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Emerging Technologies for Government

Matthew N. O. Sadiku[1], Paul A. Adekunte[2], Janet O. Sadiku[3]

[1]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2]International Institute of Professional Security, Lagos, Nigeria
[3]Juliana King University, Houston, TX, USA

ABSTRACT

Technology is primarily changing how the government functions. Modern technology encompasses a large array of tools, systems, and innovations developed to enhance various aspects of human life. Emerging technologies are not just a trend; they are a transformative force reshaping the public sector. These technologies are being leveraged to modernize government operations, improve cybersecurity, optimize workflows, and provide better public services. They are transforming the public sector, offering significant opportunities to improve efficiency, enhance services, and better serve citizens. They enable governments to tackle complex problems with greater speed and accuracy than ever before. They will play a pivotal role in shaping the future of governance, driving innovation, and improving public services for local communities nationwide. This paper discusses how emerging technologies are influencing government agencies.

KEYWORDS: *technology, emerging technologies, government, public sector, public administration.*

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INTRODUCTION

You can look around and see countless examples of how technology is transforming an individual's life thoroughly. Pioneering organizations, including governments, realize technological tools that are beneficial to customers and citizens. These tools help maximize operational efficiency for government and related organizations.

With the exception of the military, government has been generally slower to adopt technology than the private sector. Reasons for this include lack of funding, higher public scrutiny, complex contracting processes, lack of internal IT capacity, and agency fragmentation. The slow pace of technology adoption in some cases has led to both costly and cumbersome service provision [1]. Technology can enhance the quality of governance in public institutions in terms of responsiveness, inclusiveness, trustworthiness and effectiveness, and can encourage citizens' participation in development processes.

Emerging technologies matter significantly in public administration. These innovations, ranging from artificial intelligence (AI) and blockchain to big data analytics and the Internet of things (IoT), are transforming how public services are delivered while also redefining the very fabric of government operations and citizen engagement. Embracing these technologies can allow local governments to improve service to their constituents, engage these citizens, make more data driven decisions, modernize infrastructure, and promote sustainability and collaboration. In today's rapidly evolving digital landscape, public sector agencies must leverage emerging technologies to keep pace with the needs and demands of the nation. The efficiency and effectiveness of any government agency is dependent on the technologies it uses to provide services and protect the health and welfare of its citizens. Figure 1 shows a representation of government's adoption of technology [2].

WHAT ARE EMERGING TECHNOLOGIES?

Technology may be regarded as a collection of systems designed to perform some function. It can help alleviate some of the challenges facing business today. Emerging technology is a term generally used to describe new technology. The term often refers to technologies currently developing or expected to be

available within the next five to ten years. Any imminent, but not fully realized, technological innovations will have some impact on the status quo.

Emerging technologies are shaping our societies. They continue to affect the way we live, work, and interact with one another. Emerging technology (ET) lacks a consensus on what classifies them as "emergent." It is a relative term because one may see a technology as emerging and others may not see it the same way. It is a term that is often used to describe a new technology. A technology is still emerging if it is not yet a "must-have" [3]. An emerging technology is the one that holds the promise of creating a new economic engine and is trans-industrial. ET is used in different areas such as media, healthcare, business, science, education, or defense.

The characteristics of emerging technologies include the following [4]:

- *Novelty:* Emerging technologies are typically new or novel, meaning they have yet to be widely adopted or used. They often represent a significant departure from existing technologies or processes.
- *Potential for Disruption:* Emerging technologies have the potential to disrupt existing markets, industries, or ways of doing things. They may also displace existing businesses or industries.
- *Uncertainty:* Because emerging technologies are still in the early stages of development, there is often a high uncertainty surrounding their future potential and impact. It can be challenging to predict how they will evolve.
- *Rapid Change:* Emerging technologies often evolve rapidly, with new developments and innovations emerging frequently. It can make keeping up with the latest trends and advancements challenging.
- *Interdisciplinary*: Emerging technologies often involve multiple disciplines or fields of study, such as computer science, engineering, and biology. They may require collaboration across different fields and industries to develop their potential fully.

