International Chamber of Commerce
Policy and Business Practices

ICC POLICY PRIMER ON THE INTERNET OF EVERYTHING

PREPARED BY THE ICC COMMISSION ON THE DIGITAL ECONOMY

INTERNATIONAL CHAMBER OF COMMERCE
The world business organization

POLICY STATEMENT

SUMMARY AND HIGHLIGHTS

As today's technological advances are happening dynamically, only flexible, globally-minded, and industry-driven policies will continue to fuel innovation. The paper aims to improve the understanding of how the overarching technological concept "Internet of everything" can be understood. This paper offers recommendations for governments and businesses looking to harness and benefit from emerging technology. By explaining the existing and emerging elements of Internet of everything (IoE): Internet of things, machine to machine, the industrial Internet, industrie 4.0, and the ecosystem in which they operate (i.e., cloud and big data analytics), this paper evaluates the benefits and risks posed by their application and considers the governance models and industry practices that are emerging to support the IoE.

EXECUTIVE SUMMARY

Emerging technologies are being used in a variety of ways for societal benefit and are strengthening the global economy. As today's technological advances are happening dynamically, only flexible, globally-consistent, and market-driven policies will continue to fuel innovation. With an improved understanding of how the technology operates in practice, policymakers will be in a position to better determine which policies may be most appropriate to avoid unintended consequences and remove barriers or constraints to innovation.

In light of the growing deployment and application of emerging technologies, the International Chamber of Commerce (ICC) has developed this policy primer to improve the understanding of the overarching technological concept "Internet of everything" and how it is broken down into component and related parts. By explaining the existing and emerging elements: Internet of things, machine to machine, the industrial Internet, industrie 4.0, and the ecosystem in which they operate (i.e., cloud and big data analytics), the statement evaluates the benefits and risks posed by their application and considers the governance models and business practices that are emerging to support the Internet of everything.

Highlighting the cross sectoral ways emerging technology can be leveraged to help reach the United Nations Sustainable Development Goals (SDGs), ICC encourages policymakers to remove barriers to implementation and introduce new regulatory obligations only if necessary and supported by evidence based analysis. Governments should consult with stakeholders when reviewing the adoption of new technologies to consider whether existing regulation facilitates adoption or whether new issues may arise that would require a different policy response.

Specific ICC recommendations for policymakers include:

- Efficiently manage spectrum, invest in high performance and secure broadband networks
- Connect legacy systems
- Focus on accountability for the appropriate collection, use, and protection of data
- Provide robust and appropriate data protection
- Encourage commercially available solutions and drive innovation
- Enhance skills and training
- Enable convergence and adopt technology-neutral and interoperable approaches
- Sustain adequate and effective intellectual property protection
- Develop common or interoperable approaches between countries or regions
- Foster public-private partnerships

Business is taking important steps to ensure the full potential of the emerging technologies of Internet of everything are realised. In order to harness emerging technology and increase its societal and economic benefits, ICC encourages business to pursue efforts to:

- Address connectivity
- Design privacy and security strategies
- Enrich consumer experience
- Collaborate in open participation
- Manage data dynamically

ICC considers public-private partnerships as essential to facilitating the research, leadership, and governance required to advance an overarching Internet of everything vision and remains available to work with policymakers as they continue to define practical, optimally effective policies to reap the full benefits of the Internet of everything.

CONTENTS

INTRODUCTION

This paper provides a starting point for considering policy in light of how emerging technologies and their related ecosystems are catalysing sustainable development, enhancing applications across areas including healthcare, elder care, medical research, urban planning, logistics, environmental protection, resource management, education, strategic planning, and measuring effectiveness across all disciplines.

Emerging technologies are being used in a variety of ways for societal benefit and are strengthening the global economy. The ability to link the physical world and human activity with **sensors** and networks (including the Internet) and to gain insights through advanced analytics is transforming our daily routines, economies, and sectors of activity. **Ingestible sensors** assuring the proper timing and dosage of medication help doctors during clinical trials; real-time in-flight data collection from jet engines are used to identify and schedule necessary and preventive maintenance; embedded sensors and related analytics help enhance the independence of the elderly and visually impaired, and improve the quality of life in cities and rural areas.

Specifically, emerging technologies are expected to have a profound economic impact[1]. McKinsey estimates that the **Internet of things** (IoT) can have a total potential economic impact of $3.9 trillion to $11.1 trillion a year by 2025 and at the high end that level of value—counting the consumer surplus—would equate to around 11 % of the world economy.[2]

Through sensors and **actuators** connected by networks to computer systems, **machine-to-machine** (M2M), **industrial Internet** and Internet of things technology are able to monitor and manage the state and actions of connected objects, machines, humans and the world around us. There are more than nine billion connected devices globally and over the next decade this number is expected to increase, with estimates ranging from five billion to 25 billion in 2025.[3] These devices provide a rich new vein of raw data, doubling in size every two years[4], which will be correlated and analysed by ever more sophisticated techniques and algorithms, uncovering new relationships and insights that will foster development of innovative solutions across a broad range of applications.

This interaction of people and objects across and between themselves in computer aware environments, using cloud services supported by analytics is the intersection of the emerging technologies that are having a transformative impact on developed and developing countries alike. M2M, industrial Internet and IoT are all components of the **Internet of everything** (IoE) and it is predicted that there will be $14.4 trillion (USD) worth of “value at stake” over the next decade in the IoE economy, driven by “connecting the unconnected”.[5]

Although the terms IoE and IoT are often used interchangeably, it is useful to recognise IoE as an overarching term in which IoT is not a synonym, but rather an important component. For example, IoE encompasses the interaction of people, objects and processes in which IoT is one of the components. This differentiation highlights the interconnected and interdependent

1 McKinsey Global Institute, Internet of everything: Mapping the value behind the myth, June 2015

2 McKinsey Global Institute, Internet of everything: Mapping the value behind the myth, June 2015

3 McKinsey Global Institute, Internet of everything: Mapping the value behind the myth, June 2015

4 EMC Digital Universe with Research & Analysis by IDC. The digital universe of opportunities: Rich data and increasing value of the Internet of Things, April 2014

5 White Paper. Internet of Everything: A $4.6 trillion public-sector opportunity, 2013

nature of emerging technologies and distinguishes IoE as the term that captures the entire object ecosystem.

Contributing to the valuable potential of IoE application is the ecosystem in which the emerging technologies operate, which also includes **cloud computing** and **big data**.

Discussed in more detail later, cloud services and big data help emerging technologies within IoE add greater value—enabling all stakeholders to benefit from physical and virtual interactions, without which analytics would be meaningless. The cloud is able to store and secure generated data which can then be analysed and transformed into actionable information through big data analytics. Thanks to the cloud and big data, IoE not only connects objects to one another but actively accumulates and analyses behaviours, processes, and things (i.e., all data) so that the information and intelligence generated can be used to improve decision making and in turn enhance the global economy. Indeed, one of the most promising aspects of big data analytics is its potential to deliver predictive insights.

IoE is on a trajectory of exponential and unparalleled growth that could be truly transformative. These transformational opportunities will significantly impact the entire marketplace across numerous sectors from manufacturing and transportation to utilities and healthcare—fueling gross domestic product (GDP) growth, creating new jobs, and boosting trade and the global economy.

As today's technological advances are happening dynamically, only flexible, globally-consistent, and market-driven policies will continue to fuel innovation. With an improved understanding of how the technology operates in practice, policymakers will be in a position to better determine which policies may be most appropriate to achieve the benefits of IoE. Decision-makers also need to better understand which polices may create unintended consequences, or act as unnecessary barriers or constraints to innovation or technology use.

Removing policy barriers, limiting needless burdens, and minimizing unintended consequences are essential factors where government plays an important role. The role of government is also important in facilitating and incentivizing the use of emerging technologies in a number of ways and as an early adopter can help create familiarity and trust in new technologies. Working in conjunction with business and other stakeholders, governments play a crucial role in adapting existing privacy and security polices to create flexible, yet effective frameworks of trust that enable innovative uses of technology while appropriately protecting privacy and providing security.

This policy statement aims to improve the understanding of how IoE operates and offers recommendations to governments and businesses looking to harness and benefit from IoE. By explaining the existing and emerging elements of IoE: IoT, M2M, the industrial Internet, industrie 4.0, and the ecosystem in which they operate (i.e., cloud and big data analytics), this primer evaluates the benefits and risks posed by their application and considers the governance models and industry practices that are emerging to support the IoE.

THE BUILDING BLOCKS: EMERGING TECHNOLOGIES AND THEIR BENEFITS TO SOCIETY

The world is in the midst of a dramatic transformation from isolated systems to Internet and network- enabled devices that can communicate with each other and the cloud. This new reality is being driven by the **convergence** of increasingly connected devices, enhanced computing power and economies of scope and scale, as well as the proliferation and acceleration of cloud computing and big data analytics. This shift in technology is generating unprecedented opportunities for the public and private sectors alike to develop new services, enhance productivity and efficiency, improve real- time decision making, solve critical societal problems, and develop new and innovative user experiences. IoE encompasses many different components; including M2M and the industrial Internet. In order to improve the understanding of how this technology operates in the greater ecosystem of interconnected and interactive systems and services, it is important to consider the underlying business models supporting this technology and the significant benefits their application is providing to society.

Internet of things (IoT)

IoT—the infrastructure that allows all types of devices and machines to communicate with one another—is one of the fastest-growing and most impactful technology trends. Simply stated, IoT is the connectivity that enables connected devices to interoperate. IoT connects the world's physical systems such as power meters, vehicles, containers, pipelines, wind-farm turbines, vending machines, personal accessories, and much more. McKinsey Global Institute identifies IoT as one of the most under-hyped technologies with great economic potential—on the scale of $2.7 to $6.2 trillion

(USD) of estimated global economic impact in 2025.[6] With such a pervasive reach, IoT is transforming how we live and work, with solutions that connect and monitor assets from virtually anywhere for almost any business sector. It is estimated that by 2025, best-in-class organizations that use IoT technologies extensively in their products and operations will be up to 10 % more profitable.[7]

Beneficial application

IoT application is providing opportunities to a variety of sectors including fleet management, energy management, connected car, health monitoring, and cargo management.

