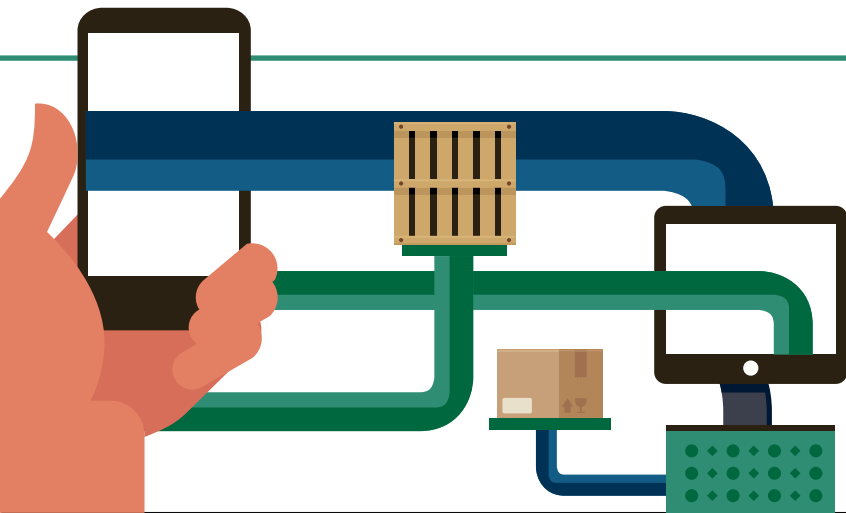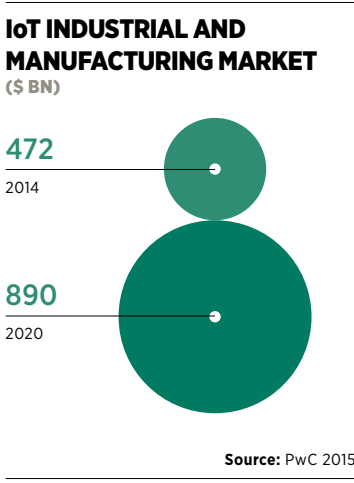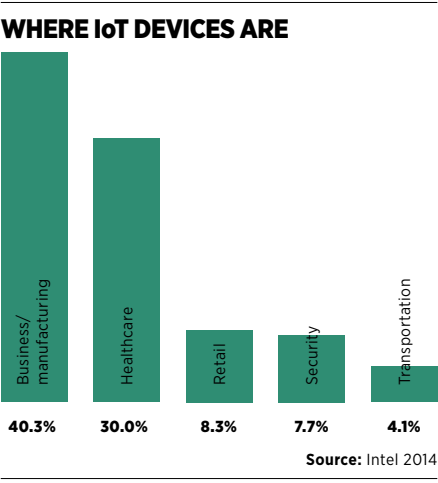
gives Wickens an exact idea of how many more steel rails it could cut in a day and should eliminate any downtime. And attached to the scanner via a wireless internet connection is a Raspberry Pi, a cheap device built to teach schoolchildren how to write computer code.

WMG's Piero Filippin chose this austere set-up because it was "very, very cheap, and simpler and more reliable than a normal PC". When the Raspberry Pi is plugged into a computer screen it presents its findings as a conventional spreadsheet. "The idea is not to involve an IT department," says Mr Filippin.

Keeping the more intense aspects of high technology at arm's length suits Steve Wickens, who runs the business his father founded 40 years ago. For the Wickens' managing director, the IoT is merely a phrase beloved of technology fanatics. "All I want is to measure the efficiency of my key machines," he says, and the internet-of-things approach has allowed him to work out how

to dovetail older equipment with state-of-the-art kit. Maximising the efficiency of every machine is only possible if you know exactly how it is running.

Exception EMS is a British manufacturer of specialised electronic components for the aerospace, and oil and gas sectors. Quality is what keeps Exception in business. It has linked up what technical director Adam White calls a "simple old test machine" to a scanner used by staff who pack the firm's circuit boards into boxes for shipping out.

