

THE INTERNET OF THINGS: APPLICATIONS FOR BUSINESS

Exploring the transformative potential of IoT



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Contents

Preface	2
Executive summary	4
1. Introducing the Internet of Things	5
1.1 What is IoT?	5
1.2 What can IoT do?	6
1.3 Why is IoT important?	8
2. How is IoT transforming different sectors?	11
2.1. IoT across Sectors	11
2.2. Applications for Industry: Sector deep dives	11
2.2.1 Energy	13
2.2.2 Healthcare	15
2.2.3 Logistics	17
2.2.4 Transport	19
2.2.5 Retail	22
2.3. Telecommunications as a partner	25
3. What are IoT's challenges?	31
3.1. Security and privacy	32
3.2. Regulation	34
3.3. Digital Infrastructure	35
4. Conclusion	37
Special Report 1 – The Evolution of IoT	10
Special report 2 – IoT and COVID-19: Agility, Resilience and Speed	27

Preface

This report summarises the key findings of the Internet of Things (IoT) – Applications for Business research programme, developed by the Economist Intelligence Unit (EIU) with support from China Telecom Global. The report is based on an extensive literature review and a comprehensive interview programme conducted by the EIU between January and May 2020. In total, more than 20 experts were interviewed representing academia, businesses, start-up leaders, consultants, and representatives from firms that are early adopters of IoT.

The EIU bears sole responsibility for the content of this report. The findings and views expressed do not necessarily reflect the views of the partners and experts.

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1. Introducing the Internet of Things

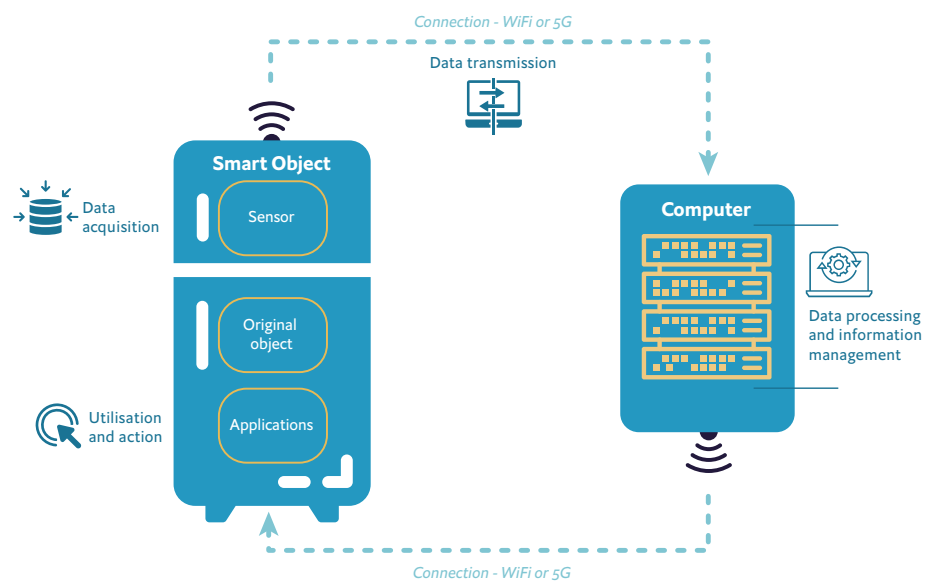
Thirty years ago, the first known Internet of Things device—a vending machine at the Carnegie Mellon University in the US with remote temperature monitoring—kept Coke cans cool in the summer heat.³ Today, the Internet of Things is everywhere. From connected cars, fridges and virtual assistants to applications in healthcare, logistics and retail that are keeping supply chains and hospitals running during the COVID-19 pandemic, the Internet of Things (IoT) is a technology that is transforming business operations and creating new revenue streams. However, adoption rates are currently lower than expected, given the gains businesses could realise. The aim of this paper is to showcase how IoT can bring benefits to different parts of the economy and discuss the potential solutions to the challenges currently limiting broader take up.

1.1 What is IoT?

Defining IoT is hard for two reasons. Firstly, IoT has a breadth of applications; from monitoring supply chains to stopping trains and lighting homes. This wide range of uses means it is often hard to pinpoint exactly what unites the technologies grouped under IoT. Secondly, the technology is often referred to alongside Artificial Intelligence (AI) and Big Data as part of a triad at the centre of the Fourth Industrial Revolution (4IR). This is a relevant grouping, as IoT is a source of the Big Data needed to create AI algorithms; however, this coupling has resulted in limited understanding of IoT itself.

On the grid

The IoT consists of more than just a smart device



Sources: AVSystem 2019, IPWatchdog 2016

³ The little-known story of the first IoT device, IBM (2018)

For this research, we asked 20 industry professionals and academics how they define IoT. The recurring message focused on IoT's ability to bridge the digital and material worlds. Therefore our definition hinges on the following aspect of IoT's transformative potential:

The Internet of Things is **a network of physical objects or devices that communicate and interact with each other via an internet connection.**

The other central component of IoT is the internet connection. Connectivity is necessary for the transmission of data between the IoT object and the computing power that is collecting and analysing the information. Telecommunications (telecoms), as the sector that provides internet connections, is therefore at the heart of IoT transformation (see Section 2).

1.2 What can IoT do?

IoT can revolutionise the business and consumer landscape by bridging digital and material worlds. Any industry reliant on making, moving or selling objects that were previously not connected to the internet stands to benefit. The specific benefits IoT can bring to a business depend on how the technology is used. For example, sensors can be used to reduce waste by optimising lighting or heating based on occupancy levels, or reduce spoilage of products in transit by monitoring temperatures. IoT can also generate revenue and increase productivity, such as acoustic offshore oilfield sensors that analyse activity through pipelines to maximise output and help identify new resource pools.

To help build an understanding of the potential for IoT in any given business, it is useful to consider the five key capabilities of IoT: **connecting, collecting, monitoring, monetising** and **optimising**.

- **Connecting** – IoT allows all manner of devices to become integrated and connected, moving them out of their respective silos and bridging the gap between the digital and the physical or “real” world. As the digital footprint of devices expands, the global system of connectivity becomes more robust and responsive to change.
- **Collecting** – Sensors are a core component of IoT technology. They collect data from the object they are placed on, which can be used to inform other functions. The data collected also has value. Companies can aggregate, anonymise and sell data to interested third parties.

There's an [IoT] app for that

The main characteristics of the Internet of Things can be encapsulated by these keywords



Sources: EIU 2020

- Monitoring** – In its role as aggregator, IoT facilitates the ability to engage in remote monitoring, providing a rich, detailed snapshot of the world as it stands in real time. Existing compliance and monitoring of processes and assets can be automated and made more efficient through preventative and predictive applications of IoT.
 - Optimising** – New levels of efficiency can be attained through IoT data collection, providing potential cost, energy or time savings in a variety of sectors, from healthcare to energy.
- In Section 2, we will look more closely at how these characteristics are already impacting different sectors.
- Monetising** – IoT allows companies and sectors to become data-rich, both in terms of collecting and analysing data, sometimes from unexpected or hard to reach places. These new data streams bring with them significant opportunities for new revenue streams, either through aggregation or anonymisation or through adding new functionality that can be sold to the consumer.

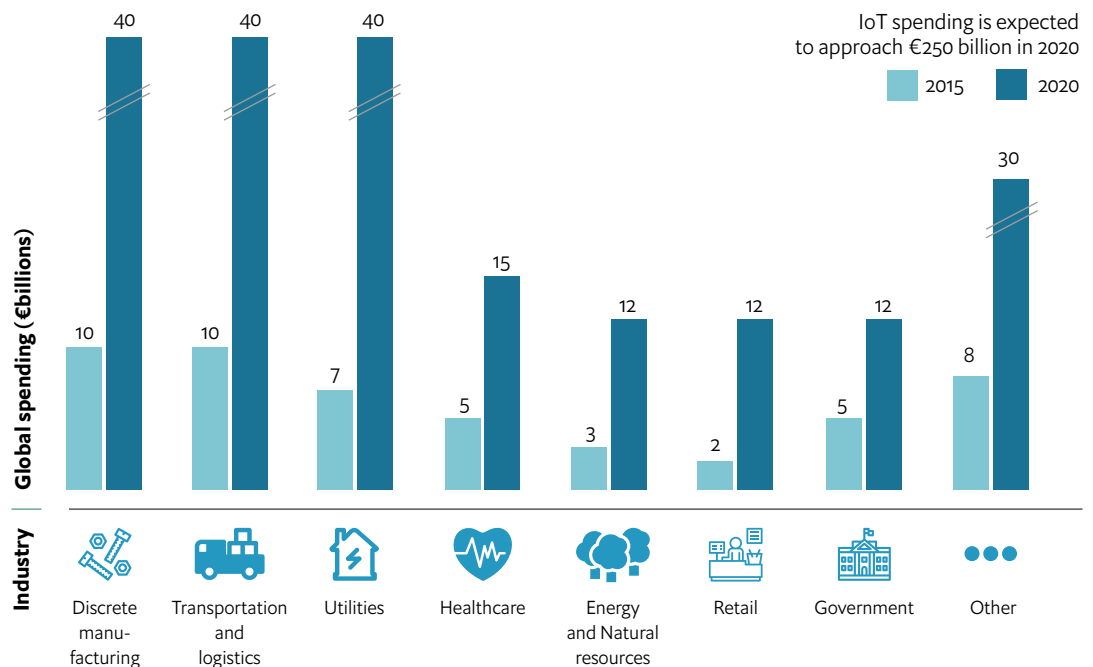
1.3 Why is IoT important?

This breadth of applications means IoT is set to have a major impact on the global economy in the next five years. Some of this transformative potential is already being seen. For example, the consumer product market is already posting gains, thanks to the growing popularity of health and entertainment wearables and smart homes. IoT solutions are estimated to have risen from US\$72bn in 2015 to US\$236bn in 2020.⁴ Improvements in natural language processing will see voice functionality further integrated into smart home tools; one forecast predicts that voice assistants will be integrated into eight billion domestic products by 2023.⁵

Businesses that adopt IoT in their operations will become more competitive and new digital products will appeal to increasingly connected consumers.^{6,7} Those who do not adopt IoT may struggle as the technology increases the efficiency of competitors to meet the needs of their target markets. Awareness of the benefits IoT can bring is seen in the rise in spending on IoT. Approximately US\$6trn will be spent on IoT solutions over the 2016-2021 period⁸ and globally, IoT has fuelled more than US\$80bn in merger and acquisition (M&A) investments, along with more than US\$30bn in venture capital.⁹

Sensors on the dollar

The global spending on IoT across all sectors



Source: BCG 2017

4 Wearable Devices Market Share, International Data Corporation (2020)
 5 The best of CES 2020: the smart home gets a lot smarter, Financial Times (2020)
 6 The Deloitte Consumer Review Digital Predictions 2018, Deloitte, (2018)
 7 Leveraging the Internet of Things for Competitive Advantage, Knowledge @ Wharton (2016)
 8 Market Pulse Report, Internet of Things, Growthenable (2017)
 9 Choosing the Right Platform for the Industrial IoT - Bain Brief, Bain (2017)

According to Daniel Price, CEO and cofounder of Ioterra, a B2B marketplace of IoT solutions and services, this spending is focused on two dimensions: “Top-line businesses are investing in an IoT product to sell it. The bottom-line approach is improving operations and efficiencies internally”. Each delivers different benefits and is overseen by different departments, he adds. “Bottom-line IoT tends to be overseen by the CIO or IT department, while top-line is overseen by the R&D or product department”.

