TECHNIUM
SOCIAL SCIENCES JOURNAL

Technium.

46/2023

2023

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Technium Social Sciences

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International Communication & PR

Technium Social Sciences Journal
Vol. 46, 87-104, August, 2023
ISSN: 2668-7798
www.techniumscience.com

5G Impacts, Internet of Things (IoT) and Businesses in Developing Countries

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Abstract. This study addresses the ramifications of 5G technology for enterprises in developing countries and how it affects the Internet of Things (IoT). The IoT ecosystem is expected to see considerable improvements in connectivity, speed, and capacity with the introduction of 5G networks. The potential advantages and difficulties of integrating 5G technology into the IoT landscape are discussed in this study, along with how it might change several industries in developing nations. This research also highlights how 5G technology might boost IoT capabilities through higher device densities, lower latency, and faster data transmission rates. Additionally, it looks into the particular ramifications for enterprises in underdeveloped countries, taking into account the difficulties with infrastructure, affordability, and the digital divide that these countries confront. It also discusses the potential hazards and obstacles to the deployment of 5G, such as the requirement for suitable legal frameworks, security precautions, and talent development. The results of this study help to improve awareness of the potential effects of 5G technology on the IoT landscape in developing countries and offer guidance for stakeholders, enterprises, and policymakers in properly using its advantages.

Keywords. Internet of Things, Technology, Digital Divide, Connectivity, Business Ecosystem, Networks

Introduction

The Internet of Things (IoT), which is changing how we interact with technology, has received a lot of attention recently. According to Atzori, Iera, and Morabito (2010), it refers to a network of physical things like computers, cars, and other machinery that can connect to the internet and exchange data without the need for human involvement. These things are implanted with sensors, software, and other technologies. By increasing efficiency, productivity, and lowering costs, the IoT has the potential to revolutionise a number of industries, including healthcare, transportation, agriculture, and manufacturing. However, dependable and fast connectivity is necessary to fully realise its potential. The vast amount of data traffic produced by IoT devices can be supported by 5G since it offers faster data transfer rates, low latency, and larger capacity (Li, Lu, and Li, 2018).

The potential of 5G technology to improve IoT has been recognised by numerous research. In comparison to 4G technology, 5G technology may be able to support up to 10 times faster data transfer rates, 100 times more connected devices, and 10 times reduced latency. Real-

Technium Social Sciences Journal
Vol. 46, 87-104, August, 2023
ISSN: 2668-7798
www.techniumscience.com

time services and applications like remote control of machines, self-driving cars, and smart cities might be made possible by this. Furthermore, IoT device energy consumption may be decreased by 5G technology, which may be advantageous to sectors like agriculture and healthcare (Wu et al., 2020).

While 5G networks have already been implemented in developed countries, the adoption of IoT solutions in underdeveloped nations has been relatively slow as a result of a number of issues including a lack of adequate connectivity, insufficient network infrastructure, and high implementation costs (Dey et al., 2020; Ojha et al., 2020). These difficulties have hampered the mainstream adoption of IoT technologies in industries like manufacturing, transportation, healthcare, and agriculture. The adoption and use of the IoT technology in these nations, and subsequently, their economic development, may be significantly impacted by this delay.

The IoT and 5G technology integration have the potential to revolutionise a number of businesses in developing nations. The efficiency, performance, and scalability of IoT applications can be improved by 5G's faster data transfer rates, increased network capacity, and reduced latency. The rollout of 5G networks in underdeveloped nations has the potential to solve some of these problems and maximise the use of the IoT applications in these industries. Faster data transmission, real-time analytics, and more responsive control systems may be made possible by 5G's high-speed connectivity and low latency capabilities (Daz-Montero & Garca-Sánchez, 2020).

In light of this, the IoT has already fundamentally transformed how devices are interconnected and how data is shared, and the advancement of 5G technology is predicted to have a significant impact on the IoT. Faster data transfer rates, lower latency, and more network capacity are promised by 5G technology, which may allow for more advanced IoT applications and services. However, it's unclear how 5G technology will affect the IoT in underdeveloped nations. The development and uptake of 5G technology could be hampered by the particular difficulties faced by developing nations, such as their poor infrastructure, lack of resources, and lack of technical know-how. Therefore, it is important to examine how 5G technology will affect the IoT and what it means for different industries in emerging nations.

