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Intelligent Computational Model for Energy Efficiency and AI Automation of Network Devices in 5G Communication Environment

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Abstract: Currently, the 4G network service has caused massive digital growth in high use. Video calling has become the go-to Internet application for many people, downloading even huge files in minutes. Everyone is looking for and buying only 4G Subscriber Identity Module (SIM)-capable mobiles. In this case, the expectation of 5G has increased in line with 2G, 3G, and 4G, where the G stands for generation, and it does not indicate Internet or Internet speed. 5G includes next-generation features that are more advanced than those available in 4G network services. The main objective of 5G is uninterrupted telecommunication service in hybrid energy storage system. This paper proposes an intelligent networking model to obtain the maximum energy efficiency and Artificial Intelligence (AI) automation of 5G networks. There is currently an issue where the signal cuts out when crossing an area with one tower and traveling to an area with another tower. The problem of "call drop", where the call is disconnected while talking, is not present in 5G. The proposed Intelligent Computational Model (ICM) model obtained 96.31% network speed management, 90.63% battery capacity management, 92.27% network device management, 93.57% energy efficiency, and 88.41% AI automation.

Key words: hybrid energy; storage system; 4G; digital growth; 5G; downloading; Subscriber Identity Module (SIM); generation; network; energy efficiency; Artificial Intelligence (AI) automation

1 Introduction

5G stands for the fifth generation mobile Internet. Efforts to develop the fifth generation mobile network started as early as 2013, and its rollout started worldwide in 2019[1]. When the 5G network was

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tested, its speed was 1 Gbps, where bps is short for bytes per second. 5G network is now operational in 70 countries with an average download speed of 700 Mbps[2]. With 5G, data travel at much higher speeds via radio waves. To make it easier to understand, this can be called superfast Internet, which is a hundred times faster than 4G Internet speed[3]. Many hope that with the switch to 5G Internet, applications will not crash halfway through, videos will not buffer, and they will not struggle with persistent download identifiers[4]. If 4G has problems, 5G will indeed have them because 5G will require a much denser network. Now the priority of the operators should be to meet the needs of the paying customers[5]. Initially, focus on industry. It may take more time to reach the ordinary person. The International Telecommunication Union (ITU), a part of the United Nations, defines the facilities that must be present in each generation of network service[6]. Based on this definition, mobile manufacturing and telecommunication companies offer their products and services[7]. In this case, ITU has recently published a report about some facilities that must be present in 5G network service[8]. Even a full-length movie can be downloaded in minutes as the Internet works at lightning speed on 5G network service.

Downloading and uploading will be faster than ever[9, 10]. When making a video call, we hear the other person speaking with a delay of a few seconds. Video and audio may not match properly. In 2014, the World Health Organization stated that cell phone use does not cause adverse health effects[11]. However, the World Health Organization and the International Agency for Research on Cancer (IARC) have classified radio frequency radiation as probably carcinogenic[12]. This classification is included because there is some evidence to conclude that humans exposed to this radiation may develop cancer[13]. Although statistics show that heavy cell phone users have an increased risk of developing cancer, there is insufficient evidence to support this need to take precautions[14].

As the Internet speed will be superfast on the 5G network, a video call can be made without delay. Augmented Reality (AR) service will be used more and more in real-time as Internet speed will be higher[15, 16]. For example, while walking down the road, the full details of a place are instantly loaded into augmented reality. The Internet of Things (IoT) and smart devices will be used more extensively in 5G network services than at present[17]. Cooking can be done from the comfort of the office with a bright stove. Self-driving cars that can operate without a driver can find routes with the help of the Internet[18]. Autonomous car technology will also improve after the advent of 5G, as uninterrupted network service is essential. The fifth generation telecommunication service has high-speed Internet and efficient communication medium[19]. While 4G service has made mobile broadband possible, 5G technology will provide even faster Internet speeds. However, 5G is more than the Internet speed[20]. Known as latency, the few seconds of delay before a data transfer begins is said to be virtually nonexistent with 5G technology[21]. The 5G will enable the industry to connect various devices and objects. In this way, there will be an impact of this technology in many fields like medicine and transportation[22].

The telephone central offices are yet to reveal how much the 5G plans will charge. However, it will have to spend more money than 4G. There currently needs to be factual information about this[23]. The advancement in technology from 1G to 4G has brought about various changes in our lives, from making simple wireless voice calls to high-speed Internet usage[24]. In this way, technologists believe that 5G technology will cause unprecedented changes in intelligent phone use and other fields[25]. For example, by introducing 5G technology in vehicles, all vehicles plying on a particular road can exchange information with each other to avoid accidents and waste of fuel[26]. The Internet of Things, Artificial Intelligence (AI), and Machine Learning (ML) technologies can introduce accuracy in various issues, including city security, energy saving, environmental management, and disaster management[27]. Apart from that, sports and entertainment-based live shows, movies, and applications centered on technologies like Virtual Reality (VR); augmented reality will facilitate their use[28]. 5G communication is the fifth generation of mobile communication and is set to revolutionize the way that telecom providers and users connect. This new technology has been designed to provide an enhanced user experience with faster speeds and a more reliable connection. 5G is designed to employ a range of advanced technologies to increase the number of users that can be served without sacrificing service quality or introducing interference. The new 5G cellular network has also been designed with Energy Efficiency (EE) in mind. The recent 5G standard allows the use of lower frequency radio waves which consume less power than traditional 4G technology. Additionally, because 5G is designed to work with a large number of devices in a small area, it also reduces the number of cell towers needed and increases the efficient use of spectrum. Besides, 5G networks can use techniques such as beamforming and network Multi Input Multi Output (MIMO) which further improve energy efficiency. Finally, the 5G standard is designed to use the least energy and emit the least amount of radiation as possible. In summary, 5G is designed with energy efficiency in mind and provides improved capabilities for telecom users and providers. The use of lower frequency radio waves, reduced energy consumption, and efficient use of spectrum and radiation make 5G a more efficient and environmentally friendly option than current cellular technology. With the 5G standard, users and telecom providers can benefit from improved user experience, increased energy efficiency, and better service quality.

The paper will focus on energy efficiency and AI Automation (AIA) of network devices specifically related to 5G communications. This paper will discuss the current technologies used in energy efficiency and AI automation implemented in 5G networks and identify areas for improvement. It will evaluate the various energy-saving strategies and AI automation techniques employed in 5G networks and provide guidelines for maximizing their benefits. Additionally, future research directions in the field of energy efficiency and AI automation of 5G networks will be explored. The paper will end with an outlook on possible applications of energy efficiency and AI automation in 5G networks and their potential impact on businesses and consumers. The main contributions of this work are as follows:

- Energy efficiency and artificial intelligence management in 5G communication network environment are improved. If the energy efficiency is high, then the energy consumption of the network devices is appropriate.
- Achieving maximum energy efficiency means accomplishing much work efficiently using minimum energy. After calculating the energy required for the devices, energy allocation should be done according to their requirement.
- When excess energy is required, the request should be given again, based on the fact that the required excess energy should be provided. Thus the energy expended on work is saved. Thus it is considered possible to achieve high energy efficiency.
- Moreover, all these operations should be done entirely through artificial intelligence without any manual method. It improves not only the quality of work but also the quality of service.

The rest of the paper has organized as the following. Section 2 explains the existing works related to the research, and Section 3 illustrates the real-world problems and challenges faced in implementing 5G communication. Our proposed model is discussed in Section 4, and the results are discussed in Section 5. Finally, the results and future implementations are discussed in Section 6.

2 Related Work

Monteiro et al.[29] discussed that the impact of 5G will bring many more changes. It will have a significant impact, especially in medicine, education, manufacturing, and science. The most significant benefit of 5G networks will be in the manufacturing sector, but rolling out this network is costly and time-consuming. Dangi and Lalwani[30] have explained that smart cities can be interconnected, doctors can perform surgeries remotely, and vehicles can operate on roads without drivers. 5G is a new telecommunication technology with high speed. It is expensive. It requires much investment. A large number of towers will be required to set up its network. There are many challenges in setting up 5G. Ramesh et al.[31] provided a 5G network that can be operated in two ways. First, a separate network should be set up for this, called a stand-alone network. The second is to use an already established network called a stand-alone network. However, wherever in the world where 5G has been launched through a stand-alone network, it has to be connected through a stand-alone network. The radio network will have to build new structures. Network provider companies must also ensure that 3G and 4G networks continue functioning as before.

Kannadhasan et al.[32] illustrated there are two aspects to 5G network expansion. One is to expand wireless technology geographically, and the second is to increase its use. There will be problems in expanding the network. Several types of permits are required. Alrajeh et al.[33] highlighted a considerable challenge that a large customer segment needs help to afford a 5G mobile or pay expensive data charges. From the users' point of view, they also need a device that supports 5G. Not everyone can afford them. The price of 5G mobiles may come down later. El Amraoui[34] explained that 5G will not make a big difference to ordinary users in the short term, but surfing the web will be faster. However, there are many benefits that 5G will bring that must be addressed. Its most significant advantage will be in the field of automation and technology. However, 5G will have a significant impact in the long run. Hasan et al.[35] illustrated that there will be a revolution in the manufacturing, education, and health sectors. Automated vehicles can be operated in manufacturing units. Doctors can perform surgery remotely. Hitherto, communication has generally been human-to-human. However, now with the Internet of Things, devices and machines will be interconnected and share data in real-time at high speeds, which will benefit almost all industries.

