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Integration of Internet of Things, Data Sets, and Cloud computing towards Space-Science 5.0

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***Abstract*--Technology has been influenced by the Internet of Things technology (IoT) in many different ways. It started as a network of interconnected devices communicating over the Internet has become tremendously complex system as network nodes were added and particular IoT domains were formed. There are numerous sub domains for IoT. IoT has yet to be implemented in a number of fields, including healthcare, robotics, and other related ones. one of the space research technologies that is advancing quickly. Over the past few decades, space research has grown significantly, with studies covering exo-planet discovery, colonization, space communication, and the potential for life on distant planets. In this study, we propose an unique Internet of Space Things (IoST) infrastructure that is cloud-compatible for the rapidly expanding and far-reaching field of space technology. The essay offers a thorough logical and physical architecture that takes into account ground stations, interstellar communication, public networks, cloud providers, enterprise networks, and cloud networks. The study will be helpful towards scientists and researchers working on IoT, emerging technologies, migration, robot assisted surgeries, space farming, etc.**

Keywords—Satellite networks, the Internet of Things (IoT), the Internet of Space Things (IoST), and space science.

I. Introduction

The ideas of machines corresponding with each other During the middle of the 1980s, however, the World wide Web just became popular during the early 2000s. A Coca-Cola machine from of the mid 1980s is the first instance of IoT. Machine from the University of Carnegie Mellon, connected to the refrigerator-style device. As technology has advanced over the past few decades, improved, and increased technologies, there has been ecstatic expansion of IoT technologies. In a nutshell, IoTincludesany appliance that has an on/off switch that is connected toa website. Almost everything is included in it, from repairing an airplane's engines to using telephones[1].

Over the past few years, computing power has significantly increased after claiming the presence of Moore's Law for fifteen years. Real-time analytics apps, for example, have discovered a lot more advanced platforms that have shifted toward the cloud and the edgecomputing.Moreover, the arrival of 5G has made improvised. Applications like augmented reality and virtual reality are supported by mobile connectivity. Presently available information technologyTheIoT will be used to connect gadgets, whichmarket expansion for IoT. The Internet of Things includes billions ofphysical objects linked to the internet globally,both gathering and distributing data. The prevalence ofthe use of wireless networks and highly effective computer processors It is feasible to integrate both large and tiny devices intotheIoTThese various items are interconnected across thearound the world, they are provided with digital intelligence byto them, sensors. As a result, these gadgets communicate directly without any human involvement. These technologies rely on TCP/ IP (IP) communication, which can find and facilitate communication between computers which are now being used around the worldwide. It is predicted that the gadgets will quickly self-report with increased effectiveness[2].

It is clear from the prior discussion that now the network is essential for transporting digital information from one place to another, but still the VPN connection is intentionally heterogeneous and operationally dependent upon protocols and network design. Consequently, merging various Developing apps for this architecture is challenging. IoToffersan internet-based platform that is universal and standardised that connects all the gadgets together. Previousthere have been developments in space communication works. From a variety of unrelated angles of the different initiatives.

With each new route, communication services should be providedas it goes along. For instance, Earth communicationobservational flights like those in the human orbited and ISSwas created separately from other missions. As part of the NASA Management Space Network for Earth observation missions, NASA created a satellite-based processes and information system known as the Data capture and Intelligence Relay Space Probe (TDRSS). Amount spent on using the Tracking and Relay Satellite System, or TDRSS, was usually believed to be too high for Earth observation missions[3].

These missions therefore made use of already used, modified terrain. To record their information at stations. Separately from exchanging the Deep Space Connection with others and developing communications for Mars and interplanetary missions (DSN). The specifications enable handling and autonomous networks even while many processes were under supervision. The necessary skills for coming missions have been acquired throughout prior operations. But the cited business Future communication techniques will still rely on services. The solutions are specific to the goals of each company. In a NASA communication, they are not entirely mentioned. Infrastructure incorporating space-based nodes can communicate with both other nodes and users on Earth. Constellation proved that communication and communication between spacecraft were possible.

