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INTERNET OF THINGS (IoT): APPLICATIONS AND RESEARCH DIRECTION

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Abstract: - Internet of things can be considered as a network in which all objects are uniquely identifiable and are able to communicate with each other. Internet of thing (IoT) architecture is composed of wireless sensor network, cloud storage data analytic techniques and visualization tools. Data is collected from sensors then transferred to central cloud storage and at this centralized storage various data analytic techniques are applied to data to generate useful information which can accessed by user using visualization tools. Internet of thing is a very new concept and various research directions are associated with it. In this paper we have discussed various application and research direction of Internet of Things.

Keywords: Internet of Things, Wireless sensor network (WSN)

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INTRODUCTION

The next era of computing will not just be confined to desktops, laptops and mobile but many day to day usable things comes under the umbrella of IoT. IoT can be considered as networks where many objects surrounding us are uniquely identifiable and are able communicate with each other. Technologies like RFID(Radio Frequency Identification) and WSN (wireless sensor network), wifi, bluetooth etc. will provide the basis for connecting things and creating the network of things. IoT will not be considered as just measuring sensor data, but include various components like middleware software for collecting sensor data, analyzing them and visualization software to present a user interface for viewing that information and analyzing it. The sensors normally generate large amount of data and data which is collected, have no value unless it is processed so that we can understand, interpret and analyze data. Data collected for sensors should be stored somewhere for processing; since the data is very large size and it should be accessible to all so data should be stored on cloud. Cloud computing provide infrastructure for software which monitor sensor device, provide storage services, analytic tool and interface for visualization. Basically IoT comprises three component first sensors which measure the data second software architecture and network which collects the data and stores it, third analytic tool which analyze the data to get meaningful information and taking decision. Khoo [2] explained the evolution of web in four stages (1) Web 1.0- It is readable version of web only with flat data (2) web 2.0 – It is writable version of web with interactive data (3) web 3.0- It is executable version of web with application program (4) web 4.0 which includes IoT. The invention of internet provided interconnection among peoples via network and next era of computing like ubiquitous computing or context aware computing will provide connection between objects.

DEFINITION OF IOT

Various standard definition have been given by researchers

According to Jayavardhana Gubbi[3] “Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless large scale sensing, data analytics and information representation using cutting edge ubiquitous sensing and cloud computing”

According to Cluster of European research projects on the IoT [5] “ Things are active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and

information sensed about the environment, while reacting autonomously to the real/physical world events and influencing it by running processes that trigger actions and create services with or without direct human intervention. “

According to Forrester [6], a smart environment “Uses information and communications technologies to make the critical infrastructure components and services of a city administration, education, healthcare, public safety, real estate, transportation and utilities more aware, interactive and efficient.

According to Guillemin [10] “The IoT allows people and things to be connected anytime, anyplace, with anything, anyone, ideally using any path/network any service”

APPLICATIONS OF IOT

IoT a technology which connects objects over internet so that they can transfer information to each other. The IoT has found its way into our homes, cars, clothing, and much more, introducing new levels of convenience, interactivity, and monitoring. Beyond consumer and commercial applications, reliance on the IoT has extended to the industrial sector.

Environmental Monitoring- sensors can be deployed to monitor environmental parameters such as data of rainfall, temperature, pressure, moisture, soil health etc at various location and this data is used by scientist for doing predictions about rainfall, earthquake, tsunami etc. Environmental sensors can monitor the movement of wildlife and their habitats.

Smart Home- The concept of IoT can be used in small premises even in home. There are various ways to use sensors in home by changing passive home to smart home. Smart home can include door control, lighting control, motion detector, window control by using sensors to detect the changing context position. Wearable devices like smart watches, fitness band are also available in the market.

Smart Industry – Latest technological changes brings an assortment of opportunities along with challenges in industry sector. IoT can play a vital in manufacturing companies by together with smart machines that can perform machine to machine interaction along with transforming data over internet. Industrial IoT include machine to machine interaction and big data technologies, analysis of sensor data, information transfer and automation technologies. The data generated by sensors or smart devices is used for automation and control means converting the data and analysis collected through the IoT into instructions that feed back through the network to actuators that in turn modify processes. Use of these new smart technologies in industry increased production and reduced energy, cost and human intervention.

