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STUDY OF ADVANCED PROFESSIONAL SOLUTIONS FOR INTERNET OF THINGS (IOT) BASED IDEAS SMART CITIES: CHALLENGES AND OPPORTUNITY

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ABSTRACT:- The smart cities and the Internet of Things (IoT) represent a revolutionary leap in urban development, reshaping the way city's function and interact with their inhabitants. This paper provides a concise overview of the landscape, focusing on emerging technologies and challenges within the realm of Smart Cities and IoT integration. Smart Cities leverage IoT technologies to enhance efficiency, sustainability, and the overall quality of urban life. The Internet of Things is a novel cutting edge technology that proffers to connect a plethora of digital devices endowed with several sensing, actuation, and computing capabilities with the Internet, thus offering manifold new services in the context of a smart city. The appealing IoT services and big data analytics are enabling smart city initiatives all over the world. These services are transforming cities by improving infrastructure and transportation systems, reducing traffic congestion, providing waste management, and improving the quality of human life. In this article, we devise taxonomy to best bring forth a generic overview of the IoT paradigm for smart cities, integrated ICT, network types, possible opportunities and major requirements. Moreover, an overview of the up-to-date efforts from standard bodies is presented. Later, we give an overview of existing open source IoT platforms for realizing smart city applications followed by several exemplary case studies. In addition, we summarize the latest synergies and initiatives worldwide taken to promote IoT in the context of smart cities. Finally, we highlight several challenges in order to give future research directions.

KEYWORD:- Smart cities; IoT; data collection; urban environment; urban development.

INTRODUCTION:-

The Internet of Things (IoT) is a revolutionary communication paradigm that aims to bring forth an invisible and innovative framework to connect a plethora of digital devices with the Internet. Thus, it intends to make the Internet more immersive and pervasive.

In the 21st century, the concept of Smart Cities has emerged as a visionary approach to urban development, transforming traditional urban landscapes into intelligent, interconnected hubs of innovation (Bibri and Krogstie, 2019). At the heart of this evolution lies the integration of the Internet of Things (IoT), a network of interconnected devices and sensors that bridge the physical and digital realms (Upadhyay *et al*., 2023).

The advent of IoT technologies has provided cities with unprecedented capabilities to collect, analyze, and leverage data in real time (Bauer *et al*., 2021). This connectivity extends across diverse sectors, from transportation and energy management to healthcare and public services, creating a fabric of interwoven systems aimed at enhancing efficiency, sustainability, and the overall quality of urban life (Priyanka and Thangavel, 2020). As city planners and policymakers increasingly turn to these technologies, understanding the intricacies of their integration becomes paramount.

A smart city is a complex ecosystem characterized by the intensive use of information and communications technologies (ICT), aiming to make cities more attractive and more sustainable, and unique places for innovation and entrepreneurship. The major stakeholders include application developers, service providers, citizens, government and public service providers, the research community, and platform developers. Furthermore, the smart city cycle consists of numerous ICT technologies, development platforms, maintenance, and sustainability, apps for evolving citizens, and technical, social, as well as economic key performance indicators (KPIs).

Consequently, IoT systems will play a fundamental role in the deployment of large-scale heterogeneous infrastructures. A high-level illustration of an IoT-based smart city is given in Fig.1.

