The Internet of Things

MIS 6372 – IT Service Management

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Executive Summary

The Internet of Things is an emerging topic of technical, social, and economic significance. Consumer products, durable goods, cars and trucks, industrial and utility components, sensors, and other everyday objects are being combined with Internet connectivity and powerful data analytic capabilities that promise to transform the way we work, live, and play. Projections for the impact of IoT on the Internet and economy are impressive, with some anticipating as many as 100 billion connected IoT devices and a global economic impact of more than $11 trillion by 2025.

While there is no universal definition for IoT, it generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. The key concepts about IoT are understanding the definition, various communication models used to connect the devices, enabling technologies (like cloud computing, virtualization). Like any new technology, IoT has some challenges and issues to be addressed like potential security breaches due to poorly interconnected devices, privacy issues due to huge amount of data collected about users, interoperability issues between various devices and legal issues in countries that concern data retention policies, flow of data across borders and so on.

ITSM lifecycle processes has helped so far in managing traditional IT services in various sectors. ITSM will help IoT service management extensively because IoT is still about products, people, processes and partners, though the products are now smarter in IoT. Service management processes like Incident management, Change management, Information Security management, Asset and Configuration management will be very useful in IoT service management. For instance, Incident management will be more proactive as the devices will be able to self-report any issues, thereby making the process more efficient. The Internet of Things is characterized by constant change – old products will evolve while new products will be introduced into the system. This dynamic nature and the requirements of quick solutions will be best supported by Agile methodologies.

In a data-intensive environment like IoT, communication and data efficiency is critical to meet capacity requirements and ensure system availability. If wastage is not handled, the system would become redundant. LeanIT aims towards ensuring minimum wastage in terms of data and communication of information. The goal of LeanIT in an IoT system will be to build a strategy that can define the required information that needs to be stored or communicated and the storage location. This will reduce resource (storage and communication bandwidth) wastage at important bottlenecks and distribute loads throughout the system. Also, LeanIT will help in maximum utilization of the available resources.

DevOps will help bridge the cultural divide between IT and business operations and help in taking up interoperability initiatives to build new standards. DevOps best practices will also help overcome security and privacy issues in IoT systems. Also, understanding operational limitations like device battery life, form factor and environmental conditions apart from programming language while developing solutions will require DevOps based development.

Cloud computing and Virtualization are two of the most important technology that enables IoT. Cloud computing will help IoT systems in data storage, providing users with access from anywhere and anytime, access through multiple platforms, ensuring high availability and providing scalability. Cloud computing and virtualization are very important in IoT systems and are more like supporting pillars.

The Internet of Things Overview

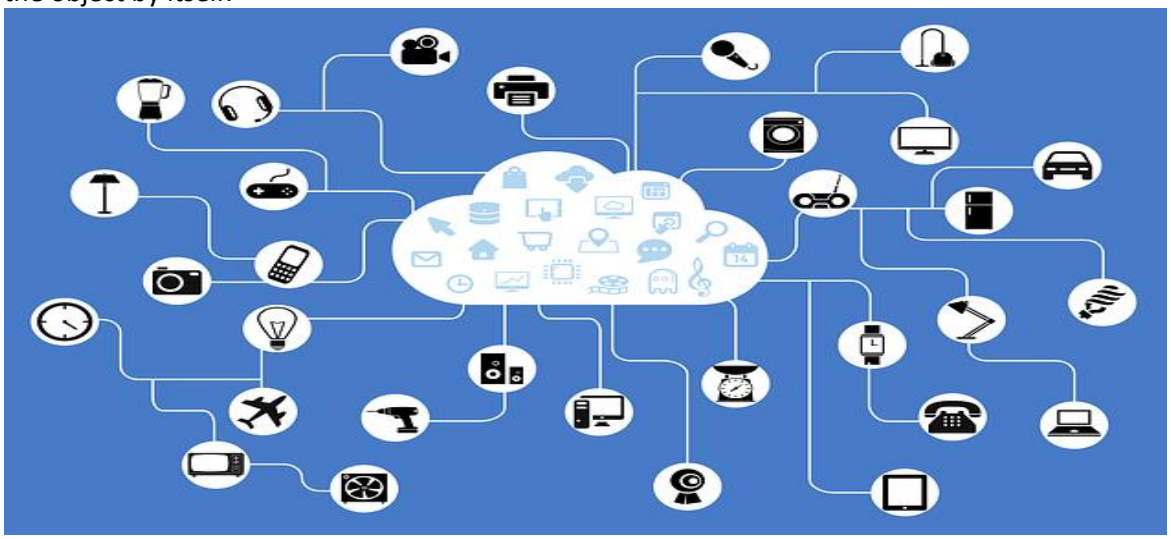
The Internet of Things (IoT) is an important topic in technology industry, various other sectors like manufacturing, infrastructure management, logistics and so on. This technology is embodied in a wide spectrum of networked products, systems, and sensors, which take advantage of advancements in computing power, electronics miniaturization, and network interconnections to offer new capabilities not previously possible.

