

Design & Implementation a Ecosystem for Smart City using Blockchain Technology

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Abstract:-Smart city brings out the integration of society, government, and the technology through smart economy, mobility, environment, people, living and governance. These characters are involved in the framework of the ecosystem of smart city. The sustainable and vibrant smart city ecosystem consist of integrated process which includes laws, policies, businesses, organizations and people. The city will be more responsive and adaptive with relevant to all the people who are living in the city, working and visiting the city. For transforming this ecosystem smart city integrates technology to facilitate and accelerate many technologies together. The main scope of the study with block chain technologies for the contribution for the development of the smart city ecosystem is implemented. The potential of the blockchain is used in solving the problems in the public and perceiving through the associations with the help of crypto currency bit coins as the innovative perspective for the organized city and transparent model for management of resources and economy.

Keywords: Smart city, ecosystem, block technology, economy, transforming

1. Introduction

The cities or municipality which uses the information and communication technology for increasing the efficiency of operation and in sharing the information with public and helping in improvement of the citizen welfare and the quality provided by the government services is known as smart city. The smart city mission depending upon the type of government and it optimises the functions of the city and helps in driving the growth of economy through improving the life quality of citizens with the use of data analysis as well as smart technologies. The values depend upon the number of technologies which is used by the smart cities. The continuous development in the urban areas through the integrated policies which are required for the improvement of urban lives residence through implementation with secured kind of interoperable and integrated electronic services. Administrations of public can be recognised for the potential of block chain for solving the problems (Rotuna et al., 2019).

In the Internet and digital age due to the advance in emerging technologies and rapid communication helpful in making the intelligent society which is also known as smart city. The huge acceptance of block chain technologies and artificial intelligence by the people acts as the paradigm to shifting the cities into a new dimension which is referred to as digital ecosystem of the smart city. Due to the rise of many applications in blockchain resolutions and artificial intelligence marks as a challenge in field from financial services and managing the threats to cryptocurrency and from the public and social services to the Internet of Things. Integration of AI technologies and block chain technology drives the economy and transforms the network of architecture of smart cities for the development of sustainable ecosystem. This integration helps in development of smart societies for solving the security issues with blockchain and implementing many technologies in smart city in transportation and other many fields. The future regulations and security using new proposals in the blockchain technology implemented for building up the sustainable ecosystem in smart society.

Smart city includes various aspect for the convergence and support for the development of safe and secure activities depending upon the reliable sources and data. By adopting block chain technology model in smart city helps in characterizing from governance through electronic age, products and services related to contracts, data collection and sensing. Multiple number of IoT things and number of networks along with the block chain technology resulting in the output of safe and efficient cities. The concept of building up in the small city ecosystem using the block chain technology acts as the platform for reliability and safety of the data. By looking through various aspects and reflection critically involve the concepts of block chain technology implementation in smart city ecosystem with use of trusted information, quality data, integration and generic data models (Brandao et al., 2018).

I. Literature review

A. Blockchain technology and smart cities

Shilpi&Ahad(2020) Blockchain technology has been dubbed a revolutionary invention because it has changed how data is shared by making it more secure and unchangeable. It has recently been a widely used technology since it has a mutual trust paradigm that encompasses all involved entities. Blockchain technology gradually becomes the potential technology for enabling the driving force of the present world because of its excellent application fields. One such area where blockchain is finding several applications and implementation paths is the ecosystem of smart cities. Blockchain is regarded as an appropriate technology given the variety of smart devices and data heterogeneity present in the sustainable city ecosystem. The present state of the "blockchain-based smart cities" is discussed in this study. The article also conducts a thorough evaluation of the many existing frameworks, concepts, and architectural designs created by researchers to address problems and difficulties associated with implementing smart cities by employing blockchain innovation.

Mora et al., (2021) Blockchain is a disruptive technology that has the potential to totally transform industries. Where there were none before, they can offer solutions. This technology has recently gained more focus with the intensive research and the development of the areas by both business and academia. As a result, a ton of intriguing works that provide frameworks, services, solutions based on the technology is produced in a variety of fields. In today's society, the research concentrating on the past difficulties is particularly intriguing. The recommendations come in faster than society can absorb them, though, and occasionally they are not fully utilized. In order to determine the characteristics of blockchain technology to make thing possible by addressing it successfully among the societal concerns, this article offers a thorough introduction of the technology. To address all of the present social concerns, the evaluation was performed from the perspectives of service delivery, resource management, and city administration, with a particular emphasis on the developmental goals of the nation.