Smart Medical and Healthcare-IoT is a technology which improves the quality and increase easy usability of healthcare equipment that reform the medical industry. According to a new report from MarketResearch.com 2015, the healthcare IoT market segment is poised to hit $117 billion by 2020. IoT devices can be used for remote health monitoring, remotely actuation of medical equipment etc. IoT in healthcare can connect various units like hospital like doctor, equipment, response vehicles, emergency units, smart healthcare devices etc. Data should be in encrypted form so that personalized medical data will not be accessed by unauthorized person. There are plenty of wearable devices are available in market like smart watch, fitness band, the Sony Smart B Trainer, the Myo gesture control, or LookSee bracelet, smart glass etc. which are able to sense human body activities.

Smart City- The popularity of smart cities is getting amplified from some years due to many smart city solutions promise to provide proper management of cities. Smart city covers various aspects like traffic management, water distribution, waste management, urban security and environmental monitoring. IoT solutions can solve various problems like traffic congestion problem, over energy usage and pollution problems

Smart Agriculture- Modern famers are not only using classical method of farming but they take advantage of sensors, apps, Mobile, Tablets and all generated data. Experts use this data for taking decision of farming like which seed to sow, when to harvest, when to irrigate etc. By data generated from GPS and sensors on the field and farming equipment, and using big data analytics, farmers have been able to improve crop yields and water utilization. Various platform solutions for farming IoT have been developed like AgVerdict, Open Ag Data Alliance (OADA) for precision farming, semios for pest control etc.

CHARACTERISTICS

Interoperability- This means IoT requires standards to enable horizontal platforms that are communicable, operable, and programmable across devices, regardless of make, model, manufacturer, or industry. Without interoperability it is not possible to standardize IoT concept. All the devices participating in IoT should have common architecture standard so that common protocols can be developed which can work on all devices. IEEE Standards Association (IEEE-SA) has a number of standards, projects and events that are directly related to creating the environment needed for a vibrant IoT.

Real Time working- The concept of IoT will totally not useful if it will not ensure real time working. Any information which arrives late will not be useful any more so it is necessary that sensor device should respond in real time as well time taken by network to transfer the data

and processing time of data in centralized processor should be minimized so that user will be in illusion whole IoT system is working in real time.

Open architecture- Open architecture is a type of computer architecture or software architecture that is designed to make adding, upgrading and swapping components easy [8]. Specification of open architecture is public. Since different architecture based devices and sensors are used in IoT so there is a need that IoT devices will have open architecture so that different devices can work with each other as well as anyone can design add-on products. By making architecture specification public it is easy for anyone to add additional features to it.

Scalable- The IoT technology should be scalable so that network extension will be possible. Addition of new devices should not hamper the performance of network as well as existing software and hardware should be able to tackle extension of existing network.

Intelligence- Without intelligence the concept of IoT will only be passive. Centralized data processing units should have intelligence so that action could be taken same as human takes decision. Without proper data analytic schemes centralized data center will only work as centralized storage which don't have capacity to analyze large amount of data.

IoT ELEMENTS

IoT has three key elements

Wireless Sensor Network - First step in IoT is get started with accumulating information from surroundings. Sensors are objects which detect events or changes in environment or surrounding. This information can be captured by sensing devices like wearable devices, environment sensor, proximity sensors, material sensors, voice sensors, optical sensors etc. The sensing can be biometric, environmental, audio visual etc. Sensing technologies provide us with the means to create experiences that reflect a true awareness of the physical world and the people in it. Sensor used various signal transferring technology like Radio Frequency Identification (RFID), Wifi, Bluetooth, ZigBee, Near-field or a range of other short range communication methods.

Cloud based capture & Analytic Tools- when the data is gathered from various devices, it must pass to cloud based platform where data is piled up. The data being consolidated can be information from other internet sources as well as from others with similar IoT devices. Various analytic tools are there which uses artificial intelligence techniques to analyze the data and generating meaningful information from that. Novel fusion algorithms need to be developed to make sense of the data collected. State of the art nonlinear, temporal machine learning

methods based on evolutionary algorithms, genetic algorithms, neural networks, and other artificial intelligence techniques are necessary to achieve automated decision making [3]. Various cloud solutions for IoT are available in market like RTI, ThingWorx, Cisco, SalesForce, gePredix etc.

