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Contents

IoT beyond the obvious

Driving value differentiation for cities of the future

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Abstract

IoT has changed the way machines interact with humans or other machines. The information that is now available through sensors can mimic that gathered by the human senses to a large extent. This white paper, however, does not talk about IoT and its advantages. Instead, it discusses how a confluence of new-age technologies can be leveraged to create use cases that go beyond the obvious ones.

Foreword

Debjani Ghosh
President, NASSCOM

The Internet of Things (IoT), which is enabling increased connectivity of everyone, everything, everywhere and every time, is causing a fundamental shift in how we do things. IoT, broadly classified into consumer and industrial IoT, is expected to be a 3 trillion USD global market by 2020. India's player landscape with ~120 IoT firms, of which >60% are start-ups, has the necessary technical and technological skills to power the IoT revolution.

India has, at the same time, taken up a mission to rejuvenate its cities through various mission programmes. The Smart Cities Mission is the most prominent among them and is aimed at transforming the urban experience through infrastructure and ICT interventions. Deployment of IoT devices on the field is a key aspect of the ongoing ICT interventions in these cities. We at NASSCOM see this surge in IoT deployments in the urban environment as a critical phase in leveraging technology for delivering citizen-centric services. While these IoT deployments across most cities have focused on addressing the urban challenges around transportation, traffic, solid waste management, public safety, etc., the evolution of other emerging technologies will bring possibilities that do not exist today. Driving a convergence of technologies in the urban context will help address challenges far more effectively and efficiently. This potentially addresses challenges that would not be solved by IoT alone. This calls for ingenious thinking and nimble-footedness.

NASSCOM has established a Centre of Excellence for IoT, as an initiative with MeiTY and ERNET. The purpose of the CoE is to expand product and service opportunities and maximise solution stack across the value chain to enable India to leapfrog in the IoT space. With technology convergence, there is a growing need to draw insights from the reams of data made available through IoT sensors. To this end, NASSCOM has also recently launched a Data Science and Artificial Intelligence CoE. We strongly believe that the true value of IoT lies well and beyond the implementations seen till date.

1. Preface

Technology continues to evolve at a very rapid pace and more often than not, organisations find it difficult to keep pace with it. As a key building block for the growth of any organisation, technology can provide a significant competitive advantage to an organisation over its competitors.

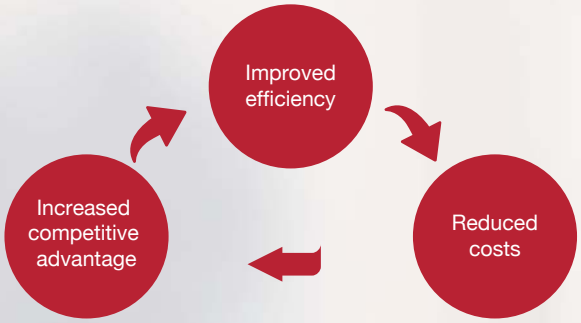
In this white paper, we explore how multiple technologies, when used in tandem, have the potential to provide an undeniable value proposition that can influence all stakeholders. The concept of 'IoT beyond the obvious' (IoT BtO), as introduced in the subsequent sections, is nothing but a philosophy that places IoT as the foundation for the future of technology. We also highlight that the synergies that complementary technologies bring when used together are much higher than their individual contributions.

We have described some use cases of IoT BtO in the white paper; these use cases only scratch the surface of the concept's potential. IoT BtO can not only reshape Industry 4.0 but also positively impact the life of every citizen by making more and more information available and accessible to them.

At PwC, we believe that IoT BtO has massive potential in the smart urbanisation space. IoT BtO can help both government and private organisations achieve all the three aspects of the growth cycle (Figure 1); we therefore refer to it as the next wave of transformation in the world of IoT.

This white paper is not intended for those trying to seek information around IoT. We start with the assumption that the reader is already familiar with what IoT is and how it works, and believes that it has the potential to revolutionise the world in more than one way.

Figure 1: The growth cycle



2. Executive summary

IoT has changed the way machines interact with humans and other machines. The sensors that form the building blocks for IoT create tonnes of data every minute and every day. This data largely mimics that gathered by the human senses (heat, humidity, light etc.). However, we believe that the current IoT use cases are only the beginning and the concept's applicability can be extended much further.

In this paper, we talk about some 'beyond the obvious' use cases. We also explore how sound, camera feeds and images, etc., can be used in IoT. Some of these use cases require significant investments in new-age technologies like speech synthesis, image analytics and artificial intelligence. We define 'IoT beyond the obvious' (IoT BtO) as a new wave in the world of IoT, which leverages the synergies of multiple new-age technologies to address real-world problems.

We discuss multiple technologies, some of which are time-tested and have proven their potential independently. We believe that bringing them all together shall create synergies that are way more than their individual contributions.

The urban sector can be a key focus area for us to leverage the potential of IoT BtO, specifically owing to its technology-first outlook and endeavour to create operationally efficient cities with improved liveability for citizens.

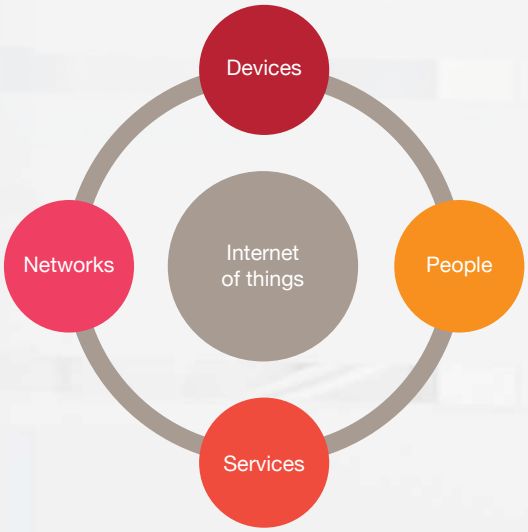
In addition, the paper also talks about some of the challenges that smart cities continue to face and proposes solutions that can help address the same. We believe that many such use cases can be formulated for IoT BtO. We have also explained the implementation of a typical IoT BtO use case in the 'Way forward' section. The implementation process for these use cases differs from that of traditional IoT implementation. The confluence of multiple new-age technologies poses significant complexities and thus adequate due diligence must be performed before any implementation.

3. Introduction

Since its advent in the early 1990s, the development of the Internet has been revolutionary. Now in 2018, the Internet has become an integral part of our lives—from booking a movie ticket to fetching news headlines, from simply browsing locations for your favourite restaurant to following maps to reach the selected restaurant. The Internet is omnipresent in our lives.

IoT is an area of interest for many. In layman's terms, it can be described as a connected mesh of devices to other devices (like mobile phones, ACs, washing machines), networks, people, etc., through a communication protocol (Bluetooth, mobile networks, WiFi, NFC, etc.) using embedded software/sensors, etc., to communicate, collect and exchange data with one another. A simple example of IoT would be regulating your home AC temperature through your mobile phone or making a video call to your friend through mobile data or Wi-Fi. The latest urbanisation initiatives in India like the 'Smart Cities Mission' are hugely dependent on IoT.

Figure 2: The Internet of things



The International Data Corporation (IDC) estimates that there will be 30 billion connected devices in the market by 2020 and the economic value of IoT would be around 1.46 trillion USD by 2020. In a recent IDC IoT Decision-Maker Survey, 73% of respondents indicated that they have already deployed IoT solutions or plan to do so in the near future.

From the above discussion and data, it is very evident that industries and organisations are rapidly adopting IoT to boost their growth. Therefore, it becomes imperative for organisations to invest in IoT BtO to gain a competitive edge.

