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A Research Overview Of Smart Technologies In Communication Networks Backed With Artificial Intelligence To Support Sophisticated Optimization And Reliability

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Abstract

Every industrial revolution's prime motive is to find how to utilize the human workforce smartly. Machinery dominates every prime industry sector like food, textile, agriculture, and transport. The task of the industrial revolution is to evolve technology that trains machinery smartly. In addition, also how to compete with smart technology in routine life? Due to communication network advancements, sector like telegram and fax have vanished. Communication arises as a way of clearly expressing one's mindthoughts to others. Communication networks establish the systematic flow of information effectively within the organization. The modern business world pulse represents speedy, accurate, and timely information. For example, in banking and money exchange quick money transaction is possible because of communication network technology. The word "Smart" is a prefix with all current technologies. A future era of the upcoming decades is artificial intelligence (AI). Smart technology is one of the ingredients of AI. Especially machine learning remains the base for smart technology. Let us focus on smart technology research aspects in a communication network. Further, we discuss green AI, smart grid, and sensors MAC protocol (S-MAC), wireless sensor algorithms, green cloud architecture, communication connectivity between satellites, and underwater communication networks. This paper's specific intention is to help researchers in this field. The researcher must recognize various aspects of subsequent research projects in a communication network. This paper will include an overview of all related sectors of communication networks. Simultaneously, this paper may promote the researchers to convince a concrete base idea about upcoming research in this field.

Keywords—Sensors MAC protocol, Green AI, Wireless sensor Algorithm, green cloud architecture, smart grid, Fog computing

I.INTRODUCTION

A communication network remains a structure that will construct the pattern of how information flows in the organization. Generally, network information flow classified based on the authorization that is formal networks and informal networks. The formal networks restrict the authority level. On the other hand, the informal networks bypass or skip the authority level. There are various distinct types of communication networks in the organization based on requirements [21]. They are Chain Network, Y, wheel, circle, and All-Channel.

In a communication network, the essential features are reliability and integrity. Reliability describes the amount of time the network is available to the end-user. It specifies the percentage of time the network is accessible to the user or time-frequency. Next, integrity represents trustworthiness. Reliability challenge is how to transfer data without any loss or damage through the network path. For fulfilling the above two features, the need is failure detection and error compensation method. It is possible when AI in communication networks monitor and diagnose every continuous operation.

The AI algorithm, in specifically the machine-learning algorithm, is playing a significant role in smart technology. The second part of this paper is a literature survey. In the literature survey, four distinct topics reviewed. Every topic handle various facet of the communication network. The first topic is AI-enabled communication network projects. The second topic covers edge computing and the smart grid. Third topic wireless sensor type, classification, sensor nodes components, algorithms, and manufactures details. Fog computing is the last topic. The conclusion of the paper is in the third part. The fourth part of the paper is future research opportunities in a communication network.

II. LITERATURE SURVEY

A.AI-enabled Communication Network projects

In technology, Green implies energy efficiency. Artificial Intelligence (AI) is not a recent topic in Information technology. AI also has various phases based on technology growth. Artificial Narrow Intelligence (ANI), Artificial General Intelligence (AGI), and Artificial Super Intelligence (ASI) represent distinct phases of AI. Green AI is the subsequent phase of AI. Machine learning remains a significant part of green AI. Green AI ensures lessenergy consumption or efficiency and includes network performance. Especially communication network energy-efficient AI algorithms support sophisticated optimization.

The next phase of machine learning is deep learning. Deep supervised and deep reinforcement learning algorithms are novel trends for resolving AI-based wireless communication networks. ScanR is a service tool of higher education research and development introduced in the country, French.ScanR tool provides the latest company research activities and their associated research laboratory collaboration details [1]. In table1, some of the ongoing projects of ScanR and their focus details are available. Other ScanR project

objectives are advanced 5G network architecture, bandwidth, network reconfiguration, and sensor communication.

Project Name	Project Focus
Artificial Intelligence Aided D-band Network for 5G Long Term Evolution (ARIADNE) project [2]	The project focus is to investigate a high frequency of advanced radio architecture. AI utilized managing network processing.
D-band radio 5G network technology (DRAGON) project [3]	This project has two cost estimation objectives. First, cost estimation planning in telecommunication networks while using seamless fiber. Then, BiCMOS silicon transceiver and D-band power efficiency cost calculation.
A secure and reusable Artificial Intelligence platform for Edge computing in beyond 5G Networks (AIatEDGE) project [4]	With the support of AI-enabled applications, it is simple to execute an automated closed-loop network programmable pipeline.