It is crucial to pinpoint the precise consequences and potential advantages in various businesses as the influence of 5G on the IoT ecosystem in developing nations is still not fully known. Examining potential obstacles to the acceptance and deployment of 5G-enabled IoT technologies in these nations is also necessary. Therefore, the purpose of this research was to examine how 5G technology will affect the IoT and what it means for different industries in developing countries. The combination of 5G and IoT in industries including manufacturing, transportation, and agriculture has the potential to bring about a number of advantages, difficulties, and possibilities. The study will also looked at possible obstacles to the adoption and deployment of 5G-enabled IoT technologies in underdeveloped nations. This study aims to contribute to the knowledge of how 5G technology might accelerate digital transformation in underdeveloped nations by offering a thorough analysis of the topic. This research is significant because it sheds light on how 5G technology may completely alter how IoT devices are connected to and communicate with one another. The findings of this study contribute to a greater understanding of the possible impacts of 5G technology on the IoT environment in developing nations and provide direction for stakeholders, businesses, and policymakers on how to effectively utilise its benefits.

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Literature Review

Evolution of Mobile Technology

After its creation in the first part of the 20th century, mobile technology underwent numerous generations of advancements until the 1970s (Gordon, 2014). According to Giordani et al. (2020), two of the most important advancements in mobile technology were the significantly lower costs and enormous performance gains from generation to generation. The most important contribution of mobile communications is its potential to serve as a base for people's abilities to learn more and express themselves more creatively by making information accessible at the touch of a button or symbol.

Additionally, having access to both wired and wireless high-speed Internet connections is predicted to increase GDP by 5%, resulting in substantial economic gains due to increased productivity (Gruber, Hätönen, & Koutroumpis, 2014). By combining advancements in communication theory, computing power, and analogue radio frequency (RF) circuit electronics, Claude Shannon's solid theoretical foundations for communications from 1948 served as the catalyst for the subsequent advancements in cellular technology (Viswanathan & Weldon, 2014). Mobile technology can be broadly categorised into generations, commencing with the First Generation (1G), moving through the Second Generation (2G), Third Generation (3G), and Fourth Generation (4G), with a Fifth Generation (5G) now under development.

The first generation of cellular phone technology is referred to as "1G" and was only intended for voice calls when it was initially released in the United States in the 1980s under the name Advanced Mobile Phone Service (AMPS) (Bhalla & Bhalla, 2010). Using the Global System for Mobile (GSM) protocol, the second generation of cellular phone technology—also referred to as "2G"—was first made available for purchase in Finland in the late 1980s. In addition to phone calls, 2G supports capabilities including digitally encrypted text messages, photo messages, and MMS (multimedia messaging) (Bhandari, Devra, & Singh, 2017).

Third-generation (or "3G") refers to the Wideband Code Division Multiple Access (WCDMA) technology, which enables mobile phones to access the internet and perform tasks like online browsing, video calls, and music downloads. A component of 3G is General Packet Radio Service (GPRS), a packet-oriented mobile data service with data rates of 56 to 114 Kbit/s. Agrawal et al. (2015) define 2.5G as the technology that combines 2G and GPRS, falling between the 2G and 3G standards.

The successors of third generation (3G) standards, the fourth generation (4G) standards provide mobile ultra-broadband Internet connectivity. It incorporates features like IP telephony, gaming apps, high-definition mobile TV, video conferencing, 3D television, and cloud computing in addition to the currently available basic calling and messaging capabilities. Later, 4G-LTE (Long-Term Evolution) was introduced, offering speeds that were considerably faster than 3G but still being fundamentally distinct from 4G (Zeqiri, Idrizi, & Halimi, 2019).

The existing 4G/IMT-Advanced standards will be followed by the fifth-generation wireless systems, or 5G, which are now under development and are projected to represent the most significant stage of mobile telecommunications standards (Bhalla & Bhalla, 2010). The idea of a mobile phone has completely evolved, and it is now seen as an additional IoT. According to Paudel and Bhattarai (2018), 5G is anticipated to be 100 times faster and more efficient than 4G, with a speed of up to 100 gigabits per second. In terms of data speeds, it can outperform the quickest consumer-accessible residential broadband network.

