Future of IoT

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Fore

Enterprises and service providers have been looking at IoT as a key enabler to drive digital transformation and to unlock the operational efficiencies. Advances in Artificial Intelligence coupled with ubiquitous connectivity, and real-time communication are enabling exponential growth in efficiencies generated by IoT. As machines and products have started communicating with each other without any human intervention, the real value of data is getting generated through better and faster decision-making, predictive analytics and automation.

India is already matching the pace in adapting new technologies like IoT, 5G, AI and cloud to drive new business models. The Government of India has introduced various policies and initiatives to leverage benefits of these disruptive technologies in various sectors. Many start-ups in India are also using these technologies to create new and innovative business models.

Through this paper, we have attempted to outline the future of IoT, from business potential and technology point of view, and its impact along with other emerging technologies such as 5G, Artificial Intelligence, Digital Twin, Edge Computing, Immersive User Experience, etc. on various sectors such as manufacturing, utilities, transport and logistics, agriculture, oil and gas and smart cities.

We are glad to be the knowledge partners with FICCI for the first edition of IoT Summit on "Transforming businesses through technology disruption" in Rajasthan. This is an exclusive platform for stakeholders from the government and industries to collaborate on the adoption of these disruptive technologies.

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word

Emerging technologies such as Internet of Things (IoT) are shaping our lives and disrupting the traditional businesses at a rate of change never seen before in the history. Enabled by exponential increase in computing power and availability of large amount of data, machines are fast learning to replace humans in several areas. This "intelligence" is moving away from central server farms into devices and things that will soon become a part of our everyday lives. These devices will potentially negotiate their own way in our world via "smart contracts" and without any significant human intervention.

India is fast leapfrogging the deployment of emerging technologies. India offers an opportunity to deploy these emerging technologies at a large scale to bring efficiencies and economies of scale. Newer opportunities and ecosystems are developing every day. The Government of India is taking several steps to push the adoption of emerging technologies with innovative initiatives such as Digital India [1], Make in India [2], Smart Cities [3], etc.

It is our pleasure to launch the first edition of IoT Summit on "Transforming businesses through technology disruption". This summit is conceptualized to discuss on the technology disruption in today's era and where it is enabling us in the future.

FICCI is committed to work closely with the government, industries and different sectors so as to put Rajasthan and the nation at large in a bright spot. We are glad to provide a platform for collaboration of stakeholders from different industries to develop a new solution for India's future.

Bimal Patwari
Chairman
FICCI Rajasthan IoT Summit

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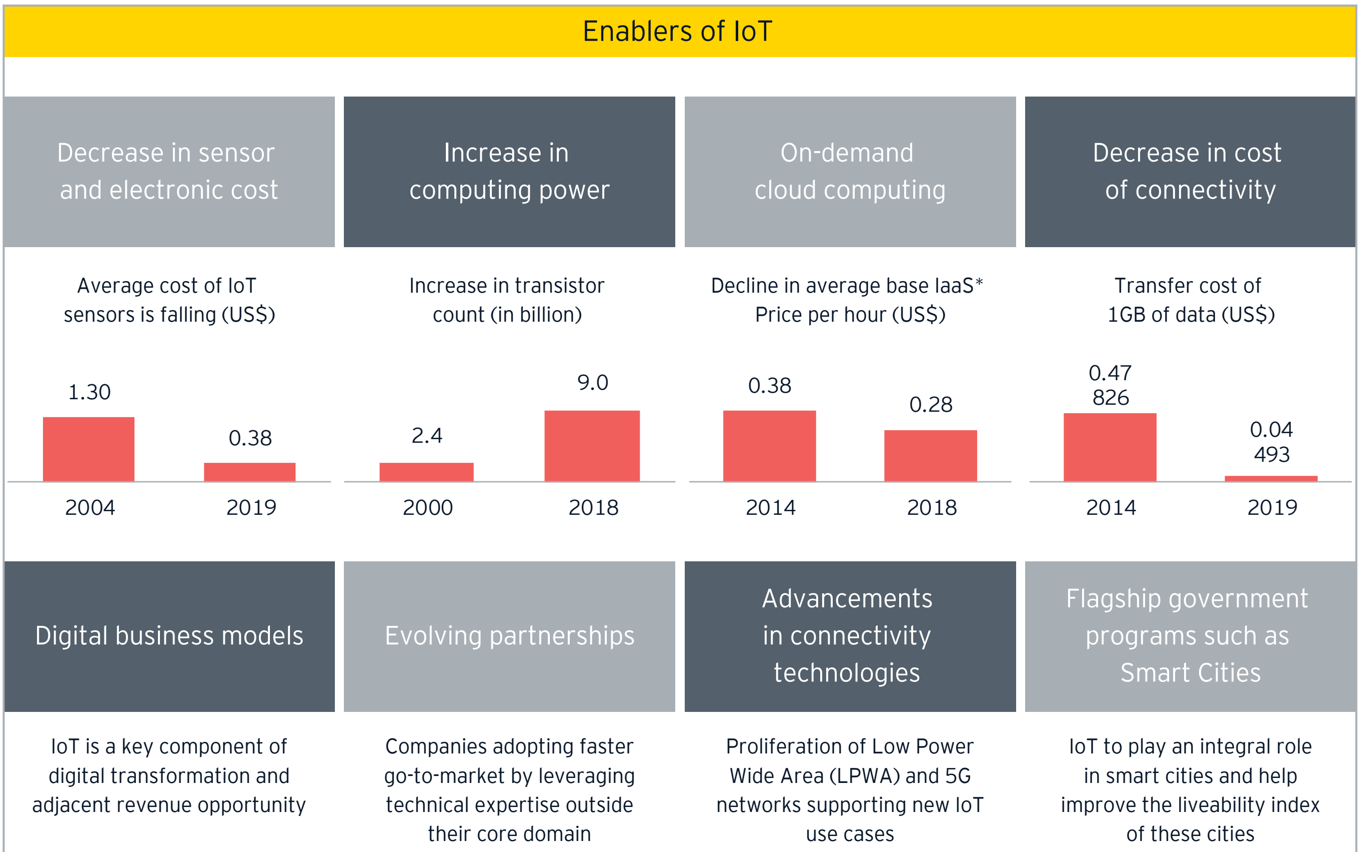
1 Executive summary

As billions of devices, services and systems get connected, we see consumers getting benefit from the improved lifestyle use cases and companies becoming more efficient as they minimize their operational costs and increase their asset utilization. IoT will work hand in hand with the real-time Artificial Intelligence (AI) as edge connected devices shift the paradigm from central clouds to decentralized, ubiquitous intelligence.

Kurzweil curve [4] predicts an exponential increase in intelligence and expects the advanced computing platforms to equal the intelligence of a human brain by the end of the coming decade. This is primarily being driven by a combination of exponential increase in data being generated by IoT devices, multifold increase in computational power, advanced AI algorithms, compact form factors and low power requirements. This increase of intelligence of machines is getting more pervasive across all sectors and devices.

The IoT market is expected to grow steadily as billions of devices, services and systems become connected, mainly driven by increasingly ubiquitous and cheaper sensors that convert the physical data to digital content. The IoT use cases focused on delivering cost savings from fuel, energy and labor often have a significant financial impact and shorter payback time frames. In terms of the market size, IoT spending is expected to register 15.4% y-o-y growth to reach US$1.1t by 2025 [5].



*Infrastructure as a Service

Source: Press articles; EY analysis

It is predicted that IoT devices worldwide generate 90 zettabytes [6] of data by 2025. This data is sent directly by sensors or via gateways to centralized platforms that aggregate, process, store, analyze and visualize this data to create insights and improve operational efficiencies of processes. The centralized architecture offers large scale computing and storage tasks to be done centrally so as to increase the operational efficiencies. However, centralized architectures increase latency of data exchanged, increase the time to act on actionable intelligence, are less resilient to environmental disasters, more prone to security hacks, are more expensive to scale (e.g., building a new data center in a new geography) and are designed using commodity hardware which may lack versatility of appliances dedicated for specific tasks. These shortcomings are leading to the evolution of computing platforms from centralized architecture to distributed or decentralized architecture with a focus on fog computing and AI capabilities closer to sources of data.

This knowledge paper highlights examples and other such use cases made possible by amalgamation of IoT, fog computing, Big Data, analytics and cloud technology. The volume of data that new web-connected systems will have available, combined with their ability to self-enhance through increasingly sophisticated artificial intelligence (AI), could fundamentally change how the world operates.

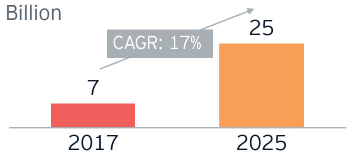
2 Market analysis

2.1 Global market analysis

IDC predicts the IoT global market revenue to reach approximately US$1.1 trillion by 2025. Global IoT connections are predicted to increase with 17% CAGR (Compound Annual Growth Rate) from 7 billion to 25 billion approximately from 2017 to 2025.