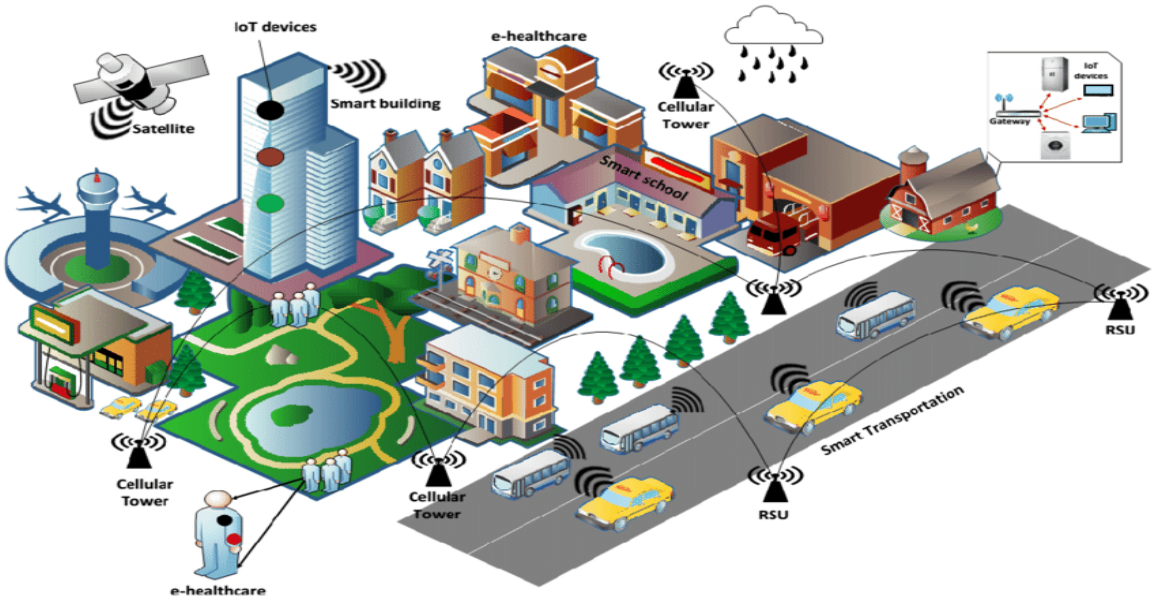

Figure 1. An illustration of an IoT-based smart city

IoT-based smart city applications can be categorized on the basis of network type, scalability, coverage, flexibility, heterogeneity, repeatability, and end-user involvements. In general, these applications can be grouped into personal and home, utilities, mobile, and enterprises. For instance, personal and home applications include ubiquitous e-healthcare services to live independently via body area networks (BANs), which help doctors monitor patients remotely. Utilities applications include smart grid, smart metering/monitoring, water network monitoring, and video based surveillance. Similarly, mobile applications include intelligent transportation system (ITS) and logistics, traffic management, congestion control, and waste management. Additionally, IoT based enterprise applications usually consist of a network of things within a work environment.

However, with innovation comes a set of challenges that demand careful consideration. Privacy concerns, cyber security risks, and the need for standardized frameworks pose complex hurdles on the path to realizing the full potential of Smart Cities (Javed *et al*., 2022). This research navigates through the promising advancements and critical challenges, offering a comprehensive perspective for stakeholders invested in shaping the future of urban environments where connectivity and intelligence converge for the benefit of citizens and the sustainable growth of cities.

Data collection, transmission, storage, processing, and analysis are steps in implementing an innovative city application. After completing this step, deep learning or AI-based techniques can be used to make the final decision Osman (2019). Applications for intelligent cities involve a specific set of steps, beginning with the essential data collection stage and progressing through the stages of forwarding, storing, and finally processing and analyzing the data. Once this is complete, deep learning or other AI-based techniques can be used to make the final choice Jawhar et. al., (2018). The last step is to save the data to the cloud to be analyzed later Sandeep et.al., (2021). As a result, smart cities require a clearly defined IoT

architecture. The architecture is broken down into five layers for building an application, as depicted in Fig. 2.