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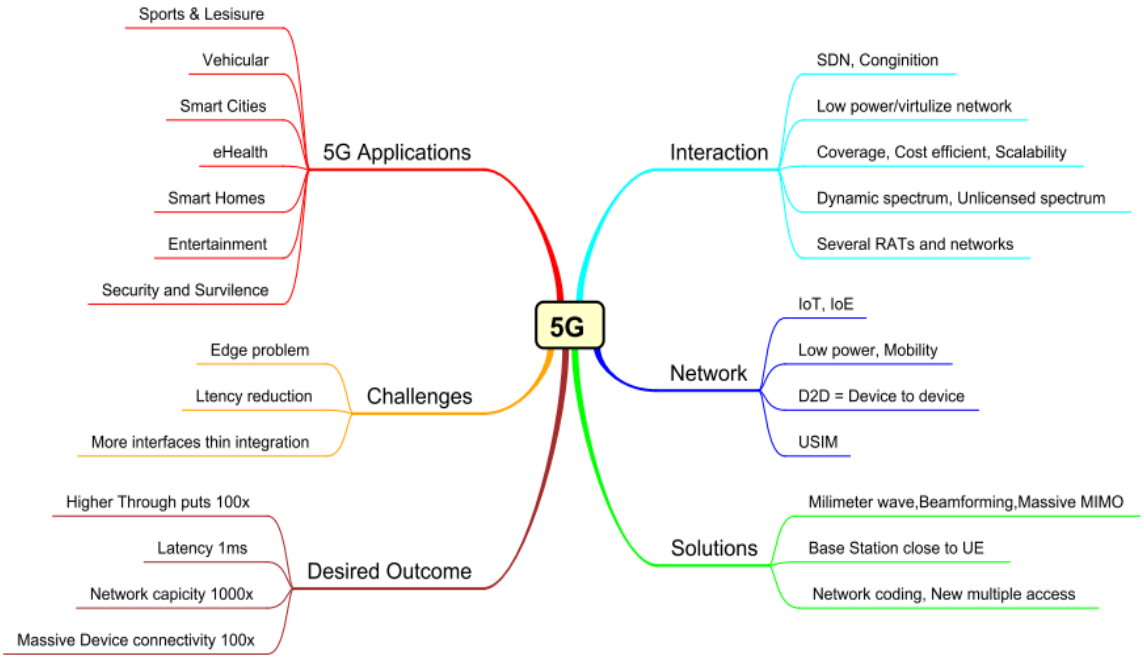

Figure 1: 5G Mind Map (*source; adopted from Saqlain, 2018*)

The Internet of Things

The "Internet of things" (IoT) is a network that connects various sensors, devices, and "things" to the Internet and other networks. According to Attaran (2017b), the concept is based on the adage "anything that can be connected will be connected." This covers a wide range of devices, including washing machines, coffee makers, cellphones, wearable technologies, jet engines, an oil rig's drill, and many more. Ahmed et al. (2017) argues the IoT gives even lone things a better level of processing and analytical capabilities. More and more industries are prepared to adopt the IoT, a rapidly evolving technology, to boost productivity. Smart terminals, mobile internet, and cloud computing provide widespread connectivity, which alters how we perceive the world (Wan, Cai, & Zhou, 2015).

According to Verma et al. (2020), digitization has boosted the potential of IoT for general use and service cases. Aoun et al. (2021) reckons the digitization of industry is also growing and developing at a faster rate, unleashing the potential of industrial IoT applications across all industries, enabling modern operation management in technical processes, as well as the opportunity to increase efficiency and cut costs. IoT solutions are projected to play a significant role in the industrial development of organisations in the years to come through digital IoT activities (Aoun et al., 2021).

By connecting everyday systems, devices, and objects to the internet, the IoT, which is rapidly growing, has completely changed various industries. According to Pereira and Romero (2017), the data and information exchange made possible by this network of links between physical objects improves productivity, judgement, and efficiency. Ai, Peng, and Zhang (2018) point out that there are now problems with the IoT infrastructure, such as poor bandwidth, high latency, and security concerns. In order to overcome these limitations, fifth-generation (5G) technology has the ability to dramatically expand the IoT ecosystem.

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www.techniumscience.com

With its unmatched speed, capacity, and dependability, 5G, in Eriksson's opinion, constitutes a paradigm leap in wireless communication (Eriksson, et al., 2016). By offering high-speed connectivity, low latency, and enhanced security features, the technology promises to address the IoT's current shortcomings (Eriksson et al., 2016). This will present fresh opportunities for IoT installations across a range of businesses, particularly in poorer countries where the digital divide is still a major issue.

It is anticipated that 5G will have a significant impact on the IoT, particularly in developing nations. According to Ahmed et al. (2019), 5G-enabled IoT devices can significantly improve the healthcare sector in developing countries by improving telemedicine services, remote patient monitoring, and efficient healthcare delivery. Like other sectors, agriculture could leverage 5G technology to adopt smart sensors and precision farming techniques, boosting crop output and resource efficiency (Almeida, et al., 2020).

Additionally, 5G-enabled IoT devices can enhance transportation systems in developing nations by delivering real-time traffic monitoring, intelligent transportation systems, and smart parking management (Zanella et al., 2014). According to Amandeep et al. (2020), this can ease traffic congestion, lower accidents, and boost overall transportation effectiveness. In addition, Rao and Prasad (2018) point out that the industrial sector may benefit from 5G technology and experience increased operational efficiency and cost savings by using IoT-enabled sensors for real-time monitoring and predictive maintenance.