A new Web of The Web of Things concept was developed by Akyildiz and colleagues. The IoST Cube-Satsserve as the backbone of the network that provides. Global connectivity that is scalable and serves as passive as well as live actual environment sensors. Moresignificantly the merging of Cube-Sat detection and CubeSat in a closed-loop.An improved cyber-physical system with communication novel uses on land, in the air, and in space. It may Be aware that even if IoST differs greatly fromEarlierIoST systems, we anticipate getting more connections.As required, from GEOs, MEOs, and LEOs. in 2018.

The delay can be reduced by integrating edge and cloud technology into an IoTnetwork.The proposed system described a compatible architecture. With the aid of this integrated cloud architecture, various. A platform for IoST can incorporate IoTfunctionalities.One of the key aspects is connectivity, which permits among the connected components there is constant communication which might create the IoST ecosystems. Additionally, cross-platform Services and technologies can collaborate totheIoST components to engage in active participation. Longevity is yet another important characteristic. As a result, the IoST study also suggests an architectural framework for the IoST. The remainder of a essay has been set up as follows. Application scenario section III.Explaining the Systems Application Architecture in Section IVInfrastructure layer discussion is found in Section V. Chapter VIexplains the Management and Control Layer's architecture.System procedure in Section VII and Section VIII are covered.The Verdict and Upcoming Workassemble different cross-domain models and make sure a infrastructural and operational costs are traded off.

II. Literature Review

Essential requirements is the mother all innovation, the Iot technology has the power to reshape many technological fields. By integrating equipment, medical professionals can keep an eye on individuals within and around the hospital. Computers can analyse patient data to improve patient outcomes and modify therapies. Due to transformation, IoT has recently become more prevalent in urban planning. City authorities can alert drivers to imminent delays and accidents by installing sensors with IP addresses in a popular thoroughfare. Additionally, smart trash cans can notify users when they are full, resulting in improved waste collection.

Strategic usage of smart gadgets can also greatly benefit enterprises. Costs can be cut overall, for instance, by using a service that monitors information on inventory levels and energy consumption. Additionally, connectivity can help businesses better understand consumer behaviour and produce more specialised product recommendations. When a product is linked to the Internet and placed in the customer's home, it can also provide updates on service schedules and appointment scheduling, which could enhance the overall amount of the transaction.

The Internet of Things thus encompasses a wide range of devices that are specialised to various utilities in addition to those that are globally connected. Recent domains that demonstrate the importance of IoT include Upcoming Internet, Interstellar IoT, Internet of Small Things, and Network of Deep Things[4].

One of the sectors with the quickest growth and exploration is space technology. Curiosity knows no bounds, and since humans are naturally inquisitive beings, we have begun exploring the universe using a variety of technology. There are numerous objects encircling Earth in space, and increasingly more space missions are being launched. Other items are now being launched into interstellar space for data collection, while a variety of satellites and the Space Station oversee keeping an eye on events on and around Earth.

A cellular network is being developed on the Moon in cooperation between Nokia and the NASA's National Aeronautics and Space Administration (NASA). Information about soil, atmosphere, climate, and other aspects of Mars is transmitted to Earth by the Curiosity rover[5].

It is essential to designate an IoT platform for communicating beyond Earth because colonisation is being suggested as a possibility and various planets appear to be suitable possibilities.

Numerous IoT research projects have been designated specifically to domains and activities based on the existing work. The IoT of Space Things is proposed to have a new architecture in this research (IoST). This IoT platform synchronises and controls inter-object connectivity while storing all data that is integrated into the cloud. The IoST may be constructed and extended as necessary even if the universe is vast & expanding at a startling rate. The proposed platform might be built to connect the devices on Earth to those on Venus, Mars, and other worlds beyond the asteroid belt. The proposed station could assist in relaying information between far-off possibly inhabited worlds because so much of the universe is still unexplored. For instance, the active moon Escalades conceals vast lakes of salty water underneath its surface.

This study takes into account a number of new factors that affect how life may survive as well as whether humanity colonisation is feasible, including the environment, climate, amount of solar receives, soil toxicity, etc. It's crucial that this critical information be communicated efficiently, precisely, and on time. There may be significant noise in space-based data. Therefore, to optimise data transmission, IoST systems must be integrated with IoT. .