Global IoT market — Witnessing exponential growth leading to significant revenue opportunities across the ecosystem

Global IoT connections forecast

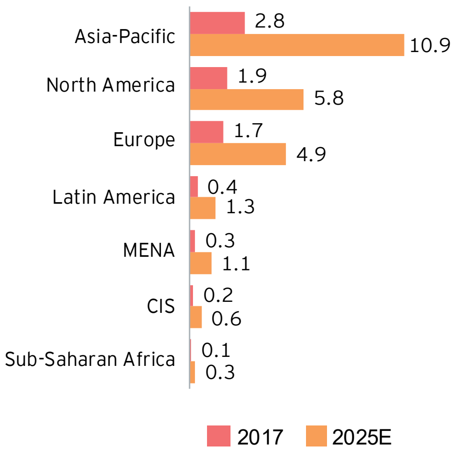


Global IoT market revenue by 2025*

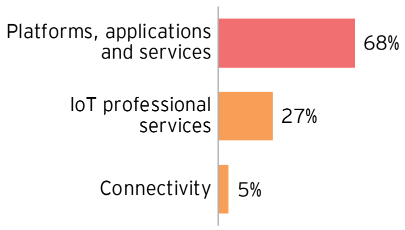
Billion

US$1.1t

Global IoT connections by region



Share of IoT revenue in 2025



Platforms, applications and services segment spans multiple IoT layers such as platforms, application services, cloud, data analytics and security.

IoT professional services include system integration, managed services and consulting.

1 **Asia-Pacific** region is forecasted to become the largest global IoT region in terms of both connections and revenue by 2025.

2 IoT connections (cellular and non-cellular) may be driven largely by growth in the industrial IoT market, accounting for more than 50% of the connections.

3 IoT market's **value shifts** from connectivity to platforms, applications and services.

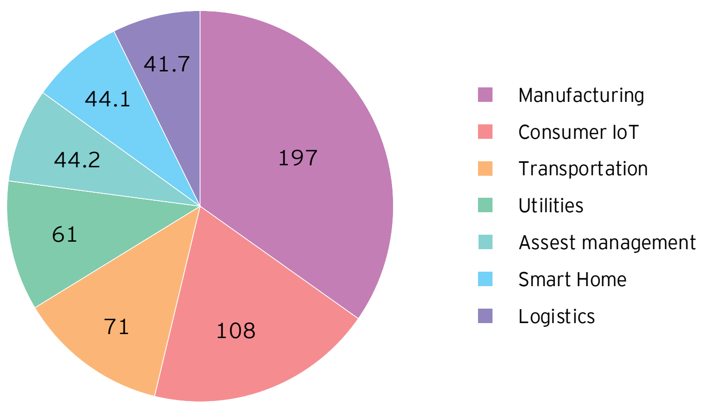
Licensed cellular IoT connections is expected to reach 3.1 billion by 2025, accounting for 12% of total IoT connections

Source: GSMA, IDC, *Note: Excluding IoT hardware revenue (device, module and chipset)

From a regional perspective, Asia-Pacific region is forecasted to be a leader followed by North America and Europe in terms of IoT market size and revenue with US$10.9 billion by 2025. Yet Europe and Middle East (EMEA) is the fastest-growing region at a CAGR of 15.7% through the forecast period.

The industries that are forecasted to spend the most on IoT solutions in 2019 are manufacturing (US$197 billion), consumer IoT (US$108 billion), transportation (US$71 billion), and utilities (US$61 billion) [5]. IoT spending among manufacturers will be largely focused on solutions that support manufacturing operations and production asset management. In transportation, more than half of IoT spending may go toward freight monitoring, followed by fleet management. IoT spending in the utilities industry may be dominated by smart grids for electricity, gas and water.

IoT spending worldwide (in billions)



Source: EY analysis

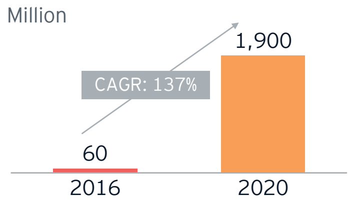
2.2 Indian market analysis

As per NASSCOM report [8] on IoT Landscape, India will be a front runner in IoT adoption in Asia Pacific (APAC). The IoT market size in India is expected to grow at rate of 62% CAGR and reach US$9 billion by 2020. The number of IoT connections are expected to grow at a CAGR of 137%, increasing from US$60 million in 2016 to US$1.9 billion in 2020.

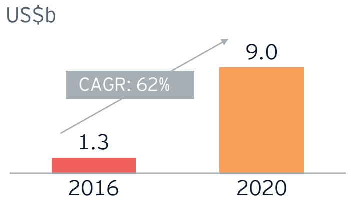
This increase in IoT market revenue share will be distributed across different industry sectors like utilities, manufacturing, transport and logistics, automotive, healthcare and so on.

IoT market size in India | IoT offers a significant untapped potential in India

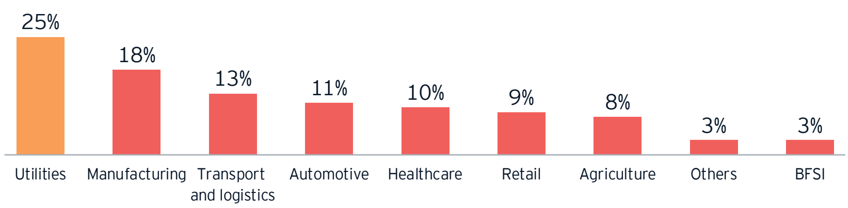
IoT connections forecast in India



IoT market size in India



Share of IoT revenue by industry, 2020



Total addressable industrial IoT market size in 2020 = US$4.5b

Others include food technology, education, construction, etc.

Source: NASSCOM

1

Factors driving IoT growth in India

- Innovation in product offerings
- Increasing operational efficiencies
- Improving customer experience
- Thrust on evolving partner ecosystem
- Maturing IoT solution
- Increased network coverage and data speeds

2

IoT's solution deployment for digital utilities/smart cities and in the manufacturing, transportation and automotive industries may drive the demand for industrial IoT applications, going forward.

3

Rise of the tech-savvy consumers along with increasing smartphone and mobile internet penetration is driving consumer IoT applications in the Indian market.

The key sectors for IoT are expected to be utilities (water and electricity), manufacturing, transport and logistics, automotive industries and healthcare, going forward.

3 Government of India initiatives on IoT

The Government of India (GoI) has taken the following key initiatives on IoT:

Draft IoT Policy 2016

In line with the GoI's vision of a Digital India, the Department of Electronics and Information Technology (DEITY) [9] launched India's first draft IoT Policy Document in 2016. The policy lays the foundation of a strong governance framework for holistic implementation and execution of IoT-related policies and campaigns. It will play an essential role in realizing the GoI's vision of building US$15b Indian IoT market and enabling India to hold nearly 5%-6% of global IoT industry.

National Digital Communications Policy (NDCP) 2018

NDCP [10] has set futuristic goals and undertaken crucial policy initiatives to address the problem of communications and access of digital services in India. According to Internet and Mobile Association of India, the goals set for 2022 are crucial policy initiatives which will address the problem of access and are a welcome step to take India towards a vibrant digital economy. This policy aims to create a roadmap for the emerging technologies in areas like IoT and may result in improving the efficiency and economic benefits.

India IoT roadmap

Government measures enabling a connected ecosystem in India – progressive policy to provide impetus for IoT growth

2018
- NDCP 2018

2017
- TRAI recommendations on M2M

2016
- M2M numbering scheme
- TRAI consultation paper on M2M
- M2M service providers' registration guidelines

2015
- Constitution of apex body, review committee and consultative committee
- Smart Cities Mission
- National Telecom M2M roadmap

2014
- Draft policy on IoT by MeitY
- Make in India

2013
- Smart grid pilots

2012
- National Telecom Policy

NDCP IoT goals

5 billion connected devices by 2022

- Creating a roadmap for emerging technologies such as 5G, AI, robotics, IoT/M2M and cloud
- Simplifying the licensing and regulatory frameworks whilst ensuring appropriate security frameworks for IoT/M2M/future services
- Allocating 13-digit numbers for all M2M mobile connections
- Earmarking adequate licensed and unlicensed spectrum for IoT/M2M services

TRAI recommendations

Spectrum, roaming and QoS related requirements in M2M

- Suitable amendments in licensing conditions for provisioning of M2M services
- No separate spectrum band is to be allocated exclusively for M2M services
- Devices with embedded SIMs should be allowed to be imported only if they can be remotely reconfigured over the air with local subscription
- Country-specific relaxation on permanent roaming of foreign SIMs to be considered
- Not mandatory to use only domestically manufactured SIMs in M2M

- IoT Centre of Excellence set-up as part of Digital India initiative
- Accelerate IoT ecosystem by capitalizing on the ICT strengths of the country
- Help start-ups utilize the latest technologies to develop innovative IoT applications

- Develop 100 smart cities by 2021-22
- 99 smart cities have already been selected at an outlay of US$28 billion
- More than 2,500 projects currently underway worth over US$305 million

*QoS: quality of service, ICT: information communication technology, M2M: machine to machine

Source: Press articles; EY analysis

Smart Cities Mission (SCM) 2015

The SCM aims at developing 100 Smart Cities with a total proposed investment of nearly US$31b. The Ministry of Housing and Urban Affairs data indicates that 33% of the total 5,151 SCM projects have been completed/are under implementation, utilizing 25% of the allocated investment. However, SCM projects' implementation stepped up a gear during last year, registering a solid 290% increase in tendered projects, 332% increase in the projects that were grounded/completed and 479% increase in the projects completed since October 2017.