Methodology

A mixed-methods research approach was used for this study, including both qualitative and quantitative evaluations. A review of the body of research on the effects of 5G technology on the IoT and its implications for various industries in emerging nations was part of the qualitative study. In order to understand the effects of 5G technology on the security and privacy of data communicated through the IoT, as well as the possible advantages and difficulties it may present, it was imperative to perform a literature review. The review of the literature was based on a thorough search of academic databases like IEEE Xplore, ScienceDirect, and ACM Digital Library as well as on pertinent grey literature like reports and policy documents from international organisations like the International Telecommunication Union.

In order to conduct the quantitative analysis, a survey of industry participants in developing countries was used. The survey was made to gather information on the IoT's current situation in underdeveloped nations as well as the advantages and disadvantages of 5G technology in relation to the IoT. A poll was given out to industry participants in developing countries, including government officials, telecom companies, and representatives of a number of different industries, including transportation, healthcare, and agriculture. Online survey administration took place using platforms like Google Forms and SurveyMonkey.

Using qualitative and quantitative data analysis methodologies, the information gathered from the literature review and survey was examined. The thematic analysis of the literature review, which was part of the qualitative data analysis, revealed the major topics and trends in the literature. To summarise the survey results, descriptive statistics, such as frequency distributions and percentages, were also used in the quantitative data analysis. Finally, the results of the qualitative and quantitative assessments were combined to offer a thorough knowledge of how 5G technology is affecting the IoT and what that means for different industries in developing nations.

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Results and Discussion

African Developing Countries' Current IoT Adoption Status

There is a lot of possibility for growth and effect even if IoT acceptance and implementation in poor African countries is now in its infancy. Among the key areas where IoT adoption and utilisation have been effective are listed below are:

i. **Agriculture**: IoT is being used in agriculture to boost crop yield, reduce water use, and keep an eye on livestock. IoT devices are also being used by farmers in countries like Kenya and Nigeria to monitor weather patterns, crop growth, and soil moisture (Ayaz et al., 2019). Real-time data provided by these tools enables farmers to make informed decisions and enhance their farming practises (Saiz-Rubio & Rovira-Más, 2020).

ii. **Healthcare**: IoT is being utilised to improve healthcare services in African countries with limited access to medical facilities. According to Al-Khafajiy et al. (2019), IoT technologies like wearable sensors and remote monitoring systems have made it possible for healthcare personnel to remotely monitor patients' vital signs and implement the necessary interventions. This is especially beneficial in rural areas with a shortage of healthcare professionals.

iii. **Smart Cities**: IoT technology is being applied to enhance municipal services in a number of African communities. IoT-powered traffic management systems, garbage management solutions, and energy-efficient street lighting are being adopted in cities including Lagos, Johannesburg, and Nairobi. These initiatives aim to create more livable and environmentally friendly cities. In order to improve infrastructure, energy management, and transportation systems, certain African countries are also implementing smart city efforts that leverage IoT technology (Echendu & Okafor, 2021). For instance, Konza Technopolis and the Nairobi Metropolitan Area Transport Authority have used IoT technology in Kenya to enhance urban planning and transportation, as reported by K'Akumu, O. A. (2023).

IoT adoption issues in poor nations

For the IoT to be widely used in Africa, a number of issues must be resolved. These include a lack of technological know-how, poor infrastructure, expensive deployment, and data privacy issues. To get beyond these barriers and encourage IoT adoption, governments, for-profit businesses, and international organisations ought to work in collaboration.

Inadequate infrastructure

According to the majority of respondents (82%), one of the biggest obstacles to IoT deployment in African nations is the absence of infrastructure, which includes inconsistent and expensive internet connectivity as well as unstable power supplies in many rural locations. These results add to the argument made by Miazi et al. (2016) that the widespread deployment of IoT devices and networks in underdeveloped African nations has been hampered by a lack of adequate infrastructure. In an effort to solve these problems, Gurstein (2003) claims that initiatives are being made to increase internet access in rural regions and close the digital divide. To overcome connectivity issues, projects like the One-Web Satellite Constellation and the creation of inexpensive, low-power IoT technologies are being investigated (Narayanasamy, Ahmad & Othman, 2017).

Price of IoT Equipment and Services

The cost of IoT devices and services, which can be exorbitant for many people and businesses, was another issue raised by the respondents. According to Mattern and Floerkemeier (2010), IoT solutions are becoming more accessible and inexpensive due to cost reductions and technological developments. El Aynaoui, Jadi, and Zaoui (2022) also mention programs that offer money and support to IoT start-ups and entrepreneurs in African countries .