Beyond providing a competitive edge, the true global potential of IoT puts it at the forefront of technological solutions. Overall the value of this potential impact is staggering; according to GSMA, it could equal ~11% of the world economy in 2025.¹⁰ Though the IoT market today is dominated by developed countries, the same report highlights that in five years’ time, over 20% of all IoT revenue will originate outside of North American and Europe.

According to Chintan Bhatt, Assistant Professor at Charotar University of Science and Technology in India, what is interesting about IoT applications in developing countries is their potential to deliver social, alongside economic gains. “Some of the most interesting applications in developing markets are those that help address common problems in low-income countries, such as food insecurity”. He describes IoT’s role in new attempts at precision agriculture, which improve productivity and market efficiency through tools that draw together data and analytics to optimise crop schedules and use of inputs.

¹⁰ The Internet of Things: Mapping the value beyond the hype, McKinsey & Company (2015)

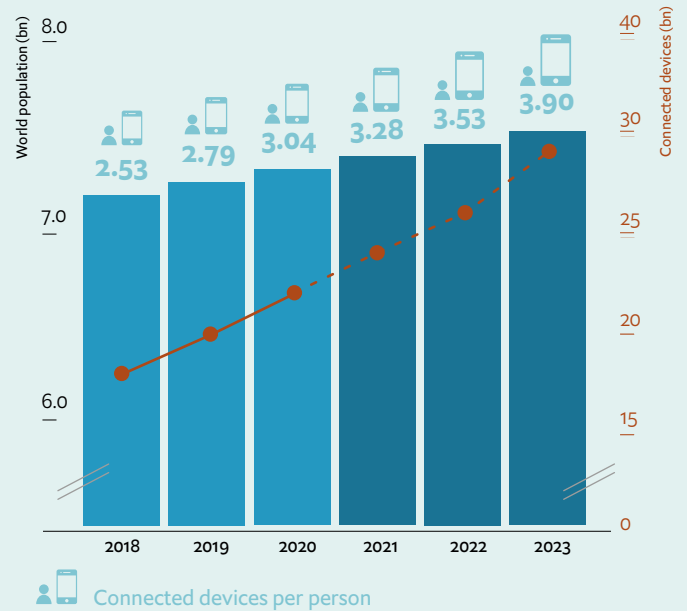
Special Report 1 – The Evolution of IoT

The idea of IoT has existed for decades – the term was coined in 1999¹¹ – but until recently, key pieces were missing from the jigsaw (see timeline). Microsoft and Novell, for example, both attempted to link business machinery during the 1990s, in projects that were later aborted. A turning point, according to Cisco, was in the previous decade when the number of connected devices outstripped the number of human beings for the first time. Uptake has since quickened with improvements in devices, such as greater processing power and falling costs. The evolution of digital networks, especially as 5G infrastructure begins to roll out, and advances in artificial intelligence, machine learning and data science, are at the root of IoT's sector-wide presence and major expansion potential.

Key to continuing growth is creating some form of compatible standards – making IoT devices of different origins capable of working together. “Currently, IoT devices are like incompatible Lego blocks” says Brian Subirana, who teaches at Harvard and at the Massachusetts Institute of Technology (MIT) and is director of the MIT Auto-ID Laboratory, “they’re growing organically in different areas and we need to find a way to fit them together to form a system”.¹²

Chips with everything

By 2023, there will be approx. 4 connected devices per person



Source: EIU Population Data - Cisco Annual Internet Report, 2018–2023

IoT Timeline

- 1980s** Researchers at Carnegie Mellon University connect a Coca Cola machine to the internet to remotely monitor the temperature inside the machine.¹³
- 1993-94** US tech companies Microsoft and Novell explore early attempts to connect business machinery (e.g. faxes and photocopiers) with common communications protocols.
- 1999** Founding of the Auto-ID Centre at the Massachusetts Institute of Technology (MIT), a research endeavour pushing the frontier in networks and sensor technologies.^{14, 15}
- 2007** Launch of the iPhone augurs in the smartphone era, followed by a mushrooming of wearables, tablets and sensor technologies. By 2008, the number of connected things surpasses the number of people.¹⁶
- 2010** Number of devices connected to the internet reaches 12.5 billion, nearly double the human population.¹⁷
- 2014** Tech giants ramp up their AI and smart technology systems. Google buys world-leading AI start-up DeepMind and Amazon launches the first generation of Amazon echo, a smart home assistant.
- 2016-17** European Commission initiates IoT focus under the Horizon 2020 innovation programme.
- 2017** China IoT market exceeds RMB100bn
- 2019** 5G infrastructure begins rollout across the world, providing speed, bandwidth and network flexibility to take IoT mainstream.

¹¹ Introduction to the Internet of Things, Kramp T., van Kranenburg R., Lange S. (2013)

¹² A Brief History of the Internet of Things, Dataversity (2016)

¹³ A Brief History of the Internet of Things, Dataversity (2016)

¹⁴ The Internet of Things How the Next Evolution of the Internet Is Changing Everything, CISCO (2011)

¹⁵ The Computer for the 21st Century, Mark Weiser (2011)

¹⁶ The Internet of Things How the Next Evolution of the Internet Is Changing Everything, CISCO (2011)

¹⁷ The Internet of Things How the Next Evolution of the Internet Is Changing Everything, CISCO (2011)

2. How is IoT transforming different sectors?

The difference between IoT and other technology advances over the last 20 years is its focus on existing, non-technology focused objects. Where previous technology improvements, such as the launch of smartphones or 4G, created high growth opportunities for businesses in that sector, IoT can support gains in many different industries.^{18, 19} To highlight this potential across industries, we now focus on tangible applications employed by real businesses across six sectors that are seen as prime for transformation:

- Energy
- Logistics
- Telecommunications
- Healthcare
- Retail
- Transport

¹⁸ Digital Spillover, Huawei (2017)

¹⁹ Growing opportunities in the Internet of Things, McKinsey & Company (2019)


2.1. IoT across Sectors





IoT will have a particular impact on sectors that are focused on the making, moving or selling of physical objects; from drugs to electric vehicles. In this section of the report we focus on five of these sectors in particular; Energy, Healthcare, Logistics, Retail and Transport. Below we link IoT's core capabilities with potential transformation points for each industry.

2.2. Applications for Industry: Sector deep dives

Network Expansion

IoT has applications across sectors

Industry	Characteristics	Application
Energy 	Connecting	Create smart home management systems, control home appliances remotely
	Collecting	Generate real-time power consumption data to match demand-supply
	Monitoring	Remote monitoring of assets in hard to reach places, e.g. wind turbines and geothermal plants
	Monetising	Better distribute investment and R&D by analysing consumer data
	Optimising	Alert operators on outages, manage congestion and inform on need for machine upgrades

Industry	Characteristics	Application
Healthcare 	Connecting	Track own health more effectively and receive real-time feedback using wearable technologies
	Collecting	Build complete picture of health of patients with historical analysis
	Monitoring	Reduce need for hospital visits and maintain complete visibility of patient condition
	Monetising	Commercial retail opportunities in patient monitoring/wearable devices
	Optimising	Minimise waste and reduce error to improve patient care, reduce wait time at emergency room and enhance drug management
Logistics 	Connecting	Enhance communication by connecting all elements in a supply chain
	Collecting	Improve efficiency and accuracy of assets by creation of digital replicas
	Monitoring	Track and trace inventory and improved monitoring of production flow
	Monetising	Utilise logistics data as a market research product
	Optimising	Enhance operations through data capture and by mapping supply chains virtually
Retail 	Connecting	Location-based beacon technology
	Collecting	Improve in-store layout, insights on how customers like to shop
	Monitoring	Operate smart shelves to prevent theft
	Monetising	Creation of higher margin products
	Optimising	Repurpose existing enterprise technology like security cameras
Transport 	Connecting	Allow vehicle-to-vehicle communication for asset sharing schemes
	Collecting	Use collected data to offer customers better value for money offers, e.g. in insurance industry
	Monitoring	Engage in preventative maintenance
	Monetising	Reduce management and maintenance costs via smart parking solutions
	Optimising	Yield operational efficiency in vehicle fleet management

Source: EIU 2020

2.2.1 Energy

The global climate crisis calls for far-reaching innovations. In the energy sector, IoT can support changes to power grids at a system level and help end-users conserve energy in their homes.

In the current fossil-fuel era, many power grids are one-directional with a small number of centralised plants sending energy to consumers. Low-carbon energy systems necessitate multidirectional power produced from new origins, like solar rooftop panels and community wind turbines, with smart grids and peer-to-peer energy systems that let consumers sell power back to the grid. New sources of demand are also emerging and requiring **connection** into grid systems, like electric-vehicle charging stations and e-scooter docks. To allow these new and diverse energy sources to be brought into the network, and to let new types of actors, like consumers, sell excess energy back into the grid, there is a need for an 'energy internet' which IoT can deliver.

IoT can **collect** highly granular energy data through **connected** sensors and smart meters that let network operators **optimise** the rollout of renewables, such as making informed decisions about how much green energy capacity can be brought online without posing risks like voltage surges. In the past, this has, in some potentially high growth solar markets like Australia, led to overly conservative approvals for consumer-built solar panels.²⁰ This could help consumers and non-traditional energy generators like local businesses, to **monetise** their renewable assets, improving the cost effectiveness of the initial outlays.

IoT is also changing how domestic consumers use energy. The most visible example of this is smart meters, which **collect** near real-time information on energy usage and make it available to homeowners through a dashboard. The aim is to help people understand exactly how much energy they are using, and where they can be more efficient. This technology is evolving quickly as more devices become **connected** to the internet, allowing their data to be added to a smart meter. Functionality is also improving, as devices go from alerting users of energy wastage to being able to automatically **optimise** energy use, e.g. modifying ventilation and temperature based on occupancy. According to Frank Puhlmann, who is developing a smart home platform at Residential IoT services, the key to success with IoT in the home will be overcoming data silos between appliances from different brands so that all relevant data points can be collected. "Cloud-to-cloud communication will help a resident control all of their appliances from one central dashboard – regardless of whether they are built by different manufacturers".

²⁰ Scaling Solar: How Richer Data Integrates Renewables to the Grid, The Chronicle of Higher Education

CASE STUDY **Apartmentum: the IoT based home of the future**

Buildings constitute a significant source of energy use. When construction and operations are combined, they account for 36% of global final energy use and 39% of energy-related CO₂.²¹ As a result, governments, companies and consumers have been focusing on ways to make buildings more climate-friendly for more than a decade. In 2010, the UK government launched the Energy Company Obligation (ECO) – a subsidy that reduced the cost to companies for installing efficiency devices in people’s homes.²² The cutting-edge IoT technology at the time was the smart meter – a device that gave consumers access to almost real-time data on their energy usage – and it was included as a key priority in the bill. Today nearly 16 million homes in the UK have one of these devices installed and smart meters have proven to be a launch pad for a broader suite of innovations; the smart home.²³

and hold parcels. Mobile notifications when a doorbell is rung allow remote opening, for deliveries, a cleaner, a family member or friend.