The large-scale implementation of IoT devices promises to transform many aspects of the way we live. For consumers, new IoT products like Internet-enabled appliances, home automation components, and energy management devices are moving us toward a vision of the "smart home'', offering more security and energy- efficiency. Other personal IoT devices like wearable fitness and health monitoring devices and network- enabled medical devices are transforming the way healthcare services are delivered.

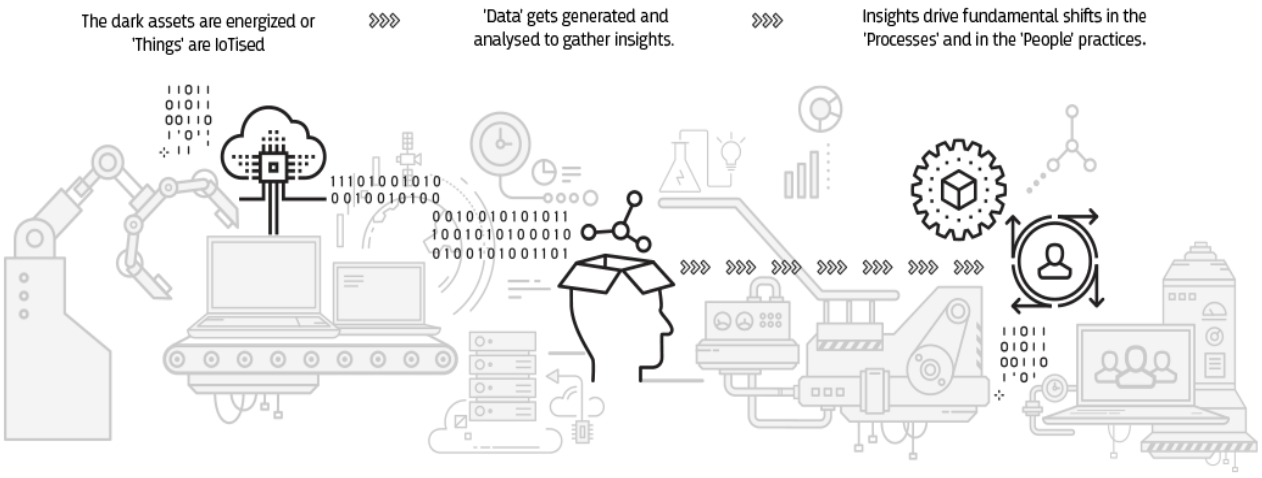
Several companies and research organizations have offered a wide range of projections about the potential growth of IoT on the Internet and the economy during the next few years. Cisco, for example, projects more than 24 billion Internet–connected objects by 2019; Morgan Stanley, however, projects 75 billion networked devices by 2020. Looking out further and raising the stakes higher, Huawei forecasts 100 billion IoT connections by 2025. McKinsey Global Institute suggests that the financial impact of IoT on the global economy may be as much as $3.9 to $11.1 trillion by 2025. While the variability in predictions makes any specific number questionable, collectively they paint a picture of significant growth and influence.

What is IoT?

The internet of things (IoT) is a computing concept where every day physical objects are connected to the internet and can identify themselves to other devices or processes, via an IP address. The IoT is significant because an object that can represent itself digitally becomes something greater than the object by itself.