Emerging technologies are worth investigating. They are responsible for developing new products or devices. As emerging technologies continue to evolve, engineering is poised for a transformative future. Emerging technologies have driven innovation and progress in today's rapidly evolving digital landscape. The collective impact of emerging technologies such as artificial intelligence, machine learning, big data, and the Internet of things is undeniably transformative. Some emerging technologies are shown in Figure 2 [5].

EMERGING TECHNOLOGIES FOR GOVERNMENT AND PUBLIC SECTOR

Emerging technological advancements offer unprecedented opportunities to tackle complex societal challenges, such as improving public health, enhancing urban infrastructure, and ensuring environmental sustainability. There are countless new forms of technology that seem to pop up on a regular basis. Popular emerging technologies used in government and public service include the following [6-9]:

1. *Artificial Intelligence*: Artificial intelligence mimics human thought, action, and expression. It has the potential to transform the government and public sector along with saving billions of dollars. From virtual desktop assistants to apps that can regulate big, shifting systems, each aspect of government operations is being revolutionized by AI. Generative AI is being used to summarize large documents, find answers in existing policies, and even suggest content for review. AI-powered chatbots are improving citizen engagement and providing faster responses to queries. Artificial intelligence is increasingly vital in the federal government. It helps agencies make smarter, data-driven decisions and improve service delivery. AI applications are broad, from predictive analytics that guides public policy decisions to automating administrative tasks, which helps streamline operations and reduce costs
2. *Robotic Process Automation:* Automation is one step below artificial intelligence on the technology ladder. It is perhaps the most useful technology in terms of impacting government services from both the agency and the constituent perspectives. In particular, process automation can free employees from mundane tasks such as filing paperwork to concentrate on more meaningful projects or tasks that require their full attention, such as addressing constituent issues. Robotic process automation is a technology that allows organizations to automotive repetitive, rule-based tasks by using software "bots" to emulate human interactions. These bots can perform a wide range of tasks, such as data entry, data manipulation, transaction processing, and communication with other digital systems. Robotic process automation can allow your local government to streamline operations, reduce errors, and free up your employees from mundane tasks so they can focus on higher-value activities.

This can have positive impacts on cost savings and efficiency. Robotics is becoming a way for agencies to spend less and do more. Requiring minimal system integration, bots can be deployed in as little as a few weeks depending on the complexity of the process. Chatbots are a simple example of intelligent automation, while IBM's Watson with its cognitive analytics, which has the ability to learn and solve problems, offers a prime example of more complex intelligent automation.

3. *Internet of Things*: IoT is a term that describes networks of physical objects, devices, and equipment that use sensors and inputs to exchange data and remain in constant connection with one another. IoT helps the development of smart cities and nations. It embellishes the infrastructure of healthcare, transportation, energy, defense, and maintenance of communities. IoT devices can be used to monitor and manage resources in smart cities, improving traffic flow, waste management, and energy consumption. Government organizations and employees can leverage IoT to assess the complicated aspects of city planning and management that include population surges, zone partitions, mapping, water system service, transportation structure, delivering food, social welfare, and land use.

4. *Big Data:* Data is the backbone of effective decision-making in the public sector. Governments are grappling with vast amounts of data generated from diverse sources, including citizen interactions, IoT devices, and administrative processes. Government at all levels is trying to cope with large volumes of diverse data flowing through multiple complex systems in real time. Organizations need to use data analytics to make better decisions, respond to changing needs, and serve citizens well. Analyzing large datasets allows governments to make data-driven decisions, improve public services, and identify trends. Figure 3 shows a display of data [10].

5. *Cloud Computing:* Cloud computing provides secure and cost-effective solutions for storing and managing government data. Cloud computing provides more flexibility to government bodies compared to old-school IT infrastructures. There is no need to worry about restricted resources, purchasing servers and hardware, continuously updating software, or data security. When more space is required, the expenses of extra servers and hardware are removed with cloud computing. Cloud platforms offer scalability, flexibility, and cost savings for government agencies, allowing for faster access to information and improved collaboration. In the age of cloud computing, technology plays a major role in empowering governments to become the data-driven organizations they aspire to be. A SaaS platform allows government organizations to expand their service offerings. Figure 4 shows SAAS government platform [11].

