Regional Industry Focus

Internet of Things

Refer to important disclosures at the end of this report

DBS Group Research. Equity

16 Aug 2018

IoT: The Pillar of Artificial Intelligence

- IoT (Internet of Things) to become a mainstream technology by 2019; The combination of Artificial Intelligence (AI) and the IoT will result in new leaders and laggards emerging across all industries.
- IoT would change the dynamics of competition from discrete products to product ecosystems
- Key beneficiaries are Alibaba, AAC, ST Engineering, HCL Tech, L&T Infotech (LTI) and Mphasis.

IoT on the verge of becoming a mainstream technology. Our estimates indicate that IoT will reach the inflection point of 15-20% in 2019, at which point adoption will start to accelerate among the masses. We believe that the advent of IoT would provide a much-needed boost for the development of AI with billions of IoT devices creating ample data to feed AI systems. IoT would change the dynamics of competition from discrete products to product ecosystems, leading to the emergence of a few leading players at the cost of others in many industries. Rapid adoption of IoT would also offer consumer companies access to customer usage data, which is currently limited to a few Internet companies.

Asia leads in IoT adoption. About 36% of Asian enterprises had adopted IoT solutions as of 2017 versus 29% globally. Asia is expected to account for ~48% of global IoT share by 2021, with projected spending on IoT exceeding US$500bn. Asia is on track to becoming a global hub for AI developments, backed by Smart City initiatives.

Key beneficiaries in the digital space. **Alibaba's** differentiated online ads should allow the e-commerce giant to improve its Gross Merchandise Value (GMV) monetisation rate leading to ~24% earnings CAGR over FY3/18-20F. **AAC** (2018 HK) to benefit from continuous smartphone spec upgrade in acoustics, haptics, and optical solutions for IoT applications to drive 24% earnings CAGR over FY17-19. **ST Engineering** aims to more than double smart city revenues by 2022, offering earnings CAGR of ~6% over FY17-19. **Mphasis** offers ~19% earnings CAGR over FY3/18-20F due to anchor clients (HP and Blackstone) and digital revenues accounting for ~40% of total revenue. **L&T Infotech** to benefit from large deal wins and signifiant digital revenue (34% of group) leading to 21% earnings CAGR over FY3/18-20F. **HCL Tech's** deal wins, R&D investments and 27% digital revenue contribution to lead to FY3/18-20F earnings CAGR of 8%

STI	: 3,242.12
HSI	:27,323.59
BSE Sensex	:37,852.00

STOCKS

	Price	Mkt Cap	12-mth Target Price	Performance (%)		
	LCY	US$m	LCY	3 mth	12 mth	Rating
Alibaba Group	172.53	455,449	na	(12.3)	13.7	na
AAC Technologies Holdings	85.75	13,360	165.00	(22.1)	(19.6)	BUY
ST Engineering	3.32	7,516	4.10	(2.1)	(10.3)	BUY
HCL Tech	999.70	19,916	1200.00	8.0	6.6	BUY
L&T Infotech	1784.75	4,418	1850.00	9.1	18.8	ACCUMULATE
Mphasis.	1163.25	3,217	1300.00	18.3	30.6	ACCUMULATE

Source: DBS Bank, Bloomberg Finance L.P.
Closing price as of 14 Aug 2018

Internet of Things: The Pillar of Artificial Intelligence
Start Building Your Ecosystem

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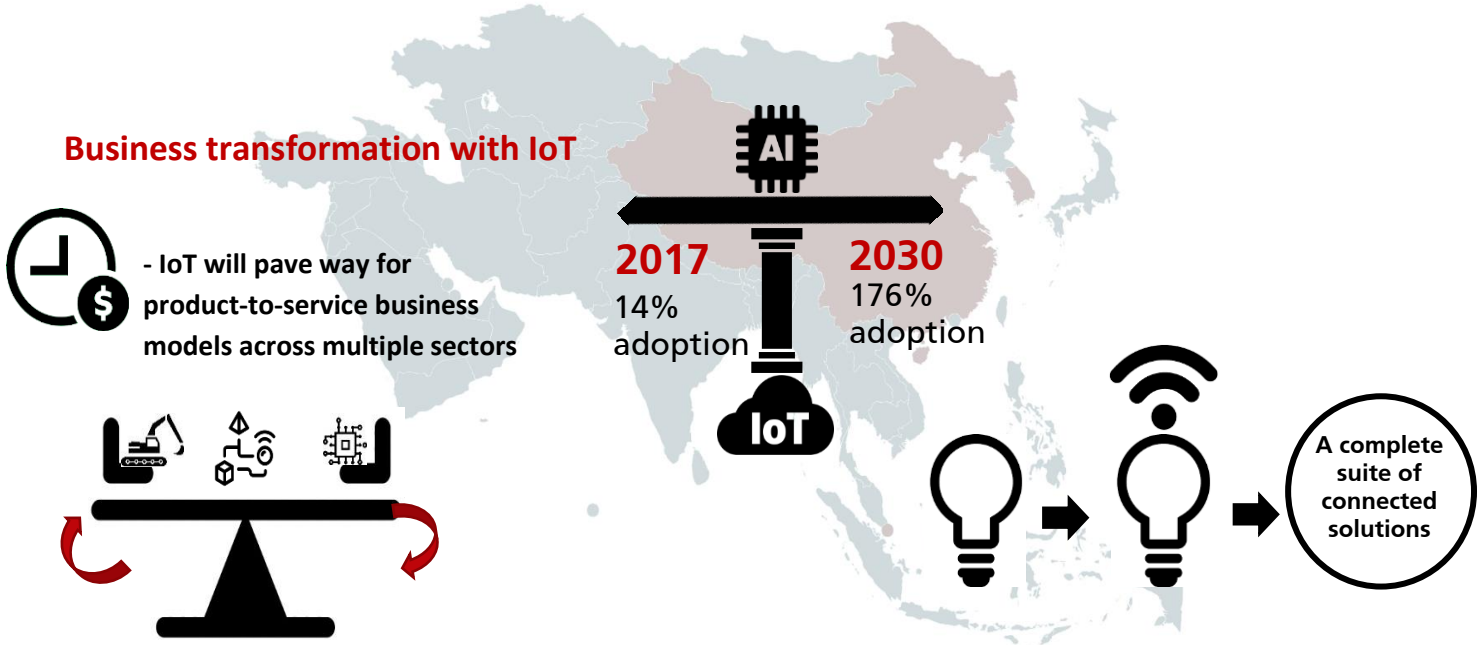
With special thanks to Rahul Jain and Devanshu Bansal of Emkay Global for their contributions to the report

IoT in a nutshell

IoT will set the path for developments in Artificial Intelligence (AI)



	Consumer	Manufacturing	Utilities & Energy	Transportation & Logistics	Telecommunications
Primary uses	• Shift from one-time product sale to recurring revenue stream • Shift from best product features to best connected solutions	• Factory automation yielding improvements in productivity and efficiencies • Predictive maintenance minimising unplanned downtime	• Predictive maintenance and real-time visibility for early detection of contaminations/leaks • Cost savings through automated smart meters	• Asset tracking to minimise wastage of goods-in-transit • Efficient traffic and transport management through real time visibility	• Provision of IoT connectivity via cellular and Low-Power networks • Provision of integrated end to end IoT solutions and support services

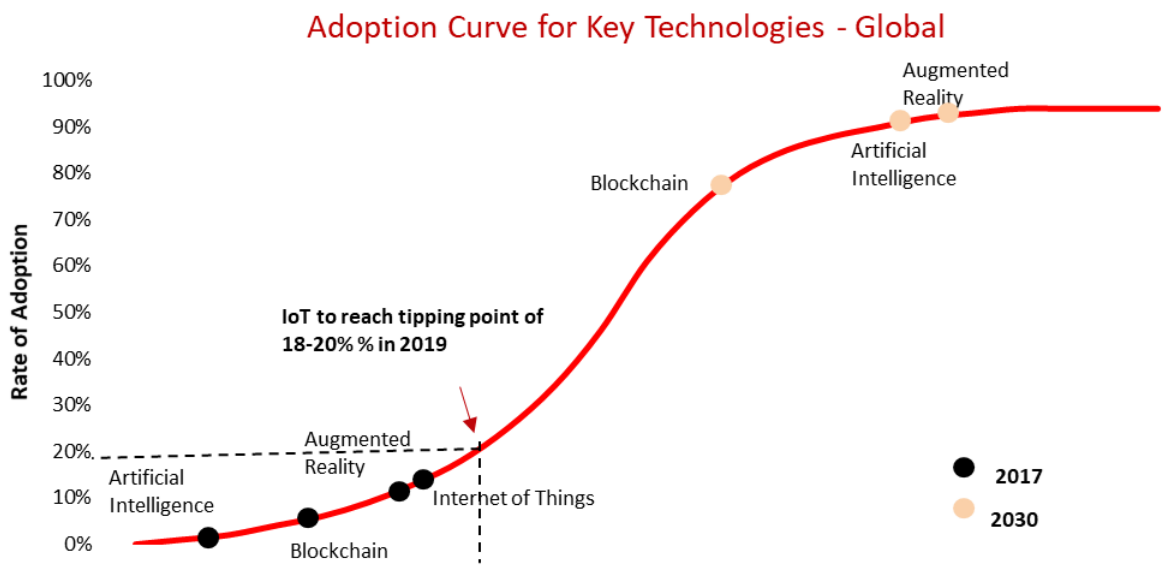
Source: DBS Bank

Executive Summary

Asia the clear leader

Asia is set to lead the development of the Internet of Things (IoT) and Artificial Intelligence (AI) in the forthcoming decade. Our estimates indicate that the IoT will reach the inflection point of 18-20% in 2019, at which point the adoption rate will start to accelerate. Consumers lead the adoption of IoT solutions, accounting for over 60% of IoT devices globally, followed closely by industries such as energy & mining, transportation, and manufacturing.

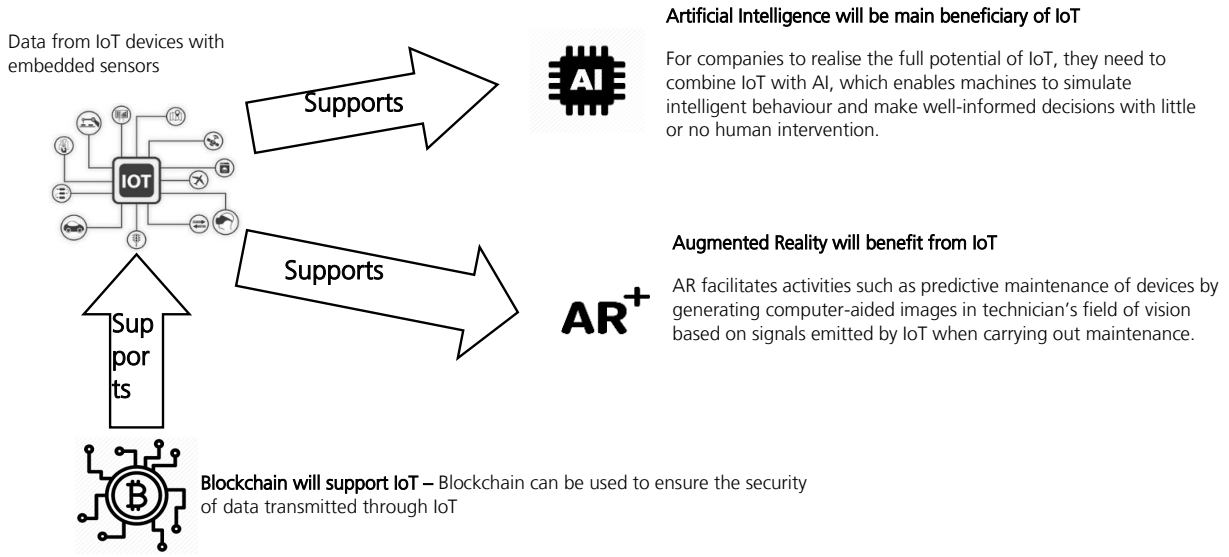
Diagram 1: IoT adoption to approach 100% over the next 10 years



Source: DBS Bank

The combination of the IoT with developments in AI and Augmented Reality (AR) will bring forth a new realm. Blockchain technology will support the IoT by addressing security and privacy issues.

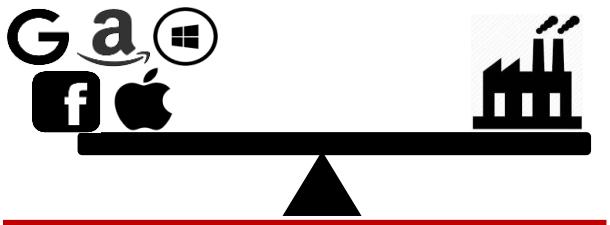
IoT's links to other technologies



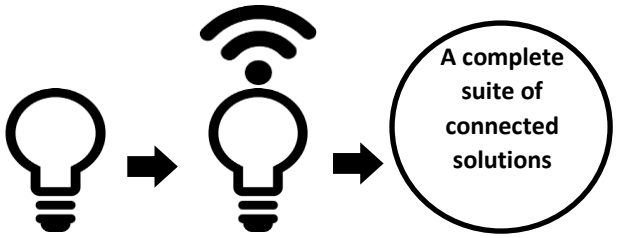
Source: DBS Bank

Four key transformations by IoT

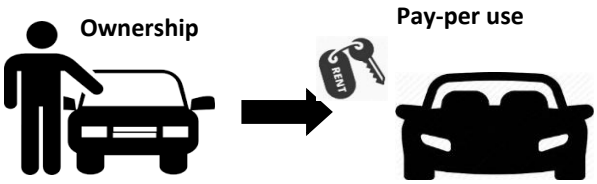
The advent of the IoT has the potential to redefine the way businesses and industries operate. We see four key ways in which the IoT will make a big difference



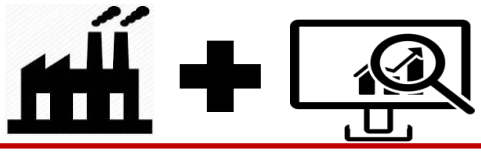
IoT will level playing field on data front between tech giants and non-digital players. IoT would provide a mechanism for players in non-digital domains to collect and analyst customer data, a privilege once exclusive to only those with digital presence.



Industry competition would shift from discrete products to eco-systems and a few dominant players will emerge in most industries. Basis of competition within industries should shift from discrete products to eco-systems of closely related products. This would require unprecedented levels of collaboration between disparate industries and would lend a substantial advantage to larger operators in each industry, leading to the emergence of a few dominant players at the expense of smaller players.



Product-to-service models will emerge with adoption of product-as-a-service business model. Ability to track product performance and usage on a real-time basis will shift industries from a traditional asset-ownership model to an asset-rental model.



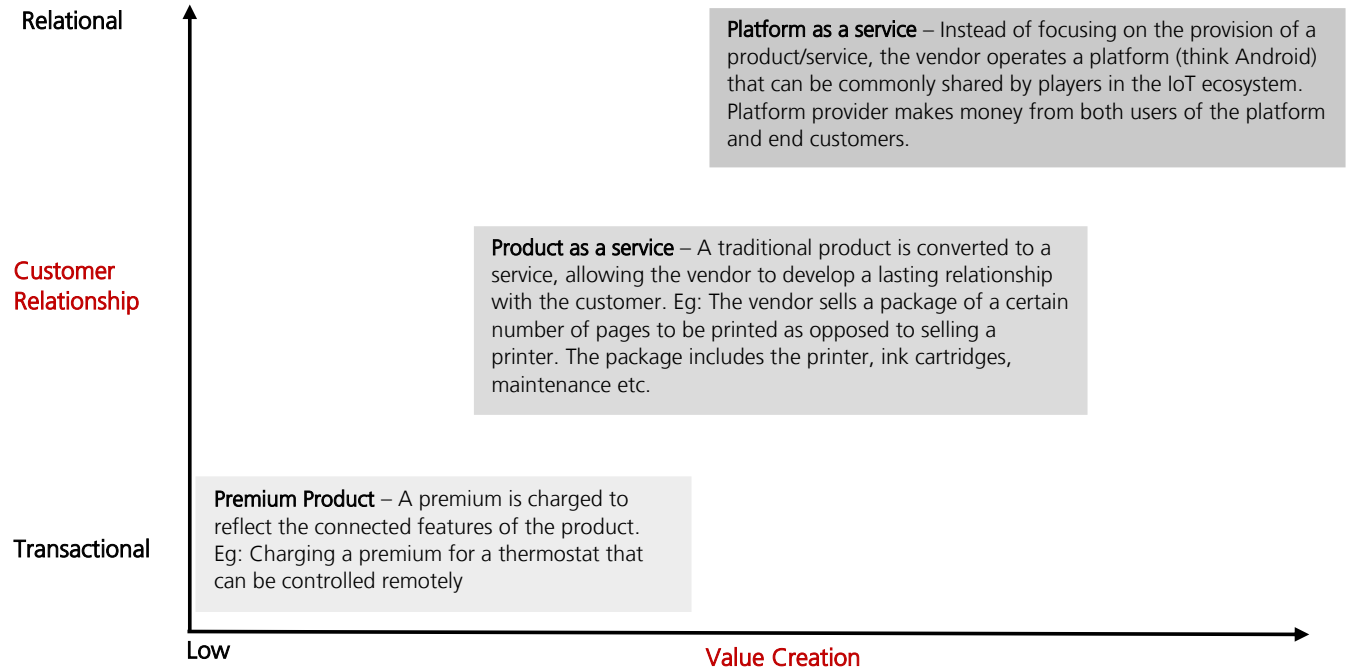
Ability to collect and use data will be key competitive advantage. With the IoT, enterprises across the board will gain access to an unprecedented quantum of data. This will allow players in each industry to continuously develop and optimise their products to suit the changing needs of the environment and their customers. Businesses with little capability in capturing, storing and managing data will see significant losses in market share and profits.