4. IoT beyond the obvious (IoT BtO)

4.1 What is IoT BtO?

While IoT has become a necessity for most of industries, it has now begun losing some of its lustre because these days, adopting IoT alone as the technical strategy ceases to be considered as a competitive advantage. In a completely outcome-oriented set-up, IoT as an independent technology attracts little attention. When we focus on the applications of IoT BtO, we closely monitor the value (economic or social) created when traditional IoT is coupled with other emerging technologies like augmented/virtual reality (AR/VR), drones, artificial intelligence (AI), and machine learning. A combination of these technologies creates an undeniable value proposition for multiple public and private sector organisations.

The next section discusses some of the supporting technologies and their value propositions.

Augmented reality

AR is a mobile-based or embedded technology that senses, processes and outputs data in real time. It recognises and tracks real-world objects, and provides contextual information by supplementing or replacing human senses. A simple example could be a spectacle and lenses store that allows you to virtually try multiple spectacles or lenses through your smartphone or headgear.

Today, a sizeable number of companies are investing in AR. One of the biggest advantages of AR is that it has the potential to provide great value even to populations with limited resources.

Artificial intelligence

In simple terms, AI refers to a system's data-driven decision-making skills. From suggesting the best restaurants around your area based on your food preferences to face recognition on your smartphone while clicking a selfie, AI has certainly grabbed a huge mindshare in the world of technology.

Machine learning

Machine learning may be considered a part of AI that uses a data-driven approach to help a system learn or acquire intelligence by itself, without being explicitly programmed to do the same.

Put simply, a machine learns whenever it changes its structure, program, or data (based on its inputs or in response to external information) in such a manner that its expected future performance improves.

Connected devices

To understand IoT BtO, we need to understand the concept of connected devices, which are often misunderstood as smart devices. Connected devices are electronic devices that can communicate with each other (usually two-way communication) through a network. It is important to note here that the network that the devices use for communication (Bluetooth, cellular networks, LAN, etc.) does not bear much importance.

A typical example of connected devices could be your car audio system connected to your smartphone through Bluetooth, and your phone in turn connected to a music download server via a cellular network (VoLTE, 4G, etc.).

Connected devices have what we often call a protocol or a rule that decides the communication pattern among them. For example, a Bluetooth speaker can connect to only one device at a time for playing music. These protocols, more often than not, are programmed into the systems.

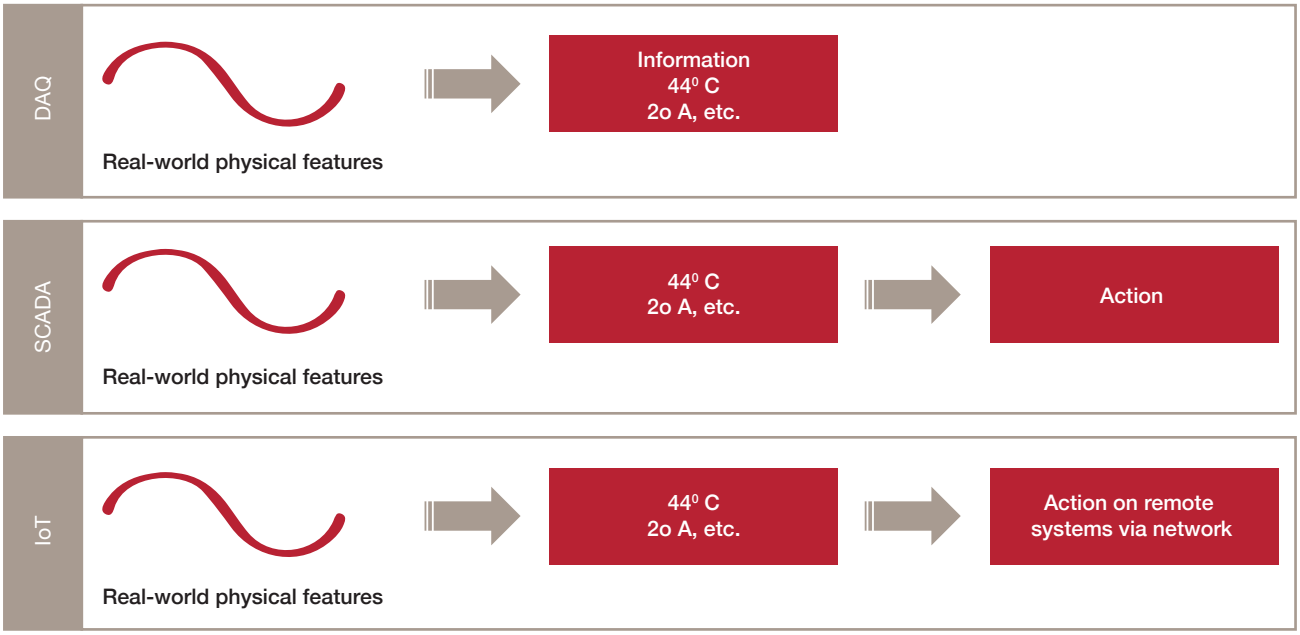
When multiple such devices connect with each other with defined protocols, we call it IoT.

Examples may include the heating, ventilation and air conditioning (HVAC) systems connected to your smartphone or a smart TV connected to a WiFi network through a WiFi router and, through the same router, to your smartphone. These are some typical applications of IoT in real life. We will now try to understand how complex protocols can be built between multiple connected devices by leveraging multiple new-age technologies, thus giving us beyond the textbook use cases of IoT.

The philosophy of IoT

To understand the philosophy of IoT BtO, we will have to take a step back and understand the evolution of IoT.

Figure 3: Evolution of IoT



Data acquisition (DAQ): Perhaps the foundation of all subsequent technological advancement in the field of IoT, DAQ is the process of sampling signals to measure real-world physical conditions. In simple words, the technology uses sensors to measure light, sound, pressure, acceleration, etc.

Supervisory control and data acquisition (SCADA): DAQ capabilities, when coupled with the ability of a system to take action (supervision), form SCADA systems. In simple words, if a machine has the capability to shut down automatically upon reaching a particular temperature, it is a SCADA system.

IoT: It comes into play when SCADA meets the Internet—for example, using a smartphone connected to the Internet to control the temperature settings for a machine to shut down.

IoT commonly uses sensors and actuators.

Sensors: They convert real-world physical phenomenon like light, heat and weight into electrical impulses—for example, LTH sensors, weight sensors.

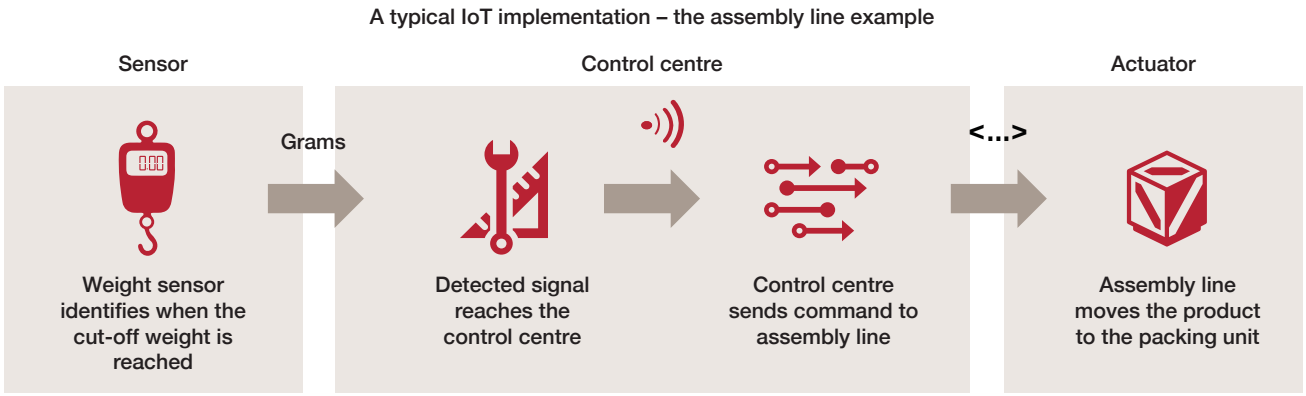
Actuators: They convert electrical impulses into real-world physical phenomenon, thus doing the opposite of what sensors do—for example, electric motors and hydraulic systems.