6. *Quantum Computing:* Quantum computing is an interdisciplinary field that draws upon the power of computer science, mathematics, and physics to solve complex problems far faster and more efficiently than traditional computers can. It is an area of computing focused on utilizing the principles of quantum mechanics to perform operations on data in ways that standard computers are not able to. At its most basic, quantum computing exploits the properties of quantum bits, to perform computations rather than standard binary digits, as in conventional computers. Local government officials can look to utilize this technology to optimize resources and increase overall workflow within their departments. With the promise of quantum computing in public administration, this technology is poised to redefine the landscape of government operations and policymaking. One of the most compelling prospects of quantum computing in the public sector is its potential to revolutionize cybersecurity. Governments are making massive investments in quantum computing for comprehensive simulations and optimization while prioritizing quantum-resistant encryption standards.

7. *Blockchain:* Blockchain technology is a decentralized ledger system that records transactions across a network of computers in a secure way. It is an advanced form of data storage that makes information sharing entirely transparent within a business network. A blockchain-based government model can address legacy challenges, secure confidential data of government, businesses, and citizens, reduce labor-intensive procedures, reduce expenses of account management, reduce the possibilities of corruption, and boost trust in government and online civil systems. Blockchain technology offers secure and transparent ways to manage data and transactions, which can be particularly useful in areas like land registry and voting systems. Local governments can look to blockchain technology to help them keep more efficient track of records, as well as make places like the clerk's

department far more organized. Figure 5 shows a representation of blockchain [11].

8. *Immersive Technologies*: Beyond using the immersive nature of the VR headset to train employees, forward-thinking public administrators can place community partners and ordinary citizens within a virtual or augmented reality (VR/AR) during project demonstrations and other events. VR outpaces both printed plans on paper and 360-degree computer screen images when it comes to generating citizen feedback on the design of public spaces. A typical use of immersive tech is shown in Figure 6 [12].
9. *Green Technologies:* These also known as sustainable or eco-friendly technologies. They are innovations designed to mitigate or minimize environmental impact while meeting the needs of a community. These technologies aim to promote environmental sustainability by conserving resources, reducing pollution, and addressing climate change. By integrating green technologies and sustainability principles into their policies, programs, and operations, local government officials can play a crucial role in building more resilient, sustainable, and livable communities for their residents.
10. *Cybersecurity:* Emerging technologies are being integrated to strengthen cybersecurity measures, protect sensitive data, and mitigate potential threats. Cybersecurity has become one of the most pressing concerns for federal agencies as cyberattacks become more sophisticated and frequent. Protecting sensitive government data and critical infrastructure is paramount for national security and the integrity of government operations. With increasing dependence on digital platforms, the federal government invests in advanced cybersecurity measures to safeguard against cyberattacks, data breaches, and system vulnerabilities.
11. *Digital Government:* The term "digital government" is an umbrella term used to describe technologies such as mobile services, common online identities, and crowdsourcing—all designed to streamline services and improve the end-user experience. Mobility in particular is an area where governments at all levels can increase the quality of their services and the efficiency of their employees. Mobile technology is transforming how people develop and utilize information and services. Mobile government aims to make government available anywhere, anytime, on any device today and in the future. The mobile government maintains the online collaborative network, which distributes information, strategies, and technologies online and at events to keep the government updated on all things digitally. Digital government is depicted in Figure 7 [6].
12. *Autonomous Vehicles:* Governments can benefit from the use of autonomous vehicles in multiple ways. The federal government operates a fleet of more than 600,000 vehicles, including US Postal Service trucks and General Services Administration vehicles leased to various agencies. In 2016, USPS vehicles were involved in about 30,000 accidents nationwide, resulting in about $67 million in repair and legal costs. As a result, the agency is considering autonomous vehicles for its fleet, not only to help improve safety but also to increase productivity of letter carriers.