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The effects of 5G technology

In order to handle the volume of data that needs to be gathered, processed, and transferred, cyber-physical systems must be used in environments (such as connected industrial applications, autonomous vehicles, smart buildings, and smart cities) that aim for ever-increasing automation and autonomous decision-making. With current network technologies, it is impossible to attain the ultra-connectivity needed for the future. The combination of fixed and wireless network technology is typically required for large-scale IoT applications. 5G might provide the reliability, latency, scalability, mobility, and security requirements for mission-critical applications in the IoT ecosystem (i-SCOOP 2018).

Faster Data Speeds

The potential of 5G technology to handle enormous amounts of data at high speeds was cited by the majority of respondents (77%), who noted that this is one of the technology's most significant effects on IoT. These results are in line with those of Al-Falahy and Alani (2017), who claim that 5G networks will enable IoT devices to transmit and receive data up to 100 times faster than they can currently accomplish on 4G networks. As a result, faster decision-making and more efficient operations are made possible by real-time connectivity between IoT devices and the cloud. When compared to older generations, 5G networks offer substantially faster internet rates. IoT devices will be able to respond faster and perform better overall because to real-time data transmission and reception (Jain et al, 2011).

The present 4G and 4G LTE networks are unable to meet the mobile telecommunication needs of the IoT. In contrast to current 4G LTE networking technologies, Agiwal, Roy, and Saxena (2016) came to the conclusion that 5G can also provide a solution to the issue and can provide the fastest network data rate with a relatively low price and broader communication coverage. New technological advancements will result from the 5G network's fast speeds. Future 5G technology will be capable of supporting hundreds of billions of connections, 10 Gbps transmission rates, and incredibly low 1 ms latency. In addition, it increases the dependability of rural service, reducing the difference in service between remote and metropolitan locations (Li et al. 2018).

Although the 5G network is a progression of the 4G and 4G LTE networks, Attaran (2021) also mentioned that it includes a whole new network design and characteristics like virtualization that offer more than simply astonishingly fast data speeds. Network function virtualization offers the ability to split real networks into a number of virtual networks, where the parts can be changed to form other networks. According to Kumhar and Bhatia (2021), this functionality will give 5G enabled IoT applications an immediate processing capability, enabling higher speed and coverage as well as the ability to meet application demands.

Increased Capacity

The results of the study demonstrate that 5G's potential to handle a significantly greater number of linked devices has an influence on IoT as well. These results add to the argument made by Reja and Varghese (2019), who claimed that 5G would enable up to one million devices to connect to networks per square kilometre as opposed to the few thousand that can do so now. As a result, numerous IoT applications will be made available, such as those for driverless vehicles, smart cities, and industrial automation. Due to their vastly increased capacity, 5G networks can manage a huge number of connected devices at once (O'Connell, Moore, & Newe, 2020). This suggests that IoT devices can connect easily and without experiencing network or performance issues.

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The IoT technology solutions currently in use must address a variety of issues, including security concerns and a large number of node connections (Mahmoud et al, 2015). According to Varga, et al. (2020), in order to serve wide applications and different industrial demands, IoT will need improved performance standards in areas like security, credibility, wireless coverage, extremely low latency, and mass connectivity. By enabling the autonomous communication and data sharing of billions of smart devices, 5G can help shape the IoT of the future, improving processes at various stages of the IoT architecture (Li et al., 2018).

The adoption of 5G, which is regarded as a key enabling technology, will make it easier for IoT to grow steadily and become widely used. As networks are modified or redesigned, 5G will use new Radio Access Technologies (RAT), smart antennas, and higher frequencies (Li et al., 2018). With the aid of the 5G enabled IoT, a sizable portion of these IoT devices will be connected, which will also assist in meeting customer demand for wireless services.

Lower Latency

According to the study's findings, there is hardly any delay in data transmission between devices while using 5G technology. This will be crucial for applications like real-time remote monitoring or autonomous vehicles that require virtually rapid data delivery. Bello-Orgaz et al. (2019) claim that 5G has the ability to completely transform the IoT by enabling faster internet connectivity, real-time data analysis, and simultaneous connection of more devices.

Furthermore, according to Wang et al. (2019), the low latency and high bandwidth characteristics of 5G can increase the dependability and efficiency of IoT applications like self-driving cars and intelligent healthcare systems. Therefore, 5G technology may pave the way for the development of more sophisticated IoT systems, which could alter how numerous industries operate in the future.

Enhanced Reliability

According to the study's findings, 5G networks are built to be extremely dependable and to provide improved network stability. For critical IoT applications like smart grid control, industrial automation, and healthcare monitoring, this is necessary. In less developed countries, the impact of 5G on IoT may be especially noticeable. Many developing countries lack the infrastructure and resources needed to support substantial IoT installations. However, 5G technology may provide a low-cost method of tying rural communities together and facilitating access to essential services like healthcare, education, and agriculture (Cullen, 2001).

