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YOUR HANDY GUIDE TO EVERYDAY TECHNOLOGY

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INTERNET OF THINGS
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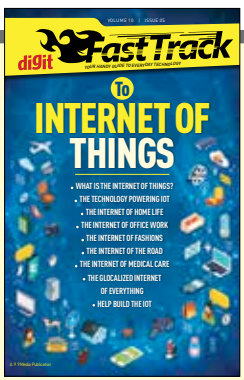

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Introduction

If there's one thing we can say with absolutely certainty the human race has been striving towards since the time we started thinking is this – finding an easier way to do something. Anything. Be it getting from your home to school, managing your shopping, trying to crack the code on 100% earthquake resistant building material, or making adorable cat videos. To do all of that (and more) better than we've ever done before, utilizing the Internet is key.

The Internet has not just democratized knowledge in the 21st century, it has also become an important pivot on which our species' progress depends heavily, playing an important catalytic role in anything we do or achieve from this moment on.

We all know how the Internet literally spreads across the globe much like a spider's web, with every node in its interwoven, multilayered structure representing a computing device with a unique IP address. We have a few billion people connected to the web right now – think about the computing devices they own. There's more. Add everything from your watch, car, mixer, oven, washing machine, fridge, thermostat, light bulbs, flower pot, clothes, sunglasses, door lock, and fifty different household items to that list. That's just the number of devices which are going to come alive, thanks to the Internet. But what about the devices that power the Internet itself? If you put all of this together, there's only one number that anyone can come up with – mindboggling. And that's just the start of the Internet of Things.

With a myriad sensors interconnected on a vast global network, we can learn and track processes (internal or external) to make better, informed decisions. There's no hit and miss anymore, only tried and tested behaviour models to learn from with the help of machines, putting us on an exponential path of progress like never before. If the Industrial Revolution led to the events that put a man on the moon, then just try and imagine

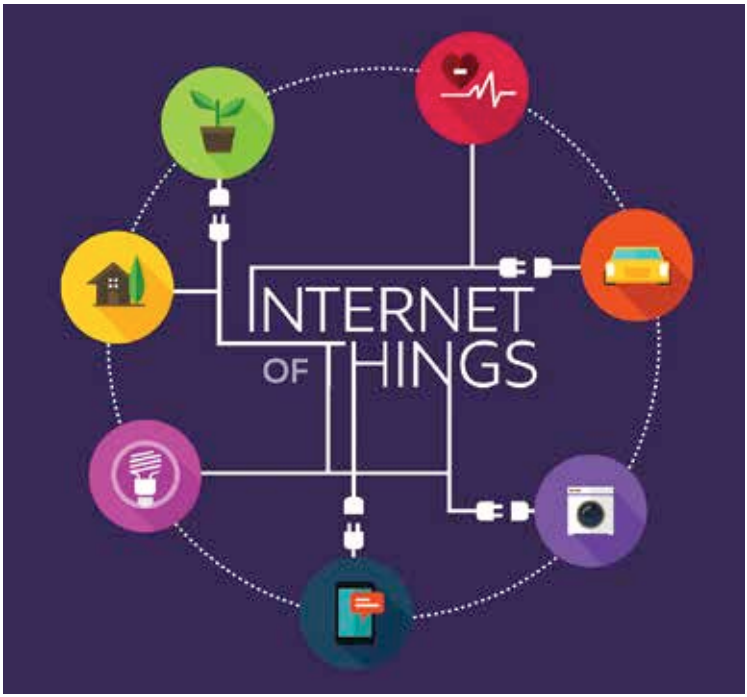
where we're headed if you think about the mother of all disruptions, the Internet of Things, and its truly transformative power. It's the beginning of a whole new era in our digital journey, one that will affect our species unlike anything we've seen or heard before.

Welcome to the present digital world, a place divided into two factions – everything and everyone that's connected, and those that are going to be. Welcome to the Internet of Things!

We really look forward to you enjoying this edition of Fast Track and welcome your feedback at: *editor@thinkdigit.in*

WHAT IS THE INTERNET OF THINGS?

Interconnectedness is inevitable – and it's good. But will we like it?



Internet + Micro-electromechanical systems + Wireless technology = Internet of Things (IoT)

1. The concept

When you connect your home desktop or your laptop to the "internet", you're simply connecting it to a huge number of other computers – some similar in size, others much larger – all around the world. These computers are able to understand the requests sent in by your personal laptop (clicking on a link or searching for "how to bench press" on Google) and are able to exchange information with it so that you get your answers.

The idea behind IoT is to connect commonplace machines and appliances – say, your microwave or air conditioner at home, or the traffic lights of your entire city – to each other and then use their ability to exchange information to make our lives easier.

For example: a home automation system would connect your bedroom lights, the air conditioner and the water heater at your place to a single network that you can control from your iPad. So that when you begin your hour-long commute back from work in the sticky and dusty March heat

in Mumbai, you can switch on your airconditioner 30 minutes before you reach home, dim the lights and have hot water ready for your bath well before you actually reach home.

The concept of IoT has been around for a long time. In the 1970s, some folks in the Computer Science department at Carnegie Mellon University decided to make things convenient for people by connecting the Coke vending machine in the department building to all the computers in the department, so that anyone from anywhere in the building could check if a cold bottle of Coke was available before going down to the vending machine, saving people from the unnecessary hassle of several futile trips to the machine. A simple convenient solution to the problem.

IPv4 used 32-bit addressing, while IPv6 uses 128 bits – an immense increase in the number of addresses, ushering the era of IoT

This is an isolated example, and there's no denying that large scale applications of IoT will naturally come with concerns of privacy and security of the enormous amounts of data that the devices would generate.

2. The reach

Potentially, IoT can connect everything – and that means everything that can be assigned an IP address – in the next few decades or even less. The underlying idea behind the internet as we know it is that each computer connected to it can be identified with a unique address – called the IP (Internet Protocol) address. The latest version of the Internet Protocol, IPv6, can support up to 2128 = 3.4 × 1038 addresses, which is close to about one trillion trillion trillion addresses per computer on the planet!

This new protocol was developed because IPv4, currently the most common version, had a limited address space. Eventually the available

addresses would have been exhausted and therefore the complete adoption of IPv6 worldwide is only a matter of time, and critical to the success of IoT. IPv6 creates an independent network parallel to that of IPv4. However, intermediate trans-protocol systems are available and are indeed widely used today as IPv6 is gradually adopted. The numbers involved here are ridiculous and, for those who are analytically inclined, very exciting.

Currently, there are over three billion internet users. Imagine each of those individuals using basic electronic equipment at home, work and in their cars. Now imagine each of those devices generating small chunks of information throughout the day – when you switch on your TV, when you put on some music, when you ask the in-car navigation system for directions to the local mall, when you make a phone call – and you soon begin to see that an enormous amount of data is generated by people all over the world, and how these tiny bits start adding up.

According to IC Insights, a market research analysis firm focussed on the semiconductor industry, global sales from IoT are expected to grow from $57.7 billion in 2015 to an astounding $103.6 billion in 2018, representing a compound annual growth rate of 21% over five years starting from 2013.

3. The improvement

Convenience is usually a commodity that is worth its price, and IoT (at the cost of making us more lazy) has immense potential to bring about transformative convenience in our lives – both personal and public.

Home automation: Numerous companies now manufacture "smart plugs" that allow you to control anything plugged into a power socket using just an app. By using multiple smart plugs, you could control your entire home remotely.

Industrial applications: Sensors on manufacturing equipment can monitor their designated thresholds, and error reports can automatically be sent to the manufacturers. This helps early prediction of equipment malfunction and therefore improves service maintenance.

Logistics: UPS, one of the world's largest shipping companies, uses analytics on large-scale data obtained from hundreds of data points in each of their 80,000 delivery vehicles. This has helped UPS optimise its delivery process and reduce fuel costs and idling time.

Smart cities: Smart parking meters in Barcelona, Spain are connected to the city-wide Wi-Fi network. This system gives out real-time updates about available parking spaces, and also allows the residents to pay through

The benefits of IoT are not limited to your home. It can control and improve entire cities.

their phones. Smart bus stops give real-times updates about schedules, and sensors spread across the city provide real time traffic and temperature data online. A big-data system built on Microsoft Azure manages all this data and analytics enable the city to offer better public transportation and better planning for events.

4. The impact

There are some basic truths about human nature that are universally applicable – we crave comfort and security, we resist change, and the need for instant gratification is intense and always increasing.

The impact of IoT can be linked to these basic human truths. IoT offers high-value convenience and productivity in terms of increased functionality at home, smarter traffic control during rush hours and improved manufacturing processes. However, concerns are naturally raised over the privacy of the data that's being handled. The thought of someone sitting in a corporate office having specific details of when you microwave your dinner every night is indeed unsettling. If your local supermarket is scrutinising how long you spend in the liquor section, it does feel a tad intrusive. There's every right for all of us to be concerned about this, and for good reason.

Despite the obvious benefits and concerns to this new era of interconnected gadgets, predicting the response to IoT's adoption is anyone's guess

Of course, at least ostensibly, all that data is only ever going to be used to run analytics so as to find optimum solutions to seemingly simple everyday problems. Also, any such setup without adequate security provisions to ensure the safety of the data is bound to fail. Necessity is the mother of invention, and thus more data will bring about stronger security.

Nevertheless, when technology starts to affect people in such a personalised manner, the question drifts away from the pragmatic realm and into the grey areas of morality. Ideally technology and its applications should be amoral – having nothing to do with morality at all, but we don't live in an ideal world. These subtleties will cumulatively affect the way people adopt IoT in their daily lives – both as part of their personal and public lives.

Indeed, the most fundamental dichotomy that exists in the world of technology has always been convenience versus security. Should you lock your phone and suffer the extra few seconds while trying to make an urgent call, or should you leave it unlocked for easy access at the risk of invasion of privacy? Should you let minor yet personal details like your dinner timings and your preferred TV shows become not-so-personal any more if it helps have your dinner ready when you need it?

It's a delicate compromise that almost all of us have had to make at some point in our lives, moreso in the advent of the Digital Age. However,

the nature of people's response at large to any service, product or content can be notoriously difficult to predict. Case in point: Harlem shakes. Also, predictions about technology tend to vary wildly in accuracy. When Bill Gates allegedly said that an individual won't need more than 640KB of memory, he was quite fantastically off the mark. However when Gordon Moore observed that the number of transistors per unit area has been doubling every two years, it became a self-fulfilling prophecy and arguably an industrial standard that companies actively strived to match.

The benefits of IoT are there for all to see even today. How it will be received by people once it becomes ubiquitous is the million dollar question, something that remains to be seen.

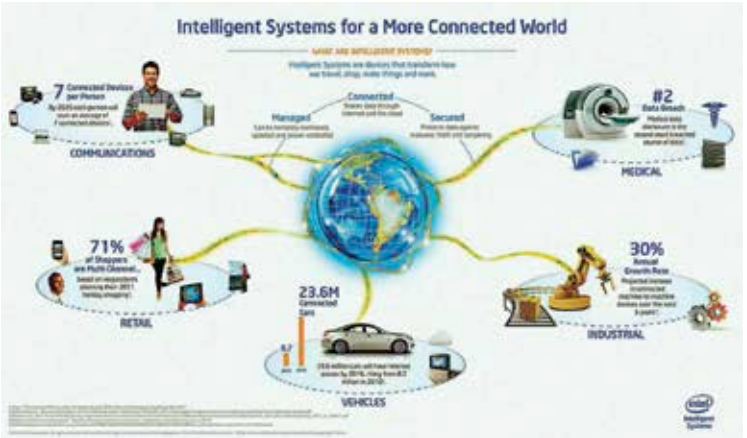
THE TECHNOLOGY POWERING IOT

The Internet of Things is a redesign of the way technology communicates. We look at the existing and developing systems that power it.

As we've discussed earlier, the concept of the Internet of Things is far more futuristic than currently experienced. Of course, we already have small self-enclosed systems which are performing at near autonomous efficiencies but the world of true intelligence powered technology networks is yet to become a reality. This is not to say that we don't have the means or the motivation to make it so – just the right solution. The framework that is envisioned which will allow for a global or even a regional system of the Internet of Things requires extensive organisation and investment in traditional networking technologies. We shall be taking a closer look at this framework and the technology systems which can make it a reality.

Technology framework for the IoT

The Internet of Things is very much like a biological entity – each thing being



The future of IoT networks will permeate across people, devices and environments seamlessly.

a single cell making up a larger entity. Each of these cells, or technology devices, connects with others using various forms of wireless connectivity to create a near autonomous intelligent network which can execute multiple tasks and hold immense data in an intuitive like manner. The interconnectivity of these devices across the wireless medium however requires a networking system to take effect. In this regard we have many options to turn to, the most obvious being the Internet and its underlying framework of protocols, addresses and applications. The real work is done by the applications or software which collects, evaluates and executes actions based on sensory data from all the things.

In current times we are witnessing the proliferation of the wireless connectivity through Wi-Fi, Bluetooth and Near Field Communication (RFID) technology. Its not at all unexpected that as time goes on we shall broaden this list to include many other forms of wireless technologies for network building. The combined interconnections of all devices or things on this network forms the foundational skeleton on which the Internet of Things is to be built. These networks can exist in isolation within a specific environment, like a factory or home, or transverse across the world, such as complex weather prediction systems. The nodes of these networks are the things which can be tasked to be passive non-connected data gathering devices which can push or be pinged to upload data as and when required. The combination of uses is numerous and applicable to customised solutions.

The software that layers on top of this network can also be just as versatile. It can be utilised at specific nodes or junctions, or at the final point of execution, wherever the data might need interpretation for further deployment. The applications used on the network would treat the data across the network for specialised task when required until the time the network traffic remains minimal. The types of applications would vary at the device level due to the radically varied types of data sources e.g. agricultural harvester yield data to proton emissions in the upper atmosphere.

The framework in short will work with three key set ups – sensor devices, network infrastructure and advanced software applications. The beauty of this framework is that it would allow developers, programmers and innovators to create completely unique and customised solutions for highly specific problems. The use of sensor devices in itself has seen an immense uptake in the last five years in the form of smartphones. The embedded sensors in these phones allow the measurement of movement, height, direction, health data and so much more. Other types of sensors are already being seen in consumer devices such as smartwatches and health bracelets. In the corporate and manufacturing sector these sensors become all the more prevalent in factories, farms, offices and laboratories as well. By connecting these devices to a universal network, developers can write software which analyses, processes and devises solutions using cutting edge programming which can border on the intelligent. The framework is fortunately for the time being, a public good which follows easy to learn rules and languages ensuring that even Do-It-Yourself projects can be utilised to set up an Internet of Things system by proactive makers.

The network connections for things

The Internet of Things works off an invisible network which is constantly trading data. The network itself is within two or more devices which are linked together on the wireless platform. In the earlier generation of network building, we required cables and wires to piece together different computers and devices, however with trillions of pieces of technology out in the world, this has become impractical. The boon of wireless networks is that it doesn't require hardware connections as present in old fashioned traditional hubs but utilizes nearly the same protocols as before.