With cargo management, for example, logistics providers gain greater control when moving perishable or high-value cargo with a near real-time view of the location and condition of their shipment. Specifically, companies can use IoT technology to create intelligent container fleets to improve operations with information that is delivered based on specific business needs.

Likewise, healthcare is being transformed by IoT technologies, with the potential to improve health outcomes, reduce health expenditures and facilitate the offering of care in more patient-friendly ways. IoT provides enormous opportunities to reach the United Nations sustainable development goals (SDGs) including goal three: *To ensure healthy lives and promote wellbeing for all ages.*[8] For instance, wireless, body-worn sensors increasingly will allow the healthcare

6 McKinsey Global Institute, 2013, Disruptive technologies: Advances that will transform life, business and the global economy (p.12)

7 Verizon State of the Market: Internet of things 2016

8 http://www.un.org/sustainabledevelopment/health/

industry to free patients from a hospital stay that would otherwise restrict patient mobility. New heart monitor devices can be worn at home for extended periods of time giving doctors much more visibility into heart function during a variety of times and activities. If a patient were required to stay in the hospital for such evaluation the costs would be exponentially greater and the information generated would be less likely to reflect the actual patients lifestyle and habits. In-home healthcare also tends to enable a quicker return to normalcy for patients, facilitates the patients' interaction with their support network and limits the patients' exposure to hospital-born infections. Similar technologies are migrating into homes, allowing the remote and continuous monitoring of patients' vital information.

Case Study: *Healthcare organisations are increasingly challenged to maximize their healthcare funds by reducing costs and improving the speed and efficiency of diagnoses and care. IoT and remote monitoring can assist with this challenge by helping caregivers improve processes and lower the impact of acute health problems—especially those that could return patients to the hospital. Remote patient monitoring (RPM) software as a service (SaaS) solution uses a cloud-based platform to connect customer-provided, bluetooth-enabled peripherals with mobile devices and caregivers' monitoring systems. Participants receive timely automated healthcare guidance, and are able to conduct video conference calls that are initiated by caregivers through an intuitive user interface. Patients with chronic illnesses can follow their care plan via easy-to-use monitoring devices and simple-to-follow directions—all from home.*[9]

This medical information typically is wirelessly linked to a local monitoring hub (i.e., from a device to a router) in the patient's home, which then passes the information to the broadband network, routing it to the cloud where analytics continuously monitor a patient's status, notifying a healthcare provider of any anomalies. More broadly, the pharmaceutical supply chain continues to evolve and will require greater IoT visibility of products being distributed around the world. In addition, the field of **telehealth** holds the promise of extending the reach of healthcare practitioners into remote, underserved and high-risk areas.

Case study: *A powerful example of combining industry-leading clinical trial data capture and management solutions with emerging technologies are digital pills, which help health sciences organizations transform the drug development and approval process through the use of integrated software ingestible sensors for clinical trials. For example an integrated digital health feedback system, includes an ingestible pill sensor, a wearable patch, and a software system, with software that collects data to enable clinical trial researchers to track patients' medication adherence.*[10]

IoT is improving the quality of life and integration of elderly people in the community. Apart from home healthcare solutions, the elderly can benefit from safety and lifestyle enhancements facilitated by sensors in the home. IoT technology can securely collect, analyze and automate appropriate responses and actions to real-time data drawn from sensors and other devices within homes or other properties. The technology can identify and send alerts on acute emergencies requiring urgent intervention as well as identifying, tracking and monitoring trends and patterns

9 https://www.business.att.com/enterprise/Family/internet-of-things/iot-healthcare/

10 http://mobihealthnews.com/39612/proteus-oracle-launch-integrated-software-ingestible-sensors-for-clinical-trials/

over time that may be indicative of health or other problems. This information can be accessed securely and remotely, by people such as family members, emergency services or healthcare professionals who could intervene when there is an emergency or growing problem.[11]

Cloud-based services can also include medical image archive applications and security services, which will permit healthcare providers to share clinical data over a secure network. The network can host live video conferences between physicians and patients, as well as share images and medical records.[12] These are some of the many examples where IoT solutions can be integrated with people- based services to bring improved outcomes at a reduced cost. With a growing aging population, many deaths, and other health-related issues, could be prevented by installing an IoT connected sensor in the homes of vulnerable and elderly people.[13]

Advancing sustainability initiatives is another benefit that IoT offers. Smart information and communications technology achieved through IoT, has the potential to enable a 20 % reduction of global CO_2 emissions by 2030, keeping emissions at 2015 levels[14] according to recent reports. One of the most substantial benefits of smart ICT includes increasing agricultural crop yields by 30 % and saving over 300 trillion litres of water and 25 billion barrels of oil per year.[15] Thus, by enabling the smart application of ICT, IoT has the potential to reduce global carbon emissions and resource intensity, and to stimulate economic growth—helping the global community reach sustainable development goal 13: *take urgent action to combat climate change and its impacts*.[16]

In another example, traffic-utilising technology, namely digital real-time map and autonomous driving, will help solve fundamental real-world problems. An estimated 1.3 million people are killed as a result of road accidents every year worldwide. In addition, estimates suggest that cars are responsible for about 12 % of the total European Union (EU) emissions of carbon dioxide, one of the main greenhouse gasses. Autonomous driving, where cars effectively drive themselves (i.e., without human intervention), can have a massive impact considering that driver error is the cause of about 90% of all car crashes. Even if one assumes that autonomous driving would result in only 50 % fewer annual fatalities, that would be more than half a million lives saved every year. At the same time, autonomous cars could reduce annual CO_2 emissions by as much as 300 million tons. That is almost the same amount as half of all CO_2 emissions from current commercial aviation, globally.

Another important area of IoT opportunity is improving congestion management and reducing carbon emissions. In Europe, 70 % of the population now lives in cities and similar urbanisation trends have been observed elsewhere in the world. This increase in population density brings challenges in urban areas, such as traffic jams and increased pollution. Traffic congestion has economic, social, and environmental costs. Products have been developed for the automotive industry designed to ease traffic congestion, e.g. traffic forecasting products that can anticipate future traffic conditions in real- time, helping drivers to learn of delays in advance and avoid them. Another application is providing real time data to help urban drivers find parking more quickly and efficiently. While driving, 30 % of a car's greenhouse emissions are generated when finding a parking spot, technology can help drivers find parking more quickly and avoid unnecessary driving.

---

11 http://betanews.com/2015/05/27/internet-of-things-can-help-keep-the-elderly-safe-at-home/

12 http://www.computerworld.com/article/2513900/healthcare-it/at-t-rolls-out-patient-data-exchange--mobile-monitoring-services.html

13 http://betanews.com/2015/05/27/internet-of-things-can-help-keep-the-elderly-safe-at-home/

14 A recent report by the Global e-Sustainability Initiative and Accenture Strategy, and supported by the United Nations Framework Convention on Climate Change (UNFCCC), Global e-sustainability initiative, 2015 #SMARTer2030 ICT Solutions for 21st Century Challenges

15 Global e-sustainability initiative, 2015 #SMARTer2030 ICT Solutions for 21st Century Challenges

16 http://www.un.org/sustainabledevelopment/climate-change-2/

Logistics companies are able to use similar initiatives to obtain traffic footprints of urban centers to help define cost- and time-efficient routes for the delivery of vehicles.

Other examples under the smart traffic theme support sustainable development of urban areas through emerging technology. By combining ICT, energy and transport management it is possible to create innovative solutions to the major environmental, social and health challenges facing cities—making significant contribution to the global attainment of sustainable development goal 11: *To make cities and human settlements inclusive, safe, resilient and sustainable.*[17] Urban planning can achieve many gains through the use of modern remote sensing technologies. Using digital exhaust from cell phones, data can provide a footprint of pedestrian, bike and vehicular use of city resources which can be essential to urban planning of streets, bike lanes etc. For example, urban sensing projects provide a network of interactive, modular sensor boxes that can be installed around cities to collect real-time data on cities' environment, infrastructure, and activity for research and public use—measuring factors that impact livability such as climate, air quality and noise. Information generated allows researchers, policymakers, developers and residents to collaborate and make cities healthier, more efficient and more livable—saving costs by anticipating and proactively addressing potential problems like urban flooding.[18]

Resource efficiency is another key area where IoT will bring major benefits. Water management is a good example. Large-scale water systems can typically lose about 20 % in leakage before the end- customer is reached. In the future, an interconnected and programmable system that links sensors in pipes, homes and industrial premises, to cloud services with massive analytical capabilities will enable substantial amounts of water savings. Furthermore, that system has the ability to understand usage trends, weather forecasts, special events that drive demand, maintenance activities, new housing and factories coming online, and so on. Such a system could bring a completely new level of efficiency to water consumption around the world. Better capacity and demand optimisation, better network and leakage management, lower unbilled water volume, and much more.