Using fairly basic software and a wireless internet connection, Exception EMS has armed the box packers with an alert that flashes up on the scanner if any of the parts have failed a previous quality check. This error-proofing has seen the number of returned products cut by half and is part of a wider connectivity project that links an increasing proportion of the machines at its Wiltshire factory.

Mr White thinks the whole IoT bandwagon has got out of control. "People make this out to be amazing, but for me it's just the evolution of connected devices," he says.

He has a point. Computer chips with a radio transmitter for unique identification have been allowing companies to track goods for decades. What has changed is these tags are now so cheap they can be pasted on to just about anything, while wireless connections and the computers that display their output have become extremely cheap. The IoT is as much about the proliferation of these technologies as it is about any big idea.

WHERE IoT DEVICES ARE

Business/ manufacturing	Healthcare	Retail	Security	Transportation
40.3%	30.0%	8.3%	7.7%	4.1%

Source: Intel 2014

IoT INDUSTRIAL AND MANUFACTURING MARKET
($ BN)

472 — 2014

890 — 2020

Source: PwC 2015

BUILDING A BRILLIANT FACTORY

At US industrial conglomerate General Electric, the internet of things (IoT) is being adopted, and adapted, on a truly grand scale. The GE empire spans 400 factories worldwide and they are all being plumbed in to what the company terms the "industrial internet". Marco Annunziata, GE's chief economist, explains this in terms of an ambition to collect information on everything that happens on the factory floor.

Embracing the new world of 3D printing, where prototypes of new parts or products can be made in minutes, the industrial internet allows ideas and information to flow around a plant, and should speed up every aspect of production.

Embedded sensors in GE products, such as aero-engines, feedback information on performance and maintenance needs. This is shared online with GE's

design teams, giving them an instantaneous insight into which parts may benefit from redesigning.

It's all part of exploiting information in a way that was not economic before the advent of cloud computing made storing and analysing massive amounts of data a practical proposition. For Mr Annunziata, the IoT is about capturing as much information as possible and then crunching it to light

up different aspects of the manufacturing process.

GE wants to extend its control of the shopfloor through an online world called Predix. This is a software shell written by GE to hold and run special applications created for its industrial internet. And Predix will fuel what GE calls its "Brilliant Factory". Stephan Biller, GE's chief technology officer in manufacturing, points to the company's gas turbine

plant at Greenville in South Carolina as a shining example of such brilliance.

Data flows around the plant from machines and chipped identification tags giving managers an instant picture of every metric. Energy use, parts throughput and every other activity within the Greenville site are monitored to produce better quality turbines that are delivered on time.

This latter aspect of

web-powered industry can get forgotten in the noise around the IoT. The enormous effort that goes into connecting innumerable industrial devices is all about giving the customer a reason to come back and order from that source again. Whatever snappy slogan it appears under, the IoT is about connecting manufacturers to their customers in a way that has never been possible before.

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COMMERCIAL FEATURE

BRIDGING THE DIGITAL AND PHYSICAL WORLDS

Digital technology has shaped our world for decades, changing the things we make, the way we communicate, connecting people and ideas. But now that digital world is set to collide with the world of physical objects in a way that will redefine business and how we go about our daily lives

PTC® PRODUCT & SERVICE ADVANTAGE™

James E. Heppelmann
President and chief executive

The internet of things (IoT) connects everyday objects, from bicycles and refrigerators, right up to electricity generators, to the cloud. This provides designers, manufacturers and service companies with real-time feedback about the way their products perform in the field, helping to revolutionise the way in which businesses design, build and maintain their products through the whole of their product life cycle.

Jim Heppelmann is president and chief executive of PTC, a company at the forefront of technology-enabled solutions that help manufacturers transform the way they create, operate and service products – and an evangelist for the competitive advantage that IoT can deliver.

PTC's ThingWorx dashboard displaying real-time data from the Santa Cruz V10 bike, alongside PTC chief executive James Heppelmann at the recent LiveWorx conference

"The internet of things is a subject that's full of buzz and hype," says Mr Heppelmann. "But there's going to be a lot of value created here."