Illustrative example

Consider an assembly line with a weight sensor at the end, which starts moving products to a packing unit upon reaching a particular weight (say every time 200 g of produce reaches the end of the assembly line, the assembly line directs the produce to a packing unit). DAQ units are the sensors that help convert the physical real-world information to signals (in this case, weight).

These signals then trigger a supervisory action through actuators (in this case, redirecting the produce to a packing unit). Now, if instead of 200 g, as a special offer, the organisation decides to give 10% extra on each packing, the supervisory systems/control centres would need to be reprogrammed with a new value. If this reprogramming can be done from the manager's smartphone via the Internet, this is an IoT implementation.

Figure 4: A typical IoT implementation



Triggering events and associated actions in IoT

From the previous example of a sensor-based assembly line, two characteristics of the way technologies like SCADA and IoT operate clearly stand out:

1. Triggering event (through sensors; for example, weight) and
2. Associated action (through actuators; for example, moving the produce to the packing unit)

Triggering events:

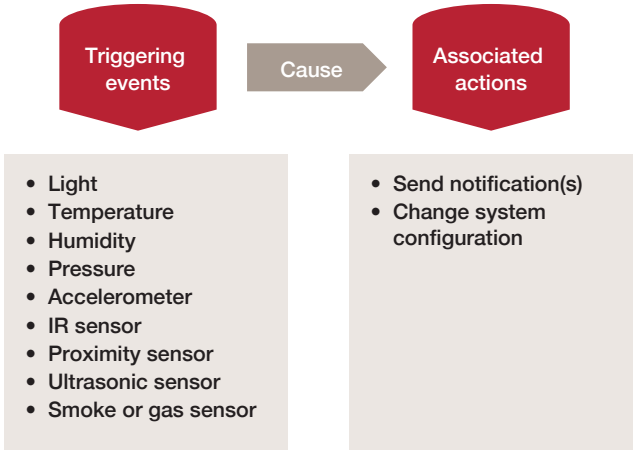
Triggering events are information from a sensor, like light, temperature, humidity and pressure, or as discussed in the above illustration, weight.

Associated actions:

Associated actions are the way the system reacts to the trigger—for example, shutting down street lights, shutting down a machine, or as discussed in the illustration above, moving the produce to the packing unit.

In the case of IoT, multiple triggers and actions exist simultaneously. Going back to the previous example of the assembly line, the input from the smartphone acts as a trigger for the action on the SCADA system. The associated action is the SCADA system being reprogrammed to allow 10% extra weight. Now, the weight sensor acts as a trigger upon reaching 220 g (200 + 10% extra) and the associated action is moving the produce to a packing unit (change in configuration of the system). This may be an oversimplification of how the system operates, but it makes the concept of triggering events and associated actions clear.

Figure 5: Traditional triggering events and associated actions



4.2 The philosophy of IoT BtO

IoT BtO aims at creating triggering events that are not commonly used in today's world. Most of the triggering events used these days are from sensors. Figure 5 above shows common types of sensors used in a standard IoT implementation. IoT BtO takes the concept of triggering events beyond these traditional sensors to visual and audio perceptions (for example, using image or sound as a trigger to change the system configuration).

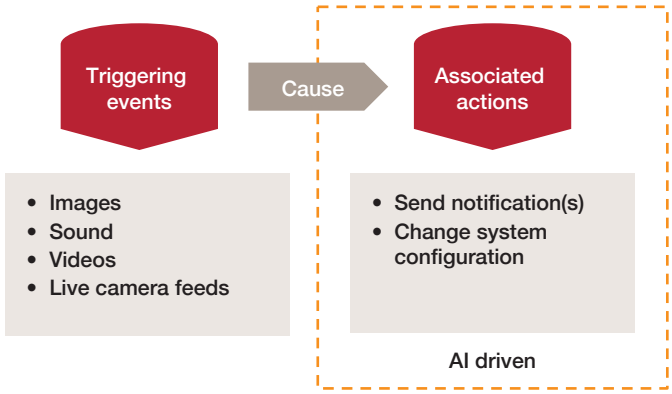
Using an image as a trigger entails the creation of a system that understands and analyses images. Such technologies already exist and are being widely adopted these days. In fact, AR technology can be leveraged to create such triggering events using live camera feeds too. This idea alone opens up solutions to multiple real-world problems.

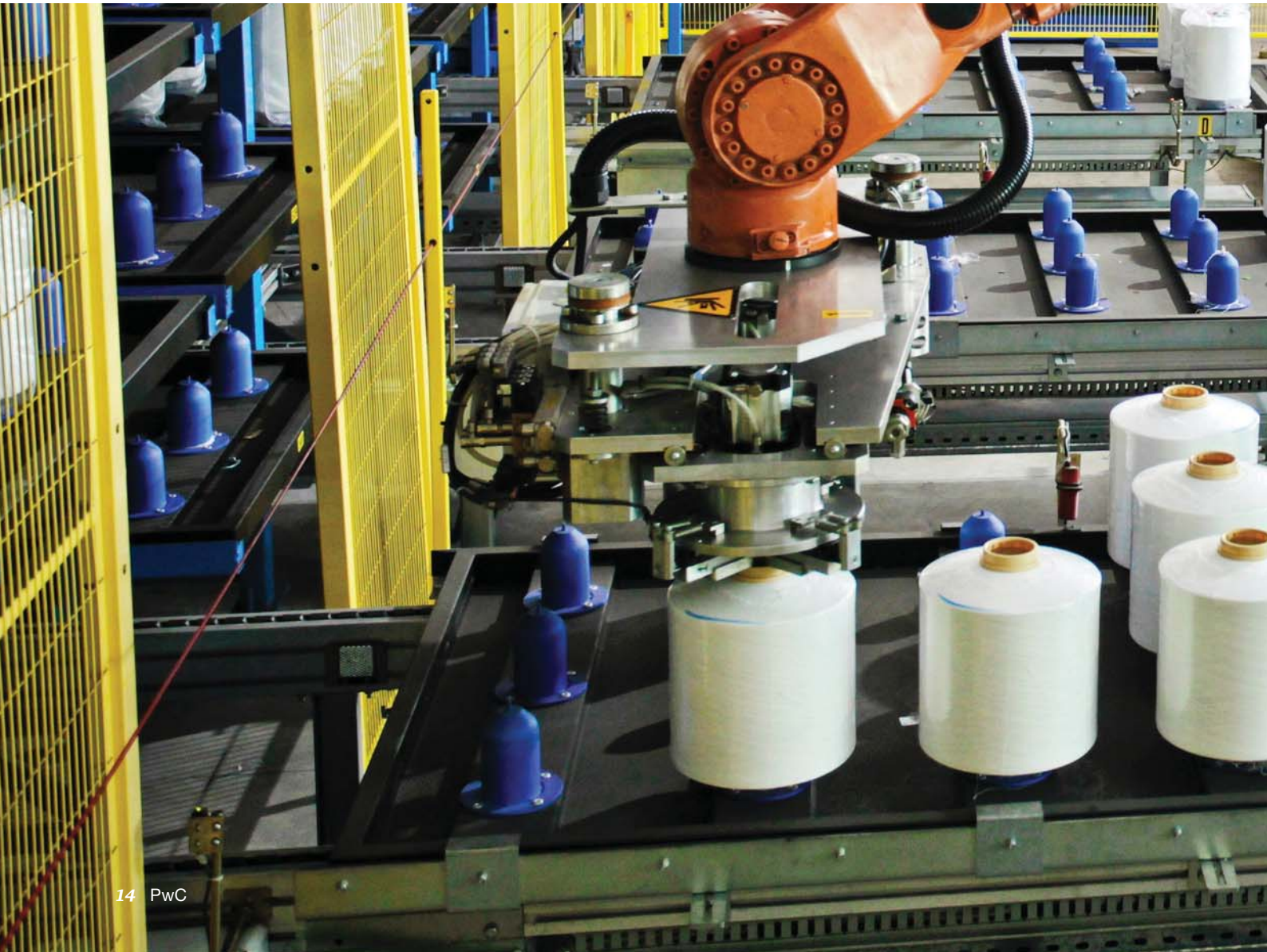
It is also important to note that a single image can be the source for multiple triggers, each having its own associated actions and creating a complex mesh of trigger and associated action pairs.