Source: DBS Bank

How to monetise the IoT

The IoT allows manufacturers to track product performance and usage in real time: allowing vendors to adopt "product-as-a-service" monetisation models. This will help manufacturers develop long-term relationships with customers, while creating a recurring stream of revenues.

Monetisation models of IoT for consumer companies



Source: DBS Bank

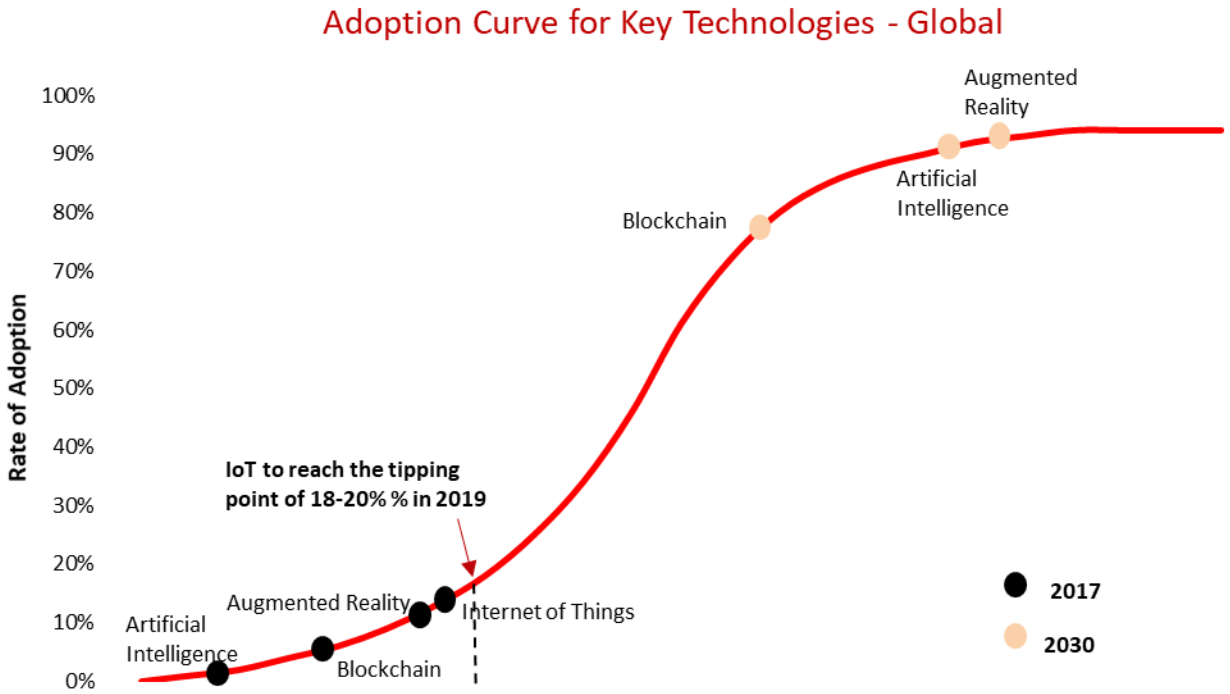
IoT is closing in on the tipping point

IoT on the verge of going mainstream

Everett M. Rogers, in his theory of "Diffusion of Innovation" published in 1962, proposed that adopters of any new innovation can be categorised as Innovators (2.5%), Early Adopters (13.5%), Early Majority (34%), Late Majority (34%), and Laggards (16%), based on the bell curve. It essentially shows a cumulative percentage of adopters over time – slow at the start, faster as adoption increases, then levelling off until there is only a small percentage of laggards. According to the theory, technologies reach an inflection point when adoption of the technology reaches 15-20%, i.e., the early majority stage, with an accelerating uptake likely past this point.

Based on estimates of global adoption, we have identified four technologies, namely, the Internet of Things (IoT), Artificial Intelligence (AI), blockchain and Augmented Reality (AR), which are likely to reach the mass adoption stage in Asia over the next five to ten years.

Diagram 1



Source: DBS Bank
Based on estimates by global research institutions

As per our estimates, the IoT is on the verge of achieving mainstream adoption with a ~14% global consumer adoption rate. According to estimates[i], there were ~5.2b consumer IoT units globally in 2017. Assuming that an individual owns on average five connected devices, this translates to a global consumer IoT adoption of ~14%.

With growing uptake, the IoT is likely to reach the inflection point of 18-20%, where mass adoption occurs, over the course of 2019. By 2030, ~125bn[ii] devices are expected to be connected to the internet, at which point we estimate that global adoption of consumer IoT technology will reach ~100%. Mainstream adoption of the IoT will also set the stage for developments in AI and automation. Hence, we believe that the IoT will have a profound impact on Asia by 2030.

IoT adoption gaining momentum

IoT adoption rate

	2016	2017	2018	2030
IoT units installed base - total (m)	6,382	8,381	11,197	125,000
Consumer devices (m)	3,963	5,244	7,036	75,000
Consumer devices as a % of total devices	62%	63%	63%	60%
Connected devices per person	5	5	5	5
World population (m)	7,400	7,600	7,700	8,500
IoT adoption rate	**11%**	**14%**	**18%**	**176%**

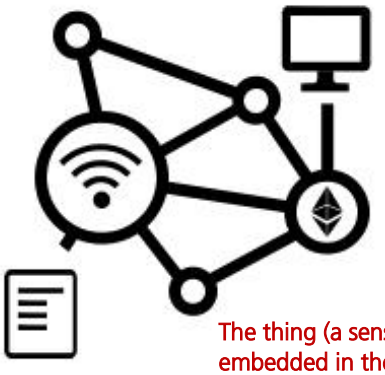
Source: DBS Bank based on estimates by Gartner, United Nations, World Bank

What is IoT?

The IoT refers to a network of things that are connected to each other and refers to an ecosystem comprising of things, connectivity and services including data analysis.

Three parts of IoT - Things, Connectivity and Service

Connectivity allows the thing to communicate data gathered through sensors with other connected devices and the service. Connectivity can be provided via cellular technologies or via Wi-Fi, Bluetooth, ZigBee etc.



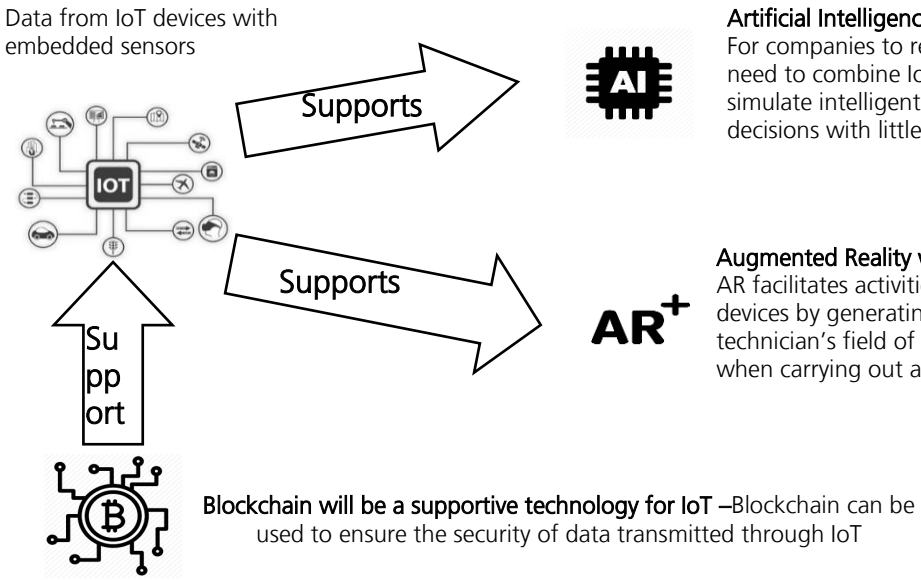
The thing (a sensor embedded in the product) has some intelligence to sense changes around it.

The service is usually hosted in a remote location away from the thing. This can be cloud infrastructure along with specific applications and data analytics. The service portion is likely to be the largest portion of the IoT revenue pie.

Source: DBS Bank

The IoT market is expected to be one of the fastest-growing segments in the technology industry of the Asia-Pacific. IoT spend in Asia-Pacific is expected to reach US$500bn by 2021, accounting for 48% of global IoT share[iii]. By 2020, estimates indicate that there will be over 8.6bn connected devices in Asia Pacific excluding Japan, accounting for ~29% of connected devices globally.

IoT's links to other technologies



Artificial Intelligence will be the main beneficiary of IoT
For companies to realise the full potential of IoT, they need to combine IoT with AI, which enables machines to simulate intelligent behaviour and make well informed decisions with little or no human intervention.

Augmented Reality will benefit from IoT
AR facilitates activities such as predictive maintenance of devices by generating computer aided images in technician's field of vision based on signals emitted by IoT when carrying out a maintenance.

Blockchain will be a supportive technology for IoT –Blockchain can be used to ensure the security of data transmitted through IoT

Source: DBS Bank

Artificial intelligence (AI)

To harness the true value of IoT devices, we insist on the need for AI. The substantial volumes of data generated from IoT devices have limited value without AI technologies capable of finding valuable insights and patterns in the data. As IoT adoption rates gradually increase, we project an increase in AI platforms offered by internet giants such as Google, Amazon, IBM and Microsoft. The connectivity between IoT and AI is analysed in depth in the phases of IoT section in this report.

Augmented Reality (AR)

AR technology can also be used in conjunction with IoT devices with embedded sensors for facilitating activities of employees in an organisation. For instance, AR devices such as electronic glasses can show the worker how to conduct predictive maintenance based on the signals emitted by the machine which detect the parts to be replaced. Once the machine needs repair, the machine itself will raise the job ticket to repair the parts, contact the technician through the base station and project computer-generated graphics in a worker's field of vision to provide real-time assistance and task instructions. This reduces the probability of mistakes, helps to train unskilled workers, reduces the costs involved and removes the necessity to go through lengthy manuals or other reference materials.

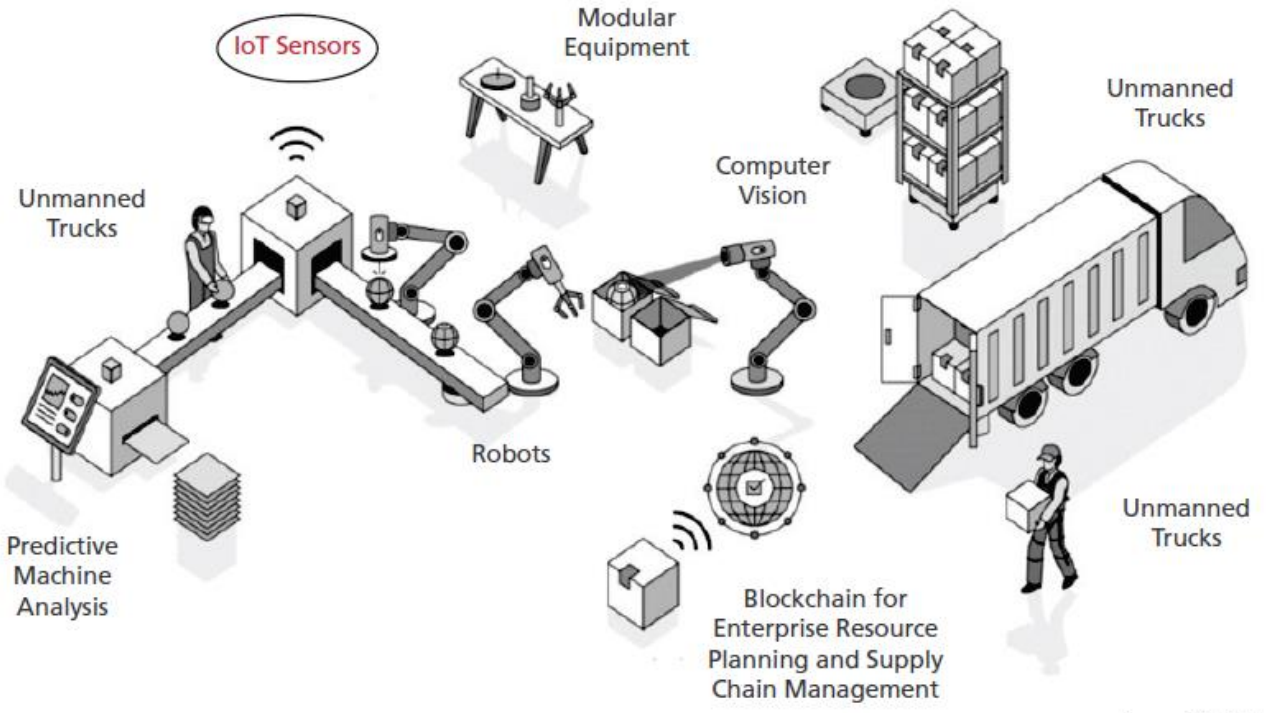
Blockchain

Currently, IoT devices often lack the authentication standards and encryption necessary to keep user data safe. Critical damage can happen if hackers gain access to IoT devices. To ensure widespread adoption of the IoT, authentication and standardisation of the IoT is integral. In order to overcome the security and trust challenges, the IoT can leverage on the distributed architecture of blockchain. This is achievable in the following ways:

- Insights from blockchain can be used to track the sensor data and prevent duplication with malicious data.
- Distributed ledger technology can provide each IoT device with a unique identification, authentication and seamless secure data transfer.
- A generalised platform like blockchain may be used by all IoT devices to communicate with other. This will reduce costs as a third-party facilitator will no longer be necessary.
- Blockchain can provide a history of connected devices for troubleshooting purposes.

In general, blockchain-based IoT solutions can be used for addressing security and privacy issues of IoT, simplifying business processes, improving customer experience and achieving significant cost efficiencies.

To illustrate IoT technology's potential to link other technologies, the following is an example from the manufacturing industry.



Source: CB Insights

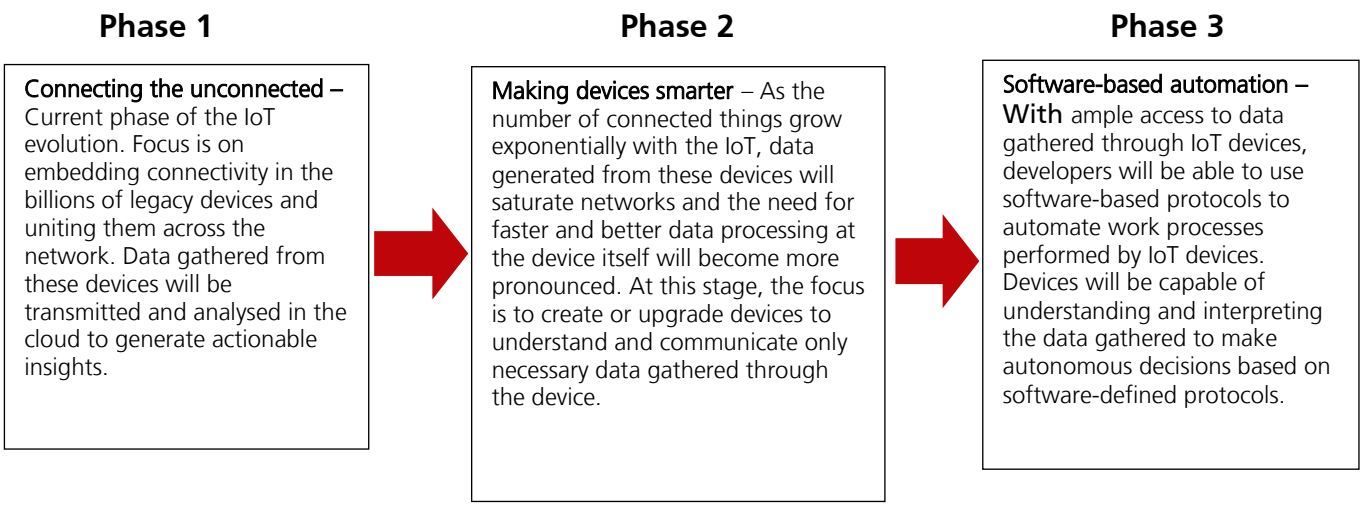
IoT sensor potential in manufacturing industry

IoT sensors on machinery will facilitate the tracking of product movement throughout the production flow. Predictive machine analytics will be possible due to sensors hooked on to machinery that derive insights with AI-aided predictive power. Furthermore, complicated tasks such as field service can be carried out remotely, using AR to map on to complicated machine interfaces, and give step-by-step instructions.