Due to the 5G networks' enhanced speed and dependability, a more stable connection will be available (Sharma, Chehri, & Fortier, 2021). All IoT devices must maintain a constant and consistent network state, especially connected locks, security cameras, and other monitoring systems that require real-time updates (Munirathinam, 2020).

Large-scale IoT deployment support

The vast majority of responses emphasised how 5G technology supports extensive IoT deployments and enables more devices to be connected at once. This will enable the development of significant IoT initiatives more swiftly. The fifth-generation (5G) mobile network will be able to accommodate all of the IoT's needs. To meet the growing demand for the IoT, the Long-Term Evolution (LTE) and 5G technologies must provide new communication interfaces for emerging IoT applications (Shah, 2022). To effectively support the diverse needs of the IoT, 5G mobile networks must make sure that huge devices and new

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Vol. 46, 87-104, August, 2023
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services like enhanced mobile broadband (eMBB), communications between enormous machines, vital communications, and network operations are enabled.

Effects of 5G Technology on Different Industries

Energy Efficiency

IoT devices have the potential to monitor factory-wide energy use and pinpoint areas where energy efficiency might be increased across a range of industries, according to the respondents. As a result, both costs and the factory's carbon impact can be decreased. IoT devices are used to track energy use in real-time and find opportunities to improve it while manufacturing is underway (Shrouf, Ordieres & Miragliotta, 2014). Utilising the approach will save energy costs and increase part-production's sustainability. According to Mohammed, Al-Jaroodi, & Lazarova-Molnar (2019), IoT technology enables smart factories to monitor and optimise energy use in real-time, leading to significant cost and energy savings. Here are a few strategies the IoT could use to help different businesses become more energy-efficient.

Energy Monitoring: IoT sensors can be used to track energy use in real-time in a variety of factory areas, including manufacturing lines, lighting, and heating systems (Munirathinam, 2020). By analysing this data, inefficiencies and areas for improvement can then be found.

Automated Control Systems: The energy utilisation of the different systems in the plant can be automated with the help of IoT devices (Holfeld et al., 2016). For instance, the lighting and heating settings can be adjusted automatically based on the number of passengers or the outside temperature.

Renewable Energy Integration:In order to establish a more sustainable production process, smart factories can incorporate renewable energy sources like solar or wind power with the use of IoT technology (Meng et al., 2018). The method can assist reduce reliance on fossil fuels and lower energy costs in terms of managing the energy use in industrial processes.

***Smart lighting*:**In industrial environments, lighting can be controlled by IoT devices. This can entail turning down the lights in accordance with the quantity of available natural light, changing the lighting to reflect the use of an area, or turning the lights off automatically in vacant spaces.

Energy-efficient HVAC: IoT devices can be used to monitor and optimise HVAC (heating, ventilation, and air conditioning) systems (Sanzana et al., 2022). In order to do this, sensors that can identify when a space is vacant may be used to reduce the demand on HVAC systems. It might also include modifying the thermostat based on the number of people inside, the outside temperature, or both.

***Energy storag*e**: To administer energy storage systems, IoT devices can be used. In order to accomplish this, it could be necessary to use stored energy during energy peaks and charge batteries during off-peak hours, when energy is less expensive.

Production Process Monitoring

In order to improve the quality of the manufactured parts, the respondents also stated that IoT-enabled production process monitoring is a crucial part of the operations of many sectors. In smart factories, IoT-enabled devices and sensors can enhance production procedures, lower downtime, and raise product quality (Santhosh, Srinivsan, & Ragupathy, 2020). They may track key performance indicators (KPIs) like production output, equipment utilisation, and product quality in real-time by gathering data from IoT sensors and devices (Wang et al., 2018). This information assists plant managers in locating production-related bottlenecks, inefficiencies, and other problems.

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Temperature, humidity, and equipment performance are just a few of the factors of the manufacturing process that IoT-enabled devices may monitor and regulate (Mourtzis, Angelopoulos & Panopoulos, 2021). Real-time data collection enables a more simplified and effective production process. IoT sensors may also monitor inventory levels, the flow of raw materials, and shipment dates, which boosts efficiency and lowers inventory costs (Attaran, 2020). IoT may help manufacturers track and enhance the production process in real-time, which can lead to increased productivity, better quality control, cost savings, and ultimately, a promotion of sustainability.

Supply Chain Management

The IoT has the potential to transform supply chain management and optimisation in smart factories in order to increase productivity in part production, according to the participants. Supply chain managers can use IoT in smart factories to monitor inventory levels and guarantee on-time delivery by utilising Radio-Frequency Identification (RFID) tags to collect precise data on parts and products (Tao et al., 2018). This enables improved cargo transportation and preventative maintenance. IoT-enabled devices can track the flow of goods and materials, which lowers costs, stock levels, and delivery times (Gregory, 2015). As a result, there is an improvement in productivity, cost cutting, and supply chain visibility. More creative solutions to enhance supply chain management are anticipated as IoT technology develops.