The NASA Glenn Research Centre developed a system for extending the internet into orbit in 2002. It is, however, exclusive to the NASA organisation. Architectural components including the backbone, interspaced communication, vicinity communication, and internet connection are explained in the paper. They claimed that they could lower the cost by using this technology. However, if we build an infrastructure continuously, constructing the full setup for a task is not cost-effective; instead, the ideal alternative is to gradually add the components as needed.

In this study, the average person access is not expanded to include access to the central repository system. The Internet of Space Thing (IoST), which will be introduced in 2019, will describe this idea. A revolutionary design employing software-defined networking and the virtualized of the server notion is proposed in the paper in question. This paper's main focus is on processing inter-satellite data, using space as a third eye to see the earth, and interacting with space IoTdevices. In this study, we suggest an iOS architecture for information transfer that is compatible with the cloud. Information can be used to create knowledge, which helps the corporate and business sectors grow their industries. AnIoST platform can incorporate severalIoT characteristics. One of the key characteristics that enable seamless communication across the connected parts that could make up IoST ecosystems is connectivity. Services and technology that span platforms can cooperate to create an engaged community among IoST components. Accessibility is yet another crucial quality. Since IoST can provide an appropriate balance among infrastructure and operational expenses, it can incorporate a number of cross-domain models.

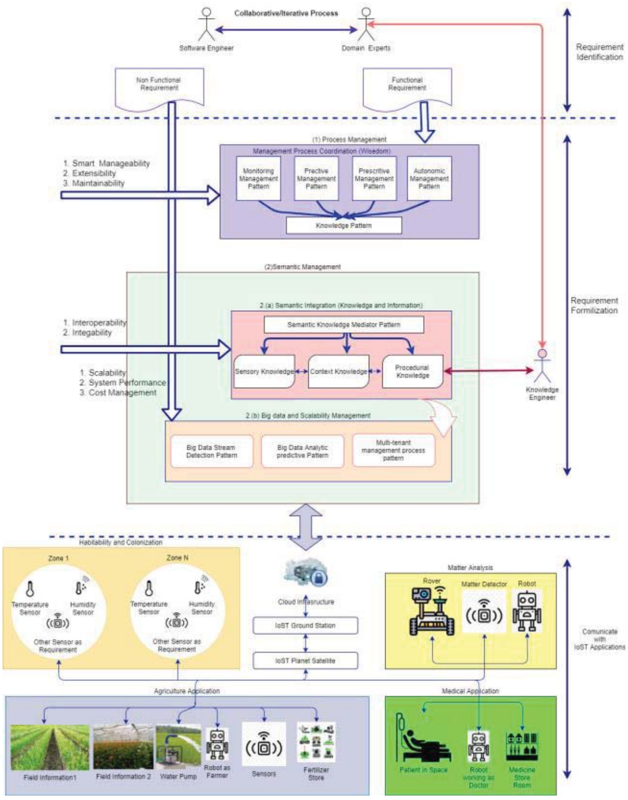

Fig. 1. Framework of Internet of space things (IoST)[6]

III. APPLICATION OF INTERNET OF SPACE THING

The principles of space communication were introduced to us in the sections before through a range of communication architecture kinds and associated Connectivity of Objects initiatives.

We pointed out the development of the Internet of Thing (IoT) enabling communication in space and the numerous attempts by researchers to share the network in space. We integrate space communication architecture with cloud computing to develop a more effective information management system. The work presented here can be useful for some IoST applications.

The foundation of the application architecture lies in the requirement identification work done by software developers and subject matter experts. Both functional and non-functional criteria are possible. Scalability management is used for non-functional needs, but process management is typically used for applicable requirements. To establish the coordinating of the management process, surveillance, forecasting, adapting, and autonomic management methods are used[7].