The format of the traditional network requires that devices do not link up directly with one another. All the devices actually connect to a central connection point which in the usual case is a router or a central hub which sorts

and transmits information across. This router could be a part of a network of routers which then connects to the Internet as well, further broadening the reach of the network. This is the typical setup for network connections even today across most spaces such as offices and home environments.

The information traffic across a network is done in small chunks known as packets. For example when we tell the computer to print a document on our wireless network, the document data is split up into smaller parts and sent to the printer. The printer then receives all these small parts and reassembles them to print out the document. This system allows for the stability and security of the data, since if files were sent in one big chunk then any

The IoT network is expected to extend invisibly across the globe.

disruption in the network would cause the data to be corrupted en route and also slow down the transmission speeds. This breaking down of data into packets allows large quantities of data to be transmitted seamlessly which also prevents the connection pipeline from becoming jammed or overflowing. The breaking and rebuilding of the data is a highly precise process which requires hardware compatibility between the devices.

The means through which the networked hardware interact to accomplish their task is through the means of a network transfer protocol. These protocols or rules define how data is managed and treated across the whole network. The standard that is currently used on almost all networks, including the Internet and the Web, is known as Transmission Control Protocol/Internet Protocol or TCP/IP. The Internet Protocol is the component of this

standard which sets the parameters and details of how the data segments or packets are routed across different networks. The TCP component of the protocol is required to support the transmission and communication between the different sources. The TCP works as a medium through which different networks can understand each other and communicate.

Another critical piece of this network naming protocol is the device's Media Access Control address or MAC address. In fact, the MAC address is the essential foundation on which IP addresses work over ethernet. Each device on a network that is transmitting and receiving data has a MAC address. The network chip or card used by devices are assigned unique MAC addresses and are the unique identification number of the transmitting device. The IP protocol is layered on top of the ethernet network where MAC address takes predominance. While the IP addresses are assigned by a router or the Internet Service Provider (ISP), the MAC address is hardwired on to the device which makes it a virtual serial number. All the devices that would make up the Internet of Things would require a MAC number which is expressed in the following alpha numeric format – 1a:2b:3c:4d:5e:6f, where each set is a representation of a binary standard. This format uses a 48 bit system which gives us 281, 474, 976, 710, 656 or 2^{48} unique possibilities.

To illustrate this relationship between the protocols and devices let us imagine a work/office computer relationship. The goal is to copy a document from the office PC to the home PC across the network. As the copy is initiated on the office PC, the Transmission Control Protocol or TCP creates a link between the two computers and authenticates the MAC addresses of the devices, and the Internet Protocol defines the routing rules which then connects the different input/output ports. Since TCP has set up the pathway between the two computers it also labels the nature of the data and the size of the file while the IP works to segment the data of the document into packets and labels it with the appropriate address and header data. This ensures that not only does the file reach its source but also the order in which all the packets need to be reorganised to become the required document. The IP does the job of sending across the data and the information in a standardised format while the TCP works to reinterpret it into the original document format which is a single file.

The system of these protocols is essential for devices on a network to communicate with one another. This makes it critical that the TCP/IP information assigned over the MAC address on each device is in the proper configuration. This is done by assigning each device a specific address which

Every device with networking capabilities is assigned a unique MAC address.

is known as the device IP address. This IP address is in effect the name of the device on the network. The IP address is a 32-bit number which is formatted in a "dot address" format which has four sets of numbers that are separated by a period e.g. 10.240.162.178. In this format each of the numbers is representative of an eight digit binary which is a series of 0s and 1s. The first set is the networks address while the remaining sets are the address of the specific host device.

The IP address is required for a network router to determine which data needs to be sent to the specific device. The protocol works to transmit the data to the router with a specific IP number or address which is the destination device's network name. The router is then able to redirect the file to the recipient's IP address device. In the current state of the Internet, the majority of IP numbers are those of computers and servers. But in the age of the Internet of Things, every connected device would require an IP address. Under the current system of IP address format (version four or IPv4) there are about 4.3 billion unique numbers, most of which have already been assigned. In the next generation of IP address format i.e. IPv6 the number of address increases to a potential max of 240 trillion trillion trillion or 240 undecillion (US format), which is 240 followed by

36 zeros. Given the potential trillions of devices that would be online with the Internet of Things, this seems like a safe upper limit which can manage all the addresses.

Another element of the network architecture which supports the Internet of Things is the Domain Name System or DNS. The system is used to name things connected to any network. Its most apparent function is to translate human readable domain names to numeric IP address for devices. It also works to index the entire network directory of names which follow the IP suite. The stability of DNS over current Internet systems has proven to be high but in the anticipated era of the Internet of Things there is still uncertainty. The question of whether DNS infrastructures currently in place will be able to sustain the load of trillions of devices is untested. The issues of performance, latency and reaction speeds is still being figured out to not only make DNS scalable beyond its current limitations but to foresee any potential gaps in its security given the flood of new devices that it is sure to encounter.

Building IoT: Proliferation, connection and intelligence

One of the most amazing aspects of the Internet of Things is sheer variety of function and form. Potentially any device could be a part of this vast network - from something as simple as a toothbrush to something as complex as a car. However, the means to make a truly useful system between them can only be designed when a clear intent and infrastructure is in place. Over the last few years, as the concept of the Internet of Things, has been tested in smaller settings such as factories and consumer systems like smart homes, a series of steps have been suggested by experts which are essential for a fully functional Internet of Things system.

The first step of establishing and building the Internet of Things is to further the proliferation of sensory devices. Since the system is powered by data obtained by “things” it becomes important for the world to have as many of these “things” as possible. The problem is that there is no limit to what device can support data sensors which raises the question of intent. Already companies are experimenting with the potential use of these devices in the world, e.g. Coca Cola purchased 16 million MAC addresses for future use on their “things”. While at present only a fraction of these 16 million devices are being used by the company, mostly in digital vending machines, there is a scope of them expanding to unknown areas as well. Similarly other devices such as shoes, apparels, televisions, appliances and many other

Coca Cola uses its MAC addresses in digital vending machines.

everyday technologies are now being tested and fitted with sensors to build the Internet of Things compatible world space. With each additional device, the scope and extent of the network expands and creates more opportunity for experimentation and solution building. This proliferation of devices is a key step towards building the Internet of Things.

The second step of evolution requires the creation of cooperative or collaborative interactions between devices. It's not enough just to have sensors measuring how often you brush your teeth and for how long, this information needs to be transmitted to your shopping list to let you know when its time to buy a new toothbrush. The sharing of data between devices on the network requires a forethought of systemic interactions. Developers and designers need to envision how different devices can support each other with useful data which would allow them to act autonomously to correct a predictive problem. For example, having a sensor in your fridge that measures the details of your groceries needs to interface and execute a task which would automatically refresh the fridge stock. By taking over the mundane decision making of small things, the system would make the lives of users more seamless and hassle free. The automation can only occur if sufficiently useful data is shared across devices which support each other.

The third and most important step is the creation of intelligent programs.

These programs are not your run-of-the-mill algorithms that execute situational choices based on a simple If/Then scenario. With the wealth of data that would become available, we need applications and software that use intelligent predictive algorithms which can foresee patterns and problems based on present and past behaviour. If such an application can use the sensor in the car to look at the tyre's wear and tear, factors in the weather forecast, takes into account real-time traffic updates and pulls the driver's alertness from his health band – it could make the decision to not start the car for safety reasons, since it's likely that the bad weather, traffic build-up, worn tyres and lack of sleep would result in an accident. The potential power of predictive intelligence from applications on the Internet of Things in unimaginable.

As the three steps of proliferation, connection and intelligent application is refined and implemented, we can expect the Internet of Things to be online in no time. But this is still a tentative framework which requires deep thought and structuring due to its immense investment in hardware, application development and most importantly, convincing the users that such deep penetration of technology in their lives will lead to a beneficial outcome.

Deconstructing an intelligent thing

Understanding a "thing" is easier than truly understanding what is an "intelligent thing". In theory, we can say that any technological device that exhibits intelligent behaviour is an intelligent thing but in the world of the Internet of Things this is still too futuristic. An intelligent thing under these circumstances is usually a larger device that utilises an assortment of different sensors for data gathering and solution building. A simple example of such an intelligent thing is a farming harvester – this vehicle would have sensor devices in its wheels, brakes, radar system, self-driving system, weather sensors, moisture sensors, engine, storage tank and other places. The combination of these sensors would allow the harvester to factor in all the data from these sensors and process it using an advanced customised application. The purpose of the application would be oriented towards making the harvester a more efficient and helpful agricultural tool.

By taking into account all the data values, the sensors in the intelligent harvester would be able to regulate internal and external tasks. From knowing when the storage tank requires unloading to deciding which routes to take across a rain drenched field. The more the number of interconnected sensors in one thing, the greater its potential to be intelligent.

Inner components of an intelligent utility meter for home use.

These sensors interact thanks to the wireless connectivity which can be customised to work within meters or even miles. The controller of these connections collates the readings and allows them to interact amongst themselves. And thanks to the miniaturised size of sensors, their increasingly refined sensitivity and the low power consumption from batteries, they can be used anywhere. The kind of information they can measure ranges across the industries, from medical tests to hardware readings of mechanical equipment. The connection between these sensors is the nervous system of an intelligent thing which makes the thing intelligent or simply bloated with useless hardware.

Wireless medium for things: Bluetooth, WiFi, RF and more

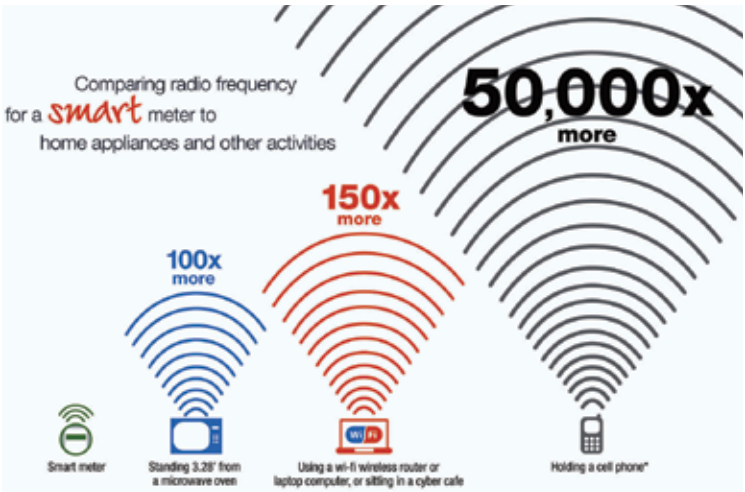
The future of communications is being built on wireless technologies. Almost every personal technology device currently being used has a wireless communicator built-in. The common thing amongst all forms of wireless technologies is that they utilise the same type of signals – except at different frequencies. The Radio Frequency signals used are the same as traditional radio with the expectation that they are capable of sending and receiving information across a wireless network. The radio wave is simply an elec-

tromagnetic pulse which is oscillating at a specific frequency. The more frequent the oscillation the higher the frequency and vice versa. The data is transmitted on these oscillating radio waves of different frequencies and require a device capable of reading them at the specific frequency. Otherwise these waves simply pass through objects without any data transmission.

The measurement of the frequencies is done on the basis of cycles per second e.g. 1MHz is a frequency of 1 million cycles per second, where MHz is megahertz. The current Internet infrastructure is built on two separate RF frequencies which are 2.4Ghz to 2.48GHz and 5.15GHz to 5.85GHz. These are typically referred to as 2.4GHz and 5GHz bands respectively. The former band is free to use by anyone, anywhere, for any purpose which makes it free but inevitably clogged if used across vast distances due to Internetwork conflicts. The current Wi-Fi infrastructure protocol of 802.11, cordless phones, newer walkie-talkies, wireless intercoms, automatic doors, microwave ovens, emergency radios and even Bluetooth is on the 2.4GHz band. In contrast, the 5GHz band is far more wider and relatively uncluttered by different device types. It is used in some consumer products but is largely the space where the Internet of Things is intended to grow.

The Wi-Fi protocol is powering modern wireless networks already and has been standardised across the globe by the IEEE (Institute of Electrical and Electronics Engineers) and the Wi-Fi Alliance. However, the standard is split across numerous 802.11 protocols which offer a range of different performances. The most current of which is the 802.11ac which primarily uses the 5GHz band but also works on the 2.4GHz band. This allows the range of a 802.11ac device to easily work across the expanse of a whole home unit. The Wi-Fi enabled router or hub is the common node for all devices and streams data through it to other devices. This means that when a user uses a tablet on the home network to push a video to the TV, it passes through the router or hub first and then goes to the TV. More the devices , more the work intensive the router becomes. This initial setup of all the devices requires a one-time manual step but with hundreds or thousands of “things” it can become untenable in the future. This places Wi-Fi in a dubious category when considering it as a primary source of networking in the age of the Internet of Things.

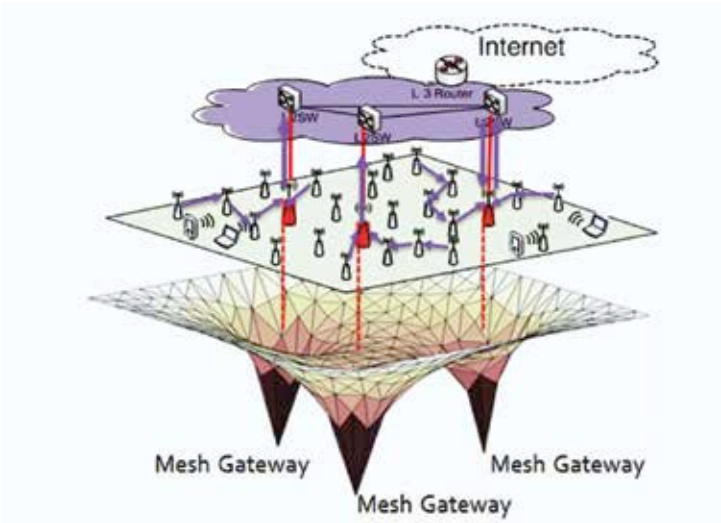
Within shorter distances the inter-device connectivity can be done using the very popular Bluetooth connection. Already used for smartphone accessories and media systems, it works efficiently within smaller locations. It also operates in the 2.4GHz range but doesn’t require a central hub or



The variety of evolving wireless technologies currently in use today.

router to transfer data between devices. This is a version of peer-to-peer networking which is what the current conceptualisation of the Internet of Things is expected to be in the future. The data on such a network is limited in its size and range which makes it suitable for sensor data. The devices on a Bluetooth network form a personal area network or PAN and are also called a piconet. In this link, one device is the primary controlling device and can link with up to eight other devices who act as its slave. This means that in an Internet of Things household, a cell phone can work as the master of the major devices like the TV, AC, lights, media center, intercom and three other things, however it does drain power. This limitation is further absolved with the new Bluetooth Smart technology which has been specifically made for the Internet of Things. It is better in many ways including its low energy consumption rate, larger range over distance (200 feet) and customised management of device applications for overall efficiency.