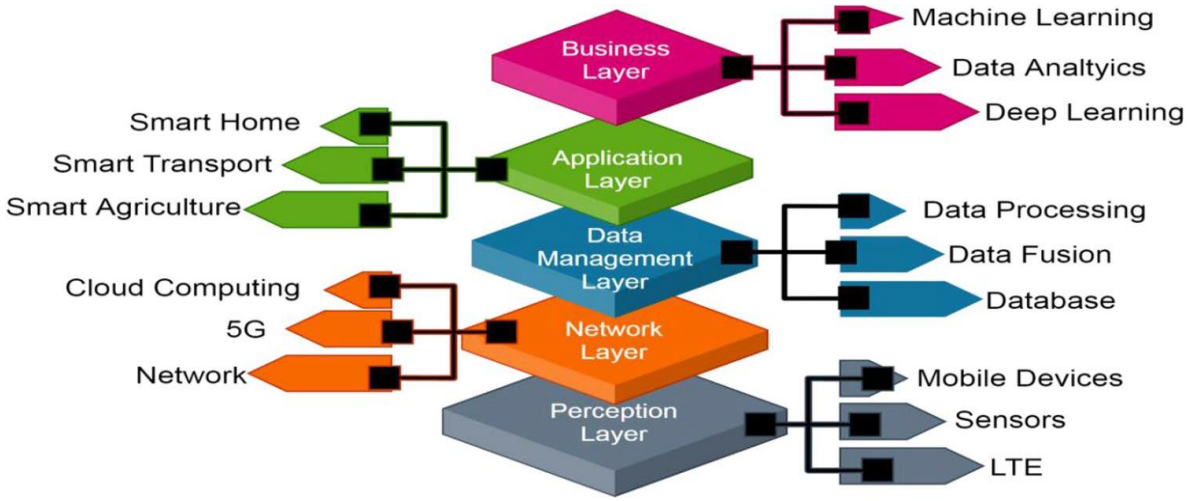

Fig. 2 Layer orientation in the IoT

LITERATURE REVIEW:-

Various researchers talk about the smart city and IoT's implementation in it. Saraju P. Mohanty presented his work on smart cities discusses the core concept about smart cities. It explains the complex nature of IoT and how it can be made possible in today's context. It explains the components, attributes, themes and infrastructure of a smart city. Iqra Rafiq et.al shows the current status of IoT features, architecture, communication infrastructure and applications. The paper briefly explains about the possible IoT applications in smart city. Work by Badis Hammi et.al. discuss the current and future trends of smart city and IoT. It also shows the interaction between smart cities and IoT and explains some of the drivers behind the evolution and development of IoT and smart city and the weaknesses of IoT and how they can be addressed when used for smart cities. Hafedh Chourabi et.al shows the directions and agendas for smart city research and outlines practical implications for government professionals. It also contains the working definitions of smart cities and success factors of smart city initiatives. Rashmi Dongre et. al contains the collective overview of the IOT paradigm for smart cities, research methodologies, integrated ICT network types, doable opportunities and considerable requirements. Suha Alawadhi et. al (2012) their research work discusses the results of an analysis primarily based on semi-structured interviews with government officials and managers. Research work by H. Samih (2019) displays the emergence, characteristics, components and architecture of the smart city. Duda O.M' research work displays the sensory structure and Generalized Architecture of the "Smart City" Information-Technological Platform. Research by Arsalan Shahid et. al. shows the use cases of IoT in smart cities such as Smart Grids and Residential E-Meters.

Research by Abbas Shah Syed et.al ((2021) contains the survey about IoT technologies, practices and challenges. Gaurav Sarin's primary purpose is to study the role of IoT in development of Indian smart cities, understand the India IoT policy, find out the key drives and advantages of IoT based smart city and identify the consumer preferences and demographics of Indian citizens who prefer IoT based smart city solutions. Shwet Ketu et. al. paper illustrates a contemporary survey of IoT-based smart cities with their potential, current trends and developments, amenity architecture, application area, real-world involvement, and open challenges. Jose Joaquín Peralta Abadía et. al work contain definitions of the terms "smart city" and "IoT framework" in condensed form, consolidated concepts and

guidelines of smart cities and IoT frameworks. Seconded European Standardization Expert in India discusses the smart city implementation in India. It shows the implementation of smart cities, Mission monitoring, Financing of smart cities, current status of Smart Cities Mission and cities selected under the mission. Khusboo and Divya shree presents a literature analysis on IoT architecture and IoT- enabled city components. Kartik Krishna Bhardwaj et. al. discusses about the ways to include fog computing and IoT in smart city scheme. Taewoo Nam et. al. aims to fill the research gap by building a comprehensive framework to view the smart city movement. Hardik Tanti et. al. claims that a mobile application will enable a user to check parking space availability and reserve a certain parking lot in accordance with such information. Prof. (Dr.) Vijay Mane proposes a model to monitor the environment using IoT sensors. Puja Sharma et. al. work displays the data on the webserver and monitor the real-time data of weather using environmental parameter or sensor.

