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INTERNET OF THINGS (IOT) AND ITS APPLICATIONS

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***Abstract*— Internet of Things is a network of internet-connected objects able to collect and exchange data using embedded sensors. The vision of the Internet of things has evolved due to a convergence of multiple technologies, including ubiquitous wireless communication(*Ubiquitous Connectivity*—Low–cost, high–speed, pervasive network connectivity, especially through licensed and unlicensed wireless services and technology, makes almost everything "connectable''), real-time analytics, machine learning, commodity sensors, and embedded systems. This offers the ability to measure, infer and understand environmental indicators, from delicate ecologies and natural resources to urban environments. The proliferation of these devices in a communicating–actuating network creates the Internet of Things (IoT).**

***Index Terms*— Internet of Things, Ubiquitous sensing, Cloud computing, Wireless sensor networks, RFID, Smart environments, Sensors, Actuators.**

I. Overview of IoT

IoT can be seen as a sophisticated network of things. Things that are not just typical computers or mobile phones or machines but the things like door-lock, diapers, watches or anything you believe in to make life smarter and easier. It is excellent combination of multiple technologies to enable better life. The Internet of Things is the collection of objects on the internet or network that humans rely on to make their lives easier.

The **Internet of things** is the internetworking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Typically, 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.

Internet of Things primarily needs 3 building blocks to make it functional. These are, a thing itself which could be door-lock, water tank, etc., then a connecting mechanism such as RF transmitter / receiver, NFC, Bluetooth, etc. and a stable & secure communication method or protocol. From purely designers' perspective, security, identity management, semantics, compatibility with multiple communication standards, lower power, lower costs and nil or least interference would be the major criterion for IoT based products.

II. IoT- COMMUNICATION MODELS

A. *Device-to-Device Communications*

The device-to-device communication model represents two or more devices that directly connect and communicate between one another, rather than through an intermediary application server. These devices communicate over many types of networks, including IP networks or the Internet. Often, however these devices use protocols like Bluetooth, Z-Wave, or ZigBee to establish direct device-to-device communications. Residential IoT devices like light bulbs, light switches, thermostats, and door locks normally send small amounts of information to each other in a home automation scenario require redundant development efforts

B. *Device-to-Cloud Communications*

In a device-to-cloud communication model, the IoT device connects directly to an Internet cloud service like an application service provider to exchange data and control message traffic. This approach frequently takes advantage of existing communications mechanisms like traditional wired Ethernet or Wi-Fi connections to establish a connection between the device and the IP network, which ultimately connects to the cloud service. This cloud connection enables the user to obtain remote access to their thermostat via a smartphone or Web interface, and it also supports software updates to the thermostat.

C. Device-to-Gateway Model

In the device-to-gateway model, or more typically, the device-to-application-layer gateway (ALG) model, the IoT device connects through an ALG service as a conduit to reach a cloud service. This means that there is application software operating on a local gateway device, which acts as an intermediary between the device and the cloud service and provides security and other functionality such as data or protocol translation. Several forms of this model are found in consumer devices like personal fitness trackers.

D. Back-End Data-Sharing Model

The back-end data-sharing model refers to a communication architecture that enables users to export and analyze smart object data from a cloud service in combination with data from other sources. This architecture supports the user's desire for granting access to the uploaded sensor data to third parties. For example, a corporate user in charge of an office complex would be interested in consolidating and analyzing the energy consumption and utilities data produced by all the IoT sensors and Internet-enabled utility systems on the premises.

III. IPV6 AND IOT

As the Internet of Things continues to grow, devices that require true end-to-end Internet connectivity will not be able to rely on IPv4, the protocol most Internet services use today. They will need a new enabling technology: IPv6. IPv6 is a long-anticipated upgrade to the Internet's original fundamental protocol – the Internet Protocol (IP), which supports all communications on the Internet. IPv6 is necessary because the Internet is running out of original IPv4 addresses. While IPv4 can support 4.3 billion devices connected to the Internet, IPv6 with 2 to the 128th power addresses, is for all practical purposes inexhaustible. IPv6 is the best connectivity option and will allow IoT to reach its potential. The Internet of things requires huge scalability in the network space to handle the surge of devices. With billions of devices being added to the Internet space, IPv6 will play a major role in handling the network layer scalability.

IV. APPLICATIONS OF IOT

The applications can be classified based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact. The first internet appliance, was a Coke machine at Carnegie Melon University in the early 1980s. The programmers could connect to the machine over the internet, check the status of the machine and determine whether or not there would be a cold drink awaiting them, should they decide to make the trip down to the machine.