B. Smart city Ecosystem

Aithal., (2020) Smart Cities are thoughtfully planned, developed, and built with the growing need of inhabitants seeking a higher quality of life in mind. Smart Cities' ability to provide improved services to their residents such as day to day activities, office, conducting of business, medical facilities, surroundings, atmosphere and living comfort has been greatly aided by technology. As a result, all of the operational procedures of smart cities have been altered, and online transactions have almost become its backbone. Naturally, any negative effect on online transactions has the potential to wreak havoc on Smart City operations. A secure and dependable online transaction is necessary to allay this worry. In this essay, we covered blockchain-based smart city technologies and their possible effects on the growth of smart cities.

Linde et al., (2021) the creation of new skills for identifying, seizing, and reconfiguring digitalization opportunities in an extremely dynamic ecosystem. However, earlier research has not provided any type of insights with the dynamic behaviors as well as functions necessary for the innovation of ecosystem. The researcher explored the kind of businesses might create that dynamic capacity for the innovation of ecosystem, through a number of case studies of smart city programs. The three orchestration processes we demonstrate in our capability-based architecture are setting up ecosystem alliances, deploying value propositions, and directing for the alignment of ecosystem. The findings have the implications for the managers as well as on the literature

for the ecosystem innovation and the dynamic capabilities. Management of innovation in ecosystem and the profit using that technology should be identified. The provided insights should give that exact subroutines or microfoundations which underlies in the ecosystem which include reconfiguring capacities, seizing, sensing of ecosystem leader are required for the coordination.

Ahlers et al., (2019) develop the flexible architecture for repeatable transferable and open ecosystem for smart city covering variety of the systems and providers, which presents IT-centered problems. The smart city and energy initiative +CityxChange is the background. Its goal is to make it possible for Positive Energy Blocks to be developed in collaborative fashion for sustainable and smart communities. This also involved creation of the framework of ecosystem as well as the auxiliary resources for promoting the integration of cities and associated communities to create a shared energy market. It will examine how the energy shift affects urban planning and the operations of city and the E mobility as a service which is incorporated into the communities that promote the positive energy and the local trading markets for the new business models which are developing. In the ICT enabled city open data, open architectures and digitization must be complemented with open urban process of innovation.

Kuru& Ansell (2020) There is no such thing as a "smart city" (SC), and there is no "optimal formula" to use to make every city a SC. By utilizing smart technology to create the convenient and comfortable ecosystem for living which is defined as the concept of opportunities sticks that continuously improves the harmony between the lives of people and environment in which they live. The concept paves the way for smarter cities, smarter nations and a smarter planet. To improve the quality of life and enabling the more sustainable future for the urban life with the increase of natural resources as constraints. Smart cities are implemented which bring together with the emerging technologies, environment, citizens, institutions, organizations and the governance with the highly synchronized synergistic ecosystem stop due to the recent development on smart city projects and the successful and useful cases with the future development plan in smart cities and many specific development solutions, they analyzed the construction of resource centric and citizen centric smarter cities in the study. The key components of smart city are given in the context that is driven by current technological development, specific urban dynamics and requirements. The framework known as smart city aspires to be the platform which seamlessly fuses the technological solutions and the engineering with the social dynamics in the new philosophical city with automation concept is known yes transition of socio techniques, incorporation of components of smart evolution, best practices and solutions in the way of modern into the coherent synergistic smart city topology for unfolding the future and current opportunities for adopting safer, smarter and the more sustainable urban environment and the goals are achieved through the development of smart cities using recent technologies.

2. Objectives

IMPLEMENTATION OF BLOCKCHAIN IN SMART CITIES

A. Use of Blockchain technology in smart cities

Smart cities use Internet of Things and artificial intelligence in both industries and academic sites in the recent years. Various kind of smart applications are used in smart cities that include smart banking, industry 4.0 smart intelligent transportation and boosting up of quality life of the citizens. Security has been considered as the major challenge in the smart city as it uses more technologies and advancements. For enabling the smart city block chain technology can be used for enhancing the security through sharing and storing the transactions in the secured way so it can be decentralized, immutable and transparent Ledger. Smart cities and blockchain are in the initial stage of growth through important research studies are required for integration and implementation. The role of block chain technology for enabling the IoT based smart city ecosystem. Block chain technology evolution has begun in construction technologies, blockchain platforms and consensus algorithms. Different types of smart applications are