METHODOLOGY:-

The data for this study came primarily from the research corpus developed using Google Scholar, which provides access to various online digital libraries, journals, and conference proceedings. The study's aims informed the selection of search phrases for online libraries. Data collection and string formulation, following the standards laid out by Kitchenham and Charters, constitute the initial stage of the research process. The search phrases identified were "IOT", "Internet of Things", "smart cities", and "smart city". In this study, the designed search strings used to extract the information were ("IOT" OR "internet of things") AND ("smart cities" OR "smart city")

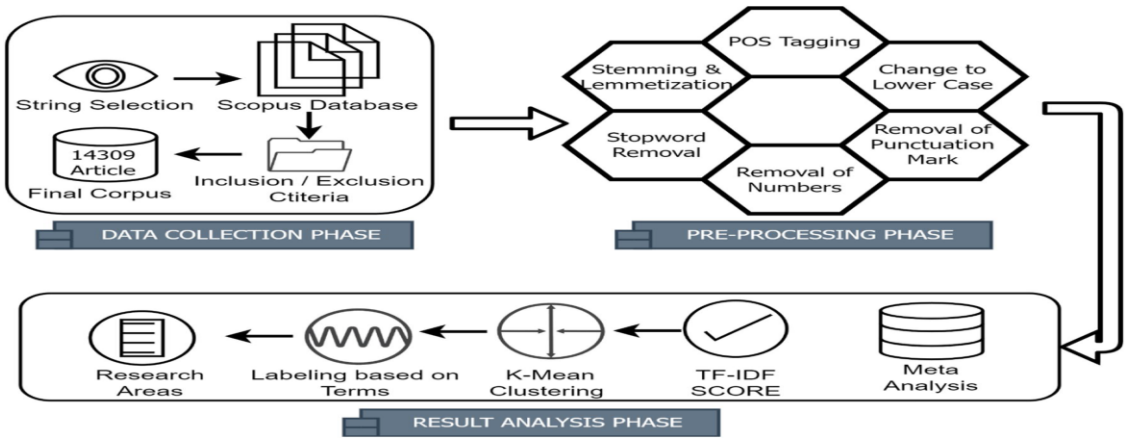

Table 1: Fundamental concepts of smart city and its sub factors

Concepts	Sub factors
Technological	Physical ICT infrastructure, Smart technologies, Mobile technologies, Virtual technologies and Digital network.
Institutional	Governance, Policy, Regulations / directives
Human's	Human infrastructure, Lifelong learning, Cosmopolitanism, Social capital, Ethnic plurality

Applications related to smart cities often have four components: data collection, transmission and reception, storage, and analysis. A smart city as an innovation harnesses the transformational potential of smart technologies (for example, instrumentation with intelligent sensors), mobile technologies, virtual technologies, cloud computing, and digital networks such as Mobile wireless and Metropolitan Area Networks (MANs).

A set of guidelines known as the "Smart city guidance package" was released by the European Innovation

Partnership on Smart Cities and Communities (EIP-SCC) is a road map outlining the necessary stages to implement smart cities and facilitating coordinated planning and execution of such initiatives. The guidelines have seven steps which is listed below:

• **Envision**: Long-term goals and vision are created or modified. Furthermore, opportunities for cooperation inside the city are investigated.

• **Decide and commit:** A strategy is the materialization of the long-term vision. The parties agree on how to begin putting the plan for the smart city's implementation into action.

• **Plan:** A plan with specific tasks, goals, benchmarks, and key performance indicators (KPI) is developed based on the preceding step's strategy.

• **Do:** The plan's real execution is carried out. Changes, modifications, and additions are anticipated.

• **Check:** Based on the KPI defined in the plan step, the progress is tracked. We investigate solutions if issues arise.

• **Act:** The previous step's problems are solved and put into practice.