Mangra et al.[36] explained that a 5G service is seen as a revolution in the telecommunication industry. With its arrival, many changes may happen around it. For example, 5G high-speed data users will get a completely different Internet experience. Bagwari and Tomar[37] explained that the demand for the Internet of Things will increase. For example, the number of IoT devices in the home will gradually increase. From Wi-Fi cameras to smart speakers, it is expected to expand rapidly. However, all this will only happen in a few days. Mazhar et al.[38] expressed that 5G will bring many new things, but it may take some time for these things to reach everyone. Some people worry that the electromagnetic radiation used in all cell phone technology can cause health problems, including some types of cancer. Table 1 provides a comprehensive analysis of the related works and the following problems are identified.

- Building 5G networks is costly and time-consuming to design its communication infrastructure.
- Building 5G networks involves high costs and many high-frequency antennas.
- The 5G requires innovative artificial intelligence technologies to handle the devices connected to the network. Moreover, connected devices have high energy consumption.

The following novelties have been proposed to resolve the above-identified issues.

- Identifying the required operational energy requirements for the periodic access to network devices is helpful in reducing energy consumption.
- All network management tasks are performed using an artificial intelligence based approach.

3 Problem and Challenge

Logeshwaran and Karthick[39] identified that the Internet technology based on the fifth generation of mobile phones is called 5G. It is expected to have download and upload speeds many times faster than the previous 4G technology. Like previous cell phone technologies, 5G network service works with signals carried over radio waves. Lee et al.[40] identified that 5G communication is a component of electromagnetic waves. This wave transmission takes place between the towers and the cell phone. Electromagnetic radiations are around us all the time. We are surrounded by radiation from all kinds of technology, including television, radio signals, cell phones, and natural sources like sunlight. Hasan et al.[41] identified that the

Table 1 Comprehensive analysis of related works.

Reference	Analysis result
Monteiro et al.[29]	Rolling out this network is costly and time-consuming.
Dangi and Lalwani[30]	A large number of towers will be required to set up its network.
Ramesh et al.[31]	Network providers must also ensure that 3G and 4G networks continue to function as before.
Kannadhasan et al.[32]	There will be problems in expanding the network.
Alrajeh et al.[33]	There is a large customer segment that cannot afford a 5G mobile or pay its expensive data charges. From the users' point of view, they also need a device that supports 5G.
El Amraoui et al.[34]	5G won't make a big difference to ordinary users, but surfing the web will be faster.
Hasan et al.[35]	With the Internet of Things, devices and machines will be interconnected and share data in real-time at high speeds, which will benefit almost all industries.
Mangra et al.[36]	Users of 5G high speed data will get a completely different Internet experience.
Bagwari and Tomar[37]	The number of IoT devices in the home will gradually increase. From Wi-Fi cameras to smart speakers, it is expected to expand rapidly.
Mazhar et al.[38]	Some people worry that the electromagnetic radiation used in all cell phone technology can cause health problems, including some types of cancer.

5G technology uses higher frequency signals than existing cell phone towers. It enables the simultaneous use of Internet service by an even more significant number of cell phones than at present, at an even higher speed. These waves travel only a short distance through the surface. Therefore, 5G network service requires more enormous towers and is closer to the ground than previous technologies. Alqahtani et al.[42] identified that the radio waves used in cell phone services do not produce ions. This means it does not have the power to damage DNA and cells. Long-term exposure to electromagnetic waves at frequencies higher than those used in cell phones poses health risks. The sun's UltraViolet (UV) rays fall into this vulnerable category. It may cause skin cancer. Bagwari et al.[43] identified that there are strict advisory limits on high-energy radiation doses such as X-rays and gamma rays in medical treatment. Both of these can cause damage to the body. People worry that we are increasing our risk of cancer. It is understandable. However, radio waves are less powerful than the light we see daily. There is no credible evidence to show that cell phones or wireless services cause health problems. Tomaszewski and Kołakowski[44] have identified that the 5G technology will require many towers. It is from this that cell phone signals are given and bought. However, if there are more towers, radio waves will be transmitted at lower power than in previous 4G towers. Hence, the radiation dose will also be less. Guidelines for high-rise cell phone towers state that radiofrequency fields in populated areas are many times lower than guideline levels.

Paul and Rho[45] have discussed that a probabilistic model for M2M in IoT networking and communication is a model that incorporates the uncertainty of certain variables, such as the reliability of data transmissions between nodes or the availability of the nodes, allowing for a more realistic interpretation of data flows between Machine to Machine (M2M) nodes. The model also includes elements of mathematical probability theory and statistics to generate probabilities for different outcomes and interactions. This model allows for better analysis of complex communication scenarios and can be used to optimize the network and the nodes to improve energy efficiency and data security. This type of model is important for long-distance M2M communication, especially in large-scale deployments.

Chochliouros et al.[46] have discussed that energy efficiency concerns and trends in future 5G network infrastructures are a set of challenges that network infrastructure providers will need to address in order to successfully deploy 5G networks that have both the highest speed and the lowest energy footprint. Challenges such as edge computing, which increases the efficiency of data communication, and cloud computing, which reduces the energy requirements of large-scale infrastructure, are expected to become a part of the 5G landscape. Other energy efficiency concerns for 5G networks include improving energy efficiency for user devices, reducing the power consumption of radio access networks, and improving energy efficiency of network functions.

Din et al.[47] have discussed a multi-parameter green reliable communication for Internet of Things in 5G network, which is a new communication solution that combines advanced technologies and techniques from the existing 4G network, such as advanced radio resource management, Distributed Coordinated Multi-Point Role (DCMPR), and network slicing, with green communications protocols to effectively reduce energy consumption while continuing to provide high-quality service. The goal of this solution is to realize reliable and low-energy communication between various Internet of Things devices and networks in a 5G network.

The research paper titled "AI-driven zero-touch operations, security and trust in multi-operator 5G networks: A conceptual architecture"[48] demonstrated how AI-driven methods can be used to configure and optimize the energy efficiency of 5G communication networks. Amongst other things, the authors of Ref. [48] selected a neural network based intelligent controller to regulate the power-level of each user in the 5G communication environment. In their experiments, the authors showed that the proposed intelligent control system reduced the energy consumption of the overall network by up to 45% and improved the overall network throughput by up to 11%. Another research paper titled "AI-assisted energy-efficient and intelligent routing for reconfigurable wireless networks"[49] outlined the design of a multi-objective intelligent model to simultaneously optimize the energy efficiency and performance of 5G wireless networks. The authors used genetic algorithms, along with other heuristic optimization algorithms, to optimize various 5G network parameters, such as transmission power, transmission/receiving time-frequency allocations, and user locations. The simulations conducted by the authors showed that their proposed intelligent model improved the energy efficiency of the 5G networks by up to 15%. Therefore, various studies have shown that both AI automation and Intelligent Computational Model (ICM) can help to reduce the energy consumption and improve the performance of 5G communication networks. The effectiveness of proposed model has focused on the following key elements.

(1) Intelligent Network Automation (INA): INA is an intelligent and automated network system which can independently and autonomously manage all types of communication networks and devices, including 5G networks and devices. It is designed to automatically optimize network configurations and paths, while maintaining high utilization of available resources and ensuring low latency. It uses machine learning algorithms to optimize and manage network settings and devices, while reducing operational overhead and cost.

(2) Deep learning for network devices: Deep learning algorithms can be used to learn the operations and behavior of 5G network devices, providing a more efficient and cost-effective management of the various components of a network. It can be used to efficiently adjust parameters and manage traffic of devices, optimizing operations and energy efficiency.

(3) Optimized energy consumption: An intelligent computational model can be used to predict and optimize the energy consumption of network devices, in order to minimize energy losses and maximize system efficiency. It can be used to find the best settings for a given environment, considering the limitations in resources in terms of processing power and energy availability.

(4) Autonomous network management: An autonomous network management system can be developed for 5G network devices, providing an intelligent solution for managing the various components of the system. It can interpret relevant data, detect faults, respond to changes, and minimize energy consumption.

(5) Virtualization of network components: Virtualization of the various components of 5G networks can help to reduce energy consumption, since the actual hardware can be run with a fraction of the power required without sacrificing performance. This can lead to improved energy efficiency and cost savings.

4 Proposed Model

The 5G networks can broadcast video with high accuracy up to 8000 with ease and non-stop as the technology makes data transfer much faster and more efficient. The fifth generation supports data transfer speeds of up to 1 GB for mobile devices and 10 GB for fixed devices, as well as live streaming of games as if they were recorded on a clip device. Our proposed transmitter blocks are shown in Fig. 1. 5G allows files and large programs to be downloaded, and new technology emerging faster than 4G will be more robust with the fifth generation. Our proposed receiver blocks are shown in Fig. 2.