TABLE 1. LIST OF ScsanR PROJECT AND THEIR FOCUS

B.Edge computing and smart grid

Edge computing is a distributed computing design to handle massive data storage. Instead of transferring all the data to the centralized data server, edge computing collects high-resolution data. The data is then processed and analyzed by the IoT edge network. Smart transportation traffic management, healthcare services tailored for rural patient treatment, and augmented reality (AR) applications are one of the edge applications. Smart grids are more reliable and safer in sensor communication technology. Smart girds represent an electricity-supplying network. It detects the flow of electricity and data in digital communication. The smart grid (SG) contains enormous sensors and data sources. Therefore, it will generate more volumes of data [6]. Edge computing performs an intermediary role in controlling computing data resources and smart grid data communication. Therefore, this technologyis referred to as grid edge technology. Smart grid used in virtual AI systems and physical AI systems. Smart grid operations are helpful in AI systems for energy consumption and power grid balancing also optimize operations [7]. Similarly, in smart grid operation, AI techniques support load forecasting and fault detection.

Load forecast is categorized into three levels based on load duration. They are short-term load forecasting (STLF), mid-term load forecasting (MTLF), Long-term Load forecasting (LTLF). For hourly-based load prediction STLF is valuable. This expectation data helps for exchange planning and demand requests of energy. MTLF predicts the load for weeks, and LTLF predicts the load for years. For load dispatching, maintenance schedules, and balance demand analysis, MTLF is useful. LTLF helps to forecast future power plan scheduling and system planning.

C.wireless sensor Network

A wireless sensor network is being used by base station (or ground station) of a global navigation satellite system (GNSS) (WSN). The WSN has quite a broad range of sensor nodes.The significant operations of WSN are to monitor and record sound, temperatures like wind, humidity, and the pollution level in the outside atmosphere. These are all inputs of WSN. Mostly, the output of WSNs is an electrical signal [25]. The WSNs type's designs are distinct based on the environment. Figure 1 illustrates types of WSN.

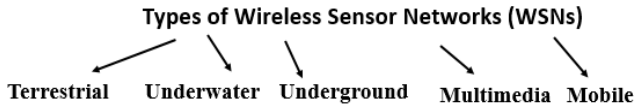


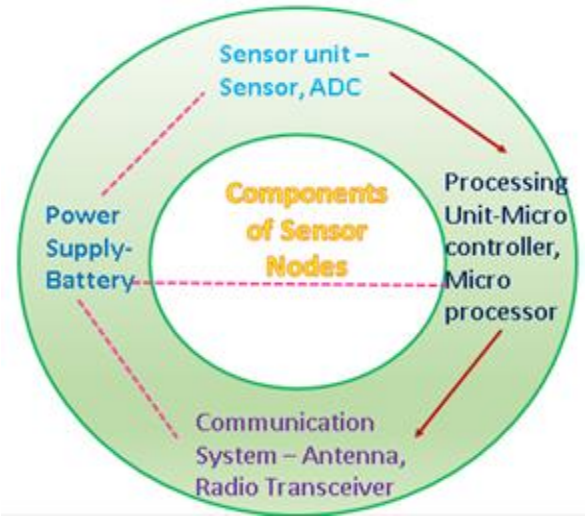
Figure 1 – Type of Wireless Sensor Networks (WSNs)

WSNs are classified depending about their use and characteristics. [8].

CLASSIFICATION	CHARACTERISTICS	APPLICATION
Static & Mobile	Sensor nodes are fixed	Animal Monitoring mobile networks
Homogeneous & Heterogeneous	Energy consumption, storage, computational power of all nodes are similar in homogeneous but it differ in heterogeneous some nodes are higher computational power than other nodes.	Intrusion Detection [26] in military application.
Deterministic & Nondeterministic	These nodes are fixed and calculated	Deterministic: Agriculture and Industrial application. Nondeterministic used in battlefield surveillance where sensor nodes cannot be determined.
Single Base Station & Multi Base Station	Based stations are either single or multiple. Depending upon base stations the nodes are arranged nearby stations.	machine health monitoring
Static Base Station & Mobile Base Station	static type base station includes a stable position and nearby sensing nodes. But Mobile base stations are moves towards to sensing area.	Biomedical application- where elderly patients are resides remote area. It monitors ultrasound dosage level and tumor thermal information.
Single-hop & Multi-hop WSN	Access through centralized monitoring system no need of wires and cables.	Smart city and environmental monitoring applications [23]

Figure 2- Wireless Sensor Network classification and Characteristics and application

The four fundamental components of sensor nodes are the power supply unit, sensor unit, processing unit, and communication unit or system. The power supply distributes the energy to all other three components in sensor nodes. The sensor unit consists of sensors like a camera sensor or temperature sensor [22]. In addition, analog to digital converter (ADC). The processing unit has a microcontroller and microprocessor. The last unit communication unit or system has radio circuits like antenna and radio transceiver.