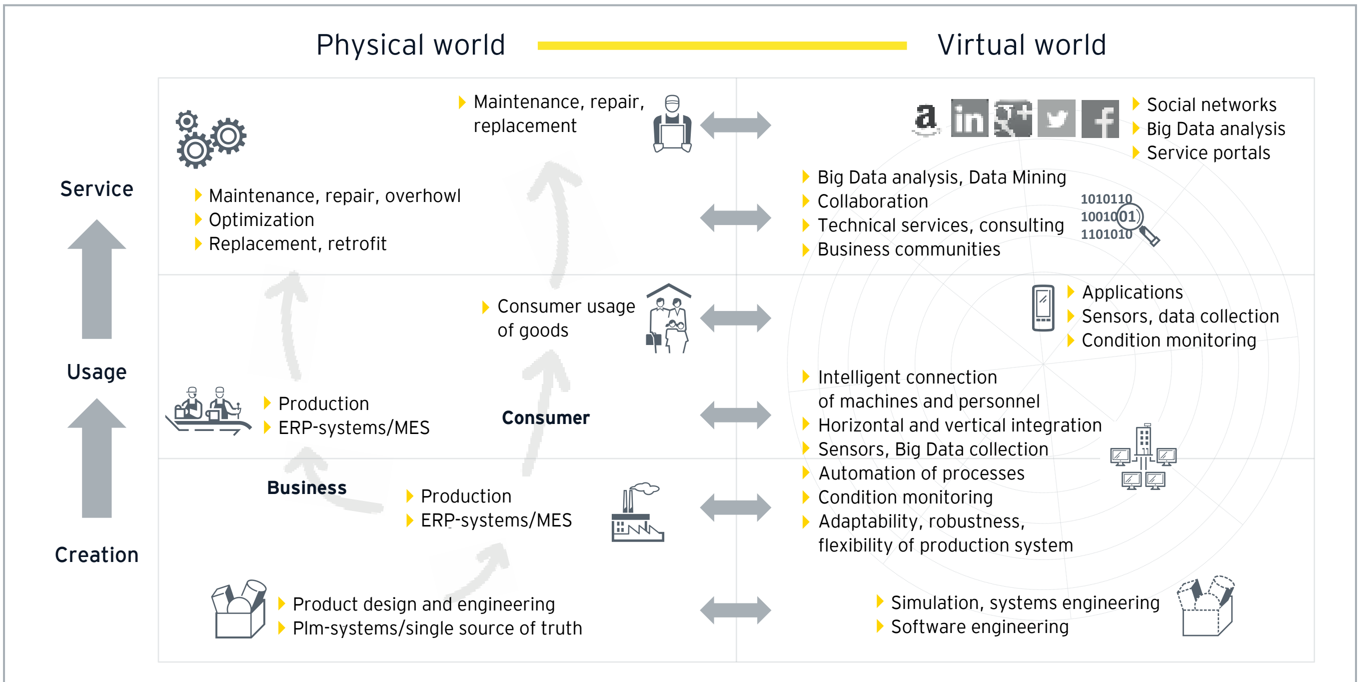
IoT Centre of Excellence (CoE) by NASSCOM, DEITY and ERNET

IoT CoE is a Digital India initiative to revolutionize the Indian IoT ecosystem with modern infrastructure and by facilitating co-creation of IoT solutions via a hub and spoke network of dedicated CoE [11] (currently present in Bengaluru and Haryana). CoE IoT aims at building "next wave" talent with incubation, funding, acceleration, networking and mentoring via IoT's tart-ups Program.

4 Key digital trends shaping the future

4.1 Digital Twin

Digital Twin is a dynamic virtual representation of a physical object or a system across its lifecycle, using real-time data to enable understanding, learning and reasoning. IoT sensors that gather information and data like real-time status, health and performance, live position, etc. are integrated with a physical object. Digital Twin ecosystem comprises of different technologies like IoT, AI, Big Data and cloud platform to enable this twin ecosystem. The diagram below depicts how the complete lifecycle of processes, products, components or services can be mapped from physical to virtual model by leveraging these technologies.



Source: EY analysis

As per M&M report [16], the global digital twin market is expected to grow at a CAGR of 37.87% during the forecast period, to reach US$15.66 billion by 2023.

4.2 Fog and Edge Computing

Edge computing – cloud computing paradox for IoT. The dialogue is shifting from centralization to de-centralization

Transition of IoT data processing to the network edge was expected to happen in the early IoT development lifecycle stage. However, decreasing connectivity costs and rising communication networks throughout led to a slow pace of this trend, which resulted in a shift towards centralized cloud processing. Now falling prices and the increasing processing power of edge devices have kickstarted the transition towards network edge.

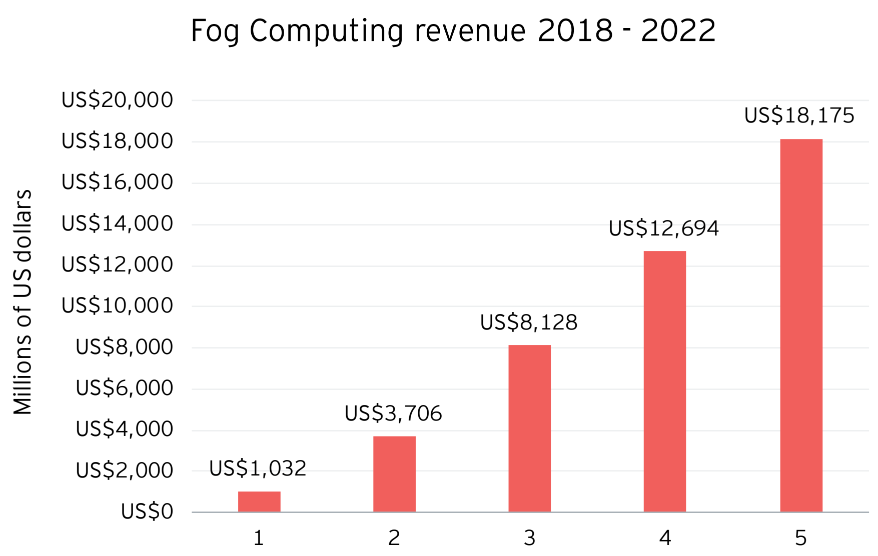
The change to edge computing may have a significant impact on an organization's IT and Operational Technology (OT) systems, and have laid the foundation of new-age digital products.

> “ A 2018 survey, indicates that **27%** of global telecom companies are implementing/expanding edge computing in 2019.

As per Open Fog Consortium [13], Fog Computing is a system-level horizontal architecture that distributes resources and services of computing, storage, control and networking anywhere along the continuum from cloud to things. By extending the cloud to be closer to the things that produce and act on IoT data, fog enables latency sensitive computing to be performed in proximity to the sensors, resulting in a more efficient network bandwidth and more functional and efficient IoT solutions.

While Fog and Edge Computing terms are used interchangeably, the key differences lie where the computing takes place. Edge Computing pushes the intelligence, processing power and communication capabilities of an edge gateway or appliance directly into devices like programmable automation controllers (PACs) while Fog Computing pushes intelligence down to the local area network level of network architecture, processing the data in a fog node or an IoT gateway. Many IoT software companies have launched products that push the limits by embedding complex event processing, Machine Leaning and Artificial Intelligence in the Edge/Fog Computing nodes catering to this expanding market segment.

International Data Corporation (IDC) predicts that by 2025, nearly 45% of the world's data will move closer to the network edge. Fog Computing architecture is a key to enable this large amount of data to be processed, stored and transported and also enables emerging technologies like IoT, 5G and AI. The overall market opportunity for Fog Computing is pegged to rise to US$18.2b by 2022, up from US$1.03b in 2018 and US$3.7b in 2019.