• **Replicate and scale up:** The dissemination and exchange of experience aids in the duplication and expansion of effective solutions.

The components of a smart cities include the following: smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart technology, smart governance, smart education, and smart citizens.

Smart Cities in India

India is a seventh-largest country by area with a population of 141.72 crores. Rural population accounts for 68.8% and urban population accounts for 31.2% in the overall country's population. Urban's population has been increasing exponentially in the past 2 decades. The Union Government has launched the smart city scheme to manage the ever-growing urban population.

The Mission will be carried out at the urban level by a Special Purpose Vehicle (SPV) that has been specifically designed for that purpose. The Smart City development initiatives will be planned, assessed, approved, monies released, managed, operated, monitored, and evaluated by the Special Purpose Vehicle (SPV).

• Smart Parking

Hassle-free vehicle entry and exit are made more convenient by method of payment. The Arduino pins 4 through 9 are connected to six infrared sensors. The Arduino's 5v supply is connected to the infrared sensors VCC pins. An infrared sensor will be used to detect automobiles. This is the Nodemcu ESP8266 Wi-Fi module, which allows us to monitor the parking spaces for cars from any location in the world. The Arduino IDE is the technology used to connect the IoT objects .

• Environmental Pollution

The data processing micro-controller, data collection sensors, and wireless data transmission sensor network are the tools that an automated monitoring system will use to control and monitor. In a wireless sensor network, nodes are capable of sensing and transmitting and receiving information. Numerous sensor nodes are either based on the predetermined structure or are fixed randomly on the restricted region. Arduino UNO, 10WATT1K, L293D, LDR, LM35, POT-HR, RELAY ULN2003A are the components of a proposed IoT system to monitor the environmental pollution.

• Weather Monitoring System

The problem with farming arises from severe rainfall because of the frequent occurrence of rainy conditions. In this case, knowing the status of the weather before planting or harvesting the crops is crucial. Therefore,

using a weather monitoring system to monitor the weather in this scenario would be beneficial to farmers. Three sensors—designated as modes1, 2, and 3 in the proposed model—are used to measure temperature, pressure, humidity, and rainfall. It lists the modes as temperature and humidity (MODE-1), barometric pressure (MODE-2), and raindrop sensor (MODE-3). There are many other IoT solutions like the above mentioned are implemented in smart city.

Challenges in smart cities implementation

Though the smart city scheme is seen as a boon to all modern day urban related issues, it cannot be implemented in all urban areas at once. It has some constraints to be executed in real time. Few of them are listed below:

• Complexity and Big Data Analytics:

The Internet of Things (IoT) network will be connected to billions of devices, systems, and things, making it more complex than the current system. Its heterogeneous nature, which includes a variety of systems with distinct architectures, designs, and communication infrastructures, presents a significant challenge to developers of software, hardware, and communication protocols and makes deployment difficult.

• Security and Privacy issues:

Sensing data and control information are transmitted over local networks and the internet in smart cities. Furthermore, a number of smart city components tend to be crucial to a city's functioning and are deeply entwined with its residents' personal and social lives. Typical security strategies may not always be as effective in securing the Internet of Things for Smart Cities, necessitating the development of novel techniques to address security and privacy concerns.

• Reliability:

The entire IoT infrastructure is solely dependent on sensors or sensors that are already incorporated into the device. These smart devices produce data, which is wirelessly transferred to the cloud and among several other linked devices. As a result, we need to guarantee that the data being transmitted is accurate.

• Sustainability: There are five issues:1)strategic evaluation of the indicators to determine a SC's significance and assist in setting priorities; 2)reduce the impact of ICT on infrastructure development because its advantages also degrade ecosystems; large corporations' systems; 3)products, and services could monopolize and undermine the viability of cities, while small initiatives' efforts to advance their management would be difficult to achieve significant change; 4) Cities' ICT proficiency needs to improve in order to match large corporations and submit sufficient ICT demands; 5) to establish a specialized committee to evaluate ICT investments would help the city government concentrate on sustainable growth.