As shown in the picture below, no longer does the object just relate to the process; it now connects to surrounding objects and database data, permitting “big data” analytics and insights. The objects or devices, generate data once they are all IoTised. The data generated by the devices is analysed for business insights. This results in fundamental shits in the processes or business trends.



Things might communicate autonomously with other things and other devices, such as sensors in manufacturing environments or an activity tracker with a smartphone or a fitness wearable.

The Internet of Things engages a broad set of ideas that are complex and intertwined from different perspectives. Key concepts that serve as a foundation for exploring the opportunities and challenges of IoT include:

IoT Definitions: The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. There is, however, no single, universal definition.

Enabling Technologies: The concept of combining computers, sensors, and networks to monitor and control devices has existed for decades. The recent confluence of several technology market trends like Ubiquitous Connectivity, Widespread Adoption of IP-based Networking, Computing Economics, Miniaturization, Advances in Data Analytics, and the rise of Cloud Computing are helping IoT in tremendous ways.

Connectivity Models: IoT implementations use different technical communications models. Four common communications models described by the Internet Architecture Board include: Device-to-Device, Device-to-Cloud, Device-to-Gateway, and Back-End Data-Sharing. These models highlight the flexibility in the ways that IoT devices can connect and provide value to the user.

Transformational Potential: IoT may force a shift in thinking about the implications and issues in a world where the most common interaction with the Internet comes from passive engagement with

connected objects rather than active engagement with content. The potential realization of this outcome – a "hyper connected world". The products and services will not have any inherent limitations on the use of technology.

Like any new technology that pops up in the world, Internet of Things has some challenges and issues that need to be addressed. Although, these issues are not insurmountable, addressing these issues is imperative for the technology to be accepted and implemented, not just across various sectors, but also in countries where privacy and online content are scrutinised by the government organizations. Some of the key IoT issue areas are examined to explore some of the most pressing challenges. They are discussed below:

Security: Security considerations are not new in information technology, the attributes of many IoT implementations present new and unique security challenges. Poorly secured IoT devices and services can serve as potential entry points for cyber-attack and expose user data to theft by leaving data streams inadequately protected. As IoT is set to become extensive and an integral part of our daily lives, we need to trust that IoT devices and related data services are secure from vulnerabilities.

Privacy: Internet of Things is redefining the debate about privacy issues, as many implementations can dramatically change the ways personal data about users is collected, analysed, used. IoT amplifies concerns about the potential for increased surveillance and tracking, difficulty in being able to opt out of certain data collection due to interconnectivity of everything that we use in our daily lives.

Interoperability: Full interoperability across products and services used in IoT may not be always feasible or necessary. So, customers may be hesitant to buy IoT products and services if there is integration inflexibility or high ownership complexity. Also, poorly designed and configured IoT devices may have negative consequences for the networking resources they connect to. Hence, it is very important to have standards, reference models and best practices to curb these issues.

Legal issues: The data collected by IoT devices is sometimes susceptible to misuse, potentially causing discriminatory outcomes for some users. Other legal issues with IoT devices include the conflict between law enforcement organizations and civil rights; data retention and destruction policies; and legal liability for unintended uses, security breaches or privacy lapses. Data flow across borders can also pose a serious threat to various industries, especially Finance, as protection of client identifying data are of utmost importance in this sector.

Internet of Things Services

IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid, and expanding to areas such as smart cities. The forces that are driving it and the benefits that are

motivating it are increasingly numerous, as more and more organizations, industries, and technologists catch the IoT bug.

IoT services are used in numerous fields now due to the huge advantages it brings and the value adds it give to the business. Some typical advantages of IoT services are:

- Tracking behaviour in real-time;
- Enhanced situational awareness;
- Sensor-driven decision analytics;
- Process optimization;
- Optimized resource consumption; and
- Instantaneous control and response in complex autonomous systems

Some IoT services that are currently used across various sectors are mentioned below:

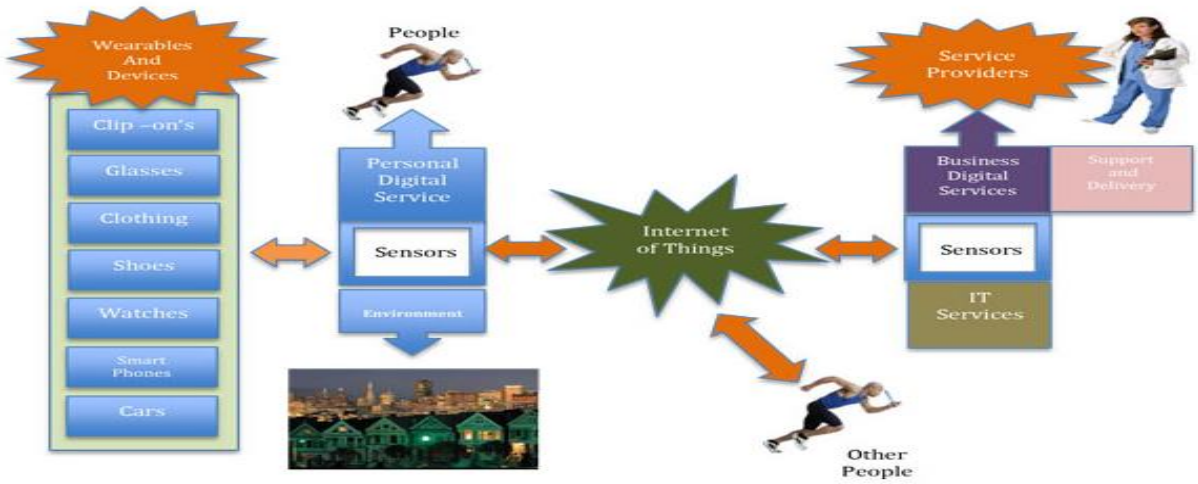
- Infrastructure management – Predictive Maintenance, Distribution Automation, Smart Buildings
- Manufacturing - Inventory and Material Tracking, Real-time asset monitoring, Single screen operator view, Connected Operational Intelligence
- Healthcare – Remote Health Monitoring, Smart Beds, Heart rate monitors
- Automotive – Predictive Maintenance and Safety, Fleet management, Connected cars
- Building and Home automation – HVAC, Light control, Security systems, Smart thermostat, Connected appliances
- Retail – Smart Shelves, RFID technology for Kiosks and Self-Checkouts, Temperature Monitors
- Smart cities – Street lighting, Environmental monitoring, resource management

In the case of ***Spectio***, they offered IoT services through the Light Management Systems (**LMS**) that provided values beyond the lighting services. Spectio improved the value proposition of lighting systems by connecting them through a wireless network and integrating sensors for ambient light, energy use, occupancy, and temperature. Spectio's central light management and analytics software called SpectioData, allowing a user to easily adjust the parameters of each luminaire from a central location. With SpectioData, a user could analyse the data and easily generate charts about lighting use, energy costs, and facility occupancy patterns. This resulted in huge savings for the companies and some were ready to use Spectio's IoT services beyond the LMS. They wanted an IoT service that would be a Building Management System, so that the whole infrastructure can be managed though IoT services.

IoT services are a mix of business and technical services. Though the services are primarily enabled by IT, these are very much required for the business. In Spectio's LMS systems, the services are enabled by sensors, devices that generate data and report business trends and issues. These data are then analysed with SpectioData and business insights are driven. Although, this sounds like it is an IT service, the LMS systems are expected to provide these outcomes. Thus, these are the business requirements too. Hence, IoT services can be called primarily IT enabled business services.

IT Service Management and the Internet of Things

ITSM lifecycle processes has helped so far in managing traditional IT services in various sectors. ITSM will help IoT service management extensively because IoT is still about products, people, processes and partners, though the products are now smarter in IoT. The products being made smarter now will only make ITSM processes become more efficient as a service management process in the context IoT service management.



The above picture appropriately shows the place of IT service providers in the context of IoT service management. The support and delivery of IT enabled business services will be managed by the service providers.

The fact that the products are smarter in IoT in a way that they generate data and report them in a timely interval will help to extract insights about the processes and business. Due to the huge amount of data generated by the various components in an IoT model, we get valuable information about the business. IoT provides the opportunity for managed services to improve their service interactions, gain more information about the users and their behaviors related to specific devices and services, and ultimately provide better support, maximize operational efficiency and reduce operational overhead.