Security Enhancements

The responses emphasised that IoT devices are used to monitor employee safety, ensuring that staff members are following safety rules and that any hazards are swiftly detected and remedied. According to Shukla, Nefti-Meziani, and Davis (2022) predictive maintenance for machinery and equipment is made possible by IoT-enabled production process monitoring, recognising wear and tear signs and minimising downtime. This technology provides real-time monitoring, predictive maintenance, automatic alarms, wearable devices, and safety analytics to improve safety monitoring in smart factories (Hamilton, 2021).

Factory managers can enhance safety protocols and avert future mishaps by analysing data. Wearable technology can track employees' vital signs, lower the risk of human mistake, and analyse patterns to enhance safety protocols (Nnaji, Okpala & Awolusi, 2020). IoT technology, as a whole, improves safety monitoring in smart factories by supplying real-time data and predictive analytics, enabling proactive maintenance, and warning workers of potential hazards.

Maintenance Planning

Predictive maintenance, which works to reduce unplanned downtime throughout the part-production process, was named by the majority of respondents as one of the most significant IoT applications in various industries. By providing predictive maintenance and real-time monitoring of the production process, IoT can benefit the industrial sector (Sang et al., 2020). By estimating the repair time for machines and production equipment using data and analytics, this technique reduces downtime and boosts productivity. IoT sensors collect and transmit data about machinery and equipment, such as temperature, vibration, and energy use, allowing maintenance schedules to be optimised and downtime to be kept to a minimum (Bloom et al., 2018).

By enabling real-time performance and equipment health monitoring, this approach improves a variety of sectors by enabling manufacturers to plan maintenance before problems occur, decreasing downtime and costs. Additionally, IoT gadgets can automate procedures like

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product assembly and material handling, lowering the need for human intervention and boosting productivity (Aoun et al., 2021). Overall, IoT in smart factories is revolutionising the manufacturing sector by boosting productivity, lowering downtime, and improving product quality, which in turn spurs growth and profitability.

Quality Assurance

The IoT in smart factories can offer a potent instrument for quality control of manufactured parts in industries, the participants further noted. IoT sensors have the ability to identify flaws in items in real-time, providing precise dates and lowering the likelihood that faulty goods will reach the market (Soori, Arezoo & Dastres, 2023). IoT gathers and analyses data in real-time by fusing sensors, devices, and machines into a network, offering insights into the manufacturing process and spotting potential quality concerns in parts produced (Shrouf, Ordieres & Miragliotta, 2014). The IoT can be used in smart factories for predictive maintenance, real-time monitoring, quality testing, and traceability, allowing factory managers to analyse and take remedial action in quality assessment and modification of produced products. IoT can enhance product quality and lower the possibility of faulty items entering the market by connecting sensors, devices, and machines into a network (Soori, Arezoo & Dastres, 2023).

Asset Management

Participants discussed how asset monitoring, which uses sensors and other IoT devices to track the location and condition of assets like machinery, tools, and raw materials in real-time throughout component manufacture, is one way that IoT is being used in diverse industries. IoT devices ultimately improve production operations in smart factories by decreasing downtime and extending asset lifespan (Conway, 2016). Manufacturers may acquire a better understanding of their operations and increase efficiency and profitability by monitoring and tracking assets in real-time. Asset location, status, and movement data are gathered by IoT-enabled asset monitoring systems employing wireless sensors and RFID tags. This data is then analysed by artificial intelligence systems to gain insights into the performance and utilisation of the assets (Lee & Lee, 2015).

Inventory control

The respondents also said that IoT-enabled sensors can track inventory levels in real-time, giving manufacturers precise information on stock levels, enabling them to improve their production processes, and reducing the environmental impact of industry part production. According to Mohammed, Al-Jaroodi, and Lazarova-Molnar (2019), IoT devices automate inventory management procedures in smart factories, lowering production costs, boosting efficiency, and enhancing accuracy. Real-time data on stock levels, locations, and movements are made possible through real-time tracking, automated replenishment, and demand forecasting (Arica & Powell, 2014). The efficiency, precision, and cost-effectiveness of inventory management are eventually improved by these technologies, which lessen manual involvement and waste.

Potential Ramifications In Developing Countries

1. **Security Issues**: As 5G networks increasingly connect IoT devices, security issues are becoming more and more important. The increased attack surface and possibility for cyber attacks are caused by the growing number of connected devices.

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2. **Privacy Concerns**: The IoT creates a significant amount of data, and 5G allows for the collection and transmission of this data at a previously unheard-of scale. This presents privacy issues because if handled improperly, sensitive data could be compromised.