Collaborative robots (Cobots) can easily navigate their way in factories processing sensor-fed information using their AI capabilities. Sensor cameras have the capability to categorise products in warehouses, and scan for defects using AI-based machine learning.

Labour cost can be drastically reduced in factories using unmanned trucks, automating deliveries and facilitating 24/7 movement of products. Furthermore, wearables with embedded sensors can protect human workers from repeated motion and strain, and monitor their health. In the future, manufacturers will explore decentralised technologies to make their organisations more autonomous, and their product and asset movements more digitised and trackable in real-time. Blockchain not only promises to simplify supply chain management, but can also make payments frictionless. Furthermore, factories employing blockchain will be better positioned in the event of a recall. In factories where food or automobiles are processed, a single system for managing recalls could more swiftly figure out the origin of faulty parts or contaminated batches, potentially saving lives and money.

Three Phases of IoT[iv]



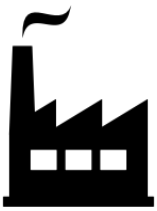
Source: DBS Bank

IoT and AI – A new realm

The combination of the IoT with developments in AI will bring forth a new realm. At this stage, "things" will be intelligent enough to act on their own, improvise under unusual circumstances and function without human interference. AI affects IoT solutions in two key dimensions, in enabling real-time responses and in post-event processing, such as seeking out patterns in data over time and running predictive analytics. The combination of AI and the IoT will result in new leaders and laggards emerging across all industries. The combination will also allow machines to take over routine, monotonous jobs and radically disrupt the competitive landscape. Early adopters will have tremendous advantages in terms of lower costs, better customer experiences and a head start in new business opportunities.

The combination of IoT with AI will affect all industries

Airlines – Sensors on aircraft continuously monitor the status of various systems and sub-systems, helping to pinpoint existing faults and predicting potential faults and their degree of severity. The result is better safety and fewer aircraft delays and downtime.



Manufacturing – Large manufacturing and industrial companies — in markets as diverse as domestic appliances, aircraft, automobiles, ships and mining — are enabling their machinery with sensors to perform predictive maintenance and create the autonomous factories of the future.

Body sensors – Smart sensors can monitor various bodily activities and metrics to enhance safety and maintain health. For example, a construction company can use body sensors to monitor the load-carrying ability and posture of manual labourers, thus helping to avoid injuries, reduce compensation claims from workers and improve productivity. Certain devices can track people's activity levels and help change behaviour to improve well-being, while medical sensors can support overall health, for example, by monitoring blood sugar levels and dispensing insulin when necessary.

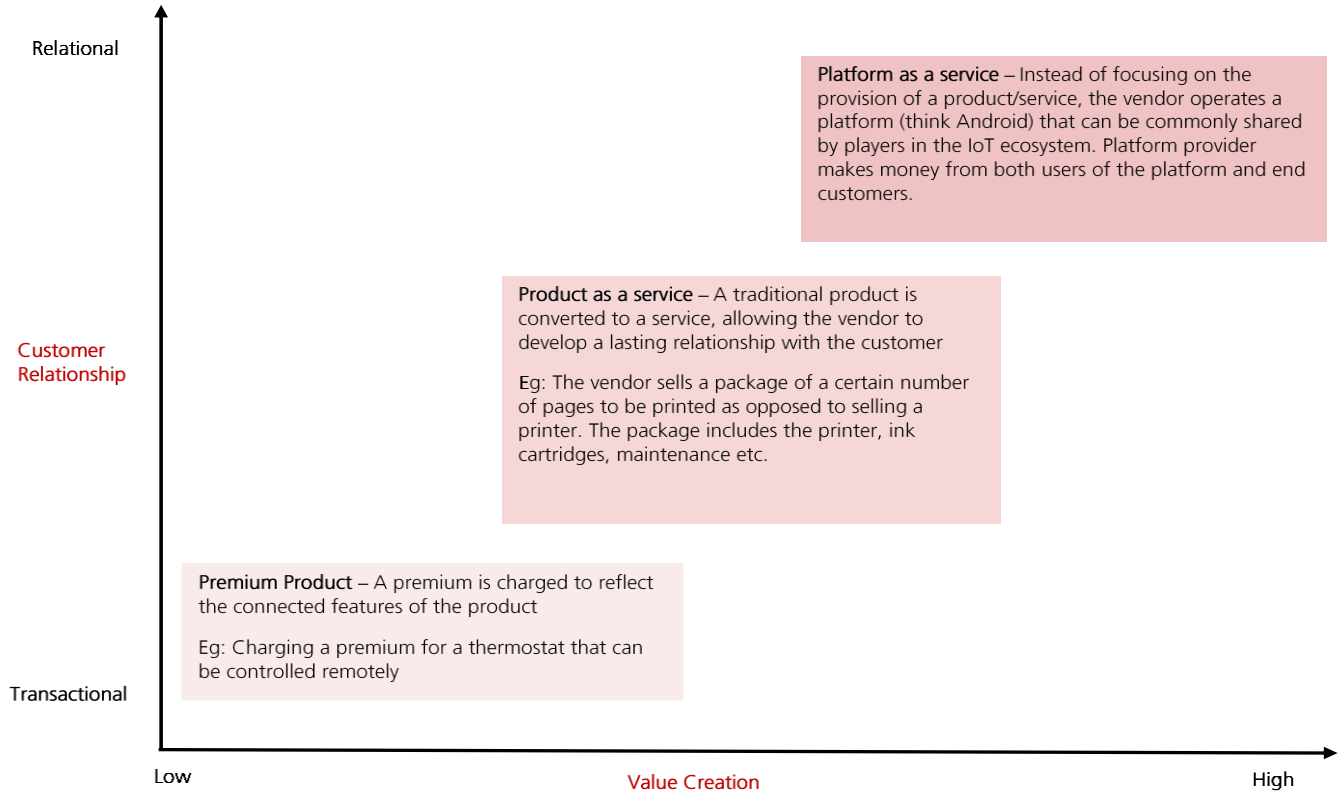
Oil rigs – Oil companies spend substantial amounts on procuring and operating special-purpose oil drilling machinery. When these machines fail, companies can incur huge losses — yet the equipment cost means having spare machines on standby is not economically viable. Smart sensors attached to oil rigs and related equipment can monitor and recommend preventative maintenance, enabling significant reductions in operating costs.

Smart buildings – Smart sensors attached to buildings can substantially increase safety by reducing risks such as fire and flooding, while also bringing down operational costs, and improving energy efficiency through capabilities such as monitoring the movement of people around the building and adjusting temperatures accordingly. Insurance companies are working with large enterprises and construction companies to create smart buildings and reduce the insurance premiums for companies that deploy such capabilities.

Smart home – Smart sensors in homes can simultaneously increase safety by reducing risks like fire and flooding, and bring down operational costs, improve energy efficiency by switching heating and air-conditioning on or off at the right times to exploit off-peak rates, and enhance the household experience, for example by optimising climate control to suit different individuals.

Source: DBS Bank

Monetisation models for IoT for consumer companies



Source: DBS Bank

Premium products

The integration of sensors and connectivity features into ordinary products will allow vendors to charge a premium for products with IoT capabilities. This model would suit early adopters of the IoT in an industry where customers are willing to pay the premium. With the widespread adoption of the IoT however, we believe the premium will be wiped out as customers come to see these features as a given.

Eg: Smart-connected thermostats by Nest are sold at ~US$249, at a premium of close to 10 times over the price of a traditional programmable thermostat.

Products as a service

In this much-desired model, a vendor converts a traditional product into a service, allowing the vendor to develop a long-term relationship with the customer while creating a recurring stream of revenues. While the model calls for material changes in product design and development, and close collaboration within the vendor's value chain, we believe this model can transform the way certain industries operate.

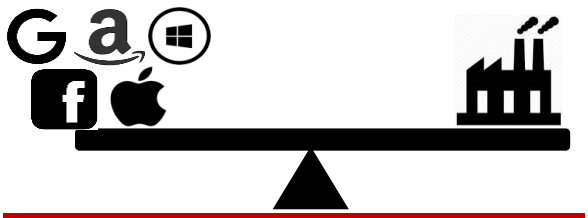
Eg: The HP Instant Ink programme allows customers to subscribe to a monthly service that enables the customer to print a fixed number of pages through their printer. A sensor is installed in the printer to detect when the printer will run out of ink and HP will mail the customer an ink cartridge before this happens. The monthly charge covers the ink cartridge, shipping and recycling of cartridges.

Platform as a service

Under the platform-as-a-service model, the focus is not on selling a product or a service, but on providing a shared platform to other players in the IoT ecosystem (think Android for smartphones) such as hardware manufacturers, software developers, service providers. The platform provider ideally makes money from both end customers as well as other platform users. Platform users pay for listing and the platform provider also gets a share whenever a product is sold on the platform.

Eg: SmartThings sells its own products and services while creating a platform for other IoT companies to sell their connected home solutions. SmartThings offers design guidelines to developers who want to make products for its platforms. SmartThings also works with partners such as Belkin and Phillips, and on operating systems such as Android and iOS.

Business transformation with IoT



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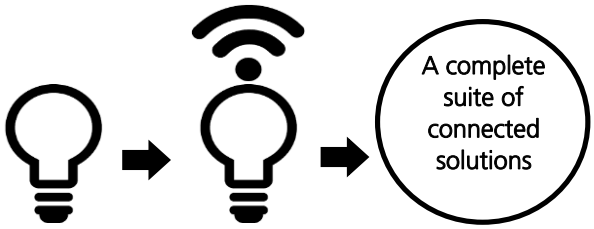

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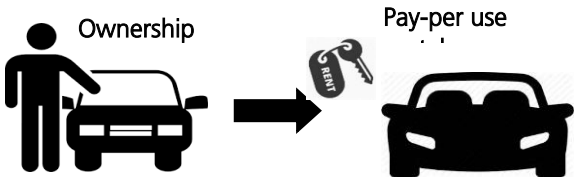
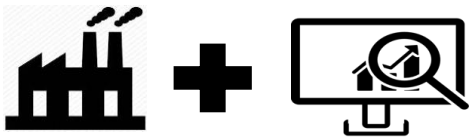


Product-to-service models will emerge with adoption of product-as-a-service business model. Ability to track product performance and usage on a real-time basis will shift industries from a traditional asset-ownership model to an asset-rental model. For example, customers may no longer be interested in owning automobiles but will rent as and when the need arises.



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Source: DBS Bank

Redefining how businesses and industries operate

The advent of the IoT has the potential to redefine the way businesses and industries operate. The IoT provides businesses with access to a plethora of data on aspects such as product performance, and customer behaviour and usage patterns, the likes of which businesses never had before. With this, enterprises can enact truly transformational changes to their product lines and make incremental improvements to their products remotely, even after their sale, as they see fit, continuously meeting customer expectations.

We believe several major changes will take place with the proliferation of the IoT.

Tech players' dominance of customer data will be threatened

The IoT will allow non-digital businesses to gather and collect data once only available to digital companies, levelling the playing field between digital and non-digital players on the data front. Rapid adoption of the IoT, fuelled by the declining cost of technology will soon mean that non-tech players can embed sensors and microprocessors into a growing number of non-tech devices, allowing them to collect a myriad of data on their products and customers. Data of customers and products coupled with advancements in analytics will allow non-tech players to gain insights to their customers similar to those currently enjoyed by the tech giants such as Google, Amazon and Facebook.

For example, before the IoT, consumer electronics giants like Philips had to resort to consumer surveys, data gathered from after-sales services etc., to collect data on product performance and customer usage habits. However, with the IoT, Philips can now view the performance of a product category in real time and gain deeper insights into aspects such as the time of day customers use its products and how long customers use Philips products on average per day, which can help Philips to better the design and development of its existing/new product lines.

We also believe this could herald a new era of collaboration between digital and non-digital players, where anonymised customer data is shared with each other for the purposes of augmenting product features, performance and customer experience. This will result in non-tech players challenging the competitive advantage of tech players, who once dominated the playing field.

Industry competition to move beyond discrete products to encompass an eco-system.

The ability of devices to communicate and share information with each other allows manufacturers to create a system of closely related products serving a range of different customer needs.

For example, giants like Samsung and Philips in the consumer electronics industry will no longer compete on product features or price, but on whom can deliver the best overall connected home solution, encompassing aspects such as home safety, entertainment, household chores, lighting, heating, and ventilation etc.

This radical shift in competition will inevitably would favour the larger players with operations in different sub-segments of the industry, and those with the operational and financial capacity to develop product eco-systems. This could lead to the emergence of a few dominant players in every industry, at the expense of smaller operators who specialise in the development of discrete products.

Monetisation models in certain industries to change

The connected features of an IoT product allow manufacturers to track product performance and usage in real time. This could transform the way companies monetise their products, by converting their physical offering into a service, allowing the vendor to develop a long-term relationship with the customer while creating a recurring stream of revenues. From the customer's perspective, this can mean a shift from owning to renting products.

BMW DriveNow, for example, eliminates the need to own a car for residents of major metropolises in selected countries in Europe including the UK. The service allows users to rent a BMW/Mini vehicle via a mobile phone app and pay for usage per minute. Car sensors automatically calculate the time the vehicle was in use and bill the customer via the app. The sensors also monitor vehicle conditions and maintenance requirements, proactively notifying BMW of potential breakdowns and servicing requirements, minimising vehicle downtime.

BMW DriveNow reduces the need to own a car in major European cities

Users download and register with the DriveNow app. A one-off fee of GBP 4.99 applies

A car is reserved via the app. A number of options including hourly, daily and monthly packages are available to customers to choose from.

The car can be found and unlocked via the mobile app.

Customers can use the vehicle, inclusive of all costs for as little as GBP 33p per minute (~GBP 20 per hour). Sensors installed in the car would automatically calculate the time used and bill the customer via the app. Vehicles stats generated via sensors would also inform BMW of the vehicle's condition and any requirement for maintenance.

Source: BMW, DBS Bank
**All prices are for the city of London*

Ability to collect and analyse data will become a key competitive advantage

The plethora of data gathered through the IoT has to be efficiently stored and analysed to be of use to enterprises. Firms that excel in doing this will be able to develop and improve their product lines to closely match customer needs, allowing them to gain market share and enjoy higher margins compared to those fail to optimise data.

Leading auto insurers in the USA such as Statefarm, Allstate and Progressive have now adopted Usage Based Insurance (UBI) models with the help of the IoT dongles and mobile apps. Traditional auto insurance premiums are based on aspects such as driver's age, gender, driving experience, vehicle condition etc., rather than individual driving habits. UBI takes in to account precisely aspects such as hard braking, rapid acceleration, and usage of mobile phones while driving etc., to determine the driving habits. Safe drivers are rewarded with discounts on insurance premiums. Drivers on Progressive auto insurance for example, save ~US$130 on average on premiums with its UBI programme, Snapshot. Traditional auto insurers that fail to adopt UBI policies with the help of the IoT are set to cede market share as more customers realise the benefits of UBI and enrol with insurers that offer it.

Close collaboration will be required within value chains and creation of partnerships.

The IoT will push firms to redefine the way products are designed and developed. For the first time in history, the IoT will enable products to become first-class participants in their own value chain, communicating directly with creators, designers, marketing teams etc. Ensuring close collaboration among value-chain participants will prove to crucial to successful product development.

The IoT will also require the addition of new members to a company's supply chain. For example, a traditional manufacturer of LED bulbs will have to create partnerships and source supplies from developers of sensors and connectivity equipment to be embedded in the LED bulb. They may also need platform providers to ensure their products can be controlled on common platforms.