However according to Lars Hinrichs, a local entrepreneur and leader of the Apartmentum smart home initiative, this greater connectivity has led to new challenges. For example, in order to connect appliances to one central system, different manufacturers had to share sensitive business information. “It was a big challenge. Established players were not thinking of opening up the tools that provide the gateway to integrate software into the cloud”. One of the big worries behind partner companies’ reluctance was cyber-security. However, investments in cyber-security by leading cloud providers like Amazon, Microsoft and Google are starting to mitigate the risks. According



By 2022 estimates suggest the global smart home market will be over US\$50bn

One of the most advanced examples of this concept is Apartmentum, a Hamburg-based initiative redeveloping a 35-apartment historic building in the city with a focus on incorporating cutting-edge technologies. The approach incorporates smart functionality comprehensively through a redevelopment process, which allows a wider range of innovations to be built in. The apartments have connected smart meters directly to adaptive ventilation systems, allowing apartments to be heated or cooled automatically based on activity and occupation levels. It is also helping to support the green transportation transition: each parking space has a charging dock for electric vehicles. Digitisation has expanded beyond just energy, other conveniences include a digital post-box that allows parcel retrieval and deliveries authorised via mobile phone, without relying on neighbours to pick up

to Frank Puhlmann, who is developing a smart home platform at IoT Residential Services, the key is to integrate security at each step of the process. “Both the appliance vendor and the cloud have to meet a sufficient standard in order to work together, this helps keep consumers confident their information is protected”.

The Apartmentum project is, unsurprisingly, not a mass-market prospect as yet; rental prices are around 10-15% higher than the average in Hamburg, with tenants including expatriates and professional footballers. But Hinrichs thinks smart homes will democratise “at lightning speed” thanks to further improvements in the technology; a view shared by industry experts who suggest that the global smart home market will reach an estimated US\$53bn by 2022.²⁴

²¹ Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation

²² 2010 to 2015 government policy: household energy, UK Government (2015)

²³ British smart meter statistics, Finder (2020)

²⁴ Smart Home Systems Development Services, Integra Sources

2.2.2 Healthcare

Even pre-COVID-19, the healthcare sector faced huge challenges and pain points including ageing populations, increased incidence of chronic diseases and growing financial costs, many of which are the result of inefficient systems, fragmented healthcare data and a reliance on physical patient-doctor interactions.^{25, 26, 27} IoT can provide game-changing innovations to improve efficiency and the quality of care that people receive, as well as being a technology on the front line of the pandemic (see Insert 2).

Medical devices like pacemakers and insulin pumps—essential to chronic disease management in heart disease and diabetes—are being manufactured with increasing levels of connectivity so they can **collect** data for physicians and carers to **monitor** patients and spot problems and abnormalities. By continuously gathering data on indicators like blood glucose levels, blood pressure and heart rate, these devices can **optimise** readings by providing more accurate data than the one-time measurements taken in clinics, as well as reducing demand on doctor's surgeries where medical tests are usually conducted. "The beauty of IoT is that I can, at a very modest cost, get a medical-grade device that I put on my arm and press one button," says Glen Gilmore, former mayor and professor of Digital Marketing, Crisis Communications and Social Media Law at Rutgers University. "The information gets shared to my mobile phone and, if I choose, to my doctor who can then say if there's an issue", explained Gilmore, who also served on the board of directors of a university hospital.

Health IoT is also working its way into digital therapies, known as 'digi-ceuticals', which use software and data to **optimise** existing medical interventions. Examples include pills that contain ingestible sensors that tell a doctor when a patient has taken a medication, helping to ensure adherence to a regimen. This can be critical for patients that are elderly, cognitively compromised or suffering conditions like depression that might affect their ability to stick to a routine.²⁸

More exotic IoT-driven interventions include remote surgery, which leverages the low latency of 5G systems. In China, one patient with Parkinson's disease recently received a remote brain surgery operation to install a deep brain stimulation impact while the doctor was 3,000 kilometres away; such innovations could be critical in a country of China's size allowing patients to access the best experts regardless of their location.²⁹

25 2018 Global health care outlook, Deloitte (2018)

26 Healthcare 2030, KPMG (2019)

27 Take Action Now to Avoid These Healthcare Pain Points in 2020, Software Advice (2020)

28 'Digital pill' for cancer patients, a first, aims to improve outcomes, Statnews (2019)

29 World's first remote brain surgery highlights the IoT's healthcare potential, Internet of Things News (2019)

CASE STUDY Smart health solutions: myAirCoach

Around the world, 235 million people suffer from asthma, a figure greater than the entire population of Pakistan (the world's fifth most populous nation).³⁰ An incurable lung condition, asthma causes breathing difficulties and is triggered by external conditions such as pollen, animal fur and pollution as well as infections like colds and flu. Asthma can result in tiredness, stress, anxiety and depression and, in some cases, attacks can be fatal.³¹ The WHO reports that over 80% of asthma-related deaths occur in low- and lower-middle-income countries.

Given its incurable nature, regular medical check-ups and vigilance in treatment are crucial to managing the disease. The most common form of asthma treatment is an inhaler. The treatment is effective if used at the right time, however poor inhaler technique is fairly common. Almost a third of participants in a recent study were not

patients themselves³⁴. Crunching this data, the tool can predict potential attacks up to a week in advance. This ensures that patients can use their inhalers before they start experiencing symptoms; helping to prevent a severe attack.

"We assess each factor individually and develop analytics to combine all these measurements and make predictions," say Dr Konstantinos Votis and Dr Dimitrios Tzovaras, Researchers at the Centre for Research & Technology Hellas / Information Technologies Institute (CERTH/ITI) in Greece³⁵.

The project has undergone user trials in the Netherlands and UK, and teams are on the verge of extending access to external patients. Furthermore, experiments to integrate smart inhalers with other IoT devices like FitBits are underway to help users better



MyAirCoach inhalers can predict a potential asthma attack up to a week in advance

using their device correctly.^{32, 33} Conventional inhalers do not provide significant self-management benefits beyond immediate symptom relief, while connected devices have the ability to help patients understand how changes in their environment could be laying foundations for future attacks.

myAirCoach, an EU-backed initiative, is experimenting with smart inhalers. These IoT-enabled devices analyse environmental conditions, including levels of pollution, temperature and humidity, alongside vital signs from

understand what triggers their individual symptoms, while also creating a new pool of data for research into the disease. "We want a solution that is open and can be integrated with other IoT devices. This is a decision we took when we designed the architecture, to support implementation with third-party services," says Dr Antonios Lalas, Postdoctoral Research Associate at CERTH. Additionally, the project has extended from personalized monitoring to IoT supported inhalation technique training for asthma and COPD patients in the form of a national funded project 'Take-a-breath'.³⁶

³⁰ Asthma, WHO

³¹ Asthma, NHS UK

³² Common inhaler mistakes, Asthma UK

³³ Systematic Review of Errors in Inhaler Use: Has Patient Technique Improved Over Time?, Science Direct (2016)

³⁴ myAirCoach

³⁵ Official website CERTH/ITI

³⁶ Take-a-breath

2.2.3 Logistics

Logistics made possible the global trade flows that brought millions of people out of poverty over the last three decades. However, sector-wide hurdles include waste, inefficiency, emissions and a need to keep pace with changing consumer purchasing trends. How can IoT help?

Optimising supply chains to reduce emissions, monitoring assets in transit to reduce product spoilage, and enabling the rollout of fully autonomous vehicles to improve road safety all rely on IoT development and deployment. The latest innovations in this area include artificial intelligence and machine learning systems that can flag supply chain problems based on variance between current asset movements and planned expectations and alert participants.

In transport fleets moving products to markets, sensors and analytics can notify companies of breaches in temperature and cold chains that could damage products like electronics, food and medicines. By connecting containers and assets to mobile networks, IoT sensors can show logistics managers, via a dashboard or virtual control tower, where assets are, how fast they are moving and when they will arrive based on current travel and weather conditions in real time.³⁷ This can also be done in an energy-efficient manner, as today's sensors use low power and activate to initiate a response only when a threshold, like temperature, is breached.³⁸

As well as **optimising** the shipment of goods, IoT can also help improve efficiency in the various nodes along the transport network. Daniel Price, sees one growth frontier for logistics IoT in **monitoring** facilities in supply chain nodes. "At shipyards or deep industrial settings things can get dirty and greasy and require automated cleaning," says Price. "These tools are now digitally connected and intelligent, so industrial IoT is not limited to manufacturing assembly lines."

Alex Gluhak, Head of Technology (IoT) at Digital Catapult, the UK's leading agency for the early adoption of advanced digital technologies, also sees potential gains in logistics **monitoring**. "A quick-win IoT is where you have a lot of human involvement activity doing repetitive periodic tasks related to compliance or monitoring of assets. An example is where you need to do regular measurements on the condition of assets you are going to ship around the world to ensure compliance, like stock levels in warehouses, how full an oil tank is and the temperature in fridges. Anywhere where someone goes with a notebook, you can automate with IoT and cut a lot of costs".

37 The New IoT-Powered Supply Chain: How Smart Logistics Tracking is Creating a Leaner, More Agile Global Economy, Sigfox

38 5G and IoT are revolutionising the logistics sector, here's how, Raconteur (2018)

CASE STUDY Data-driven supply chains: Traxens

Visibility of real-time supply chain dynamics is a significant pain point for participants in the logistics sector. For instance, one survey found that only 6% of firms were confident with the amount of information they receive on their supply chains.³⁹ An opaque supply chain has serious implications. This rings true in the current global environment. As early as February, Fiat had to halt production at its European plants due to problems in shipment of parts from China. While, in Singapore, disruption led to food being left to rot in farms while shop shelves stood empty in the city centre.^{40, 41}

One of the reasons that visibility is so hard to achieve is the truly global nature of the world's supply chains. Firstly, this means goods often travel across multiple borders where customs checks, sometimes still done with pen and paper, can cause unexpected delays.⁴²

temperature, humidity, pressure and movement. Sensors even detect whether doors have been opened during a journey. This raw data is helpful to users, including shipping lines, cargo owners, freight forwarders and ports, but to be actionable, it requires analysis. "A dot on a map indicating where a container is limited in terms of service; we go much further in letting our customers know the estimated time of arrival, or confirming that a GPS position is a depot. This is far more useful and goes over predictive and preventive management," says Hanane Becha, innovation and standards senior manager at Traxens.

However, developing sensors and analytics is just the first step in the process. Global supply chains transfer goods from country to country, system to system and company to company. Global data standards that capture and share supply chain data across players

Only 6% of firms were confident with the amount of information they received on their supply chains

Secondly, goods transportation typically involves large, sealed metal boxes that cannot be easily checked for changes in conditions or damage to the products inside.⁴³

IoT systems are a game-changer in tackling visibility problems. Traxens, a logistics data specialist, has developed sensors and analytics that are placed inside trade containers to track conditions, including

are key. A synchronised digital picture of the supply chain can enable automated workflows and help regulatory agencies who need detailed information about consignments arriving at their borders. Traxens is leading the charge to develop the first standards for smart container data exchange, which have been published by the United Nations Centre for Trade Facilitation and Electronic Business.