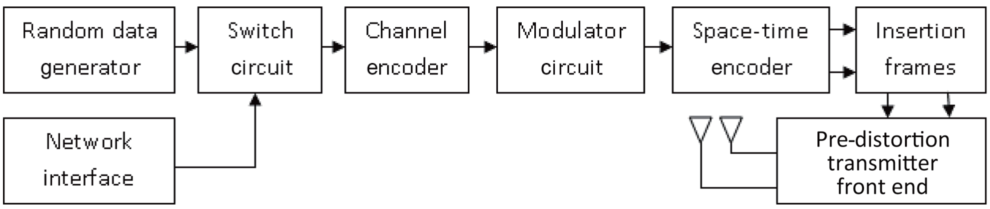

Fig. 1 Proposed transmitter block diagram.

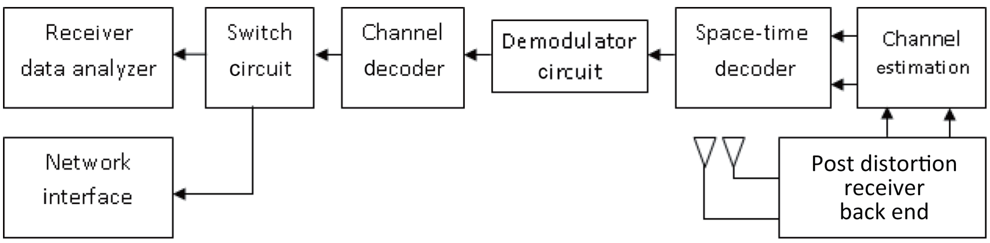

Fig. 2 Proposed receiver block diagram.

4.1 Network speed

Before we know what the Internet speed will be with 5G technology, let us know about the average 4G speed. Although specific bandwidths, quality, and average speeds are set for 4G technology worldwide, there are considerable differences in Internet speeds between countries. International wireless speed research firm OpenSignal says that Singapore has the highest number of 4G Long Term Evolution (LTE) users in the world, with an average speed of 44 Mbps, while India has an average speed of 9 Mbps.

4.2 Wi-Fi access point switching

After the arrival of the 5G network, no change will happen overnight. The only benefit for the customer is to get better quality calls. It will start getting better connectivity in cities with 5G coverage. Apart from this, Internet speed will increase. If it gets 100 Mbps on 4G, it can comfortably get 1 Gbps on 5G. Wi-Fi will not be needed after 5G. The reason is that it may affect the Wi-Fi market, while the arrival of 5G will continue the Wi-Fi business as 5G service is only available in some places. Many believe that 4G service will end after 5G comes. Now both 4G and 3G services are available. Likewise, both 4G and 5G services are available. All of the wavelengths used by 5G are entirely safe and have been under research and testing for decades. When the phone is in use, it communicates with the nearest phone tower via radio waves. The phone tower then connects to a primary network (also via radio waves) and then transmits the information it received and sends the information back.

4.3 Handling of Subscriber Identity Module (SIM)

The 5G networks are already installed in most parts of the world. At the same time, some countries are actively working on setting up their connectivity stations. Put 5G as a new dimension of data speed development. It leads consumers to access additional features and products. While feature phone customers use 2G SIM cards, smartphone customers use 3G and 4G SIM cards. 5G SIM will be introduced soon. It will be like the current 4G SIM. There will be no change in the size and shape of the 4G SIM. 5G SIM can only be used in 5G phones. Also, mobile users who have purchased 5G phones do not need to purchase a 5G SIM separately. Customers can connect to the 5G network from their 4G SIM. 5G has been heralded as the next-generation "connectivity source" for the evolution of AR/VR technology and for making online gaming more accessible. It also gives a new lease of life to IoT. Thus, as we see 5G as the future, so are 5G network services. It means that speed is the bandwidth of the wireless radio communication. Here, some of the issues were faced by the service providers in the existing models.

(1) Service provider issues and challenges: Service providers must address multiple issues when deploying and managing networks in 5G environments, including reliability, scalability, latency, energy efficiency, and the introduction of artificial intelligence for automated Network Device Management (NDM). They must also ensure that any upgrade process is secure and protects customer data.

(2) Energy efficiency: Service providers must ensure that the network is powered efficiently and optimally. This means minimizing power consumption while maintaining high performance. To do so, they must implement new technologies and procedures to reduce the environmental impact of the network.

(3) AI automation of network devices: The introduction of AI for automated network device management simplifies many network management tasks, such as network provisioning, configuration, health monitoring, and fault management. AI-enabled networks can also provide predictive analytics and proactive network troubleshooting.

(4) Implication for service quality: The upgrade process for energy efficiency and AI automation of network devices in 5G communication environment can significantly enhance service quality and customer experience. Service providers can use AI-enabled network automation to reduce human intervention in network management, improve reliability, and deliver faster and more accurate services. Additionally, customers will benefit from a more reliable and energy-efficient network that can be managed remotely with minimal latency.

The primary type of network device that can be managed by an intelligent computational model for energy efficiency and AI automation of network devices in the 5G communication environment is a 5G mobile network base station. This device requires a lot of power to operate, so intelligent models can help to detect network signals, perform automatic signal optimization, and enable dynamic network reconfiguration in order to reduce energy consumption and optimize network performance.

The secondary types of network devices that can be managed by such an intelligent model include optical routers, switches, and gateways. With these devices, the model can detect traffic patterns, detect threats, and enable efficient rerouting of traffic in order to improve network speed and reliability. The model can also determine optimal network configuration parameters, such as routing protocols, to ensure that communication is maximized.

Overall, an intelligent model can be used to manage 5G user devices, such as smart phones and tablets. The model can analyze user behavior and detect threats, allowing for automated protection of user devices. Additionally, the intelligent model can be used to optimize network usage for 5G users, by enabling prioritization of data traffic and detecting abnormal user activities. This can help to reduce energy consumption while improving user experience.

Here, AI-based automation techniques can be used to increase energy efficiency in network devices. AI-enabled devices can use machine learning algorithms to optimize energy use in the network by analyzing the current network resources and usage patterns from past data. AI-enabled devices can also detect and adapt to changes in network traffic or environmental conditions to reduce power consumption. Moreover, intelligent scheduling can be used to prioritize and mismatch power consumption during peak and off-peak hours. Finally, AI-enabled devices can monitor device functions such as physical interface utilization and power cycling to reduce power consumption.

4.4 Proposed algorithm

The energy computation algorithm is an intelligent computational model for energy efficiency and AI automation of network devices in 5G communication environment, as indicated in Algorithm 1. It automates the process of allocating resources, such as bandwidth, for 5G usage, while optimizing energy efficiency. Algorithm 1 uses a machine learning approach and evaluates the energy requirements of each network device over a given period of time. By determining the device-level energy requirements and understanding the communication between devices, Algorithm 1 can determine the best-suited hardware configuration to maximize energy efficiency. The proposed algorithm also takes into account the environmental parameters, such as climate and usage patterns, to further enhance its efficiency. It can also detect and alert users to anomalies, such as malicious activity, on the network. With the introduction of 5G, Algorithm 1 will be extremely useful in optimizing network devices for energy efficiency and automation. The proposed algorithm uses AI to identify the optimal loading conditions for each network component. It then optimizes the network's resources and configuration based on energy consumption, cost, and performance. The proposed algorithm is able to collect a variety of data points related to the performance and status of the network and the number of active devices connected to it. These data are then evaluated to identify the most efficient way to configure and allocate resources while still meeting the performance requirements of the network. The proposed algorithm makes use of deep learning and other AI technologies to enable automated network structure optimization. Using an AI-driven approach to analyze the data points provided by the proposed algorithm, the network is able to self-adjust its performance and usage in order to optimize its energy efficiency. This allows for significant cost savings in energy bills, while also improving the reliability and security of the network. Additionally, this technique can help network operators to reduce their carbon footprint by ensuring that the devices are using energy efficiently. The energy computation algorithm for an intelligent computational model for energy efficiency and AI automation of network

Algorithm 1 Energy computation algorithm

Step 1: Start;
Step 2: Slice the network as per the device region;
Step 3: Analyze the energy requirements as per the device request;
Step 4: **if** (requirements = available)
Step 5: **then** send the energy request as per the requirements;
Step 6: **if** (request = approved)
Step 7: **then** fulfill the energy requirements;
Step 8: Compare the device performance;
Step 9: **if** (energy utilization < 50%)
Step 10: **then** the high level energy efficiency has achieved;
Step 11: **else if** (energy utilization = 50%−80%)
Step 12: **then** the mid level energy efficiency has achieved;
Step 13: **else** the low level energy efficiency has achieved;
Step 14: **else** go to Step 2;
Step 15: **else** go to Step 3;
Step 16: Store the excess energy;
Step 17: Stop.

devices in 5G communication environments is an effective way to improve the overall energy efficiency of the 5G infrastructure. It provides an automated approach which can save energy, reduce costs, and improve the reliability of the network. The technology used to implement an intelligent computational model for energy efficiency and AI automation of network devices in a 5G communication environment would include the following:

(1) AI and machine learning algorithms: This technology is used to train models on large datasets which can then be used for decision making processes. ML algorithms are used to automate network operations and make use of data to provide insights and alternatives for optimizing and improving energy efficiency and performance.