Case study: *IoT is often perceived as a major enabler for the 'smart cities' of the present and future. IoT-powered smart cities aim at improving the quality of life of their populations in a variety of ways, including through measures that promote eco-friendly, sustainable environments and the delivery of 'connected health/care' services to citizens at home and on the move.*[19]*The Provincial Electricity Authority (PEA) of Thailand is to release a smart grid pilot project in Pattaya by early 2018 in a bid to improve citywide energy efficiency. The project is the first in Thailand and will allow PEA to understand consumer behaviour and utilise behavioural data to improve service delivery. Under the project, PEA will install 120,000 smart meters in homes, and construct a data centre for the processing of data. The authority chose to implement the smart grid pilot project in Pattaya due to the high-energy consumption rate in the popular tourist city. The project will allow inhabitants to access reports of their energy consumption on mobile devices as well as via PEA's web portal. The project is aimed at encouraging inhabitants to adopt energy-efficiency measures that can help them save money on their energy bills and offset price increases. Data analytics will also be used to produce a forecast of energy demand, savings and prediction, enabling efficient management of electricity generation.*[20]

---

17 https://sustainabledevelopment.un.org/topics/sustainablecities

18 https://arrayofthings.github.io/faq.html

19 https://ij-healthgeographics.biomedcentral.com/articles/10.1186/1476-072X-13-10

20 http://www.metering.com/thailand-prepares-for-2018-smart-grid-pilot-launch/

Food security continues to be one of the main issues on the global agenda as highlighted by sustainable development goal three: *End hunger, achieve food security and improved nutrition and promote sustainable agriculture*[21] and IoT shows great promise for agriculture by providing farmers with useful information such as weather reports and crop prices as well as educating them about new farming techniques. Through data generated from global positioning systems (GPS) and sensors on the field and farming equipment, and using big data analytics, farmers have been able to improve their activities spanning from crop yields to water utilization. This is important because by 2050 the global population is expected to grow by over two billion to nine billion people and in order to keep up with this population growth, food production needs to increase by at least 70 %.[22] Supported by data and analysis, farmers can benefit from precise advice about the seeds to plant, time to harvest, and expected yield.[23] Monitoring of crops and weather patterns is also used by international organizations to issue early warnings of famine or the shortages resulting from natural disasters. This can make it possible for governments to take preventive action in areas at risk.[24]

Case study: *In Indonesia, the factors contributing to the decline in cocoa production include effects of climate change, aging trees prone to pests and diseases, and lack of scientific knowledge on the crop at the farm level. As Indonesian cocoa farms and research stations are located in remote areas that require experts to travel for days in challenging conditions to access the field and the data, IoT solves one of the major challenges of access, via remote monitoring systems. As part of Indonesia's sustainable cocoa production program*

21 http://www.un.org/sustainabledevelopment/hunger/

22 http://www.sensegrow.com/blog/iot-remote-monitoring-smart-farms

23 http://www.sensegrow.com/blog/iot-remote-monitoring-smart-farms

24 https://www.itu.int/net/itunews/issues/2009/08/25.aspx

(SCPP), a remote site has been transformed into a smart cocoa research station that monitors environmental parameters, automatically manages data collection and storage, and transmits information to the cloud. The smart cocoa research station provides information to enhance sustainability and the commercial viability of important elements in the cocoa sector value chain. This involves coupling real time measurement of environmental factors with scientific observations and manual data collection from trees equipped with near field communication (NFC) tags.[25]

Machine-to-machine (M2M)

Machine-to-machine (M2M) broadly describes any technology that enables networked devices to exchange information and perform actions without human assistance through the Internet or other networks. In other words, M2M may be viewed as the non-human mediated application of IoT that usually involves some level of automated decision-making. Key components of an M2M system include sensors, including radio-frequency identification (RFID) tags, a Wi-Fi or **cellular communications** link and **autonomic computing** software programmed to help a networked device interpret data and make decisions. Products with M2M capabilities are sometimes referred to as "smart" products.

M2M technology is frequently used for remote monitoring. One example is product restocking, where a vending machine can directly message the machine's distributor when a quantity of a particular item is low. **Telemetry** is another well-known example of an M2M application that is used to transmit operational data. Pioneers in telemetry first used telephone lines, and later radio waves, in order to transmit performance measurements collected from monitoring instruments in remote locations. The role of telemetry has greatly expanded due to the Internet's increased presence to where it is now common place—that is, used in everyday products such as appliances and electric meters. Telematics is another example of M2M that enables manufacturers of equipment to remotely correct mechanical problems via software adjustments.

Beneficial application

With its varied applications, M2M presents new opportunities for business. In its early days, M2M focused on using data on stock levels in supply chains to create efficiencies. M2M is now also an important aspect of warehouse management, remote control, robotics, traffic control, logistics services, supply chain management, fleet management and telemedicine. Today, a fifth of global businesses have an M2M deployment in place with 98% receiving a return on their investment and 75% projected to expand M2M from internal operations into customer-facing processes within the next three years.[26]

In addition to data, speed in connectivity impacts the types of business models that use M2M. With evolving communications technology, like 4G, LTE-A, 5G and next generation fibre technologies, businesses will have a greater opportunity to create applications that are practical, efficient and cost effective. These could include video-based security, in-vehicle information services, assisted living and mobile health solutions, energy solutions, manufacturing solutions, and the creation of smart cities. This faster connectivity will also enable businesses to enhance

25 http://www.sensorsmag.com/humidity-moisture/sustainable-farming-and-iot-cocoa-research-station-indonesia-20649?page_id=2

26 Vodafone's M2M adoption Barometer, 2015

their focus on the big data insights (discussed in more detail later) that can be gathered through M2M technology, providing new opportunities to increase revenue while improving customer choice and service.

For several years, M2M technology has been rapidly improving internal processes and decreasing operational costs in manufacturing, automation and logistics. The cost of deploying M2M has also significantly decreased, enabling business from a wide range of sectors including healthcare, automotive, and consumer electronics to improve processes and enhance customer experiences. M2M development is also allowing businesses to focus on providing end-to-end global solutions.

Today, businesses, governments and organizations continue to gain a better understanding of the abilities of and value in the data in M2M technology. M2M technologies offer organizations the opportunity to transform how they operate, and give both new entrants and established players the ability to innovate and disrupt.[27] Transportation companies are saving millions by reducing fuel consumption using data captured, transmitted, and analysed in near real-time.

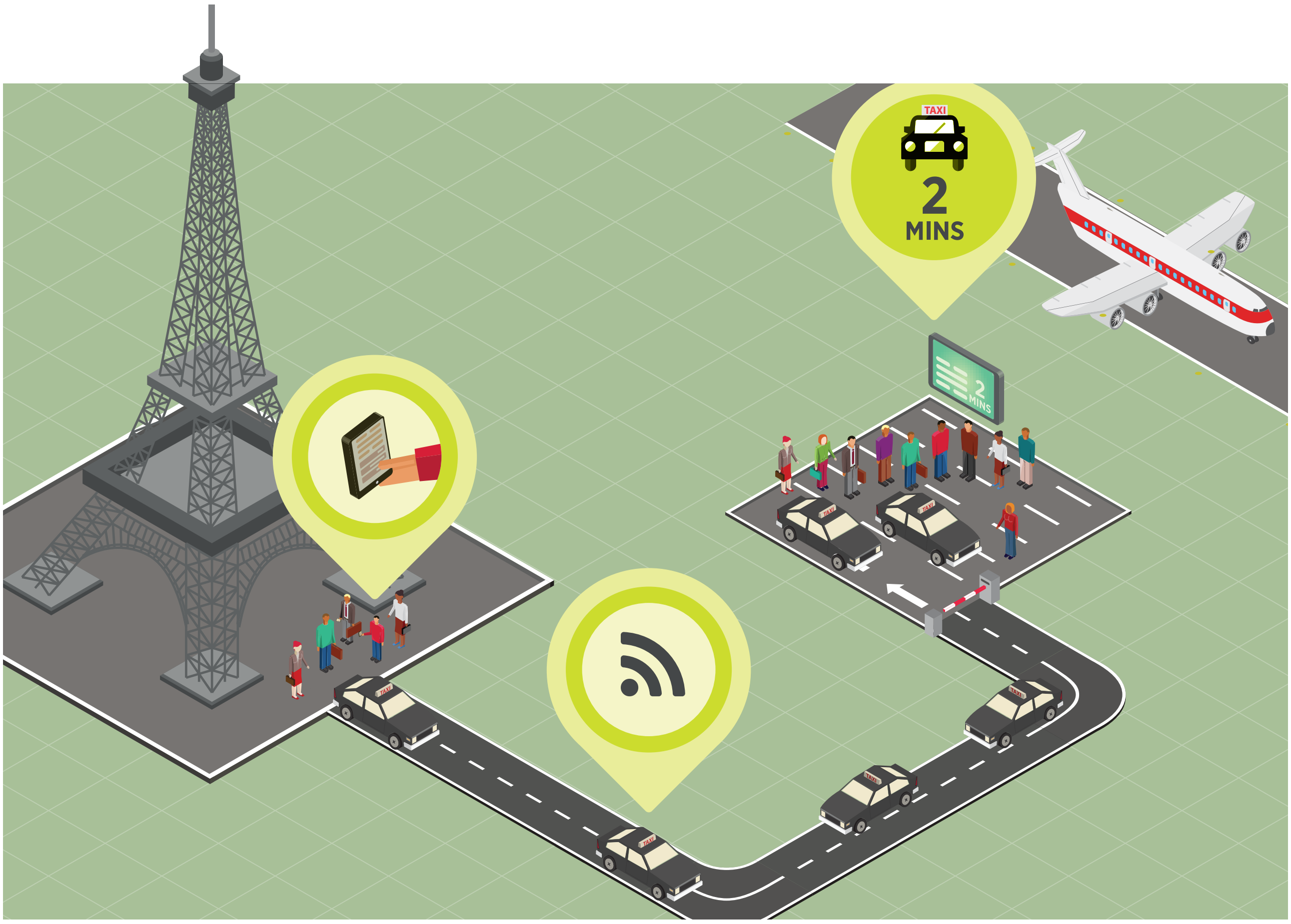
M2M solutions are reaching and empowering underserved populations in the developing world. For example, a new type of energy service company is providing decentralised clean energy systems which integrate global system for mobile communications (GSM) connectivity to rural families. This is helping communities overcome some of the main barriers to micro-utility sustainability, affordability and maintenance. Remote monitoring allows companies to have real time information about on-going operations and regularly send information about unit failures. A central server can communicate with customer cell phones and the local meters using hypertext transfer protocol and SMS messaging over the GSM network—speeding up efficiency of energy services and improving access.[28]

Case study: *A Paris airport has arranged a service that optimises the flow of taxis through the terminals. On average, 30 percent of the 15,200 taxis in Paris are within the perimeter of Paris- Charles de Gaulle airport at any given time. This causes many problems for passengers, for taxi operators and for the airport, with passengers waiting more than 15 minutes for a taxi, taxis waiting over 200 minutes for passengers and taxi spaces near ranks and terminal entrances being rare and expensive. To improve flows, the airport created a taxi waiting area in a large car park within two kilometers of the terminals, and a buffer zone near the passenger pick-up point. Taxis are also fitted with RFID badges so that vehicles can be detected automatically at the entrances and exits of parking areas and pick-up areas. A software application counts the number of taxis in the various areas, shows drivers waiting times on electronic displays and advises them either to move from the waiting area to the buffer zone as passenger numbers rise, or to return to Paris if waiting times are too long. The contribution made by the M2M project has been significant: improved management of the areas surrounding the terminals, enabling them to be used for other, more profitable purposes; much happier taxi drivers; shorter taxi waiting times of under 90 minutes; shorter passenger waiting times of under two minutes on average. The experience gained will be shared by offering similar services to other companies, such as railway stations and other airports worldwide.*[29]

27 Verizon State of the Market: Internet of things 2016

28 GSMA Sustainable energy & water access through M2M connectivity, P.8, 2013

29 Orange white paper, Machine to Machine: Stakes and prospects, 2006



Industrial Internet

Referring to commercial, not consumer/individual application, the industrial Internet takes data from sensors and uses it to optimise systems of development and deployment. Estimated to potentially add $10 to $15 trillion (USD) to global GDP over the next 20 years, the industrial Internet is the next evolution from **just-in-time operations** to smart operations.