Other devices for the Internet of Things are being designed with cellular network in mind. Its almost similar to different devices making phone calls to each other and trading information. And even though cellular technology uses types of radio waves, they are not routed through local hubs or even directly between devices – in fact, they travel across a global network of receivers and transmitters via cellular towers and base stations. This makes the range of things on the network infinite as long as there is a signal between



A possible configuration of wireless devices on a mesh network.

the devices on the cellular network. The cellular infrastructure is already in place and being regulated towards lower data costs. This means that devices can use it to transmit data globally thanks to the layered overlapping geographic network grid made by cell towers and base stations. However, over short distances the routing time and effort would make the technology ineffective for Internet of Things implementation.

Another alternative to the traditionally existing types of networks is that of mesh networks. These networks are custom designed and built by companies that wish to execute seamless Internet of Things connectivity in a stable environment. These small scale wireless networks work as relay transmitters which pass along data through a mesh or chain of nodes. This form of a network is decentralised and doesn't require a central hub to operate. And even though the range of the devices is small, it can hop across clusters of devices spread across a larger area. A potential mesh network can have hundreds or thousands of devices e.g. if every Android device is utilising this network system then there would be hundreds of million of contact nodes across a country like India through which signals could be transmitted. Currently there are a few mesh networks underway across the world but are not compatible with each other due to a lack of standardised protocols.

At present its not definitive which wireless platform is best suited for the Internet of Things. And in the absence of a new globally standardised protocol coming into existence, we can safely assume that existing systems will be used to a great degree. A very likely outcome is that innovations in devices would allow them to switch between different wireless platforms depending on the need of the operation. So when a user is at home, Bluetooth would be the primary network but when they are travelling they will remain connected to the Internet of Things by the cellular network. But the true future is still under R&D somewhere in a tech lab waiting to be unleashed on to the world.

THE INTERNET OF HOME LIFE

The Internet of Things begins at home. From managing food stocks to keeping things clean - the potential use of the IoT in everyday life is amazing.

There is a big difference between "smart" and "intelligent", specially in the world of technology. We are already witnessing the selling of consumer gadgets such as televisions, refrigerators and phones that are touted to be "smart". But while smart technology is able to access information in useful ways, intelligent technology can gauge relevance and even exhibit autonomy. The extent to which true technology intelligence can be useful to users is dependent directly on the amount of data it has access to. This is where the Internet of Things comes into the picture. With hundreds of sensors across any given environment the potential for solutions to future problems makes consumer goods truly intelligent.

In the home environment we find ourselves surrounded by different types of technology. Ranging from house lights to washing machines we can see the potential spaces where the Internet of Things can be used to enhance day to day living. In many cases most of these devices have already been included into the first generation of Internet of Things design. The

The future of home life will be at the fingertips of users.

ability for enhanced operations by any of these machines can do wonders for the modern human who is low on time and high on tasks - specially the dreaded home oriented ones like washing, cooking and cleaning. We take an overview of how the Internet of Things is already a reality in the home space and the wonders it aspires to do.

Fridges, food and the intelligent kitchen

The most important room in the home (other than the loo) is the kitchen. And the centre piece of technology in most kitchens is the refrigerator. And while a typical smart fridge might come with a fancy touch screen display it still does little more than keep stuff cool and make ice for parties. But once we connect this device to the internet we find that it begins to exhibit intelligent tendencies as if it was made with that purpose. The market already has fridge models that connect to the internet and allow users to browse for recipes or stream media content while going about their kitchen duties. However, are these features worth the extra tens of thousands of rupees being charged? Not really.

The intelligent kitchen requires a far more proactive fridge that not only preserves food but also participates in the choices we make in our eating habits and helps us save time. This becomes possible once the fridge is able

to connect to other devices in the kitchen and generate useful solutions. The most fundamental step of which would be for the fridge to monitor and maintain its own systems so users are not left in the lurch when it suddenly stops working. The self-diagnostic features measure the fridge's performance with regards to temperature and energy consumption, and senses if it's not performing at full potential. This irregularity is then passed on to the owner with the one-touch option of registering a maintenance call that fits into the user's schedule. This is useful even on a warning level which can help ensure that timely action is taken and no food goes to waste due to spoilage. In addition, other features like sending a personal alert to the user on their smartphone or smartwatch letting them know if the door has been left open for longer than usual or if the fridge needs to be defrosted would be essential.

But more than these simple communications, the fridge of the next generation can do so much more. By equipping fridges with barcode sensors and scanners, we can let the fridge keep track of the expiry dates of all its contents. This would result in users being warned when items are about to expire and even present an option for creating a grocery list which can be used when the user is out shopping. Imagine sending a message to your fridge asking it what needs to be brought? It isn't that unreal a scenario given the technology that exists. The fridge can even be trained to recognise preferred brands, food items, flavours and eating patterns, and be authorised to conduct online shopping for essential items autonomously without ever bothering the user.

The interactivity of the device with others in your home is also useful. For example, being able to transfer a recipe from a TV show to the fridge's memory would quickly run a cross check to see which ingredients are missing and execute a command for the next shopping run. Alternatively, another feature is the ability of the fridge to make recommendations of what to cook based on the items currently in stock - not only would this save time in searching and figuring out what to cook but also allow for new experiences that compliment your tastes (as learnt by the fridge). The potential for the interactivity takes us into a whole other world of implementations which we shall discuss next.

Intelligent cooking and cleaning

The fridge is but one device. Once it is connected with the cooking appliances such as a microwave, electric gas, oven and other gadgets things can

A prototype design of a futuristic networked kitchen.

really take off to the future. By running prep operations for different recipes remotely, users can save great deals on time and effort when preparing meals. Intelligent cooking would also include making sure that the vital nutrients within the ingredients are not lost and each preparation is just right. The ability of the kitchen network to recognise eating patterns and tendencies can prove useful when planning a diet as well. The combined forces of the appliances can be used to direct users to healthier food alternatives and make polite suggestions for alternatives on your shopping list that focus more on health than indulgence. More than anything, we find that the potential to save time and make for a more efficient lifestyle can be accomplished using Internet of Things in the home. It would be possible for intelligent cookers and ovens to alert users in advance of their food being ready to "set the table" or "call the family for dinner". The remote dialing option would allow for cooking a prepped dish from the morning in the oven while an user is on their way home - saving hours everyday in the cooking process. The level of customised learning possible with food is immense and a home system capable of learning it can only do so when it is powered by the Internet of Things.

Beyond just cooking and food, another essential chore of the household is cleaning, washing and drying of clothes. In the age of intelligent homes this task also becomes automated and technology centric. At the simplest

level enhanced machines can wash clothes better thanks to a variety of sensors such as moisture detection, fabric sensors and remote operations. Modern machines can alert users on their personal mobile devices the status of the wash as well as be remotely activated. Washing dishes in a machine isn't a typical Indian habit but with the right technology it could very well become one. The same conveniences we find in washing machines translate to cleaning dishes. The ability to alert, sense and activate remotely not only makes it convenient but also easy to schedule during the day.

Similar technological techniques can be used for automated vacuum cleaners that roam around household surfaces like pets. One such device - the Zumba - has already impressed many with its automated cycle of covering all floors without requiring constant monitoring. But taking it to the next generation would display a level of intelligence that not only cleans but does so as it realises a mess has been made. By utilising its link to the household network, a cleaner on the Internet of Things would be alerted when something is spilled or broken, and it would jump to action. By reacting immediately rather than in a zombie like fashion, we would find the trusty butler we've always wanted ever since the Jetsons.

Functions: monitoring, energy efficiency and maintenance

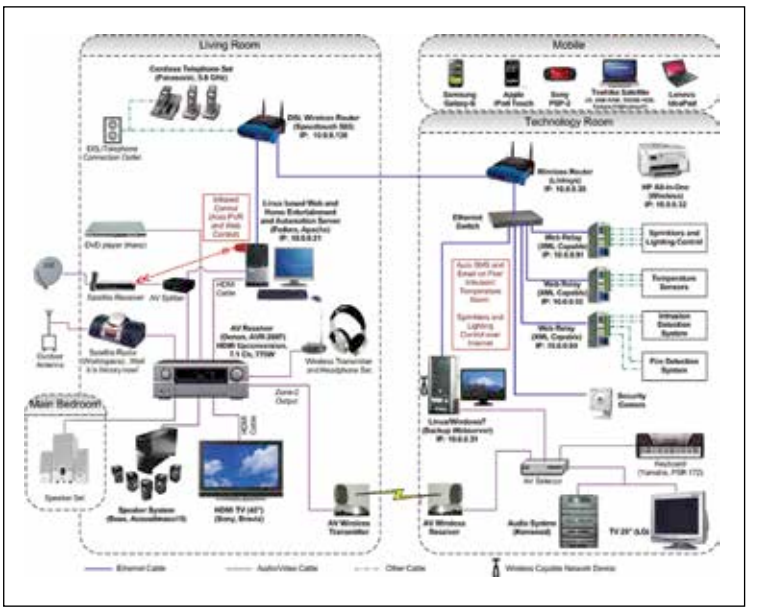
But most of these features just seem like indulgences or vanities to the lay person. This isn't an incorrect reaction - do we really need this level of automation? Well, that is for each individual to decide for themselves, but it must be known that this automation has its advantages - such as lower electricity bills and a greener environment. Since these technologies rely on sensors that measure every little details essential to their operation, they can be programmed to be as energy efficient as possible. Wouldn't it be great if a fridge that was practically empty powered down and didn't keep going at full blast? What about a washing machine that can regulate the water temperature and spin cycle at a custom level depending on mass and types of clothes? Each of these types of options makes for lesser energy consumption which leads to lower bills and a more greener environment.

The constant monitoring of the machine, its activities and the environment also has added benefits in the form of self-maintenance. A machine that is designed to sense as much as possible can be instructed to detect faulty performance and adjust its output accordingly. Specially in a country like India where something as simple as electric voltage can vary or fluctuate an intelligent home machine is able to insulate itself on early detection or

not activate when it senses a risk to its own systems. This feature alone can save users thousands in repair and replacement costs alone.

Automated services via the IoT at home

The end result of an interconnected home appliance environment is to create an automated home. The broad extent of intelligent devices in every room of the house can work together to monitor, maintain and execute



Home automations require hundreds of things connected via the IoT.

all household tasks. The goal of home automation is fairly futuristic but not entirely out of the realm of possibility since different versions of it already exist today. Simple home automation features such as temperature control, lighting management and home security have all been successfully implemented. The next stage calls for the home environment to intelligently cater to the needs of the resident based on learned patterns and other device data.

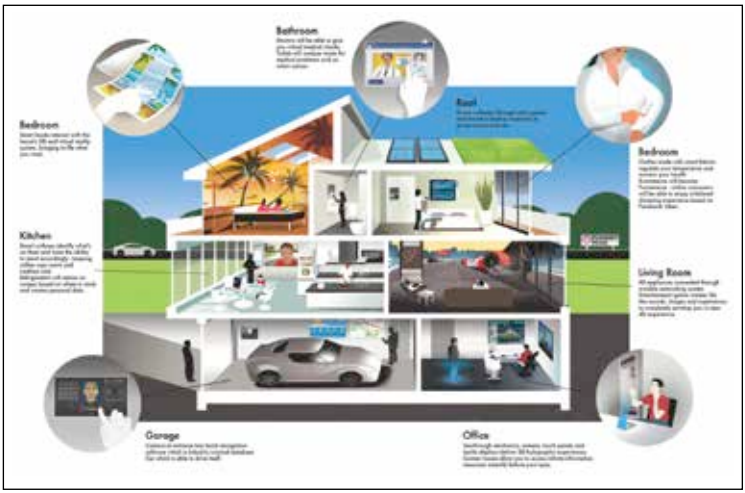
The automated home serves to execute the many small tasks which individuals have to do themselves - from opening the curtains to cleaning the house. In an Internet of Things home system, all these tasks would be

self-taught by the machine or trained by the user. By eliminating the manual interaction of a user towards these tasks more time will be freed up for a productive lifestyle. By monitoring the habits and needs of the user, all the home systems will learn how to align their different functions. For example, if the house intelligence observes that the user has forgotten to turn off the lights it can do it to save energy, even motion detected lights are an option in case of intruders and remote cell phone monitoring of the house by the user are the most basic features.

One of the most critical areas where home automation can prove invaluable is security. An intelligent home fitted with sensors on the Internet of Things can almost work as a fortress. By incorporating the sensors in the doors and windows, along with security cameras outside the house supported by motion detecting lights, the house can spot intruders quickly. As the house gathers the data and senses a threat it can even be programmed to alert the user if they are not at home or unaware, and even communicate with the police to ask for assistance. This level of security is supported by a great degree of surveillance which is currently accomplished using simple webcams. But with enhanced sensors come enhanced cameras which can even be used for facial recognition and advanced alerts as to the identity of the threat. This can help avoid over reactions or embarrassments since the system can recognise a familiar face from a stranger. The level of security also reaches to safety from hazards like fire and smoke, which is accomplished by gas detectors. They can warn users of any building issues and give enough notice for everyone to get to safety.

Intelligent home designs today and the future

Intelligent homes haven't been around for a long time, but the idea of a smart home has been around for nearly a century. The early era of science fiction looked towards a future where the whole world was a utopia of technology. Many of the concepts introduced during this period have gone on to inspire modern creations. The most reality driven models were however during the mid-20th century and were often claimed to be the "Homes of Tomorrow" where automation played a large role in daily activities. And as the computer age dawned, the inclusion of a "mechanical brain" serving mankind became all the more apparent. But the real creation of the intelligent household came with a Scottish Company in 1975, called Pico Electronics who began the X10 project. The X10 project was the first home automation project that used electrical wiring to operate.



X10 offers intelligent small houses that eliminate the small mundane activities from the equation.

However, despite many iterations of their designs the idea of an automated household hasn't yet found an affordable price. At present only the most premium houses have the option to utilise a select few automated services, with full and complete automation reserved for only the uber-rich like Bill Gates. However, the implementation of intelligent homes is better understood today than ever before and is being taken on by home owners in a DIY spirit. As newer technologies continue to emerge over time the essential knowledge of home automation can be explained in just a few steps.

The most fundamental step towards building an intelligent home by designers is connecting people within the household with people outside the household. The use of the modern internet is the obvious choice. The next step requires defining commands and directives which control specific household tasks. These can range from something as simple as turning lights on and off, to alerting people if there is a fire. These commands help build a language of communication between the user and the technology. Next comes the hard part, building an automotive intelligence. This is usually done using advanced programming which can work on robotic levels, such as for a vacuum cleaner, as well simple deductive reasoning using a predictive algorithm. The next step is monitoring activity in the household via the machine, which can be done using cameras and other data outputs. By knowing what is going on users can determine the correct

course of action. Users also need to define the communications protocol between the machine and themselves, this means that the data which users require should be taught to the machine and a format be devised for two -way communications. By incorporating natural language programming and response intelligence, users can have a more intuitive relationship with their technology. And finally, once designers are able to observe and study the relationship between users and their home, they can create an environment perfectly suited for automated human life.