Comprehensive data scalability management and semantic integration make up semantic management. Input from participants' experiences, context knowledge, and logical data model are used in semantic integration. Big data stream recognition trends, predictive shapes, and process management patterns are all included in big data scalability management. Smart manageability, extensibility, and maintainability are considered in process management. Big data and scalability management, in contrast to semantic integration, considers scalability, system performance, and cost management. Knowledge engineers frequently handle the three management components, which together make up the formalisation of requirements.

There are many applications for this fundamental application architecture. The fundamental framework and specific apps are connected through the cloud infrastructure. The ground station receives the information from the cloud, which may also be relevant to the IoST equipment. The following list includes a few of the applications as shown in figure-1.

1) Colonization and Habitability:Ever since mankind first learned to distinguish celestial bodies in the night sky, there has been a persistent fascination concerning whether there is life on other planets and space formations other than the earth.Space technology has recently discovered a number of extra solar planets. Some of the planets circling their host stars might be suitable for life. Elemental indicators of life, such as freshwater, carbon, nitrogen, phosphorus, sulphur, etc. Consequently, data collection from the planets is required in order to discover planets that may one day support life. It is common knowledge that space missions have the duty of exploring planet surfaces and closely inspecting them to find ingredients necessary for life. Due to the length of these missions, the data transfer to the planet, however, is not in real-time and may take many hours.

2) For expeditions to close systems like Mars and Venus this might not be a significant problem. IoT modules around and within the solar system could communicate with one another more quickly thanks to IoST. Additionally, the use of cloud infrastructure may significantly prevent information loss; yet, due to distributed servers, this information may be stored in various locations. Colonization is a crucial application along similar line. The potential to lessen the likelihood of extinction for humans by colonisation of other worlds. Consequently, it is possible to terraform potentially liveable planets to maintain life. The SpaceX Mars initiative, which intends to colonise Mars, was just launched by SpaceX.

Drones and rovers that are based on the globe gather data on a variety of subjects, including the environment, climate, humidity, soil toxicity, and other issues, even when the earth's natural atmosphere has now been mentioned briefly in a handful of studies in the past. IoST has a strong ability to improvise.

3) Agriculture: Among the most difficult challenges has been space farming. Space farming involves components whether it's growing plants in spacecraft for crew to consume or transferring easy-to-grow plants like algae and lichens to a planet's surface for colonisation. The elements required are the same for agriculture on Earth as they are for growing food in space or on non-Earth celestial worlds. Plants, however, live in a microgravity environment in lights.

Because of this, many plants produced outside of Earth are noticeably smaller and grow more slowly than plants grown on Earth's surface. Sensors can be installed for colonisation purposes so that crop data can be transmitted between planets. Moreover, robot farmers might keep an eye on the entire agricultural sector. Similar to this, automatic water pumps might be placed all over the world.As we can see in fig-2, the basic architecture which shows the integration of communication systems with IoST.

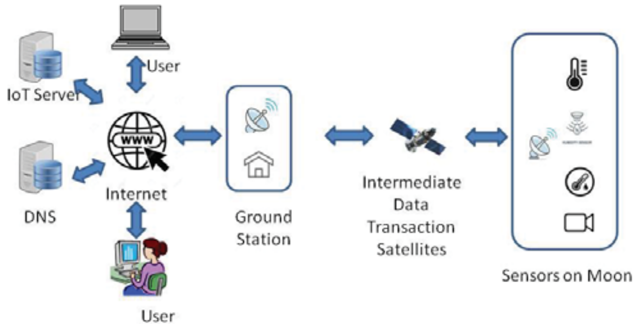

Fig. 2. Basic building block associated with IoST and communication field[8].

4) Matter evaluation: Cosmologists investigate the vast-scale characteristics of the entire cosmos, including its material constituents. These phenomena occur in outer space, together with plasmas of heavier elements, cosmic radiation, neutrons, electromagnetic fields, magnetic fields, and dust.

There is a fluctuation in gravity across the universe as a result of the abundance of bodies. The structure of space-time is influenced by gravity. It can be required to pinpoint the components and the layout of the structure because the make-up of matter differs across the universe.There are a number of undiscovered elements whose discovery would represent a significant advance in space technology and study. Several of these bodies might contain materials that humans could find helpful. The reduction of problems like pollution and climate change on Earth might essentially be achieved by finding other resources on a planet. IoST could make sure that all of this data is transmitted to Earth as soon as feasible so that necessary, timely responses can be taken.