The industrial Internet provides increased visibility and better insights into the performance of equipment and assets. Through asset performance management, answers on what equipment is most important, how it should be maintained and how unexpected failures can be avoided can be provided. The industrial Internet transforms the way people and machines interact by using data and analytics in new ways to drive efficiency gains, accelerate productivity and achieve overall operational excellence. Ultimately, the industrial Internet allows the combination of machines with best-in-class analytics to deliver valuable new insights.[30]

A key characteristic of the industrial Internet is that it installs intelligence above the level of individual machines. This enables remote control, optimisation at the level of the entire system, and accurate machine-learning algorithms that consider vast amounts of data generated by large systems of machines and the external context of every individual machine. It is also able to link systems together end-to-end such as integrating railroad routing systems with retailer inventory systems in order to anticipate deliveries accurately.[31]

30 https://www.ge.com/digital/blog/what-is-the-Industrial-Internet

31 Bruner, John , Defining the industrial Internet, 2013

By connecting sensors to analytic and other systems industrial Internet can automatically improve performance, safety, reliability, and energy efficiency by:

1. collecting data from sensors in a cost effective manner because sensors are often battery-powered and wireless,

2. interpreting data strategically using big data analytics and other techniques to turn the data into actionable information,

3. presenting actionable information to the right person such as plant personnel or remote experts, and at the right time,

4. delivering performance improvements with corrective actions.[32]

The industrial Internet represents a paradigm shift from centralised to decentralised production made possible by technological advances, which constitute a reversal of conventional production process logic. Simply put, industrial production machinery is able to no longer simply “processes” the product, the product communicates with the machinery to tell it exactly what to do. The objective is to connect embedded system production technologies and smart production processes to enable a new technological age which will radically transform industry and production value chains and business models (e.g., “smart factory”).

M2M technologies will increase automation within companies. Advanced robotics makes automation cheaper and more flexible. This automation process is activated by many enabling technologies including sensors and actuators, wireless networks, high-performance cloud computing and big data analytics. Together they are accelerating deployment of the factory of the future.

The digitalisation of the industry will mean the networking of all departments involved in a certain value chain and the ability of real-time data to derive the optimal flow at each time. This means that the factory of the future will be so flexible that each individual order can be different from the previous one, without increasing the costs of mass production. All production segments are linked together and are constantly in contact.

Closely related to and mostly synonymous with digital transformation in manufacturing is industrie 4.0. Industrie 4.0 is the digital transformation of manufacturing and the term emerged publicly in 2011 when an association of representatives from business, politics, and academia promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry (Kagermann, Lukas, & Wahlster, 2011). The term embraces a number of automation, data exchange and manufacturing technologies and concepts of value chain organization which draws together cyber-physical systems, IoT and the Internet of services. Indeed, industrie 4.0 facilitates the vision and execution of a “smart factory”.

Described as the next phase in the digitization of the manufacturing sector industrie 4.0 is driven by four trends:

1. the rise in data volumes, computational power, and connectivity, especially new low-power wide- area networks,

2. the emergence of analytics and business-intelligence capabilities,

---

32 http://www.controleng.com/single-article/industrial-internet-of-things-iiot-benefits-examples/a2fdb5aced1d779991d91ec3066cff40.html

3. new forms of human-machine interaction such as touch interfaces and augmented-reality systems, and,

4. improvements in transferring digital instructions to the physical world, such as advanced robotics and 3-D printing.[33]

Industrie 4.0 offers new tools for smarter energy consumption, bigger information storage in products and pallets (so-called intelligent lots), and real-time yield optimization.[34]

In the manufacturing environment, cyber-physical systems comprise smart machines, storage systems and production facilities which autonomously exchange information, trigger actions and control each other independently. This improves the industrial processes involved in manufacturing, engineering, material usage and supply chain and life cycle management. Smart factories are employing a completely new approach to production. For example, uniquely identifiable **smart products** may be located at all times and know their own history, current status and alternative routes to achieving their target state. The embedded manufacturing systems are vertically networked with business processes within factories and horizontally connected to dispersed value networks that can be managed in real time, enabling and requiring end-to-end engineering across the entire value chain.[35]

An example of industrie 4.0 from the automotive sector notes that a future component of a vehicle will be its ability to continuously gather data about its status and provide information when a replacement part is needed—and all this before a possible failure occurs. The product will send a message to the manufacturer informing that a repair has to be made. Furthermore, any order will contain detailed information on the types of vehicles and where the component must be shipped. In the new smart factory, an order is processed and the machine will set itself up so that the right part is manufactured. Finally, it will contain the necessary information in order to be sent to the correct destination.

Beneficial application

Businesses, as well as governments and organizations, are acquiring a better understanding of the capabilities and value of industrial Internet and industrie 4.0 for improving health, resource efficiency and sustainable development. For example, industrie 4.0 technology is helping farmers in developing countries keep pace with accelerating demand for milk products that have been a force in improving quality of life and boosting rural economic growth. Preserving large amounts of a time sensitive item such as milk in tropical countries requires extensive processing and distribution planning. Control systems provide intuitive automation and maintenance solutions that ensure a hygienic, efficient environment for processing and preserving milk's health benefits. For instance, automation determines percentage of milk, cream fat and non-fat solids, while queue-handling ensures timely refilling of silos to maintain continuity without delays.[36] This is one of the many examples industrie 4.0 is helping attain sustainable development goal number 12: *To ensure sustainable consumption and production patterns.*[37]

33 http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act

34 http://www.mckinsey.com/business-functions/operations/our-insights/manufacturings-next-act

35 Hermann, Pentek,Otto, Design Principles for Industrie 4.0 Scenarios:A Literature Review, 2015

36 http://new.abb.com/docs/librariesprovider19/default-document-library/india-contact-_industry-4-0.pdf?sfvrsn=2

37 https://sustainabledevelopment.un.org/topics/sustainableconsumptionandproduction

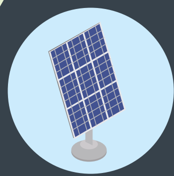
Case study*:* *The industrial Internet is playing a crucial role in solving the global resource challenge. The integration of efficient hardware with Internet-enabled software is the new frontier of natural resource productivity. This approach provides an avenue to achieve resource productivity improvements above and beyond those that can be achieved through hardware advances alone. With energy demands rising and reserves of oil and gas becoming more challenging to access, the resource productivity transformation promoted by the industrial Internet is of vital importance to the oil and gas sector. In the oil and gas sector, the operation of critical rotating machinery found on the energy company's production facilities is important. Such equipment includes compressors, generators, and critical pumps that are key to ensure the safe extraction and transportation of oil and gas around the globe. By analysing sensor data such as vibration, rotor position, temperature, pressure flow, and other parameters, changes can be identified in the operating condition of the machine or determine that the machine is no longer performing at its optimal capacity. Identifying the early onset of abnormal operating conditions minimizes disruption and avoids unnecessary periods of interruption that often result in lost production or increased costs. Industrial Internet examples such as these are being used throughout the United Kingdom and Norwegian sectors of the North Sea, along with other key oil and gas areas such as the Gulf of Mexico.*[38]

Similarly, industrial Internet solutions are aiding sustainable development by improving resource productivity, resulting in energy and water savings, increased reliability, and greater levels of output for industrial machines. Today's industrial Internet solutions represent the beginning of a long journey to digitize the industrial system and maximize the use of all industrial resources

38 http://www.ge.com/sites/default/files/ge_digital_resource_productivity_whitepaper.pdf

in the process. For example in the case of street lighting, energy efficient initiatives in cities are using wireless control systems that allow remote operation and monitoring of lighting fixtures through a web-enabled central management system. This is not only saving energy and money, but also enables controllers to turn off or dim streetlights as needed—providing unique flexibility and resource efficiency.[39]

Case study: *Street lights can be used to improve traffic congestion. LED lights containing sensors that compile traffic data can help drivers avoid busy roads and intersections, and ease congestion. Also, with lamppost apps data can be used from sensors to build new online services and make cities more efficient. This improves public transportation by sending more buses to areas congested with pedestrians.[40] In addition, the street light can also sense vibrations which, when located on bridges, can help identify issues of structural integrity.*



THE ECOSYSTEM: ROLE OF CLOUD AND BIG DATA

As noted in the examples above, through IoE billions of sensors and millions of devices are collecting information on everything from energy use, crop development, blood pressure and much more. As the examples and explanations above have demonstrated, emerging technology can be understood by considering: IoT as referencing the connectivity between devices, M2M as the non-human mediated application of IoT that usually involves a level of automated decision-making, Industrial internet as the commercial, not consumer or individual application and industrie 4.0 as the digital transformation of manufacturing. IoE refers to the superset of these concepts as well as connecting people, in addition to the objects and systems.