CHALLENGES AND FUTURE DIRECTIONS

This section is divided into merits, demerits, challenges and future directions of IoT networks and applications. Block diagram in Figure 3 shows IoT challenges and future directions that are subsequently discussed in detail.

Merits of IoT:-

- Minimum or no human intervention: In IoT aided systems, devices are self-healed due to wireless M2M and D2D communication through wireless sensor networks which reduces the need of manual supervision of equipment. Large number of devices are automated and controlled by signal transmission without any help of workers and manual involvement.
- Time saving: Task is done with in short time through real time device interaction and automatic control with accurate precise and fast results. Time of user can also be saved using IoT based automation system.
- Quality of life and comfort: IoT has improved quality of human life by providing smart services. IoT health applications make life of a patient easier by remote sensing and monitoring. Comfort of people may be increased by home automation,

energy management, online shopping, smart parking, security monitoring, safety and smart health services. In addition, user can increase comfort by switching on household electronics before reaching home, shutdown the systems from anywhere, automatic purchasing of goods through fast RFID sensing, online control using remote cellular technologies etc.

- Cost effectiveness: Cost effectiveness can be achieved by managing production cost by adopting IoT technology in such a way that consumers can receive real time information about demand and supply of products. Optimal solutions are given by IoT frameworks for utilizing resources, taking decisions, scheduling tasks, assets and energy management to save money and achieve more revenue. Further cost reduction can be achieved by preventing damages to IoT devices and appliances through alert signals of fast sensing systems.
- Updated solutions: IoT aided smart cities and services are currently updating hardware, software and communication technologies according to changing requirements of modern world. People and users are also becoming aware of new technologies for effective, efficient and safe use of IoT aided services.
- Safe and healthy environment: IoT based smart monitoring through sensors and cameras makes cities safe and secure. Online monitoring can be done for crimes, mishaps, accidents and technical issues in home, smart grid system, streets, roads vehicles, markets and hospitals etc. to make systems and environment secure, safe and healthy.

Demerits of IoT

- Complexity and Big data analytics: Billions of devices, systems and objects will be connected to IoT network that will make it more complex than existing system in term of data processing, communication jobs and power management for devices. Its heterogeneous nature having various systems of different architecture, design and communication infrastructure is a big challenge for hardware, software and communication protocols developers and it cannot be easily deployed. Moreover, processing, identification, authentication and task scheduling of same type of data from different nodes increase complexity of system.
- Expensive devices and compatibility: IoT devices are very expensive and capital cost of any IoT aided smart system is high due to expensive material, advance manufacturing, designing technologies and complex processes. Compatibility and standardization of devices, software and communication protocols also include in IoT challenges. Less security and privacy: Security of data and privacy issue is much important to be concerned for data processing and encryption. As IoT aided systems deployment is becoming famous, security threats are also increasing due to free internet linking of things. Cyber-attacks can potentially increase problems for consumers, utilities, developers and service providers in terms of data and money theft etc.
- Fear to adopt/lack of trust: Security and privacy issues would increase lack of trust on IoT aided systems. IoT devices embedded with sensors and RFID tags can monitor and collect information about user's activities, financial status, lifestyle that one doesn't want to share with neighbors.

Challenges and barriers

Smart grid challenges

- Smart grids have self-healing feature that differentiates it from existing grid. Tasks such as real time monitoring, response to technical faults and environmental effects detection in generation, transmission, distribution and utilization systems are efficiently and accurately carried out via IoT technology to enhance the self-healing capability. However, in adverse climate changes, alternate source of communication should be available for service continuity and real time automation in case of any device or network failure which is one of the smart grid implementation challenges.

- Smart grid is an interconnected system of producers, utilities and consumers with diverse nature of technologies and architectures. Various types of data are to be processed, analyzed and managed through wireless communication infrastructure with different characteristics. So it is a big challenge to overcome limitations of IoT communication infrastructure for big data handling and smart grid deployment (Saleem., 2019).
- A large number of devices are connected through the Internet in smart grid with different power consumptions, operational time, application software and wireless protocols. For reliable smart grid operation and interoperability of smart devices, it is important to ensure efficient processing without any complexity and data loss. Interoperability of IoT systems and devices is a challenge as well as key of successful implementation of heterogeneous systems.
- Cyber security of communication network for a smart grid is also a major challenge.