(2) Network automation: This technology is designed to automate the operations of devices within the 5G network, making them more efficient and reducing their costs and manual effort. This technology can be used to detect anomalous events and optimize the network without manual intervention.

(3) Data analytics: This technology is used to collect large quantities of data from the 5G network and its devices, and then analyze them to provide insights and make predictions. It can be used to improve energy efficiency and automated network operations with the help of AI and ML algorithms.

(4) Cloud computing: This technology is used to store data centrally and make them accessible to all the devices of the 5G network. This allows these devices to access the data in real-time, providing businesses with powerful insights that can be used to optimize the network and reduce energy costs.

(5) 5G technology: This technology gives network devices ultra-low latency, increased data rates, and improved coverage by connecting the devices to multiple 5G base stations. This provides the devices with the capacity to utilize AI and ML algorithms for optimizing energy efficiency and automating network operations.

A computational algorithm for energy efficiency and AI automation of network devices in 5G communication environment could be based on Interactive Machine Learning (IML). It would encompass three key areas:

(1) Optimizing energy efficiency: IML algorithms would be used to analyze network device data such as power consumption, server load, and temperature. This would enable the optimization of energy use by adjusting settings accordingly.

(2) Network automation: IML algorithms would be used to automate the setup and management of network devices. This would allow for a more efficient operation of network infrastructure.

(3) AI-driven network security: IML algorithms would be used to detect and respond to suspicious activity on the network, and detect anomalies and behavioral patterns of devices. This would provide better protection against possible threats.

Overall, IML algorithms would enable the efficient use of energy and improved management of network infrastructure, as well as enhanced security measures.

$$x(a,b) = p(a,b)\times q(a,b) + r(a,b), \tag{1}$$

$$1 \leqslant a \leqslant S, 1 \leqslant b \leqslant S$$

where $x(a,b)$ and $p(a,b)$ represent the samples received from the subcarriers "a" and "b" in Eq. (1). The $q(a,b)$ represents the transfer function of the communication channel from the subcarriers "a" and "b". The $r(a,b)$ indicates the channel noise created from the subcarriers. S is the sub-carrier. Hence, the computation values obtained here are as follows:

$$M = 0, \quad V = E\,|\,r(a,b)\,|^2 \tag{2}$$

where M is the mean, V is the variance, and E is the energy.

The overall noise variance (V_{all}) produced by all the subcarrier channels is computed as Eq. (3).

$$V_{\text{all}} = \frac{1}{2U_{\text{all}}}\sum_{a=1}^{U_{\text{all}}} |P(a,1) - P(a,2)|^2 \tag{3}$$

where $P(a,1)$ and $P(a,2)$ represent the samples received from the subcarrier "a" from the Channels 1 and 2, respectively. U_{all} is the all used subcarriers in the entire communication network. Now the log-Likelihood Ratio (LLR) calculations are initiated in Eqs. (4) and (5).

$$Z(a,b,c) = \frac{\min\limits_{t\in T_0^1}\left(|p(a,b)-Q(a,b)t|^2\right)}{V_{\text{all}}} - \frac{\min\limits_{t\in T_1^1}\left(|p(a,b)-Q(a,b)t|^2\right)}{V_{\text{all}}} \tag{4}$$

$$Z(a,b,c) = \frac{\min\limits_{t\in T_0^1}\left(|p(a,b)-Q(a,b)t|^2\right) - \min\limits_{t\in T_1^1}\left(|p(a,b)-Q(a,b)t|^2\right)}{V_{\text{all}}} \tag{5}$$

where a, b, and c are the sub-carrier variables, T is the initial timing, and Q is the communication frame.

Our proposed model flow chart is shown in Fig. 3. Here Algorithm 1 explains the proposed process. First,

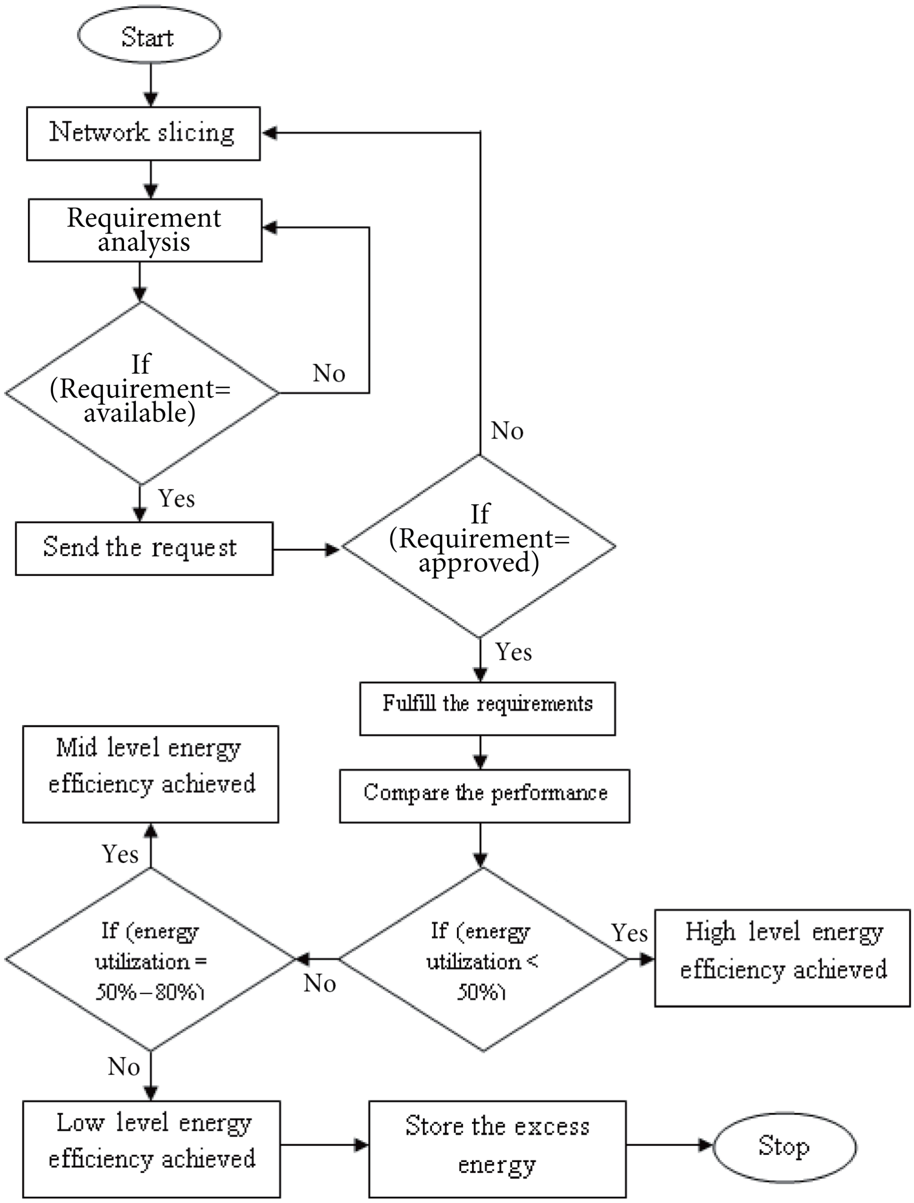

Fig. 3 Proposed flow chart.

the definition of the network is measured based on the given inputs. Based on these measurements, network devices and their requirements are calculated. The resources used by this device (bandwidth, energy, and speed) are calculated based on these calculations. Network devices request the energy they need based on the calculated resources. Network energy is allocated based on this request. When the network energy usage is less than 50%, it can achieve high energy efficiency. Moreover, it can achieve mid level energy efficiency when energy utilization is between 50%−80%. Finally, when the energy utilization is more than 80%, it reaches the minimum energy efficiency. Currently, if your phone uses 4G, the frequency of radio waves it uses is anywhere between 2−8 GHz. This is found to be 2−3 GHz on 3G (it may be slightly different depending on your region). Using higher frequencies has both advantages and disadvantages. The higher the frequency of the radio wave, the shorter the waves. Like sound waves, short waves lose energy faster as they travel, so they disappear over shorter distances. Short wave means more devices can connect to a phone tower at the same time. 5G network connectivity provides speeds for those frequencies that will be significantly higher than currently available. One of the reasons people are so worried about 5G is that the new network will be able to support frequencies up to 300 GHz. Short waves with their great energy may seem dangerous, but there is no basis for these concerns. 5G's 26 GHz radio wave is absorbed in the outer layers of the skin rather than penetrating the brain tissue. The skin has nerve endings that can alert you to any exposure.

4.5 Integration

The proposed model is designed to integrate AI and machine learning capabilities into existing 5G network architectures to achieve energy efficiency and automated network device operations. The proposed model utilizes existing 5G capabilities and adds energy efficiency and AI automation of network devices to them. It is based on a distributed AI engine and system-level optimization strategies and intelligent algorithms to enable real-time optimization and intelligence for 5G networks. The model is also designed to provide an end-to-end analytics platform for optimizing the energy efficiency of 5G networks. The AI engine collects the data from network devices and analyzes them in order to optimize the network by identifying the hotspots and potential areas for energy savings. The model will also generate a dynamic profile of the network with the utilization of machine learning models and real-time data in order to identify and optimize the network performance. The model will improve energy efficiency of 5G networks by managing the power consumption in each layer of the network and reducing the power consumption of the network devices. The integration of this model into existing 5G networks will enable energy savings while also enhancing the performance of the networks.