Citizens of smart city are offered with more facilities for the interaction through public administration as well as local communities with the use of digital technologies for the increased security and efficiency using block chain technology. Blockchain helps in the development of large number of interaction models with same time

distributed storage with the persistence add it could not be designed for the centralised model. Administrations of public r emerged for the recognition of the potentiality of block chain model which act as the platform for transactions and communication in implementing the electronic services for the local communities Living in the smart city. The study analyses different types of blockchain areas and technologies for implementing the smart city ecosystem development (Rotuna et al., 2019).

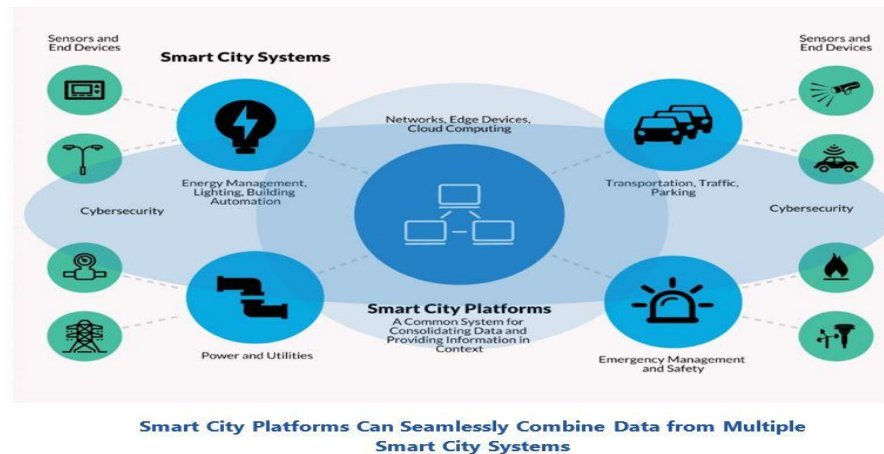


Fig. 1. Smart City System

B.Smart banking for Smart city implementation

Decentralized and distributed system of financial and banking block chain technology has been gaining its attraction over the time. In financial and banking sector block train has numerous numbers of applications which allows for storing information safer for the customers, payers and providers for sharing the data. Block chain technology is more potential and more practical helpfulness.

Exchange of data in financial and banking among the multiple organization in the computer system s more significance in using blockchain and it offers extremely safe transfer of sensitive and financial information. The date a r stored very confidential. The quality can be increased for reliable and secure storing and transmitting data. Strong accountability and transparency procedures are required for the financial data exchange.

C.Private messages security

In smart city private messages are the most important kind of data which facilitate for the interaction of people but the public administration for reporting the incidents, announcement of cultural events, administrative procedures and receiving clarifications. The most important thing is messaging applications which lack standard security protocols on the smart city framework should enable the communications between them. Communication system based on the blockchain technology allows the exchange of data and relationship between different types of messaging platforms for solving the problem. The major capability for the blockchain in security related to private messages the decentralization method for cyber security. The control of access network traffic and data transfer from one location is more secured using blockchain for difficulty in exploiting the system by the attackers.

It is advised against disclosing the sensitive data and the private information with the third partywho is considered as the trusted party due to the risk of abuse or attacks. Users must thus take ownership of their data without being subject to numerous threats related to security or the restriction for the capacity of providers and businesses to offer the particular services and owning their information and data. The suggested method makes the potential possibility for creating most safer route through the blockchain network(Mohammadinejad.,&Mohammadhoseini., 2020).

D.Pollution tracking

The potential use of blockchain technology in the water infrastructure industry is to track water pollution. Blockchain facilitates the correct tracking of information in cumulative succession by providing accurate timestamps. As a result, using this technology to track pollution may help by giving real-time information about the sources of pollution. In order to collect and store sensor data, appropriate sensors may be placed in trouble spots in the water infrastructure. Engineers may then respond correctly because the data can be arrived with location and time stamps. With the use of blockchain technology which will not allow the tracking on real time and the prompting reaction which would also offers a thorough record of the pollution in the certain areas. By management of wasters on right time and beyond being able to respond with having access to this information could boost the transparency of data, tightening the enforcement of restrictions on pollution and the decisions on environment (Lin et al., 2020).