IoE contains more information about the world than we have ever accessed before and this interconnectedness is generating vast amounts and varieties of data from numerous devices, objects, people and systems at a supreme volume and velocity.

Within the ecosystem of interconnected and interactive systems all devices must be integrated, work together and communicate seamlessly with all connected systems and infrastructure. The data generated from these multiple interactions must be secure, analysed, integrated and actionable. Two essential elements within this ecosystem that help store, secure, and analyse the vast amounts of data generated are cloud computing and big data.

Cloud computing

The cloud has evolved to provide numerous services which can be delivered with improved efficiency, economy, scope and scale, and which are completed by increasingly rich and granular data and related correlations and analytics.

Cloud computing is a style of computing in which dynamically scalable and often virtualised resources are provided as a service over the Internet. Users need not have knowledge of, expertise in or control over the technology infrastructure in the 'cloud' that supports them. The concept generally incorporates combinations of the following: infrastructure as a service (IaaS),

39 https://www.ge.com/sites/default/files/ge_digital_resource_productivity_whitepaper.pdf

40 http://www.gereports.com/post/109224867910/between-you-me-and-the-intelligent-lamp-post/

platform as a service (PaaS) and software as a service (SaaS). Cloud computing services often provide common business applications online that are accessed from a web browser, while the software and data are stored on the servers. Cloud applications can be accessed not only from individual personal computers but from many other devices as well.[41]

Cloud computing systems allow remote storage of and access to data through secure login technologies. In general practice, the cloud permits users to perform work and access data at any time and from anywhere with a secured Internet connection. This can boost productivity and increase efficiency. In the context of IoE, cloud systems can allow truly scalable data storage for large projects and daily needs which makes big data analytics an affordable possibility for the public sector and small and medium enterprises.

In many sectors, cloud computing is being used increasingly, bringing numerous benefits. For example, healthcare providers can easily scale cloud storage to manage growing patient data.

Electronic health records lead to greater and more seamless flow of information within a digital health care infrastructure and can transform the way care is delivered. With electronic health records, information is available whenever and wherever and is facilitating; improved patient care and coordination, improved diagnostics and patient outcomes and significant efficiencies and costs savings.[42] Through the cloud, patient information is readily available improving efficiency and reducing paperwork and costs. Patients can also retrieve their medical records on mobile applications.[43]

Case study: *In Australia, cloud computing services are being used to enhance university research and education a pursuit well aligned with sustainable development goal four: To ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.[44] In this example, the university uses cloud computing services to streamline its learning environment so that students and staff are presented with a space that uses familiar terms in teaching practice, such as assignments; resources; and collaborative projects.[45] Through the use of cloud computing, the university has found research collaboration improvement, secure sharing and collaboration spaces and a consistent set of tools for all students and researchers regardless of their physical location.[46]*

Big data

The term "big data" refers to more diverse and ever-larger data sets that are updated in real-time. Data can be unstructured or structured, numerical from traditional databases, created by applications, or from documents of unstructured text such as e-mails, videos, audio formats. The hallmarks of big data are volume, variety, and velocity. This includes data generated by connected devices—from personal computers and smart phones to sensors including RFID

41 ICC Commission on the Digital Economy, Business views on the regulatory aspects of cloud computing, 2016

42 https://www.healthit.gov/providers-professionals/benefits-electronic-health-records-ehrs#footnote-1

43 http://www.forbes.com/sites/centurylink/2013/05/02/why-healthcare-must-embrace-cloud-computing/#9e6c6713a78a

44 https://sustainabledevelopment.un.org/topics/education

45 http://www.deakin.edu.au/clouddeakin

46 https://www.crucial.com.au/blog/2014/12/17/cloud-computing-in-education-deakin-university-case-study/

readers.[47] Big data is crucial to IoE as it allows the handling of the vast amount of data generated by IoT, industrial Internet and M2M technologies in an efficient and productive manner. In collaboration with the cloud, big data accelerates the process of synthesizing and contextualising generated data and facilitates how to determine, act and communicate new knowledge based on whether it has been generated from a user or a machine.[48]

If we draw an analogy between big data and its relationship to IoE and the human body, sensor inputs can be represented by the senses, the Internet, communications systems, and the cloud may be represented by the human nervous system that carries the impulses. The analytics and big data processing can therefore be likened to some of the brain functions that process data to make decisions. Applying that analogy further, in city management one can relate the interdependence of the system as in the human body. Public services overlap and rely on each other to function coherently (e.g. the sewage system depends on the water system and the transport network relies on roads, railways, etc.), but one can note the essential backbone the central pathway that links up all the individual specialized networks is the network of networks. When networks of different kinds are equipped to work together the sharing of networks and facilities uncovers potential for cross- fertilization between services and beneficial synergies. Big data helps utilize the vast amount of capabilities of IoE whether through data, processes or services—thus increasing the quality of services.[49]

More and more data, both structured and unstructured from an increasing variety of sources, benefits from enhanced analytics (known as big data analytics) as well as the discovery and communication of meaningful correlations in data. The use of increased volume, variety and velocity of these virtual information flows provides value by improving both the information available and the related predictability and customisation of needs and preferences as well as improved service efficiency and effectiveness of outcomes.

Big data represents, not only a significant advance in the ability to capture and process data, but also significant progress in the ability to find correlations across these new and varied data sources as well as more sophisticated analytics to apply to them. As interconnection and interactivity has increased, so has complexity. Where a main focus of interest of ubiquitous computing was once radio- RFID sensors, today the breadth of objects that can be connected has exploded to include ambient sensors, **wearables** and even **ingestibles**. This explosion of sensors creates an ever increasing variety of data types that can be collected, often in real-time.

Big data is helping support and create many innovative business models. For example, this technology is bringing new levels of personalisation and relevance to consumers generating increased contextualisation and optimisation.

Insights from big data are being used in a variety of sectors. For example, the World Bank Group has recognized big data's transformative potential for socioeconomic development.[50] Big data techniques can complement official statistics in the intervals between official surveys. In many cases, insights derived from big data sources may help to fill in the gaps. Mobile-network big data are one of the few big data sources in developing economies that contain behavioral

---

47 Inter IT Center, Big Data in the Cloud: Converging Technologies, 2015

48 http://blogs.cisco.com/ciscoit/big-data-and-the-internet-of-everything

49 Oracle white paper, Oracle's smart city platform -Creating a citywide nervous system, 2013

50 World Bank report: Big data in action for development, 2014

information on low-income population groups.[51] For example, changes in the number of Tweets mentioning the price of rice in Indonesia were closely correlated to more directly measured indicators for food price inflation. In Mexico, analysis of call detail records enabled tracking of population movements in response to the spread of epidemic disease and provided insight into the impact of policy levers like transportation hub closures. This has led to the reduction of velocity of infection rates by as much as 40 hours.[52]

Case study: *In the Middle East and North Africa region, the rise of non-communicable diseases is predicted to cost over $68 billion (USD) by the year 2022 and the region is lagging behind when it comes to gathering and sharing clinical data. Reliance on traditional data like medical records, as well as real-time data on a patient's condition, such as blood pressure or heart rate, with little sharing of data is resulting in inefficiencies. In Egypt and Turkey, image exchange capabilities are being used, enabling hospitals to share, store send diagnostic images for remote assessment by radiologists. The productivity transformation through big data is meeting the requirements of patients with the services provided by healthcare practitioners. Big data helps patients seek more face time with providers, care that revolves around them, more active role in decisions about their care and more consistent and higher quality outcomes. In a region containing some of the most densely, and sparsely, populated areas of the planet, linking patients, doctors and hospital equipment using big data could bring quality healthcare much closer for all in the Middle East and North Africa.*[53]

51 Measuring the Information Society Report 2014: Chapter 5. The role of big data for ICT monitoring and for development, 2014

52 World Bank report: Big data in action for development, 2014

53 http://newsroom.gehealthcare.com/middle-easts-evolving-healthcare-landscape-big-data-big-deal/

Another key area in which big data analytics is having a significant impact is precision or personalized medicine in healthcare. **Predictive analytics** is playing a crucial role in early detection of disease as well as ensuring patients receive personalized and effective care. Predictive analytics uses technology and statistical methods to search through large amounts of information, analyzing it to predict outcomes for individual patients. That information can include data from past treatment outcomes as well as the latest medical research published in peer-reviewed journals and databases. Predictive analytics can also reveal insightful unexpected associations in data. Examples include: predicting infections from methods of suturing, determining the likelihood of disease, helping a physician with a diagnosis, and predicting future health.[54]

Case study: *Precision medicine has made significant advancements in lung cancer treatment. Genetic discoveries over the past decade have transformed the way doctors treat and interpret the disease. One of the applications of precision medicine for lung cancer treatment is to develop treatments that exploit weak spots in tumor cells to destroy only the cancer cells. Precision therapies are lengthening progression-free survival. With regard to diagnostics, doctors are using mutations and a gene called KRAS to reclassify lung cancer. In the future new treatments for lung cancer in clinical trials are expected, including using the patient's own immune system to block tumors.*[55]