IoT BtO also allows multiple associated actions for a single triggering event. Leveraging technologies like AI and machine learning, an optimum action may be selected for a single triggering event from multiple associated actions. There will therefore be more than one associated action for a single triggering event and the system shall (based on multiple other parameters) programmatically determine which action to perform for the triggering event.

There are multiple use cases that can sprout out of these ideas, some of which have been discussed in the white paper.

Figure 6: Triggering events and a mesh of associated actions for IoT BtO





5. Use cases for IoT BtO

5.1 Leveraging AR capabilities to control billboard revenue leakage

The outdoor media industry is a rapidly growing industry and in the year 2017, there was a two-percentage point growth in outdoor advertisements in India. Figure 7 shows the four stakeholders in an outdoor advertisement project, and Figure 8 shows the market size of the outdoor advertising industry in India.

What's BtO?

Inaccuracies identified by citizens/local bodies on their smartphones are processed to calculate fines and are directly shared with the billboard vendor over his device.

IoT + AR + AI + machine learning

Figure 7: Key stakeholders in the outdoor billboard industry

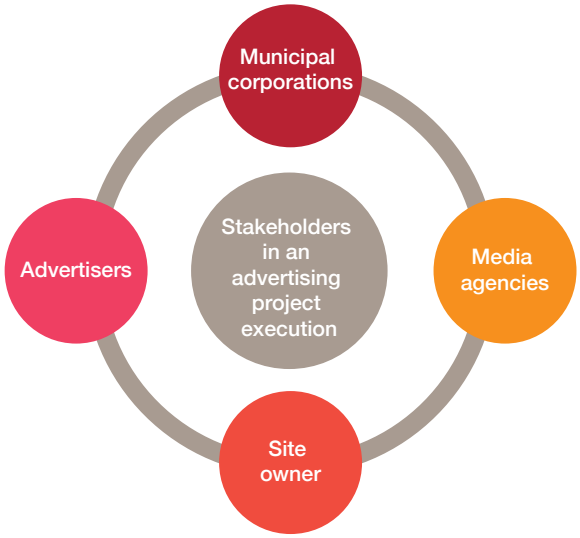
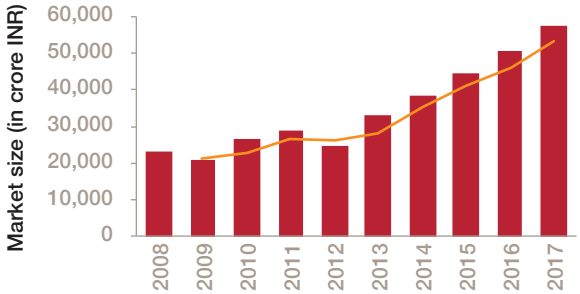


Figure 8: Revenue generated from advertisements in the last 10 years[1]



1. http://www.madisonindia.com/media/pdf/Madison-pitch-Presentation.pdf

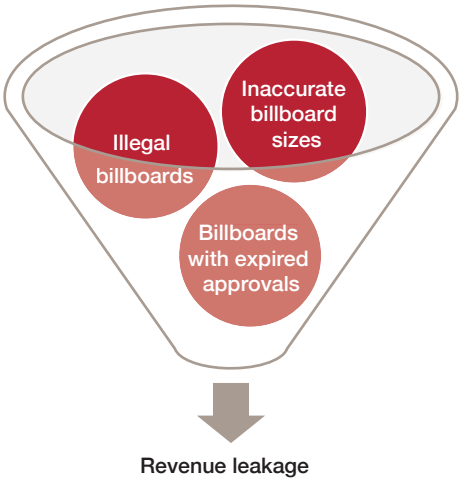
However, we believe that the potential market size for outdoor advertisements is much higher than what the current numbers indicate. Municipal corporations continue to face significant revenue leakages due to systemic inefficiencies, which to a large extent can be overcome by IoT BtO.

The loss of advertisement revenue arises from three factors. (For the purpose of the study, we assume that irregularities in outdoor billboards due to legal non-compliance are negligible; in reality, however, organisations face significant losses due to incorrect advertisements/false promises, etc.)

Illegal billboards: These are areas where permission/approval to put up a billboard is not taken at all, or the approval is taken for one billboard, but two or more billboards facing multiple sides of the road are put up instead. These billboard are the prime targets to prevent leakage since they lead to a total loss of revenue for the municipal corporation.

Inaccurate billboard size: Sometimes advertisers increase the size of billboards marginally beyond the approved size. Besides being a loss of revenue for the department, these billboards might also be a matter of citizen discomfort. These cases result in partial (percentage) revenue loss based on the deviation of the installed billboard size from the approved size of the billboard.

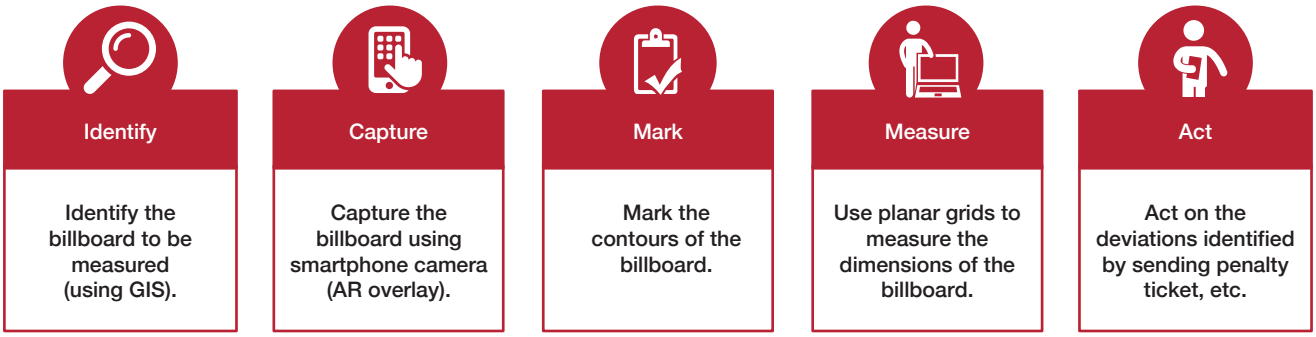
Figure 9: Factors causing advertisement revenue leakage