PTC has been in the business of "things" for more than three decades, pioneering technologies, such as computer-aided design (CAD), that now underpin research, prototyping and product development across every industry and sector.

"All things – at least those that are manufactured – start as 3D, digital things," explains Mr Heppelmann. "CAD is a great way to validate ideas, to build digital prototypes. When you're ready, you take that digital prototype and you give it to the factory. But at that point the prototype is no longer as valuable, once the thing is physical and out

in the world. In most product life cycles, we go from digital to physical and nobody ever looks back."

While CAD and manufacturing have transformed the way products are brought to market, he says, in-life product assessment has scarcely moved on.

"Currently, if you're wondering how your product is doing out there in the hands of the customer, nobody really hears what's going on until the phone rings," he explains. "Information about physical things rarely makes it back to the digital world where the whole thing started. Most of today's products are built on the understanding that there's no feedback loop. You just put things out there and hope for the best, and maybe occasionally you'll hear back from a customer, but usually, by that point, it's a little late and they're already angry."

That one-way, digital-to-physical transition is becoming a thing of the past. According to Mr Heppelmann, backed up by research PTC has undertaken with Professor Michael Porter of Harvard Business School, we're entering an era in which mechanical, standalone products have become smart. Cars now come with software integrated into the engine control unit; everyday appliances can monitor their own maintenance status.

> I believe that pretty much every type of product will end up this way, from medical devices to refrigerators, planes, trains and automobiles

And now that devices are smart, they're becoming connected. By linking them via the cloud, they can be remotely monitored and controlled by computers, smartphones and other devices. Families of products that share common elements can now be joined up via the cloud to create product ecosystems.

"If you think about Apple products, such as the iPad, iPhone or iMac, they all share a common cloud with iCloud, iTunes and the app store. That's what's happening with all kinds of product families, where they act together in fundamentally new ways because they're sharing common digital componentry," says Mr Heppelmann. "Take that idea to the next level, and you get smart cities and smart farms and smart infrastructure – whole systems of systems, working together to make the world

a safer, more efficient and more economical place to live."

These are the product ecosystems that PTC is at the forefront of helping manufacturers to develop. Part physical and part digital, they're part client and part server, part on-premises and part in the cloud. And they're taking over.

"The very DNA of these things is changing," says Mr Heppelmann. "I believe that pretty much every type of product will end up this way, from medical devices to refrigerators, planes, trains and automobiles. This is the new reality of things. The digital world and physical world are inseparable, and they're working together."

Over the last three years, PTC has invested more than $500 million in making this physical-digital convergence a reality. Under the consolidated brand ThingWorx it has acquired a number of key startups and technologies, including connectivity specialist Axeda and Coldlight, a system of automated, predictive analytics that "listens" to the data that streams from connected devices – and crucially, help manufacturers and service providers decide what to do with those insights.

Mr Heppelmann explains the thinking behind this joined-up approach to product design, manufacture and life-cycle management. "All of the products you create now have a voice. When you send them out into the world, they connect

back to you and tell you what's going on. How are they performing? How good is your design? How effective is your service? We shouldn't run systems any more that ignore the voice of the product," he says.

The example Mr Heppelmann uses to demonstrate this comes, perhaps surprisingly, from a bicycle. The Santa Cruz V10 downhill racer was the first all-carbon bike to win the Mountain Bike World Cup, in 2010. Designed using PTC's Creo CAD system, the bike has been fitted with a Raspberry Pi computer to provide connectivity and a number of sensors monitoring key characteristics, such as wheel speed, the rider's pedalling cadence and any compression of the suspension.

"By connecting it up using an IoT platform, we've created a bike that's part physical, part digital," says Mr Heppelmann. "Now we can look at online dashboards that tell us what's going on with that bike from literally thousands of miles away."

But the concept goes further. A "trail file" of data produced by the bike is used to create a "digital twin" which is an exact representation of an individual, physical bike and its reactions. "Everything that's experienced by the physical product can be captured, replayed and tested against its digital counterpart," he explains.