A. Medical and healthcare

IoT devices can be used to enable remote health monitoring and emergency notification systems which range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants, such as pacemakers, Fitbit electronic wristbands or advanced hearing aids and many people are already strapping smartwatches or fitness bands to their wrists to track their steps or heartbeat while on a run. Some hospitals have "smart beds" that can detect when they are occupied and when a patient is attempting to get up, adjust itself to ensure appropriate pressure and support is applied to the patient without the manual interaction of nurses. Specialized sensors can also be equipped within living spaces to monitor the health and general well-being of senior citizens, while also ensuring that proper treatment is being administered and assisting people regain lost mobility via therapy as well. Sensors placed on the patient can monitor many of these signs remotely and continuously, giving practitioners early warning of conditions that would otherwise lead to unplanned hospitalizations and expensive emergency care. Pill-shaped microcameras already traverse the human digestive tract and send back thousands of images to pinpoint sources of illness.

B. Agriculture and Farming

Precision farming equipment with wireless links to data collected from remote satellites and ground sensors can take into account crop conditions and adjust the way each individual part of a field is farmed by spreading extra fertilizer on areas that need more nutrients. Farmers have also been turning to connected sensors to monitor both crops and cattle, in the hopes of boosting production, efficiency and tracking the health of their herds. Water network monitoring and quality assurance of drinking water sensors are installed at important locations in order to ensure high supply quality. This avoids accidental contamination among storm water drains, drinking water and sewage disposal. The same network can be extended to monitor irrigation in agricultural land. The network is also extended for monitoring soil parameters which allows informed decision making concerning agriculture.

C. Business and Industry

When products are embedded with sensors, companies can track the movements of these products and even monitor interactions with them. Insurance companies, are offering to install location sensors in customers' cars. That allows these companies to base the price of policies on how a car is driven as well as where it travels. In the business-to-business marketplace, sensors are used to track RFID tags placed on products moving through supply chains, thus improving inventory management while reducing working capital and logistics costs. In retailing, companies gather and process data from thousands of shoppers as they journey through stores. Sensor readings and videos note how long they linger at individual displays and record what they buy. Simulations based on this data will help to increase revenues by optimizing retail layouts.

In the aviation industry, manufacturers of jet engines retain ownership of their products while charging airlines for the amount of thrust used. Airplane manufacturers are building airframes with networked sensors that send continuous data on product wear and tear to their computers, allowing for proactive maintenance and reducing unplanned downtime.

In the chemical industry, sensors feed data to computers, which in turn analyze them and then send signals to actuators that adjust processes, by modifying ingredient mixtures, temperatures, or pressures and to change the position of a physical object as it moves down an assembly line, ensuring that it arrives at machine tools in an optimum position .This improved instrumentation, multiplied hundreds of times during an entire process, allows for major reductions in waste, energy costs, and human intervention.

In the pulp and paper industry, production is increased by using embedded temperature sensors whose data is used to automatically adjust a kiln flame's shape and intensity. Reducing temperature variance to near zero improves product quality and eliminates the need for frequent operator intervention.

In the oil and gas industry, extensive sensor networks placed in the earth's crust produce more accurate readings of the location, structure, and dimensions of potential fields than current data-driven methods allow thereby causing lower development costs and improved oil flows.

D. *Security sensors and Defense*

Security personnel can use sensor networks that combine video, audio, and vibration detectors to spot unauthorized individuals who enter restricted areas. Logistics managers for airlines and trucking lines already are tapping some early capabilities to get up-to-the-second knowledge of weather conditions, traffic patterns, and vehicle locations thus increasing their ability to make constant routing adjustments that reduce congestion costs and increase a network's effective capacity. Law-enforcement officers can get instantaneous data from sonic sensors that are able to pinpoint the location of gunfire. Scientists in other industries are testing swarms of robots that maintain facilities or clean up toxic waste, and systems under study in the defense sector would coordinate the movements of groups of unmanned aircraft causing major gains in safety, risk, and costs.

E. *Media*

The combination of analytics for conversion tracking with behavioural targeting has unlocked a new level of precision that enables display advertising to be focused on the devices of people with relevant interests. From a media perspective, data is the key derivative of device interconnectivity, whilst being pivotal in allowing clearer accuracy in targeting. The Internet of things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness.

F. *Environmental monitoring*

Environmental monitoring applications of the IoT typically use sensors to assist in environmental protection, by monitoring air or water quality, atmospheric or soil conditions, and can even include areas like monitoring the movements of wildlife and their habitats. Development of resource constrained devices connected to the Internet also means that other applications like earthquake or tsunami early-warning systems can also be used by emergency services to provide more effective aid. IoT devices in this application typically span a large geographic area and can also be mobile. Data from large numbers of sensors, deployed in infrastructure (such as roads and buildings) or to report on environmental conditions (including soil moisture, ocean currents, or weather), can give decision makers a heightened awareness of real-time events, particularly when the sensors are used with advanced display or visualization technologies.