4.6 Handling of Signal-to-Noise Ratio (SNR)

The SNR is a measure of the relative impairment of a signal due to noise, and the impacts of an intelligent computational model for energy efficiency and AI automation of network devices in a 5G communication environment can be dramatic.

Step 1: AI-based approaches to control network equipment in 5G networks are able to reduce the transmitter power necessary to reach a certain quality of service. This in turn reduces the overall environmental interference, which can generally be seen as noise (interference from other transmitters). This improves the SNR for the chosen device.

Step 2: AI-based approaches can improve the adaptive scheduling of network equipment. For quality service, it is important to ensure that the maximum signal strength is achieved between two nodes. With AI-based scheduling, nodes can better predict and intelligently allocate the needed power for optimal signal strength while maintaining an SNR which is high enough for good communication quality.

Step 3: AI-based approaches can enable more accurate frequency tuning, which affects the noise level. AI-based models are able to identify different types of noise, analyze its impact on network communication, and then modify parameters to reduce the noise level and improve the SNR.

5 Result and Discussion

There are many differences between 4G and 5G like latency, download speed, base stations, cell density, etc. 5G is not one step but several steps ahead. You can even access speeds of up to 20 Gbps fewer than 5G; high resolution streaming and High Definition (HD) video viewing experience reaches a new high. So much more can be done under 5G with unlimited possibilities. Our proposed intelligent computational model has compared with the existing 5G Network Management (5GNM), Energy Storage and Conservation Model (ESCM), and Dynamic Spectrum Allocation Scheme (DSAS). Table 2 expresses the simulation parameter values. Here, the Network Simulator version 2 (NS-2) has been used for simulating the results.

5.1 Model analysis

5G network management model: The 5G network management model for automation of network devices is a system designed to deliver faster wireless network performance and enhanced network management capabilities. By leveraging the features of automation

Table 2 Simulation parameters.

Parameter	Value
Duration of the simulation	3000 channel frames
Preamble duration	20 ms
Detection connectivity	0.6
Frame duration	200 ms
Busy state parameter of Primary User (PU) (on)	8
Idle state parameter of PU	3
Maximum interference ratio	1.2
Permission connectivity	0.8

control, network management, and artificial intelligence, the 5G model allows for the more efficient and effective configuration, deployment, and monitoring of 5G networks. The 5G model is built around an advanced control plane component that can autonomously detect and respond to performance issues with greater agility. Artificial intelligence algorithms can process large datasets to optimize communications through the network and are capable of predicting network events. Additionally, the 5G model also includes an analytics component that can provide users with more granular visibility into the performance of their wireless networks. By automating the configuration and monitoring of 5G networks, the 5G model helps businesses to increase efficiency and reduce engineering costs. Automated network monitoring can reduce the amount of work required for manual operations, helping to reduce the overall cost of network maintenance. Automation can also reduce manual errors, enabling faster response time in solving network issues. Additionally, the use of artificial intelligence algorithms allows for more efficient resource allocation. It can lead to increased speed and improved network performance.

Energy storage and conservation model: An energy storage and conservation model for automation of network devices is an important tool in energy management and optimization. This model allows network devices to optimize their energy usage while still maximizing performance and reliability. It also ensures that the network is adequately supplied with energy when demand is high. The energy storage and conservation model consists of three main components: energy storage, energy conservation, and energy optimization.

- **Energy storage:** This component acts as a buffer to store energy. It allows the network devices to draw power from the energy store when needed rather than drawing power directly from the power grid. It reduces energy consumption and helps to optimize the use of natural resources.
- **Energy conservation:** This component helps to reduce energy consumption by implementing measures such as turning off network devices that are not being actively used and using energy-efficient hardware and software.
- **Energy optimization:** This component helps to optimize the energy usage of the network devices by scheduling tasks and adjusting power consumption levels.

It can also optimize energy usage by turning off network devices that are not being actively used or by controlling the power consumption of devices in order to meet specific power requirements. It helps to conserve energy and improve performance.

Dynamic spectrum allocation scheme: The dynamic spectrum allocation scheme is a system that allows for the automated management of network devices over wide geographical areas. It is designed to enable spectrum to be dynamically allocated to different devices while ensuring the efficient use of the spectrum and a minimum amount of interference between them. The system is designed to allow for low latency and improved performance, particularly in mission-critical applications. It uses algorithms to efficiently allocate spectrum to devices based on their current network load. The system can be used in both wireless and wired networks. It can also be integrated with other systems, such as network management and analytics tools. The system is capable of optimizing the performance of networks by reducing interference. In order to ensure that data from sensors are valid, several techniques can be employed:

- Sensor readings can be cross-checked against each other to ensure accuracy. Readings from two separate sensors may be taken and compared against each other to ensure that the readings are equal.
- Any data that appear unusual can be flagged and reviewed. Determining typical sensor data and outlier data can help to flag anything that may look suspicious.
- Measurements can be validated against known values or industry standard datasets to ensure accuracy and reliability.
- The accuracy of sensors should be validated against other independent and objective sources of information.

It could take the forms of surveys, human observations, or other datasets that could corroborate the information obtained from the sensors.

5.2 Network Speed Management (NSM)

The shorter the time it takes to exchange information from one connection to another, the faster the Internet. In 5G network service, this time should be between 4 ms to 1 ms. Even on the fastest 4G service, it takes 50 ms to exchange data. With a 5G connection, speeds of up to 10 Gbps will be achieved. Currently 4G network has a maximum speed of 100 Mbps. Table 3

Table 3 Comparison of network speed management.

Number of connections	Network speed management (%)			
	5GNM	ESCM	DSAS	ICM
100	64.23	56.64	66.87	95.14
200	65.73	57.23	68.74	96.15
300	66.84	58.21	69.57	96.31
400	67.22	59.42	70.48	97.27
500	68.23	60.56	71.40	96.84

shows the comparison of network speed management. Figure 4 compares the network speed management of our proposed ICM model and existing 5GNM, ESCM, and DSAS models. In Fig. 4, the *x*-axis indicates the number of available connections in the networks, and the *y*-axis indicates the network speed management in percentage. In Fig. 4, the red color represents the ESCM model, the green color represents the 5GNM model, the blue color represents the DSAS model, and the yellow color represents the ICM model, respectively. In a comparison point, the existing 5G network management has achieved 66.84%, the energy storage and conservation model has achieved 58.21%, and the dynamic spectrum allocation scheme has achieved 69.57% of network speed management. In this similar point, our proposed intelligent computational model has reached 96.31% of network speed management. The frequencies used by today's 3G or 4G communication systems are less than 3 GB. 5G plans to use 30 GB of radio frequencies. 30 GHz at a core frequency of 3 GHz is equivalent to communication termination. 3 GB is like 300 MB at today's frequency. With 5G technology, maximum download speed of 7 Gbps and upload speed of 3 Gbps are possible.

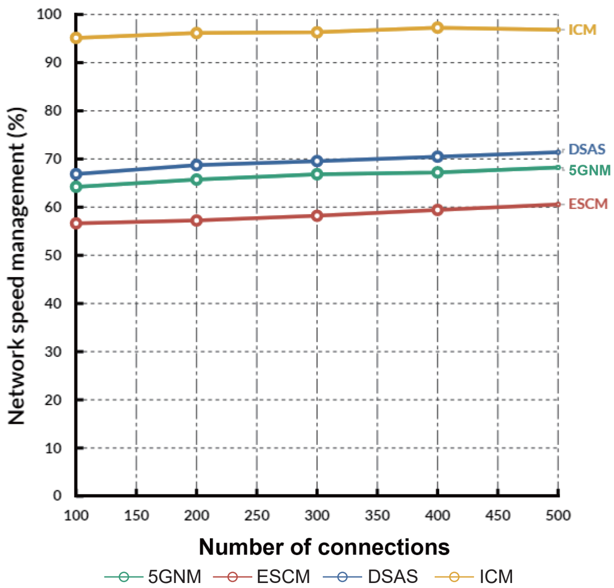

Fig. 4 Comparison of network speed management.

5.3 Battery Capacity Management (BCM)

Everyone who uses 4G network has the problem of mobile battery draining quickly. To compensate for this, mobile manufacturers are producing more powerful batteries than before. Long-lasting battery capacity is also essential in 5G network service. Most people think that 5G is a technology only for mobile phones. But this is not true. 5G is a technology designed to change the way the Internet works. This is going to bring a drastic change not only in mobile phones but also in everything from gaming to businesses. Table 4 shows the comparison of battery capacity management. Figure 5 compares the battery capacity management of our proposed ICM model and existing 5GNM, ESCM, and DSAS models. In Fig. 5, the *x*-axis indicates the number of available

Table 4 Comparison of battery capacity management.