Source: EY analysis

As an example, turbines are installed with multiple sensors to generate predictive maintenance alerts in the industry. These turbines, deployed in electricity generation, create terabytes of data in real-time and limited memory buffers present in IoT devices store this locally in IoT sensors. The data stored in the sensors is sampled at a high sampling rate and measures electrical parameters, pressure, flow rate, etc., which are later analyzed by specially designed algorithms based on turbines' manufacturers' performance data to find anomalies that may cause premature turbine failures. Some other failures may also require tripping the system in short durations to avoid damage. If algorithms can run on an edge computing node within the same LAN network, the response time to take preemptive actions can significantly improve in comparison to algorithms processing this data on a centralized platform on the cloud that may get delayed due to network latency. So, the industry has adopted Fog Computing of data locally at the edge with distributed Artificial Intelligence and performs these real-time operations as well as improves the life of costly equipment. Trend analysis on key data points of long-term value is still being done on a central infrastructure on a case-by-case basis that can process years of data using Big Data platforms. These hybrid architecture measures have benefited the industry by integrating the platform with the source where the data is generated, effectively improving latency, reducing data transfer costs and yet utilizing the benefits of central cloud based data analytics platforms.

Fog Computing provided the key benefits given below:

- Improved performance: there is a significant increase in the system's performance as edge/fog computing nodes are installed in the local network with data sources which are generating data by reducing the turnaround time.
- Data security and privacy concerns: organizations deploying IoT systems have data security and privacy concerns for sharing sensitive information to cloud platforms. In Fog/Edge Computing, architectures data reside locally in organization's networks so that the organization gets full control over the security and privacy of the data.
- OpEx reduction: operational cost incurred on bandwidth reduces increasingly as aggregating, processing and storing of data is performed locally on Fog/Edge Computing platforms.

4.3 5G and IoT

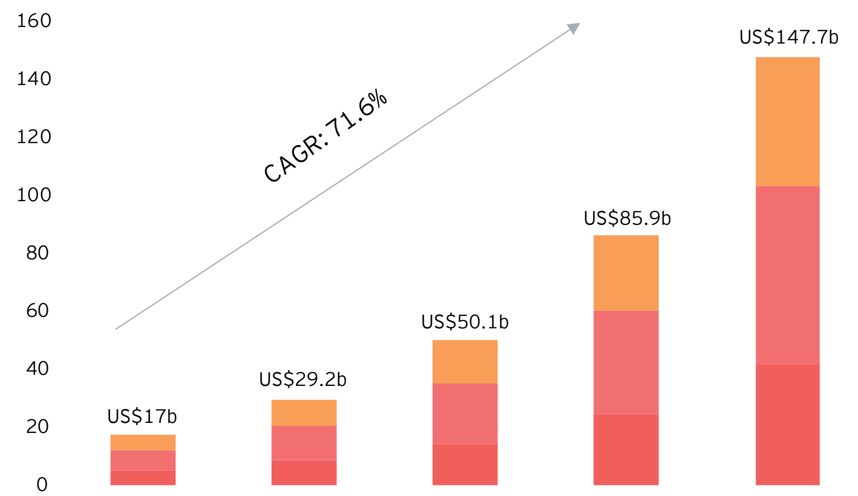
5G may unlock immense IoT potential

The dawn of the 5G era is likely to reshape current wireless communication methods used for IoT-based applications. According to Aleksander Poniewierski, EY Global IoT Leader, "IoT cannot thrive without effective and affordable wireless connectivity, interoperability and common standards. We believe 5G has the potential to make a ground-breaking impact on the way in which future IoT ecosystems are designed, especially in the areas of scalability, latency, reliability, security and the level of individual control on connectivity parameters."

4.4 Virtual, augmented and mixed reality applications

Virtual reality (VR) provides a computer-generated three-dimensional (3D) environment that surrounds a user and responds to that user's actions in a natural way, usually through immersive head-mounted displays and head tracking. Augmented reality (AR), on the other hand, is a technology that bridges the physical and digital worlds by overlaying information, such as audio, text, images and interactive graphics, onto the physical environment. AR offers context based digital information right where you need it. Mixed reality (MR) is an overarching technology solution which merges the real and virtual worlds. It goes beyond to extend their capabilities that can best mix the real and virtual worlds. VR, AR and MR technologies are projected to grow at a fast pace reaching a CAGR of 71.6% reaching market size of US$147.4 billion by 2022.

Global AR/VR market spending by hardware, software and services, 2018-2022 (US$ billion)



	2018	2019	2020	2021	2022
Services	5.1	8.8	15	25.8	44.3
Software	7.1	12.2	20.9	35.9	61.7
Hardware	4.8	8.2	14.1	24.2	41.4

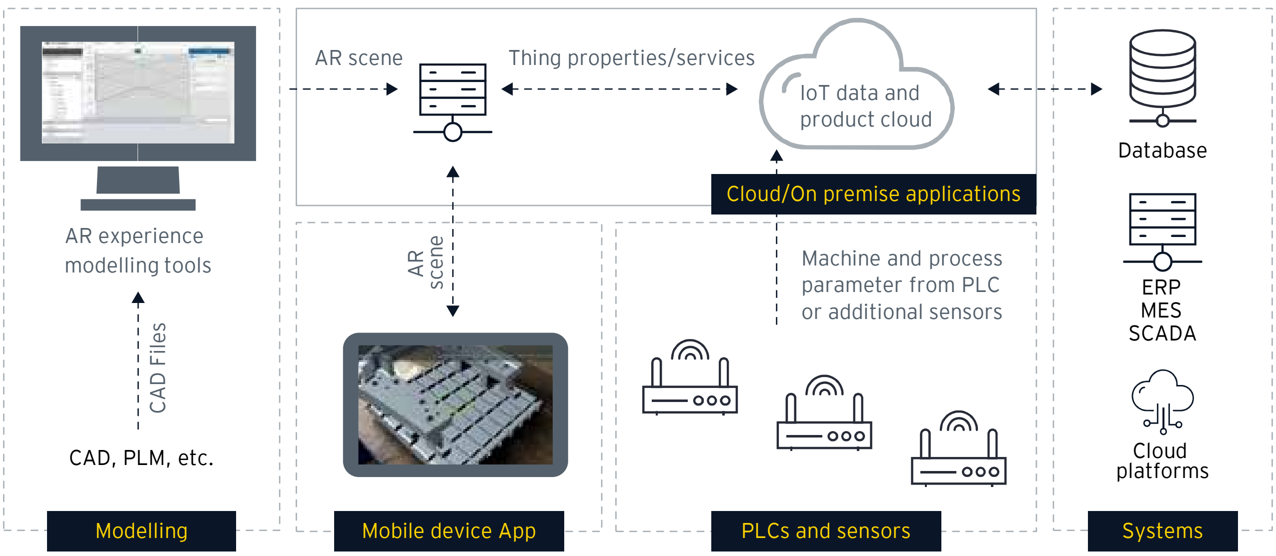
Source: EY analysis

Areas of application of VR, AR and MR include:

- Overlaying live feeds with digital information i.e., highlighting parts to be changed
- Additional viewers through wearer's eyes i.e., remote service
- Leveraging virtual reality technology for simulations
- Highlighting localization and positioning of objects

The diagram mentioned below provides an illustrative infrastructure setup for generic IoT and augmented reality. Virtual objects are recreated using computer aided design (CAD) tools to model the AR experience and scenes that are created. Equipment properties and services are exposed by IoT/Manufacturing Equipment Services (MES)/Supervisory Control and Data Acquisition (SCADA)/Enterprise Resource Planning (ERP) software and are merged with virtual objects. This is then superimposed on real-time feed of cameras to present an enriching user experience with contextual data superimposed on the recreated AR scenes on devices such and smartphone screens or AR headsets.

Generic IoT and augmented reality infrastructure



Source: EY analysis

5 IoT security

IoT security has become a concern for organizations as without a strong security architecture, massive amount of data flowing and stored across the networks is exposed to vulnerabilities in the infrastructure that can be exploited by hackers. To reduce cyber threats and hacking, we must maintain data confidentiality, integrity and availability across the IT infrastructure. Mechanism or methods for a secure communication, storage and sharing of data should be implemented including the use of latest cryptographic methods or security algorithms.