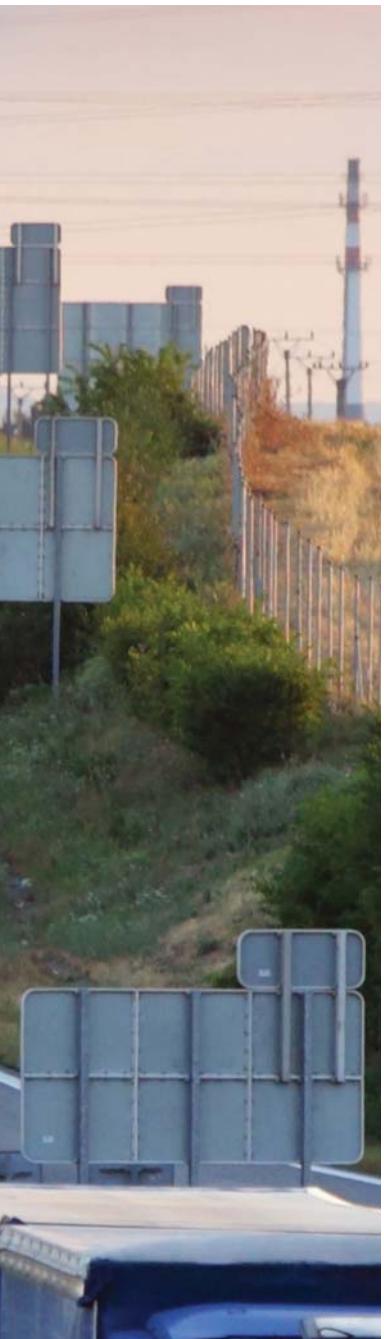


Billboards with expired approvals: Usually, approvals for putting up a billboard are given on a timed-lease contract. At times, advertisers may not renew the contracts on time and continue to advertise, although their approval has expired. Again, these cases result in a partial (percentage) revenue loss depending upon the time of discovery.

Figure 10 shows how a simple and easy-to-use mechanism can help achieve mass acceptance, especially among citizen groups.

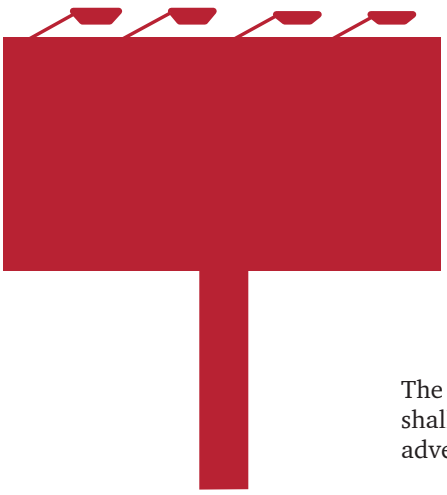
Figure 10: Billboard revenue leakage control system in action

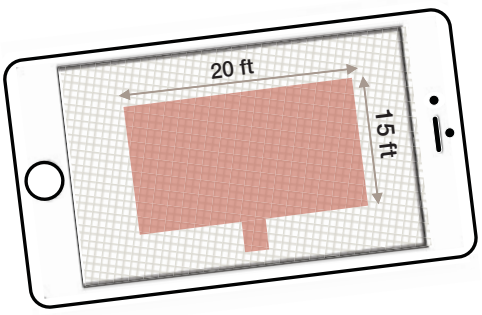




AR technology allows citizens/department employees to identify all the three factors of revenue loss described above and report them to the department through a mobile application. The technology can provide fairly accurate measurements, deviations, etc., even while using a low-end smartphone, thus eliminating the use of an expensive or difficult–to-operate devices.

Figure 11: Billboard revenue leakage system – measuring the dimensions of a unipole billboard





The deviations identified through the above process shall trigger actions like charging a penalty on the advertising agency via email.

5.2 IoT BtO for public infrastructure assessment

Public infrastructure forms the backbone for the growth of an economy. Some common types of public infrastructure include transportation, energy, water and public spaces.

Leveraging IoT BtO to measure public infrastructure facilities (e.g. height of an overbridge, a building, telecommunication pole) can help the state/regional authorities get a real-time assessment of the physical progress for any public infrastructure.

Imagine a world where head-mounted displays, drones or even a smartphone can help identify structural defects in public infrastructure. Drone imagery coupled with advanced image analytics may be used to measure the development progress of physical infrastructure from an integrated command and control centre.

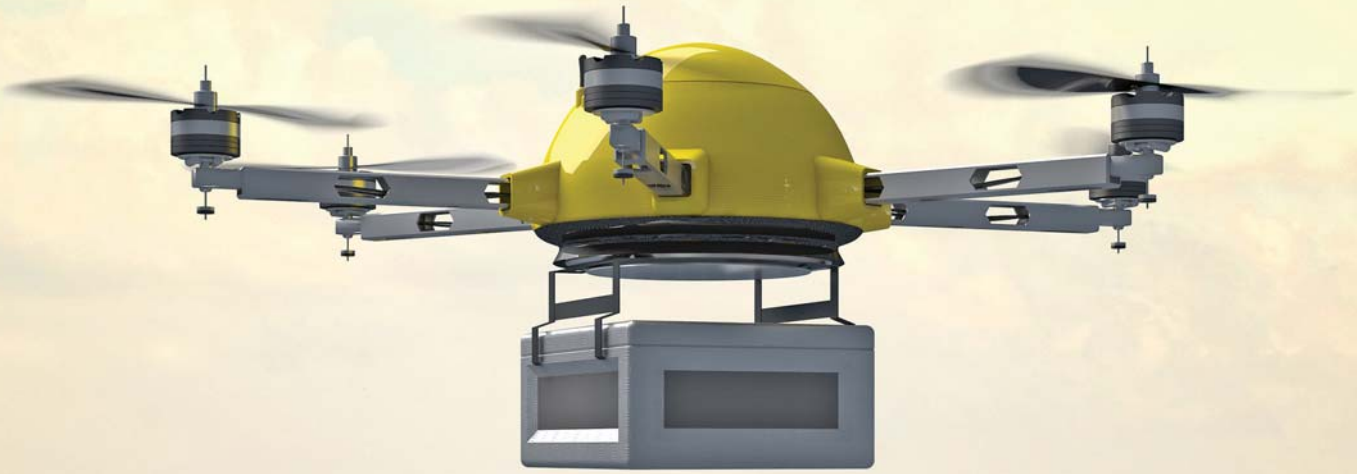
Unmanned aerial vehicles (UAVs) or drones are extremely useful to safely inspect hard-to-reach areas; the images/information captured by drones, if clubbed with AI, can be used to trigger actions in other connected devices.

IoT BtO has multiple use cases in the field of urban mobility and transportation. A user can visually connect multiple modes of transportation like railways, buses, modern on-demand and shared mobility services using IoT BtO.

What's BtO?