Key drivers of IoT adoption

Deployment of 5G and narrow band IoT (NB-IoT) networks, breakthroughs in biometrics sensing technologies and AI are the key drivers in IoT adoption across industries. A survey carried out in 2017 indicated that where organisations saw an uplift in revenue from implementing IoT, the average increase was ~19%, while reduction in costs from implementing IoT averaged ~16%[v].

Barriers hindering IoT adoption

Privacy, security and interoperability, and a lack of standardisation remain the key issues for the widespread adoption of IoT.

Privacy

Through the IoT, data, a substantial portion of which is personal information, can be collected by devices across networks without the user's knowledge, intervention or control. Moreover, IoT devices frequently have no user interface with which to configure privacy preferences. Given that any digital device with an internet connection is susceptible to hacking and the sheer number of tech and telco companies entering the IoT market, we believe there are now many points of access for intruders. The lack of accepted standards such as data encryption also demands more stringent precautions.

For an instance, Samsung caused ripples among its customers when it included the following condition in its privacy policy covering smart devices – "Please be aware that if your spoken words include personal or other sensitive information, that information will be among the data captured and transmitted to a third party through your use of Voice Recognition"[6]. Samsung had to clarify and amend its privacy policies following the incident. The thought of sharing highly sensitive personal information and the lack of knowledge of the security of such data has deterred consumers and enterprises alike from adopting IoT solutions.

Security

Devices were historically designed to be secured in isolation. However, with IoT, devices talk to each other using systems through external networks. In this way, IoT devices may open up security loopholes in enterprise networks. Hence software security, as well as embedded security, will play a vital role in ensuring the security of IoT devices. For example, Starhub, the second largest telecom operator in Singapore, recently suffered a cyber-attack that was routed through its customer's IoT devices such as security cameras and internet-connected DVD players. The lack of security standards governing IoT devices is another key deterrent to widespread adoption of IoT solutions.

Interoperability/standards

Interoperability, standards and protocols are a primary issue in the early development and adoption of IoT devices. Many new industry coalitions have emerged alongside traditional Standards Developing Organisations (SDOs) to increase efforts to develop, modify, or harmonise standards and protocols related to IoT. This includes, for example, long-standing SDOs such as the Internet Engineering Taskforce (IETF), International Telecommunication Union (ITU), and IEEE, and comparatively new efforts such as the Industrial Internet Consortium and Open Interconnection Consortium. However, a number of key interoperability/standards challenges still persist.

- **Proprietary ecosystems and consumer choice** – Some device manufacturers see a market advantage to creating a proprietary ecosystem of compatible IoT products, sometimes called walled gardens, which limit interoperability to only those devices and components within the brand product line. These manufacturers can create user lock-in to their particular device ecosystem by increasing the switching cost for the consumer to change to a different brand or substitute components from another vendor. Eg, in the home automation market, light bulbs from one vendor may not be interoperable with a light switch or control system manufactured by another.

- **Faulty devices affecting the overall ecosystem** – Lack of standards and documented best practices have a greater impact than just limiting the potential of IoT devices. Without standards to guide manufacturers, developers of these devices sometimes end up with products that operate in disruptive ways on the Internet without much regard as to their impact. These devices are worse than simply not being interoperable. If poorly designed and configured, they may have negative consequences for the networking resources they connect to and the broader Internet.

- **Legacy systems** – Interoperability standardisation is a challenge for new IoT devices that need to interface with systems already deployed and operating. IoT engineers are faced with design trade-offs to maintain compatibility with legacy systems while still trying to achieve greater interoperability with other devices through the use of standards.

IoT in Asia

Asia the clear world leader

Asia is set to lead the world in the development of the IoT and AI. The Asia Pacific region excluding Japan is expected to account for ~40% of global IoT spending in 2018, forking out ~US$312bn during the year[7]. A survey on the enterprise adoption of IoT solutions estimates that ~36% of Asian enterprises have adopted IoT solutions as of 2017 versus 29% globally. Asian enterprises have also seen the biggest gains in IoT adoption, with adoption tripling from 12% in 2013 to 36% in 2017[8].

Asia is also well on track to becoming a global hub for developments in AI, backed by advanced developments in the IoT, forward-thinking government initiatives, and a growing pool of tech talent. Surveys[9] have revealed that Asian enterprises are investing ~US$8.3mn on average on AI initiatives, nearly 30% higher than the global average of US$5.5mn. The AI talent pool in China and India combined is expected to exceed the AI talent pool in the US by 2025, according forecasts. There is also strong government support for the development of AI in Asia. China, for example, has set aside nearly CNY1tr (US$148bn) to develop AI in the hope of becoming the leading AI innovation centre by 2030[10]. China has also overtaken the US to emerge as the leading financier for AI startups[11], accounting for nearly 48% of global AI startup funding in 2017.

The advent of the IoT and eventual progression towards AI and automation will have a profound impact on Asia by 2030.

Proliferation of the IoT in Asia is likely to be supported by several factors:

- Urgent need for urban solutions. Asia is home to some of the most densely populated cities on the planet, with Manila, Mumbai, Shanghai, Jakarta and Hong Kong often at the top of world rankings. Asia is also braced for a significant rise in its urban population. According to the United Nations, urban population as a percentage of total population in Asia is expected to increase to 64% by 2050 from 48% in 2014[12]. Governments have to make substantial investments in infrastructure and, most importantly, look for ways to maximise the efficiency and productivity of existing infrastructure and resources. Adoption of the IoT will immensely help improve asset productivity and reduce wastages of resources such as energy and water.

- Big millennial population. Asia is home to 58% of the world's millennial population, much of which is in China, India and Indonesia[13]. Millennials' desire to stay connected will drive the adoption of solutions like connected home and smart healthcare.

- Strong government commitment. Thanks to solid government support, Asia is already home to a growing number of smart city projects of which the IoT play an integral role. South Korea has some of the smartest cities in the world such as Seoul and Songdo while Singapore wants to be the first smart nation in the world. India expects to develop 100 smart cities at an investment of over US$1.1bn while China is piloting over 500 smart city projects.

IoT and the telecom industry

Opportunities and challenges

The IoT offers a new set of opportunities and challenges for telecom operators. Successful IoT implementation requires ubiquitous connectivity via cellular and low-powered networks such as NB-IoT, but also requires telcos to upgrade their existing network infrastructure. The IoT will also require strong capabilities in cybersecurity and data analytics; again, new revenue opportunities for telcos with such capabilities.
For mobile operators, the IoT is already a fairly substantial revenue generator. Mobile operators generated over EUR 11bn (US$13bn) from IoT solutions in 2016[14]. Forecasts indicate that by 2025, IoT would account for ~20% of the topline of the telecom industry[15].

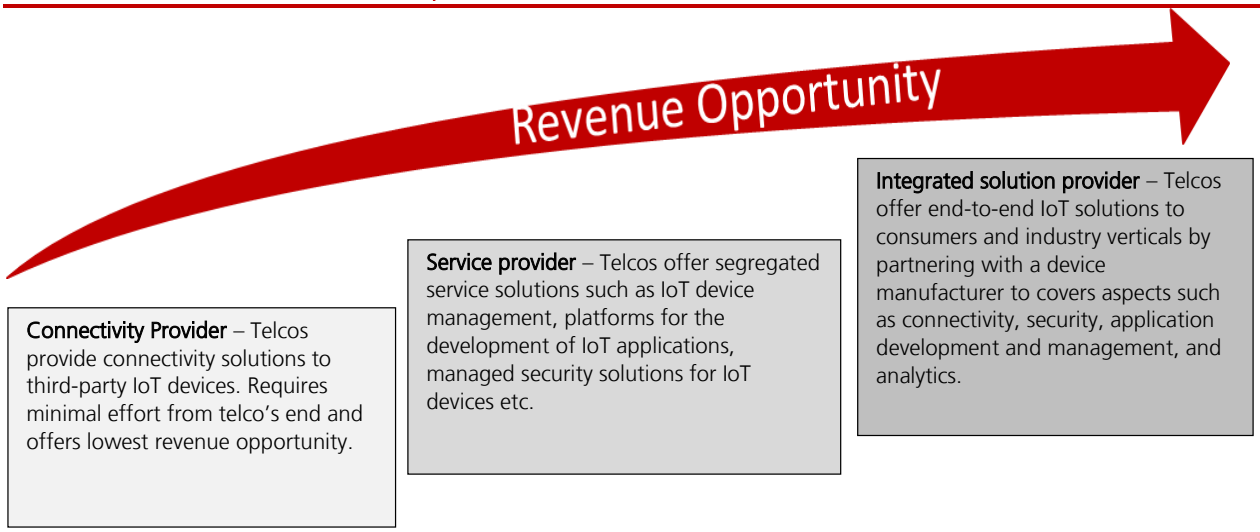
Early adopters are recording considerable contributions from the IoT. Verizon's IoT revenues for instance surpassed the US$1bn mark in 2016 and the telco recorded a 52% Y-o-Y rise in contributions from IoT solutions, with revenues from IoT reaching US$1.5bn in 2017. The IoT accounted for ~1.2% of the telco's topline in 2017[16]. Vodafone,[17] on the other hand, recorded estimated revenues of ~EUR 734mn from IoT in 2017, accounting for 1.7% of the telco's topline.

Telcos need to offer complete, integrated solutions

We believe that the revenue opportunity through the provision of connectivity solutions alone, however, would be fairly limited for telecom operators.

Estimates indicate that average revenue per connected cellular IoT device hovered around EUR1.4 (US$1.7) in 2016[18]. To put this in perspective, a telecom operator in North America would need to sell ~25 IoT connections to earn about the monthly revenue they do from a mobile subscriber[19]. Competition and churn is also likely to be high, as the bulk of IoT devices are expected to be equipped with eSIMs allowing users to change operators remotely at will. Of the estimated US$263bn IoT support services market by 2020, only 12.5% or US$33bn is estimated to be the revenue opportunity available to telcos' through the provision of connectivity solutions[20]. Hence, we believe telcos should go beyond connectivity opportunities, to offer end-to-end integrated solutions to consumers and enterprises, bundling connectivity, security and analytics solutions, to maximise gains from IoT.

Monetisation models of IoT for telecom operators



Source: DBS Bank

1. Connectivity provider

The basic monetisation model for telcos is through the provision of connectivity for IoT devices. Telcos can capitalise on the growing proportion of cellular-connected IoT devices by upgrading to low-power wide area networks (LPWAN). This requires minimal investments and capabilities from the operator's end, but also presents the least share in revenues to be derived from the provision of services to the IoT. Estimates indicate that by 2020, connectivity would account for only 12.5% of IoT's total service revenue pool[21].

2. Service provider

In this model, telcos build on their position as connectivity providers to offer adjacent services such as device management, managed security services, platforms for the development of IoT applications etc. Vodafone for example, offers a platform for users of IoT devices connected via the Vodafone network to develop their own IoT applications or to connect with Vodafone or third-party developer communities for their application needs. There is potential for Vodafone to eventually monetise its platform and cross-sell add-on IoT services such as device management.

3. Integrated solution provider

In this model, telcos offer end-to-end IoT solutions to consumers and industry verticals. Here, the telco partners with an IoT device manufacturer to offer a fully integrated solution including connectivity, device management, data storage, application development and management, and security, capturing the lion's share of the revenue opportunity across the IoT services value chain. Vodafone for example, partnered with Arlo, to offer consumers a wireless connected camera solution. Customers pay a one-time fee of GBP339 for the camera and GBP4 per month for connectivity, and cloud-based storage of video footage and voice connectivity whenever required. Offering integrated solutions however, would require telecom operators to create, closely collaborate and establish strong partnerships with other parties in the IoT value chain, while acquiring new capabilities to cater to customers in an IoT environment. Telcos adopting this model will venture far beyond their role as providers of connectivity but are also likely secure a greater share of the IoT service revenue pie.

Case Study – AT&T's venture into the IoT world

AT&T, the world's largest telecom operator by revenue, is one of the first in the industry to experiment with the IoT. It has since created an unparalleled portfolio of end-to-end IoT services providing guidance and assistance to enterprises from the start of their IoT journey.

AT&T's professional services for IoT goes way beyond connectivity

Source: AT&T

Case in point: AT&T's integrated approach

A key differentiating factor of AT&T's IoT strategy is its integrated approach. The carrier engages with its clients at the start of their IoT journey, helping clients to design an IoT strategy, a business plan and to identify the most value-adding uses. Clients can then use one of the five IoT foundries of AT&T's Innovation Centers to connect with the AT&T IoT development team or with third-party device makers, start-ups and other industry partners to develop the solution they require. Rockwell Automation, a leading developer of industrial automation products for example, managed to develop a prototype sensor to test the use of the IoT within its manufacturing plans in a week with the help of the teams at AT&T's IoT foundries.

Once the solution is finalised, AT&T offers its clients nationwide and even global connectivity via AT&T's and its partners' networks. AT&T offers nationwide low-power connectivity in the USA via LTE-M technology and offers satellite-based communication for remote IoT applications in verticals such as marine, oil and gas and agriculture.

Enterprises can also use AT&T's IoT management platform to monitor and manage their IoT devices, and take advantage of the platform's third-party IoT-related services. Later this year, AT&T will launch its Multi-Network Connect cloud platform, allowing enterprises to monitor and manage their IoT endpoints regardless of location or the connectivity provider. Enterprises connecting with AT&T can also leverage on the carrier's strong capabilities in security and analytics to suit their IoT requirements.

Whilst AT&T provides IoT solutions across a number of industry verticals, the carrier specialises in the provision of IoT-based solutions in the connected car, fleet management and logistics and healthcare verticals. AT&T was the first telco to create a research facility focused on connected cars with its AT&T Drive Studio and gained the lead by establishing exclusive partnerships with key industry players such as BMW which accelerated the carrier's connected car business. Since then the carrier has established partnerships with 19 vehicle manufacturers and had connected over 12mn[22] cars on AT&T's network as at March 2017.

Integrated connected car solutions offered by AT&T

Source: AT&T

Substantial potential revenue opportunities in IoT

So, telcos in Asia have welcomed the potential revenue opportunity in IoT connectivity and solutions. Our estimates indicate that Asian telcos could generate revenues of ~US$10bn from the provision of connectivity solutions by 2020, which would be fairly insignificant for the topline of the APAC telecom industry (to put this in to perspective, IoT connectivity represents a meager 7% of cellular revenues in China as of 2017). The size of the IoT pie up for grabs for telcos expanding into the provision of IoT-related services and integrated IoT solutions will be far more substantial in our view.

Diagram 7: Asian IoT market – great opportunity for telcos[23]

	2020	
		Enterprise
Connected devices (b)	5.2	3.4
% of devices connected via cellular networks	5%	30%
No. of cellular connected IoT devices	0.3	1.0
% of devices connected via		
-Mobile networks	80%	60%
-Low Power Networks	20%	40%
Average monthly revenue per connection (US$)		
-Mobile networks	1.1	0.8
-Low Power Networks	0.3	0.2
Connectivity revenue opportunity for telcos (US$bn)	2.8	7.2
Average monthly revenue per connection (US$)	0.9	0.6

Sources: DBS bank

Estimates[24] indicate that there will be 8.6bn connected devices in the APAC region excluding Japan by 2020, ~15% of which we estimate will connect on cellular networks as opposed to WiFi or Bluetooth networks. Our projection is ahead of forecasts[25] of ~10% IoT devices using cellular networks by 2021 as we believe that Asia, with strong backing from China, will be ahead of the curve in adopting cellular IoT applications. China is already home to the largest NB-IoT network in the world and hosts over 330mn IoT connections. We believe that ~80% and 60% of IoT devices connected to cellular devices in the consumer and enterprise spheres respectively will use mobile networks such as 4G LTE and 3G. IoT devices connected via these technologies accounted for over ~75% of total cellular IoT connected devices in 2017[26].

Our consumer Average Monthly Revenue per Connection (ARPC) estimates are based on projections by Analysys Mason and low-power network connection pricing data from China Telecom. Estimates[27] indicate that global average monthly revenue derived from connections powered by mobile networks will hover around ~US$1.5 by 2025. We have assumed a 30% discount to arrive at the ARPC for mobile networks in 2020 to reflect the competitive pricing points telcos are likely to adopt at the early stages of the IoT boom in a bid to accelerate adoption and gain market share. China Telecom[28] priced its low-powered NB-IoT connections at US$3 per year in 2017, which works to a monthly ARPC of US$0.25. We have attached a 20% discount to the consumer ARPCs to arrive at the enterprise connection price points.

Accordingly, we believe that IoT connectivity solutions alone could present a US$10bn revenue opportunity for Asian telcos by 2020.