The key measures that can ensure security across the infrastructure are:

- Authentication of all the entities before they can join the network using a public key cryptography and X.509 certificates signed by a trusted root authority. These keys and certificates should be stored securely in Federal Information Processing Standards (FIPS) compliant hardware security modules.
- Data confidentiality is implemented using encryption standards/protocols like Transport Layer Security (TLS)/Datagram Transport Layer Security (DTLS) for the secure transfer of data over the network.
- Data integrity is a basic mechanism of verifying the data based on cryptographic hashes like Secure Hash Algorithm (SHA).
- Digital signatures give a recipient a strong reason to believe that the message or file was created by a known sender.
- Role Based Access Control (RBAC) should be implemented across all the services offered by the applications.
- Heightened security can be provided through secure boot mechanisms in IoT devices.
- All data should be classified based on the security levels and critical data, like user authentication data, should be stored in an encrypted manner in the storage systems.
- All software and firmware of devices should be security hardened to avoid backdoor entry attacks.
- All the centralized infrastructure should be protected against Distributed Denial of Service (DDOS) attacks.
- All computing systems should receive the latest security patches updates against known vulnerabilities.
- Advanced security should be implemented to protect critical IT infrastructure in cloud and data centers, including Anti-APT (advanced persistent threat) systems, intrusion protection systems, network behavior analysis tools, antivirus and anti-malware systems, next generation firewalls, security information and event management, email security systems, data loss prevention systems, etc.

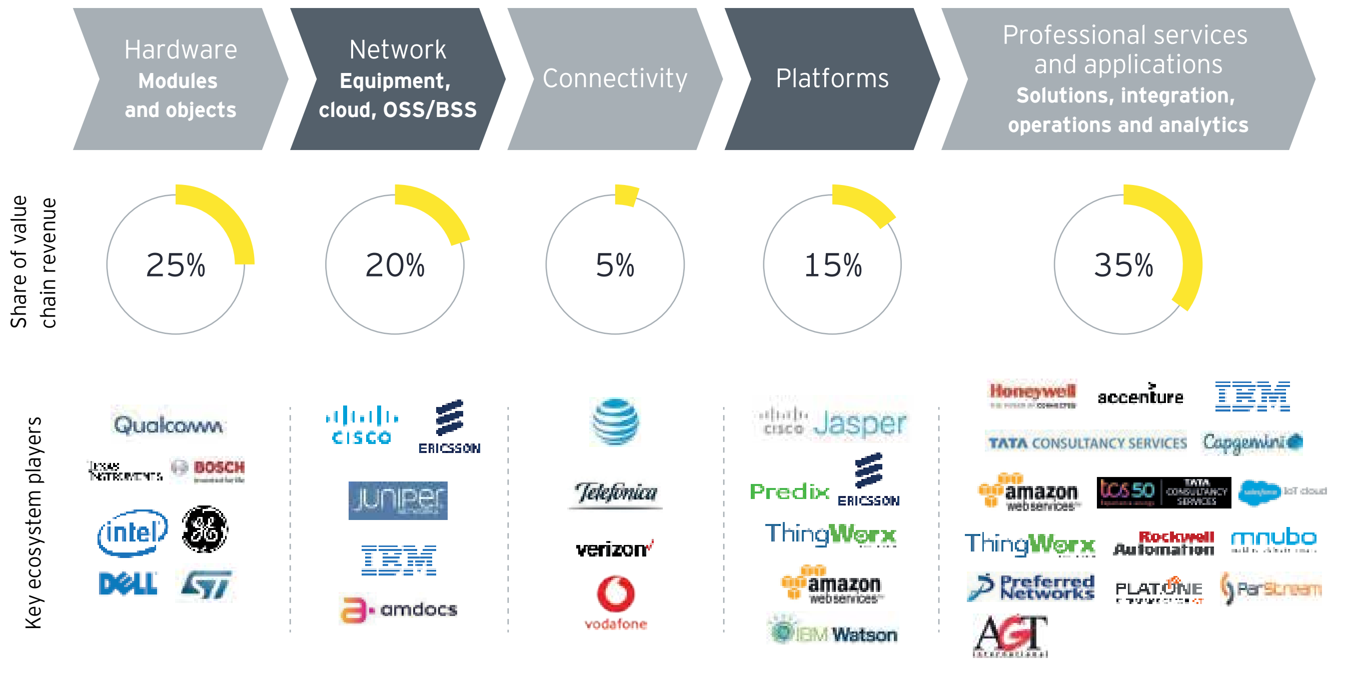
6 IoT value chain

The IoT value chain explains the building blocks of IoT, how value is created, who the players are and how they interact with each other to deliver the value.

- Chips/modules segment constitutes of embedded chipsets, IoT modules, transponders, etc.
- Devices/equipment constitutes smart appliances like smart thermostats, smart meters, smart parking sensors, IoT gateways, etc.
- Connectivity segment constitutes of networking equipment and devices for facilitating end-to-end connectivity of IoT devices installed in the network.
- Platform segment constitutes of different software platforms for aggregating, processing, securing, storing, analyzing, visualizing, controlling, monitoring and making sense out of IoT devices/data.
- Solution and applications segment constitutes of software and domain specific applications and services that leverage IoT data.
- Integration, operations and services segment constitutes of system integration services to integrate the end-to-end ecosystem, operationalizing the services and providing managed or other services to the clients.

IoT value chain

Ecosystem players are capitalizing on growing convergence and collaboration in the value chain to move beyond core offerings



Traditional IoT value chain boundaries are blurring. Players are moving beyond their core expertise to offer services across the value chains. It is being possible through a growing partner ecosystem and targeted acquisitions

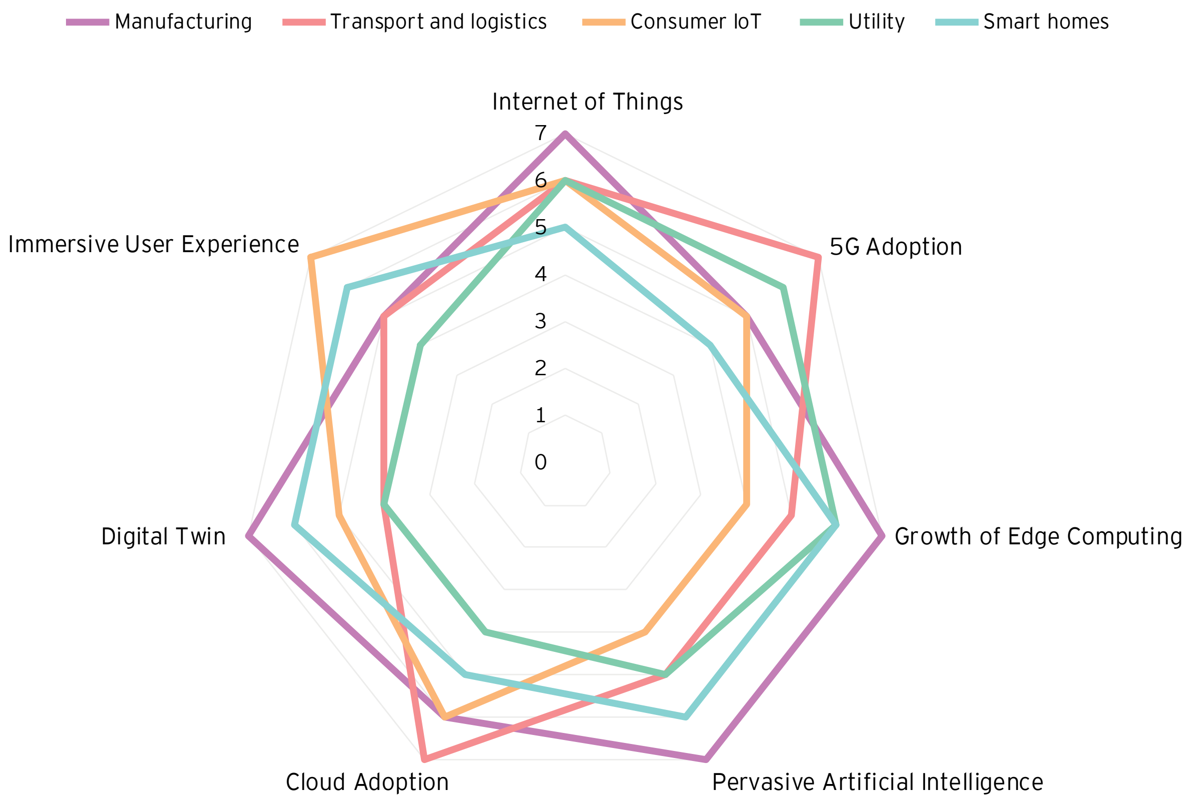
Source: EY analysis

7 Key insights:
how future trends are shaping key sectors

- IoT is enabling new ways to monitor, manage and control devices. It is enabling real-time monitoring of the product performance leading to better insights and faster development of new products.
- IoT, combined with powerful analytics, is also automating and improving the decision-making in businesses.
- Presently, most of the IoT data is being used for anomaly detection and control, whereas in future, the data may be used for predictive analysis and optimizations, which may generate opportunities for new and innovative business models.
- IoT deployments also raise questions around data security and privacy and the wider adoption of IoT requires policies and frameworks to handle these concerns.
- The penetration of future technology trends is shaping how the key sectors are evolving today.