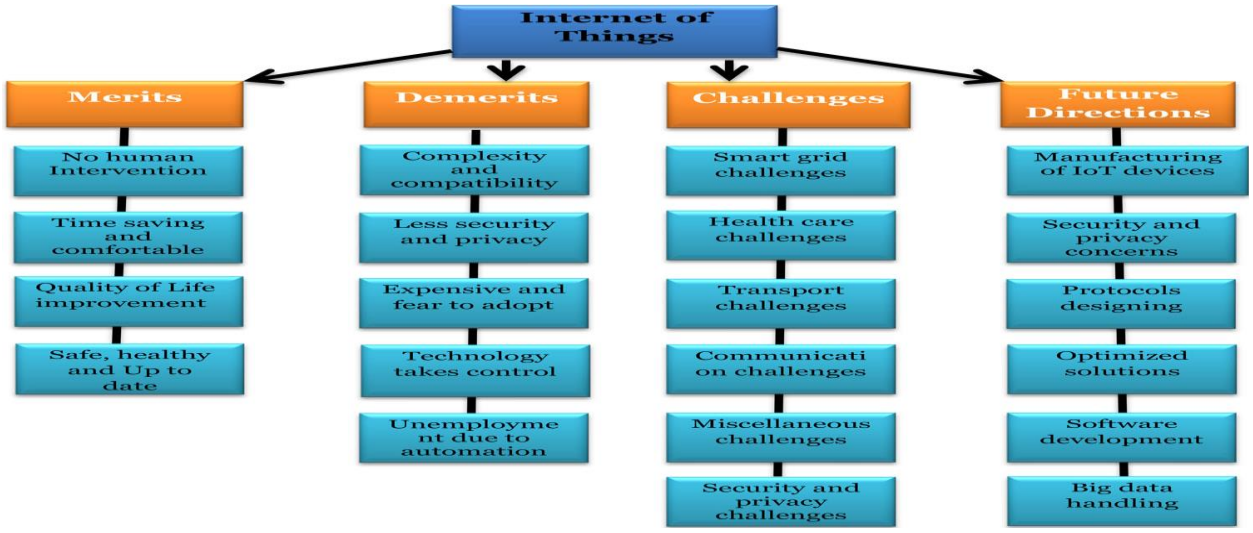

Fig 4- IoT challenges and future directions

Future directions

- Manufacturing of smart devices, sensors and IoT objects with high reliability, interoperability, battery life and efficiency are main concerns for manufacturing industries.
- Design of communication protocols with high data rates, long range and high band width is also an important area for future research.
- Security, privacy, trust, safety and quality of services management of IoT systems are challenging research directions for researchers and developers.
- Power management and energy harvesting solutions for smart devices are important to be considered for reliable and uninterruptable services in IoT aided smart cities.
- Optimized solutions and algorithms development is a vast field of research in context of IoT operations and big data handling.
- Application and system software development for programming, data processing, security and privacy assurance is another important area for IoT researchers and developers.

CONCLUSIONS:-

IoT technology is a future paradigm for smart city development to overcome problems created by urbanization. It gives the promising solutions for life of smart cities by providing number of utility services like street light management, water and gas

management, security services, smart energy management, smart parking and home automation. IoT health system has enhanced the reliability and comfort of patient's life by giving real time information about healthcare and emergency services. Road accident and crimes may play an important role in reduction by IoT connected transport and security monitoring system. Smart grid is also improved by IoT technology and enhanced energy management and cost minimization by fast and instantaneous load management, home appliances automation, data communication and smart energy metering.

Internet connectivity of IoT systems produced enormous security issues and privacy risks that have to be overcome and solved. Number of challenges related to services, communication frameworks, protocols standardization, architecture designing and IoT device manufacturing have been discussed for future recommendations. Future directions give a way to understand and research solutions, strategies, techniques and models for making better deployment of smart city applications.

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