Stock recommendations

HCL Tech: Mode 2&3 (Digital and IP portfolio) gaining traction

HCL Tech is seeing good traction in its Mode 2 & 3 services (26.6% of revenue; up ~10% q-o-q in Q1FY19 and ~40% y-o-y in FY18) and expects growth momentum to continue in these services. Q1 Mode2 (Digital) Commentary - HCL Tech indicated that enterprises are now moving from Proof of Concept (POC) to large digital transformations. It also indicated that the digital wave which started with focus on improving the end-customer experience (UI/UX) is now also focusing on adopting large scale business transformations to drive outcomes. However, HCL Tech indicated that clients are consolidating existing vendors based on their capabilities where its early investments and proof cases are helping it to emerge as a clear winner. Q1 Mode3 (IP) commentary - HCL Tech indicated that its IP partnerships (largely with IBM; invested ~US$1.2bn in IPs) and organic IPs (DryIce-Automation platform) built over the last two years are now being clubbed as part of complete transformative solutions (i.e. along with Mode 1 and Mode 2 services) to clients, some are being taken to market independently and some have found places in product catalogues of enterprise platform vendors such as SAP which provide a strong growth opportunity going ahead (See Page 3 of our latest note for detailed info on IPs).

Mode1/2/3 revenue growth and margins (newly introduced metric)

	% of Revenues	EBIT %	QoQ growth
Mode 1	73.3%	19.9%	0.5%
Mode 2	15.6%	14.8%	8.2%
Mode 3	11.0%	25.2%	11.7%
Total	**100.0%**	**19.7%**	**2.7%**
Mode 2/3	26.6%	19.1%	9.6%

Source: Company, Emkay Research

Engineering R&D is the next big theme in the Services segment

ER&D segment (~23% of sales and at US$1.8bn run-rate) is much larger than any of its peers in India. ER&D Services are dominated by GIC and pure-play vendors given the strong domain understanding requirements. HCL Tech has been investing consistently in this space organically as well as inorganically (Geometric, Butler and H&D acquisitions) to emerge as a differentiated digital player in this segment which is growing at double the pace of other service lines (ER&D exports from India - US$25bn industry size - grew by 12.8% in FY18. Global sourcing also grew by 10% on industry size of ~US$88bn in CY17).

IOT Use Cases

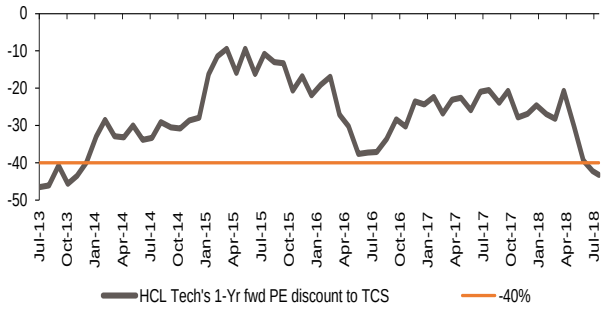
Client Name	Case study	Remarks
Xerox	Remote diagnostics and assets, tracking & maintenance	Lowered upfront development cost in a business model where HCL could also gain upon product success - flexibility and adaptability
Intel	Working together on Smart buildings, smart workforce helmets- now providing solutions on IOT	

Source: Company

Medium-term visibility, reasonable valuation leads to BUY

HCL Tech commentary turned significantly optimistic as it expects the organic growth momentum to accelerate going forward given highest ever deal bookings recorded in Q1FY19. HCL also shared greater insights into metrics and commentary in the IP investments that would boost financial estimates as well as sentiments from these investments. Our sector outperformer view on the stock got further reinforced post Q1 commentary and we believe that positive commentary would result in earnings upgrade and eventual re-rating of the stock. We upgrade HCL Tech to BUY with TP of Rs1,200 valued at 16x FY20e earnings.

HCL Tech has been trading at a significant discount to TCS which provides valuation comfort



Source: Company, Emkay Research

LTI: Strong positioning leading to good all-round growth

LTI has attributed its recent strong growth to: (1) continued client mining efforts (Analytics and Digital in Every Account; ADEA), (2) new account openings, and (3) large deal wins. LTI's deep domain knowledge, micro-vertical focus and right size are helping it to gain traction with existing clients and new clients (who are not happy with incumbent vendors). Also, parent's (L&T) engineering heritage and use cases are helping it to demonstrate cost optimisations, which are resulting in large deal wins. While strong growth in BFSI, Retail and Hi-Tech is expected to continue with increasing regulation requirements (GDPR compliance), clients' focus on launching new products and clients' increasing emphasis on improving end-customer experience, hitherto slow verticals viz. ENU and Manufacturing, are also expected to recover starting Q2FY19 on the back of recent deal wins (Exxon deal win in Q4FY18). With strong revenue growth and margin improvement in Q1FY19, the company is delivering to our expectations of OPM improvement of over 200bps for the year.

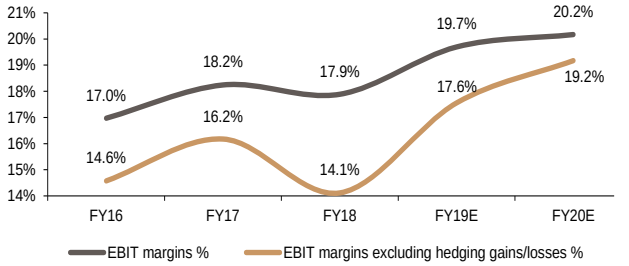
While growth in Digital has been secular across industry players (~18-20% sales contribution in FY18 and growing at ~30% y-o-y; source - Nasscom), revenue contribution and growth in LTI's Digital portfolio (~34% of sales; up ~45% y-o-y in Q1FY19) has been much stronger than the rest of the industry. Also, strong growth in the rest of the business (66% of sales; up ~15% y-o-y) amid mediocre growth (flattish to slightly negative; see Exhibit 8) for other industry players is commendable and suggests its ability to sell complete business transformation solutions to its clients.

IOT Use cases

Client Industry	Use Case
Manufacturing	Use of IoT leading to a 50% reduction in the inventory counting time and production shutdown time.
Financial Services	Helping an insurance company with IoT-based leak-detection solution for one of its clients to improve coverage, suggests enhancements and faster claims management
Healthcare	IoT-led energy management for a medical devices major
Construction	IoT analytics-driven asset utilisation, predictive maintenance and spare parts & fuel fraud detection of 35,000 assets; 60% reduction in asset failures; 30% increase in asset utilisation and 25% cost savings

Source: Company

EBIT margins are expected to increase on the back of strong revenue growth*



*Source: Company, Emkay Research, *FY18 nos. include one-time expense related to a client settlement (Rs617mn) which impacted margins*

Overall robust outlook, reasonable valuation leads to BUY

We remain selective in our approach with preference for names with high growth potential, client stickiness and differentiated digital capabilities. Thus, we maintain LTI as one of our preferred picks. Our confidence in LTI delivering sector-leading financial performance further gets reinforced due to its strong broad-based growth, deep domain capabilities, focus on micro verticals (which is driving client confidence) and overall robust outlook for FY19. We maintain LTI as our preferred pick in the space with TP of Rs1,850.

Mphasis: Renewed strategy and better execution explain turnaround story

Post sluggish overall revenue growth over FY12-FY17 period (due to continuous ramp-down in HP revenues), Mphasis's strategic changes in FY18 which involve proactively approaching clients (16 strategic accounts, HP channel clients, Blackstone portfolio companies and new clients) with client-specific Front-to-Back (F2B) transformation solutions have helped it to deliver strong growth and win large-scale next-gen transformational projects in FY18.

Two anchor client channels and growth-centric strategy drive outperformance

Mphasis has a unique advantage wherein it has two anchor client channels (HP/DXC and Blackstone) that can fuel its growth significantly given the large opportunity they can offer. The new management is leveraging these channels along with the direct channel to drive financial outperformance. Mphasis's management indicated that its proactive sales approach, with its global account delivery leadership being onsite to engage with clients, is helping it to post strong growth in deal TCVs and win large transformational programmes with increased mining of strategic accounts, hunting of Blackstone portfolio companies and new clients.

IoT Use Cases

Operational goal	IoT use cases
Develop an end-to-end IoT solution that allows clients to make real-time operational decisions	Mphasis has helped its clients create product concepts, build a prototype, connect with eco-system of partners, and delivered end-to-end development, analytics and testing services. Mphasis created Fleet management solution with on-board computers, software and data communication services, Prototype creation with firmware, Ecosystem connection with partners

Source: Company

HP channel (~25% of sales): After posting >20% growth in FY18 in HP channel, MPHL expects market-leading or matching growth in this channel in FY19 on the back of regional leadership restructuring and revamping of third-party advisory services (to increase new client acquisitions) in Europe. While most of FY18 growth was skewed towards DXC Tech (one of the four HP entities), it expects expansion in other HP channels/Geos (i.e. HPE/HP Inc/Microfocus and Europe) to help it to deliver industry-leading or matching growth in this channel in FY19.

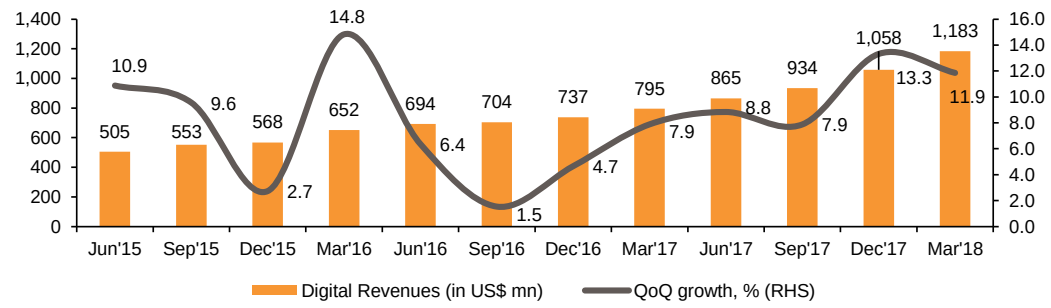
Direct International Business (~70% of sales): Management indicated that it is working with the largest bank, insurance company and publicly traded investment services firms in this category. It also reiterated its confidence in Direct core (~58% of sales) with industry-leading growth expectations in this business in FY19. It is focusing on a proactive solutions-driven sales approach to continue its industry-leading growth trajectory in this segment.

Margins: With revenue growth visibility, it is also focusing on margin expansion with pyramid optimisation, i.e. by creating a balance between lateral hiring and fresher hiring, more of FP projects (still 26% of overall sales vs. industry average of ~50%) and pricing improvement with more of better-priced next gen/digital projects. Mphasis has increased its margin guidance by 100bps to 15-17% for FY19 from 14-16% in FY18. to be behind the overall growth and margins turnaround as

Healthy outlook, strong valuation leads to BUY

Given its growth hungry attitude (deal win TCV was up 51% to US$552m in FY18), client intimacy (with HP and BX portfolio clients), strong pipeline in the Direct channel, scope for expansion in the HP channel, stability in Digital Risk, optimal strategy, focused management and impressive execution, we feel comfortable about our higher-than-consensus growth estimates for FY19/20E. We expect upgrades on the street as they account for constructive commentary.

Growth in Digital (q-o-q) has been strong over many past quarters



Source: Company, Emkay Research

Alibaba (BABA US): E-commerce upside on online advertising gain

Alibaba is China's largest e-commerce platform, with 75% market share in terms of gross merchandise value [GMV] in 2017. We have a BUY call on Alibaba on its online ad monetisation momentum. We analysed the advertising market based on advertising objectives (namely, "attention", "interest & desire" and "action"), instead of traditional matrix such as user numbers and time spent. We forecast that advertisers will spend more of their budgets on "actionable ads" (ads which lead to action [i.e. sales]), driven by improving data analytics and therefore better targeted marketing. Alibaba's e-commerce platforms have the highest actionable ad inventories, which allows it to benefit from the budget shift.

A leading beneficiary with the proliferation of IoT and connected vehicles in China. Alibaba's AliCloud is China's largest IaaS service provider, with a market share of c.50% and accounts for c.5% of Alibaba's revenue. We expect AliCloud to become a leading IoT cloud platform in China which collects, stores and analyses data generated from IoT devices. AliCloud has launched AliOS Things in 2017, which is the operating system developed by Alibaba to connect its cloud computing with a wide variety of IoT devices, including consumer IoT (i.e. smartphones, smart wearables, smart home appliances), and connected vehicles. AliCloud aims to connect over 10bn devices to the platform over the next five years.

A number of automobile manufacturers including SAIC Motor and Dongfeng Peugeot-Citroën Automobile have partnered with Alibaba to use AliOS in their connected car strategy. Over 500,000 AliOS-powered internet cars have already been rolled out and Alibaba has also managed to establish a partnership with NXP Semiconductors N.V., the world's largest supplier of automotive semiconductors to jointly install automotive infotainment solutions in millions of vehicles in China by 2020. With its current market leadership in cloud computing and heavy focus on IoT and connected vehicles, we believe Alibaba would be a clear winner with the growth in adoption of IoT in China.

Robust online ad outlook and IoT potential, attractive given historical trading band leads to BUY. We prefer Alibaba on its robust online ad outlook, as China's largest e-commerce platform, which has most actionable ad inventories. We expect its online ad revenue to post a CAGR of 38% over FY3/18-21F through continuous market share gains. We also see potential in its IoT development, as a leading IoT cloud platform in China. Alibaba is trading at 22x FY3/20F PE, which is attractive compared to its historical trading band of 21-32x.

AAC (2018 HK): Growing demand for acoustics and optical solutions for IoT applications to drive growth

AAC is the world's leading smartphone component supplier, with c.30% and c.40% shares in acoustics and haptics markets respectively. AAC began its optics business by investing in Kaleido in 2010. After years of development, AAC can now supply plastic and its proprietary wafer-level glass (WLG, glass lenses manufactured by semiconductor wafer processes) lens sets. Current customers are Samsung and China's smartphone vendors. AAC stands out in the high-end (i.e. 3D-sensing and hybrid) lens set market, as its proprietary WLG has higher scalability and temperature tolerance vs peers' moulding or wafer-level optics (WLO). We expect AAC's optics revenue to ramp up to Rmb3,698m and account for 10% of FY20F revenue, from 1% in FY17. AAC is a key beneficiary of continuous smartphone spec upgrade in acoustics, haptics, and optics. We also expect growing demand in acoustics (i.e. speakers and MEMS microphones) and optical solutions for IoT applications to drive growth of AAC. AAC is trading at 14x FY19F PE, which is attractive compared to its historical trading band of 12-25x. We currently have a BUY call on AAC with TP of HK$165.

Positive growth expectations, attractive given historical trading band, leads to BUY

AAC is trading at 12x FY19F PE, which is attractive compared to its historical trading band of 12-25x. We currently have a BUY rating on AAC with TP of HK$165.

BUY ST Engineering on multiple re-rating drivers ahead

We like STE for a combination of factors: i) award of some of the larger contracts that STE is vying for (e.g. US Postal Service vehicle contract and US Marine Corps contract) are expected to be announced in 2018, providing potential upside catalysts if STE (and partners) are chosen; ii) improved visibility from STE's target to more than double smart city revenues by 2022 and grow other segment revenues at 2-3x the global GDP growth rate; iii) Aerospace segment rebound, with margins improving this year on stronger CFM engine MRO demand, and in the longer-term, sizeable contribution expected from P2F programmes currently in ramp-up phase; iv) expected deliveries of the two problematic ConRo vessels in 2Q/3Q18 which should help shipbuilding turn profitable, though it is slightly delayed than expected. Meanwhile, dividend yield is around 4.5%, which should provide support to the stock price.

ST Engineering is riding on the digitisation trend to grow its smart city business. ST Engineering (Singapore Technologies Engineering Ltd) is an integrated defense and engineering group with a global presence, specialising in the aerospace, electronics, land systems and marine sectors[xxix]. In recent years, the company has increasingly positioned itself to capitalise on growth from smart city and robotics markets, including the hospitality, healthcare, transportation and security industries. Digitisation of processes within these industries will be complementary to the adoption of ST Engineering's smart city products. In terms of size, in 2017, the company's revenues from smart city markets were S$1bn, and it aims to more than double this by 2022. Leveraging on its track record in Singapore, ST Engineering is now targeting the global smart city market.