Different smart home devices and how to make the most of them

Today's marketplace already has an assortment of devices and starter kits that can help transform any house into a intelligent home. While most of them are just small enhancements on earlier concepts they are the technologies that are paving the way for the future where the Internet

The NEST thermostat is a cutting edge example of an IoT device.

of Things is not just many devices in the home, but the whole home as an intelligent device.

Nest Learning Thermostat

The Nest Learning Thermostat made headlines in 2014 when it was launched. It garnered the interest of computing giant Google and has since made a significant impact in the market place. The device while being a simple thermostat is indicative of the predictive nature of home technology. The device is made to learn the needs of the people in the household and regulate itself to provide the most comfortable environment possible. The company also connects with energy companies where such links are possible and ensures efficiency in energy consumption. The thermostat is created with an easy to use and intuitive interface which can also be remotely operated. So users can monitor and alter their home environment while they're on their way home. The unique aspect is its self-learning feature which is able to determine the minimal energy to comfort ratio and tune the environment accordingly. It takes into account airflow, weather and other personal preferences to do its job. The company has already made moves to broaden its range and is expected to introduce more devices in the near future.

Amazon Echo

The Amazon Echo is like a voice controlled system which interacts with people. It functions by connecting to the internet and using voice recognition technology to answer queries. In many ways, it is the household equivalent of a Siri or Google Now. The design of the device is a simple cylinder that also has the ability to play music on command. The technology behind it is rooted on cloud based processing which allows it to respond to natural language queries. The device can also be used to make notes such as shopping lists, play radio, set alarms and even access Wikipedia. One of it's next generation features is its ability to interface with a few other sensor driven home devices like the Belkin WeMo.

In addition to these high profile consumer-end products there is a vast marketplace of home automation devices. Although this market segment is highly specialised it still doesn't as of yet leverage the Internet of Things to accomplish its goal of home automation. While we will be discussing a few of these companies in later chapters we need to remember that the difference between smart devices and intelligent devices is the degree and depth of the interconnectivity and software applications.

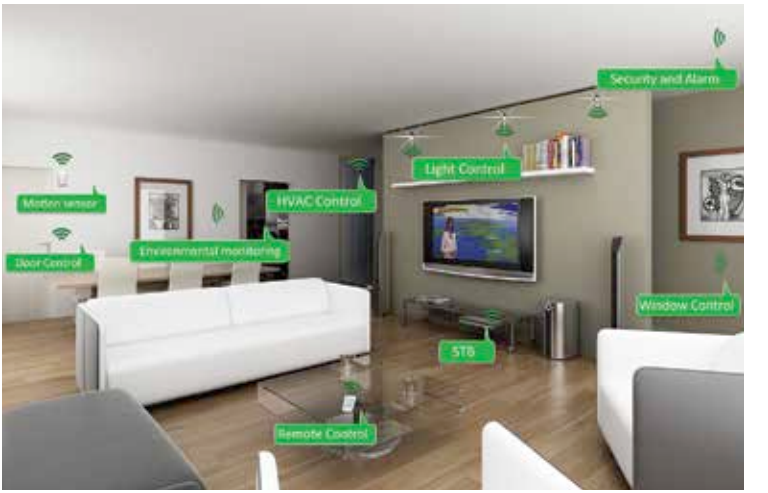
THE INTERNET OF OFFICE WORK

The Internet of Things is making its way into our offices. Smart offices or intelligent office suites will soon be the next big thing.

While offices are equipped with computers and connectivities, we still have a long way to go before we can say that all devices perform to the optimum when it comes to communicating with each other. Look at your smartphone, you can check for meetings, respond to emails and are reminded to complete specific tasks. However, your smartphone and your office aren't connected. Sure, you can connect to your office Wi-Fi, but there's so much more the devices in your environment are capable of. There lies infrastructure, but a foundation to connect them together isn't yet available. In this chapter, we'll look at how getting more devices to speak to one another can change the way we work.

Communication

The success of a business lies in its Customer Relationship Management (CRM) system, i.e. its system for managing a company's interactions with



Automated home analogous to automated office

current and future customers. Discarding old techniques, IoT brings along entirely new methods to manage customer interaction and customer relations. 'Salesforce' is a top-notch CRM application that does this by focusing on the sales, marketing and technical support. The CRM system organises, automates and synchronises all these aspects. Automation includes track leads, managing emails, task assignment as well as notifications and approvals.

It would be very difficult to go through all the documentations of a product if a question about that product was to be answered. Salesforce works to quickly retreive responses from the concerned person using one of its tools called 'Chatter'. No matter where you are, you can reach out to the right person of the team within minutes to get an answer to a query.

Salesforce also provides various products that span multiple devices and provides a platform to integrate existing products and services.

Connected environments

Offices are connected, however, this connection is limited to LANs. To work smarter, we need to make the most of existing infracture. Currently, with the help of local area networks, we can print from anywhere as long as we're connected to that network. Besides this, an existing network can also be used by employees to communicate with each other using IP phones.

However, to actualise an intelligent workplace, we need to move beyond the local area. The most vital aspect of an office environment is its security. By replacing traditional CCTV cameras with IP cams, administrators can surveille the office surroundings from any part of the world.

Smart door locks will make redundant the need to change locks if you lose the keys or if an employee leaves abruptly. A smart lock will enable you to manage lock codes from a smartphone.

Gone are the days when a product broke down and you had trouble calling the technician urgently. Smart products are enabled with a monitoring facility to check for the state of the product and call the technician if service is required.

Even the plants in your cubicle can become smart with the help of smart devices. Once installed, a sensitive planter sensor will notify you on your smartphone whether your plants need water, fertilisers or sunlight.

Programmable thermostats will help to cut down on electricity bills by turning off the air conditioner or heater when either isn't required.

Applications are not limited to corporate environments only. Disneyland is keen on replacing the traditional tickets with a smart band that will serve as a ticket, payment method and tracking item that will track visitors' spending habits, movements and wait time for rides. Upon analysing the data collected, the theme park is expected to be able to better control the traffic and develop targeted marketing strategies.

Wirelessly presenting from anywhere

Inventory management

Inventory management is another area where IoT has paved a path for itself. The challenge of inventory management is made easy by deploying sensors and RFIDs on products. Such sensors and radio frequency ID tags can help to track down a product in real-time. This data is handy in finding a particular product from an entire inventory. Additionally, these additions can track down an entire pallet. Moving further, this tracking system can help to monitor levels, provide alerts if a particular product is low in quantity and automatically place orders.

Inventory equipped with automatic identification technology

Sensors can also remotely monitor warehouses, helping cut down on the number of employees required, thus saving on costs. Walmart being the early adopter of this technology is optimising its warehouse and supply chain with this technology.

Manufacturing

IoT has something for every industry and manufacturing hasn't been left out. The concept is playing an important role in revolutionising manufacturing. Manufacturing equipments connected to the internet reportedly yield more than their non-connected counterparts.

The internet can give employees direct access to the historical and real-time data of the system. In addition to this, it can feature a production dashboard to provide a comprehensive picture of the entire system. Such provisions can improve asset utilisation and optimisation, lower total cost of ownership, maximise workforce efficiency and allow better enterprise risk management.

Additionally, it can help reduce maintenance costs and down time, which in turn will boost production. With internet connectivity, it's possible to remotely operate the machines, hence companies will be able to set up plants around the world and monitor them in real time.

Remotely handled automatic manufacturing

Along with increased production, IoT helps decreases safety hazards in the workplace. Various applications have already been developed to monitor workplaces for safety hazards. These applications provide real-time view of the manufacturing area, monitor safety and allow communication with the workers. With such applications, it's possible to quickly respond to emergencies.

Intelligent workflow automation

Automation has always been a part of manufacturing. With systems such as SCADA (supervisory control and data acquisition), these automations can be achieved. However, these are traditional automations systems that aren't intelligent.

The idea of Internet of Things can give these traditional automations systems a whole new identity. The prevailing working process can be coupled with sensors to provide real-time updates about the system and settings it is working on. SCADA systems integrated with Internet of Things can make these work automations easy to handle and monitor remotely.

This Machine to Machine (M2M) communication over the internet will ensure that automation processes require no human intervention. By 2019, it is expected that RFID, sensor nodes, gateways, cloud management, NFC,

DID YOU KNOW?

- There's a sensor you can swallow. There's a pill with a tiny sensor inside it which transmits data about when a patient takes his/her medication, and pairs with a wearable device to inform family members about it.
- Autonomous vehicles belong to the Internet of Things family. Self-driving vehicle Audi A7, showcased at CES, is powered by Nvidia processor.
- People are concerned about IoT security. Due to security concerns, 69% of people think they should own the personal data on all the internet-connected devices they own.

ZigBee, SCADA, software platforms and system integrators markets will be worth $947.29 billion.

Intelligent goods transportation

Cargo theft is a common but serious problem faced by many companies. Integrating Internet of Things with logistics, this security risk can be averted and intelligent transportation can be achieved.

RFID tags on cargos and GPS systems within the cargo container can easily track goods. With this, it's possible to better track delivery progress

Container equipped with RFID

and keep a closer eye on shipments. The containers shipped across countries can be equipped with robust RFID sensors to ensure shipment integrity. The reader device can be fixed at ports to read the RFID and alert if the container has been damaged.

The sensors can also monitor temperature levels inside the container. If the temperature level goes over/under the allowed range, the dispatchers are alerted. Some goods require an additional level of security. With the installation of IP cameras and motion sensors, security guards for such a shipment can keep an eye on the status inside the container.

The processing centers process the data provided by GPS and let you know the location of your shipment and the estimated delivery time or if the item has been jeopardised.

IoT-powered sales

Internet of Things is boosting the retail sales industry. By having access to information such as why, where and how products are being purchased, marketers can design their marketing strategies accordingly. Alongside, communication with the customer makes it possible to quickly know if certain products aren't meeting their expectations.

Products are becoming smarter. Some products have the ability to self-diagnose and repair the problem. In the case of traditional devices, IoT can be applied in a divergent way. If a problem is detected in such devices, provision can be made to automatically call the technician to service it. This helps to keep the downtime as low as possible, leading to increase in sales.

Social media is contributing a major share in the growth of sales. Gadgets already optimised to be used with social media allow automated post shares generated by the device themselves. E-commerce apps are integrated with an engine that tracks down users' purchasing habits and browsing history, and respond back to them with suggestions and promotions.

Super-smart cars

The ability to exploit machine-learning algorithms by employing predictive analytics will lead to long-term sustainability. Predictive algorithms are proving valuable in reducing errors, especially in the automobile industry.

Such predictive algorithms, already in place in the some vehicles, help determine the cause of engine instability. Automobiles can now analyse their internal conditions and status, and predict if there are any chances of failure or error. Such a system will keep the down time as low as possible.

Additionally, the fuel tanks are provided with sensors that predict how long the fuel will last.

BMW is outfitting cars with thousands of sensors that send data to its factories, where predictive analytics offers adjustments that can be implemented in the next manufacturing stage itself. Predictive algorithms can also be implemented during the manufacturing process to complete it quicker.

Pros and cons of IoT

The Internet of Things concept can certainly help companies make lots of money. For instance, the unattended automation process is cutting down

Machine learning powered self-driving BMW car

on labour costs and adding up to the company's profit. Though it's just the beginning, many companies who've already implemented Internet of Things have started seeing profits.

Studies have found that Internet of Things can help device companies such as Apple make up to 45 per cent in profits, while data analytics and big data companies like Hadoop could make up to 43 per cent, API companies could make 35 per cent, and IT solution providers could make 30 per cent.

Rockwell Automation, a leading company in enterprise automation, adopted Internet of Things. Its food and beverage client, King's Hawaiian was able to put out an additional 180,000 pounds of bread every day. That almost doubled its profit.

Intel's adoption of the idea helped it generate 22 per cent in revenue growth year over year. Google acquired home automation company Nest

DID YOU KNOW?

- In 2008, there were already more "things" connected to the Internet than people.
- It is expected that by 2020 the amount on things connected to the Internet will reach over 50 billion, raking up $19 trillion in profit.
- Not many are aware of the concept of Internet of Things. Studies say that about half of the Americans right now don't know about smart thermostats and smart refrigerators.
- IPv6 is enough to provide an IP address to every atom on Earth.
- An IPv6 address relies on 128-bit, addressing which is enough to provide a unique address to every atom on Earth. Things connecting to the Internet will never have to worry about running out of addresses.
- Internet-connected clothing is coming by 2020.
- It is expected that by 2020, at least 14 per cent of the consumers would have purchased some form of IoT.
- Internet of Things isn't just about devices. A Dutch company uses sensors on cattles to tell farmers when animals are sick or pregnant. It is reported that each cow consumes up to 200MB of data every year.
- The U.S. Government doesn't dominate Internet of Things. A report by GSMA states that 29 per cent of global M2M connections are made in Europe, 27 per cent in China and just 19 per cent in the U.S.

Labs for $3.2 billion, along with Wi-Fi webcam maker Dropcam and smart home automation start-up Revolv, which could grow to $490 billion by 2019.

Wearable tech makers are also expected to profit with wearable tech owners pegged to grow by the end of next year. General Electric believes that using Industrial Internet of Things to make oil and gas exploration and development even one per cent efficient would result in savings of $90 billion.

THE INTERNET OF FASHION

From buying the next best wearable sensor to smartwatches and smart clothes, the ideal interconnected wardrobe will relegate fashion woes to a bygone era

The Internet of Things (IoT) may sound like a cutting-edge term, yet it is as of now here and enhancing our lives. Numerous gadgets and appliances consolidated with the Internet in different fields are furnishing consumers and businesses with new services regularly. Wearable technology is at its peak with new players and devices entering the market that cater to a wide range of consumers. They're playing a significant role in every discussion and theory related to the concept of Internet of Things (including those mentioned in this FastTrack). Some of these discussions usually birth a greater number of questions than answers. For instance, in regards to wearable devices, the question on many minds nowadays is: "Are wearable devices simply peripherals for a smartphone or will they play an essential role in the future of IoT?" However, when we say the the word "Internet of Things", our perspective shouldn't simply be limited to the wearable technology segment. Indeed, there are many things to be explored in this deep ocean of IoT.