³⁹ Only 6% of companies believe they've achieved full supply chain visibility, Supply Chain Dive (2018)

⁴⁰ The Big Read: Global supply chain shock has farmers dumping food as consumers fret over shortages, price hikes, Channel News Asia (2020)

⁴¹ Supply chains have been upended. Here's how to make them more resilient, World Economic Forum (2020)

⁴² SMART Borders, World Customs Organisation (2019)

⁴³ Top 25 causes of container claims, UK P&I Club (2017)

2.2.4 Transport

The presence of brightly coloured bikes and scooters across urban centres makes personal transportation one of the most visible ways IoT is changing the way people live, shifting vehicle usage of all kinds from an ownership model to a sharing economy.

Ride-hailing, vehicle-sharing and on-demand mobility solutions, like e-scooters, are among the innovations that could improve the agility and efficiency of transport, especially in cities, by **connecting** urban residents with low-cost mobility options. This is especially the case for “first and last mile” transport options, which provide highly personal routes from and to public transport stations from someone’s original or final destination.⁴⁴ These innovations must be ‘smart’ and digitally connected to allow maintenance, fleet coordination and accurate pricing and billing to be linked to the apps.

For example, e-bike fleets are equipped with sensors meaning someone leaving a station can easily locate a bicycle using the app on their phone. The user unlocks the vehicle through the app and speeds to their final destination using the motor-assisted pedalling. On arrival, the user stands the bike in a safe location and locks it using the app, leaving it ready for the next rider.⁴⁵ These last mile options have been shown to do everything from decreasing journey times and reducing urban car usage and ownership to maximising efficiency for public transit operators.⁴⁶ Additionally, Dimitrios Spiliopoulos, IoT Business Consultant and Adjunct Professor of Internet of Things at the MBA of IE Business School, points out that these bikes can also have connected lights that collect data

related to road surface quality, prevalence of accidents, air quality, and stealing incidents, which is used by users, the scheme operators as well as city planners.

Connecting these vehicles to information networks creates a data resource. Transport for London’s Bicycle Share makes all of its journey data available online. This helps support over 600 different travel apps, used by almost half the urban population, letting residents **optimise** their commutes and journeys and adjust to short-term problems like engineering works, traffic or transport delays.⁴⁷ According to Sascha Westermann, Head of Project Management Office for the Intelligent Transport Systems Projects of the City of Hamburg operated by Hamburger Hochbahn AG, “the next step for many urban areas is to connect all mobility services, from first and last mile to normal public transit, into one consumer-facing system” – a goal referred to as “Intelligent Transport Systems” or “Mobility as a Service” (MaaS).⁴⁸ This will help users access the range of transport options available to them from one system, improving overall efficiency. The effect of diverse approaches to mobility is already being seen in consumer studies; almost 40% of car owners surveyed by KPMG in 2019 did not think they would own their own vehicle in 2025.⁴⁹

Personal transportation also shows how IoT can facilitate cross-sector collaboration. Aside from reducing overall ownership, a sharing economy for personal transportation also speeds up adoption of new, greener technology, such as electric vehicles. IoT-enabled network management also supports the mass rollout of electric vehicles (EVs) by enabling monitoring systems that can ensure availability.

44 The first and last mile — the key to sustainable urban transport, European Environment Agency (2019)

45 Shen, S., Wei, Z. Q., Sun, L. J., Su, Y. Q., Wang, R. C., & Jiang, H. M. (2018). The Shared Bicycle and Its Network-Internet of Shared Bicycle (IoSB): A Review and Survey. *Sensors* (Basel, Switzerland), 18(8), 2581. <https://doi.org/10.3390/s18082581>

46 How Have Travelers Changed Mode Choices for First/Last Mile Trips after the Introduction of Bicycle-Sharing Systems: An Empirical Study in Beijing, China, *Hindawi Journal of Advanced Transportation* (2019)

47 Future of Mobility the transport system, UK Government Office for Science (2019)

48 Ibid.

49 Chapter 3: The rise of on-demand mobility and MaaS, KPMG (2019)

“Imagine 20 EVs arrive in a parking lot, a shopping centre, an employment area, at the same time and all need to recharge,” says Michael Enescu, co-founder and chief technologist at Energy Adaptive Networks. “You want to have an adaptive grid between them that doesn’t burn your circuits. A traditional infrastructure that has 20 separate circuits is not compatible with reality today. You need a smart network that balances them and rotates the energy pulse across those EV chargers. This is a win for the infrastructure sector, a win for the energy sector, a win for the city”. By facilitating the mass uptake of EVs, such innovations can help the industry **monetise** following significant R&D outlays.

Over time, transportation will also benefit from the scale effects that come with IoT networks and supporting regulations. For instance, Europe’s eCall regulation, which requires new cars in Europe to include equipment that automatically notifies emergency services in the result of a serious accident, is helping push all manufacturers towards connected car innovations. One forecast predicts that shared driverless cars could cut total US auto sales by 40%, requiring automakers to shrink dramatically if they are to survive.⁵⁰ The smart-car era could also give rise to new services and innovations that mainstream incumbent companies could take the lead in, in terms of innovation, like on-board diagnostics and usage-based insurance/pay-as-you-drive.

⁵⁰ Who owns the road? The IoT-connected car of today—and tomorrow, Deloitte (2015)

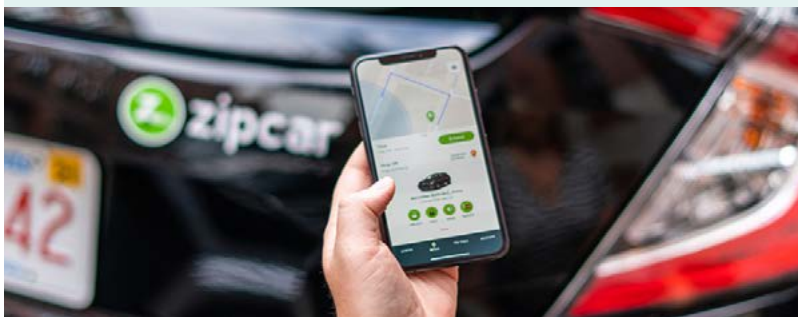
CASE STUDY Transforming car ownership: Zipcar

Almost 285 million registered vehicles emitted over 4.6 metric tons of carbon dioxide in the United States alone in 2019.⁵¹ Over the past 20 years, the US transport sector's greenhouse gas emissions (GHG) increased more in absolute terms than any other industry.⁵²

Inefficiency is a big driver of transport's emissions problem. There are more cars in the US than there is demand for driving: the average car is immobile 95% of the time, and substantial amounts of time are spent not in necessary travel, but in 'cruising for parking'. Lack of infrastructure to accommodate demand for parking in cities further exacerbates the problem. Removal of open green spaces and vegetation to make room for car parks and roads compromises cities' abilities to naturally remove greenhouse gas emissions from the air.⁵³

reserve and locate a car through the app and use their phone as the "key" to start the engine. The 'black-box' then records the duration of the trip, which is billed to the member automatically. Connectivity thus enables network coordination and ensures a smooth user experience.

Having accurate location information has allowed Zipcar to add a significant proportion of electric vehicles (EVs) to their fleet. They were the first car-sharing provider in the US to introduce both electric (in Boston in 2002) and hybrid vehicles (in Seattle in 2003). With on-going testing for EVs in London and Sacramento, their vision is to be fully electric by 2025, however this will only be possible with further public and private investment in efficient and accessible charging infrastructure.⁵⁵



Zipcar's IoT enabled business model has taken over 400,000 cars off the road

Companies are transforming the personal transport sector from an ownership model to a sharing economy to tackle this inefficiency. One of the most successful examples is Zipcar. Described as a "software company that runs cars", they have over 1 million members worldwide and are credited with taking over 400,000 cars off the road.⁵⁴ Their business model is simple: each car in their fleet is equipped with an IoT-enabled 'black box' that is connected to the ignition. A user can

According to Zipcar co-founder Robin Chase, having EVs within a car-sharing fleet is a great way for consumers to get comfortable with using the vehicles, noting "people aren't as afraid of electric vehicles as they used to be".⁵⁶ This green business model means Zipcar alone lowers CO2 emissions from the transport sector by 1.6 billion lbs per year – equivalent to the total emissions produced by flying from London to New York over a million times.⁵⁷

⁵¹ Greenhouse Gas Emissions from a Typical Passenger Vehicle, United States Environmental Protection Agency (2018)

⁵² Carbon Pollution from Transportation | Transportation, Air Pollution, and Climate Change, United States Environmental Protection Agency (2018)

⁵³ The Environmental and Welfare Implications of Parking Policies, Environment Working Paper No. 145, OECD (2019)

⁵⁴ How Zipcar Customizes Cloud Foundry to Work for Them, Cloud Foundry (2018)

⁵⁵ ZipCar UK representative speaking with EIU

⁵⁶ Can Car-Sharing Culture Help Fuel an Electric Vehicle Revolution?, Inside Climate News (2017)

⁵⁷ Calculated using Greentripper (2020)

2.2.5 Retail

The retail sector today can be divided into two distinct camps: the physical retail sector, which has suffered disruption from the rise of ecommerce platforms – a situation that is being compounded by COVID-19 movement restrictions. And the internet retail sector, which is going from strength to strength – with over half of UK consumers now shopping online and the sector forecast to account for over 50% of all retail sales within 10 years.⁵⁸ IoT has the potential to support both sides, helping brick-and-mortar outlets leverage the very perks that digital players like Amazon pioneered, and online platforms manage ever expanding, complex supply chains. Broadening adoption could help reinvigorate the sector; overall the global IoT retail market is forecast to reach US\$94.4bn by 2025, a 21.5% compound annual growth rate from 2020.⁵⁹

Retailers are making the in-store experience more efficient and personalised, eliminating pain points like products being out of stock, and helping companies better **monetise** their customers. Target uses IoT to **collect** shopper data and provide personalised recommendations as they move through the store, enabled via a mobile app that gives product recommendations based on their location within the physical store. Bloomingdale's has won plaudits for digital transformation initiatives that include a 'scan and send' tool enabling in-store users that cannot find their size or colour to scan an item, check for its availability and have it

shipped to their home. Other gadgets include in-store notifications that alert users to nearby items on sale.^{60, 61}

Omnichannel retail is one key area where IoT is contributing. This approach decouples information from products, letting consumers seamlessly learn about, test and purchase products across physical and digital domains. For instance, retailers and manufacturers are using augmented reality to let customers see how a product will look in their home, or on their body. IKEA has built an app that lets consumer visualise how an item will look in a desired location in their home, and cosmetics giant L'Oréal offers AR-enabled visualisation through an app on which customers can see how different lipstick shades would look on them using their camera phone.⁶² Such experiential innovations can increase customer conversion and drive monetisation.