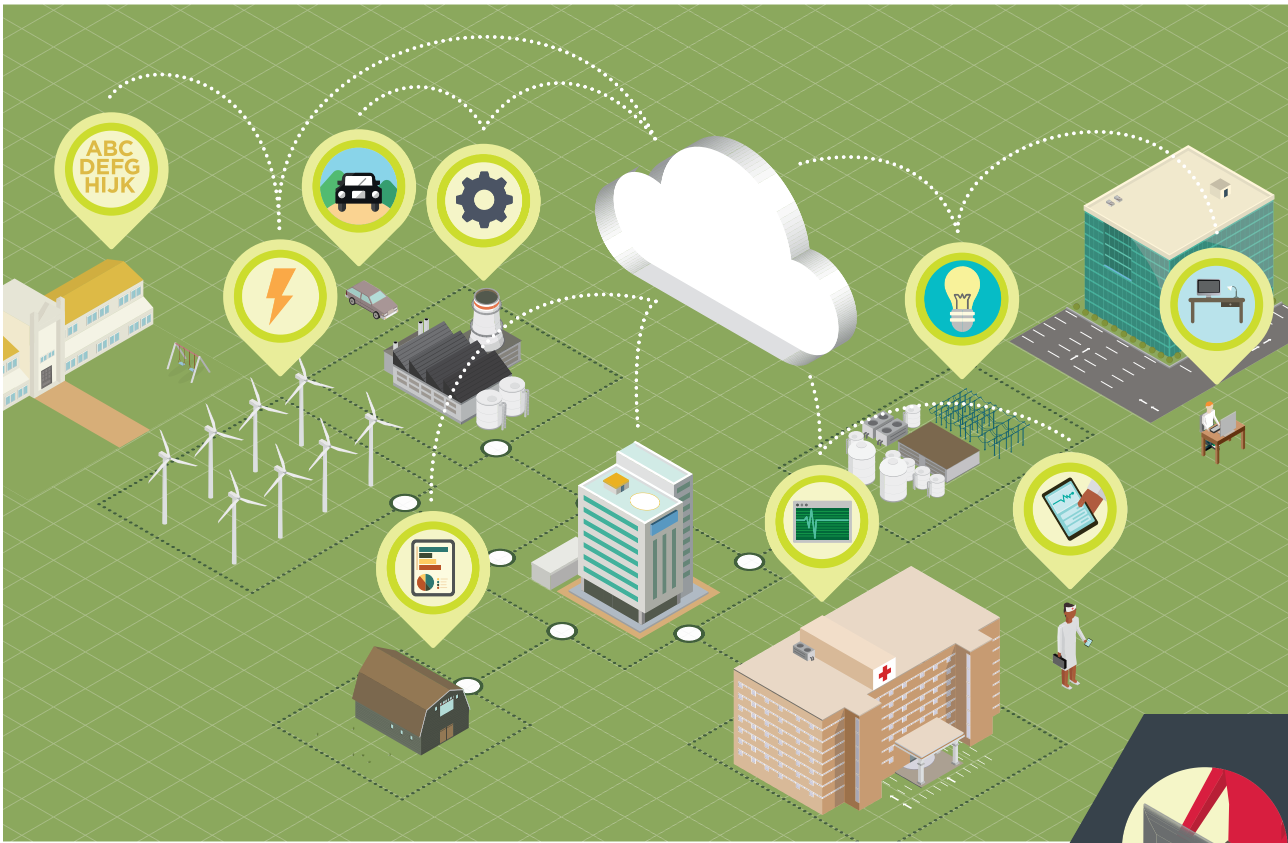
THE INTERNET OF EVERYTHING IN ACTION

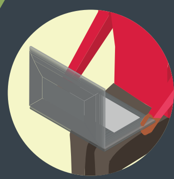
The ecosystem, which includes complementary cloud and big data analytics, provides the ability for a level of real-time product and service optimisation and interaction never seen before. A variety of sensors from connected environments provide a continuously updated real time inventory for conditions across a number of variables.

The sensor feeds can include location data, information on speed and direction, seismic data, data on moisture and fluid dynamics as well as other data including audio and video. This variety of sensor information is analysed by various systems powering manufacturing, services and any number of smart devices and implementations from phones to cars to jet engines to homes and cities. The sensor data, updated by the correlations and other findings from the analytics, is then fed to cloud- based services that power a range of applications including e-health, environmental, electrical, agricultural, device operations, and manufacturing. All of those are updated and optimised with the new data and related analytical information. This ever improving feedback loop can make existing activities, services and products more effective and efficient and new data and observation can create new business models that power economic growth and increase societal benefit.

54 https://www.elsevier.com/connect/seven-ways-predictive-analytics-can-improve-healthcare

55 http://genomemag.com/how-personalized-medicine-is-changing-lung-cancer/#.Vz1vHPmLRaQ





POLICY OPPORTUNITIES AND CHALLENGES

As with many accelerating technologies, challenges exist for policymakers. The extent to which existing policies apply and whether or not they are sufficient is consistently questioned. It is, therefore, crucial to assess the appropriate approach required to facilitate the innovation, adoption and implementation of IoE to allow society to benefit from its potential, and address the risks that may exist with some of its applications. To properly assess existing policies and develop new ones, the potential risks must be appropriately considered and addressed. In much the same vein, consideration should be given to the potential opportunity cost of overly-burdensome administrative and operational requirements ranging from the detail of documentation and filings to the requirements that either constrain innovation or create unintended consequences that limit societally beneficial uses of information within or across borders.

A policy issue of great concern is the need to appropriately protect personal data and provide assurances of privacy. The economy is now data driven and data can contain information about individuals' interests, networks, habits and behavior. This issue, is, however, predicated on the nature of the information being collected and used. At the business-to-business level many of the applications deal with non-identifiable or non-personal information, such as a jet engine providing automated reporting of its oil consumption or efficiency of operation. Separating personal information from non-personal information in cases where the personal information has implications for non- personal purposes is also a challenge. In healthcare, de-identified data can be used for some research purposes and for big data purposes for the benefit of all citizens. Policymakers are thus challenged to develop frameworks which appropriately protect privacy while considering the context and nature of the information being collected and used. Properly applying risk-benefit frameworks will be essential to this task.

IoE may pose a challenge to privacy because of its often imperceptible collection of information. For instance as the environment, both indoors and outdoors, becomes more computer-aware with sensors that are not controlled by any individual and for which neither the collection nor the use of the data is obvious. The issue has been experienced to some extent with video cameras and related privacy concerns, but sensors may become more ubiquitous, much harder to spot and less apparent as to what data they collect. As more devices allow people to interact with their environment, sometimes seamlessly, it is necessary to better understand the potential for the devices to be linked to individual identity, as well as the potential for those devices to be a way for users to exercise choices related to data collection and use. There will come a point, however, when consideration should be given to the development and use of models that are based on reasonable consumer or personal expectations.

IoE may pose equal security challenges. There are issues emerging concerning the security of devices and the ability to hack into the device or the data stream that emerges from the device. In the case of the former, the concern is that device function may be altered. This is of significant concern for health devices or those involved in critical systems. For data streams the issue is pertinent to the sensitivity and confidentiality of the data. Standards are currently being considered that would improve the security of the devices while still permitting the interoperability that makes them useful. One issue which will be solved over time, but the impact of which is hard to measure is the existing deployment of embedded sensors that may not be software upgradeable. In some cases, these sensors will be accessed through systems that can be enhanced to provide protection, but the nature and prevalence of deployed sensors is not always known.

For both privacy and security, it is important to note that IoE may be part of a larger system. The self- monitoring, analysis, reporting technology or ‘smart’ house may contain a number of enabled devices, smart appliances, outlets and wiring, all of which may be controllable through a centralised house system. That system may serve as a point of shielding and securing as well as a point of governance. If each device’s connectivity beyond the house is mediated by the house system it may be more updateable than the device itself. That does not mean that one can or should ignore device security, but it does mean that the security of the device should be considered in the context of its use. Similarly, these mediating systems may also serve as bottlenecks of governance and compliance where individuals may be able to control an element of data collection and sharing. Sensors, as devices can be evaluated by functionality including inherent security, but their advisability needs to be considered in the context of their use and deployment. Similarly it is impossible to conduct a credible **privacy impact analysis** on an individual sensor, but privacy impact analysis can be a very useful tool at the system level.

The convergence phenomenon, which is core to IoE, presents huge opportunities for economic productivity and particularly developing countries’ participation in the digital economy. As markets develop, their structures are affected by changing technology creating opportunities for new business models, increasing competition, challenging and altering existing and traditional business models. Changes to the affected sectors will also challenge the existing regulatory and legislative norms and cause a wide range of stakeholders to re-consider their relationships with the affected sectors. The availability of sufficient infrastructure capacity, innovative products and services is crucial for IoE. In such an environment, interoperability, affordable pricing and choice should constitute the primary market characteristics.[56]

56 ICC Policy statement, Digital convergence: An economic opportunity, 2008

POLICY AND PRACTICE FRAMEWORKS FOR INTERNET OF EVERYTHING

The complexity and interconnectedness of these technologies create additional issues for policy-makers. These issues are multi-disciplinary by definition, yet the policy issues and technical implementations are often compartmentalised to fit existing administrative departments, divisions of labour or portfolios. Developing countries are reaping the benefits of IoE by leapfrogging gains in productivity and competitiveness. By directly implementing and operating IoE technology, business models and development initiatives are transforming. To ensure the long-term benefits and use of this technology is sustained, in developed and developing countries alike at a minimum close coordination, collaboration and cooperation is required (i.e., all government regulators and policymakers, providers and end users). This coordinated effort needs to extend to businesses which develop the technology, its applications and related business models, as well as those that need to implement or use these technologies.

BUSINESS PRACTICES

Business is taking important steps to ensure the full potential of the emerging technologies of IoE are realised. In order to harness emerging technology and increase its societal and economic benefits, business should pursue its efforts to:

Address connectivity

As more than 85 % of existing devices worldwide are based on unconnected **legacy systems**, it is critical that industry focuses on the development and deployment of solutions needed to address connectivity and interoperability of legacy devices as an interim step to avoid replacing all existing infrastructure and still realise the benefits that IoE can deliver to this legacy environment.

Design privacy and security strategies

Privacy and security are critical building blocks for the IoE ecosystem—and capabilities that must be designed into IoT systems from the outset using appropriate **privacy-by-design** methodologies. Therefore, to maximize the potential of an IoE ecosystem a successful IoE governance framework must include a viable privacy and security strategy. This strategy must consider existing rules and assess the range of benefits and risks among the various market applications, sectors, and domains, to create a logical and implementable framework through industry-led initiatives.

For trusted data exchange in the IoE ecosystem, data generated through IoE must be able to be shared between the cloud, individual networks, and intelligent devices to enable aggregation, filtering, and data sharing from the edge to the cloud with robust protection. Moreover, data must be accurate to be beneficial; therefore, a successful implementation strategy must promote the importance of the integrity of data in all market sectors.