IoT will particularly impact processes like asset and configuration management, incident management, change management etc., Asset and configuration management must deal with huge number of devices and sensors that will be used in the IoT services. Incident management will become proactive, as opposed to its reactive nature in the current scenario. The devices will be able to self-report any failures and hence Incidents can be identified and resolved efficiently and proactively. Hence, the incidents don't have to reported to a service desk. Change management must deal with highly complex changes. Unlike a traditional IT service change, any change to a node in IoT model must be assessed with respect to all other devices connected to that network as any change to a node can potentially impact other nodes or

even the whole network it is connected to. Due to the benefits IoT can give to ITSM, ITSM will move from a mere tactical service provider to a strategic business enabler.

In the case of ***Spectio***, they want to, beyond the Light Management System, provide new services to the customers by adding new software and services, like CO2 monitors, humidity monitors, air quality monitors to their portfolio. ITSM lifecycle processes from Service Strategy to CSI will help Spectio in planning, designing, transitioning, managing and continually improving their IoT services. ITSM will help Spectio in streamlining their IoT services through the best practices framework.

Service Management Processes for IoT

Considering the ITIL best practices, all phases and their associated processes would need to be considered. But a few of these are more important

- Event management – the rise of IT usage through IoT systems would increase the number of events generated. These events must be reported, analysed and serviced. Critical operations and devices will become digital dependency and any issues encountered must be resolved in a timely manner to prevent loss of business value. To ensure proper handling of unforeseen events, a robust and accessible process must be incorporated into the IoT system to ensure operational continuity and performance.
- Continual service management – the large dependency of digital devices for operations would require that the IoT system implemented would have robust availability and capacity. Apart from this, service warranty must be ensured so that operations are not hindered by discontinuity in service.
- IT security management – One of the primary concerns of an IoT system is operational and data security. A fully digital process would inject security vulnerabilities and make it more susceptible towards unauthorized access. This could lead to abnormal behaviour through intentional intervention, unauthorized control of devices and sensitive data exposure. Securing data and encrypted communication channels would be essential to ensure safety of the system and the information it contains. A traditional system although important is not as critical or life threatening in case of failure with abnormal operations. An IoT system that is more integrated into processes and daily life is more important towards operational functionality of the ecosystem it controls.
- Asset and configuration management – the large collection of connected devices will each have their own unique configurations and will be dependent on a large collection of assets. An IoT system must be designed to properly handle these assets. A well-documented system with easy access to asset information and control configurations is required to ensure that each device is serviced by its required assets and is configured per requirements. Any changes required in the IoT devices must be easy to make which can only be possible if the assets and control configurations are well-documented and operations are educated with the required information regarding these devices. Sufficient safely measures must be undertaken to secure these assets and configurations from unauthorized access.

Role of DevOps in the Internet of Things

The Internet of Things will bring about the convergence of previously disconnected devices and operations. IT and non-IT components will need to be more compatible requiring better co-ordination between development and operations to understand limitations of both current device operation as well as software. DevOps would help in the following ways

- The cultural divide between IT and industrial operations would surge with the introduction of IoT. Software engineers understand programming languages like Java, Python and the overall IP stack while industrial engineers speak of programmable logic controllers, sensors and SCADA (supervisory control and data acquisition). Apart from this, what may work in one isolated industry vertical may be incompatible in another vertical. DevOps will help bridge this ever-growing cultural divide and help in taking up interoperability initiatives to build new standards.
- The threat of connecting isolated physical devices to a network would result in complex security issues. Vulnerability in the system could disrupt operations and result in more adverse, life threatening situations. DevOps will help in understanding these operational concerns to develop a solid, secure system.
- The fusion of the physical and digital world will introduce privacy issues. Everything and everyone will be trackable, always. DevOps will help in understanding these concerns and accordingly make data ownership, compliance, access and sharing decisions to ensure critical privacy concerns.
- Device limitation is another factor of concern for IoT systems. Applications will run on smaller devices in differing environments. Understanding operational limitations like device battery life, form factor and environmental conditions apart from programming language while developing solutions will require DevOps based development.

