Smart Technology: Ecosystem, Impacts, Challenges

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Abstract*: Smart technologies have become increasingly integral to modern society, bringing many benefits and opportunities. However, they also raise important questions about their impacts on individuals, organizations, and society and how everyone can move forward smoothly in integrating and adopting technology. Therefore, this study analyzed and reviewed the literature to address the questions. The study provides an overview of the potential benefits and challenges of smart technologies and applications, including artificial intelligence, machine learning, natural language processing, robotics, and the Internet of Things. The review also explores the key entities involved in a smart technology ecosystem, including governments, businesses, and international communities, and each entity's unique role in developing and implementing smart technologies.*

Keywords: IoT; artificial intelligence; machine learning; impacts

I. INTRODUCTION

Smart technology has been a game-changer in how we live, work and communicate. It refers to integrating advanced technology into various aspects of our daily lives, such as homes, cities, and transportation. As a result, it has rapidly emerged as a transformative force in our society and profoundly impacted individuals, businesses, and governments. The technology, which includes artificial intelligence (AI), machine learning (ML), natural language processing (NLP), robotics, and the Internet of Things (IoT), to name a few, are designed to be intelligent, self-learning, and adaptable to changing circumstances. However, despite their many benefits, there are also significant challenges and risks associated with using smart technologies. In light of these impacts and challenges, it is crucial to critically examine the current state of smart technologies and consider the path forward.

While there have been many previous studies and reviews on smart technologies, this review seeks

to address some of the limitations of existing research. For example, many existing studies focus solely on the technical aspects of smart technologies and overlook their deployment's social and ethical implications. Furthermore, previous studies have often failed to consider stakeholders' diverse perspectives and experiences, such as government, businesses, and individual users. Additionally, some studies have been limited in scope, focusing on specific applications of smart technologies without considering their broader impact on society. Therefore, this review addresses these limitations by providing a comprehensive and inclusive examination of the impacts, responsibilities, and path forward for smart technologies. By incorporating diverse perspectives and experiences, this review seeks to provide a more comprehensive understanding of these technologies' potential benefits and risks and the steps that need to be taken to ensure their responsible development and deployment.

Definition and Ecosystem of Smart Technology

The concept of smart technologies has been around for several decades, with early developments in AI and ML dating back to the 1950s. However, it was not getting attention until the widespread adoption of personal computers and the Internet in the 1990s that the term "smart technology" began to be widely used. The growth of the Internet, combined with advancements in computer processing power and data storage capabilities, has enabled the development of smart technologies on a large scale. In addition, the widespread adoption of smartphones and other mobile devices has played a significant role in developing smart technologies. It is due to the advancement in computing technology at the backend that provides the computing power and connectivity needed to run complex algorithms and analyses vast amounts of data. Later, the rise of the IoT marked a turning point in the history of smart technology. The IoT is a

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network of connected devices that can collect and exchange data, allowing for the creation of intelligent systems that can make decisions based on that data.

The rapid pace of technological advancement in recent years has led to the development of new and sophisticated smart technologies, such as robotics, text analysis, and autonomous vehicles. These technologies can potentially revolutionize many industries, from healthcare and transportation to manufacturing and retail. Smart technology is a term used to describe a wide range of technologies designed to be intelligent, self-learning, and adaptable. These technologies are based on advanced

Algorithms and data analysis techniques that allow them to process large amounts of data and make predictions or decisions based on that data. In addition, they are designed to be flexible and responsive to adjust to changing circumstances and continue to be effective and efficient. There are many instances of specific types of technology that make up smart systems. **Table 1** summarizes the technologies used for developing smart systems. **Figure 1** illustrates the technology.