The following are the major trends based on analysis of applications and market size in these sectors:

How future trends are shaping key IoT spend areas?



Source: EY analysis

- 5G may be useful in applications with wider geographical spread and require mobility like transport, traffic and vehicle to everything (V2X) communication.
- Edge computing may be useful for Industry 4.0 applications like water pumps and turbines and even in the aviation industry where each aircraft can generate huge amout of data.
- Immersive experience might be a key enabler to use cases around consumer IoT.
- Digital Twin may find a wide variety of applications in manufacturing, Smart cities and smart home sectors.
- Artificial Intelligence may become more pervasive and be available on all devices from mobile phones to high-end servers and may be key in manufacturing, smart homes and smart cities.
- Centralized cloud-based infrastructure shall remain the underpinning for majority of IoT applications, providing low-cost and scalable computing, storage and geographical coverage.

7.1 Manufacturing

Smart manufacturing, the 4th industrial revolution presents a set of threats and opportunities for manufacturing companies.

Smart manufacturing

The 4th industrial revolution presents a set of threats and opportunities for manufacturing companies

From mechanical to smart manufacturing

1700's - first Industrial Revolution

Mechanical

Technology was steam and water powering the first factories

1800's - second Industrial Revolution

Electrical

Electricity made possible the division of labor and mass production

1900's - third Industrial Revolution

Automated

IT enabled programmable work and an end to reliance on manual labor

Today Fourth Industrial Revolution

Connected

Cyber-physical systems, powered by IoT and fuelled by data, create a fully interconnected society

Extreme experiences	Digital natives
87% Percentage of customers looking for a more seamless experience	75% By 2025, the makeup of the workforce is projected to be majorly digital native
Connected chaos	**Unprecedented pace**
50bn Internet connected "things" by 2020 including sensors, RFID chips etc.	35Days For a new technology to reach a critical mass of 50m users

Key considerations for manufacturers

Big Data and Analytics
- Normalizing data is an effort
- Tons of data - no clear paths of value
- Organizational silo

Digital strategy and roadmap
- Leverage what I have
- Fill the gaps and fulfil the opportunities
- "Living strategy" - flexible; recognizing that technology is changing

Emerging/disruptive technology
- Proof of concepts
- Fear of putting data in the cloud - am I vulnerable?
- Lack of infrastructure to support IoT

Beyond the shop floor
- Supply chain visibility
- Enabling field service
- Selling data

*IIOT: industrial Internet of Things

Source: EY analysis

Industry 4.0 will use the IoT and cyber-physical systems such as sensors having the ability to collect data that can be used by manufacturers and producers. Advancements in Big Data and powerful analytics mean that systems can trawl through the huge sets of data and produce insights that can be acted upon quickly. Smart factories, which will be at the heart of Industry 4.0, will take on-board information and communication technology for the evolution in the supply chain and production line, bringing higher level of both automation and digitization. It allows machines to use self-optimization, self-configuration and even Artificial Intelligence to complete the complex tasks and deliver vastly superior cost efficiencies and better-quality goods or services.

The following may be the key use cases for smart manufacturing:

Smart products

a. Enable products to self-process, store data, communicate and interact within the industrial ecosystem.

b. Describe their status and lifecycle history and are capable of computing algorithms and Machine Learning.

Smart equipment

a. Production equipment uses on-board data, IoT and soft sensors to measure operating conditions, quality results, faults and environmental data.

b. Machine Learning improves productivity and continuously refines settings.

Smart maintenance

a. IoT sensors generate data to drive condition-based maintenance and reduce downtime.

b. Generates and refines operating model for predictive maintenance.

c. Provides additive manufacturing for spare parts to reduce inventory cost.

Smart material

a. Use of smart labels and radio-frequency identification, and self-identifying materials that understand their properties and quality characteristics.

b. Smart systems actively participate in inventory, transportation, manufacturing transformations and scrap management.

Smart metrics

a. The measurements made by the process, material and equipment help in refining the models of zero-loss operation.

b. Advanced analytics provide actionable data for control during short-intervals.

Smart workforce

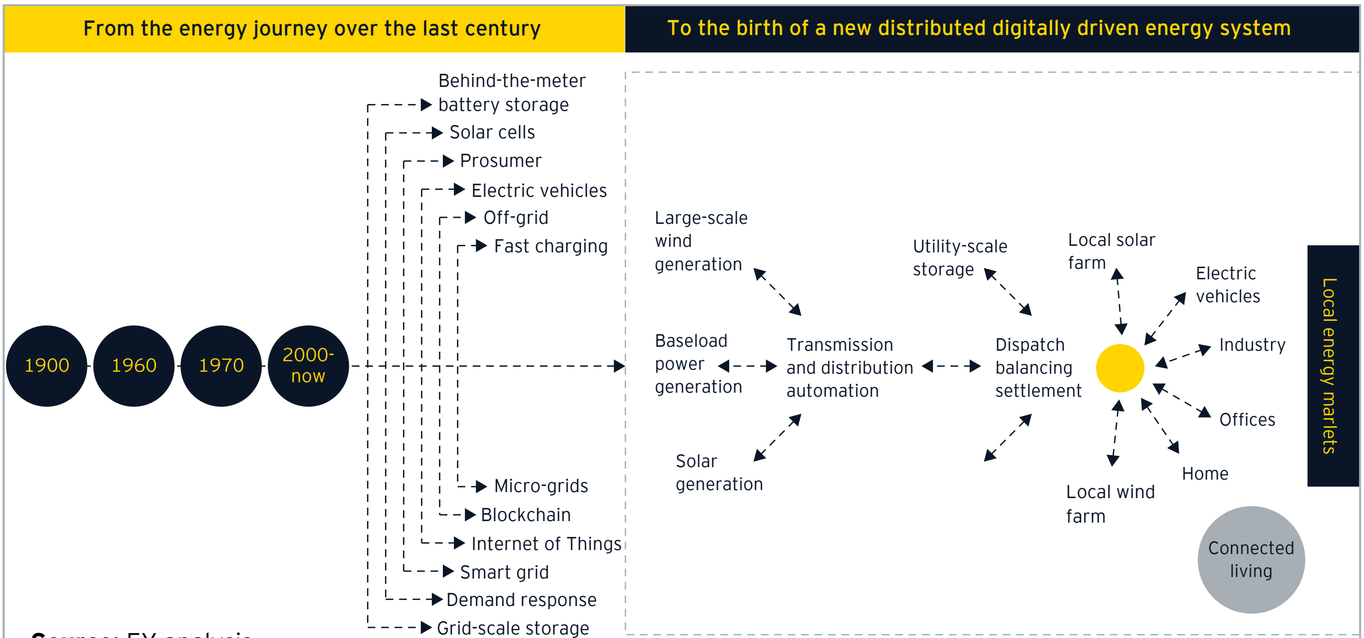
a. Mobile workforce working in high-performance teams.

b. Executes right operations or maintenance tasks at the right time.

c. AR/VR provides situational awareness and activity coaching.

7.2 Utilities

We are moving towards a new energy system, augmented and interconnected by digital technologies, where power and information flow in both directions. The confluence of smart energy networks and digital solutions allow controlling the energy demand and trade and electrification. Low-cost renewable power has the potential to transform the energy sector in a way that seemed improbable a few years ago.



Source: EY analysis

Retail energy providers are using advanced IT infrastructure and data analytics to reduce costs and improve meter-to-cash process and workforce management as well as optimize operations. The two-way flow of data improves organizations' business performance, service reliability and customer relationships. Utilities are investing in technologies such as IoT, Robotics Process Automation (RPA), AI to automate maintenance of assets and improve responsiveness towards customer.

The following may be the key use cases for utilities:

Outage optimization

- AEP is leveraging data analytics for monitoring, alerting and generating emergency response, disaster recovery and criminal activity reporting.

Using analytics to improve customer experience

- Australia's leading energy company, AGL, is leveraging customer segmentation analytics to improve customer experience.

Improving brand image by using analytics

- American utility, Duke Energy, is leveraging social media analytics to analyze the company's brand performance.

Theft identification

- ConEd uses a variety of tools and data analytics to help identify theft leads and unmetered current.

Understand customers' demands

- Origin Energy deployed SAS Energy Forecasting to shift from random pricing to a predictable plan of charging customers the same amount each time.

Reduce customer churn

- EDF Energy uses SAS analytics to customize their marketing tactics by identifying the risks of leaving a customer.