These are just some examples. Other emerging technologies include digital twin, data sharing, zero trust edge, digital identity, automation and self-servicing, smart devices, biotechnology, and decision intelligence.

APPLICATIONGS OF EMERGING TECHNOLOGIES FOR GOVERNMENT

The public sector is often more constrained than its private-sector counterparts. As such, the technologies that will reap the most benefits are different than for other industries.

Common applications of emerging technologies in public sector include the following [1,8,10,13]:

- *Local Government:* More than 20 million people—about 15% of the United States workforce—work for a local, state, or federal government entity. A majority of these work in local government (e.g., schools, police and fire departments, county social service agencies), about a third in state government (e.g., universities, tax bureaus, state hospitals), and the remainder in federal government (e.g., post offices, national parks). The new wave of technology can help in revolutionizing how local governments operate. Local governments are expected to leverage emerging technologies at increased rates. These emerging technologies will all enhance efficiency, transparency, and security across various departments in local government, overall doing a lot of good. It may feel difficult to navigate this landscape while also wanting to ensure that members of your community are put first. Many local government officials face similar hurdles, from bureaucratic red tape to budget constraints, making the integration of new technology less and less seamless.

- *Federal Government:* As technology evolves, the federal government embraces these innovations to streamline operations, enhance citizen services, and strengthen national security. As technology advances rapidly, the federal government increasingly relies on emerging technologies to modernize its operations, improve services, and secure sensitive information. From artificial intelligence (AI) to cybersecurity, digital transformation, and cloud computing, several key trends are shaping the future of federal government operations. From updating legacy systems to adopting cloud-based solutions and creating user-friendly digital interfaces, federal agencies strive to deliver better services while improving efficiency and reducing costs. For example, federal agencies like the Department of Homeland Security (DHS) and the Federal Bureau of Investigation (FBI) use AI and emerging technology capabilities to analyze large data sets for security threats and criminal activity. AI-powered chatbots are deployed across various federal services, such as the Social Security Administration (SSA) and the Department of Veterans Affairs (VA), to provide 24/7 assistance to citizens, answer queries, and help with applications. The Office of Critical and Emerging Technologies (CET) leverages capabilities and expertise across the Department of Energy (DOE) and its 17 National Laboratories to sustain and extend US leadership in technology in support of DOE's energy, science, and security mission.
- *Public Administration:* Government agencies stand to benefit from emerging technologies in many unique ways. IoT's capabilities in the management of public infrastructure, such as roads and bridges, have proven particularly useful in the world of public administration. From monitoring infrastructure components for safety to coordinating traffic lights, IoT supports automated operations of all kinds with an emphasis on energy efficiency and public safety. Beyond handling routine daily operations, AI is a remarkable tool for predictive analytics and digital modeling. These capabilities enable public administrators to prepare for future events and evolving issues ahead of time. Quantum computing's unique ability to handle complex computations at unprecedented speeds opens new horizons for tackling some of the most pressing and intricate challenges faced by public administrators. Quantum computing is not just an incremental improvement over existing technologies. It represents a leap forward into a future where public administration can be more proactive, predictive, and precise.
- *Smart Cities:* As we move forward, there is a growing emphasis on cross-agency collaboration, interoperability, and the development of smart cities. The Internet of things (IoT) is facilitating the emergence of smart cities, where interconnected devices enhance the management of urban environments. Sensors deployed throughout cities can monitor air quality, traffic flow, and energy usage, enabling governments to respond proactively to issues. For example, smart traffic lights can adapt to real-time conditions, minimizing congestion and promoting efficient transportation. Smart cities are developed by smart government, which is used to characterize activities that creatively invest in emergent technologies coupled with innovative strategies to achieve more agile and resilient government structures and governance infrastructures. Being a smarter government seems to require having a forward-thinking approach to the use and integration of information, technology, and innovation in the activities of governing. Figure 8 shows a typical city [14].
- *Virtual Assistants:* AI-powered virtual assistants like chatbots can handle routine tasks for your office such as scheduling meetings, answering common inquiries, and providing information to employees. These basic and common questions can all be answered immediately so that employees are not stuck waiting for answers.