**Table 1.** The technologies used for developing smart systems.

Smart technology	Descriptions	References
AI	Computer systems can perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and pattern recognition.	[15], [16]
ML	A subset of AI involves the development of algorithms that can learn from data and improve over time without being explicitly programmed.	[17], [18]
NLP	A field of study focuses on the interaction between computers and humans through natural language. It involves the development of algorithms that can understand and process human language, allowing for more human-like interactions between computers and humans.	[19], [20]
Robotics	Machines that can perform tasks that humans typically perform. Smart robots are equipped with sensors and algorithms to perceive and respond to their environment.	[21]
IoT	A network of physical devices, vehicles, home appliances, and other items are embedded with electronics, software, and connectivity, allowing them to communicate with each other and the Internet.	[8]
5G	Cellular network technology promises faster speeds and excellent connectivity for individuals and businesses.	[22]
Augmented reality (AR) and virtual reality (VR)	Technologies that enhance or create immersive digital experiences for users.	[23]
Blockchain	A decentralised, secure and transparent ledger for recording transactions and tracking assets.	[24]

Before discussing the impact of smart technology, it is necessary to discuss the ecosystem of smart technology and applications that involve many entities, including technology companies, businesses, governments, academic institutions, civil society organizations, and end-users. Each entity is critical to the development, deployment, and impact of smart technologies. smart technology ecosystem summarise their roles in **Table 2**. The communication between the entities is illustrated in **Figure 2**.

Table 2. The entities and their roles in a smart technology ecosystem.

Entities	Roles
Government agencies	Regulate and promote the development of smart technologies. They set standards, provide funding, and encourage innovation in this field.
Technology companies	Develop and produce smart technologies. They are responsible for creating new products, services, and applications to impact society significantly.
Researchers and academics	Conduct research, develop smart technologies, and study their impact on society. They also play a critical role in ensuring that new technologies are safe, secure, and ethical.

Businesses and enterprises	The primary users of smart technologies are responsible for implementing these technologies and reaping the benefits. They are also responsible for ensuring these technologies are used ethically and responsibly.
Consumers	The end-users of smart technologies utilise them in their daily life. They are responsible for using these technologies responsibly and making informed choices about how they interact with these technologies.
Industry associations	Promote and regulate the development of smart technologies. They are also responsible for developing standards and best practices for using these technologies.
Non-profit organisations	Promote the responsible use of smart technologies and advocate for their potential benefits. They also provide education and training to ensure individuals can make informed decisions about interacting with these technologies.
Service providers	Deliver the infrastructure, networks, and services that make smart technologies possible. They play a critical role in ensuring these technologies are accessible, reliable, and secure.
Regulators	Ensure that the use of smart technologies is consistent with laws and regulations. They are essential in protecting individuals' and organisations' privacy, security, and safety.
Investors	Provide funding for the development and implementation of smart technologies. They are also responsible for ensuring that these technologies are used ethically and responsibly and deliver a return on investment.
Media	Shape public perception and understanding of smart technologies. They are responsible for providing accurate and balanced information about the impact of these technologies on society.
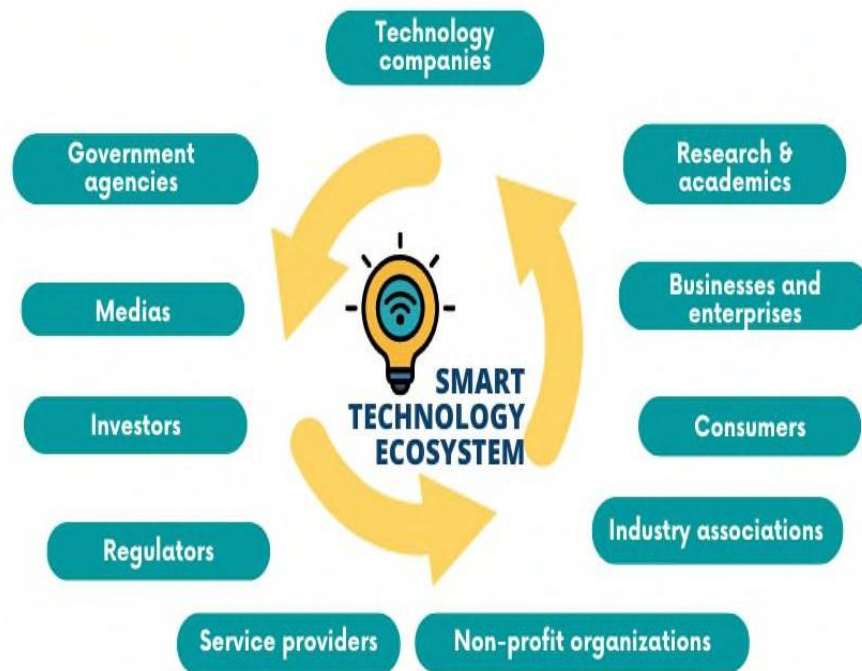
Figure 2. The smart technology ecosystem.