7.3 Transportation and logistics

The connection of vehicles to internet gives rise to a wealth of new possibilities and applications making transport safer and more convenient for users. Key applications in the transport industry by leveraging IoT are connected cars, fleet management, vehicle to vehicle and vehicle to infrastructure communication, vehicle pooling and hiring services and self-driving vehicles.

Connected cars are vehicles equipped with internet connectivity and embedded sensors in different part of vehicles like engine, brakes, gear, tires, etc. that gather data and transmit the gathered data to remote diagnostic applications for predictive maintenance and servicing. Connected cars also offer increasing levels of multimedia connectivity and automation, such as dashboard interfaces for accessing email, music and video streaming, and social networks, and the promise of self-driving and self-parking modes.

The following are the potential solution areas in connected cars for original equipment manufacturers (OEMs), passengers and insurance service providers:

- An OEM wants to increase revenue and sales for their cars. To have this positive impact in their organization, some statistics are needed to be with them. So, they need to perform some analysis and proactive sales.
- Customers or passengers need to have a real-time diagnostic of their vehicle i.e., the time of service, engine health, oil usage, brakes, speed and performance of tires, etc. To have these data analytics points in real-time with them, IoT devices should be installed in their vehicles to measure it.
- Insurance organizations: data availability for insurance service providers play a vital role in reduction of claims and recovery of stolen cars.

Fleet management

When it comes to transportation and logistics, fleet management plays a critical role in managing the maintenance schedules, everyday vehicle usage and service routes. To maximize productivity and operational efficiency, the fleet downtime must be minimized. With mobile scanners, computers and RFID systems alone, enterprises can gain visibility into their assets and streamline their operations in a better way to keep their fleet moving.

Solutions		Value proposition
Connected cars	Auto OEMs	▶ Sales improved by 2% with analytics that matched the consumer needs
	Passengers	▶ Reduction in maintenance cost by 10%-40% ▶ Vehicle lifecycle increase by 3%-5%
	Insurance providers	▶ Reduction in claims by GPS tracking of stolen cars to decrease premium cost by 25%
Fleet management	Fleet owners	▶ Increase in number of trips due to optimized fleets to increase efficiency by 20%-30% ▶ Timely diagnostics to reduce maintenance cost by 10%-40% and extend vehicle life by 3%-5% ▶ Optimized fuel costs may result in improving the profit margin ▶ Driver behavior monitoring may enhance passenger safety ▶ Real-time decisions on goods movement may reduce wastage
	Insurance providers	▶ Reduction in claims by GPS tracking of stolen cars to decrease premium cost by 25%

Source: EY analysis

7.4 Agriculture

The Food and Agriculture Organization of the United Nations [15] estimates that almost 800 million people in the developing world remain chronically undernourished. Additionally, it estimates that the world will need to produce 70% more food by 2050 in order to feed the growing population. This means that there is a need for the agriculture industry to focus on dramatically increasing their efficiency and productivity while optimizing their resource allocation. IoT technologies can thus be the catalyst to push agriculture to the next level.

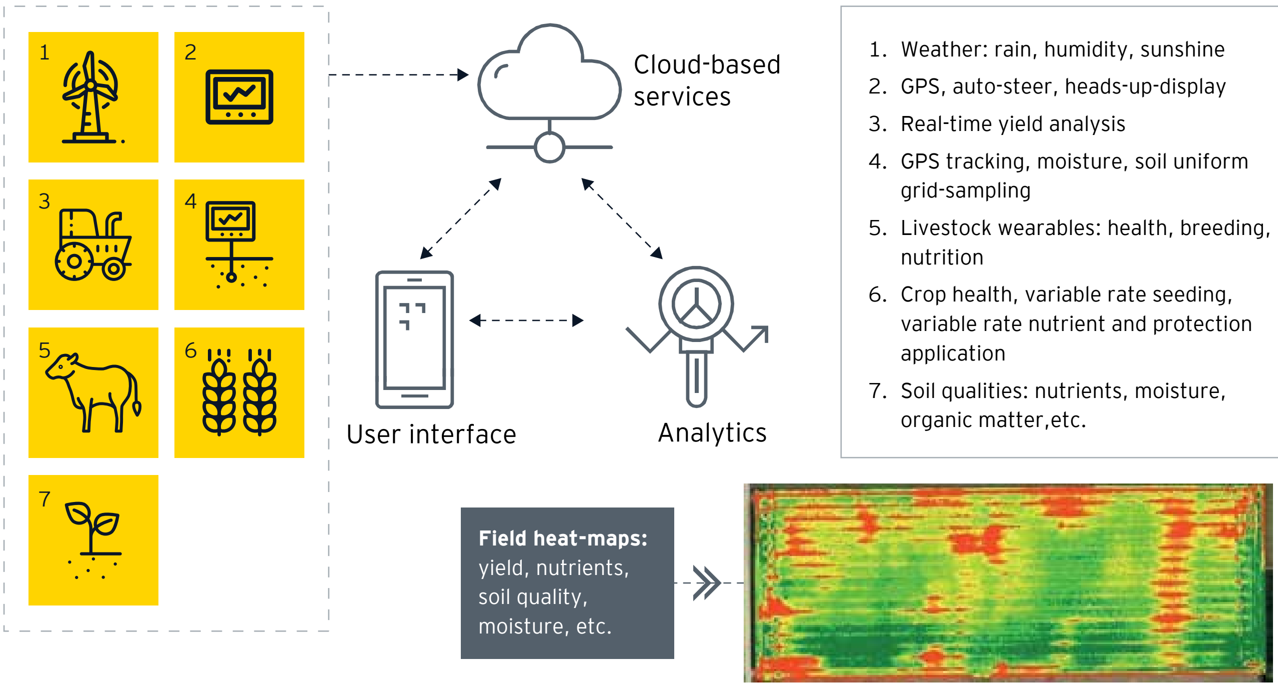
There are many ways in which IoT is impacting agriculture today. For example, wireless IoT sensors are capable of forecasting weather conditions, measuring hyper-local conditions of fields, and monitoring soil quality and moisture. As a result, farmers are not only able to plan their course of activities in a better way beforehand, but they also know precisely when and where they need to take preventive measures. Consequently, farmers are also able to improve the production output while preserving their resources and minimizing costs.

Today, farmers can track the state and behavior of livestock remotely via IoT sensors and embedded devices. Even further, thanks to advancements in data analytics, they can run statistical predictions and evaluate any necessary interventions for specific animals. For example, IoT sensors have the ability to notify a farmer that an animal is sick, so that the said animal could be separated from the herd and measures could be adopted to prevent the spread of the illness.

IoT devices and software are being deployed throughout a farm to monitor crop health, manage inventory and supply chain and provide similar new and innovative service offerings. They also help in daily farm activities. The diagram below highlights how IoT and other related technologies are impacting agriculture businesses throughout the lifecycle from sourcing to retailing and consumption.

Internet of Things (IoT) collects and analyses data to deliver actionable insights and improve decision accuracy

Sensor networks: in the field, on animals or on equipment



Internet of Things analysis with sensor networks allow producers to gather data in real time and generate usable, insightful analyses to help make for crop and decisions about the timing and intensity of protection and nutrition activities for both crop and livestock operations.

Source: EY analysis

7.5 Oil and gas

Oil and gas sector is facing the following key challenges:

Conventional resource deposits exhaustion

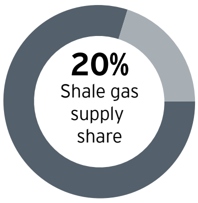
- Production of oil from conventional sources is shifting to more remote, challenging and expensive deepwater locations and sub-Arctic locations.
- Development of unconventional oil sources – extra heavy oil, oil shale and oil sands – requires more advanced technologies and, therefore, more research investments.
- Alternative sources of hydrocarbonates are extending their market share.
- In 2010, the share of shale gas in the total energy supply has reached 20%, and it is forecasted to reach 50% by 2035.

Unstable market demand

- Global oil demand is unstable and constantly changing due to various geopolitical and technological factors.
- China is the largest oil consumer, creating 10% of global oil demand and forecasted to grow by one-third by 2020.
- Meanwhile, more governments and consumers are seeking a less carbon-intense energy mix.
- Share of renewable energy sources in the electricity generation process is forecasted to grow by 3% each year and reach the level of 23% by 2035.

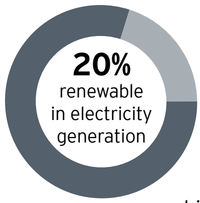
Oil price dynamics

- One of the most valuable factors for oil and gas industry's development – the price of the crude oil barrel – is facing dramatic challenges caused by various factors:
  - Unstable demand
  - Cost of mining and transportation
  - Geopolitical instability
  - Environmental safety risks
- Gas prices that are closely linked to oil prices are also experiencing a strong decline.
- Oil exporters are facing the challenge of cost optimization to stay profitable.