Visualization- Visualization tools provide interaction of user with IoT. Various visualization tools are available in market like IBM Bluemix, ThingSpeak, Freeboard etc. These visualization tools uses multimedia techniques like 2D, 3D, Rendering etc. to show real fluctuation in sensor data. For a layman visualization tools are really useful by being easy to use and attractive.

CHALLENGES AND RESEARCH DIRECTION IN IoT

IOT is a very advanced concept covering all things in umbrella of internet so there are various challenges associated with it and based on these challenges research areas can be easily extracted. We can classify challenges associated with IoT in following directions.

Identification- We have already discussed that it is necessary condition for every device to be part of IoT that it should be uniquely identifiable. For applying this concept to worldwide we need to have global ID scheme and there should be proper management of these IDs like which id belongs to which device, whether the ID is permanently issued or for temporary basis. Other issue which should be addressed is that for security purpose ID can be encrypted so that no one can unveil identity of other. Psuedonymity is also other issue which should also be considered. Psuedonymity means if someone want to participate in IoT without unveiling its identity then he can also be part of IoT as anonymous user. If there is some unwanted activity by a device then this identity should be revocable. If something new is getting connected to IoT then It should be authenticated to identify which is true participator and which is fake.

Network- Networks which connect devices can be both wired and wireless. Wireless network technology has gained more attention due to providing unobtrusive communication. Chip communication architecture is a necessity of an hour where small chips are able to communicate with each other. Power aware network design will be needed in future which will turn on or off the links based on increase or decrease in network traffic. Scalable communication infrastructure will be needed which can dynamically support network architecture on varying workload. Dynamic routing schemes and ability to provide variable number of virtual connection will be required. Various issues to be address in research work on network part of IoT like autonomic computing and networking, scalable network, Anonymous network, IP and post IP technologies etc.

Communication- communication technologies presented today are not enough to cater need of IoT. New radio and service architecture is required to fulfill connectivity demand of connecting devices. It is necessary to ensure that hardware up gradation should be minimum with new protocol. IPv6 came into existence to provide unique address to devices because IPv4 was not enough. In future as the connectivity of devices will grow up there will requirement of addressing techniques even beyond IPv6. Protocols which are scalable and having high performance will be need of future. Communication technologies should consider sensor to sensor communication, communication from sensor to distributed storage devices, communication with cloud platform, communication for localization and tracking of devices etc.

Architecture- Since billions of devices are connected to IoT then there should be adequate architecture to cope with interoperability, communication and connectivity. For globally connecting things the IoT architecture should be open architecture. Open architecture is needed because mostly connected devices are heterogeneous and for connecting heterogeneous devices open architecture is needed which should be understood every device without regard of its make, model, type etc. Net neutrality is also applicable to IoT. Net neutrality is a principal that all internet traffic should be treated equally [4] and not discriminating data on the basis of user, content, site, platform, type of attached equipments or mode of communication. Various issues like event driven architecture, open architecture, cloud architecture, synchronization are there which could be focused under IoT. A new concept a fog computing is also emerging in IoT on which research can be done. Fog computing also called fogging is a distributed architecture. Fog computing, services can be hosted at end devices such as set-top-boxes or access points. The infrastructure of this new distributed computing allows applications to run as close as possible to sensed actionable and massive data, coming out of people, processes and thing[9]

Algorithms- Only with appropriate software concept of IoT can be realized to day to day use. Software and algorithms should be manageable and they should support self configuration and auto recovery after failure. Software provides abstraction from underlying heterogeneous hardware dispersed in various geographical locations. Software can be executed and deployed remotely like some IoT device has been installed in some remote location then software should provides such type of services by which there is no need to go to that location for operating that device this can be done remotely then this type of software services are called distributed intelligence. Various software issues on which research work can be focused are(1) service discovery and composition since there are millions of IoT devices are available of how does an IoT device identify a particular service(2) semantic interoperability- It means software are able

to work on devices which have different architecture (3)data sharing between various services(4) propagation (5)autonomous agent (6)human machine interaction (7)self management and self recovery techniques (8) lightweight open middleware (9) Energy efficient micro operating system (10) Virtualization software (11) software for object interaction (12) Bio Inspired algorithm for self healing and self management (13) Data mining (14) Big Data analytics etc.