Smart technology applications are designed to automate tasks and processes, reduce human error, and improve decision-making and problem-solving. They are used in various industries and applications, including healthcare, retail, finance, transportation, and construction. **Table 3** summarizes some of the most common areas where smart technology applications are being used, and **Figure 3** illustrates the applications.

Table 3. Some of the most common areas where smart technology applications are being used.

Areas	Description	Examples of studies
Home automation	Allow individuals to control and monitor various aspects of their homes using their smartphones or other connected devices, such as lighting, heating, and security.	[27], [28]
Smart city	Improve efficiency, sustainability, quality of life, safety and security, economic opportunities, and citizen engagement through technology and data-driven solutions.	[29]
Healthcare	Boost efficiency and patient outcomes. Patients can check their health and get medical advice remotely, such as telemedicine software and wearable health monitoring equipment.	[30]
Transportation	Make travel safer, more efficient, and more sustainable. For example, connected vehicles and the infrastructure can communicate with each other to reduce accidents and improve traffic flow.	[31]
Energy	Minimise carbon emissions and increase energy efficiency. For instance, smart grid technology enables suppliers to manage energy supply and demand more efficiently, lowering waste and conserving resources.	[32]
Manufacturing	Boost productivity while cutting waste and increasing efficiency. For instance, predictive maintenance technology may identify potential equipment issues before they arise, minimising downtime and maintenance expenses.	[33]
Retail	Customers' purchasing experiences will be improved, and companies will operate more effectively. For instance, omnichannel retail technology enables customers to effortlessly shop across several channels, such as online and in-store.	[34]
Education	Enhance the learning experience for students and improve educational outcomes. For example, learning management systems and educational apps allow students to access educational materials and resources anywhere, anytime.	[35]
Agriculture	Increase efficiency, reduce waste, and improve the quality of crops. For example, precision agriculture technology can collect and analyse data from sensors and drones to optimise irrigation, fertilisation, and pest control.	
Financial services	Enhance efficiency, lower fraud, and increase access to financial goods and services. For instance, robo-advisors and mobile banking applications let users manage their accounts from their smartphones.	
Government	Improve the delivery of public services and increase transparency and accountability. For example, e-government portals and digital identity solutions can simplify accessing government services and reduce the risk of fraud.	
Environmental monitoring	Monitor and manage the environment, including air and water quality, wildlife, and weather patterns. For example, IoT sensors and drones can collect and transmit data on environmental conditions in real-time, enabling proactive responses to environmental threats.	
Emergency services	Increase the speed of reaction and save lives. For instance, emergency dispatch systems may optimise the deployment of emergency responders using real-time data and advanced analytics.	
Sports	Enhance the viewing experience for fans and improve performance for athletes. For example, wearable technology and performance tracking systems can provide real-time data on an athlete's performance, enabling coaches and trainers to make more	

|	informed decisions.
Media and entertainment	Streamline the production, distribution, and consumption of content. For instance, immersive entertainment experiences are being made possible by VR and AR technology, while streaming services have made it simpler for individuals to access movies, TV episodes, and music online.
Construction	Enhance the sustainability, safety, and efficiency of construction projects. For instance, wearable technology may be used to increase worker safety on construction sites, and building information modelling (BIM) software can be utilised to simulate and optimise building designs.
Logistics and supply chain management	Improve the efficiency and accuracy of deliveries and reduce waste. For example, GPS tracking systems and real-time data analytics can be used to optimise delivery routes and reduce the risk of lost or damaged shipments.
Disaster response	Improve disaster response and recovery efforts, reducing the impact of natural disasters and other emergencies. For example, real-time data analytics and communication systems can be used to coordinate disaster response efforts and provide real-time information to first responders and the public.
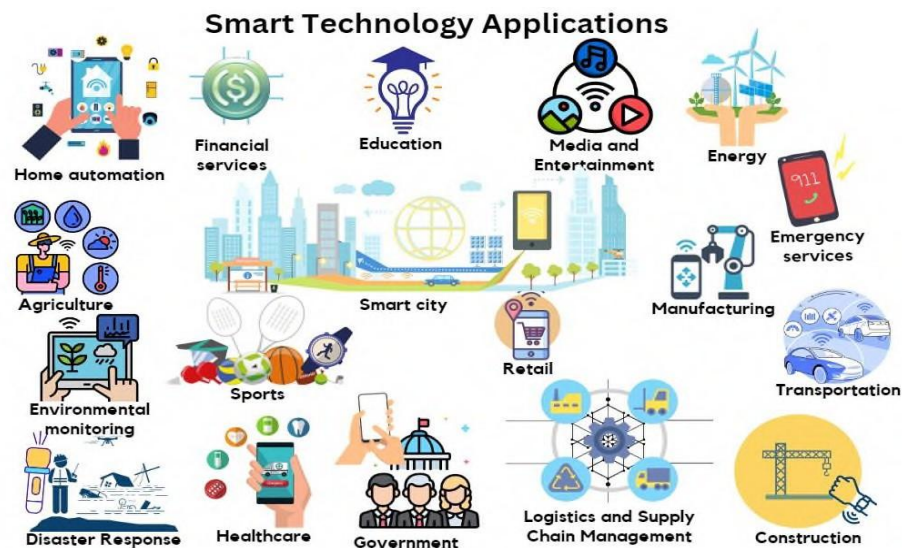
Figure 3. Smart technology applications.