For wholly online retailers, IoT is helping stack, move and track products with greater precision. Amazon is the market leader, using an army of 100,000 robots to move products around its warehouses for sifting and sorting by human workers.⁶³ It is also developing wearables like buzzing wristbands that direct employees to the correct shelf locations, freeing up their hands and eyes, which no longer need to look at scanners and screens to navigate around warehouses [See **Geek+** case study for more details].⁶⁴ Amazon has also stepped up its use of IoT in response to the current COVID-19 crisis. Operationally, it has started using thermal cameras in UK warehouses to monitor the health of staff

58 Half of UK retail sales will be online within 10 years, report predicts, The Guardian (2019)

59 IoT in Retail Market Size Worth \$94.44 Billion By 2025 | CAGR: 21.5%, Grand View Research (2018)

60 Bloomingdale's, JC Penney, Lids Top Omnichannel Retailers List, MyTotalRetail (2019)

61 The Internet of Things (IoT) in the Retail Industry, Digiteum (2019)

62 L'Oréal's ModiFace brings AI-powered virtual makeup try-ons to Amazon - Press releases, L'Oréal (2019)

63 Amazon's Growing Robot Army Keeps Warehouses Humming, Bloomberg (2019)

64 Wrist Watching: Amazon Patents System To Track, Guide Employees' Hands, NPR (2018)

based on body temperature variations.⁶⁵ It is also helping the UK's health service to build a public service response platform, providing infrastructure that allows the NHS to **collect** information on issues like occupancy levels of hospitals and capacity of accident and emergency (A&E) departments.⁶⁶

One area where both online and in-store retailers can benefit from adopting IoT is in inventory management. Here, tags placed on products known as RFID tags allow store managers to remotely monitor stock levels, both on the floor, in the stock room and the immediate supply chain.⁶⁷ These tags can be passive meaning power from a scanner is needed to activate them, or in cutting-edge adoptions, they can contain low-power battery cells meaning the tags themselves transmit location information.⁶⁸ One of the most important benefits of these systems is improving accuracy. For example, use of a RFID system achieves around 95% accuracy in inventory visibility, compared to an average of 63% in non IoT enabled systems.⁶⁹

65 Coronavirus: Amazon using thermal cameras to detect Covid-19, BBC (2020)

66 Amazon's actions to help employees, communities, and customers affected by COVID-19, Amazon (2020)

67 IoT-driven inventory management, Science Soft (2018)

68 IoT-driven inventory management, Science Soft (2018)

69 GS1 US Standards Usage Survey (2014)

CASE STUDY Flexible operations in the ecommerce age: Geek+

The emergence of COVID-19 has caused massive challenges for retail sector supply chains, with companies facing inventory depletion as consumers stockpile, and production losses as workers take time off for illness or are furloughed.⁷⁰ While a demand surge triggered by a global pandemic is unprecedented, annual events such as Black Friday, Cyber Monday and Singles Day (an online shopping festival in China hosted by Alibaba every November) mean e-commerce retailers increasingly need to scale operations up quickly to adapt to new consumer habits. For example, during the US 'holiday shopping season' (the five days from Thanksgiving to Cyber Monday) in 2019, over half the population shopped online or in person, an increase of over 24 million shoppers compared to 2018.⁷¹

Retailers are struggling to adapt to this new reality; 40% of sector executives said they experienced an operations issue during Black Friday/Cyber Monday at least once in the past three years, resulting in revenue losses and a negative impact on brand perception.⁷² Additionally,

Crucial to this process is using data to work out the most efficient sorting strategy through smart order-grouping. "What makes this system intelligent is the software powering the robots, not the hardware" says Chief Technology Officer, Hongbo Li. Robotic solutions are particularly helpful when it comes to scaling up for peak demand periods. "It is not always easy to find workers, especially temporary ones that can come during peak seasons" says Hongbo. "To meet this demand, you would have to double or triple your workers and then let them go. You can add robots seamlessly, though, and then take them out".

Geek+'s philosophy is to use automation to figure out how robot and human workers can most efficiently collaborate. Their core team is interdisciplinary, combining experts in computer science and robotics with those with backgrounds in factory operations. "That's the strength – putting these skill sets together so you have hardware, software and algorithms. Operational experience is particularly important in designing a smart factory

"[In the periods of high demand] you can add robots seamlessly"



more than 80% of respondents said they were at least somewhat concerned about the efficacy of their supply chain in these periods of high demand.⁷³

These new industry dynamics call for smarter manufacturing and sorting innovations. Geek+, a smart retail supply chain company headquartered in Beijing with offices around the world, uses software-powered robotics and intelligent warehouse management systems to make goods logistics more efficient, flexible, safe and agile. Robots can reduce the time spent by humans searching for items in large facilities. Instead of a worker picking an item from shelves in a big building, robots can bring shelves to picking stations where workers are situated.

system", says Hongbo. "There are companies that can create a nice robot, but they are not going to bring value if you don't understand the application".

While Geek+ originated in Asia, it has operations globally, including in Europe, where it gained trading approvals for its warehouse robotics in early 2018.⁷⁴ Its current markets include Poland, as a supplier for MW (a logistics company), and Russia, where it has deployed robotics for retail product refreshment in sports store Decathlon.⁷⁵ Its offerings could provide a 'facelift' for Europe's legacy warehouses and help address labour shortages.⁷⁶

⁷⁰ COVID-19: Preparing Your Supply Chain in Times of Crisis, Publicis Sapient (2020)

⁷¹ Why Black Friday Had More Online Shoppers Than Cyber Monday, And 3 Other Trends From Retail's Big Weekend, Forbes (2019)

⁷² New research shows retailers' state of mind ahead of Black Friday/Cyber Monday, GoogleCloud (2019)

⁷³ New research shows retailers' state of mind ahead of Black Friday/Cyber Monday GoogleCloud (2019)

⁷⁴ Geek+ Robotics Receives CE Mark Approval for Warehouse Robots System, Geek+ Robotics website (2018)

⁷⁵ Geek+ Success Stories, Geek+ website [undated]

⁷⁶ On offer: a hassle-free digital facelift for Europe's legacy warehouses, The Daily Telegraph [advertisement feature] (2019)

2.3. Telecommunications as a partner

At the root of IoT lies internet connection. Telecommunications companies have traditionally supported IoT by providing this rapid and reliable connection. This fundamental, although relatively straightforward, contribution is a result of current IoT innovations being built largely within the confines of the bandwidth and speed offered by the conventional internet. Once the telecoms company has provided the initial internet connection, many companies have been able to run basic IoT services without further telecoms involvement.^{77, 78, 79}

However, telecoms companies are now starting to move beyond this, supporting partners in developing data analytics capabilities to understand the information from their IoT devices. “[Telecoms companies] have been providing interactive platforms that help companies gather data, analyse it and glean more insights,” says Matthew Kendall, Chief Editor of Technology and Telecoms, at The Economist Group.

Partnerships are also expanding into IoT education. Telecoms companies are sharing expertise about how IoT products and services could benefit business clients. “A lot of companies are reluctant to engage in IoT because of the cost and complexity and the fact they do not have knowledge about big data and analytics,” says Matthew Kendall. “Telecoms companies are trying to move towards an educational and support role. Those with the resources and skills have moved quickly, not just to enable IoT through infrastructure but to be an educator too”.

IoT, Telecommunications and 5G

Today, cutting edge IoT applications are increasingly requiring faster and more flexible internet connections, which are only supported by new 5G networks. According to Matthew Kendall, “There are certain areas in which IoT has been constrained by the lack of 5G.” For example, the traditional internet cannot move the large quantity of data generated by IoT devices quickly enough to allow for real-time automated responses. 5G on the other hand will bring quicker data transmission and more bandwidth, enabling more devices and systems to be connected to the internet.⁸⁰ This improved coverage is a result of 5G’s decentralised structure: small cells usually placed on urban infrastructure, such as lampposts and bus shelters, bring the source of internet connections closer to users. This decreases latency, the time it takes devices to communicate with wireless networks.⁸¹

This is the next step for telecoms companies: providing the digital infrastructure required for 5G, and, ultimately, IoT. Forward-looking operators have already created dedicated IoT business units. Their efforts include running pilots, creating test beds and innovation hubs to create the next generation of internet products and services. This involves working with partners including governments, start-ups and software companies. For example China, one of the global leaders on 5G, ran the first ever government-industry test bed on the new technology in 2017-2018. This partnership allowed local and international companies to trial pre-commercial products on the pilot 5G network and supported the development of the first standards for the new technology.⁸²

77 The “Bank of Things”: The Application of IoT in the Financial Sector, Cyberstartup Observatory

78 Nanosatellite Telecommunications: A Market Study for IoT/M2M applications, London Economics (2017)

79 Telecom Crimes Against the IoT and 5G - TrendLabs Security Intelligence Blog, Trend Micro (2019)

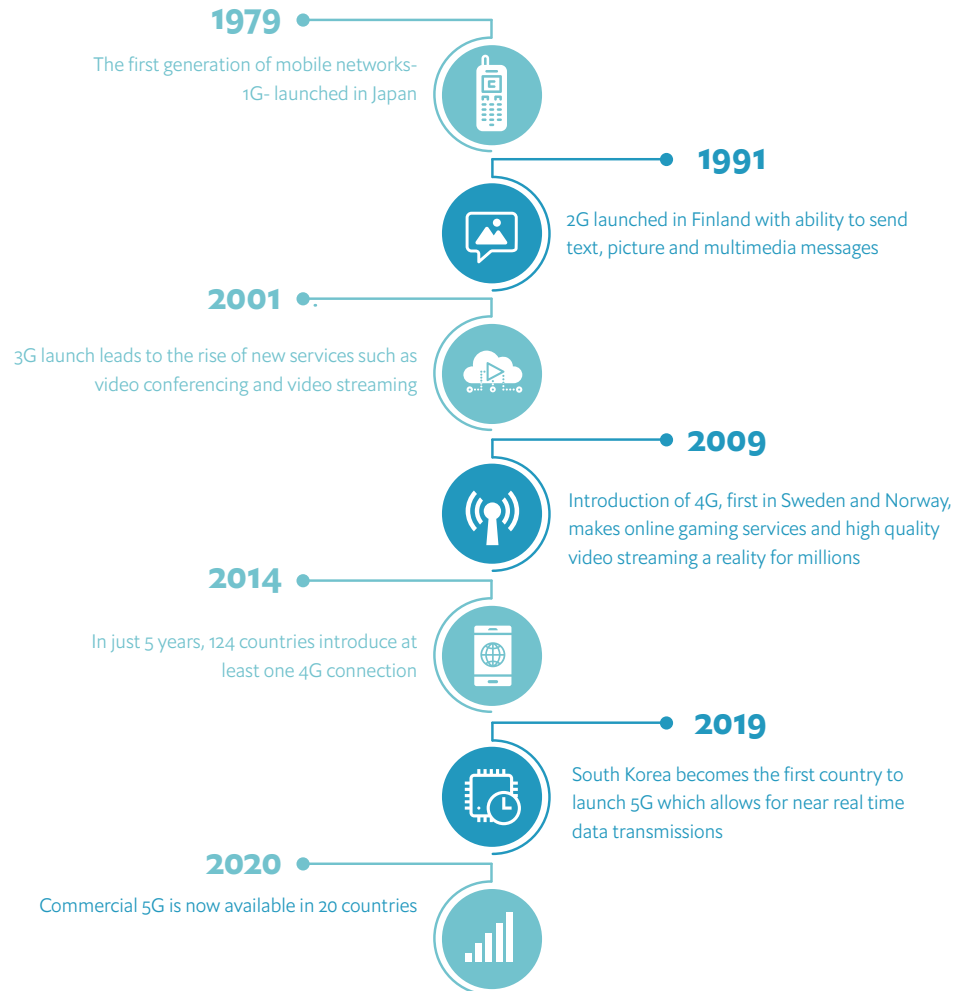
80 The road to 5G: The inevitable growth of infrastructure cost, McKinsey (2018)

81 Ibid.

82 China is Poised to win the 5G race, EY (2018)

High 5

The steady expansion of connectivity from 1G to the present day



Sources: Brainbridge, Open Signal, GSMA

One focus area of test beds around the world is combining 5G with Narrow Band IoT technology (NB-IoT). This standard is designed to deliver highly-efficient and cost-effective connectivity using only a small bandwidth. These features mean objects in hard to reach places (or inside buildings) can experience seamless connectivity with limited battery use.⁸³ This allows connections to run, without needing to be manually updated, for up to 10 years.⁸⁴ Though lower bandwidth does

restrict the amount of information that can be transmitted, this is not limiting for most IoT devices rather, by 2028, industry experts suggest low power connections such as NB-IoT will account for over 60% of all IoT connections.⁸⁵

For the telecoms industry, 5G gives them an opportunity to be “there at the beginning, in terms of offering services that help companies understand current and future IoT,” says Matthew Kendall.