Public infrastructure assessment can aid in faster and more frequent assessment of physical progress by the state and Central Government without the need to pay physical visits:

IoT + drones + image analytics



5.3 IoT BtO for combating vector-borne diseases

As per a study published by WHO, vector-borne diseases account for more than 17% of the infectious diseases around the globe and around 3.9 billion people (more than 50% of the world population) are at risk of dengue infection.[2]

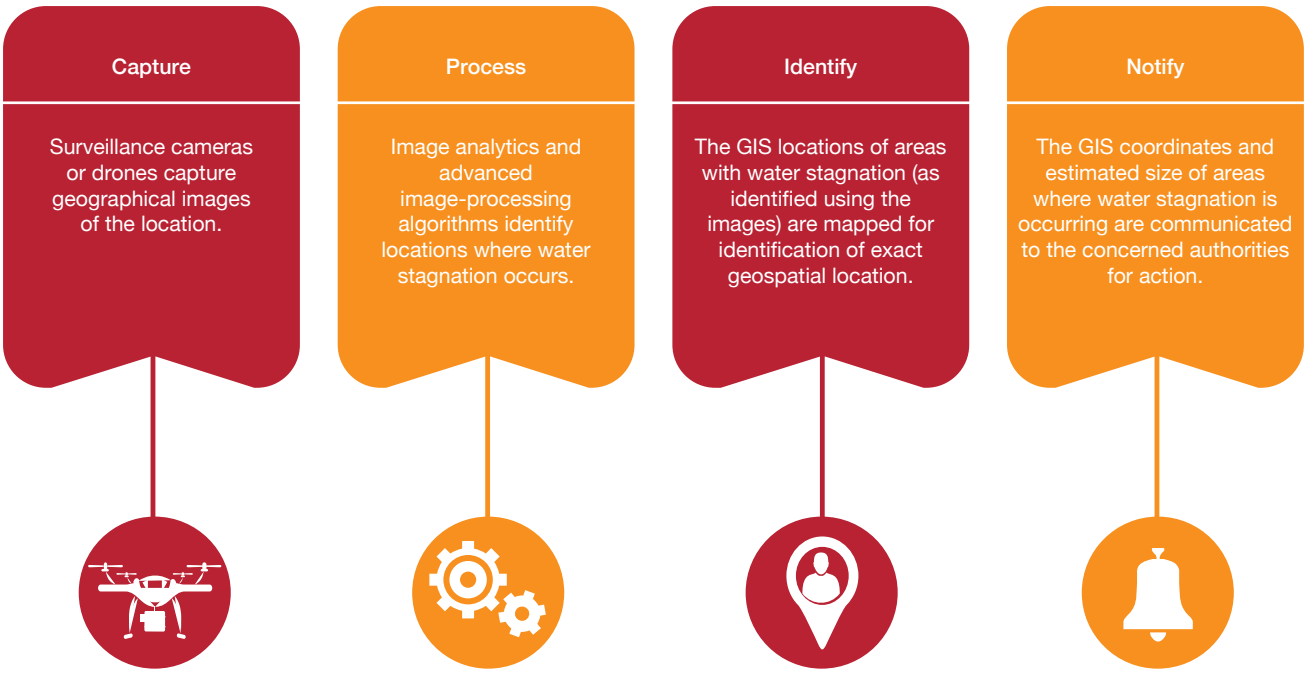
While there is no way the world can be made completely free of vector-borne diseases, governments may take some preventive and corrective actions to combat the problem. WHO/CDC/ECDC[3] have all recommended better surveillance systems to identify high-density areas for mosquitoes and take necessary actions.

IoT BtO can help combat the situation using technologies like image processing to identify critically infested areas. In fact, research has shown that the colour of stagnant water bears a strong correlation with larvae count.

Drones (another connected device) may be used for identifying high-density areas for mosquitoes extensively. However, due to their limited flight time, they can be used mainly as a corrective measure. City surveillance camera feeds can serve as a preventive measure to reduce waterlogging and stagnation, which are the main factors supporting the breeding of mosquitoes. Real-time analysis of the data received from such sources can be used to provide vector-borne disease risk ratings for areas of cities. Such ratings will help the authorities to prioritise areas for instant remedial programmes and channelise their resources more effectively.

To understand the technology behind this use case, let us break the idea down to triggers and associated actions. The image captured by the drone serves as the primary input. Analysing the image would help to determine the mosquito count in the sample area covered by the image. Using analytics, the density (i.e. mosquitos per unit area) can be calculated. This data now serves as an input for an associated action to take place—for example, spraying insecticide.

Figure 12: IoT BtO for prevention of vector-borne diseases



There are technologies that can be used for trapping mosquitoes and luring them to a mosquito dehydration unit by releasing an odour similar to that of humans. These devices make use of lactic acid and carbon dioxide to do so. Such IoT-enabled devices can also help to identify the type of mosquitoes based on their wing flap frequency, time when they are most active, etc. The data thus collected from the devices can be used for predicting the possible outbreak of a vector-borne disease in a region much earlier than the actual occurrence. The local bodies can then take preventive actions to decrease the magnitude of damage if not curb it entirely.

2. http://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases
3. WHO - World Health Organization
   CDC - Centres for Disease Control and Prevention
   ECDC - European Centre for Disease prevention and Control

5.4 IoT BtO in other government departments

Tourism sector

We live in a culturally rich and dense world with thousands of places that have interesting histories and appeal to tourists. Imagine using AR to experience life a few thousand years ago, just about the time a grand monument was being built.

Museums and culturally rich/significant areas are, in fact, the best candidate for IoT BtO. These areas have rich content in the form of artwork, artefacts, etc., which can attract and educate users.

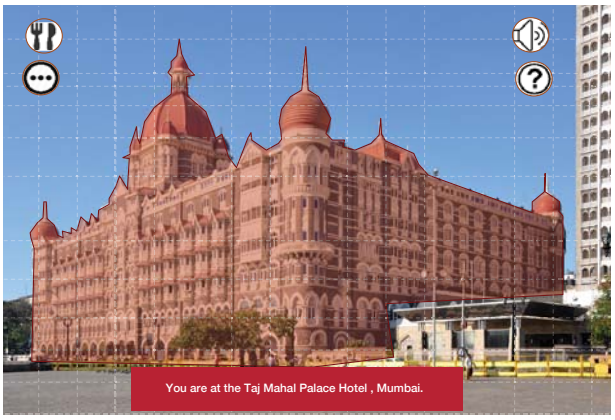
What's BtO?

Language translators and visual positioning systems help overcome the major problems in the tourism sector and improve it:

IoT + AR + AI

Figure 13 shows how an image of a monument is analysed. Once the system identifies the building, it triggers actions like finding eateries around the place, some trivia about the place, etc.

Figure 13: IoT BtO in the tourism sector



Further, translation functionalities can be used to overcome language barriers in tourism. Research show that the language barrier poses a strong challenge to the growth of the sector. ICT initiatives like language translators can help address this challenge.

A simple extension of the use cases would be to identify various road signs. Language translation and road sign identification can prove to be extremely instrumental for self-driven cars.

Figure 14: IoT BtO in tourism

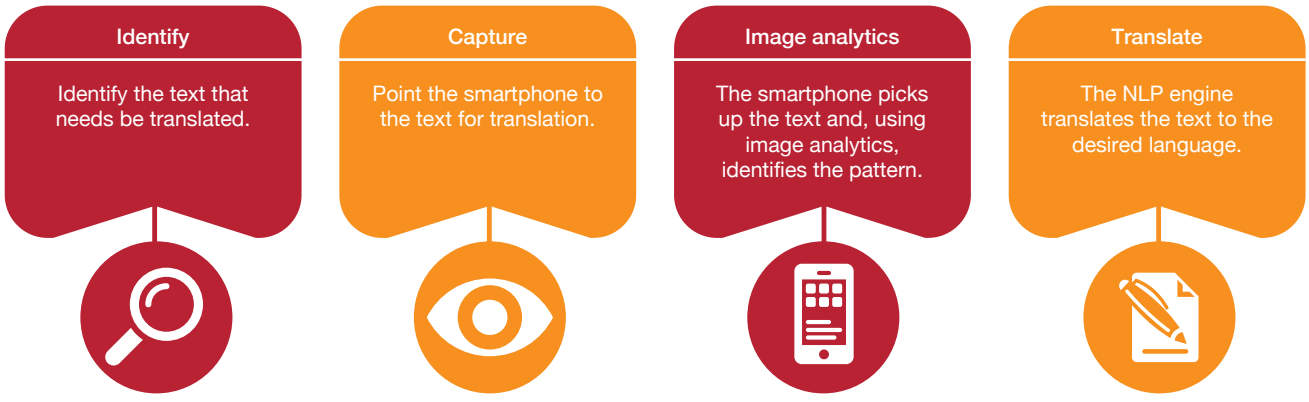
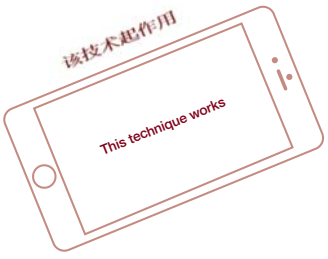


Figure 14 above shows how IoT BtO can be used to address the language barriers in the easiest way. AR technology coupled with AI and machine learning capabilities can help improve the accuracy of translations. In fact, the system may be built with natural language processing (NLP) capabilities to improve performance and make it more user-friendly.