Examples of ST Engineering's smart-city developments:

i) In July 2017, ST Engineering acquired Aethon, a provider of autonomous mobile robots (AMRs) which has deployed its AMRs in more than 200 sites globally, including in 140 hospitals in the US. The acquisition has allowed ST Engineering to develop new applications based on a proven robotic solution for indoor applications for the healthcare, industrial and hospitality sectors[xxx]. For example, by deploying the Aethon Tug robot to hotels, the laundry process can be reduced from a seven-step manual process to a three-step automated one, with the use of radio-frequency identification tagging.

ii) With the acquisition of a 51% stake in SP Telecommunications, ST Engineering now has access to an extensive network of fibre optic backhaul infrastructure and facilities in Singapore, enabling the company to move up the information and communications technology (ICT) value chain to provide connectivity and other bundled enterprise ICT services for smart city initiatives.[xxxi]

iii) ST Engineering has assumed a strategic role towards achieving Singapore's Smart Mobility 2030 vision of a smart transportation network. The company has been developing its autonomous vehicle (AV) capabilities and technologies for commercial smart mobility applications from as early as 2015, when it deployed the Autonomous People Mover in Singapore's Gardens by the Bay. LTA and ST Engineering are also jointly developing autonomous buses and mobility on demand vehicles (MODVs) for Sentosa Island. The autonomous buses will go on trial on Jurong Island at end-2018 and will undergo public road trials by mid-2020[xxxii] while MODVs are expected to be deployed in 1Q19[xxxiii].

iv) ST Engineering has also ventured into the satellite business. After the success of its first satellite TeLEOS-1, ST Engineering started building TeLEOS-2 (targeted for launch in 2022), Singapore's first synthetic aperture radar-based imaging satellite, which will provide round-the-clock, all-weather imaging to a wide range of industrial clients[xxxiv].

v) ST Engineering is deploying the company's expertise in wireless smart sensor technology to power smart street lighting and efficient utilities management in cities across China, Europe, India and the US with the installation of 18m wireless smart sensors[xxxv].

vi) In 2017, ST Engineering launched Innosparks, an engineering-based incubator programme enabling individuals or startups to accelerate technology innovation from idea to market within 18 months or less. Once the individual or startup reaches the commercial scaling stage, Innosparks will connect with ST Engineering's Corporate Venture Capital unit (a US$150m open-ended fund)[xxxvi]. The unit made its first investment in Janus Technologies, a US-based end-point cyber-security provider, which helped ST Electronics launch its Black Computer, an industry-first, hardware-based cyber-security solution.[xxxvii]

ST Engineering's Smart City Global Presence

Source: Company

Appendix

Recent notable acquisitions in IoT

Acquirer	Acquisition	Deal value	Year of acquisition	Target expertise	Description of the target
Nokia	SpaceTime Insight	NA	May 2018	Data visualization and analytics softw are	Provider of software and monitoring and analytics applications to clients in energy, logistics, transportation and utilities sectors
SoftBank	ARM Holdings	US$31.4bn	July 2016	Semiconductor and chip designing and software development	Designer of chips and licensing them to companies like Apple and Samsung. Mainly focused on phones and tablets. SoftBank is expected to use the ARM deal to bolster its IoT plans
Verizon	Fleetmatics	US$2.4bn	August 2016	Telematics	Provider of wireless, software and hardware solutions to power connected-vehicles around the world
Verizon	Sensity Systems	NA	September 2016	Connected LED lighting systems	Provider of smart lighting solutions through IoT
Cisco	Jasper Technologies	US$1.4bn	February 2016	IoT connectivity management platform	Provider of Software as a Services (SaaS) platform to connect IoT devices
TDK	InvenSense	US$1.3bn	December 2016	Sensor manufacturing	Provider of sensors for consumer electronics and industrial markets
General Electric Digital	Meridium	US$495m	September 2016	Asset tracking software	Meridium provides predictive maintenance software for industrial customers to predict when machineries might fail and track the efficiency of their operations
Nokia	Withings	US$193m	April 2016	Digital health products and service	Provider of wearables and fitness devices
Google	Nest	US$3.2bn	February 2014	Smart temperature monitoring	Manufacturer of learning thermostats and smoke and carbon monoxide detectors
General Electric Digital	ServiceMax	US$915m	November 2016	Cloud-based field service management	Provider of cloud-based software applications such as inventory and logistics management, scheduling and workforce optimisation, and work order management
Cypress Semicondu ctor Corp	Broadcom's Wireless IoTBusiness	US$550m	June 2016		Broadcom's Wi-Fi, Bluetooth and ZigbeeIoT product lines were transferred to Cypress under the agreement

Source: DBS Bank

Low power network deployments

Operator	Country	Technology
3	Hong Kong	NB-IoT
AIS	Thailand	NB-IoT
AT&T	North America	LTE-M
AT&T	Mexico	LTE-M
China Mobile	Hong Kong	NB-IoT
China Mobile	China	NB-IoT
China Telecom	China	NB-IoT
China Unicom	China	NB-IoT
Chunghwa Telecom	Taiwan	NB-IoT
Dialog Ataxia	Sri Lanka	LTE-M
Dialog Ataxia	Sri Lanka	NB-IoT
Elisa	Finland	NB-IoT
Etisalat	UAE	LTE-M
Etisalat	UAE	NB-IoT
FarEasTone	Taiwan	NB-IoT
KDDI Corporation	Japan	LTE-M
Korea Telecom	South Korea	NB-IoT
KPN	The Netherlands	LTE-M
LGU+	South Korea	NB-IoT
M1 Singapore	Singapore	NB-IoT
Mobitel	Sri Lanka	NB-IoT
Orange	Belgium	LTE-M
Orange	Belgium	NB-IoT
TDC	Denmark	NB-IoT
T-Mobile	Austria	NB-IoT
T-Mobile	Germany	NB-IoT
T-Mobile (DT Croatia)	Croatia	NB-IoT
T-Mobile (Cosmote)	Greece	NB-IoT
T-Mobile (DT Poland)	Poland	NB-IoT
T-Mobile (Slovak Telecom)	Slovakia	NB-IoT
T-Mobile	The Netherlands	NB-IoT
Telia	Finland	NB-IoT
Telia	Norway	NB-IoT
Telecom Italia	Italy	NB-IoT
Telstra	Australia	LTE-M
Telstra	Australia	NB-IoT
True Corporation	Thailand	NB-IoT
Turkcell	Turkey	LTE-M
Turkcell	Turkey	NB-IoT
Velcom	Belarus	NB-IoT
Verizon	North America	LTE-M
SingTel	Singapore	LTE-M
SingTel	Singapore	NB-IoT
Vodafone	Spain	NB-IoT
Vodafone	Australia	NB-IoT
Vodafone	Netherlands	NB-IoT
Vodafone	Germany	NB-IoT
Vodafone	Ireland	NB-IoT
Vodafone	Italy	NB-IoT
Vodafone	Czech Republic	NB-IoT
Vodafone	Turkey	NB-IoT

Source: GSMA

Early adopters of the IoT

Consumers

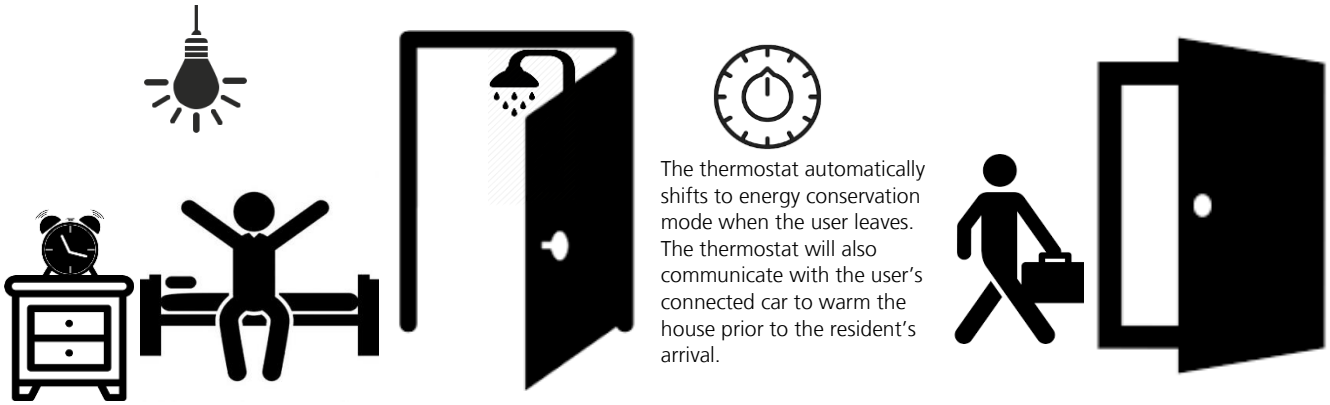
Consumers have become a dominant force in the IoT, driving up the adoption of IoT solutions faster than most industry segments. According to Gartner, consumer IoT (CIoT) endpoints accounted for ~62% of all IoT devices in 2017. Consumer IoT hardware spend is also expected to be the fastest growing category in IoT, growing at a 27% CAGR from 2016-2021. Connected home applications, healthcare and entertainment are the key driving forces behind consumer IoT. Greater China, North America and Western Europe are at the forefront of consumer IoT adoption globally, accounting for over 65% of connected devices globally[xxxviii].

What a typical morning looks like in a future connected home

Lights and the connected thermostat are automatically activated with the alarm and adjusted to the morning preferences of the user.

The water heater is automatically activated with the alarm and heats the water taking into account the temperature outdoors and user preferences.

Security systems are activated once the user leaves. All doors and windows are locked automatically and intruder detection systems are activated. The user can remotely check the security status of the house, open doors and be notified via smartphone when anyone else enters the house.



The thermostat automatically shifts to energy conservation mode when the user leaves. The thermostat will also communicate with the user's connected car to warm the house prior to the resident's arrival.

The alarm signals the connected coffee maker to start brewing the user's morning coffee. User can change his/her preferences via his smartphone without getting out of bed

All non-essential appliances including Smart TVs, stoves are turned off as soon as the user leaves. Smart labels on the food inside the fridge would also help the smart fridge generate a list of shopping items, which is directly sent off to the user's smartphone. A reminder would also be sent out to the user at the usual time he/she gets off work

Source: DBS Bank

Connected home solutions

Smart household appliances, smart security systems, residential heating, ventilation and air-conditioning (HVAC) systems comprise some of the key components of connected home solutions. Cost, security and privacy were among the top concerns deterring consumers from adopting connected home solutions, according to a survey[xxxix]. For manufacturers of connected home devices, two key issues are the focus on the development of a single product as opposed to the product's positioning in a connected home, and a lack of integration or a platform to communicate and share information with devices developed by other manufacturers.

Residential HVAC systems, which include smart thermostats, are expected to be one of the largest and fastest growing connected home applications. Smart HVAC applications pave the way for significant improvements in energy conservation, and produce smaller heating and power bills. Smart HVAC devices will be able to communicate with each other and share a direct line of communication with smart meters to choose the best energy plan for the resident.

Connected household equipment, which includes refrigerators, stoves, cleaning devices, is another key growth segment. Major household equipment manufacturers, such as Samsung and Phillips, are aggressively investing in the development of connected product eco-systems. Samsung SmartThings for example, offer a range of connected home and security solutions including smart door bells and video cameras, connected plugs complementing the range of connected electronic equipment including connected dishwashers. The SmartThings platform has also been extended for use by third-party manufacturers such as Phillips and Google for smoother integration between devices.

The smart home security market, which comprises another key segment in consumer IoT, is expected to grow at a CAGR of 7% from 2018 to 2022[xl]. Some key forces driving demand for smart security solutions are the ability to gain real-time visibility remotely into the user's assets and AI-based security assistance services. Google Nest, Samsung SmartThings and US-based Simplisafe and Netgear are some of the leading developers of smart security solutions.

Consumer Healthcare

While still in their infancy, connected health devices including wearables and fitness trackers are seeing increasing adoption globally. The smart healthcare device market is expected to grow at a CAGR of 38% from 2015-2020, reaching US$163bn by 2020. The factors driving adoption are the rising uptake of wearable fitness trackers, a growing elderly population and the need for remote monitoring, the ability to gain AI-based health notifications. Corporate giants such as IBM, Microsoft, Google, Amazon, Cisco, and GE are among those exploring IoT uses for consumer healthcare.

Other than the Fitbit-type technology that many are familiar with, there are many other IoT-powered devices that can track a person's sleep, heart rate, breathing, blood sugar, exercise, and much more. For example:

Owlet - This anklet-boot wraps around a newborn's foot and tracks oxygen levels, heart rate, sleep, and temperature.

HealbeGoB -Measures calorie intake via the wearer's skin.

Lechal - Footwear that measures step count, calories burned and heart rate. Interaction with the device is done through tapping the shoes in a certain way.

Omron – A blood pressure monitor.

Hoxoskin - Clothes that can monitor heart rate and exercise.

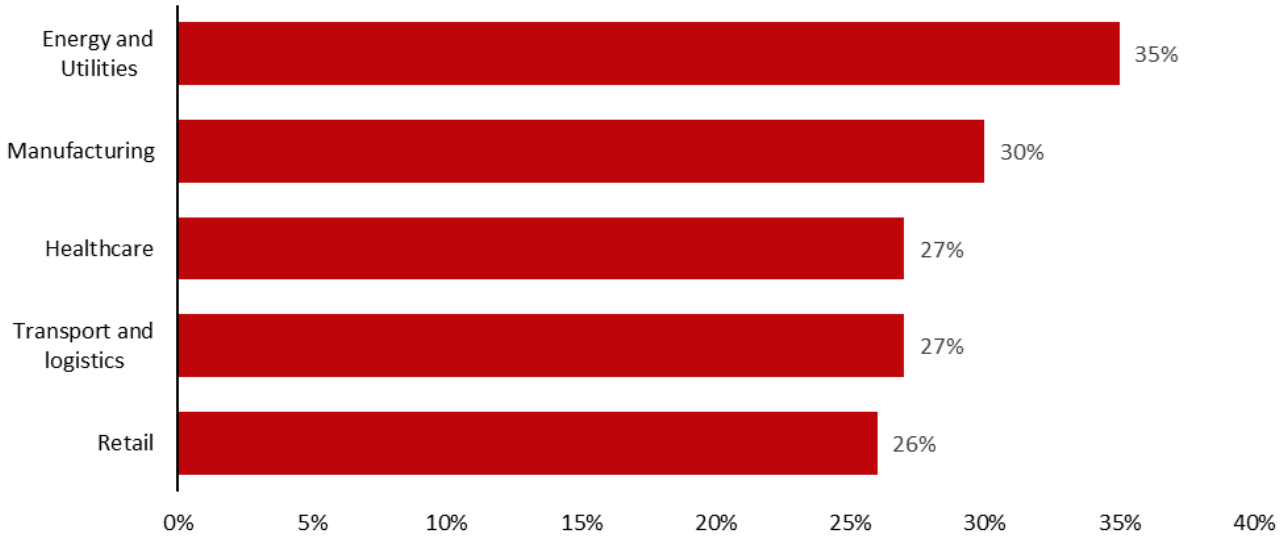
Source: Companies, DBS Bank

Manufacturing, energy and utilities Industries lead in IoT adoption

The IoT is affecting almost every industry in ways barely thought of, and opening up a host of new opportunities and threats. With IoT adoption rates surging, many industries are committing more resources to the IoT and forming cross-industry partnerships — increasing their spending and connecting more devices. For instance, Toyota partnered with Hitachi in October 2017 to implement smart manufacturing in Toyota's model plants using Hitachi's Lumada technology. This technology uses advanced data analytics from sensors embedded in manufacturing equipment and AI to draw insights through predictive analytics and real-time monitoring.

We have identified five industries leading the adoption of IoT solutions.

Diagram 2: : Industry-based IoT adoption rates in 2018



Source: Survey by Vodafone

IoT in Manufacturing

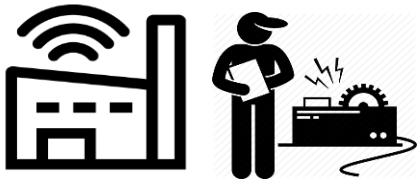
The manufacturing industry is experiencing significant impact from the IoT and the industry adoption rate has risen to 30% in 2017 from 11% in 2013[xli]. Globally, manufacturers are projected to invest ~$70bn on IoT solutions in 2020 at a CAGR of 19.3%, against the ~$29bn they spent in 2015[xlii].

In general, IoT initiatives in manufacturing include placing sensors on factory equipment to collect performance data. This enables factory operators, field engineers and original equipment manufacturers to not only see when a piece of machinery needs repair, but also gives insight on how to make the entire system work more efficiently. By connecting physical equipment to processes, systems and people, plant processes can be better integrated and taken to the next level of transformation known as Industry 4.0. This fourth wave of industrial revolution will be the era of cognitive manufacturing – where IoT sensors, big data, predictive analytics, and robotics will forge the future of manufacturing operations.

The companies that lead the way in IoT smart manufacturing include IBM, Cisco, Microsoft, Black and Decker, General Motors, Lockheed Martin, Epson and Intel.