Figur3 –Sensor nodes components

Based on the design approach WSN algorithms are classified into three. They are centralized algorithms, distributed algorithms, and Local based algorithms [10]. Each WSM algorithms' characteristic design explained in figure 4.

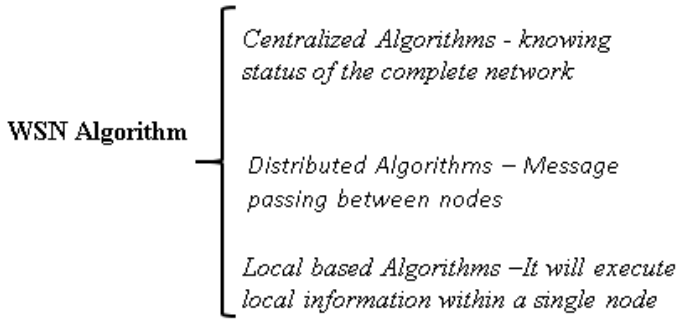


Figure 4- WSN algorithm characteristic approach

In the WSNs routing protocol, the task is to establish the route to exchange communication between routers. This task implemented based on routing algorithms, procedures, and messages, which will populate the routing table with the routing protocols to select the best route to travel for communication between routers. Local-based algorithmic approachesused majorly in routing protocol for optimization between nodes communication. Routing protocol algorithms are significant in WSN.

In figure 5, it explains the crucial drawbacks of algorithms. The main pitfalls of the WSN algorithm are redundancy data, which means rehearsing the same transfer of the message and missing unique identification of specific nodes.

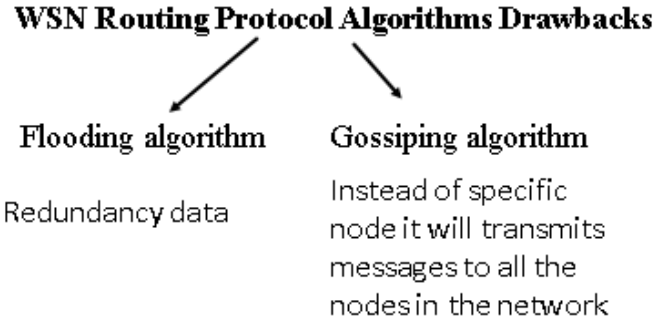


Figure 5- WSN routing protocol algorithm drawbacks

The Medium Access control (MAC) layer hasgiven a solution for this drawback in MSN. The MAC layer identifies each node uniquely in the WSN. Simultaneously it is also responsible for reducing energy waste while controlling the radioactivity of sensor nodes [9]. The MAC protocols classified based on their approaches are contention-based and schedule-based. The top five WSN manufactures list available in Figure 6.

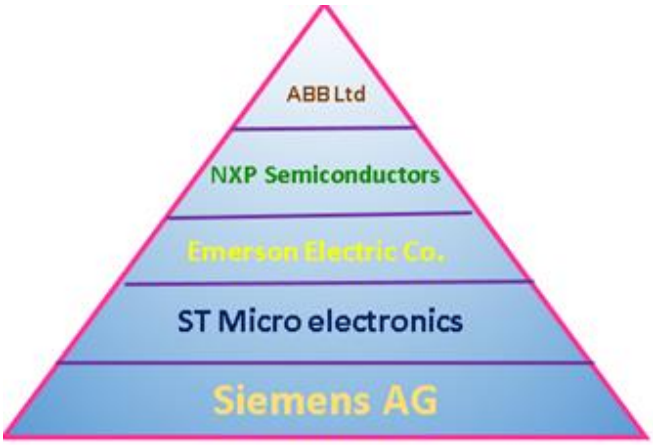


Figure 6- Top five WSN manufactures

D. Fog computing

Fog computing is a model of decentralized cloud that allows for the storing of data. It will do data processing and analysis. Any device connected to the internet with big data analytic computation is fog computing. Fog computing is also called Fog networking or Fogging [16].

Fog nodes reside between cloud and Edge gateway. Fog nodes are physical servers. Fog nodes process the data from various edge devices and respond directly to edge devices. The edge device is a subset of Fog computing. Fog nodes reside closer to the cloud that is a reason it will send and process very quickly.