BENEFITS

Emerging technologies are transforming the government and public sector by enhancing service delivery, increasing efficiency, and boosting citizen engagement. Technologies such as cameras and drones may be used to enforce laws or regulations and feed information into other government processes. Other benefits include the following [8]:

- *Automation:* Process automation refers to the automation of once-manual government processes such as submitting/reviewing permit applications. This improves the efficiency of your office workflows, saves your employees time, and keeps them from performing tedious tasks that can be automated and done fully digitally. Organizations in government and public sectors acknowledge automation's significance that boosts work efficiency and cuts redundant costs, along with improving citizens' experience when it comes to public services. AI can automate the generation of reports by collecting and analyzing data from various sources, streamlining the reporting

processes for your office, and freeing up employees from manually performing analysis and reporting. Administration software automates forms and permitting across the department to streamline and simplify the review processes.

- *Cost Savings:* The public sector is under pressure to modernize while also keeping costs down. Adopting emerging technologies can lead to cost savings for your local government. This can be achieved by automating processes, reducing resource consumption, and optimizing your available infrastructure. For example, predictive analytics can help optimize resource allocation in areas such as waste management and public transportation.
- *Citizen Engagement:* City managers and administrators have important decisions to make, constituents to keep happy, and elected officials to report to. Modern technologies can help your local government engage with citizens more effectively and transparently. Tools such as mobile apps, social media platforms, and online portals can facilitate better communication, gather feedback, and involve residents in decision making.
- *Personalization*: Big data analytics can help governments understand citizen needs better and provide more personalized services. AI-driven personalization refers to the use of artificial intelligence (AI) technologies to tailor products, services, content, and experiences to individual users' preferences, behaviors, and characteristics. It involves analyzing large amounts of data to understand user preferences and then delivering personalized recommendations, content, or experiences in real-time. AI-driven personalization offers local government officials the opportunity to better understand and serve the needs of their community, improve operational efficiency, and foster greater engagement and participation in local government processes.
- *Public Safety*: IoT sensors can be used to monitor public spaces and infrastructure, enhancing public safety and security. AI and ML are at the forefront of enhancing public safety through intelligent surveillance systems that can detect anomalies and predict potential threats with remarkable accuracy.
- *Trust:* Blockchain technology is gaining traction as a means to enhance integrity and trust in public systems. Its decentralized, immutable ledger design can secure essential public records, ensuring transparency in various transactions, such as land registration and public procurement processes. The power of blockchain reinforces the idea that a transparent public sector is a trustworthy public sector.

CHALLENGES

Technologies considered "emerging" have yet to show their full capabilities. So, it is important to stay abreast of these capabilities as they evolve. Governments need to carefully consider the challenges and ethical implications associated with emerging technologies to ensure responsible and equitable adoption. Regulatory constraints, complex systems, conflicting interests, and shifting mission priorities mean that, despite enthusiasm and an appetite for new technologies, the public sector is often more constrained than its private-sector counterparts. Other challenges include the following [1,15]:

- *Risks:* Some technologies present inherent risks, such as those intended to replace or supplement human decision-making. Emerging technologies introduce new cybersecurity risks, requiring governments to invest in robust security measures. As governments become more reliant on technology, they must also address potential security vulnerabilities. Forward-looking agencies will begin to assess whether these advanced technologies have a place in their roadmaps and whether they will be worth the investment.
- *Ethical Concerns:* The use of AI and other technologies raises ethical questions about bias, transparency, and accountability. There has been considerable evidence that advanced technologies can replicate or even exacerbate racial and ethnic biases. Governments should be deliberate and cautious as they adopt such technologies. Privacy concerns arise when data is collected and analyzed on a large scale, which raises questions about how that data is used and who has access to it. Cities must emphasize ethical data governance, ensuring that the implementation of IoT technologies respects citizens' rights and maintains public trust.
- *Job Complexity:* Working with new technologies may require new skills, which are not always accompanied by training or the time to adapt. Automating technologies may take over the more mundane aspects of work, making jobs more complex and rewarding for workers. But more advanced technologies—such as automated decision-making systems—may have the opposite effect, taking over complex thinking tasks and leaving workers to simply verify outcomes.