And information doesn't just travel one way, from the physical world to the digital world. Data is used equally valuably in the other direction, from digital to physical. Technicians can scan a bike's unique serial number using an iPad and connect to its digital twin via the cloud. This enables them to overlay a digital dashboard of information over an image of the bike itself, using augmented reality.

Augmented reality can be used to provide on-the-spot instructions to service engineers of devices as complex as electricity generators, says Mr Heppelmann. This will not only identify problems, but show how to fix them through overlaid, animated simulations of maintenance procedures. It replaces cumbersome written documentation with practical, graphical demonstrations that are not only faster and more practical to use, but which don't need to be translated into multiple languages.

Using data collected from thousands or millions of individual products in the field, Mr Heppelmann and service agents can begin to use big data analytics to aggregate that information, feeding it back into the manufacturing process to drive product innovation and improved service.

"If service is the killer app for IoT," Mr Heppelmann concludes, "then augmented reality and digital twins on the internet of things are the killer technology for service – it's a big and exciting idea."

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Unicorn hunting among the startups

The internet of things presents a prime opportunity for newcomers to make their billion-pound fortunes

◆ **STARTUPS**

● **CHARLES ORTON-JONES**

The word of the moment is "unicorns". They are startups that achieve a billion-pound valuation. Unicorns number 40 in Europe, with 17 in the UK, including Shazam, Wonga and Just Eat.

Hype around the internet of things (IoT) means investors are looking for the potential unicorns in the sector. But where should they be hunting?

We know unicorns hide in unlikely spots. US startup Nest focused on central heating. Users can alter heat settings using their mobile. Google bestowed the unicorn horn in a $3.2-billion cash acquisition in 2014.

Taxi firm Uber is arguably an IoT startup. The app turns a smartphone into a GPS tracker for taxis, a key part of the appeal. Fundraising valuations place it at $40 billion.

So it can be done. Who are the outstanding candidates?

In the consumer sector, Bluesmart is luggage bristling with IoT features. There's a GPS tracker, built-in scale, a digital lock managed from a smartphone and a battery reserve for charging mobile phones – surprisingly handy for long journeys. Bluesmart's luggage set retails for £245 and has picked up awards such as "Most life-changing product 2014" from BuzzFeed.

Netatmo is a face-recognition camera for the home. The device looks like a webcam mounted on a cylinder and it can be placed anywhere to scan passers-by for familiar faces. When it spots someone friendly it sends a message to your smartphone. Ideal for parents of latch-key kids who come home to empty houses.

Mybitat takes the concept a little further for the elderly. Sensors monitor the condition of senior citizens who live alone and supply updates to the family or to the emergency services in extremis. The market is huge as more than 10,000 baby boomers retire every day in America alone. Samsung has stepped in to develop a range of products with the company.

Heavy industry ought to be a rich environment for IoT startups. The energy sector in particular is providing fertile ground. Oil and gas wells are labour intensive to monitor. PumpWELL Technologies supplies sensors to send remote health checks to an engineer's mobile phone.

Chief executive Nav Dhunay says: "One of the main challenges in IoT adoption by oil and gas producers has been distrust of change, and a costly barrier to entry. We are building sensors that are substantially less expensive than anything else in the market and are able to place those sensors strategically across a pumping well.

"If remote sensors could do nothing more than simply confirm a well is pumping and fluid is flowing, then that would be a disruption within the industry, as there would be no need for highly paid operators to physically visit the site which often can cost between $500 and $1,000 per well per visit.

"The fact that these sensors and control mechanisms can also analyse patterns in pumping data for every individual well and literally adjust the pump in real time to operate in the most efficient way is a game-changer."