Hardware – IoT hardware chips should be able to work in low power situation. We need the hardware for IoT which is programmable but having very low power field programmable gate array for dynamically changing environment. The IoT devices can have context switching architecture, where a set of configurations are available and device can switch between these configurations depending upon requirement. Research is needed for very large scale integrated (VLSI) circuit containing scalable cognitive hardware system and self adaptive network on chip that adapt underlying infrastructure on demand in response to changing demand imposed by application or context. Research on IoT related to hardware technology can be focused on nanotechnologies, Sensor technologies, solution bridging systems, self healing circuit architecture, Polymer electronics, micro energy microprocessor, hardware acceleration, Spintronics, Low cost and High performance devices, Temper resistance technologies etc.

Search Engine Technology- In IoT all devices are located in dispersed geographical locations so it is necessary to develop technologies for searching and discovering resources according to capability, offered services, locations, information that they can provide etc. Search and discovery services are not only used by human but they can also be used by application software to search objects. For efficient search and discovery semantic tagging of information will be necessary because a large volume of information is generated by devices every minute and it is great challenge to ensure that this large volume of data will be tagged automatically without human intervention. Discovery and search engine technologies should be to include geometry concept like spatial overlap and separation. Research on IoT can be focused on data discovery and distributed repository, geographical positioning, mapping of real digital and virtual entities, semantic tagging, Universal authentication mechanism etc.

Power and energy storage- Objects require a digital self for being part of IoT. IoT devices need batteries to power the electronic devices. Energy storage has become one of the most important obstacles to the miniaturization of devices. Today all sensors and electronic devices depends upon batteries that will require recharging. Energy harvesting is very inefficient process that will require a greater research emphasis. Sources for energy harvesting in embedded devices could include solar energy, thermal energy, geothermal energy etc. Micro

power technology has emerged as new technology that can provide many development opportunities for IoT devices. Various research issues that need to be addressed are energy harvesting/scavenging for micro devices, Energy conservation schemes, Thermoelectric system and microcoolars, Photovoltic systems, Micro fuel cell and micro reactors , Micro power ICs , Micro battery technologies, energy storage and micro super capacitor technologies etc.

Privacy and Security- IoT is a technology which covers millions of devices so it should ensure privacy and security of data. Consumer needs confidence to fully rely on IoT. Privacy of human and things must ensure to prevent unauthorized identification and tracking. Various research issues that need to be addressed regarding security and privacy are self aware behavior of devices, privacy preserving technologies for heterogeneous set of devices, models for decentralized authentication and search, Energy efficient encryption and data protection technologies, data ownership, legal and liability issues, access and use rights, Rules to share added value responsibility, liabilities, self healing intelligence etc.

Standardization- The IoT support interaction among many heterogeneous sources of data and heterogeneous devices through standard interface and data models to ensure high degree of interoperability. Almost every standard body is working in IoT like IEEE, IETF, ITU, ETSI etc. Seven organizations joined together to avoid duplication ARIB, ATIS, CCSA, ETSI, TIA, TTA, TTC are combined to oneM2M. Although many standards may co exist but there should be semantic mapping and cross referencing to enable information exchange. Various issues that need to be addressed regarding standardization are IoT standardization, Ontology based semantic standard, communication protocol standard, standard for communication with cloud, International quality and integrity standard for data creation and data traceability etc.

CONCLUSION

In future, computing power will not only limited to laptop, Mobiles, desktop but other things like TV, car, machines, home appliances will also covered under the umbrella of IoT. Application of IoT covers various areas like smart home, smart healthcare, smart vehicle, smart traffic management, smart agriculture, smart industry etc. IoT opens up new directions for researchers by merging real world and virtual world using embedded devices and sensors. In this paper we have discussed basic concept of IoT, Applications, architecture, challenges and research direction. IoT is considering as a future technology which accelerates ICT growth and opens up various research directions.

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