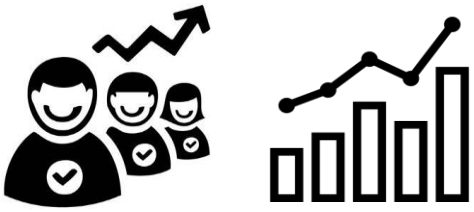
For instance, IBM's Watson IoT cognitive manufacturing framework transforms manufacturing processes in three ways, through intelligent assets and equipment, cognitive processes and operations, and smarter resources and optimisation. By intelligent assets and equipment, IBM means using the IoT and analytics to sense, communicate and self-diagnose issues to prevent and correct problems, thus reducing downtime. Through cognitive processes and operations, IBM analyses data from workflow processes to improve quality, yield and throughput, thus reducing defective products. With smarter resources and optimisation, IBM optimises its resources such as energy and employees, reducing costs drastically. Once these steps are implemented, cognitive capabilities such as machine learning can be leveraged upon to diagnose and rectify complex problems in manufacturing.

Future of manufacturing

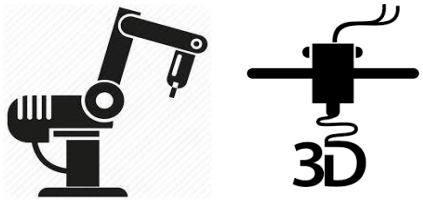


Connected – factory equipment continuously communicates with a platform like Watson to exchange real-time updates of inventory levels, conveyor belt situations and machine functionality. Purchase orders or equipment maintenance requests are made autonomously depending on real-time information.

Decrease in defective products – analysis of data sourced from workflow processes can be used to improve quality, yield and throughput, and to reduce defective products.



Increasing productivity – resource optimisation results in overall increase in the productivity and efficiency. Employee downtime also reduced drastically.



Robots with embedded sensors and 3D manufacturing are the future – manufacturing will be fully automated in the future with limited human involvement as sensor-embedded equipment connected to a platform can make autonomous decisions regarding the production line.

Source: DBS Bank

We believe manufacturing will be one of the biggest beneficiaries of IoT adoption. There is room for improvements in productivity through automation, potential cost savings through efficient energy and waste management, significant cutbacks in potential equipment downtime and optimisation of inventory through real-time visibility. IoT in factories can add an estimated value of around US$1.2tr to US$3.7tr by 2025[xliii], around 20-45% of which would be derived from energy savings and potential improvements in labour productivity[xliv]. Factories could account for as much as 30% of economic value addition from IoT by 2025[xlv].

Early adopters such as Harley Davidson seeing gains

Early adopters of the IoT in manufacturing are already seeing gains in productivity and cost savings. US motorcycle manufacturer Harley Davidson has integrated the IoT throughout its manufacturing processes, installing software and sensors that measure, record and manage the performance of different equipment and processes. The paint booth, for example, is monitored for heat and humidity, and software automatically adjusts the speed of fans when measurements deviate from acceptable ranges. The system also returns real-time data to employees and managers via large screens, computers and smart devices. This information gives Harley Davidson better visibility of the plant floor and improves decision-making in the fast-paced environment. The use of IoT has allowed the motorcycle manufacturer to reduce costs by 7% while improving employee productivity and net margins by 2.4% and 19% respectively[xlvi].

IoT uses in manufacturing

Connected factory and production flow monitoring

Here, sensor-embedded machinery transmits operational information to original equipment manufacturers and field engineers. This also enables operation managers and factory heads to remotely manage the factory units. Along with this, a digitally connected factory will establish a better line of command and help identify key result areas for managers.

The IoT in manufacturing also facilitates the monitoring of production lines starting from the receipt of raw materials to the packaging of final products. This complete real-time monitoring enhances the productivity of operations thus cutting operational costs. Moreover, the close monitoring helps to detect and rectify lags in production, eliminating waste.

Facility management and predictive maintenance

Embedding sensors in manufacturing equipment enables condition-based maintenance alerts. Some machine tools are required to function within certain temperature and vibration levels. IoT sensors can actively monitor machines and send alerts to engineers and technicians when the equipment deviates from its prescribed parameters. By ensuring the prescribed working environments, producers can conserve energy, reduce costs, eliminate machine downtime and increase operational efficiency.

Logistics and supply chain optimisation

The IoT can provide real-time access to supply chain information by tracking materials along the chain. By connecting plants to suppliers, all parties concerned can trace interdependencies, material flow and manufacturing cycle times. This data will help manufacturers predict issues, reduce inventory and potentially cut capital requirements. The IoT facilitates inventory management as well by tracking them globally and notifying of significant deviations from the schedule. This provides cross-channel visibility into inventories and managers have realistic estimates of available material, work in progress and estimated the arrival time of new material.

IoT benefits for manufacturers

Greater energy efficiency

Energy presents manufacturers with one of their largest bills in terms of cost but currently, there is no way to break down the bill to better understand where specific inefficiencies reside. But the IoT can pinpoint the devices that should be reconfigured to boost efficiency as every machine on the floor can be tracked for energy consumption.

Higher product quality

The IoT can help to avoid product recalls, angry customers, and damaged client relationships by using alerts generated from sensor-embedded devices in factories to notify the managers when the equipment deviate from prescribed parameters like temperature.

Reduced downtime

The IoT takes the guesswork out of maintenance and eliminates the need to plan maintenance schedules based on historical information. Instead, sensors provide relevant real-time data on machine performance and drastically cuts downtime and waste from the manufacturing equation.

IoT in Transportation and Logistics

The transportation and logistics sector is another early adopter of IoT technology, with adoption rate at ~27% in 2017[xlvii], from ~12% in 2013. For now, the IoT is mostly used to track the vehicle, but not the goods. But we expect many logistics and transport companies to soon start embedding Low-Power Wide Area Network (LP-WAN) or NB-IoT sensors in either the goods or the packaging to better track the item itself. This will allow the company to precisely track the location of an item within a warehouse or during shipment, while monitoring conditions like temperature, humidity and vibration.

Future of transportation and logistics with IoT

Connected – Vehicles receive real-time traffic and environmental updates and autonomously selects the best route.

Real-time visibility in logistics – The IoT can drive material cost savings and efficiencies. For example, sensors embedded in goods in transit could provide real-time visibility of their condition, ensuring minimal wastage. IoT could also help logistics operators automate aspects such as sorting cargo, yielding cost efficiencies.

Plunge in vehicle ownership in metropolitan areas – Demand-driven public transportation and pay-per-use vehicle-sharing models enabled by IoT makes the ownership of vehicles less appealing for residents in metropolitan areas.

Demand-driven public transport – Data derived from sensors in public spaces, video cameras and smartphones is used to gauge real-time demand for routes and destinations, which helps in the automatic scheduling of public transportation.

Source: DBS Bank

How we travel will fundamentally change

The IoT in transportation has the potential to fundamentally change how passengers travel, the concept of car ownership (Transportation-as-a-Service or TaaS) and mass transit systems such as highway systems and rail.

For instance, by installing IoT sensors in buses operating in a city, administrators can allow passengers to easily track the location of public vehicles so they can reach the stop or station in time to catch the bus. Transit agencies can install GPS systems on vehicles to transmit data to a central command centre. Once the GPS data is received by the central command, the information can then be disseminated to the passenger's internet-enabled mobile device or to an electronic sign at transit stops. Data from sensors, video feeds from CCTV cameras and location data from smartphones can also be used to determine the demand for destinations and routes in public transport systems, leading to the development of an on-demand public transportation system.

These initiatives result in benefits such as cost savings, improved efficiency and quality of life in cities. Real-time traffic updates can also help vehicles to avoid traffic jams and provide clients with timely updates in the event of any unavoidable delay. As at 2017, 54% of transport and logistics companies saw reduced costs and 51% benefited from improved employee productivity[xlviii].

The IoT in transportation and logistics has garnered the attention of several large and medium-sized vendors such as Alcatel-Lucent, AT&T, Cisco, IBM, Intel, Microsoft, Amazon and Google[xlix]. In 2016, Microsoft collaborated with Rolls-Royce to gather and store flight data from each of its Trent engines, which power planes flown by more than 85 airlines. Using Microsoft's Azure stream analytics, Azure machine learning and Microsoft Power BI, Rolls-Royce is able to analyse data to better to plan fuel use and maintenance, decrease downtime and enhance the passenger experience. There are potentially very high payoffs; cutting fuel usage by 1% could save US$250,000 per plane per year[l].

Chinese IoT firm G7 and logistics firm GLP have formed a joint venture to develop a new generation of smart heavy-duty trucks capable of autonomous driving, new energy technologies as well as logistics big data, and to explore innovative models of "vehicle-as-a-service". G7 provides IoT and AI-enabled fleet management and value-added services to empower logistics companies. The venture's immediate objective is to develop autonomous electric heavy-duty trucks powered by AI, which will increase efficiency and safety at GLP.

Key success factors for IoT tech deployment in logistics and transportation:

- Clear and standardised approach for the use of unique identifiers or 'tags' for various types of assets among different industries on a global
- Seamless interoperability for exchanging sensor information in heterogeneous environments
- Establishment of trust and ownership of data and overcoming privacy issues in the IoT-powered supply chain

IoT uses in logistics and transportation:

Warehousing operations

For logistics providers, warehouse operations are a key battlefield for competitive advantage. With thousands of different types and forms of goods being stored in the average warehouse today, every square metre of warehousing space must be optimally utilised to ensure specific goods can be retrieved, processed, and delivered as fast as possible. The result is a high-speed, technology-driven environment ideal for IoT applications.

- In warehouses, the widespread adoption of pallet or item-level tagging, using low-cost, miniscule identification devices such as RFID will pave the way for IoT-driven smart-inventory management.
- Cameras attached to the gateways could also be used to detect damage by scanning pallets for imperfections
- Once pallets are moved to the right location, tags transmit signals to the warehouse management system (WMS) to provide real-time visibility of inventory levels, preventing costly out-of-stock situations.
- During outbound delivery, pallets are scanned through an outbound gateway to ensure that the right items in the right order are being sent. Stock levels are then updated automatically in the WMS for accurate inventory control.
- Beyond goods stored in a warehouse, the IoT can also drive optimal asset utilisation. By connecting machinery and vehicles to a central system, the IoT enables

warehouse managers to monitor all assets in real time. Managers can be alerted when an asset is being over-utilised or when an idle asset can be deployed.
- Eg: Swisslog's SmartLIFT technology combines forklift sensors with directional barcodes on the ceiling of the warehouse and WMS data to create an indoor GPS system that provides the forklift driver with the accurate location and direction information of pallets. It also gives managers a dashboard to observe the real-time speed, location and productivity of all forklift drivers as well as visibility on inventory accuracy.
- Connected assets in a warehouse also enable predictive maintenance for warehouse transport systems.

Last-mile delivery

- **Automatic replenishment** and anticipatory shipping solutions have implications for logistics providers. For example, sensors detect when a retailer is low on stock and places an order automatically at the nearest distribution centre, reducing lead time and avoiding stock-outs that result in missed sales.

Use of delivery drones and robots

to conduct deliveries will become a reality with the advancement of the IoT. In fact, the central Chinese city of Xi'an already has an autonomous delivery station built in partnership with Internet giant JD.com. Drones fly in from afar, land on the delivery transfer station roof, and automatically unload their goods. After the goods are distributed within the transfer station, delivery robots are automatically loaded, and leave the station for deliveries. The transfer station connects the back-end drones to the front-end delivery robots and manages app orders too. It integrates an intelligent supply chain, intelligent container shipping, and many other smart industry foundations to act as a core hub for completely autonomous logistics.

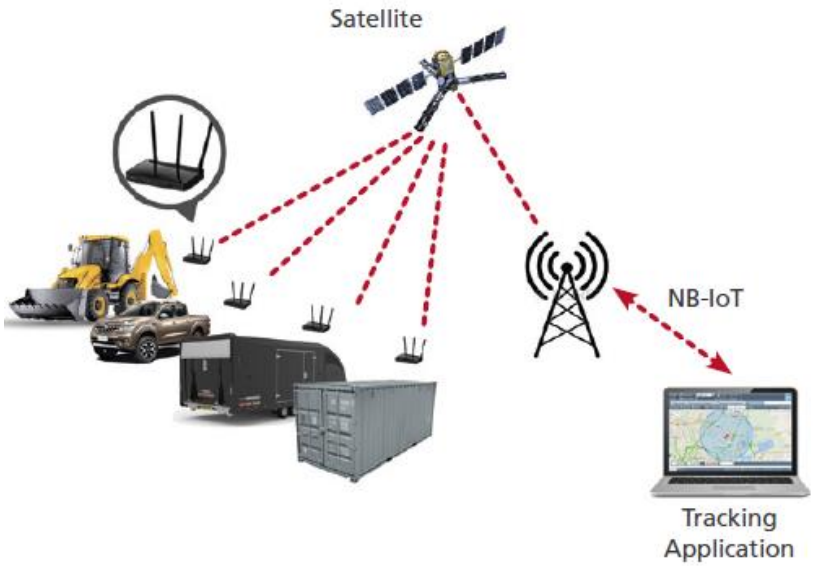
After leaving the transfer station, the delivery robots travel on the city sidewalks. From packages to hamburgers, these robots are now in operation delivering things to people in multiple cities. A six-wheeled robot developed by one American company can travel at speeds of up to 4 miles per hour, and carry goods weighing up to 10kg. They use 5G technology to determine the route, and the customer uses an app to open the lid of the robot and collect the delivery.

When these robots begin to provide courier services, delivery times within the city will drop from hours to minutes. The cost of deliveries will also plunge.

Asset tracking

deals with the monitoring of physical assets via a module on the asset broadcasting its location, usually using GPS technology. Through the use of sensors sending information over the cellular network, it is possible to gather and manage data relating to the current geographical location of assets. Asset tracking helps asset owners to detect and quickly react to unexpected events.

Asset tracking for the logistics industry



Source: DBS Bank

Transport

- IoT and AI-powered **Mobility-as-a-Service** (MaaS) and demand-driven transportation models will provide passengers with a seamless travel experience.

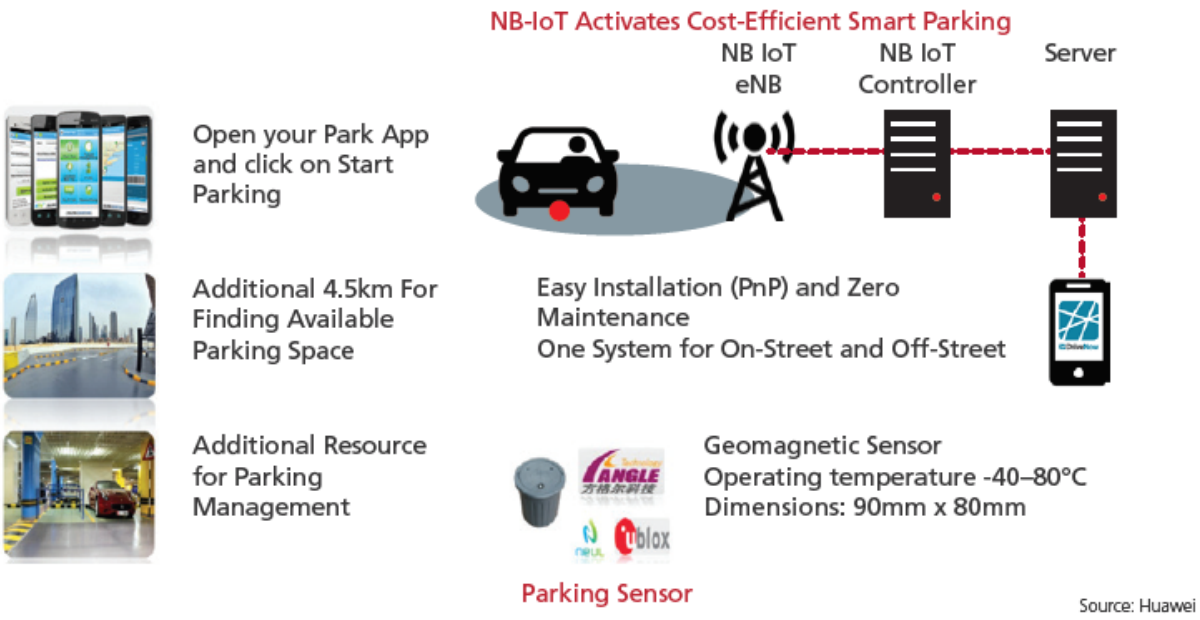
  Eg: Grab's collaboration with Equinix uses the IoT and data analytics to generate real-time report son customer churn, unique bookings and driver availability. A heat-map also identifies locations with high passenger volumes relative to drivers, enabling Grab to increase driver efficiency.