Role of Agile in the Internet of Things

The Internet of Things is characterized by constant change – old products will evolve while new products will be introduced into the system. This dynamic nature and the requirements of quick solutions will be best supported by agile strategies.

- A traditional waterfall approach towards development is more suited for a traditional IT system. In IoT, it is essential that products and services be integrated with minimal interdependency. Agile allows for modular development wherein new components can be added to an operational system with minimum risk.
- The IoT system is enormous in size Trying to develop the entire solution and then validating its viability is a huge resource risk. Agile would allow incremental development that can be tested for quality and performance before more features and products are integrated. This will allow development to identify pitfalls in the system and work towards improving the system with successive iterations.
- Agile development aims at quicker delivery. The faced paced growth of the IoT ecosystem can leverage this quick development characteristic to introduce new products and services. The constant development, feedback and improvement loop will further improve the process and allow faster delivery with assured quality.
- Once the system is operational constant feedbacks and assimilated data can be analysed to identify trends and ensure compare them to operational targets. An agile strategy will allow

for timely integration of this knowledge during iterative developments. Positive changes will be quickly incorporated into the system and a process of self-correction will be established. A traditional system could benefit from feedback but the impact would be visible after a considerable time lapse. The IoT system would not only grow but also improve in quality and performance.

Lean IT and the Internet of Things

1. The role of LeanIT in the Internet of Things

   If not properly handled, the large collection of devices and processes in the IoT system along with continuous growth of the system will bring about redundancy in data, devices and processes. In a data-intensive environment like IoT, communication and data efficiency is critical to meet capacity requirements and ensure system availability. If wastage is not handled, the system would clutter with redundant and useless information as time goes by and would increase the workload of the system. This would hinder performance of other useful components.
   LeanIT aims towards ensuring minimum wastage in terms of data and communication of information. The goal of LeanIT in an IoT system will be to build a strategy that can define the required information that needs to be stored or communicated and the storage location. This will reduce resource (storage and communication bandwidth) wastage at important bottlenecks and distribute loads throughout the system. Only important and valuable data would be communicated on priority basis. Less vital information can be stored locally or communicated during low traffic timings.
2. The role of the Internet of Things in LeanIT

   Once implemented, a IoT system will be beneficial towards building a lean process in an organization. Data collected from the devices and sensors could be used to identify trends and calculate performance metrics. This data can help in identifying bottlenecks, lags and other general wastage sources in a process. This constant feedback system would further improve the process and bolster the Lean methodology.

Cloud Computing and Virtualization in IoT

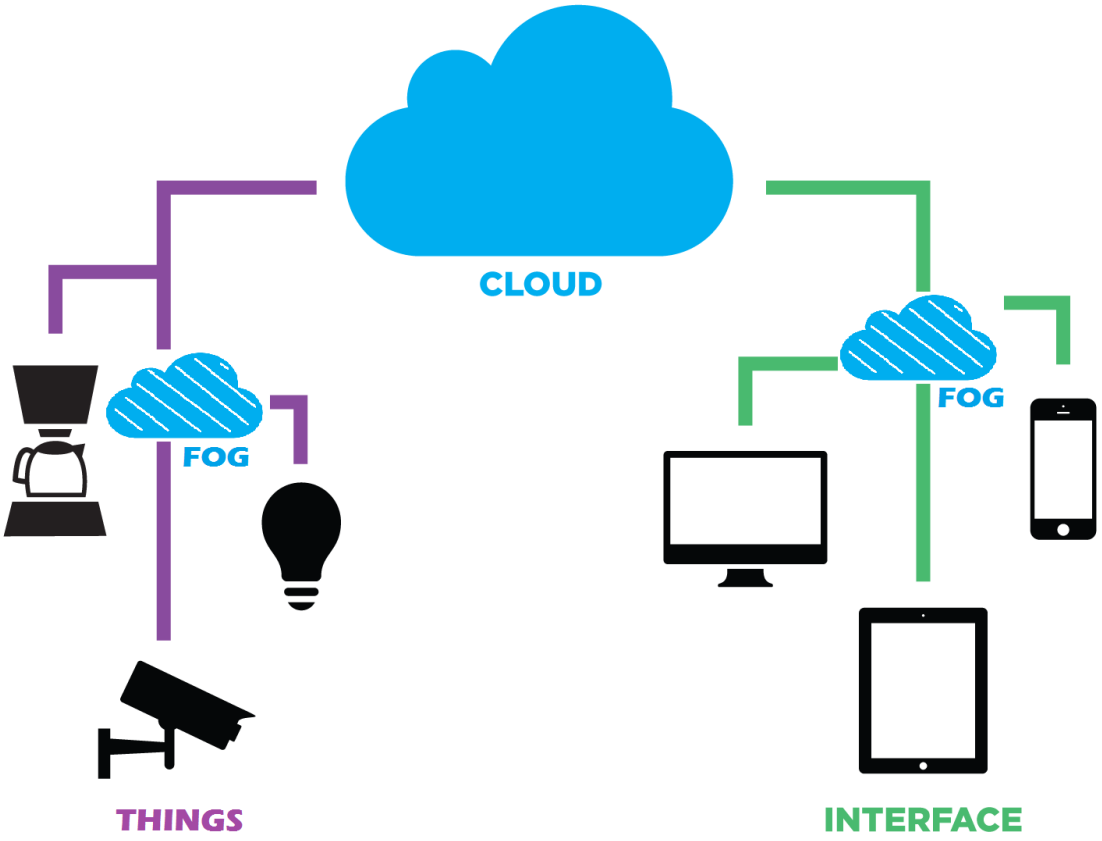
IoT will bring about associated data requirements. As the number of devices increase, so will the associated data. This data will themselves introduce their own additional requirements like storage, security and communication. Following are some of the requirements of an IoT systems and how cloud computing can help better achieve their goals