5) Applications in medicine: Robot-assisted procedures maybe a significant asset in space. Medical emergencies do not consider a person's location or if they are outing in microgravity. Considering that space itself poses a health risk, surgical emergencies are likely to occur at any time. Even though astronauts had dealt with similar circumstances in the past, Earth was still nearby for an emergency landing.

This is due to hydrostatic pressure on Earth, which causes strange modifications by keeping blood owing inside the body. Another problem is for a surgeon to perform surgery in zero gravity while in space. Additionally, it could result in difficulties after surgery. Some remedies suggested to deal with the problem include surgical bubbles and magnetising surgical instruments. The introduction of a robot that can do suction, irrigation, illumination, picking up equipment, and cauterising wounds in the bubble, however, would be a much more effective method. Such processes could be made considerably more accessible with the help of interaction between devices and servers in IoST. In addition, robot-operated surgeries may be significantly more efficient as a result of the real-time data transmission[1].

IV. Parametric System Design

It is based on Packet protocols and internet communication technology. We offer a thorough analysis of the connectivity requirements between devices and users as well as the communications requirements themselves. Hence, the solutions provided by new infrastructure will address the issues listed below.

1. it's indeed expandable because every device connects through a predefined ecosystem.
2. The cost of communication is decreased because the public platform has been built.
3. All nations' research is specialised, which allows for an improvement in performance.
4. By focusing on a different planet for communication, the number of concurrent satellites from various nations can be decreased.

Let's say, in an abstract manner, that Figure 2 is used to describe the communication architecture. The blue filled circle in the diagram indicates the Own Planet Satellite (OPS), which is the name of each planet's satellite in this scenario. Reading data from Earth and sending it to the Dataset Transactions Satellite Level (DTSL), which is indicated in Figure 2 as a circle with a red outline, is the main responsibility of OPS.

This indicates that between the planet and DTSL, the OPS is a middle communication layer. Among Earth and other planets, DTSLs serve as a communication hub. As an example, if a message is transmitted from Earth to Mars, it will first be sent to a Geostation on Earth, and then it will be sent to a satellite, as shown in fig-3 [10].

The IoST network, which includes the backbones shown in Fig-3, also includes any commercial satellite systems used to deliver communication services as well as the OPS Access Network, a ground station of satellites (GN) and space network. In order to safely share information with users in the public, the ground station channel's backbone connects to both the network infrastructure and VPN. Data and task management data from the sensor networks, databases, users, other spacecraft, and operations centres are all included in the information that may be accessed through the backbone network.