The Impacts of Smart Technology and Applications

The use of smart devices and applications has the potential to change how we work and live. In many aspects of our lives, they can increase accessibility, boost communication, and promote efficiency. For instance, automation technologies in smart homes can boost comfort, increase security, and improve energy efficiency. Another example of smart transportation technologies has the potential to increase road safety overall, decrease emissions, and improve traffic flow. Smart technologies have the potential to enhance patient outcomes in the healthcare industry, save costs, and give people in rural and underserved areas access to care. **Figure 4** summarizes the impacts.
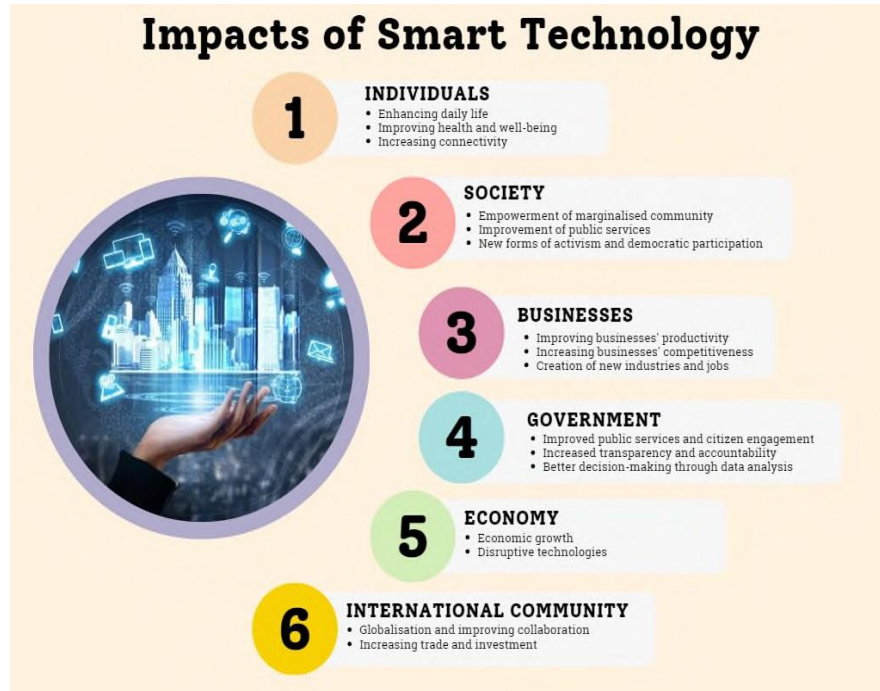
Figure 4. The impacts of smart technology applications

Impact on individuals

Enhancing daily life—The increased use of smartphones, portable electronics, and the Internet has improved our daily lives by bringing new conveniences and accessibility. We can stay in touch with loved ones, access information, and accomplish activities while on the go with a button or a few swipes on a screen. Thanks to it, we can live more effectively and take advantage of more chances. For example, streaming services, such as Netflix and Hulu, have made it easier for individuals to watch their favorite shows and movies from anywhere, at any time. It also improved access to information, making it easier for individuals to access news, research, and other forms of knowledge. As a result, it has led to a more informed and knowledgeable population, which is better equipped to make decisions. In addition, the widespread adoption of e-commerce and mobile shopping apps has made it easier for individuals to purchase goods and services, compare prices, and receive recommendations based on their previous purchases. Thanks to smart home systems, people can now more easily operate their houses, keep track of their energy usage, and manage their appliances and devices. Thanks to the growing usage of security cameras and smart home devices, people can now monitor their houses and protect their families more efficiently.