A successful IoE policy framework must recognise that analytics and its associated insights will drive IoE productivity and efficiency improvements, as well as new business and service opportunities, across both the public and private sectors. To achieve the right balance between big data business models and data privacy, privacy-friendly business models leveraging de-identification techniques, including aggregation, anonymisation and **pseudonymisation** should be fostered.

Security is an essential element of trust in an IoT infrastructure and a factor that can impact any organization connected to the Internet, but it is not a one-size-fits-all solution and thus not suited to narrow top down prescription. Efforts should be made to both highlight the importance of the issue and encourage continued research, innovation and deployment of context appropriate security solutions. As security is implemented, due regard should also be paid to assure that security solutions are consistent and appropriate with the desired interoperability across IoT implementations. Security solutions will also form an essential element of the protection of personal data; and both security and privacy should be considered as foundation elements in design of IoT systems.

Enrich consumer experience

A successful IoE ecosystem will be designed by business to unlock data intelligence from the device through the network to the cloud—enabling government and businesses to provide better products and services and enriched consumer experiences. Therefore, a successful IoE vision must include the development of horizontal building blocks for end-to-end analytics, as well as distributed analytics solutions for **edge systems** and the data centre, which enable governments, businesses, and consumers to turn big data into actionable information. With the enormous volume of new data generated and shared across intelligent devices and systems, which can now be analysed, a wealth of untapped value can be extracted to increase economic efficiency and productivity.

Collaborate in open participation

An appropriate level of standardisation and interoperability is necessary to achieve a successful IoE ecosystem. In the emerging IoE economy, voluntary industry and market-driven globally-recognised, consensus-based standards can accelerate adoption, drive competition, and enable cost-effective introduction of new technologies. Standards which facilitate interoperability across the IoE ecosystem will stimulate industry innovation and provide a clearer technology evolution path. Such standards may be developed in international standards bodies as well as global standards consortia. For this to happen, regional standardisation bodies and consortia need to cooperate in order to adopt widely recognised standards. In case of too many competing standards, such fragmentation will significantly impede large scale market entry and, thus, cost effectiveness of entries.

Manage data dynamically

Data created from devices, existing and new, and "systems of systems" in IoT deployments must be able to be managed dynamically in a common way. The ability to categorise data as public or private and manage that data dynamically will allow for increased growth in single business, cross-business, and public sector implementations.

In addition, as devices become connected, it will become critical that both the devices and the data that is being generated are able to be discovered by an application or sought out by service in a common manner to provide value. The ability to find devices and data will increase the pace of IoE solution deployment and the societal benefits that follow. This should be solved, however, through business solutions rather than by regulatory fiat.

GOVERNMENT POLICIES

Government should encourage industry collaboration in participation to open and global standardisation efforts to develop technological best practices and voluntary standards. Industry is in the best position to develop the technological solutions to address global IoE ecosystem opportunities and challenges, with government as a key participant. In order to avoid constraining innovation or creating unintended consequences that limit societally beneficial uses of information within or across borders, governments should:

Efficiently manage spectrum, invest in high performance and secure broadband networks

The International Data Corporation predicts 50 billion devices will be connected to the Internet by 2020.[57] Thus, connectivity is imperative to realise the full power of IoE. Systems of intelligent devices (often called "systems of systems") must be connected to each other and network(s) in order to exploit the transformational potential of the IoE.

Spectrum is an essential building block for the wireless connectivity of IoT devices. Ubiquitous, affordable, high-speed broadband connections over licensed and unlicensed airwaves are critical to enable consumers and the public and private sectors throughout the IoE ecosystem. Thus, effective and technologically neutral management of this increasingly scarce resource must be a priority for policymakers. They should also ensure that sufficient harmonised spectrum resources are made available in a technologically-neutral manner. In order to reduce the costs and delays in **time to market** for innovative new uses, spectrum licenses should be granted under more harmonised terms than it is often the case today, in particular in terms of timing, license durations and assignment conditions.

Additionally, investments in high performance and secure broadband networks are needed: reliable, comprehensive and robust communication networks are indispensable to IoT. Therefore governments and regulators should provide for a policy framework based on a light-touch regulatory approach that incentivises investment and enables the development of new business models.

5G mobile technology will be designed for use cases at the core of industrial Internet and industry 4.0, it will support the huge growth of machine-to-machine type communication, big data, and cloud technologies. It will offer flexibility, low costs and, low consumption of energy and it will be reliable and quick enough for even mission-critical wireless control and automation tasks such as self-driving cars.

Connect legacy systems

To address connectivity and interoperability, a successful public policy framework must contemplate intelligent gateway solutions that can connect legacy systems and provide common interfaces and seamless communication between devices and the cloud.

Connecting legacy systems will accelerate the impact of IoE by allowing data from existing infrastructure to be captured and utilised. Enabling legacy devices to seamlessly interact with each other as well as new devices and infrastructure will add to a successful IoE ecosystem. The management of such an initiative should be business led and voluntary.

---

57 http://iot-analytics.com/iot-market-forecasts-overview/

Focus on accountability for the appropriate collection, use, and protection of data

IoE presents new challenges for traditional privacy principles. Consumer notice and consent will continue to be important. However, other privacy principles also must be emphasised to ensure consumer privacy is adequately protected; for example, focusing on accountability for the appropriate collection, use, and protection of the consumer's data. A successful public policy framework must induce consumer and business trust through enhanced privacy and security solutions in order to motivate adoption of and participation in the IoE marketplace.

Optimal privacy and security methods must be developed through industry collaboration as required for different IoE solutions. Use cases should be applied to identify privacy and security risks proactively and to develop robust strategies to mitigate those risks. It is critical to understand that security and privacy issues vary according to the application, communications media used, and degree of human interaction. Not all the data processed in the context of the IoE is personal. Therefore, when applying any privacy and security guidelines, a distinction should be made between strictly consumer applications (e.g., wearable computing, home automation), which may require more stringent risk assessment, and business applications (e.g., energy efficiency, cargo tracking, agricultural monitoring), where the processing of personal data may be minimal or non-existent. As a general approach, proactive industry self-regulation and collaboration are effective measures to mitigate risk, preserve innovation, and enable sufficient flexibility to respond to new and unforeseen threats.

Provide robust and appropriate data protection

Due to an ever increasing exchange of data, including illicit actions such as cyber-attacks, the potential for privacy and data security breaches have to be treated with due consideration by policymakers. This is particularly true where information includes personal data. Policy frameworks should provide for robust and appropriate data protection that guarantees the privacy of the citizen without hampering innovation. As much of the data generated by industrial Internet does not entail personal information, both privacy and security concerns need to be appropriately taken into account in order to provide the needed trusted environments involving all players. Given that security and privacy are central to the commercial viability of IoT, there is an incentive for business to address such issues proactively. Indeed, business stakeholders are committed to meaningful voluntary efforts to improve privacy and security. Therefore the most productive approach to ensuring robust privacy and security standards is voluntary compliance with broadly accepted industry guidelines.

At the global level, more countries are imposing restrictions on cross-border data flows without considering the impact on innovation in their economy. While there can be certain compelling public policy issues—including privacy and security—recognized as possible exceptions and that may form a legitimate basis for governments to place some limits on data flows; these should only be implemented in a manner that is non-discriminatory, is not arbitrary, is least trade restrictive and not otherwise a disguised restriction on trade.[58] Restrictions impede effective adoption of innovative technologies, create fragmentation and often legal uncertainty. Many IoE innovations could be crippled without cross-border data flows as fragmentation and increased complexity caused by restrictions significantly complicate global value chains. Needless burdens or unjustified restrictions on such technologies can significantly limit the potential of these technologies to deliver economic and social benefit. Similarly, a lack of trust in these

58 Trade in the Digital Economy: A primer on global data flows for policymakers, 2016

technologies and related services, in particular how personal data is handled, can limit their adoption. Thus, policymakers must be aware of the need to remove barriers as well as create trusted environments for IoE to reach its potential.

Encourage commercially available solutions and drive innovation

Government should encourage the use of commercially available solutions to accelerate innovation and adoption of IoT deployments. To seize the full opportunities of IoE, unnecessary and vestigial obstacles to technical innovation should be avoided. The emphasis on commercially available solutions and market-adopted voluntary standards will allow for faster adoption and increase innovation, bringing IoE and its benefits to reality sooner.

Enhance skills and training

ICT skills are important for the evolving industrial Internet and enabling citizens to participate in IoE. ICT skills must be taught in schools and vocational training programs as well as integrated into lifelong learning programs. Notably, ICT itself, as a delivery mechanism, is an important tool for improving and ensuring the outcome of education. ICT skills will allow SMEs to more effectively benefit from the IoE and therefore boost their growth and success.

Enable convergence and adopt technology-neutral and interoperable approaches

As technology will continue to rapidly evolve governments should adopt flexible and long-term outlooks when approaching strategies to harness emerging technologies. Efforts should be made to evaluate policy frameworks to ensure that obstacles to the deployment of converged business models, and ICTs generally are removed. Governments should work in partnership with business to enable convergence and ensure that regulation does not create unnecessarily burdens nor unintended consequences that could impair the potential for economic societal benefit that deployment of these technologies and/or new business models can provide.[59]

Sustain adequate and effective intellectual property protection

Adequate and effective intellectual property protection and enforcement are essential components to a policy framework that will continue to advance the creativity and innovation of IoE.[60]

Develop common or interoperable approaches between countries or regions

Given the borderless nature of IoE, there is a particular need to foster collaboration between countries or regions, which may result in increased convergence and investment.[61] Moreover, governments should be encouraged to take a holistic approach across agencies/ministries, so that IoE issues are worked through as consistently as possible, and without a fragmented approach by different administrative departments. This will help ensure that governments are not creating either duplicative or conflicting approaches, nor leaving issues of concern unaddressed.