City design is boom area in IoT. Canary Wharf Group and innovation consultancy Entiq are running the Cognicity Challenge

London's "Silicon Roundabout" in an area of the capital where technology is booming

EUROPEAN UNICORNS: COMPANY VALUATION ($ BN)

■ UK unicorn

Source: GP Bullhound
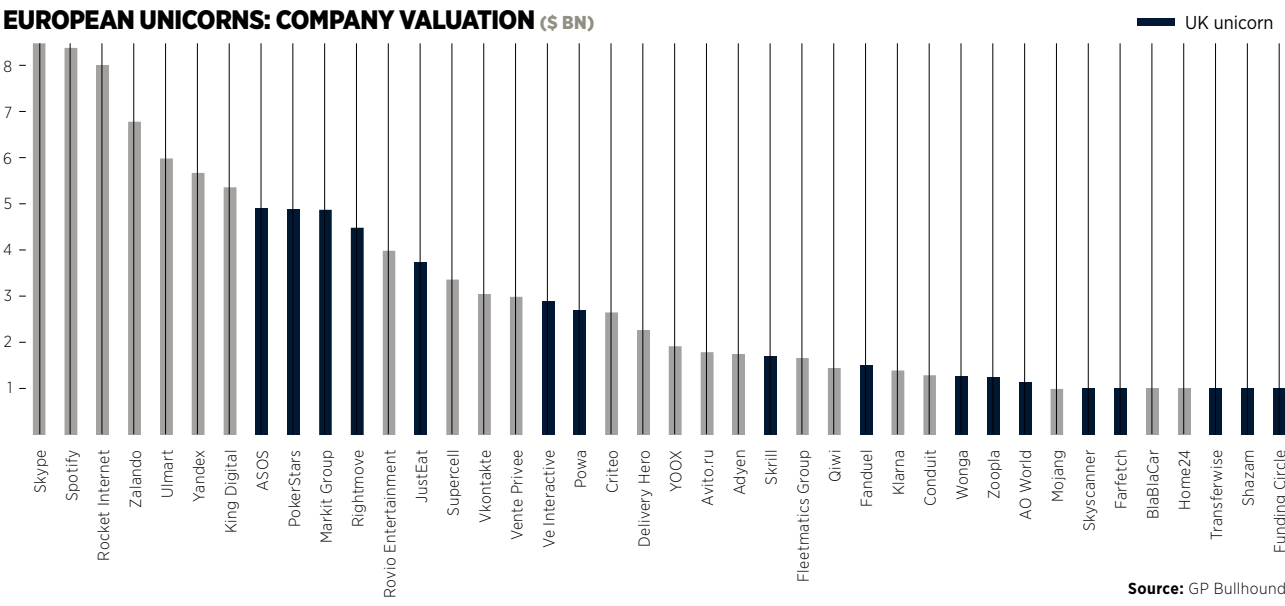
to promote smart city IoT startups. Members include Heat Genius, which takes the Nest thermostat idea, but refines the heat management for each room in the house. Boldmind uses IoT to provide analytics for retailers of traffic flow and crowd movements in built-up areas. BuzzStreets is developing traffic incident reporting systems to help commuters. Voyage Control is helping to optimise deliveries by routing trucks intelligently.

The platforms needed to make IoT work will be a lucrative arena. Jasper Technologies, a software company which provides a simple way for all sorts of products to be turned into IoT devices, raised $50 million last year giving it a value of more than

> "
> **Hype around the internet of things means investors are looking for the potential unicorns in the sector**

$1 billion. Jasper's service is used by more than a 1,000 companies in over 20 industries. Topcon Precision Agriculture, which creates automatic steering for tractors, uses the Jasper platform for its suite of services. Jasper means there is no need for Topcon to create dashboards and reporting systems from scratch.

There are well-funded platforms made by IFTTT, EVRYTHNG, Concirrus and pretty much all the major names in tech, from HP and Oracle to EMC and Huawei. Google, naturally, has its own platform for IoT called Brillo. Based on Android, it will include voice commands. But we won't find out the full details until the autumn. These may make life harder for startups to compete.

Perhaps the key to success will be the way IoT devices interact with each other. RealVNC builds remote-control systems used in more than two billion devices. RealVNC's vice president of mobile Tom Blackie says he's on the look-out for devices talking to each other.

"Think of your GPS location from your vehicle being used to trigger your smart-home Google Nest thermostat or switching on the lights as you pull into the drive. All these will be done automatically by 'intelligent agents' running in the background, learning your habits and doing useful things for you," he says.

The more devices that enter the IoT realm, the more these sorts of mash-ups will proliferate.