The future of wearable technology

Nowadays, wearable technologies are adding new layers to our connections by augmenting the reach of insights about ourselves without concern for distance. The consistent integration of these devices makes for extraordinary connection between individuals. Sometime in the distant past, consumers for its utility, not style, bought Fitbit activity tracker. At around the same time, other players jumped onto the bandwagon to offer similar products,

Wearable technology

and activity trackers began to be offered in various categories separated by weight, style, price and many other factors. Wearables with a useful function soon got attention from many industries. One such industry was the fashion industry. If you've ever watched Fashion TV, you'd know that most of the clothes worn by ramp models are impractical to wear in real life. All this, however, is changing as the industry is slowly cosying up to the concept of IoT and utility.

The offer of wearable technology is down to the rich information produced by the devices associated with it, which is put away and investigated

in the cloud. The capability of consumers to get to these bits of knowledge from the cloud is empowering. Besides the fitness trackers mentioned before, there are various other technological advancements that follow IoT. Let's look at some of these advancements that cover smartwatches, smart-shoes, fitness trackers, intelligent eyewear, wearable cameras and smart clothes.

Swarovski solar-powered wearables

Released in January 2015, Swarovski's Shine collection consolidates Swarovski's signature jewellery with connected products maker, Misfit's activity-tracking, wearable technology. It lives up to expectations and one can choose from as many as nine separate adornments – ranging from casual accessories to evening wear dressy accessories such as bracelets and pendants. Astonishingly, it even powers itself without the need to be charged. Its battery can last upto six months.

Link: *http://dgit.in/MisfitWearable*

Solar-powered wearable

TapTap Wristband

TapTap wristband

TapTap is a wearable wristband that manages different applications through gesture and touch. It has just one button that acts as a capacitive sensor connecting it to another TapTap device via Bluetooth. Six particular gestures have been isolated within the device that are operated by TapTap's accelerometer, gyroscope and capacitive sensors and mapped to particular activities. In case a call comes in that a wearer would like to respond, a double shake of the wrist could switch his cell phone to silent mode.

Link: *http://dgit.in/TapTapBand*

Smart Spider Dress

At the latest Consumer Electronics Show, Intel and experiemental designer, Anouk Wipprecht showcased their 3D-printed Smart Spider Dress. The dress combines the power of wearables, robotics, fashion and self-defense. Spider Dress acts as an interface between the physical body

Smart Spider Dress

and the outside world. As noteworthy as it may be, the Smart Spider Dress isn't just yet ready to be worn regularly. However, other fashion-friendly IoT devices can be expected to solve this issue shortly.
Link: *http://dgit.in/SmartSpiderDress*

Blinklifier electronic make up

Electronics designer Vega has created a communication interface called 'Blinklifier' for cosmetics items such as eyeshadow and false eyelashes using which the wearer can control and interact with objects such as drones. The metallised false eyelashes and conducting eyeshadow works by completing a very low voltage circuit that recognises when somebody blinks

Blinklifier Electronic Make Up

Autographer Wearable Camera

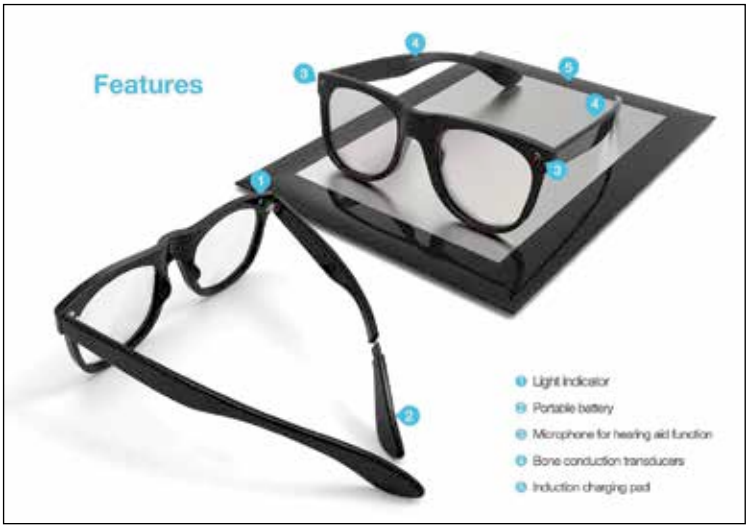
eyes. So far, the cosmetics developed by the computer scientist have been utilised to launch a smaller than normal drone into the air and actuate LEDs enhancing headwear.
Link: *http://dgit.in/Blinklifier*

Autographer wearable camera

Developed by the Oxford Metrics Group (OMG), the Autographer is a hands-free wearable cam that can take a huge number of photos a day on behalf of its user. The device uses its six on-board sensors, which incorporate GPS, color, accelerometer, motion detector, magnetometer and thermometer to focus on accuracy when pictures are clicked. Sometimes, Autographer can also capture high-speed pictures such as when the wearer runs to catch a bus. The cam has a five-megapixel sensor, OLED display, 8GB of internal storage and Bluetooth for sharing pictures. There are two buttons on the side of the unit and a rotating cover for the camera's lens. The Autographer doesn't have a considerable measure of settings to change, so its limited menu options work just fine.
Link: *http://dgit.in/AutographerCam*

NuWave glasses

NuWave glasses come in handy for the hearing impaired. It amplifies sound signals by simply changing sound waves into vibrations, working with a



NuWave glasses

comparable ability to a conventional portable hearing aid. The bone conduction transducers are ergonomically placed so as to convey these mechanical vibrations against the temporal bone and consequently to the inner ear. The Wireless Research Engineering Resource Center (RERC) drove a group of Virginia Tech students to develop NuWave glasses in a way that helps the hearing impaired better experience sound.
Link: *http://dgit.in/NuWaveGlasses*

Sensoria sensor-embedded socks

Device manufacturer, Sensoria has developed a couple of sensor-embedded socks that not just track customary fitness information such as the number of steps, speed and total distance a user has walked. It gives additional information about running structure and method. The socks keep tabs on an individual's weight and the structure of their feet while standing, strolling and running. Utilising this information, it can pinpoint poor running styles and prevent wounds before they happen. It works in conjunction with an application that conveys straightforward advice about how to unlearn poor running techniques. It can additionally benchmark and examine performance to give sock wearers a clearer picture of their how they perform.
Link: *http://dgit.in/SensoriaSmartSock*

Sensoria sensor-embedded socks

EmoPulse smartphone-enabled bracelet

The EmoPulse Smile Bracelet is a smartphone-enabled bracelet that tailors suggestions based on mood and diet. It can be worn as arm jewellery, and features sensors that can pick up on the wearer's stress, state of mind, diet and general condition. The cell phone wraps around the users' wrist and features a flexible material for its twin displays. It works with an algorithm-based, custom Linux AI OS and uses biosensors installed in the gadget to

EmoPulse smartphone-enabled bracelet

accumulate data about its wearer. After you've viewing a few films or listened to streaming music, for instance, it suggests more content that could suit the user's tastes. The suggestions get better and more accurate over time with active usage. The sensors could be utilised by virtual physical trainers to help keep users fit as a fiddle with individual, monitored workouts.
Link: *http://dgit.in/EmoPulse*

Hug simulation jacket

T.Jacket, designer by James Teh, is a wearable jacket aimed at people with autism. It's controlled by a tablet and utilises embedded air pockets to mimic embraces and calm children without human contact. It works on the 'deep pressure' theory, which proposes that weight has a mitigating impact on kids who have autism or attention deficit disorders and don't handle tactile

Hug Simulation Jacket

data in the same way as those without the condition. Though it was initially aimed at autistic children, the T.Jacket may have a more extensive application for folks in occupations that require them to spend time away from home.
Link: *http://dgit.in/Tjacket*

Tracking and analysing data

All sensors gather and transmit information, however, each sensor does this in its own unique way employing different formats and data structures. Data integration is fundamental for remote examination and control. For

instance, take fitness trackers. They progressively supply information to you as well as to your social network, your doctor, your healing facility and your health insurance company. Since they gather diverse sorts of information and utilise diverse formats, data integration is particularly tricky. Building up the databases with complete information and controlling sensors remotely over different sorts of sensors and devices can be extremely troublesome and time intensive. A key challenge is banding together with different associations for information and correspondences guidelines and issues regarding data integration. Application program interfaces (APIs) help to an extent. Say you want to make your health and fitness information from various apps accessible to a site or application. There are numerous options including RunKeeper, HumanAPI, My Fitness Pal, WalkMe, MyFitnessSyncer, MapMyRun, Strava, Argus, Walgreens' Balance Rewards for Healthy Choices and Microsoft HealthVault. Fitbit, for instance, records data from 37 separate applications or sites. Jawbone's UP records data from 30 applications including Fitbit. However, we still have some way to go before an industry-standard API exists to work with all possible devices.

Fashions and lifestyle implications

Ceaseless networking is powering a free stream of data and acknowledgment crosswise over large number gadgets and platforms. At the point, when situated inside a given connection, these mindful frameworks can encourage associated experiences that convey more prominent significance and importance into individuals' lives. Technology permits wearers to program certain gestures to compare with specific activities by their necessities. It manufactures more secure situations by empowering routine activities to make a reference point for others. Incorporating all these things in devices with cosmetics, and different wearables empower faster access to an assortment of personal devices.

Technological improvements related to accuracy, responsiveness and control have prompted the development of assistive technologies that will be able of both restoring and expanding existing faculties and capacities. This can standardise life for people while likewise extending the sorts, efficiencies and length of time of assignments that can now be finished.

The future of wearable tech

Over the next five years, we can expect to witness rapid development in the wearable technology arena. More people will be aware of the wearable

tech segment and it will definitely play a role in our daily lives. Particularly look out for sensors embedded inside garments, which we can expect in the next 2-5 years, with a few focused on enhancing people's health as well as fashion sense. It won't be long before we see such tech embedded into our bodies. By 2018, bio-integrated computing will have moved from the fringes, where it is today, and be thrust into the limelight having been taken there by its early adopters. Wearables will change the way we work, play and, of course, dress.

THE INTERNET OF THE ROAD

Traffic jams will be a thing of the past, as IoT promises to usher in a golden era of transportation on road, not just limited to a fully functional driverless car. Oh no, there's a lot more to be excited about!

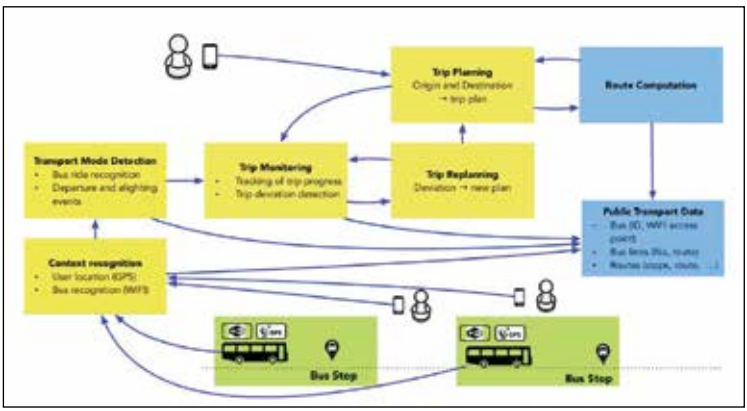
The Internet of Things encompasses every single area that we interact with in our day-to-day lives and hence the use of IoT based devices or technology cannot be omitted from the roads – our major medium of transportation. The applications of IoT on roads are endless as we can make use of intelligent technologies and services to travel better by improving planning, control, navigation, safety and plenty of more things that our squishy human mind cannot comprehend. IoT holds a lot of promise when it comes to using it on the road. Think about connected vehicles that can communicate to each other, how they can be connected to a central transportation hub from where they can gather data and relay it to the passengers as well. Not only is IoT the driving force behind self-driving cars, it's how the idea flourished into something that's now a reality and is bound to get better over time. Let's see how the Internet of Things can make travelling on roads better.

Intelligent travelling:

Smarter public transport (Know everything): We've all been in that situation where we had to wait for a bus at the bus stop for a long time in the heat. Even though we can see the bus timings on the public transport portal online for each individual bus, we know that owing to traffic snarls and punctuality issues, the buses are never on time. IoT can come to the rescue here by making use of wireless technology in buses and bus stops. A simple system can be devised which shares the current location of the incoming bus from the road, difference in distance between the bus and the next bus stop. Citizens who want to hop onto a bus from their nearest bus stop can use their smartphones to get notified of the bus' location and leave accordingly. All of the above and then some more can be seen in action with something called as Micro-Navigation for urban bus passengers using the Internet of Things which is being put to test in several countries. The current public transport system can be quite confusing and difficult to navigate for passengers such as disabled people, senior citizens and tourists. This is why the Urban Bus Navigator (UBN) which was successfully deployed and tested in Madrid, Spain should be the next big thing in urban bus transportation. UBN employs a novel concept that uses a context-aware navigation system that supports micro and macro navigation with continuous dynamic trip tracking, semantic bus ride detection and dynamic navigation information. The system can monitor the ongoing trip of the passenger and offer a plan for going ahead in the trip and tell the passengers when should they get off, is the next bus in their trip is bound to reach a bus stop that's the same for the current bus on the same route? And more. The knowing everything aspect of UBN is that a passenger is always provided with the dynamic information that he/she will ever need. If for example a passenger takes a wrong bus, gets off at the wrong bus-stop, the system immediately raises a flag and notifies the passenger. It also charts out an alternate plan with a new set of instructions to navigate accordingly. It works almost like how a simple Google Maps navigation works but is more centric to the passenger on the bus with the bus providing connectivity using WiFi and GPS and is connected to a central system. You can read more about UBN in this research paper: *http://dgit.in/UrbanBusSys*

Better on-road Safety: Safety on the road is of utmost importance and so plenty of new ideas for improving road safety are being adopted by governments of developed countries. One such example is Volvo Cloud which was demonstrated at the Mobile World Congress in Barcelona. Volvo

Cloud is a social network for connected Volvo cars that can detect and warn the drivers about dangerous road conditions. Using certain sensors in the car, the car can detect slippery conditions on the road and thus relay this information wirelessly to the system which then alerts all the connected cars ahead or behind you. The Volvo Cloud also aggregates the data sent by connected cars and notifies the transport authorities in real-time. A system like this can be really helpful especially in snowy regions and was tested successfully with the help of Norwegian public roads administration, Swedish transport administration and Trafikverket. Advanced capa-



Urban Bus Navigation System Architecture

bilities of Volvo Cloud would let the transport authorities provide better safety to road travellers by making use of the aggregated data to control traffic lights, issue speed limits and issue road warnings on wirelessly connected sign boards and lights to alert drivers of dangerous conditions. Another great addition to improve on-road safety can be seen on Skully which is an innovative new smart bike helmet. Apart from being a helmet, Skully features a heads up display, wireless connectivity and a bucket-load of other cool features. By using wireless connectivity, the helmet can notify the rider about traffic issues on the selected route, weather updates and much more thus making it a really good IoT device for safety as well as communication and navigation. Check out Skully here: *http://dgit.in/SmartSkully*
We must also add that Audi Connect, which is another technology that we've spoken of in the following paragraphs will feature lane departure sensing and thus will let the system warn you if a certain car around you is in your

blind spot and automatically take measures to protect the passengers in the car even before a collision incident takes place. This is just a brief of what IoT can do when it comes to on-road safety of passengers and we're sure with the advancement of technology, more things will surely follow.