- *Transparency:* Governments must embrace transparency as a core value and actively communicate their decision-making processes. Transparency is a foundational principle in fostering trust between governments and citizens. In the digital age, transparency can be enhanced through open data initiatives that allow citizens to access government information, from budgets to performance metrics. Technological advances in secure data storage, data sharing, data analytics, and data visualization have the potential to enhance government transparency and accountability.
- *Regulation:* Scholars have identified a host of challenges emerging technologies present to traditional regulatory models. Existing regulatory structures are often slow to adapt to changing societal and economic circumstances, and regulatory agencies generally are risk-averse. Industry regulatory challenges are compounded by the existing patchwork of regulations. With increasing regulatory scrutiny, government buyers are emphasizing Trade Agreements Act (TAA) compliance and supply chain transparency. Regulatory pressure and supply chain risks are driving government buyers toward trusted TAA-certified vendors. Sweeping technological advancements are creating a sea change in today's regulatory environment, posing significant challenges for regulators who strive to maintain a balance between fostering innovation, protecting consumers, and addressing the potential unintended consequences of disruption. Regulatory leaders are faced with a key challenge: how to best protect citizens, ensure fair markets, and enforce regulations, while allowing these new technologies and businesses to flourish. Government agencies are challenged with creating or modifying regulations, enforcing them, and communicating them to the public at a previously undreamed-of pace.
- *Workforce Training*: New tools require new skills and new rules. Governments need to invest in training programs to ensure that their workforce has the skills to adopt and utilize these technologies effectively.
- *Literacy Gap:* There is potentially dangerous "digital literacy gap" between the public and private sectors, which must be closed to promote the common good. Emerging technology is a key priority for government and public sector despite major skills shortages.

CONCLUSION

Emerging technologies are transforming the public sector, offering increased efficiency, transparency, and improved citizen engagement. These technologies are being adopted to streamline operations, enhance cybersecurity, and facilitate better decision-making. Government and public agencies embrace emerging technologies. These technologies are not merely tools for automating routine tasks; they represent a paradigm shift in how governments can understand, predict, and address the needs of their citizens. The strategic integration of these technologies into public administration enhances operational capabilities and significantly boosts the ability to respond to and anticipate the needs of the public in a more agile and informed manner. Government administrators who fail to embrace new forms of technology are bound to get left behind.

Governments have been slow to modernize than the private sector. Regulatory constraints, complex systems, conflicting interests, and shifting mission priorities mean that the public sector is often more constrained than its private-sector counterparts. However, state and local governments are quickly reaching the point where adoption of new technologies is inevitable. The way the governments use technology is always evolving. They are under great pressure to do more with less since data availability is exponentially growing and not necessarily their budget. Critical to the public sector is the ability to deliver on time, on budget and on mission. US leadership in critical and emerging technologies such as artificial intelligence (AI), biotechnology, and quantum computing is key to enabling economic prosperity and our national security. More information about emerging technologies in government and public sector can be found in the books in [16-19] and the following related journals*:*

- Journal on Emerging Technologies.
- Government Information Quarterly
- International Journal of Public Sector Management

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Figure 1 A representation of government's adoption of technology [2].