1.2t
Estimated barrels of world conventional oil reserves

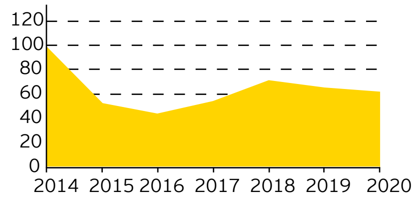
8.6t
World added barrels by unconventional oil sources



93Mb/d
World oil demand in 2015 according to OPEC

8Mb/d
Estimated amount of biofuels usage by 2035

Oil Barrel Price US$



Source: EY analysis

These challenges are registered from operations, processing, storage and distribution, which in turn can be improved via IoT solutions such as:

- Centralized surveillance monitoring solution: implementation of the centralized solution connects the distributed surveillance units and aggregates data in real-time to provide geologic personnel with up-to-date information in comprehensive dashboards and reports.
- Production process prediction solution: the advanced analytics method is based on the data generated from oil well conditions, equipment performance and production process parameters that enable a significant improvement of production planning accuracy, which optimized costs of the production process.
- Refinery equipment maintenance solution: condition-based maintenance solutions are implemented to monitor and analyze the condition of the refinery equipment that operates in a large network of sensors in real-time to detect and prevent the potential breakdown of threats.

Case studies

Centralized surveillance monitoring solution

Implementation of centralized solution that connects distributed surveillance units and aggregates data in real-time to provide geologic personnel with up-to-date information in comprehensive dashboards and reports

US$1m Annual savings on costs of surveillance processes

Production process prediction system

Advanced analytics methods based on data from well conditions, equipment performance and production process parameters enabled a significant improvement of production planning accuracy, which optimized costs of the production process

30% Increase of production planning accuracy

Refinery equipment maintenance solution

Implementation of condition-based maintenance solutions for refinery equipment operating large network of sensors to monitor and analyze the condition of equipment in real-time to detect and prevent potential breakdown threats.

15% Prevention of losses in production due to equipment breakdowns

Concept of OT SOC

Development of the concept of security operations center providing awareness of security status 24/7, minimizing response times and providing material for decision-making in crisis situations

46 Critical OT assets monitored by digital SOC

Potential solutions

Deposit field development

Deposit exploration

- Aggregation of distributed data from surveillance units
- Advanced analytics of automatically measured surveillance data
- Connected echo-sensoring systems for maximization of soil scanning efficiency

Well drilling

- Soil parameters monitoring and layers modelling
- Smart drilling process control
- Drilling process optimization
- Condition-based maintenance of drilling equipment

Upstream processes

Mining & pumping

- CBM for pumping equipment
- Smart mining process planning
- Well internal conditions monitoring
- Real-time crude oil quality monitoring

Crude oil transportation

- Smart flow management
- Transportation process optimization
- Pipelines and tanker containers inspection
- Leakages prevention
- Real-time threats reporting

Downstream processes

Crude oil storage

- Storage conditions control
- Real-time crude oil level and parameters monitoring
- Process transparency and optimization in tank farm management system
- Storage process safety management

Refining process

- CBM for refining and supporting equipment
- Real-time quality management
- Production processes monitoring and optimization
- Real-time KPI management
- Environment impact minimization

Product distribution

Finished goods distribution

- Transportation units locating and monitoring
- Transportation conditions monitoring and controlling
- Logistics optimization
- CBM for transportation units
- Leakages prevention
- Fraud prevention

Security

- OT environment contains critical assets for process continuity in all oil and gas processes.
- Characterized oil & gas sector assets, such as PLCs, SCADA systems, DCSs, ESDs, must be secured in a proper way.
- Based on our many years of experience and the knowledge of our subject matter resources in the area of security and the OT/IoT environment, we can provide a wide range of services addressing the most important needs in the area of security.

IoT/OT security transformation | **IoT/OT security architecture** | **Digital SOC** | **Critical infrastructure protection** | **Security solution advisory and implementation**

OT: operation technology, SOC: security operation center, KPI: key performance indicators, PLC: programmable logic controller, CBM: coalbed methane, DCS: distribution control system, ESD: electrostatic discharge

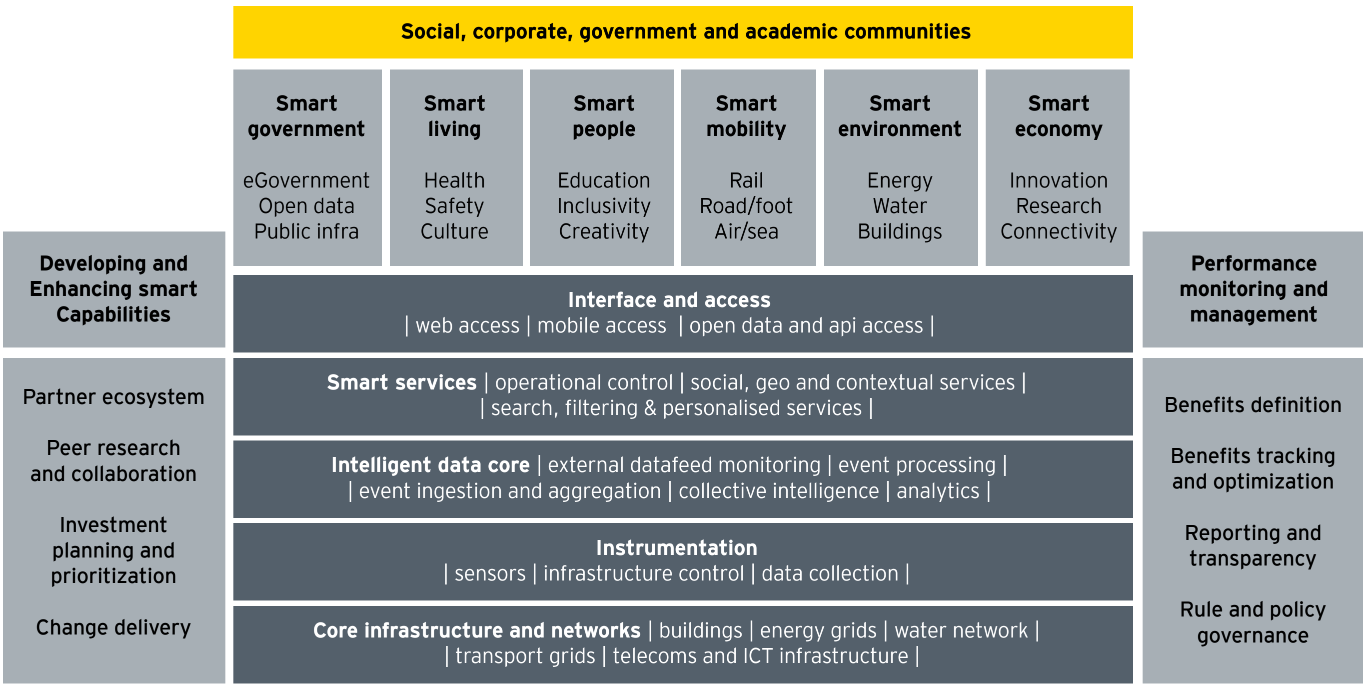
Source: EY analysis

7.6 Smart cities

Smart cities are going to be the reality for municipalities around the world. These cities may use communication networks, highly-distributed wireless sensor technology and intelligent management systems to solve the current and future challenges, and create new services. The key features of smart cities can be defined as:

- Smart governance: includes flexible governance structure, technology-enabled decision mechanisms, smart regulation to connect city laws to new digital realities, and innovation clusters to create jobs and vibrant economies.
- Smart economy: includes viable and sustainable business opportunities and the presence of innovative enterprises, clubbed with quality education and infrastructure to provide a better economic status to the city.
- Smart mobility: includes extensive and efficient public transportation network, park and ride, diffusion of ecological cars, limited traffic areas, cycle paths, bike and car sharing.
- Smart environment: includes management of waste disposal in cleaner ways, maintaining pollution-free air, water treatment plants, etc. and to provide a cleaner and greener environment to the citizens
- Smart living: includes technologies to integrate and analyze massive amounts of data to provide better living to citizens in the form of childcare facilities, community libraries, entertainment modes and hospitals according to the area needs, etc.
- Smart people: includes services, notifications and information to citizens, such as where to find a parking spot or a new local shop or even to monitor air pollution; connecting citizens to local government and encouraging a more direct participation, interaction and collaboration.
- Improved public safety: city surveillance, emergency response and disaster management are key components of a smart city.

All these solutions require an extensive deployment of IoTs across the city. Sensors provide a real-time information on the events in the city and centralized platform analyzes the data and supports cities in improving the decision making.



Source: EY analysis

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