Figure 15: Language translators



Education sector

The education sector has the potential to leverage IoT BtO to the maximum. It can improve the learning experience significantly by making it more immersive and interactive.

AR coupled with IoT devices like smartphones and display monitors can help students grasp the subject matter with ease. Moreover, vocational training can be extended beyond classroom structures to thousands of interested students using this technology.

AR is already being used in medicine and healthcare. Medical schools are using it to teach anatomy and surgical techniques. Singapore's Infocomm Media Development Authority (IMDA) has identified immersive technologies like AR and VR as one of the four frontier technology focus areas (the others being data science and AI, cyber security, and IoT and communication systems).

IoT BtO in the field of medical sciences can prove to be crucial in performing robotic surgery or robot-assisted surgery.

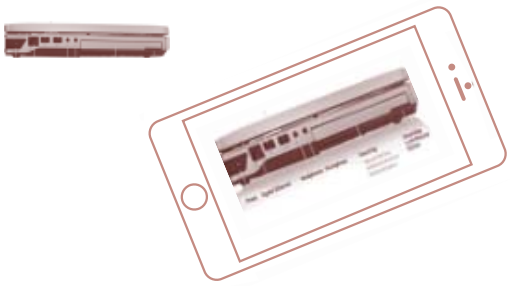
In fact, these technologies are already in use as a pilot in around five schools at Singapore. VR and mixed reality are also being used to enhance clinical trials in hospitals.

What's BtO?

Improved and more productive learning techniques can significantly shorten the learning curve for students:

IoT + AR + AI

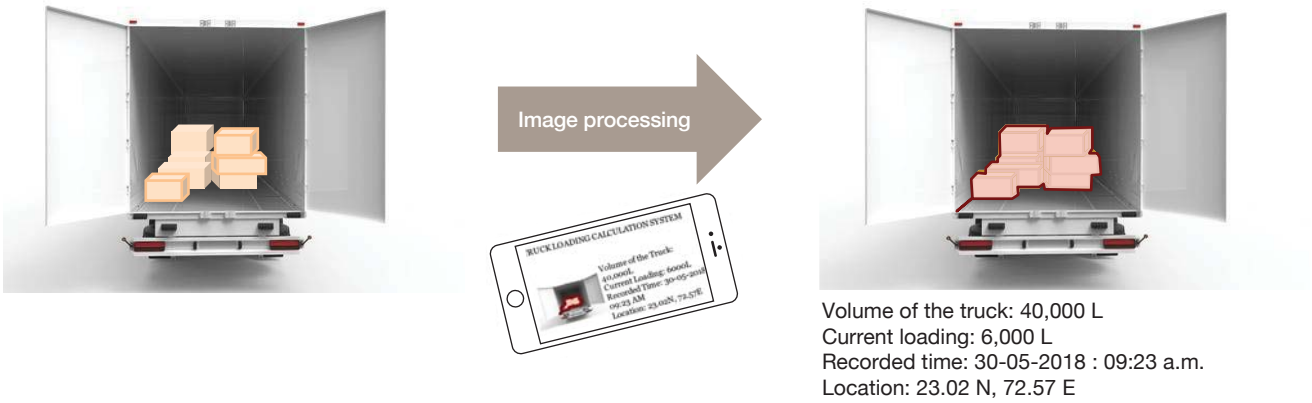
Figure 16: IoT BtO in education



Logistics and transportation

IoT BtO may also be used in logistics, particularly in trucking operations. It helps in determining the load percentage for a truck. Simple image analytics, as described in the billboard use case, will prove handy to determine the percentage of load in the truck. Figure 17 shows the truck-load measurement through volume analysis of the maximum truckload vs the time-stamped truckload.

Figure 17: IoT BtO in trucking operations



Volume of the truck: 40,000 L
Current loading: 6,000 L
Recorded time: 30-05-2018 : 09:23 a.m.
Location: 23.02 N, 72.57 E

The left-hand side image, when processed, can help to identify the empty spaces in the truck with respect to the spatial positioning of boxes. These empty spaces, when expressed as a percentage of the truck's maximum capacity, indicate the percentage of loading achieved by the truck.

This method can calculate the percentage of loading for a truck far more accurately than the currently used weight approximation technique, which is often not precise.

What's BtO?

Image analysis techniques can help calculate the percentage of load for a truck:

IoT + AR

6. Way forward

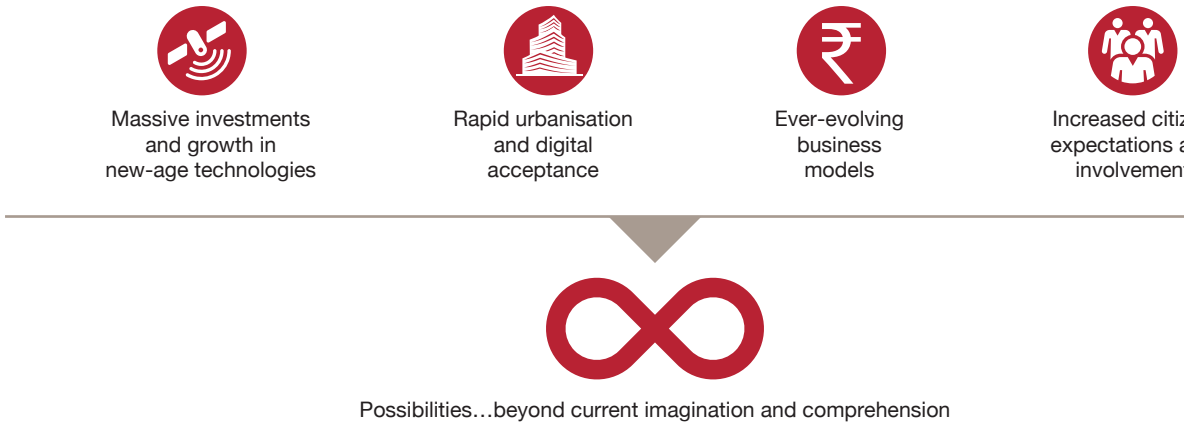
New-age technologies bring about new ways of doing things and present opportunities that one may never have envisaged otherwise. Enterprises and government sectors can leverage these technologies to ensure citizens are more engaged, happy and satisfied. IoT BtO offers a massive and undeniable value proposition.

We certainly cannot undermine the adoption curve for new-age technologies, but being a first mover has several advantages for any private organisation or government department. The set of technologies that comprise IoT BtO are seeing tremendous traction worldwide from all major technology companies.