Intelligent driving (Communication and navigation):

Remember the time when many of us referred to paper made physical maps? Well, the times have changed and hardly anyone still makes use of them now for navigation. In-car navigation systems have killed paper maps and most people make use of either that or use their smartphones for directions to head where they want to. Although GPS navigation through navigators and smartphones has become really powerful, it's just a showcase of what wireless automotive connectivity has in store for us. With the help of IoT, there is bound to be a complete overhaul of this system where navigation

Volvo Cloud is a social network of automated cars

will be like one of the basic features from among a many more advanced features. Connected vehicles for instance can inform the driver about traffic problems beforehand on a selected route of travel, notify the driver using an audio-visual medium about the nearest gas station which sells fuel cheaper due to discounts. A fine example of this is Audi Connect by Audi – the german car manufacturer. Audi Connect provides smart services like

taking some amount of cognitive load off from the driver by making the car being driven autonomous in many ways. Basically, Audi Connect is an in-car infotainment system which can turn the car into a mobile WiFi hotspot by directly being connected to an ISP of choice. Currently, Audi is trying to improve the Human-machine interface in the car by making use of gesture controlled systems instead of the usual knobs and buttons.

Self driving cars: Dream or reality? Tesla to BMW:

Self-driving cars have long been portrayed as the future of road travel in plenty of movies like iRobot, Demolition Man and Total Recall to name a few. These just showed a glimpse of what is capable with autonomous vehicles and paved the way for various biggies in the technology world to actually come up with their own self-driving car concepts. Surprisingly enough, it was in the late 1970s that the Tsukuba Mechanical Engineering Lab of Japan tested out a computerized driverless car that could achieve 32 Km/h and follow the road by tracking white coloured road markers. But it was in the early 1980s when Ernst Dickmanns, a german pioneer made a VaMoRs Mercedes van drive hundreds of miles autonomously on the highway as a part of the Eureka PROMETHEUS project. This was a huge feat considering the extremely limited amount of computing power available during that period. Time moved on and there were plenty of notable improvements in driverless car technology as a lot of organisations tried to fund amatuer to professional autonomous car projects. It was in 2004 that even the U.S. Defense Advanced Research Projects Administration (DARPA) had its hand in the push for success as they challenged multiple teams and made them compete for a huge prize of $1million to come up with a good working concept. They tested the prospects in the desert and named the event “The DARPA Grand Challenge” back then. Over the years, this project led to some serious developments in technology and the difference could be seen with the availability of better software for road-following, improved sensor and radar use and most of all, better collision avoidance. Researchers also found that an improvement in roadmapping helped them develop software that lets the car know everything of importance around it thus making it somewhat self-aware when it drives and lets it act according to certain unknown variations.

As of today, there are plenty of players in the industry when it comes to building and deploying autonomous cars and interestingly enough a few of their creations are even commercially available for purchase. The

$2,50,000 Navia is one of the first self-driving commercially available cars that is designed to work in pre-set closed environments like around a resort or an airport as a shuttle for example. In fact, you can actually take a ride in it at London's Heathrow airport.

The Navia self-driving car

As most of you would already know, Google - the technology giant has been working on self-driving cars for quite a while now right after they realised the potential of driverless cars when they launched Google Street View, they jumped into the idea with a modified Toyota Prius that they christened "Pribot" and provided the car a goal of fetching a pizza on its own. After multiple successful developments, Google's system was able to guide a whole fleet of modified Lexus and Prius cars more than half a million miles that too without causing any sort of accidents.

Google revealed its fully functional self-driving car prototype recently and it didn't look like any other car currently seen on the road. It has a cutesy look to it with a miniature body and round design. This two-seater car is electric powered and its speed is currently capped at 40 km/h although, Google has promised that it should be able to drive effortlessly at 160 km/h when it's fully developed that too without any sort of human interference.

A look at the second generation of Google's self-driving vehicle

Tesla, BMW and Google are the current front-runners when it comes to development of driverless cars. And Tesla's Elon Musk was in talks with Google to bring improved self-driving cars for the future. Tesla's very own Tesla Autopilot system in the Model S car is touted to be one of the most advanced and incremental driving system of the current generation. Couple that with the use of powerful cars, high quality sensors and innovative software and what you have is a lot of potential when it comes to making driverless cars a reality which is actually practical. Even BMW's demo of its modified electric car – the BMW i3 at CES 2015 which could drive and park itself was really interesting. What's more amazing is that, you can call this car right next to where you are on the footpath by simply making use of a smartwatch app. Watch a video of it in action here: *http://dgit.in/BMWi3AutoPark*

The transition to autonomous cars:

Well, we've seen the amount of promise that driverless car technology holds especially in terms of the Internet of Things and then comes the next question: How will the transition to self-driving cars actually work? Well, we have an answer. The transition to self-driving cars can take place in three stages:

Google's current complete build of its driverless car

1. Limited autonomy that doesn't depend on data sharing:
This is the stage that we are at right now. Most vehicles now have basic sensors like cameras, proximity sensors to warn the driver, lane keeping/ lane warning systems and tragic blind spot detection system. Even the smart Autopilot technology by Tesla in its cars and is actually a combination of all of the above and is a part of this basic stage. These technologies are powerful and form the basis of transition to self driving cars.

2. Semi-autonomy that utilizes shared data:
This stage is the actual beginning where the market penetration can start to happen and is about 5-10 years away from the present. The major part in this stage is V2X (Vehicle to 'X') communication. This is nothing but the communication between the vehicle and 'X' which can either be other vehicles or the surroundings or infrastructure around the vehicle. This would allow the vehicle to perceive the world around it as it actually is using 3D models. This is how autonomous vehicles can bridge the gap between available information from other vehicles and the road itself. At this stage, at least 50% of all vehicles on road must have IoT based sensing and connectivity systems in order to move forward.

3. Full autonomy with shared data, advanced sensors and high resolution mapping:
In order to achieve complete autonomy, this stage should have a combination

of powerful and advanced sensors, V2X and high resolution map data. The technology required for stage 3 actually exists today and all the top guns in the industry are experimenting with it right now. One of the essential requirements for this is making use of and deploying LIDAR (Laser Radar) on the vehicles and then combining it with the other tech available on the car. Even the new Google self driven car that we spoke of above has a low cost LIDAR pod onboard and making use of it with high quality precision mapping holds the key to successful deployment and transition to completely autonomous vehicles.

The future of the IoT on the road:

According to industry analysts and research firms, the Internet of Things industry is set to grow and achieve the 25 billion devices landmark in the next five years and about 250 million connected cars as well. These crazy numbers are proof enough that the future of IoT on the road holds a lot of potential and is definitely going to be another win for science, technology and the entire humankind as well. Connected cars will be one of the biggest elements in the race for expanding the Internet of Things as by the year 2020, it's projected that one in five road vehicles will have some or the other form of wireless connection.

Better deployment of IoT devices will also ensure more safety

The roads of the future will be nothing but connected Internet of Things highways as everything, right from the asphalt beneath your cars tyres to the car itself will all be interconnected wirelessly in one way out another. Information will flow between every vehicle on the road and the traffic signals to the transport department itself. Heck, with the deployment of these IoT devices and technologies for the road, human involvement will be the last and safety will take a proper front foot. After all, technology is here to make our lives simple yet unobtrusive in every way possible and the Internet of Things for the road holds a key to unlocking that potential.

THE INTERNET OF MEDICAL CARE

The world of healthcare is going to benefit the most thanks to the impending IoT revolution

Medical world has changed immensely with the rapid emergence of technology and Internet. The data maintained by hospitals is being computerized to enable physicians to access it either during consultation or surgery. Moreover, patients can access medical records from their home with the help of tablets/ smartphones, too. Nowadays, surgical procedures are performed with the assistance of machines. The world of open surgeries with large wounds surrounded by cotton to arrest incessant blood is a distant memory.

Devices communicate with other handheld machines to track, store and manage huge amounts of medical data. For example, you can now measure your blood pressure using a small device which in turn communicates with a monitoring system. This will enable physicians to access data and readings from anywhere via cloud and even real-time expert consultation even if the patient is sleeping at night.

Personalized medicine

In medical arena, condition of each and every patient will differ. Hence, a system should be tailored to meet the requirements of each individual patient. This is where the importance of Personalized Medicine comes into picture.

The term Personalized Medicine was mainly derived from Pharmacogenomics (pharmacology + genomics), which examines the role of genetics in drug response. Patients often show genetics variations while a drug is being administered and it needs to be monitored with connected devices. This is what pharmacogenomics deals with by correlating gene expression or single-nucleotide polymorphisms with a wide range of parameters such as drug absorption, distribution, metabolism, elimination in addition to drug receptor target effects.

Genetic assessment through smart devices will help advancements in medicine

Personalized Medicine relies on technology to confirm patient's disease and diagnosis by testing various aspects such as fundamental biology, DNA, RNA or protein. With the help of technology, physicians make use of various connected devices such as blood pressure monitors, glucometers, wireless weight scales, ECG and EEG for patient diagnosis.

For example, if a patient is suffering from epilepsy, doctors should make use of wireless wearable EEG devices to monitor brain signals which doesn't require application of gels. These devices issue alerts via text or email as and when a patient shows changes which need medical attention. The appropriate treatment can then be administered based on the data captured from the devices.

Research professionals also make use of personalized medicine to access the possible risk involved with various diseases by comparing genes. This research approach provides ability for the doctors to initiate preventative treatment and reducing the impact of the disease before it affects the patient directly.

If a DNA mutation indicates a risk of developing Diabetes, then the patient can begin lifestyle changes such as walking and cutting sugar intake to reduce the chance of developing Diabetes in future. In United States, blood samples are collected from newborn babies by pricking the heel to rule out any harmful diseases.

Pregnant patients who are diabetic should be monitored regularly via wireless devices powered with Bluetooth technology to make sure that sugar levels are within the limits. The end results are directly transmitted

Simplifying the future of epilepsy diagnosis

to the appropriate physician and nursing staff via Wi-Fi for further course of action.

In the same way, connected devices such as Monica AN24 can be used to monitor foetus of pregnant patients. The device makes use of electrodes to keep track of fetal and maternal ECG in addition to detection of uterine contraction. This will help doctors to provide real-time treatment in case of any abnormality. However, these devices should be used only in case of any problems found during pregnancy.

Monitor your cardiac waves on the go

The wireless ECG devices enable physicians to monitor the cardiac movements in patients who are terminally ill so that relevant drugs can be prescribed based on the severity of their conditions.

We can go on, but suffice to say that the era of Internet of Things (IoT) has thrown open immense possibilities to customized treatment.

IoT data analytics

The data collected by the connected devices needs to be analyzed with the help of various tools and software. Medical professionals only collect certain amount of data passed through them. However, there will be plenty of machine data inside log files, which can be analyzed only by specialized tools.

Glassbeam SCALAR is a tool developed to analyze the data to enable support personnel to troubleshoot problems in an efficient manner. Recently, Glassbeam has partnered with leading IoT companies such as ThingWorx to integrate their award winning analytics platform.

AGT International has developed a cloud-based analytics platform to enable connected medical devices to store and analyze data on the cloud. This technique not only reduces time but also cost involved to store massive amounts of data. AGT's analytics platform has an ability to monitor complicated environments such as data collected from Intensive Care Units, which require immediate solution.

Exosite has developed a solution named ROIoT, with which data generated from the connected devices can be viewed and accessed by only by persons who have required permissions. Moreover, the user interface can be designed with custom data, dashboards and widgets based on the scenario. ParStream's Data Analytics platform can handle massive amount of data captured from IoT devices.

Real-time monitoring

In the field of medicine, connected devices need to be monitored regularly to make sure that data is being captured correctly. RTI Connext DDS does this job by not only simplifying patient tracking but also connects to various devices in each room, which in turn connects to whole hospital. The data will be stored inside cloud-based secured databases. Hence, physicians from anywhere inside or outside the hospital with the required permissions can verify patient records and give instructions to paramedical staff.

RTI Connext DDS provides full support for emergency medical services and it integrates with several devices on ambulance vehicles. The software provides secure connectivity for these devices over the cloud which in turn connects to devices in hospital. Hence, casualty paramedical staff will be informed of the arrival of the patient. This eliminates unnecessary confusion among the hospital staff.

RTI Connext DDS provides support for Class III certified medical devices on the vehicle and it communicates data in an encrypted manner.

The companies which manufacture various connected devices also employ their own cloud based storage mechanisms to track, monitor, manage and share the collected data. For example, Aerocrine makes effective use of Microsoft Azure to store data captured from a wide range of wireless devices used by asthma patients.

Role of sensors in IoT

Nowadays, patient data is collected dynamically with the help of wireless sensors. It can also be used to measure the progress and efficacy of treatment.

When the data is captured with the help of sensors, complex algorithms are employed to dissect data in the background. This way, physicians can access the captured data and provide required treatment procedures on the go.

The sensor manufacturers should follow various standards such as Wi-Fi (IEEE 802.11), ZigBee (IEEE 802.15.4), Bluetooth, BLE, IEEE 802.15.4j, IEEE 802.15.6 in addition to GSM/UMTS and CDMA. The

Reveal the magic with sensors

products should also fulfill 25 standards recognized by the U.S. Food and Drug Administration (FDA).

DLVR Series Mini Digital Output Sensor manufactured by All Sensors Corporation decreases package stress with the help of CoBeam2 technology.

Temperature control is one of the main aspects which need to be taken into account while creating sensors for medical applications. Silicon Labs has developed a unique chip to control humidity and temperature sensors. It includes an analog to digital converter, signal processing, auxiliary-second-zone-sensor input, 100-240 operating voltage, I^2C host interface in addition to 3mm x 3mm DFN package to provide long run efficiency.

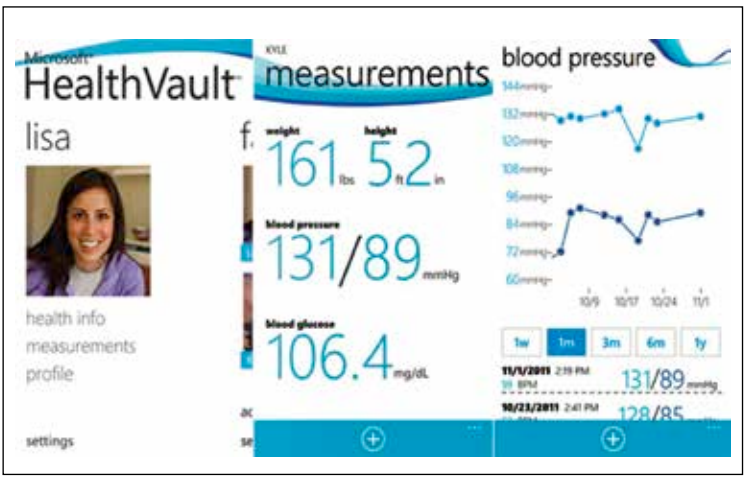
Digital medical record keeping

In the management of treatments and procedures, medical records keeping plays a pivotal role. Systematic maintenance of medical records in hard copy format were being followed in earlier times with individual patient details, doctors findings and other related notes.