Impact on society

Empowerment of marginalized communities—Smart technology can empower marginalized communities and provide access to previously unavailable resources, information and opportunities. This technology can be especially beneficial for individuals living in rural and remote areas where access to traditional services and infrastructure is limited. Through mobile devices, cloud computing, and other technologies, individuals in these communities can access education, healthcare, and financial services, which can help improve their standard of living.

Improvement in public services—Smart technology has completely transformed how public services are provided in communities. Public service providers may now provide citizens more effective and efficient services because of cutting-edge technology like IoT, AI, and cloud computing. As a result, communities experience better outcomes and are more satisfied with public services. One of the key ways in which smart technology improves public services is through the use of data and analytics.

New forms of activism and democratic participation—Smart technology has fundamentally changed how people engage with and contribute to their communities and society. People may now share information, express opinions, and collaborate with others in novel and creative ways because of the growing adoption of internet-connected devices and digital platforms.

Impact on businesses

Improving businesses' productivity—Smart technologies have enhanced efficiency by automating jobs and streamlining processes. As a result, smart technologies have increased productivity, enabling firms to complete more work in less time. For instance, organizations may complete more work in a shorter time because of automation and ML.

Impact on government

Improved public services and citizen engagement—Smart technologies such as automation, AI and the IoT can help governments streamline their operations and reduce costs. Smart technologies can help governments engage with citizens innovatively, such as through online portals and mobile applications. Governments can use smart technologies to improve the delivery of public services, such as healthcare, education, and transportation. For example, governments can use AI to analyze data to identify areas of need and target resources more effectively. Smart technologies are also transforming urban areas, with many governments implementing smart city initiatives to improve quality of life, reduce environmental impact, and increase efficiency.

Impact on economy

Economic growth—Smart technology significantly impacts a nation's economic development. It changes how firms run, boosting production and efficiency. For instance, the time and cost of completing tasks have been considerably lowered by employing automation technologies like AI and ML, freeing up resources for businesses to invest in innovation and expansion. Smart technology has also allowed enterprises to expand their reach and reach new markets and customers by removing geographical restrictions.

Impact on the international community

Globalization and improving collaboration—Globalization has been profoundly influenced by smart technology, which has also enhanced global collaboration. People from various regions may communicate more readily because of the development of communication and information technology, which has increased global connectivity. Increased international commerce, investment, and information exchange resulted from it, all of which have helped the world economy expand. The increasing use of mobile devices and the Internet has made it simpler for individuals to obtain information, interact with one another, and work together regardless of where they are. Businesses have enormously profited since it has enabled them to connect with a worldwide clientele and access the most remarkable talent and resources the globe offers. Thanks to cloud computing and online project management tools, teams can now collaborate and exchange information more efficiently, no matter where they are situated.