G. *Infrastructure management*

Monitoring and controlling operations of urban and rural infrastructures like bridges, mechanical, electrical and electronic systems used in various types of buildings, railway tracks, on and offshore wind-farms, structural conditions that can compromise safety and increase risk is a key application of the IoT. It can also be used for scheduling repair and maintenance activities in an efficient manner. When we rebuild bridges, we can use smart cement: cement equipped with sensors to monitor stresses, cracks, and war pages and alerts us to fix problems before they cause a catastrophe. If there's ice on the bridge, the same sensors in the concrete will detect it and communicate the information via the wireless internet to your car. Once your car knows there's a hazard ahead, it will instruct the driver to slow down, and if the driver doesn't, then the car will slow down for him. When a smart car and a smart city grid communicate we have traffic flow optimization, because instead of just having stoplights on fixed timers, we'll have smart stoplights that can respond to changes in traffic flow. Traffic and street conditions will be communicated to drivers, rerouting them around areas that are congested, snowed-in, or tied up in construction.

H. *Manufacturing*

The IoT intelligent systems enable rapid manufacturing of new products, dynamic response to product demands, and real-time optimization of manufacturing production and supply chain networks, by networking machinery, sensors and control systems together. IIoT (Industrial Internet of Things) in manufacturing would generate so much business value that it will eventually lead to the fourth industrial revolution by creating new business models and improve productivity, exploit analytics for innovation, and transform workforce. The objective of intelligent maintenance systems is to reduce unexpected downtime and increase productivity.

I. *Energy management*

IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, air conditioners, refrigerators, washing machines etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. Such devices would also offer the opportunity for users to remotely control their devices. This can be achieved by continuously monitoring every electricity point within a house and using this information to modify the way electricity is consumed. Networked sensors and automated feedback mechanisms can change usage patterns for scarce resources, including energy and water, often by enabling more dynamic pricing. Based on time-of-use pricing and better information residential consumers could shut down air conditioners or delay running dishwashers during peak times. Commercial customers can shift energy-intensive processes and production away from high-priced periods of peak energy demand to low-priced off-peak hours. Smart meters , have clever functions that let you turn on heating remotely, set it to turn down the temperature if it's a sunny day, or even turn off when there's no-one home.

J. Transportation

Dynamic interaction between the components of a transport system enables inter and intra vehicular communication, smart traffic control, smart parking, electronic toll collection systems, logistic and fleet management, vehicle control, and safety and road assistance. The transport IoT will enable the use of large scale WSNs for online monitoring of travel times, origin–destination (O–D) route choice behavior, queue lengths and air pollutant and noise emissions. The automobile industry, is stepping up the development of systems that can detect imminent collisions and take evasive action. Certain basic applications, such as automatic braking systems, are available in high-end autos. Automotive autopilot for networked vehicles drive in coordinated patterns at highway speeds. This technology would reduce the number of "phantom jams" caused by small disturbances that cascade into traffic bottlenecks.

K. Metropolitan scale deployments

There are several planned or ongoing large-scale deployments of the IoT, to enable better management of cities and systems. For example, Songdo, South Korea, fully equipped and wired smart city, connected and turned into a constant stream of data that would be monitored and analyzed by an array of computers with little, or no human intervention. Another application is in Santander, Spain. This city of 180,000 inhabitants, has already seen 18,000 city application downloads for their smartphones. This application is connected to 10,000 sensors that enable services like parking search, environmental monitoring, digital city agenda among others. Other examples of large-scale deployments underway include the Sino-Singapore Guangzhou Knowledge City; work on improving air and water quality, reducing noise pollution, and increasing transportation efficiency in San Jose, California; and smart traffic management in western Singapore. Another example of a large deployment is the one completed by New York Waterways in New York City to connect all the city's vessels and be able to monitor them live. New applications can include security, energy and fleet management, digital signage, public Wi-Fi, paperless ticketing and others.

L. Utilities

Smart grid and smart metering is another potential IoT application which is being implemented around the world. Video based IoT , which integrates image processing, computer vision and networking frameworks, will help develop a new challenging scientific research area at the intersection of video, infrared, microphone and network technologies. Surveillance, the most widely used camera network applications, helps track targets, identify suspicious activities, detect left luggage and monitor unauthorized access.

V. Conclusion

The term "Internet-of-Things" is used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities. Internet-of-Things envisions a future in which digital and physical entities can be linked, by means of appropriate information and communication technologies, to enable a whole new class of applications and services. IoT promises to usher in a revolutionary, fully interconnected "smart" world, with relationships between objects and their environment and objects and people becoming more tightly intertwined. Fueled by the recent adaptation of a variety of enabling wireless technologies such as RFID tags and embedded sensor and actuator nodes, the IoT has stepped out of its infancy and is the next revolutionary technology in transforming the Internet into a fully integrated Future Internet. As we move from www (static pages web) to web2 (social networking web) to web3 (ubiquitous computing web), the need for data-on-demand using sophisticated intuitive queries increases significantly.

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