- Storage is a primary requirement for and IoT system. Creating traditional, on-site storage solutions are cost heavy and bring about security concerns. A cloud solution can benefit customer as it reduces infrastructural cost. A cloud provider can provide a viable storage solution with the required security measures in place. This would reduce investments and the risk factor for customers that are present in maintaining their own servers.
- IoT requires centralized access – anyone can access the system with platform independence. The cloud allows its customers remote access to their data using any platform.
- An IoT system is highly dependent on service availability and capacity warranty. To ensure these performance measures are met, customers would have to bear considerable operational

costs. A cloud service provider ensures continuous service availability with high robustness measures and required capacity always.

- IoT systems are scalable and hence their data centres must be scalable with them. For a customer to scale his private data centre and infrastructure would be resource heavy. A cloud service, on the other hand, facilitates scaling through additional subscriptions. Thus, only operational expenses increase while capital investment is minimized.

Although a cloud solution is ideal due to its flexibility and scalability, how much can it scale and will it output the same performance levels. As more devices and sub-systems are added into the IoT ecosystem, the load on a single cloud creates a bottleneck that cannot be solved by simply scaling the resources. A structured division of the same resources through virtualization is the ideal solution for this problem. Fog computing was developed to answer the resource and compatibility issues of large IoT systems like smart cities.



Fog computing is a virtualized platform that creates an interface between the devices of an IoT system and the cloud that provides the services. It creates sub-systems within the larger ecosystem to create a hierarchical structure for better service delivery and performance.
This collection of virtual layers or 'fogs' collect data from edge devices and convert it into compatible data formats. Computations that can be handled locally are done at this virtual interface. For other critical communications and processes, the fog connects with the primary cloud that assimilates the data, performs the required service operations before distributing the information back to the required local fog. The concerned fog then converts the information back to desired formats and relays it within the sub-system to the concerned edge devices.

Fogs provide the following benefits

- Fogs create a virtual layer between the devices (sub-systems) and the main computing environment of the IoT system. By converting data from specialized format to common formats and vice-versa they facilitate compatibility and interoperability within the IoT system (which is a collection of different platforms, environments and languages).
- Fogs provide better latency in communications and better storage services by localizing non-critical data storage. The can act as buffers that delay non-critical data transmission based on network and processing loads.
- Fogs are used for localized processing to reduce the workload on the primary cloud and allow better utilization of bandwidth and processing power. The main IoT system can process more critical operations while local fogs perform local tasks (based on configurations provided by the core system). This bolsters availability and capacity to improve overall performance.

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