The challenges lie in finding the best and most suitable use case for departments, organisations and government bodies. Post use case identification, proper due-diligence would be needed to identify the trigging events and associated actions. IoT BtO has tremendous potential in itself for government process re-engineering and transformation.

The massive investments in new-age technologies, rapid urbanisation, ever-involving business models and increasing citizen expectations open up tremendous and unprecedented possibilities and opportunities.

Figure 18: IoT BtO and blue-sky thinking

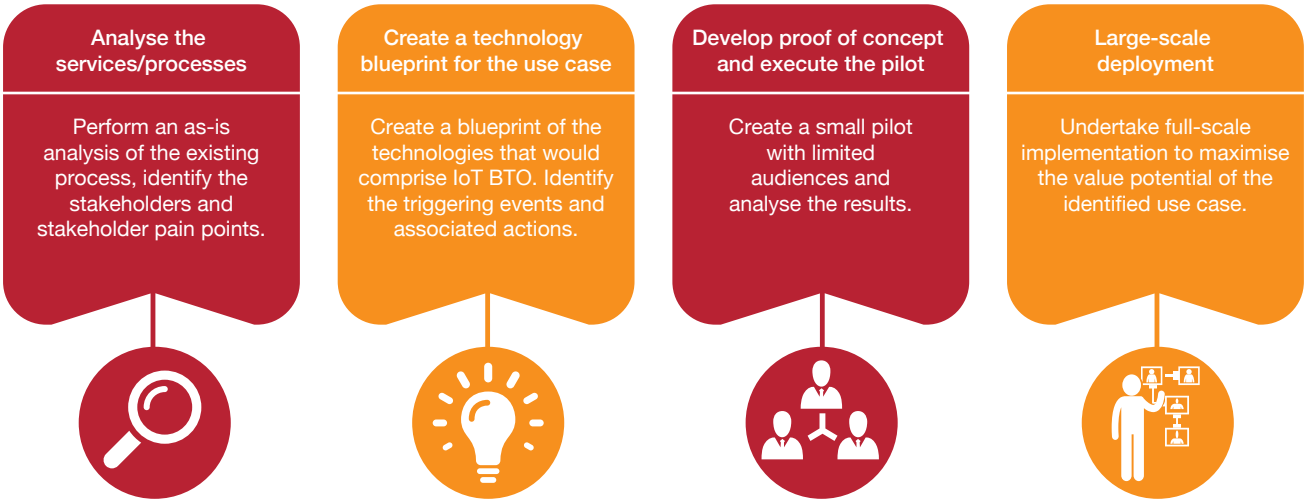


However, we believe that organisations need to be proceed with caution. The threats pertaining to cyber security and lack of standardisation of communication protocols continue to pose serious challenges and should be addressed at the outset.

In summary, we believe that IoT BtO implementation is a tightrope walk and organisations have to strike a balance between blue-sky thinking and excessive optimism.

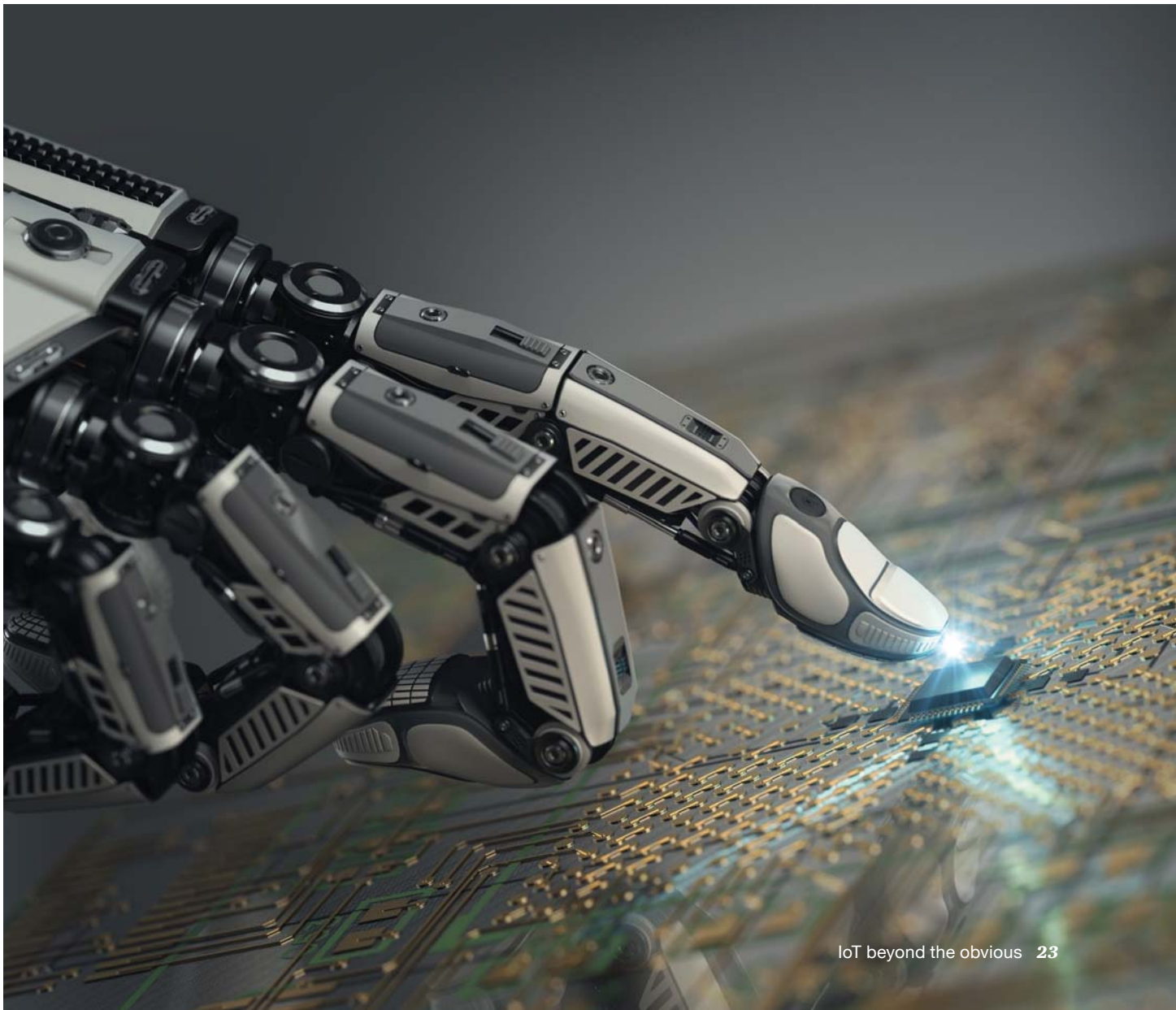
The typical process for an IoT BtO implementation is shown below.

Figure 19: Way forward for IoT BtO



Smart cities in India can leverage IoT BtO to improve the liveability of citizens to a very large extent. The technology can also be used to stop leakages in revenue, thereby leaving departments with more money for public welfare.

The potential that we have discussed in the paper is just the surface. There is a lot more that can be accomplished using IoT BtO, and it's time to seize this opportunity.



Notes

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About NASSCOM

NASSCOM is the industry association for the IT-BPM sector in India. A not-for-profit organization funded by the industry, its objective is to build a growth led and sustainable technology and business services sector in the country. Established in 1988, NASSCOM's membership has grown over the years and currently stands at over 2,500. These companies represent 95 percent of industry revenues and have enabled the association to spearhead initiatives and programs to build the sector in the country and globally. NASSCOM members are active participants in the new global economy and are admired for their innovative business practices, social initiatives, and thrust on emerging opportunities.

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