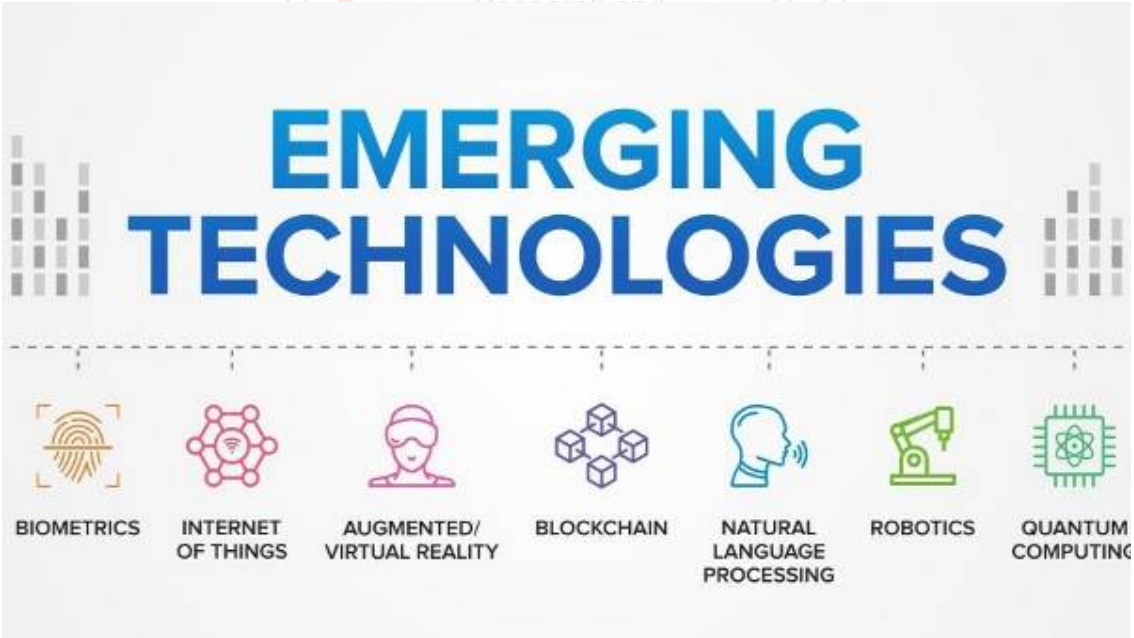

Figure 2 Some emerging technologies [7].

Figure 3 A display of data [10].

Figure 4 SAAS government platform [11].

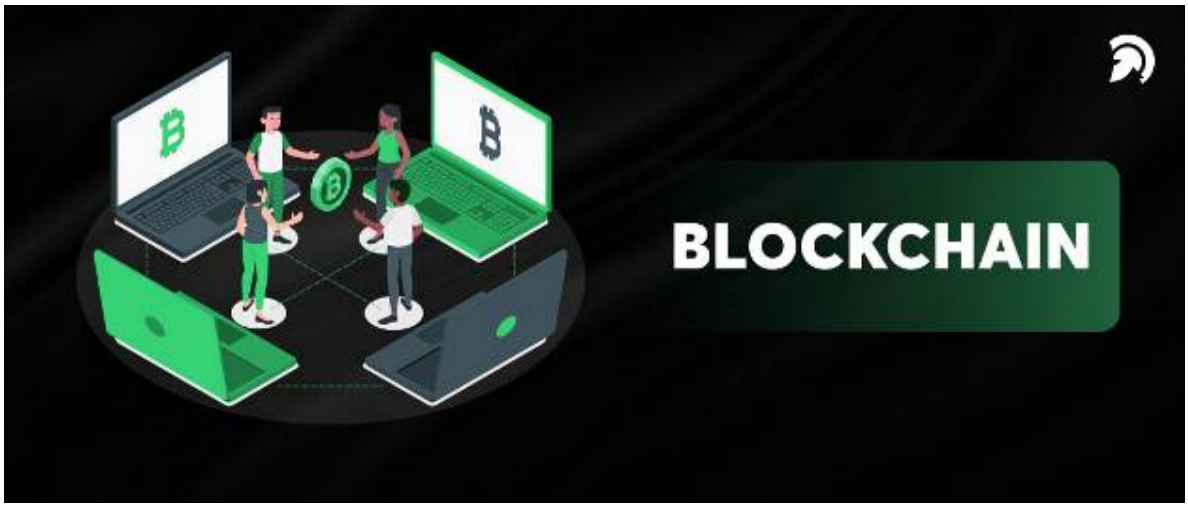

Figure 5 A representation of blockchain [11].

Figure 6 A typical use of immersive technology [12].

Figure 7 Digital government [6].

Figure 8 A typical city [14].