⁸³ Low Power Wide Area Technology, Thales

⁸⁴ Specialised Narrowband IoT Services, Vodafone

⁸⁵ Growth in the IoT market will be sizeable, but challenges remain for operators Analysys Mason (2020)

Special report 2 – IoT and COVID-19: Agility, Resilience and Speed

COVID-19 has necessitated unprecedented changes in the way almost all companies operate. Some have had to scale up operations quickly to meet increased demand for their vital services and products or adapt working conditions to keep their employees safe. The Internet of Things (IoT) has been a key factor behind enabling these changes across several industries.

The most direct impact has been the use of data, sensors and robotics to allow healthcare workers to **collect** data on and **monitor** patients while keeping to safe distances. The Shanghai Public Health Clinical Centre, for instance, utilised a continuous temperature sensor that sends real-time readings to health professionals. Israel's Sheba Medical Centre opened a coronavirus telemedicine programme to allow physical isolation of patients, while a Washington-based medical centre used a robot to take vital readings using a stethoscope.⁸⁶ Sensors are helping to optimise public health surveillance measures, such as connected thermometers to screen patients and staff. One company is using data from over a million connected thermometers to produce daily maps showing which US counties are seeing an increase in high fevers.⁸⁷

Wearables and apps can also support the phase-down of physical distancing. Smartphone apps that utilise geolocation data have been central to the contact tracing deployed in Asia, and are likely to emerge in Europe and North America as countries move towards lifting quarantines in the coming weeks and months.

Liechtenstein has even launched a biometric wristband that sends data on skin temperature, breathing rate and heart rate to a Swiss lab. The project, which they hope to launch to the full population, may optimise public health responsiveness by allowing detection of the first signs of symptoms and, through calibrating algorithms over time, even enable better understanding of pre-symptomatic changes that could enable earlier detection.⁸⁸

Quickening the dawn of smart manufacturing

The manufacturing sector provides essential technologies and appliances for everyday consumers and specialist needs alike and has been hard-hit by COVID-19-driven physical distancing measures and border closures. The crisis is prompting two IoT shifts. One is the rise of pop-up manufacturers, including academic or start-up ventures, who are rapidly constructing key technologies, like ventilators, using 3D printers and open-source solutions for prototypes that can use off-the-shelf components, including windscreen wipers, to help integrate the efforts of engineers, clinicians and manufacturers.^{89, 90} Large engineering companies, such as Airbus, Jaguar Land Rover and Rolls Royce, have all promised to convert their factories to manufacture ventilators, although this will take time as they require significant software components.⁹¹

The second shift is pushing manufacturers to quicken their automation and robotics transition. Global brands including Siemens,

⁸⁶ 5 Ways Healthcare Tech Is Helping Tackle Coronavirus, HealthTech (2020)

⁸⁷ Digital thermometer data may provide insight into COVID-19 surges, Healthcare IT News (2020)

⁸⁸ Liechtenstein rolls out radical Covid-19 bracelet programme, Financial Times (2020)

⁸⁹ Coronavirus: Turning windscreen wiper motors into emergency ventilators, Sifted (2020)

⁹⁰ OxVent – COVID 19 Ventilation (2020)

⁹¹ How does a car company make a ventilator? Wired (2020)

GE and Rolls Royce are among the leaders in industrial IoT (IIoT) initiatives, which aim to **optimise** production by eliminating defects and sharpening supply chain efficiency. In 2018, global industrial robot installations reached US\$16.5bn, representing a 6% year-on-year increase, with China, Japan, the US, South Korea, and Germany accounting for 74% of global robot installations.⁹² The COVID-19 crisis is forcing companies to double down on their efforts to invest in robotics and automation, given the impact not just of physical distancing but also the complex approvals and staff monitoring that will be needed for those re-starting operations.⁹³

Manufacturers are also increasing their flexibility and agility going forward to **optimise** logistics, including packaging products, to allow straight-to-consumer delivery, accommodating sudden demand surges and ensuring supply chain partnerships are built on real-time decision-making and communication to enable informed decision-making during the crisis.⁹⁴ This can help them **monetise** inventory by meeting demand surges. COVID-19 is providing further impetus for companies to achieve more resilient and diversified supply chains, which requires investment in end-to-end visibility of goods and services. A crop of tech start-ups, **collecting** data on everything from transport and congestion to inventory levels, can help companies respond quickly to supply chain risks and shocks, such as identifying alternate transportation routes, providing workarounds for materials shortages and managing demand spikes.⁹⁵ These companies create tools such as operational dashboards that update in real time and allow multiple collaborating parties to efficiently post updates.

Smart cities are breaking down data barriers to help track cases and resources to fight the virus

Densely populated and hyper-connected cities quicken the spread of infectious diseases through increased human contact, but they also play a central role in preparing for, mitigating and adapting to pandemics.⁹⁶

Smart cities' big data systems can **collect** data on relevant changes, like population mobility and vehicle flows, in real time to reveal how policy responses are working and whether they can be further refined and **optimised**.⁹⁷ Examples of IoT-related response measures include an analytics model in Italy, which estimates variations in public movements through national, regional and municipal areas based on **collecting** anonymised, aggregated location data from connected vehicles' sensors, navigation systems, and mobile applications. This can help assess the success of containment measures and allow more nuanced COVID-19 monitoring once measures are eased off.⁹⁸

Researchers from the University of Newcastle have also developed a way of tracking urban movement to understand if social distancing is being followed – and whether it works. It applies machine learning to around 1.8 billion data points including traffic and pedestrian flow, car park occupancy and bus activity based on GPS trackers.⁹⁹ Their work showed a 95% reduction in pedestrian movement after strict regulations were enforced. The tool can also show whether pedestrians are abiding by the minimum two-metre distancing rule, an important factor to consider in discussions

92 Executive Summary World Robotics 2019 Industrial Robots (2019)

93 The rush to deploy robots in China amid the coronavirus outbreak CNBC (2020)

94 How will COVID-19 impact the manufacturing automation market?, Manufacturing Automation (2020)

95 Supply chain issues in a world of Covid-19, Engineering & Technology (2020)

96 COVID-19: How cities around the world are coping, World Economic Forum (2020)

97 Smart cities for emergency management, Nature (2020)

98 COVID-19 emergency, Enel X is at your side with City Analytics - Mobility Map, Enel X (2020)

99 This is how smart city technology can be used to tell if social distancing is working World Economic Forum (2020)

around lifting quarantines while the virus is still circulating.¹⁰⁰

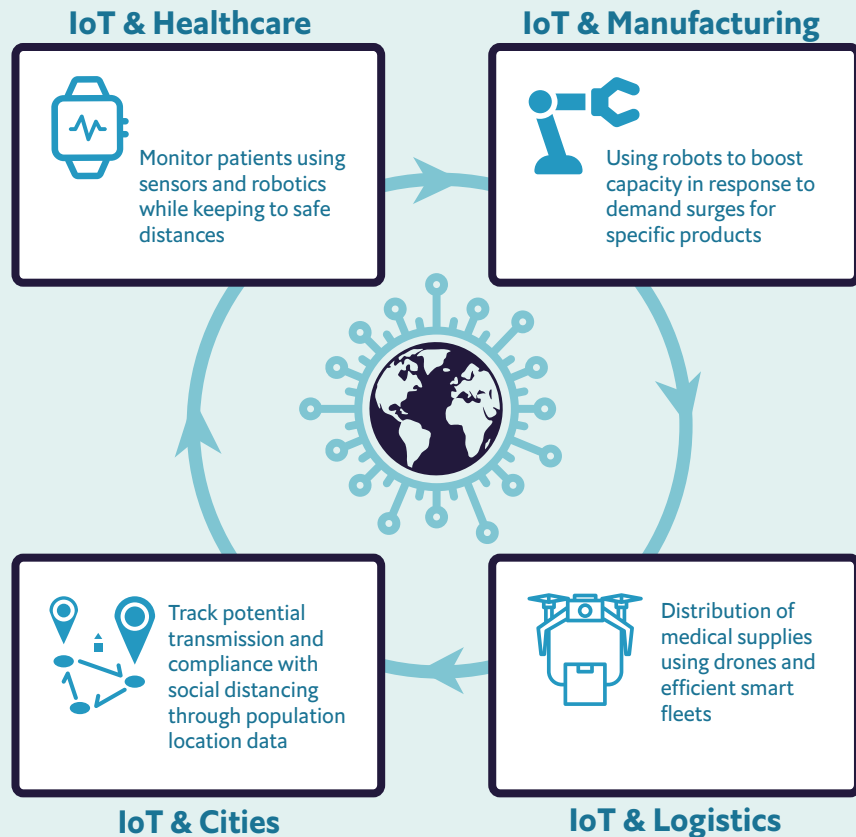
IoT can also help in fostering the co-creation of useful tools to connect urban residents to resources they need. For instance, South Korean innovators have built helpful portals, such as sharing data on locations where people can buy masks¹⁰¹, while drones are being used to monitor and enforce Shelter-in-Place laws, disinfect streets and issue public information through loudspeakers.¹⁰²

Logistics industry helps ensure frontline workers have the protection they need

COVID-19 has caused huge logistics challenges as governments and companies try to keep the trade of essential supplies going despite lockdowns and closed borders and ramp up production and distribution of vital goods like face masks and medical equipment. Logistics industry investments in IoT have positioned the sector to provide much-needed help by connecting assets and vehicles that were once isolated from networks

Safe connections

Internet of Things has been critical in enabling changes required for industrial responses to COVID-19



Sources: EIU 2020

¹⁰⁰ This is how smart city technology can be used to tell if social distancing is working, World Economic Forum (2020)

¹⁰¹ South Korea throws up innovative tech solutions in coronavirus fight, The Straits Times (2020)