However, management of all records manually became a tedious task especially with the huge influx of patients in various departments.

Hence, hospitals started to implement a computerized information system which stores all medical records for easy access at any point of time in a secured manner.

As part of the digitization process, the current system of tokens should be abolished and a unique number should be generated as and when a patient approaches the counter for fixing appointments. The relevant doctor will receive an alert or a message via e-mail with the patient details. The doctor will login to the system and searches for the medical history of patient. Doctors will be able to make a comparative study of various vital parameters



Manage all health parameters in a single dashboard

such as blood pressure and temperature with the help of charts and gauges. Lab technicians will be able to feed test results into the management system, which in turn can be accessed by doctors and patients either via apps or from the hospital portal.

In order to create a fully functional digital mechanism, hospitals should make use of software applications and tools such as HealthKit, HealthVault, OpenMRS 2.0, OpenEMR, FreeMedForms, Adastra, Chikitsa, DocEngage, Webmedy and CareCloud.

With the help of these tools, doctors will not only be able to store data, readings but also can create prescriptions, which can be handed over to patients. It will be easy for doctors to track the prescribed drugs by simply providing the prescription number on to the system during follow-

up visits. Moreover, administration, billing and store personnel will be able to keep track of daily expenses, generate discharge summaries and manage purchases.

If the available software application doesn't meet the expectations, then custom software needs to come in based on the requirements. However, this process takes time and can be expensive depending upon the scenario.

Hospitals should provide adequate training to counter staffs, doctors and nurses to enable them to work with the installed software application. Moreover, a reliable backup and disaster management system should also be created to manage any unforeseen circumstances such as hard drive failures. The monitoring system connects to several computers, modems routers and other devices. Hence, it needs to be protected with surge equipments to protect against damages caused by thunder and lighting.

The medical record system should be developed in such a way that data is replicated across several backup servers both onsite and remote locations. This will enable data recovery in case of any system failure. Hospitals should have reliable broadband internet to ensure uninterrupted connectivity, which is essential for the successful running of the system.

A big challenge to implement a digital medical record system is security. Practice Fusion (practicefusion.com) provides a facility to track and manage medical records on the cloud. The system stores data on their own servers and we need to make sure that data is stored in encrypted format. We will not be able to know where and how data is stored. Moreover, if the provider faces problems then all the valuable data will be unavailable, which will prove costly for hospitals.

There will be challenges, obstacles and loopholes during and after the installation of patient management systems but with courage and determination it can be overcomed to a great extent. All of this that we explained here, through the example of hospital record keeping, is a small part of IoT at work.

Connected medical devices

With the rapid evolution of technology, healthcare providers need to incorporate connected medical devices to provide quality healthcare to patients. These devices mainly communicate with either other devices, smartphones, tablets and patient monitoring system software applications.

QardioArm is a small wireless blood pressure monitor which displays readings on an LCD panel. These monitors are normally connected to the arm, which send signals to the app via sensors. The data is stored for future

Keep track of your BP with QardioArm wireless blood pressure monitor

reference. It is also possible to share the results with the healthcare provider so that necessary treatment can be initiated at the correct time.

Weight management is vital for both patients and doctors. The weight loss is one the common problem faced by patients with abdominal diseases. Wireless weighing scales developed by Withings enable patients to capture their weight digitally and deliver the readings to either a central processing hub or to apps. These devices not only measures weight of the body but also Body Mass Index (BMI), which will be useful in the diagnosis of the amount of calcium present in the bones.

The wireless ECG device developed by LifeSync captures electrocardiogram (ECG) either continuously or in regular intervals from patients and can be connected to monitoring devices – no more lying down on a bed to get this done.

The amount of glucose on the blood should be monitored regularly in diabetic patients. It is now possible to measure blood glucose levels continuously with the help of Dexcom G4 PLATINUM System. The built-in software application that ships with these devices enable patients to keep track of and share readings with doctors.

Heart rates can be measured with the help of wearable devices like Pulse O2, which not only measures calories burnt but also monitors the sleeping cycles at night time.

Wireless pulse monitoring devices measures blood oxygen saturation (SpO2) and pulse rate via Bluetooth and can be synced to relevant apps provided by the vendor. Some of the popular products in this category include iHealth Wireless Pulse Oximeter.

Healthcare providers can now have connected devices to monitor urine levels using Future Path UroSense and make use of Philips medicine dispensing machines to make sure that patients are consuming medicines at right time. With the help of range of devices manufactured by Niox, physicians can measure concentration of nitric oxide in an exhaled breath environment for the treatment of asthma.

Wireless EEG devices enable healthcare providers will be able to regularly keep track of patients with epileptic seizures with the help of ENOBIO wearable devices. These devices look like a helmet and communicate brain signals to the computer via Bluetooth. It also eliminates the usage of gels and abrasion of skin.

Gone are days where you need to insert thermometers into your child's mouth or armpit. With the help of Fever Smart and Cadi.Sense, doctors and physicians will be able to keep track of the body temperature and pulse readings. The device generate alerts when the readings cross the specified limit and the data can be stored on the cloud.

Seniors are prone to fall during walking and climbing steps. MobileHelp is a pendant shaped wireless fall device which sits on the patient's body and generates an alert immediately upon detecting a fall. In order to use

Manage your weight wirelessly via apps and compatible gadgets

Monitor blood glucose levels easily without needles

these devices, patients need to subscribe to a package offered by the device manufacturer and should pay monthly expenses which are expensive.

All connected medical devices can be easily paired via either Bluetooth or Wi-Fi. The recorded data can be easily shared with health care providers so that they will be able to provide correct treatment at right time.

The biggest challenge to modernize hospitals with smart connected medical devices is that the devices are expensive and its unavailability in countries like India. Hospitals should import the devices from United States and China, which will be very costly. Moreover, the doctors and nursing staff should be provided with training so that they can work with the devices. The lack of adequate service personnel to repair the devices also poses a big challenge.

Hospital authorities should provide periodic training to keep doctors to abreast of the latest in connected devices field. They should also encourage them to participate in webinars and listen to podcast shows hosted by professionals abroad.

Universities should modify the syllabus of medical courses to incorporate a separate paper on the role of technology in medical field. Government should create awareness campaign to educate medical community and the general public about the benefits of these devices.

Track your pulse

The connected devices market is evolving rapidly and is a big asset for hospitals since it will definitely improve patient lifespan and also enhance productivity.

Conclusion

IoT opens up a lot of possibilities for favourable changes in the medical and healthcare arena. Doctors and nurses can communicate via IoT devices (over the Internet or Intranet). Chances of error can be drastically reduced. For example, doctors can prescribe doses over IoT devices and nurses and patients can get confirmations.

In the future, we can expect eye lenses with sensors and microphone which enable patients to capture power and communicate with the opticians. We can also expect the arrival of reusable eye lenses with which you will be able to change the power without changing the lenses, thus reducing its overall cost.

You could have optical scanner based IoT devices to aid these. Blood stations will be integrated with IoT devices. Also room amenities such as thermostats and room temperature can be controlled with IoT. If a patient

has fever or not, the status update from a patient monitoring station could control IoT thermostat to control room temperature.

As we see, there are endless possibilities between the patient doctor network. This can be extended to pharma network, hospital administration, visitor registrations as well. This could connect hospitals as well so that when a patient is transferred between hospitals, all records accurately flow to and fro. Opens up tons of possibilities to reduce error margins and usher in a bright future in the evolution of healthcare management systems.

THE GLOCALIZED INTERNET OF EVERYTHING

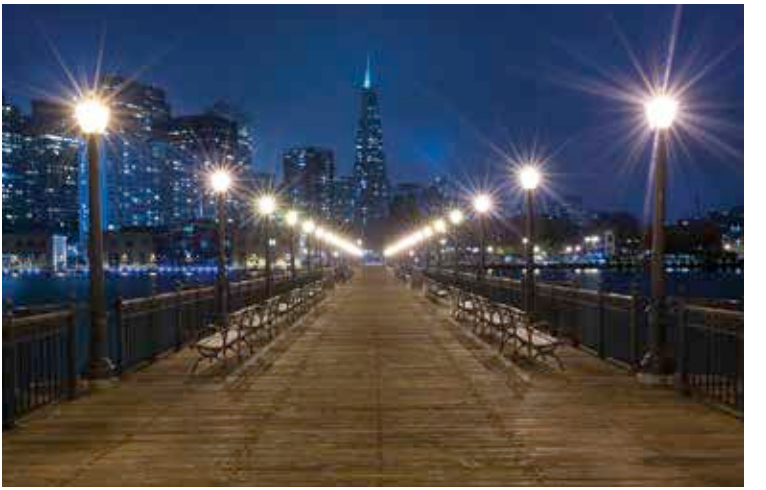
Interconnectedness of gadgets will ensure global innovations applied to solve local problems. It's inevitable.

This chapter is devoted to the role IoT has had in changing the very landscape of urban and rural lives. Every big corporation has to expand its footprint in the global world keeping in mind the difference in cultures and geography. McDonald's serves the Aloo Tikki burger in India and even has kosher meal in Israel! It is no different for impactful technology. In this chapter we give you a brief overview of how IoT has glocalized and adapted to the needs of the different sectors and walks of city and rural life.

A city has incredible potential for the IoT to increase efficiency and bring in smart tech into our daily spaces, having a direct impact on our lives. From the coining of the term in 1999, as internet usage and related technologies developed, several large companies like Cisco and IBM recognised the

A smart city is like a living being communicating constantly. You can listen in by using your phone or tablet.

feasibility of using IoT in urban areas. The concept of a 'smart city' was born. Basically, the idea is to use sensor enabled technology complete with monitoring and feedback systems to improve the quality of life in cities. IoT aims to do the following in a sustainable way that promotes eco-friendly environments to reduce the already burgeoning load on nature's resources. This topic of smart cities is currently one of the leading technology topics, receiving a large share of media and public attention as well as research funding from market giants. IoT run platforms generate large amounts of data. Making sense of all the data, storing it and processing it is a 'big data' problem and is driving innovations in associated technologies. While IoT for cities shows great promise, there needs to be extensive assessment of the area before attempting to integrate technology on such a large scale. Last but not the least, the data must be clear of noise without having an adverse impact on privacy and security of citizens. These are not small concerns



Imagine being able to sit peacefully with such a view and browse the web using the streelight as a Wi-fi hotspot!

and IoT's ability to deal with them will decide how soon we can have cities that are truly smart.

IoT has already invaded our lives in many ways. Right now, many of us might be enjoying the benefit of an IoT based technology without knowing it. IoT technology has penetrated in vital components of city infrastructure like sewage and water treatment systems, garbage disposal and waste recycling. Public transport has benefited greatly from the widespread navigation applications that make use of IoT based technology and the plethora of cab/vehicle sharing/booking apps that are available on almost every major OS's app ecosystem. All these applications have a well defined and set system for tracking customers, processing payments and keeping tabs on employees. All of them have IoT at its very core. Some smart solutions for improving road safety and general transport have been proposed. The concept of crowdsourcing could be used to map certain features which can help generate an accurate description of a route in real-time including congested areas, dug up roads etc. Transport vehicles can be installed with full blown IoT to monitor goods safety, route deviation and even driver fatigue.

IoT can be used in public spaces in a number of innovative ways. A New York City proposal came up with the brilliant idea to transform the otherwise standard streetlight space into an interactive hub of sorts, functioning as a

miniature data center and relaying information back and forth. They could also act as Wi-Fi hotspots. Sensors could monitor energy consumption and this can cut down on wastage of electricity. It will not be a drastic measure but its a start to help create an energy efficient city. In zones which are prone of natural calamities, appropriate sensors could be installed. There have been instances of sensors being installed in buildings to gather data about energy consumption and share it with other systems to optimise electricity use. This sort of a system could have major implications in disaster warning and management in the event of natural calamities as well. Barcelona has teamed up with Cisco to actually implement the above ideas. The city has a spinal cord like fibre network that is used to connect all of the city's IoT designs. The bus stops are connected to the fibre. The bus stops display bus timings and other related information besides functioning as a Wifi hotspot and charging zone. Mobile users can access information about nearby available parking zones using dedicated apps, thanks to the parking spots also being connected to the fibre network. Barcelona also has a working version of the super-streetlight technology equipped with Wi-Fi and air-monitoring systems. Barcelona has also implemented an IoT based system to monitor garbage levels and optimize garbage collection. There are sensors on bins that inform stations about level of garbage and this data is used to plan efficient routes for garbage collection. Hazardous material detection sen-

A sensor – an integral component of any IoT system

A humble sheep could become your only connection to the internet in a remote village

sors are in the pipeline. If we talk about similar plans for India we have to however install garbage bins in the first place!

What the Barcelona example essentially proves is that given a smart government and a smart technology provider, it is possible to use IoT on a large scale. IoT cannot only help improve lives in cities, it can have major impact in reducing the carbon footprint and ensure a more sustainable form of city life. Cities fit with IoT systems can act like living organisms, processing real time data, acting and reacting to it and continually adapting and providing feedback. Seeing the very nature of IoT it is very easy to put a tab on its massive potential in the urban environment, but can IoT somehow raise the quality of lives in a rural setting as well?

Integrating technology in a rural setting is always a challenge. Cities are more or less acquainted with technology on many levels but rural areas have low technology penetration and hence bringing in new technology is always a logistical hurdle. For instance, IoT could help promote smart farming but it cannot replace the knack and knowledge that the farmer has of his own land and livestock. IoT however can greatly enhance productivity and ease many processes in rural areas.

IoT designed for cities can be implemented in rural areas too. Smart bus stops, smart dustbins and smart streetlights are all viable options for the countryside. In fact with the density of population generally low and

pressure on civic services lesser than that in cities, these IoT inventions can run in a smooth manner. Another important aspect of rural life where IoT can play a major developing role is education. While education services in cities now routinely use technology enhanced learning methods, this fad is yet to come to villages. IoT can transform the way schools function by bringing in interactive learning methods. Further IoT systems can vastly improve the usually primitive rural healthcare system. Solutions like wireless patient monitoring that are infeasible for large areas can revolutionize rural healthcare. The usual IoT benefits like efficient data transfer, monitoring and networking can all help in boosting medical services in rural areas.