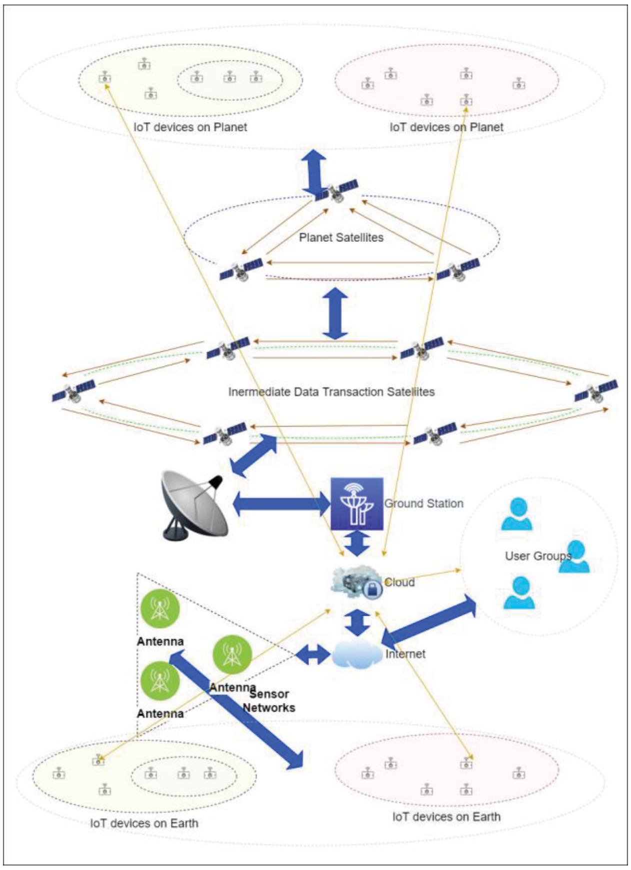

Fig. 3. Pictorial view of working of Internet of space Technology (IoST)[9].

Through the activation of activity coordination, this information access portal can significantly improve the science of the mission[11].

Thus, the space network and the terrestrial network may be compatible. The protocol should be chosen at the data connection layer in accordance with HDLC, ATM, and DVB standards for digital video broadcasting (DVB). Information is routed and devices are addressed using IP at the network layer. Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) are the two protocols that can be employed (User Datagram Protocols). Some well-known protocols can be used for the application layer, including Https (Hyper Text Transmission), File transfer (Application Programming Interface), SMF, & NTP (Network Time Protocol). Additional study on the interface used by applications for space communication is also possible [12-14].

The connectivity level and the interconnection path between layers are shown in Fig-3. The blue arrow mark indicated the connectivity route from one layer to the layer above. This globe Internet of things layer is positioned inside an oval symbol at the bottom of the gure. It mapped to each and every IoT device on earth. The gadgets might be found in any of the earth's various network zones. The internet serves as a sensor network for the flow of data from IoT devices, which is then stored in the computer to be used and analysis.

All communication has come together in the cloud. The Internet of Things (IoT) devices spread throughout the planets are connected to the ground station by means of intermediate data transmission satellites and planet satellites. The ground station sends data to the cloud where it is stored, analysed, and used to offer users with the information they need for future decision-making. The communication between hosts is shown by the orange arrow mark. Table-1 shows the comparative analysis in latest technology with future scope[15-20].

TABLE I. COMPARATIVE ANALYSIS OF TECHNOLOGY USED, PARAMETRIC VALUES, DEVICES USED WITH RELEVANT FUTURE SCOPE.

Technology Used	Parametric values	Devices Used	Future Scope
System integrated with Backbone Technology	Interconnectivity	GEO satellite, transportation satellite, customer, web service, base station, and planetary satellite	Smart optoelectronic relay
Architecture for communications	Internal operation	Customer-server architecture	Compatability with IPv6, Latest IP protocals
Software Tools, Hybrid, Web services	latest Protocals	HTTP, FTP, ATM and many more	Integration with Sensor Technology

V. CONCLUSION

Due to its level of human comfort, Internet has become a fundamental component of society. IoT has made every effort to provide humans with the highest level of comfort, from tiny smart watches to massive smart cars. IoT is used in numerous fields, as technology merges various devices. There are a tonne of Internet of Things (IoT) technologies like that though that are to be developed and found, and if they are, the network will receive billions of new devices. One of these industries that haven't yet embraced IoT device connectivity is space technology.

The idea behind the Internet of Things (IoT) allows for the expansion of connectivity beyond Earth so that gadgets on other planets and in space can talk to one another and relay data. Mars colonisation and the development of cellular networks on the Moon are being addressed, so it is evident to establish a foundation for space-related connectivity.

We have established the innovative idea of IoST and offered a thorough architecture for it in this work. Infrastructure, devices, and communication are only a few of the architecture's components that have been thoroughly examined. Additionally covered in the study are several crucial IoST-capable space-related applications. These include space analysis, microgravity surgery with robot assistance, and space farming.

Finally, we also go over potential difficulties with infrastructure design and offer potential solutions. Inside the future, we hope to thoroughly examine more of these applications and find their answers. It's probable that the IoST setup at this early stage will only be able to explore close space objects, but it may also be possible to develop methods to expand the framework to include more distant space objects. The infrastructure, if properly installed, is a triumph for space science since it would allow for a more thorough examination of the universe's makeup.

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