- The IoT can also improve the **management of traffic**, which has a significant impact on the liveability and efficiency of cities. Efficient use of data and sensors can temper the effect of population surges on traffic and render urban driving smoother.

- Emergence of **new business models** such as usage-based insurance. Sensors connected to a car's on board diagnostics port can capture data such as average speed, distance travelled, the frequency of hard braking and cornering, etc. By having a more objective measure of an individual consumer's behaviours, insurance carriers can more accurately price risk. For consumers, they can convert what is normally a fixed cost for auto insurance to a variable cost based on behaviour.

Smart Parking – Smart parking provides real-time parking information to enable better parking management. Huawei is working on a smart parking project with China Unicom (Shanghai), which expects to connect tens of millions of devices with this smart parking service.

Smart Parking solutions



Source: Huawei

IoT in Energy, Utilities and Natural Resources

Global energy consumption is expected to go up by 48%[li] from 2012-40. This, along with ageing infrastructure and inadequate equipment, is affecting the ability of the average utility company to meet consumer demand. Implementation of the IoT can dramatically help in this regard, with the installation of smart meters alone expected to create savings of US$157bn[lii] for utilities companies by 2035.

Shenzhen: World's first NB-IoT smart water project

One example is Shenzhen Water Group, which teamed up with China Telecom to launch the world's first NB-IoT-based smart water project, in which the city collects real-time data from smart water meters and monitors pipe networks. In a city listed among the top 10 most water-scarce cities in China in 2015, the project has helped Shenzhen Water Group to resolve issues such as water leakage caused by poor infrastructure management and customer disputes over water meter readings. The deployment of NB-IoT connected water meters is a success, and has significantly improved the customer experience. Water usage and water flow analysis is now easier to undertake and water flow across the network can be measured and leaks identified for further investigations. Where there are large flow issues or blockages, alarms can be activated for swift remedial action.

Forward-looking utilities companies are also embracing other IoT concepts. For example, US-based electric power holding company Duke Energy has created a self-healing grid system to overcome a power cut. Digital smart sensors at sub stations and on power lines detect problems and communicate with the control system. Switches then automatically isolate the damaged section of line to automatically reconfigure the electric grid to restore power.

Utility providers, power generation companies, and oil and gas organisations have widely adopted IoT solutions:

- Drones to inspect exteriors of large power plants and/or power lines;
- Temperature, vibration and moisture sensors and other tools for preventative maintenance or predicting of failures of power lines;
- Sensors to monitor networks of oil/gas transport pipelines, valves, and pressure gauges to prevent leaks and contamination;
- Smart grid meters for water, electricity and gas to collect usage data and run analytics on that data to gain business intelligence;
- Sensors within power plants to monitor equipment, conduct maintenance, and provide additional safety oversight; and
- Smart meters to track customers' energy usage and communicate that data to the company's central system, allowing companies to predict demand, spot outages, and conduct preventative maintenance.

Digital optimisation can boost profitability of the utilities and energy industry by ~20-30%

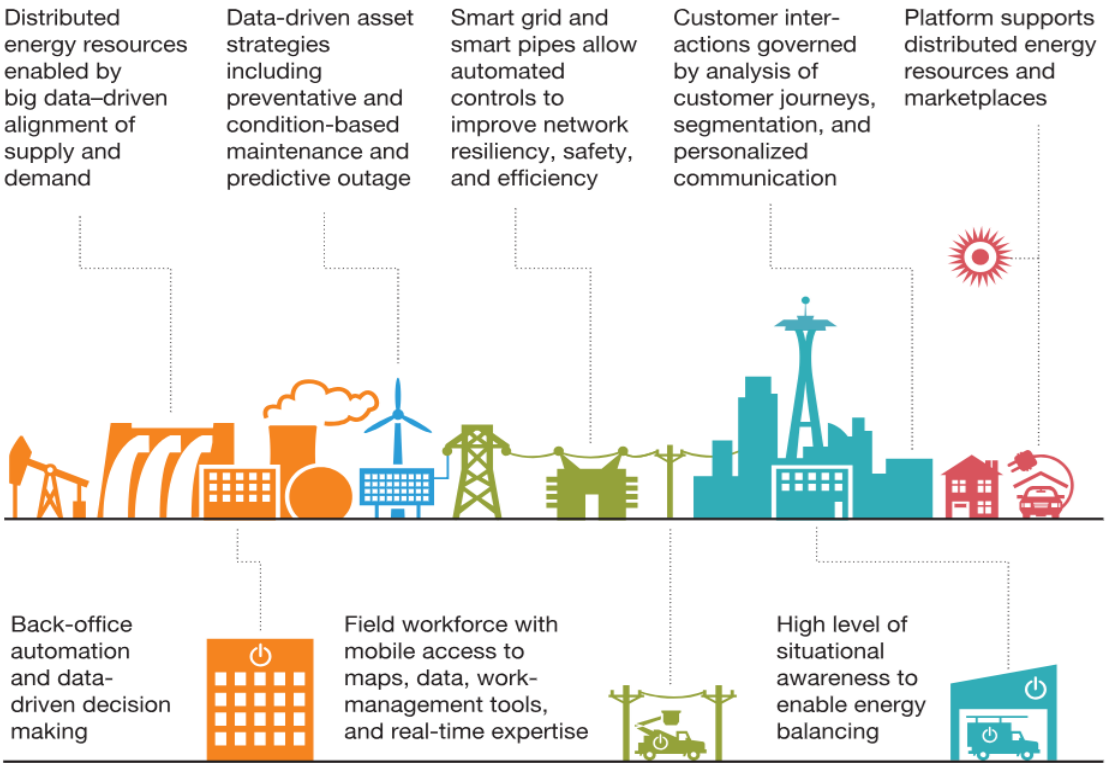
Digital optimisation led by the IoT can boost the profitability of the utilities and energy industry by ~20-30%[liii]; mostly through investment in smart meters and the smart grid, providing digital productivity tools for employees, and through the automation of back-office processes. The USA and Europe lead in these initiatives with China and India not far behind. On average, a US power plant can expect IoT-led digitisation efforts to reduce production costs by 27%[liv] (fuel costs by 28%, maintenance costs by 20%, operations costs by 19.5%) over five years.

As an example, Duke Energy has deployed an asset health monitoring and alerting system involving over 30,000 IoT sensors[lv]. It allowed the company to move from a semi-annual, manual, and paper-based asset inspection and reporting system to a fully automated, real-time system. In the three years of its operation, advanced analytics on the sensor data has helped the company avoid over US$31mn in maintenance costs alone.

New and lucrative markets in consumer data

The mass deployment of smart meters has also created a highly lucrative markets in consumer data, for example, in the sale of anonymised customer data to companies researching or designing new energy-related products and services, and the sale of specific data (with customer permission) to enable other energy-related companies to explicitly target new customers. Estimates indicate that these markets in the USA alone are worth US$1.3bn and US$3.3bn, respectively[lvi]. These highly lucrative business opportunities are also available to utilities and energy companies in Asia.

Value-chain opportunities for the utilities sector



Source: McKinsey

Mining industry an early adopter of the IoT

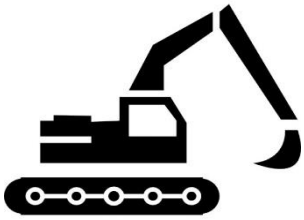
The mining industry has been quick to embrace the IoT and 40%[lvii] of the industry is expected to be leveraging on the technology by 2019. IoT has the potential to improve safety, monitor the environment, automate machinery operation, facilitate predictive maintenance, improve traceability and harness real-time data and analytics. In the mining industry, satellite technology – such as Inmarsat's L-band services, which offer up to 99.9% uptime, even in remote environments, is key to realising this potential.

Since 2008, Rio Tinto's pit-mining operations in the Pilbara region of Western Australia have used self-driving vehicles with autonomous haulage systems to move ore around. Data from the trucks, as well as from other equipment, on-site personnel, and geological instruments, is collected in Rio Tinto's comprehensive Mine Automation System, allowing Rio Tinto[lviii] to set up its operations centre in Perth, ~1,500 km away. Using the data collected via the IoT sensors, the experts in Perth come up with solutions for optimal mineral processing.

Source: Rio Tinto

How IoT improves performance at mining sites

By deploying connected smart sensors in a network, the IoT makes it possible to automatically capture data from hard-to-reach mining locations and communicate this data rapidly to other devices. This helps the network of automated devices to respond and adjust to environmental conditions, and enables mines to take more workers out of dangerous locations and replace them with robotics.



Extraction – Mining seams can be identified quickly using drones. Automated robotics systems ensure the most efficient extraction. Onsite health and safety for workers can be monitored using IoT sensors.

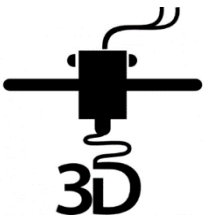
- Faster time from initial survey to material extraction
- Continuous improvement in mining efficiencies
- Fewer injuries and better protection for employees

Processing – Materials can be analysed for quality control and any delays in moving materials into the processing system identified. Sensors allow for increased automation.

- Faster processing
- Improved efficiency in logistics

Transportation – Automated, driverless vehicles can move materials efficiently for processing and be monitored for wear and tear.

- Reduced fuel consumption
- Improved, just-in-time maintenance
- Fewer breakdowns
- 24/7 movement of materials



Production – Production lines can be automated using robotics, and sensors can accurately track the quality of goods. 3D printers can be used in certain production areas.

- Reduced production costs
- Faster production times
- Higher quality products

Source: DBS Bank

Technological drivers and Inhibitors

Smart Sensors – The development of smart sensors, which are capable of collecting data from their surroundings and using in-built computing power to process the data to perform a predefined function, has become the bedrock of the IoT. A smart sensor usually comprises a sensor, microprocessor and communication technology of some kind. Advancements in the development of miniature smart sensors with a multitude of sensors and a growing number of microprocessors that consume minimal power has become a key driver for advances in IoT applications and capabilities. The IoT is set to be a key growth driver for the sensors and semiconductor market, with the IoT sensor market expected to record a 42% CAGR from 2016-2022, reaching US$38b by 2022[59].

Cellular networks for IoT – IoT devices use a variety of wireless technologies to stay seamlessly and securely connected. These range from 5G/4G/3G solutions for high bandwidth applications such as connected cars, to Low-Power Wide-Area Network (LPWANs) for machine-to-machine type communication. LPWANs are becoming a popular communication channel for IoT devices as the majority of IoT applications do not require the high speeds and bandwidth offered by cellular technologies like 4G. LPWANs allow highly efficient use of the current LTE spectrum, and require little power.

Developments in LPWAN

- LTE Cat 1 - A high-speed LTE standard designed for more feature-rich IoT applications that require higher data speeds. LTE Cat 1 technologies support speeds of up to 10/5 Mbps downlink/uplink and is typically used for IoT applications that often require video streaming and voice support. LTE Cat 1 technology supports a battery life of up to five years and is perfectly mobile, meaning handover between two cellular towers is handled without disruptions. Typically, LTE Cat 1 is used in applications in transportation and health monitoring.

- LTE-M (Cat M1) – New cellular technology that suits IoT applications with medium data rate requirements (typically 375Kbps uplink and downlink speeds. It offers improved power efficiency enabling a battery life of up to ten years and greater coverage range. LTE-M offers limited voice functionality via VoLTE (voice over LTE) and offers great mobility as it handles hand-over between cell towers similarly to high speed LTE. Key users of LTE-M include smart meters and smart buildings.

- NB-IoT (Cat NB1) – Very low-power-consuming network, ideal for IoT applications stationed in remote places. NB-IoT does not operate on LTE bands and hence there is often a heavy upfront cost for telecom operators to convert the network infrastructure to be compatible with NB-IoT. NB-IoT networks offer uplink and downlink data rates of approximately 50kbps, extended coverage indoors and underground, and are extremely energy conservative, supporting battery lives extending over ten years for IoT modules. The technology however, offers limited mobility as NB-IoT connections requires the re-establishment of a new connection when a new cell tower is reached. NB-IoT is suited for IoT applications such as mining and agriculture, smart meters and smart city applications such as waste and water management, street lighting and parking.

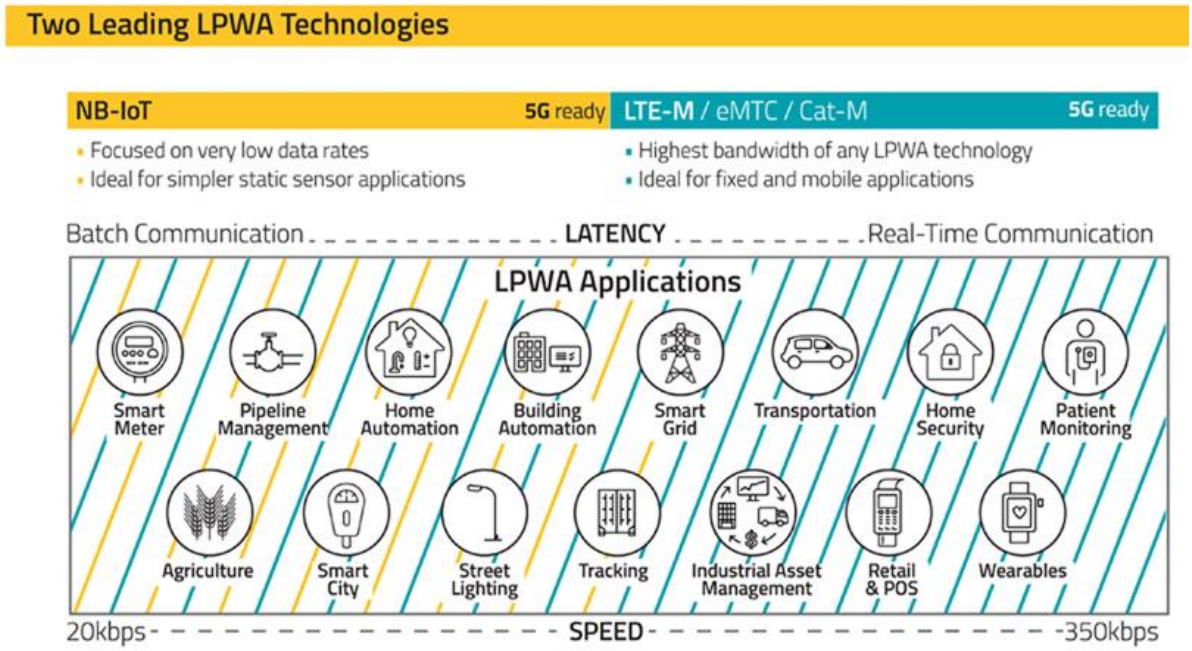
Key LPWAN technologies supporting IoT applications

Criteria	Cat 1	Cat M1	Cat NB 1
Speed	Downlink – 10Mbps Uplink – 5Mbps	375Kbps uplink and downlink	50Kbps uplink and downlink
Technology	LTE	LTE	DSSS modulation
Capabilities	Video, Voice and Data	Voice and Data	Data only
Mobility	High – fast transition between cellular cells	High – fast transition between cellular cells	Low – Need to re-establish connection when switching cellular cells
Range	Limited	Wide	Extensive – provides indoor and underground coverage
Energy Consumption	High – five years of battery life	Medium – ten years of battery life	Low – 10+ years of battery life
Uses	Moving IoT applications that require low latency and advanced voice and video features Eg: IoT applications in transportation	Moving or stationed IoT applications that require limited voice functionalities and medium data transmission speeds Eg: Smart buildings, healthcare monitoring	Stationed IoT applications that require low data transmission speeds and optimal energy conservation. Ideal for remote IoT applications Eg: IoT applications in mining and agriculture

Source: DBS Bank

Latency requirements, download speeds and mobility to determine the choice between Cat M1 and Cat NB1 for IoT applications. Both Cat M1 and Cat NB1 networks serve similar low-power uses. However, Cat M1 networks suit IoT applications that require near real-time communication (such as health monitoring and home security), some voice capabilities and the communication of larger data packets. Cat NB1, on the other hand, better suits applications that are remote, where low latencies can be accepted and smaller data packet sizes can to transmitted in batches.

Key uses for Cat M1 and Cat NB1 technologies
Around the world, 40 of the 51 low-power networks rolled out use Cat NB1 technology, with operators in China, South Korea and Europe rolling out Cat NB1. North America, on the other hand, is speadheading the development of Cat M1 networks. Availability of low-power networks should accelerate the adoption of IoT applications in the industrial segment, where cellular connectivity remains critical for sucess. We believe that both technologies will become requirements for the successful and ubiquitous implementation of consumer and enterprise IoT applications.



Source: SierraWireless

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