Number of connections	Battery capacity management (%)			
	5GNM	ESCM	DSAS	ICM
100	67.73	46.81	55.52	91.80
200	66.23	46.22	53.65	90.76
300	65.12	45.24	52.82	90.63
400	64.74	44.03	51.91	89.67
500	63.73	42.89	50.99	90.10

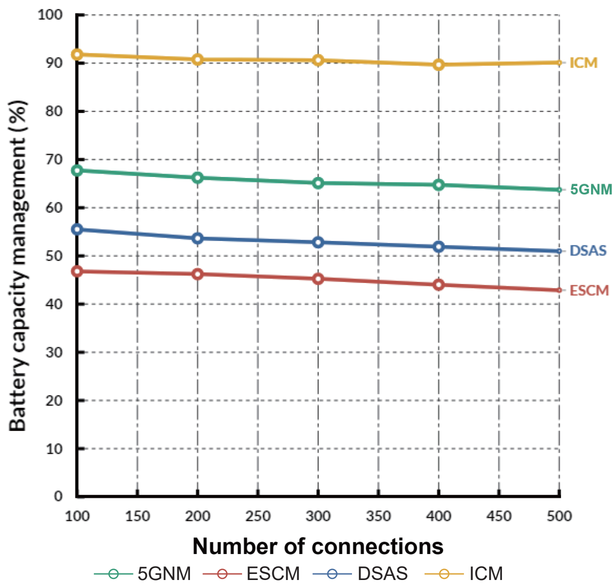

Fig. 5 Comparison of battery capacity management.

connections in the networks, and the *y*-axis indicates the battery capacity management in percentage. In Fig. 5, the red color represents the ESCM model, the green color represents the 5GNM model, the blue color represents the DSAS model, and the yellow color represents the ICM model, respectively. In a comparison point, the existing 5G network management has achieved 65.12%, energy storage and conservation model has achieved 45.24%, and dynamic spectrum allocation scheme has achieved 52.82% of battery capacity management. In this similar point, our proposed intelligent computational model has reached 90.63% of battery capacity management.

5.4 Network device management

Almost all brands have launched 5G capable phones. But, you will not be able to get the benefit of this service on 4G capable phones. For this, you need to have at least a 5G capable phone. Now that the 5G spectrum has been auctioned, you do not need to worry about whether the new cell phones will come with 5G spectrum. It depends on the recent launch of the current mobile phone. 4G service will not work on old cell phones which already have 3G service capabilities. Similarly, 5G service is not available on 3G service mobile phones. There is no need to buy a new smart phone if you already have a mobile phone or smart phone that can receive 5G network. Table 5 shows the comparison of network device management. A few brands will have 5G option along with 4G/3G. To do this you need to go to system → network → mobile network → network mode. If the handset itself does not have 5G capability, you can avail the benefit of the new service only by purchasing a new handset, and no need to buy a new SIM card for 5G service. 5G connectivity is available on the current SIM card. When you buy a new SIM card, the respective telephone central offices are also likely to offer a 5G SIM.

Figure 6 compares the network device management

Table 5 Comparison of network device management.

Number of connections	Network device management (%)			
	5GNM	ESCM	DSAS	ICM
100	54.19	52.48	61.17	89.97
200	55.93	54.06	62.59	91.26
300	58.27	56.26	63.85	92.27
400	59.08	57.89	65.84	93.16
500	61.37	59.03	68.31	93.53

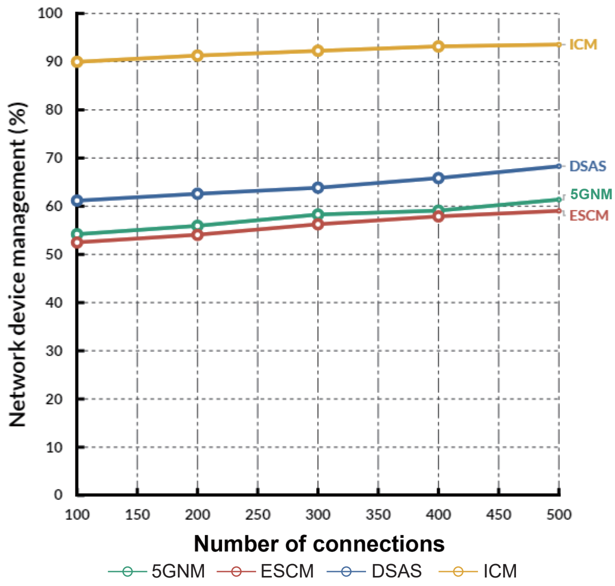

Fig. 6 Comparison of network device management.

of our proposed ICM model and existing 5GNM, ESCM, and DSAS models. In Fig. 6, the *x*-axis indicates the number of available connections in the networks, and the *y*-axis indicates the network device management in percentage. In Fig. 6, the red color represents the ESCM model, the green color represents the 5GNM model, the blue color represents the DSAS model, and the yellow color represents the ICM model, respectively.

In a comparison point, the existing 5G network management has achieved 58.27%, energy storage and conservation model has achieved 56.26%, and dynamic spectrum allocation scheme has achieved 63.85% of network device management. In this similar point, our proposed intelligent computational model has reached 92.27% of network device management.

5.5 Energy efficiency

The exposure threshold of 5G is below the required standard of antenna installation, so the radio waves of 5G signals are not going to affect any life. Moreover, radio waves are in the non-ionizing zone of the electromagnetic spectrum, so they do not have enough energy to do any damage. 5G provides cellular connectivity, whereas Wi-Fi provides connectivity for devices within a limited range. So 5G technology is never going to replace Wi-Fi technology. 5G is not just a technology, it is a breakthrough. It is a milestone. It is a technological boon that will improve our Internet and mobile networks. Table 6 shows the comparison of energy efficiency.

Table 6 Comparison of energy efficiency.

Number of connections	Energy efficiency (%)			
	5GNM	ESCM	DSAS	ICM
100	63.79	48.67	66.58	94.74
200	62.29	48.08	64.71	93.70
300	61.18	47.10	63.88	93.57
400	60.80	45.89	62.97	92.61
500	59.79	44.75	62.05	93.04

Figure 7 compares the energy efficiency of our proposed ICM model and existing 5GNM, ESCM, and DSAS models. In Fig. 7, the x-axis indicates the number of available connections in the networks, and the y-axis indicates the energy efficiency in percentage. In Fig. 7, the red color represents the ESCM model, the green color represents the 5GNM model, the blue color represents the DSAS model, and the yellow color represents the ICM model, respectively. In a comparison point, the existing 5G network management has achieved 61.18%, energy storage and conservation model has achieved 47.10%, and dynamic spectrum allocation scheme has achieved 63.88% of energy efficiency. In this similar point, our proposed intelligent computational model has reached 93.57% of energy efficiency.

5.6 AI automation

By industry standards, advanced 5G is like an upgraded version of existing 5G network connectivity. This will significantly improve the network coverage of the telecom companies, providing you with stable and slightly faster Internet speed. But advanced 5G is not just about connectivity performance. Because, its capabilities surpass the current features offered by the 5G network. Compared to 5G, it will inject more intelligence, increase overall efficiency, and do everything with the environment in mind. Table 7 shows the comparative results. Figure 8 compares the AI automation of our proposed ICM model and existing 5GNM, ESCM, and DSAS models. In Fig. 8, the x-axis indicates the number of available connections in the networks, and the y-axis indicates the AI automation in percentage. In Fig. 8, the red color represents the ESCM model, the green color represents the 5GNM model, the blue color represents the DSAS model, and the yellow color represents the ICM model, respectively. In a comparison point, the existing 5G network management has achieved 69.37%, energy storage and conservation model has achieved 45.34%, and dynamic spectrum allocation scheme has achieved 57.11% of AI automation. In this similar point, our proposed intelligent computational model has reached 88.41% of AI automation. The 5G

Table 7 Comparison of AI automation.

Number of connections	AI automation (%)			
	5GNM	ESCM	DSAS	ICM
100	66.27	42.51	54.11	85.22
200	68.24	44.93	56.31	87.21
300	69.37	45.34	57.11	88.41
400	70.58	46.94	57.78	88.89
500	70.95	49.26	59.21	90.32

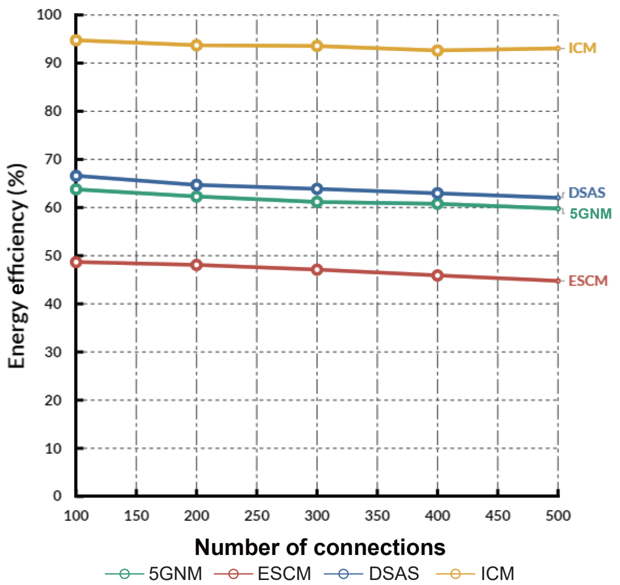

Fig. 7 Comparison of energy efficiency.