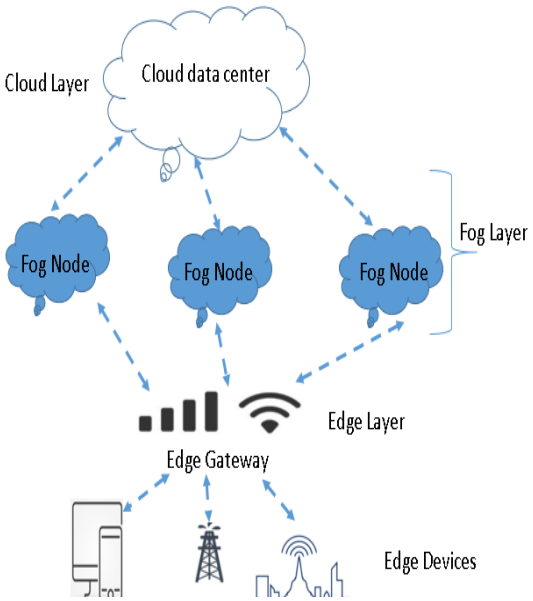


Figure 7- Fog Layer architecture

III. CONCLUSION

The base fact of the paper is communication networks are required to maintain a systematic flow of information effectively within any environment. For achieving this focus, Smart technology should be in a communication network. In AI-enabled communication network projects, deep learning will represent the sought-after technology. Deep supervised and deep reinforcement learning algorithms will become inevitable for solving AI-based wireless communication networks. The details of the French government's ScanRproject initiatives are listed in this publication. Green AI, as evidenced by the ScanR tool, is a valuable energy-efficient algorithm that supports complex optimization.We have also discussed how edge computing technology application efficiently applies in everyday activities and helps to improve progressively performance. It additionally provides much-needed security and stability to systems like Smart transportation traffic management, healthcare services for rural in rural areas, and augmented reality (AR) applications, be it for entertainment or therapeutic applications. The top industry manufacturing players of the wireless sensor network (WSN) show how this technology is leading and helps for reducing energy waste. At the same time, it also controls radioactivity, which obtains the need of the hour. We have also discussed how the decentralized nature of fog computing increases the speed and processing rate because of its conjunction with the edge gateway.

Future research challenges cover a broad spectrum from energy efficiency by inducing sleep mechanisms in idle nodes to technology requirements to create long-life batteries. It also discusses wireless sensor-based robotics, security protocols in security layers during data transfer between nodes, the environment-friendly green AI and pattern-based detection techniques. The various concepts and technologies reviewed in their own way towards enhancing the already growing AI technology to support optimization and reliability while constantly keeping the green environment requirement inclusive technology.

IV. FUTURE RESEARCH CHALLENGES

- Fog computing will remain the core component in IoT devices in the future. Fog computing handles enormous data quickly and communicates with the cloud environment [20].
- While wireless sensor network covering extensive geographical information and handling several nodes requires a secure environment (check sentence). Integrity aware counter (IA-CTR) mode and cipher block chaining (CBC) mode algorithms like AES and CTR-AEC encryption algorithms occupy a significant need in the communication network field [18].
- Energy consumption in every node battery needs to be non-rechargeable and less wastage remains the prime concern. The power consumption of each node is the most expensive. Therefore, energy efficiency is an upcoming research challenge concept that is the reason green WSN is booming. Senor MAC (SMAC) protocol and Timeout MAC (TMAC) are contention-based approach protocols. Whenever nodes are idle, it will implement the sleep mechanism and avoid energy wastage [11].
- Designing batteries for a long lifetime is also a research challenge. Lithium thionyl chloride single-use versions batteries lifespan is 20 years [12].

- Coordination WSN is a key-component especially in robotics-based applications like robotic sensing, robot planning, and navigation. In America and Australia, wireless sensor-based robots for detecting forest fires are most significant.
- All sensor techniques are possess smart technology. The sensor-based applications managing not merely in the secured sophisticated sector, but also in simple everyday requirements like employee's attendance in routing office (check) using voice recognition, facial recognition. Green AI-based medical system, e-commerce, and mobile network field research application has more research opportunity in pattern-based detection technique [19].
- The upcoming research challenge of WSN is the security layer. Particularly node authentication and data confidentiality. There are two modes of data transfer between source and destination used in WSN. The single-hop modes transfer sends data packets within the hop. The multi-hop modes transfer sends data packets to a remote destination. In this case, it is possible to avoid snooping, spoofing attacks, and forging the identity of nodes like in the Sybil attack [15]. NesC is an extended C language, using this language. TinyOS operating system supports the WSN. Security protocol TinySec supports encryption with authentication is another area where specific research is in demand. Every year WSN market value of 17.6% and is ever increasing expected to reach 123.93 billion US dollars in 2026 [13].

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