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TEN BREAKTHROUGHS IN IoT

Managing traffic
The Highways Agency measures traffic flow on Britain's roads by tapping into drivers' phone GPS. Millions of vehicles provide reports to create a traffic overview accurate to within seconds. If traffic stalls, the agency instantly knows there's a problem. Snow clearance vehicles are sent to problem spots identified this way. The service, supplied by Inrix, is used by delivery firms to send packages via the quickest route, saving money and time. Relying on traffic updates on the radio now seems positively prehistoric.

Fixing lifts
ThyssenKrupp Elevators runs 1.1 million lifts worldwide, including 73 in New York's One World Trade Center building alone. The big issue is reliability. ThyssenKrupp need to fix the lifts when they cover a certain distance. So it worked with Microsoft and CGI to create an IoT monitoring system for each lift shaft. Technicians now use real-time data to determine repair needs, examine diagnostics and move elevators, using an app. In case of malfunction, an error message is transmitted automatically, cutting repair time.

Catching burglars
Oxfordshire-based Manything has an app which turns any Apple device into a live streaming home-security camera. Use an old iPhone or iPad to watch for burglars. The app includes motion detection, which will send an alert message to your personal phone. You can then watch the video and see what is happening. A woman in Arizona has already nailed a thief using Manything by supplying footage to the police.

Caring for your dog
Dog owners can go a little bonkers over their four-legged darlings. Device maker Whistle is hoping to tap into the market with a GPS monitor and an activity monitor. The latter is a lightweight device which attaches to the dog's collar and works like a Fitbit device, measuring activity, location and sleeping patterns. Compare trends to other dogs. Know whether you are overstretching the poor mutt. Laugh – but dog accessories are a multi-billion-dollar industry.

Pimping your ride
A report by McKinsey says a "dramatic increase in vehicle connectivity" will boost the market for connectivity components from €30 billion to €170 billion by 2020. The study reveals 13 per cent of consumers would refuse to buy a car without internet connectivity and half of consumers demand the internet when making a purchase. From diagnostics to entertainment, even theft-tracking, IoT is now becoming a mainstream automotive feature.

Protecting your cranium
YouTube is full of stunning videos of extreme sportspeople landing triple somersaults on their BMXs. Trouble is less talented folk are keen to try too. The Shockbox device measures just what damage they're doing to their grey matter when they face-plant. The sensor attaches to a helmet and gauges G-force. Concussions can be identified. Shockbox is being targeted at American football and ice hockey players, who routinely take big impacts to the head.

Feeding the world
IoT is the secret to helping farmers increase production by 70 per cent to 2050, when the world population will be near 10 billion. That's according to a report by Beecham Research. IoT will be used for crop-yield management, livestock-monitoring and tracking activity across farms. IoT devices are already in animals, tracking health – hence the "internet of pigs" moniker.

Cutting industrial consumption
Aggregate Industries has upgraded its bitumen tanks at 40 asphalt plants across the UK with IoT devices made by Open Energi. The tanks now adjust their electricity consumption in response to fluctuations on the grid. The company reports: "The project is expected to reduce UK CO2 emissions by almost 50,000 tonnes over the next five years, equivalent to 390,000 individual journeys from London to Paris by plane. Embracing this innovative technology has also helped Aggregate Industries to identify significant energy savings in the region of 350,000kWh per year."

Stopping babies crying
Blue Maestro's Pacif-i baby dummy monitors temperature, reporting back to an app. Ill babies' health can be tracked, with medicine times entered. The dummy includes a buzzer which will sound on request, should the device got lost down the back of the sofa. A little more mainstream is the Bleep Bleeps range of baby cameras and screaming monitors. The Mimo baby kimono tracks sleep, body position and temperature.

Winning gold at Rio 2016
Wearable tech is helping everyone from couch potatoes looking to crack their first 6k, to Olympic contenders preparing for the Rio Games next year. Jo Pavey, European 10,000m champion, uses SMS BioSport heart-rate earphones combined with the Runkeeper app. The wireless earphones mean the user can forgo the usual chest strap, and the app compiles speed and route data via GPS, then reports back to a web-accessible analytics interface.