Challenges in smart technology and applications

This section describes the challenges in smart technologies and applications. Studying the challenges that result from implementing smart technology and applications is important to identify potential problems and develop strategies to address them proactively. Furthermore, understanding these challenges can help ensure that the benefits of smart technology are realized while minimizing negative impacts on society and individuals. Three major challenges result from implementing smart technology and applications (1) privacy and security concerns, (2) social and economic inequalities and (3) Environmental impacts, as illustrated in **Figure 5**
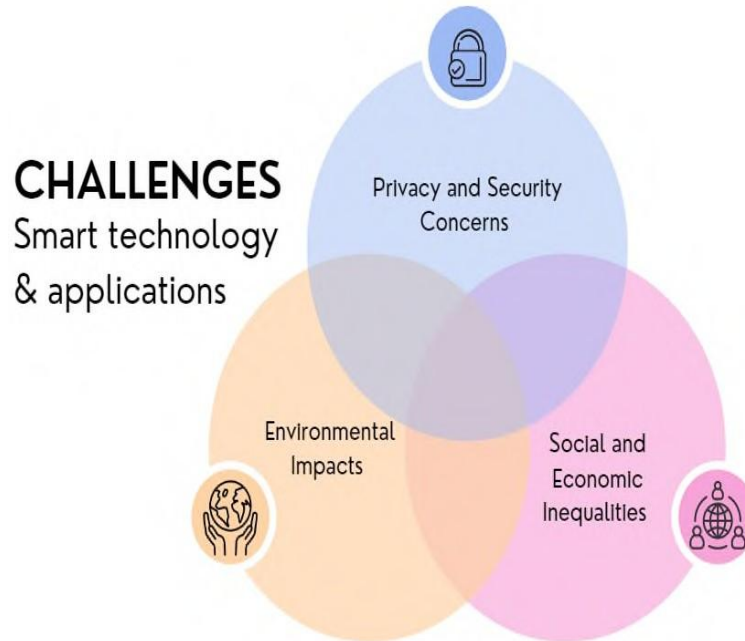
Figure 5. Challenges in smart technology and applications

Privacy and security concerns

Data breaches and cyberattacks—Smart technology has revolutionized how we communicate, access information, and live our daily lives. However, this technology also collects vast personal data, which can threaten individual privacy if not handled responsibly. It is the responsibility of individuals to understand the implications of using smart technology and to take steps to protect their personal information. It includes being aware of the terms and conditions of any apps, services, or devices they use and understanding the data types collected and how they are used. It is also crucial for individuals to understand the difference between public and private data and to exercise caution when sharing personal information online. It includes limiting the amount of personal information shared on social media platforms, being careful about what is posted, and ensuring that sensitive information, such as financial data or passwords, is protected. Another aspect of personal responsibility towards smart technology is ensuring that their devices and networks are secure. It includes updating software, installing anti-virus software, and creating strong passwords. Additionally, individuals should be aware of phishing scams, unsolicited emails, and other online fraud and take steps to protect themselves against these threats.

Social and economic inequalities

Economic shocks caused by technological change—The rise of smart technology has undoubtedly brought about significant economic changes, but it has also caused economic shocks that have negatively impacted specific sectors and industries. Job displacement is one of the most significant economic shocks caused by technological change. As smart technology and automation become more advanced, many industries are replacing human workers with machines and AI. It has led to significant job losses, particularly in industries like manufacturing and retail. In addition to job displacement, smart technology has also created a widening skills gap in the labor force. Many jobs being replaced by automation require a lower skill level, whereas the jobs being created require more specialized skills, such as programming and data analysis.

Environmental impacts

Electronic waste and resource depletion—Smart technology, such as smartphones and other mobile devices, are produced on a large scale and have a relatively short lifespan, generating a significant amount of electronic waste. The

disposal of this waste can pose significant risks to the environment, as it contains hazardous materials such as lead, mercury, and cadmium. Moreover, producing smart technology devices requires using finite resources, such as rare earth metals and minerals, which can be depleted over time. As a result, it can have significant environmental impacts, including land degradation and water pollution, and can result in social and economic impacts on communities that rely on these resources for their livelihoods.

II. CONCLUSION

Smart technology is a rapidly growing field that has the potential to revolutionize the way we live, work, and interact. It encompasses many technologies, such as AI, ML, NLP, robotics, and the IoT. These technologies are designed to be intelligent, self-learning, and adaptable to changing circumstances, and they use advanced algorithms and data analysis techniques to analyze large amounts of data and make predictions or decisions based on that data. The impact of smart Technologies on society and businesses is significant. On the one hand, it can lead to increased efficiency, productivity, and cost savings. Nevertheless, on the other hand, it can also lead to job loss, privacy concerns, and new forms of inequality. To mitigate these risks and maximize the benefits of smart technologies, everyone must play their role in ensuring a smooth transition. Everyone must play their role in the smart technology ecosystem to ensure we reap the benefits of this change and mitigate the risks. It requires a collaboration between government, business leaders, educators, and individual citizens, each of whom has a vital role to play in ensuring that the transition to smart technologies is smooth, safe, and equitable for all.

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