¹⁰² IoT take up gaining traction in the coronavirus crisis, Verdict (2020)

UPS has emerged as one leading company in the COVID-19 response effort, working to deliver components of coronavirus testing kits to countries around the world in cooperation with QIAGEN, a global provider of molecular diagnostics and sample preparation technologies.¹⁰³ The company's past investments in IoT enabled it to play this vital role. Following the 2010 volcanic eruption in Iceland, which led to the closure of large swathes of airspace over Europe, UPS was able to get its operations back up and running within a day thanks to investments in data and analytics, as connected devices and data allowed the company to deploy alternate modes of transport to restore services.¹⁰⁴

Drones are another IoT innovation helping **optimise** the distribution of medical supplies. Japanese company Terra Drone, for instance, deployed unmanned airborne vehicles to transport medical samples and supplies in China, and claims to have increased transport speed by more than 50%.¹⁰⁵ Antwork also used drones to ensure that medical samples and quarantine materials were transported between Xinchang County People's Hospital and Xinchang County's disease control centre.¹⁰⁶

¹⁰³ UPS – logistics for COVID-19 testing kits, Apex Insight (2020)

¹⁰⁴ Internet of Things (IoT) - UPS IoT strategy is fueled by analytics to bring business insight, CISCO

¹⁰⁵ IoT set to play a growing role in COVID-19 response, Technology Informa (2020)

¹⁰⁶ Drones to stop the COVID-19 epidemic, BBVA (2020)

3. What are IoT's challenges?

IoT has undergone several hype cycles over the last 20 years. To flourish, it requires synchronised technological advances across domains, from improving power and falling costs of chips and sensors to wireless connectivity that offers enough power, speed and flexibility. To date, inventors and enthusiasts have been the first adopters; the challenge going forward, says Alex Gluhak, is shifting to the mainstream.

Across different industries, IoT adoption has been lower than what experts consider commercially salient. A 2018 study by Capgemini found that, on average, only 36% of organisations were implementing IoT for optimising internal operations and many that had only deployed at one or two sites. Even businesses who had taken initial steps to implement IoT found they were adopting the technology more slowly than initially planned.¹⁰⁷

According to the 2020 IoT Business Index, almost half (47%) of respondents agreed “somewhat” or “strongly” that their progress with IoT has not happened as quickly as they expected. The Index also found that, on average, most companies who had started to adopt IoT were still in the self-described “planning” stages (51% of respondents), and a further third were in early adoption phases. Only 14% had moved into “exclusive or extensive” use cycles.¹⁰⁸

From our research, business leaders mentioned three key concerns hampering IoT adoption:

- 1 Security and privacy:** 62% organisations that were struggling to scale up IoT applications cited cyber security and data privacy threats as a top concern and a key reason behind not moving beyond initial pilots¹⁰⁹
- 2 Regulation:** 95% of businesses supported dedicated IoT regulation to help understand their responsibilities as vendors for IoT products¹¹⁰
- 3 Digital Infrastructure:** A third of businesses that adopted IoT felt they did not have the resources or workforce to scale their IoT project to full realisation.¹¹¹

To fully realise IoT's potential across industries and segments, these challenges need to be understood and addressed.

¹⁰⁷ Unlocking the business value of IoT in operations, Capgemini (2018)

¹⁰⁸ The IoT Business Index 2020: a step change in adoption, EIU (2020)

¹⁰⁹ Unlocking the business value of IoT in operations, Capgemini (2018)

¹¹⁰ High demand for IoT regulation, survey finds, GCN (2019)

¹¹¹ IoT Signals, Microsoft Azure (2019)

3.1. Security and privacy

As more devices are connected to the internet there are more ways for hackers to access smart systems, because every point in a network becomes an entry point. “Once a machine gets smart, it can be outsmarted by malware or backdoor programmes,” argues Irene Petrick, Senior Director of Industrial Innovation at Intel. “In many cases, security right now is an add-on. It’s not built into the sensors and the communication and the [computational systems]”. Anushka Kaushik, Associate Fellow in the Cyber Resilience Program at the GLOBSEC Policy Institute in Bratislava, explains “IoT devices have two principle attack surfaces (the technical term for places where malicious attackers will try and enter the system): the sensor or robotics equipment on the device itself and the connection between the device and the internet.”

IoT-era hacks include hijacking a Jeep’s steering system¹¹², entering a casino database via its internet-connected aquarium thermostat¹¹³ and accessing a baby monitor to threaten kidnapping.¹¹⁴ In addition, cyber researchers have demonstrated possible threats like manipulating pacemakers.^{115, 116} In the commercial sphere, IP and trade secrets theft and exfiltration are risks facing any company placing a product or service into an IoT system, and cyber threats can also threaten critical physical national infrastructures, such as utilities, gas, energy or water.¹¹⁷

Privacy is a linked area of concern, as more consumers are online. As AI converges with IoT, there will be growing challenges

like balancing personalisation of the digital experience with the need to maintain the privacy and confidentiality of data.¹¹⁸ This is where IoT becomes a central battleground in the debate on who owns data (the person or the collector). IoT gives companies more power to collect data from within peoples’ homes, aggregate it and sell it for a profit as a new product. As the person whose data is being collected, what rights do/should you have to that information or the gains made from it?¹¹⁹

IoT is turbo-charging data-sharing practices, often with limited transparency. One review of consumer health apps, like wearables, found 79% of those examined shared user data with third parties, such as credit agencies and private equity funds.¹²⁰ Privacy advocates have also criticised the emergence of public surveillance infrastructure, like facial recognition in public spaces without consent.¹²¹

Recommendations to address privacy and security challenges:

- **Establish codes of best practice among vendors and users, even when not mandated by law, helping to establish clarity between the two parties.** The key is informed consent and transparency. Any surveillance activity should be made clear from the outset to build trust, especially in public spaces. “If you don’t handle IoT with transparency, people may be concerned about issues like public surveillance and that information you are collecting is used in the right way,” says Alex Gluhak. Companies can also consider ways to share the economic and monetary value that comes from user

¹¹² Hackers Remotely Kill a Jeep on the Highway—With Me in It, Wired (2015)

¹¹³ How a fish tank helped hack a casino, The Washington Post (2017)

¹¹⁴ Hacker terrorizes family by hijacking baby monitor, Nord VPN (2018)

¹¹⁵ Security researchers say they can hack Medtronic pacemakers, CNBC (2018)

¹¹⁶ FDA warns patients and health care providers about potential cybersecurity concerns with certain Medtronic insulin pumps, US FDA (2019)

¹¹⁷ The Internet of Insecure Things, Australian Strategic Policy Institute (2018)

¹¹⁸ Leveraging the upcoming disruptions from AI and IoT, PWC (2017)

¹¹⁹ Defining IoT Business Models - Monetising IoT investments, maximising IoT skills and addressing IoT security, Ubuntu (2017)

¹²⁰ Data sharing practices of medicines related apps and the mobile ecosystem: traffic, content, and network analysis, BMJ (2019)

¹²¹ New details emerge of King’s Cross facial recognition plans, Financial Times (2019)

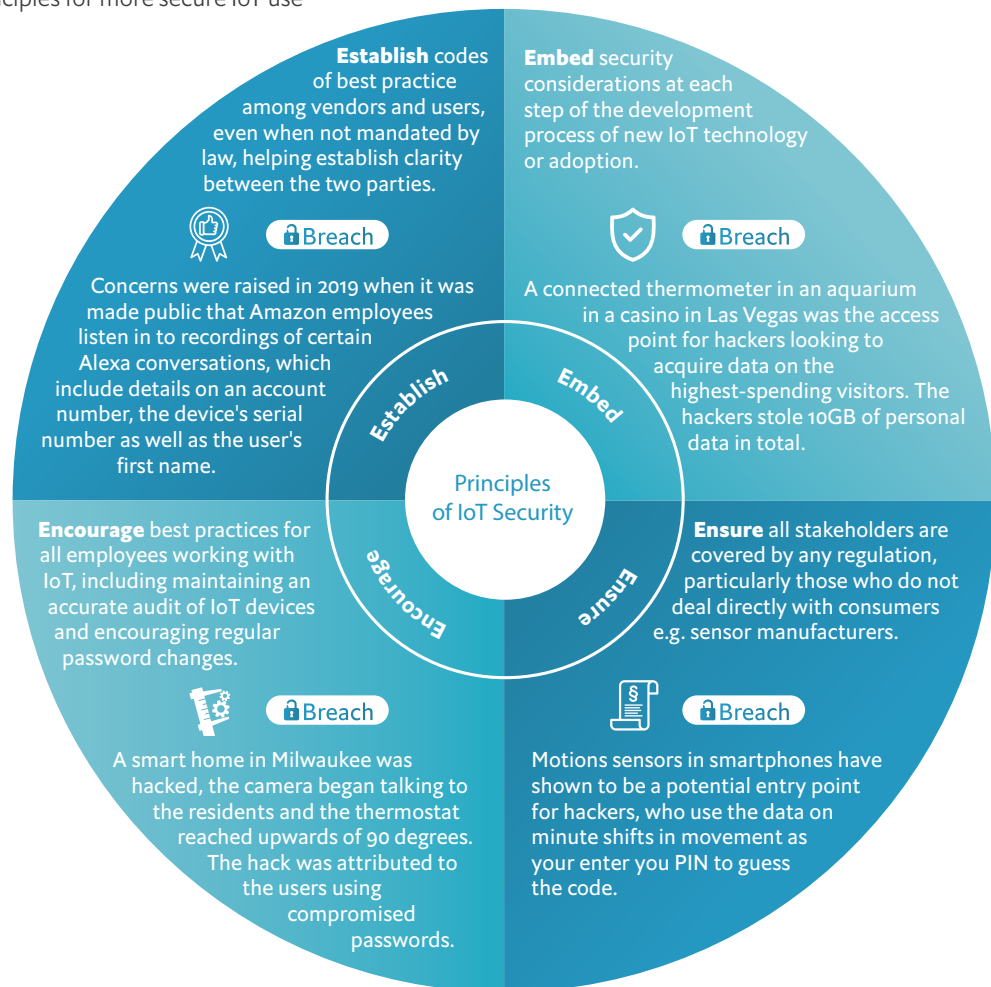
data. "We should look forward to a new world in which our data is a commodity, not just for businesses to profit from, but for us to be able to leverage in smart and sensible ways," says Glen Gilmore.