3. **Infrastructure Prerequisites**: In order for 5G technology to be deployed, a strong and dependable infrastructure is needed. When it comes to infrastructure preparation, developing countries may have issues including poor coverage, insufficient network capacity, and expensive deployment costs. The full potential of 5G for IoT in these areas may be limited as a result of slower adoption.

4. **Cost implications:** It might be expensive to upgrade IoT devices and infrastructure to enable 5G technology, especially for companies in poor countries with limited funding. Smaller firms may face financial difficulties due to the cost of replacing outdated equipment, upgrading current infrastructure, and managing increased data volumes.

5. **Digital Divide**: The adoption of 5G technology and the benefits that come with it may not be the same in all areas and industries in underdeveloped countries. This might widen the gap in internet access between urban and rural locations, as well as between bigger and smaller businesses. Companies in rural or economically underdeveloped locations would find it difficult to take use of 5G technology, which would hurt their ability to compete.

6. **Opportunities for Innovation**: Despite its drawbacks, 5G technology offers enormous potential for firms operating in developing countries. It can promote innovation in a variety of industries, enable new services, and improve operational effectiveness. Businesses may enhance their operations, provide new goods and services, and gain a competitive edge in the global market by utilising 5G-enabled IoT technologies.

Conclusion

There is a considerable potential for transformational impact when 5G technology's effects on the IoT and its implications for enterprises in developing countries are examined. A number of advantages, including as improved connectivity, quicker data transmission rates, and lower latency, are brought about by the introduction of 5G networks and have the potential to completely transform IoT applications. The IoT provided by 5G presents a wide range of prospects for enterprises in developing countries. Businesses may be able to deploy a variety of IoT solutions thanks to the increasing device density and improved connection, which will boost operational efficiency, productivity gains, and decision-making processes. Industries including manufacturing, agriculture, healthcare, and logistics stand to gain a lot from the convergence of 5G and IoT because it will enable more efficient processes, better resource utilisation, and better consumer experiences.

IoT powered by 5G opens up a lot of possibilities. Businesses may be able to deploy a variety of IoT solutions, improving operational efficiency, productivity benefits, and decision-making processes as a result of the increasing device density and greater connection.It's crucial to recognise, meanwhile, that utilising the full potential of 5G-enabled IoT may present difficulties for developing countries. Large-scale adoption is hampered by issues with infrastructure, price, and the digital divide. In order for businesses in underdeveloped countries to fully profit from this technology, it will be essential to close the digital gap by investing in network infrastructure and guaranteeing affordable access to 5G networks.

Furthermore, the need of resolving security and privacy issues related to IoT networks and devices increases in the context of 5G. To guard against potential vulnerabilities and guarantee the faith and confidence of businesses and consumers, robust regulatory frameworks and cybersecurity safeguards must be in place.

In conclusion, businesses in poor countries have a bright future thanks to the impact of 5G technology on the IoT. 5G-enabled IoT can help organisations to overcome obstacles, spur innovation, and compete on a global scale with the right infrastructure development, inexpensive access, and acceptable laws. In order to maximise the potential advantages while managing the related risks, collaboration between policymakers, stakeholders, and enterprises is essential. This will eventually result in sustainable economic growth and development in developing countries.

Recommendations

i. In order to increase operational effectiveness, optimise resource allocation, and provide real-time data analysis for quicker decision-making, businesses should investigate IoT solutions that take use of 5G's low latency and high bandwidth.

i. Companies should think about the flexibility and scalability of their IoT infrastructure, utilising 5G's capacity to serve a significant number of devices. This presents chances for a broader adoption of IoT solutions across many industries.

ii. In their IoT implementations, businesses should investigate the potential of edge computing. Businesses may process crucial data locally, enabling quicker reaction times, enhanced security, and a decreased dependency on cloud infrastructure by utilising 5G's low latency and distributed computing capabilities.

iii. Businesses should evaluate use cases that are relevant to their sector and look for possibilities where 5G-powered IoT solutions can add significant value. Effective development and implementation of these use cases can be facilitated by cooperation with technology suppliers, local governments, and industry associations.

iv. Enterprises and governments should work together to invest in infrastructure development and support alliances between local enterprises and telecom and IoT service providers. This could hasten the deployment of 5G networks and foster an atmosphere that encourages the adoption of the IoT.

v. To protect their IoT infrastructure, businesses should deploy strong security mechanisms including authentication, encryption, and frequent security audits. Effective risk mitigation for security can be achieved by working with cybersecurity specialists and keeping up with best practises.

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Technium Social Sciences Journal
Vol. 46, 87-104, August, 2023
ISSN: 2668-7798
www.techniumscience.com

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