Some researchers have worked on a plan to use sheep as Wi-Fi hotspots to provide Internet access to people in the countryside. Sheep can also be tracked and efficient tracking algorithms and apps can provide real time

A neat image composition giving an idea of what all the encompassing IoT is all about

data about where the livestock is. Besides aiding in farming this could help scientists study components of animal behaviour. Other possibilities of using IoT to improve agricultural and farming methods is to fit sensor systems in various strategic points across the farm like gates and tanks. The farmer can monitor water levels, leakages and structural damage and also look out for intruders. With automation systems industry coming up with constant innovations it might be possible to use IoT to do remote farming. Imagine the sight of a farmer sitting in the comfort of his home running tractors, sprinklers and what not from his phone. The Kirby farm in Australia is a working model of a smart farm installed with many sensors to gain data about soil moisture, salinity and temperature. The combination of sensors and livestock tagging allows the farmer to know which areas in the farm are better for the livestock and which are prone to harbour parasites. Similar sensors can also be fitted near river beds to get data about erosion and soil nature besides acting as a flood warning system. For Greenhouse based farms, these sensors can be installed inside greenhouses to enable continuous monitoring of temperature and humidity. Large farms with associated processing, storage and transportation facilities can benefit greatly from IoT technology. Produce can be tracked, processing stages monitored and controlled remotely, and various stages of supply chain can be seamlessly managed.

A company called Monsanto is using IoT in a combination of ways described above. The company has an application and program that helps the farmer single out favourable areas for growing crops and then enable to monitor the stages of planting. The company uses data of the produce to help its trademark program make better predictions. IoT has also been successfully implemented in creating a pest control system. The farmer can use visuals from installed cameras and data from sensors to help him decide when to release insect pheromones for pest control. The company that has pioneered this (SemiosBIO) claims that pesticide usage is reduced significantly by intelligent use of IoT.

The potential of IoT in enhancing the quality of living in cities and rural areas is proven. However with the kind of problems IoT is trying to target and solve, there are many challenges and hurdles, the biggest of which is arguably scalability and robustness. A sensor based technology can perform very well in a controlled setting but out there in a free environment , delicate technology can fail quite easy. Can an efficient design be adapted to be an efficient and robust design that can perform in an uncontrolled

The time consuming process of pest control can now be automated using IoT

setting? Can a single prototype translate to a successful large scale technology? It is quite obvious that IoT is not a single technology and derives its powers from other forms of existing technology. It is largely reliant on sensors and data communication. As such, IoT applications have to be complemented with innovations in Big Data processing. Dealing with the kind and amount of data IoT systems generate, it can be really difficult . If the data processing is inefficient than the front end technology, it is no more than a flashy model. IoT is one of the exciting prospects in recent times that can truly bolster the next technology revolution. Smart cities were usually staple in science fiction books and movies but IoT has the potential to make it a real existent possibility.

HELP BUILD THE IOT

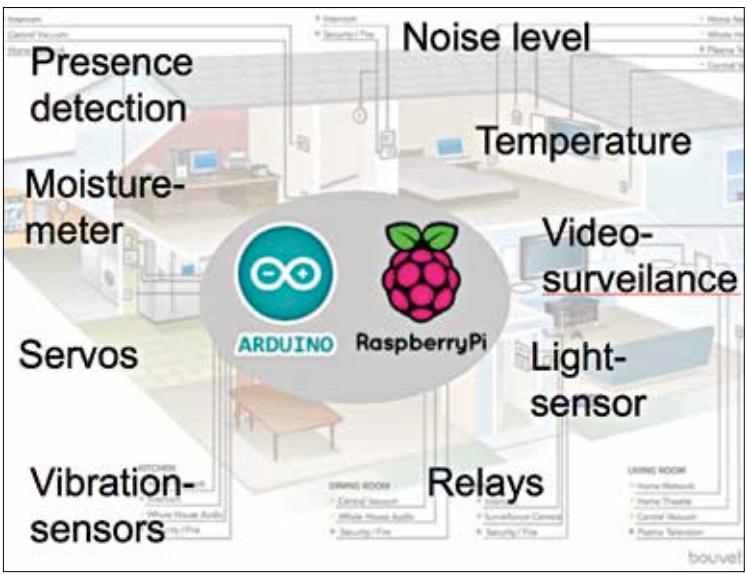
Can people like us play their part in building the Internet of Things? Definitely. How? By concentrating on the 'Things'.

The previous chapters may have given you an insight into the possibilities of IoT. But, what do we need to build the Internet of Things? Can you build it yourself? In this chapter, we'll try to answer the 'Things' part of the Internet of Things phenomenon.

Internet of Things consists of 'things' connected to the internet. These things generate a large amount of data from the measurements that they continuously take in the environment around us. The role of the things is to measure parameter. The large amount of data thus generated is processed by intelligent algorithms to help you, so that these 'things' can alert you and sometimes help to execute some action on your behalf.

What data and which measurement?

The measurement part can have many possibilities, for example, your current location as shown by the GPS in your cell phone, the distance you have walked today or the sleep you had today, in this week etc.



Data in the Internet of Things

So how huge is the data generated?

Let's take a scenario, you store the data of your daily walk, commute using a health tracking device connected to the Internet. Now imagine, your

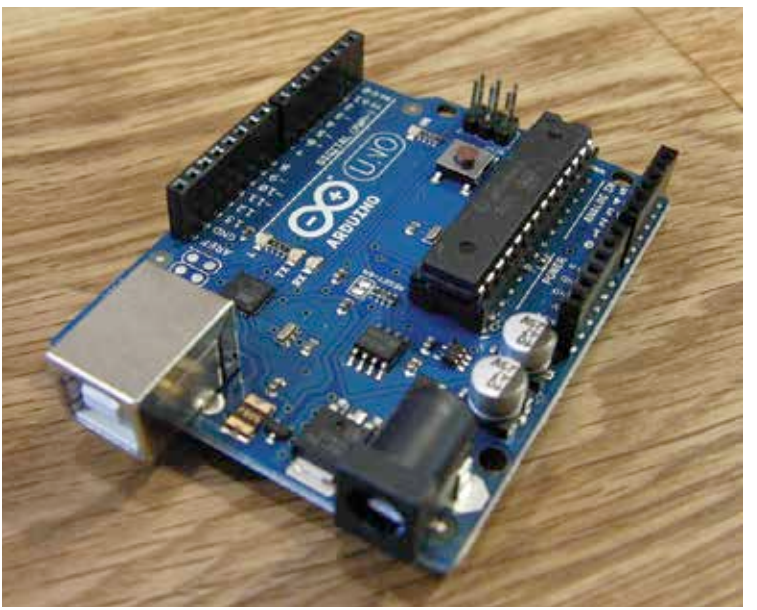
friends also doing the same, which could easily be your data measurement multiplied by few hundred people. So what if we talk about all people in a country continuously transmitting the data? Too large data to handle. Well the Internet of Things is about taking data of such large amount and processing it to help people.

As mentioned at the beginning of the chapter, we will be concentrating on the 'things' part of the IoT phenomenon. Covering all the 'things' in one single chapter is impossible. But we have already covered the 'things' part in our previous issues of fast track namely the 'Fast Track to Arduino for Everyone' and the 'Fast Track to Raspberry Pi'.

Let's look at how the two Fast Tracks to the prototyping platforms, namely Arduino and Raspberry Pi, can help you create the 'things' in the internet of things systems.

The Arduino?

The Arduino is a very simple and useful platform to help you get started with building the Internet of Things. It can connect to a wide range of sensors such as accelerometers, gyros etc. and also help you to connect to the



Arduino UNO variant for building IoT system

Internet. It has add on hardware called 'shields' to help interface components like motors, or use a GSM module for cellular network communication.

Hardware with advanced capabilities that can run modern operating systems is being continuously added to the list of Arduino devices. It also has a big community of users and developers who are continuously adding more and more features.

How can the Arduino help?

To build to build the Internet of Things, we need to measure quantities using sensors. The required sensors need to be connected to the Arduino. The microcontroller in the Arduino will read the values from the sensors and can take one of many of the actions like

- Alert the user
- Pass the data to the server for future processing
- Take some actions based on its internal programming
- Or it can perform some combination of these tasks

In the FastTrack to Arduino, we started with the possible applications of the Arduino, then we discussed the various hardware platform available.

Raspberry Pi to build the IoT system

Further we moved over to programming the Arduino with a small note on how to upload your code to the Arduino. We covered the basic operations that can be performed by the Arduino and gave some references to help you with making some. In the context of this FastTrack to Internet of Things, we covered the part of measuring the values from the sensors and the also passing the data to the Internet.

Raspberry Pi?

Though the name sounds as it being something that you can eat just right away, we won't suggest you to eat it, but you can instead use to monitor the process of making a Raspberry Pi.

The Raspberry is an ARM cortex A series processor based hardware device. It has the capability of a modern cell phone and is therefore more powerful than the Arduino boards available in the market as of this writing. It runs an operating system called Raspbian which is a highly customized Linux flavour for the Raspberry Pi.

It can be programmed using a visual programming language called Scratch. Though for building the Internet of Things, you'll have to know a more advanced programming language like Python or C, for handling all the Internet communication requests.

How can Arduino and Raspberry Pi help me build the Internet of Things?

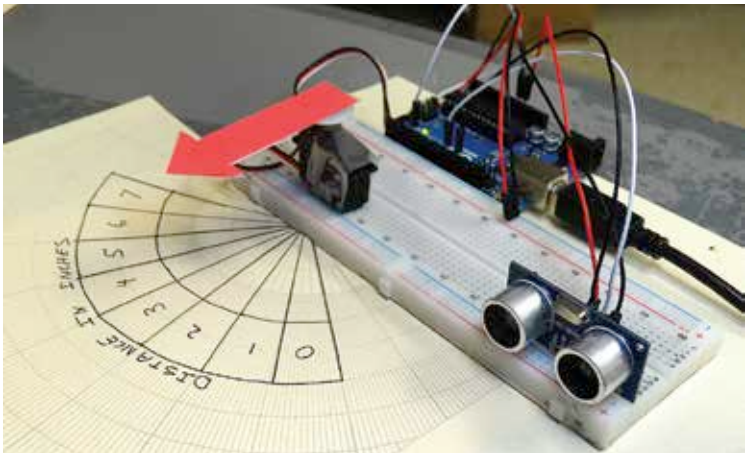
As we previously mentioned they can be used to create the 'things' in the Internet of Things. These 'things' can measure value from sensors or help control some device or hardware.

Part 1 Measurements

The preliminary task of a 'thing' in the Internet of Things is to collect data of various phenomenon around us like temperature, moisture for adjusting room temperature. This represents measurement and plays a crucial part in the IoT phenomenon.

In the Fast Track to the Arduino for everyone, we have used demonstrated how the Arduino can be used

- To get current position using GPS
- To measure distance using Ultrasonic sensor
- To interface an accelerometer
- To interface a Gyroscope



Distance sensor interfaced to Arduino

In the Fast Track to the Raspberry Pi, we've demonstrated how the Raspberry Pi can be used to:

- Stream your home temperature
- Create a weather monitoring system – AirPi
- Log temperature to Google Docs
- Monitor humidity
- Monitor dissolved oxygen

Part 2 Communicate/Connect to the Internet

The Arduino has hardware called shields like the GSM shield to connect to the cellular network for internet connection. Also there are Ethernet and Wi-Fi shields with their own libraries that can help you to connect to the Internet. The following tutorials in the FastTrack to the Arduino can help you with communication aspect

- Using the Ethernet Shield
- Using the Wi-Fi Shield
- Connect to Internet via GPRS

The Raspberry Pi uses the Python programming language and therefore itself has a rich set of libraries that can be used to connect to the Internet via the Ethernet port on board the Raspberry Pi. As an example, you can use the following DIY:

- Remotely control light

Image Credit: toptechboy.com

GSM shield for using Internet over GPRS

Part 3 Take action

The last step after communicating or taking a decision is to perform an action. The Arduino and Raspberry Pi can perform actions like control small motors to move a robot or use relays to control a water pump that pumps water to overhead tank

The following DIY in the FastTrack to Arduino for Everyone can help you:

- Control a motor using the Motor Shield
- Automatic watering system for gardens

The following DIY in the FastTrack to Raspberry Pi can help you:

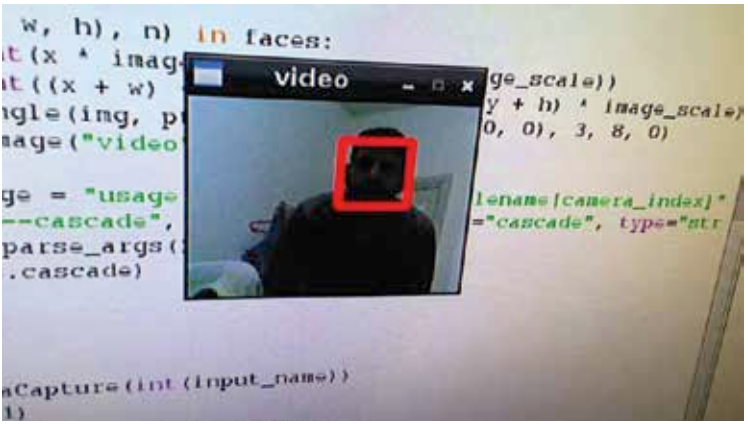
- Remotely control light
- Remotely open your garage door
- Control a plant-watering system using the internet

Part 4 Security

Security is a very important aspect. Here we aren't talking about security of data transmitted over the Internet, but about the security of physical premises. The following DIY using the Raspberry Pi can be used since, we can connect a camera to the Raspberry Pi

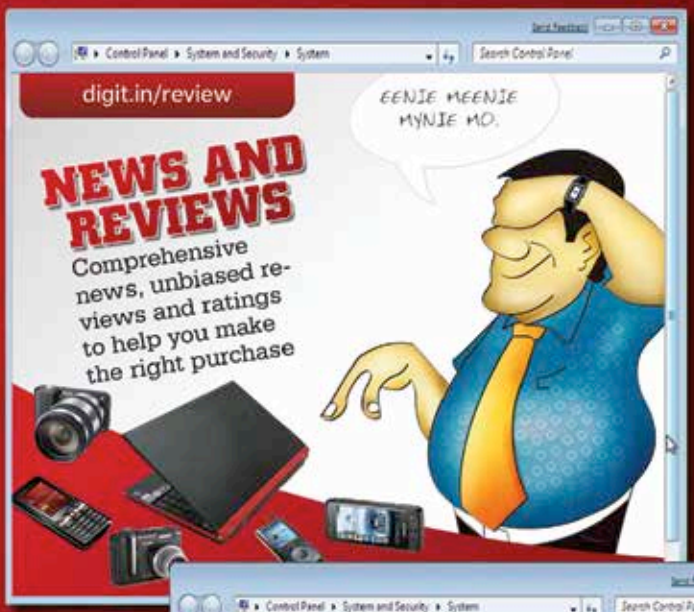
- Detect faces using Raspberry Pi
- Detect intruders

Using the above mentioned DIY, you can start building your own 'thing' in the Internet of Things. There are many resources available online that



Face detection for security purposes using Raspberry Pi

can help you find the right sensor for measurement or device to perform some action. For beginners, we recommend the help of an expert who understands various parameters.



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