- **Embed security considerations at each step of the development process of new IoT technology or adoption.** "Firms should not move forward with deployment until the security of the device is guaranteed and tested", according to Heinrich Stüttgen, Chairman of the IEEE IoT Initiative Activities Board. One of the most effective ways to

test this has been to **create 'red teams'**. This is where 'friendly hackers' actively try and break your products and services to test security. Many benign cyber security researchers in academic institutions spend time tinkering with existing systems, from contactless cards to smart-key buildings, to find flaws and weaknesses that can inform their research and publications. Companies do not always welcome notifications that such researchers offer when they find vulnerabilities, but they should see this community as a force for good.¹²²

The internet of stings

Principles for more secure IoT use



Sources: Establish: Bloomberg 2019; Embed: IoT Now 2020; Ensure: Tom's Guide 2017; Encourage: Fox6 Now 2019

122 Race is on to build quantum-proof encryption., Financial Times (2019)

- **Ensure all stakeholders are covered by appropriate regulation – avoid adopting only a “top-down” approach focused on the final output** (e.g. data captured by IoT devices). According to Anushka Kaushik, policies, in particular, need to cover those who do not deal directly with consumers, including sensor manufacturers. Companies seeking to build IoT products, or layer IoT over existing products and services, often under-estimate how cyber security risks become more complex as a product moves out of the pilot phase into wider systems, says John Barrett, Head of the Nimbus Research Centre at Cork Institute of Technology. “Companies might successfully develop a small demonstration-scale application to show how IoT is usable within a company, but scaling that up and opening it to communications on a wider level can’t be done without a parallel consideration of the [wider] cyber security aspects.”
- **Encourage best practices for all employees working with IoT.** This includes maintaining an accurate audit of IoT devices and encouraging employees and customers to change passwords regularly. Many IT systems, whether involving IoT or not, are compromised when the humans operating them fail to follow basic principles. Though new UK regulation is looking to address some of these flaws by taking steps like removing default passwords, investing in cyber security skills in your workforce is also a fundamental step. According to Cédric Lévy-Bencheton, CEO of Cetome, a cybersecurity consultancy firm, new UK regulations will address some of these flaws by taking steps to remove default passwords and mandating a public point of contact by manufacturers for reporting IoT security issues.

3.2. Regulation

IoT does not fall under a specific regulatory framework, as it describes a vast array of products, services, processes, technologies and practices. That said, many privacy and security concerns are in principle covered in broader digital economy regulatory frameworks.

The EU General Data Protection Regulation (GDPR) is the gold standard for consumer data privacy, and has informed the development of similar frameworks elsewhere, like the California Consumer Privacy Act (CCPA). Globally, governments are working to align regional legislation with that of Europe; Japan and the EU, for instance, have agreed a bridging framework to bring their privacy regulations into alignment so data can flow between them. This trend toward harmonisation is an important one, according to Rachel Azafrani, an IoT and security expert and alum of the Oxford Internet Institute. She notes how “one of the biggest policy themes in IoT is governments creating their own security standards, which is producing fragmentation. If this goes on, it could require IoT manufacturers to comply with potentially dozens of different security policies all over the world. This could slow adoption and leave some jurisdictions with weaker security”.

In Europe, GDPR, combined with the e-Privacy directive, which governs communications over public networks, are the two pillars of data protection. According to Ana-Maria Fimin, a previous IoT and AI Policy Officer at the European Commission, there are “no gaps” in data privacy when these two are taken together, but there are issues for stakeholders around implementation. GDPR should be understood as an evolutionary process rather than a one-time reform, given the pace of innovation in digital technologies and practices.

There has been momentum towards IoT-specific legal frameworks although these lack regulatory teeth. Europe has published multiple policy papers, working documents and regional strategies for or encompassing IoT including Advancing IoT in Europe (2016), the European Strategy for Data and, in February 2020, the landmark Artificial Intelligence white paper. However, political instabilities in the year ahead, notably the COVID-19 crisis and the on-going Brexit process, indicate little near-term momentum.

Recommendations to address regulatory challenges:

- **Ensure proper technical skill sets among lawmakers to ensure appropriate and technically feasible regulation.** Due to the large divergence in salaries between the tech sector and government, there is an unsurprising deficit of technical expertise in some civil services. This could lead to knee-jerk regulation based on isolated public interest problems or poorly designed rules which cannot be executed in practice.
- **Regulation must be forward-looking and harmonised.** According to Rachel Azafrani “to advance the pace of change and the scale that IoT enables, both technically and for business, the rules governing the digital economy must be informed by best practices and harmonised globally”. Regulators need to respond to emerging threats by promoting multi-stakeholder consensus building for strong and adaptable baseline security standards to support global adoption of IoT.

3.3. Digital Infrastructure

To reach mainstream adoption and realise its full potential, IoT requires 4G network upgrades and the build-out of 5G networks to provide the requisite speed, low latency, increased device density and network flexibility. This represents a significant and expensive overhaul of existing infrastructure, including the deployment of small cells, which bring connectivity to users, and large-scale ‘fiberisation’. Investment and supporting regulation is critical. Countries or regions that fall behind in 5G will also find themselves on the wrong side of a widening digital divide. However, 5G rollout faces obstacles. Spectrum auctions have been delayed in some markets, like Brazil, over a lack of clarity over rules.¹²³ Financial costs are not trivial; most operators surveyed by McKinsey (72%) anticipate the shift to 5G will be expensive¹²⁴ and these costs come at a time when the telecoms industry faces squeezed margins and intense competition.¹²⁵

A less-discussed challenge is ‘soft’ infrastructure, like shared standards and interoperability protocols that can foster market coordination. For instance, smart cities are a promising IoT segment, but both urban authorities and vendors face a problem. Cities are cautious about being locked into one provider, while vendors want to develop solutions they can sell to multiple cities, rather than navigating different legal and technical environments. More interoperability could also create new business segments and opportunities. Peter Waher, Peter Waher, author of ‘Mastering Internet of Things’, member of the Connected City Alliance and editor for standards IEEE 1451.99, contributing member IEEE 2668, IEEE 2805., cited the example of allowing e-health services to use installed smart security systems to monitor

¹²³ Brazil 5G auction delay dents country’s tech ambitions, Financial Times,(2020)

¹²⁴ The road to 5G: The inevitable growth of infrastructure cost, McKinsey (2018)

¹²⁵ State of Digital 2019, European Telecommunications Network Operators Association (2019)

the elderly at home as a means of reducing some of the pressure on hospitals. “There is a lot of interest in this kind of an approach, but a lack of interoperability limits its development. It’s just a question of time, though, and we’re working on standardisation of this so that it can become a reality”. Dimitrios Spiliopoulos iterated similar concerns, “A smart parking application needs to be able to communicate with other applications in the smart city, such as car sharing, and ideally one application catering to both needs. A lack of such integration is one of the many reasons behind slower adoption of IoT by some cities.”

Recommendations to address gaps in digital infrastructure:

- **Governments and the private sector can work together to lower the financial cost of IoT and wider 5G rollout.** This might include smart city partnerships that give telecommunications companies access to urban infrastructure for small cell deployment in return for supporting municipalities with their own technological activities.. The cost of small cells can be reduced by 50% if three companies share the same network.¹²⁶
- **Develop alliances, shared standards and interoperability protocols.** Measures are needed to create IoT standards for connectivity, interoperability, APIs, data ontologies, data sharing (e.g. cloud services), protection of personal data, and security. Open standards are particularly valuable in IoT because they allow large-scale deployment and adoption and prevent lock-in.¹²⁷ Positive case studies include the SynchroniCity project, which harmonised platforms and interfaces and provided minimum interoperability mechanisms across 20 cities, allowing urban authorities to swap vendors and allowing suppliers to build

and scale services more easily, according to Alex Gluhak.

- **Skills convergence.** IoT development is a multidisciplinary endeavour requiring expertise stretching from hardware through to data science, cyber security, IP and regulation. Companies may need to upskill their workforce through short-courses, secondments, and modular learning, says John Barrett.

¹²⁶ A 5G manifesto for the CEO, McKinsey (2019).

¹²⁷ Advancing the Internet of Things in Europe, Eur-Lex (2019)

4. Conclusion

The transformative potential of the IoT is clear across sectors and regions. Any business leader involved in the making, moving or selling of objects needs to consider if they should be using this technology. Those who do not may miss out on tangible benefits, or be left behind competitors who have realised IoT-enabled gains in productivity or consumer experience.

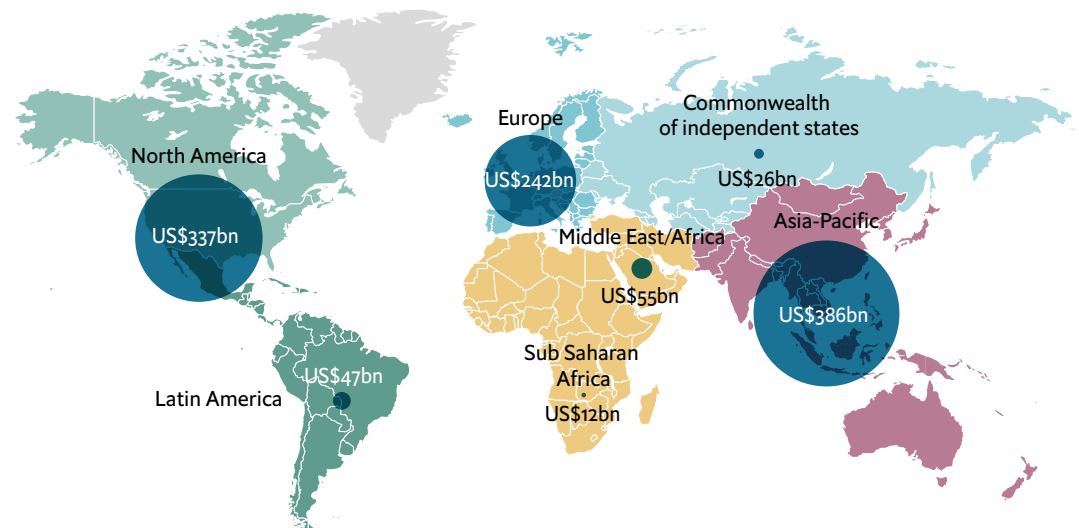
That is not to say IoT adoption is without its challenges, and not every business will be able to find a solution that works in 2020. Companies need to be aware of the security and privacy risks, the infrastructure—and, therefore, investment required—and the need to comply with regulation that is sometimes opaque. However, in each of these areas the perceived barriers may be higher than the real ones, and business leaders can do more to educate themselves on the tangible ways these obstacles can be mitigated.

What can business leaders do today to prepare themselves for tomorrow's "second phase of the internet"?¹²⁸ The fundamental message is that they need to be proactive:

- **Seek out collaborations with technical experts to understand how IoT may benefit their business.** Leaders should look to the growing number of experts in the field. This may include the work of ground-breaking companies, such as those profiled in this report, or dedicated internal IoT teams and taskforces.
- **Invest in digital infrastructure and skills as part of any new strategy.** IoT is not a cheap fix and in some cases will require a radical re-think of processes, equipment and personnel. Leaders need to invest upfront, in particular to ensure the most secure components are used throughout the process.

Internet of Everywhere

IoT will add US\$1.1trn to the global economy by 2025



Source: GSMA 2018

¹²⁸ How the world will change as computers spread into everyday objects, The Economist (2019)

- **Prepare for how IoT adoptions by competitors could disrupt their sector.**

Whether any individual company chooses to implement IoT or not, adoption rates are set to rise over the coming years. Sectors that have previously not faced disruption from start-ups in the first phase of the internet may find new tech-enabled companies in their markets.

Support exists for those who are inspired by the potential of IoT but are unsure of their own first step. In their preparations for the new IoT-enabled world, business leaders should remember the lessons of the first phase of the internet: early adopters feel the benefits most keenly and those who drag their feet are likely to find themselves suddenly in frame for their own Kodak moment.

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