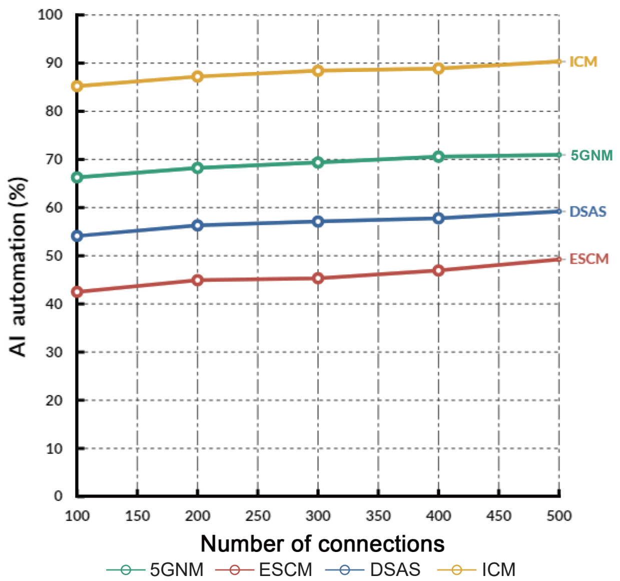

Fig. 8 Comparison of AI automation.

has all the tools needed to make the MetaWare concept a success. It is expected to be a real solution for the development of autonomous vehicles. The current 5G network is advanced, but there are some corners where any kind of connection is difficult to reach. But advanced 5G will help to bridge specific gaps and enable daily operations with the right solutions.

Table 8 shows the overall performance comparison. In a comparison point, the existing 5GNM obtained 66.84%, ESCM reached 58.21%, and DSAS obtained 69.57% network speed management. The proposed ICM reached 96.31% network speed management. The existing 5GNM obtained 65.12%, ESCM reached 45.24%, and DSAS obtained 52.82% battery capacity management. The proposed ICM reached 90.63% battery capacity management. The existing 5GNM obtained 58.27%, ESCM reached 56.26%, and DSAS obtained 63.85% network device management. The proposed ICM reached 92.27% network device management. The existing 5GNM obtained 61.18%, ESCM reached 47.10%, and DSAS obtained 63.88% energy efficiency. The proposed ICM reached 93.57% energy efficiency. The existing 5GNM obtained 69.37%, ESCM reached 45.34%, and DSAS obtained 57.11% AI automation. The proposed ICM reached 88.41% AI automation.

In the overall comparison, proposed ICM model obtained 96.31% network speed management, 90.63% battery capacity management, 92.27% network device management, 93.57% energy efficiency, and 88.41% AI automation, respectively. The computational model can help to reduce energy consumption in 5G network devices by using machine learning and predictive analytics. By applying algorithms to predict the probability of various types of traffic, network devices can adjust their power level accordingly, resulting in improved energy efficiency. AI automation can improve the performance of 5G communication network devices by learning from past experiences and making better decisions about resource allocation. With automated operation, devices can respond quickly to changing network scenarios and traffic patterns, resulting in optimal resource utilization and better performance. The computational model can also help in optimizing the system configuration of 5G network devices, including reducing the number of devices or components, optimizing the resource utilization of each device, and making the system more fault-tolerant. This saves energy and increases overall efficiency while ensuring reliable operations. AI-powered predictive analytics can also be used to detect and diagnose problems with 5G communication devices faster. By learning patterns in usage and traffic, AI can detect anomalies and diagnose problems that may be hard to spot with traditional monitoring techniques. AI automation can also be used to optimize the algorithms and parameters used for 5G network devices, resulting in improved performance and energy efficiency. By analyzing usage patterns and making decisions based on them, AI can help to adjust algorithms on an ongoing basis to ensure the most efficient operations.

Table 8 Overall performance comparison.

Model	NSM (%)	BCM (%)	NDM (%)	EE (%)	AIA (%)
5GNM	66.84	65.12	58.27	61.18	69.37
ESCM	58.21	45.24	56.26	47.10	45.34
DSAS	69.57	52.82	63.85	63.88	57.11
ICM	96.31	90.63	92.27	93.57	88.41

5.7 Statistical test

(1) T-test: This would be used to compare two sets of data, such as the energy consumed before and after the implementation of the model, to determine whether the model is more energy-efficient.

(2) Analysis of Variance (ANOVA) test: This test can be used to compare the energy efficiency of different 5G communication networks with the model to determine whether the model is providing an even better efficiency across all networks.

(3) Chi-square test: This test can be used to compare the AI automation time of the model with that of other network devices in order to determine whether the model is providing faster AI automation.

(4) Correlation test: This test can be used to analyze the correlation between energy efficiency and AI automation speed of the model to determine how energy-efficient it is compared to other devices.

Table 9 shows the comparison of statistical tests for various models including the proposed model. The results of an intelligent computational model for energy

Table 9 Statistical test result.

Model	Test result (%)			
	T-test	ANOVA test	Chi-square test	Correlation test
5GNM	74.93	76.65	83.50	72.40
ESCM	75.41	88.38	77.36	88.28
DSAS	80.05	96.80	85.77	92.51
ICM	91.12	96.80	95.16	99.02

efficiency and AI automation of network devices in a 5G communication environment show that the model is highly scalable. It can be used to provide both energy efficiency and AI automation to network devices in a broad range of 5G communication environments. In addition, the model can be adapted to various types of devices and can handle changes in communication conditions and device characteristics. It makes the model suitable for a range of 5G communication environments. Furthermore, the model can be used to automate processes that can increase the efficiency of network resource utilization, reduce latency, and improve Quality of Experience (QoE). It makes a cost-effective and reliable solution for energy efficiency and AI automation in 5G communication environments.

5.8 Analytical discussion

The model can be designed to improve energy efficiency and AI automation of network devices in a 5G communication environment. The model can be comprehensive in scope, incorporating the various elements needed for efficient and automated network operation.

(1) The model can analyze the coverage area of the 5G network, taking into account geographical distance, terrain, and other factors. It can then determine the optimal implementation of the 5G network based on energy-efficient connectivity between base stations and user terminals. It is able to dynamically monitor the current environment of the network and incorporate the appropriate measures to ensure optimal power efficiency.

(2) The model can also include mechanisms for intelligent automation of network resources. It is capable of automatically scheduling and configuring network devices based on real-time changes in traffic and user requirements. This enables the network to handle unpredictable events and changes in workload, such as surges in traffic. The model is also able to identify and mitigate interference issues and adapt to changing network conditions.

(3) The model can provide intelligent energy management techniques to reduce the electricity demand of the system and to achieve the maximum energy efficiency. This can include the ability to automatically power off and on network devices at peak time and non-peak time, as well as the utilization of smart grid technologies to regulate energy usage and to improve efficiency.

(4) The model is able to provide dynamic control of network devices, which will enable autonomous decision making for network operation. It is able to make autonomous decisions regarding routing of data, appropriate resource allocation, and traffic optimization, as well as to adapt to ever-changing network conditions. This will increase the overall accuracy and robustness of the network.

Mathews Correlation Coefficient (MCC) is a metric used to evaluate the quality of classification models. It is a correlation between the observed and predicted binary classifications. The MCC calculated value is between −1 and 1, where 1 stands for a perfect prediction and 0 indicates that the model predicts randomly. A positive MCC indicates a better performance, while a negative MCC is worse than random. For energy efficiency and AI automation of network devices in a 5G communication environment, MCC can be used to assess the performance of the intelligent computational model. It helps to compare the model’s accuracy with the actual performance of the network devices. MCC helps to understand how the model performs compared to the actual device performance and provides an overall measurement of the model’s effectiveness. Table 10 shows the comparison of Mathews correlation coefficient. The Fowlkes-Mallows Index (FMI) is a useful metric for evaluating the performance of a computational model in an energy-efficient and AI-automated 5G communication environment. This metric is used to measure how accurately the model can identify and classify various network devices for energy efficiency and AI automation and how well it can predict energy consumption. This metric takes into account the true positive rate (number of correctly classified devices) and the false positive rate (number of incorrectly classified devices). The Fowlkes-Mallows index ranges from 0 to 1, with 1 indicating perfect classification, and is calculated using the precision and recall of the model. By using the Fowlkes-Mallows index, the

Table 10 Comparison of Mathews correlation coefficient.