59 ICC Policy statement, Digital convergence: An economic opportunity, 2008

60 ICC Policy statement, Digital convergence: An economic opportunity, 2008

61 ICC Policy statement, Digital convergence: An economic opportunity, 2008

Foster public-private partnerships

Collaboration between government and business can be one of the best ways to accelerate the adoption of a world-class IoE ecosystem that successfully supports mobile, home, and industrial domains. A successful IoE policy framework should encourage government and industry to collaborate on a common set of best methods to allow data and devices to be discoverable. The result should provide a robust data exchange solution that is easy to implement for both new and existing solutions. Viable public-private partnerships will make IoE deployments an appealing investment for government and business, as well as ensure scalability and sustainability of infrastructure and technological innovation over the long term. Moreover, government and business should work together to promote an environment that motivates private investment and innovation—including the protection of commercial and proprietary data from misuse by competitors and third parties. Data ownership is a critical component to delivering economic value and must be defined between government, business, and consumers. For example, in order to incentivise investment in the IoE ecosystem, it is essential that public policy frameworks ensure protection of proprietary and commercial data that could be considered intellectual property. Public-private partnerships should leverage existing industry standards and investments and utilize both public and private resources in order to facilitate the research, leadership, and governance to advance an overarching IoE vision. Government funding may be appropriate in certain targeted situations to incentivize more rapid development and deployment of the IoE ecosystem, particularly where the outcome has significant societal benefits (e.g., smart cities).

CONCLUSION

As today's technological advances continue to develop in a more dynamic environment, transforming historic business and network models, ICC believes that only flexible, globally-compatible, and market-driven policies will continue to fuel innovation and increase the societal and economic benefits of the digital economy. In order to capture the unique and crucial opportunities of IoE, ICC urges proper assessment of potential privacy and security risks and recommends efforts to ensure better understanding of which polices may create unintended consequences, or act as unnecessary barriers or constraints to innovation or technology use. Continued research and dialogue to take full advantage of IoE and ensure data and privacy risks are considered appropriately is important. ICC considers public-private partnerships as essential to facilitating the research, leadership, and governance required to advance an overarching IoE vision and remains available to work with policymakers as they continue to define practical, optimally effective policies to reap the full benefits of the Internet of everything.

GLOSSARY OF TERMS USED

Actuator: Any mechanical, electrical, or electro mechanical system that produces linear or rotary motion to drive mechanical events like shafts, screws, slide or a manipulator can be termed as an actuator.[62]

Autonomic computing: Self-managing computer systems which contain biological attributes seen in the human body.[63]

Big data: Big data refers to data sets that are so large they can't be captured, managed, stored or analyzed with traditional database tools. This data is generated by connected devices—from PCs and smart phones to sensors. The distinctive characteristics of big data are volume, variety and velocity.[64]

Cellular communications: A cellular mobile communications system uses a large amount of low power wireless transmitters to create cells, the basic geographic service area of a wireless communications system.[65]

Cloud computing: There remains no perfect definition of cloud computing that is applicable in all circumstances or shared by all communities, but many have recognised the National Institute of Standards and Technology's (NIST) definition as a positive step forward that represents many aspects of common understanding. The Computer Security Definition of the NIST defines 'cloud computing' as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.[66] For more information please see the ICC policy statement on business views on regulatory aspects of cloud computing here.

Convergence: The evolution of previously distinguishable digitalised information formats, services, applications, networks, and business models in ways that reduce or blend the distinctions. Convergence is driven by the rapid development of the digital economy. For more information please refer to the ICC policy statement on digital convergence an economic opportunity here.

Edge systems: The systems the modern network architect uses to provide layered security boundaries around core business systems. Typically edge systems protect from spam, system overloads, sneaky viruses attached to an email or outright attacks on the core company infrastructure.[67]

Ingestibles: Ingestibles are IoT-enabled devices available to patients and providers which monitor adherence data (e.g., taking medications as prescribed), and consumer health data (e.g., physical activity). Feedback to patients can help them engage and make better health and wellness

62 Mechatronics, Ganesh S. Hedge, 2008

63 http://www.ibm.com/developerworks/lotus/library/ls-autonomic_computing/

64 http://www.ibmbigdatahub.com/infographic/four-vs-big-data

65 Nishith Tripathi, Jeffery H. Reed, Wiley Publications, 2014, Cellular Communications: A Practical & Comprehensive Guide

66 ICC Commission on the Digital Economy, Business view on regulatory aspects of cloud computing, 2012

67 http://itknowledgeexchange.techtarget.com/modern-network-architecture/what-is-an-edge-system/

decisions in real time, decreasing the need for costly doctor visits, tests, and hospitalizations and reducing the rate of progression of the disease.[68]

Industrial Internet or "industrie 4.0": The industrial Internet is an application of IoE that takes data from sensors and uses it to optimise systems of development and deployment. Industrie 4.0 is closely related to and mostly synonymous with the industrial Internet. The term "industrie 4.0" emerged publicly in 2011 when an association of representatives from business, politics, and academia promoted the idea as an approach to strengthening the competitiveness of the German manufacturing industry (Kagermann, Lukas, & Wahlster, 2011).

Internet of everything (IoE): The Internet of everything (IoE) is a term that is increasingly being used to represent the superset of concepts related to the interaction between and among people and objects using cloud computing supported by data analytics. IoE is an overarching term that captures a number of existing and emerging elements: the Internet of things (IoT), machine to machine (M2M), the industrial Internet, and industrie 4.0. These technology models work in an ecosystem that also includes cloud services and big data analytics. While many of these terms are relatively new, the concept of IoE is not. Indeed, in the late 1990s and early 2000s work was already underway in research laboratories on the topic and concepts of 'ubiquitous computing' and were being discussed in the context of the Asia-Pacific Economic Cooperation (APEC).

Internet of things (IoT): The term IoT describes the connectivity that enables Internet-connected devices to interoperate. The IoT, therefore, connects the world's physical systems such as power meters, vehicles, containers, pipelines, wind-farm turbines, vending machines, personal accessories, and much more.

Just-in-time operations: JIT is a system of production and manufacturing that cuts waste by supplying parts only as and when the process required them. It eliminates for each stage in the production process to hold buffer stocks and involves the workforce much more directly in controlling their own inventory needs.[69]

Legacy systems: Obsolete computer systems that may still be in use because their data cannot be changed to newer or standard formats, or their application programmes cannot be upgraded.

Machine to machine (M2M): M2M refers to any technology that enables networked devices to exchange information and perform actions without human assistance through the Internet. Key components of an M2M system include sensors, radio-frequency identification (RFID), a Wi-Fi or cellular communications link and autonomic computing software programmed to help a networked device interpret data and make decisions. Products with M2M capabilities are sometimes referred to as "smart" products.

Predictive analytics: PA uses technology and statistical methods to search through large amounts of information, analyzing it to predict outcomes for individual patients.[70]

Privacy-by-design: An approach to projects that promotes privacy and data protection compliance from by embedding it in the engineering process at the start of technological development.

68 http://dupress.com/articles/internet-of-things-iot-in-medical-devices-industry/

69 http://www.economist.com/node/13976392

70 https://www.elsevier.com/connect/seven-ways-predictive-analytics-can-improve-healthcare

Privacy impact analysis (PIA): The PIA is an analysis of how personally identifiable information is collected, stored, protected, shared and managed. It identifies and assesses privacy implications in automated information systems.[71]

Pseudonymisation: 'Pseudonymisation' means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person.[72]

Sensors: Sensors are hardware components that provide computers with information about its location, surroundings, and more. Programmes on a computer can access information from sensors, and then store or use it to help with everyday tasks. There are two types of sensors; built in to the computer or connected to the computer by a wired or wireless connection.[73]

Smart products: Products that are instrumented to communicate with one another and other products and services. When combined with IP connectivity, smart products are able to communicate regardless of their location or condition, either in a workflow, in the hands of a customer or installed at a customer's site.[74]

Tele-health: The use of electric communications and telecommunications technologies to support long-distance clinical healthcare, patient and professional health-related education, public health, and health administration.[75]

Telemetry: Telemetry is another well-known example of an M2M application that is used to transmit operational data. Pioneers in telemetry first used telephone lines, and later radio waves, in order to transmit performance measurements collected from monitoring instruments in remote locations. The role of telemetry has greatly expanded due to the Internet's increased presence to where it is now common place—that is, used in everyday products such as appliances and electric meters. Telematics is another example of M2M that enables manufacturers of equipment to remotely correct mechanical problems via software adjustments.

Time to market: Time to market is the period of time from when a product idea has general agreement and resources are committed to the project, to when the final product is built and out the door to a customer.[76]

Wearables: Wearables are a new technology category resulting from the convergence of mobile, Internet of things, augmented reality, and big data. Wearables' primary purpose is to support immediate, real-world actions and decisions by providing directly relevant, contextual information precisely at the point of decision-making.[77]

71 https://www.sec.gov/about/privacy/piaguide.pdf

72 Art. 4 (5) European Union General Data Protection Regulation, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

73 http://windows.microsoft.com/en-us/windows7/what-is-a-sensor

74 https://www.cognizant.com/InsightsWhitepapers/the-rise-of-the-smart-product-economy-codex1249.pdf

75 http://cchpca.org/what-is-telehealth

76 http://www.arenasolutions.com/resources/articles/time-to-market/

77 http://www.deloittedigital.com/us/blog/the-truth-about-wearables-what-they-are-and-arent

ABOUT THE INTERNATIONAL CHAMBER OF COMMERCE (ICC)

The International Chamber of Commerce (ICC) is the world's largest business organization with a network of over 6.5 million members in more than 130 countries. We work to promote international trade, responsible business conduct and a global approach to regulation through a unique mix of advocacy and standard setting activities—together with market-leading dispute resolution services. Our members include many of the world's largest companies, SMEs, business associations and local chambers of commerce.

We are the world business organization.

INTERNATIONAL CHAMBER OF COMMERCE
The world business organization

33-43 avenue du Président Wilson, 75116 Paris, France
T +33 (0)1 49 53 28 28 E icc@iccwbo.org
www.iccwbo.org @iccwbo