Number of connections	Mathews correlation coefficient (%)			
	5GNM	ESCM	DSAS	ICM
100	77.54	76.98	82.75	92.29
200	76.04	76.39	80.88	91.28
300	74.93	75.41	80.05	91.12
400	74.55	74.20	79.14	90.16
500	73.54	73.06	78.22	90.59

model's energy efficiency and AI automation performance can be easily measured and compared to other models, leading to improved network performance and energy efficiency. Table 11 shows the comparison of Fowlkes-Mallows index. The Critical Success Index (CSI) is a measure used to assess the success of an intelligent computational model for energy efficiency and AI automation of network devices in a 5G communication environment. It focuses on the Key Performance Indicator (KPI) of the system, such as network latency, throughput, uptime, data rates, and resource utilization. The CSI helps to determine whether or not the intelligent model is meeting its predefined objectives. It also helps to identify any improvement areas in the model. The CSI is calculated using the KPI metrics of the model's performance against a set of predefined benchmarks and comparing it with the desired outcomes. Evaluation of the CSI allows organizations to make better decisions concerning their energy efficiency and AI automation investments. Table 12 shows the comparison of critical success index. In a comparison cycle, the proposed model obtained 91.12% MCC, 96.80% FMI, and 95.16% CSI. The proposed computational model is designed to improve energy efficiency and AI automation of network devices in a 5G communication environment. The model should incorporate state-of-the-art tools, techniques, and algorithms to make accurate and efficient system decisions and reduce the energy consumption of the system. By providing intelligent resource management, automated network reconfiguration, dynamic control of network devices, and energy management capabilities, the model enables the efficient and autonomous operation of the 5G network.

Table 11 Comparison of Fowlkes-Mallows index.

Number of connections	Fowlkes-Mallows index (%)			
	5GNM	ESCM	DSAS	ICM
100	74.04	86.81	84.10	95.63
200	75.54	87.40	85.97	96.67
300	76.65	88.38	86.80	96.80
400	77.03	89.59	87.71	97.76
500	78.04	90.73	88.63	97.33

Table 12 Comparison of critical success index.

Number of connections	Critical success index (%)			
	5GNM	ESCM	DSAS	ICM
100	87.58	81.14	78.45	97.46
200	85.84	79.56	77.03	96.17
300	83.50	77.36	75.77	95.16
400	82.69	75.73	73.78	94.27
500	80.40	74.59	71.31	93.90

AI-based solutions tend to be complex and may require substantial modifications in existing network architecture designs and operational procedures. Here some of the limitations and challenges are available to implement the proposed model.

(1) Security analysis: As with any system involving AI technology, there is a risk of malicious actors or malicious programs exploiting weaknesses in the system to access sensitive information or control the network.

(2) Cost analysis: The hardware and software costs associated with building and deploying an intelligent computing model for 5G networks may be too expensive for many organizations.

(3) Network latency: Some AI-based system architectures can cause delays in network performance due to the need to accommodate additional layers of processing.

(4) Data management: It can be difficult for an AI model to analyze large amounts of data efficiently in 5G communication environment. AI models require efficient algorithms to interpret large amounts of data, and this process can take an excessive amount of time and resources for an AI model to complete.

(5) Limited understanding of ambiguity: AI models are not capable of determining the context of situations, as it is difficult for them to distinguish between subtle nuances in a language which can lead to ambiguous outcomes.

(6) Generalization ability: AI models are limited in that they cannot generalize information to different datasets. This can lead to models not being able to accurately make predictions for new inputs.

(7) Fault tolerance: AI models are also not particularly resistant to errors. Small mistakes can lead to inaccurate predictions or conclusions, which can have serious consequences in a 5G communication environment.

(8) Regulatory compliance: AI models can be limited by different regulations depending on the country and industry, and it can be difficult to ensure the compliance of AI models in a 5G communication environment.

AI automation has the potential to dramatically improve the energy efficiency and 5G communication systems used today. AI automation can be applied to many areas of the energy and communication sector, including energy efficiency, network optimization, and cyber security. In terms of energy efficiency, AI automation can be used to predict and monitor energy usage, and to optimize energy usage through machine learning algorithms. This can result in improved consumption patterns and cost savings for energy companies. On the communication side, AI automation can be used to improve and optimize a variety of 5G services, such as network optimization, predictive maintenance, mobility management, and dynamic spectrum management. In terms of network optimization, AI automation can be used to optimize the flow and speed of data on a 5G network. Potential impacts of AI automation in energy and communication systems can include improved energy and resource utilization, reduced costs for energy and communication companies, improved customer experience, and increased security. In the future, AI automation could play an even more important role in these sectors, allowing companies to offer more personalized services and products, as well as enhanced capabilities in cyber security. AI automation could also help to improve the scalability and reliability of 5G deployments. Overall, AI automation has the potential to revolutionize energy and communication systems and to provide major benefits to all stakeholders involved. Here, some of the solutions are provided to reduce the level of risks for the proposed model. They are

(1) Improving device capability management: Implementing capabilities such as power management, task scheduling, resource allocation, monitoring, and self-healing into a 5G environment can help to optimize device efficiency. Such capabilities help to identify wasteful operations and improve the utilization of resources.

(2) Implementing AI automation: AI automation can be used to program devices to intuitively assess network needs and make adjustments in real-time. This can help to maintain peak performance while conserving energy.

(3) Increasing security and transparency: Increasing the security of 5G systems with AI-based methods such as anomaly detection can help to protect networked devices while allowing for remote operation. Applying the same concept to a network device can also help to improve transparency by providing insights into energy usage.

(4) Leveraging cloud enablement: Developing cloud enabled solutions can help to improve organizational efficiency. It allows data to be shared, processed, and analyzed quickly and securely. This allows for increased energy efficiency as well as improved security.

(5) Consolidating infrastructure: By consolidating redundant or inefficient infrastructure components, organizations can improve their energy efficiency. With a more unified intelligence platform, all devices can be managed more effectively. This helps to reduce wasted energy and keep operations running more efficiently.

5.9 Validation analysis

(1) Identification of use case, requirement, and architecture: The use cases, requirements, and architecture of the intelligent computational model should be identified with the help of AI-based techniques and domain experts. It allows for the development of an optimized system architecture that meets the needs of different types of 5G network deployments.

(2) Simulation of use case: Use cases for energy efficiency and AI automation of network devices in 5G should be simulated with suitable simulation tools and validated with real-world data. It will help in validating the architecture, identifying the most suitable software and hardware configurations, and validating the performance of the model.

(3) Prototype development and validation: A prototype of the intelligent computational model should be developed and tested against the simulated use cases. It will ensure that the model meets the needs of different 5G deployments and the AI-based system works as desired.

(4) Real-world deployment and monitoring: The model should be deployed in a real-world environment with monitoring systems in place. It will enable the system to gather data from real-world simulated scenarios and monitor the performance of the AI model to identify any potential issues.

(5) Performance optimization: The performance of the model should be continuously monitored, and its parameters should be optimized to ensure that it is meeting AI-based standards and delivering the desired results in the 5G environment.

By comparing the performance of the proposed model with other existing methods, it is possible to validate the claims made by the paper, including the model's efficiency and its ease of use for energy efficiency and AI automation of network devices in 5G communication environments. Specifically, this comparison could take the form of testing the accuracy of the model's predictions against energy consumption or other measures while also examining how it performs in different environments. Additionally, comparing the speed of convergence as well as business cost and implementation time savings between the proposed model and other existing methods could provide further evidence for the advantages of the proposed model.

5.10 Limitation analysis

The accuracy and reliability of automated network device updates depend on the quality of the sensor data used. The use of small number of sensors is likely to result in a higher incidence of erroneous data or biased results. To address this limitation, the proposed model should consider deploying intelligent, cloud-based sensor solutions that can collect and analyze larger volumes of data from a range of sources. These data should be collected regularly to ensure that the results are valid and up-to-date. Additionally, the proposed model should incorporate powerful data-analysis tools and algorithms into the solution to ensure that the most accurate results are being produced.

• **Data quality:** Data quality is a measure of how accurately and reliably data are collected and recorded. It is a limitation of any intelligent computational model because when the data collected are inaccurate and unreliable, the model will not perform as expected and may lead to wrong decisions.

• **Sensor reliability:** Sensor reliability is a limitation for an intelligent computational model for energy efficiency and AI automation of network devices in a 5G communication environment. Sensor errors can lead to inaccurate data readings, which can further lead to inaccurate predictions and decisions.

• **Implementation challenge:** The implementation of any intelligent computational model for an AI automation of network devices in a 5G communication environment requires a lot of planning and effort. Such considerations include monitoring all data points coming from each device, combining multiple data points to generate useful insights, and developing an algorithm to automate the relevant tasks efficiently. In addition, there may be hardware restrictions and other considerations, such as cost, scalability, and security, which need to be taken into account when designing and deploying the model.

6 Conclusion

International guidelines for the permitted 5G spectrum are limited to microwaves. Microwaves generate heat in the material through which they flow. However, the resulting heat will not be harmful at 5G service levels (the levels used in previous cell phone technologies). The maximum radio frequency level available through the 5G service (or any other signals in common areas) must be higher to generate heat. When 5G service is launched with current services, exposure to radio waves will increase slightly, but not overexposure. In a comparison tip, our proposed intelligent computational model has reached 96.31% in network speed management, 90.63% in battery capacity management, 92.27% in network device management, 93.57% in energy efficiency, and 88.41% in AI automation, respectively. The bandwidth for the introduced 5G signals is below the level of ionizing electromagnetic waves. It is lower than the level prescribed by International Commission on Non-Ionizing Radiation Protection (ICNIRB) as the hazard level. Exposure to electromagnetic waves at frequencies lower than those recommended in the guidelines is not known to cause health hazards.

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