E. Smart Energy system

Today, it is common practice to integrate energy-consuming equipment through the Internet of Things over the Internet technologies such as smart security systems, smart lights, smart plugs and smart home devices. This requires the physical infrastructure and the digital assets that are typically available on the conventional technologies. Additionally, to these resources a blockchain offers the irrevocable group for decision making and it will be easier for carrying out the logical operations and algorithms for generating the outputs. Once an agreement has been obtained the ability for execution of new algorithm as the hash over with secure interface between all blockchain components reduces the possibility of human errors. Blockchain includes the input on to the hashing algorithm and the production of Unique string with the hash as new algorithm with intended one way function. The set of response rules for self-enforcing, self-executing and self-verifying are maintained and protected with blockchain can be referred to as smart contract, for instance. A set of predetermined terms or regulations can be agreed upon by a group of parties which can then be codified as the smart contract signed and broadcasted cryptographically to the peer-to-peer network for the validation. The smart contract which is confirmed will contains with the blockchain Ledger which is intended for the work as the one way function so that the blockchain can give the input data and generate Unique string using a hashing method. The application of unmanned intelligence is made possible by the usage of blockchains. A simple illustration would be the automatic execution of an energy supply at the time of delivery after an agreement, and the execution of a contract once it has been signed by both sides, as in a distributed energy system (Yuan& Wang., 2018).

F.Smart parking

The integrated smart parking system can be implemented in smart city using block chain technology. This smart parking system provided by the service providers under the unified platform for the provision of one stop information for parking services for the commuters in the smart city. Adopting this type of smart parking system can be prone for the tempering and number of data which is shared among different groups of parties for raising the concerns that are related to the performance and trust. Many challenges are addressed in normal parking and it can be compared with the blockchain based architectural working system for the integration of services.

In the smart city ecosystem management of parking vehicles is the most important recruitment for the citizens in the present scenario because each city us rapidly growing as the crowded environment. Thinking, operation and specific type of planning for addressing the problem using information communication technologies and Internet of Things. Different types of problem solutions are made for the parking system in the smart city. Many challenges that include privacy, security, integrity, energy efficiency, bandwidth in communication and centralization. It can be inspired using AI technologies and blockchain technologies the secured framework enabling Blockchainfor the smart parking using energy efficiency in the sustainable city environment. Implementation of transportation layer using algorithms for decrypting and encrypting the zones of parking area with secured communication. The network of blockchain offers verification and authentication of the data at the most secured layer for the distribution. Technology of virtualization is used for storing the data and providing the energy efficiency environment for the virtual machines. It offers the parking space and information for the drivers for besttiming and location.

G. Autonomous vehicles using Blockchain

In smart cities intelligent transport system are more popular. The stakeholders of global automotive like Uber, Toshiba and Google act as the driving forces for the interconnection of the autonomous vehicles for management of traffic which is connected to autonomous vehicle. These vehicles are more vulnerable in security and safety issues like Global Positioning System spoofing timing attacks man in the middle attacks and denial of service which gives rise for the serious concerns in the development of specific area of application. Privacy and security issues in connected autonomous vehicles at the defensive mechanism for the attacks can be solved through blockchain technologies it mitigates the privacy and security issues and it solves the challenges with the introduction of connected autonomous vehicle system using blockchain. It can be integrated in the smart cities over the edge computing using the communication and computation cost.

The CAV's blockchain-based architectural framework, which connects all of the vehicles on the sensors of IoT and other kind of smart devices for regulating, monitoring and guiding the drivers on the road. The suggested architecture makes use of communication and transmission ranges to determine how many vehicles can be linked to IoT devices or sensors. To record and track the criminal and legal action of the car and the IoT devices connected with the vehicle number, the ratings provided by the users or consumers and the IoT device that saves the regular tables of regulations as well as the blockchain network. The relevant authorities that are a part of the blockchain may be able to recognize and take immediate action against that compromised IoT device in the event that any IoT device is infiltrated by attackers. Each car may be tracked, evaluated, and recorded on the blockchain rather using IoT devices. However, the possibilities of computational power and time may increase if records of such massive vehicle data are kept while they are moving in real-time circumstances. Therefore, it can be simple to record, evaluate, and store the activities of only IoT devices in the blockchain in order to restrict the storage and computing power. It is simple to trace and record in the blockchain the devices that deliver services in accordance with user requests and track a particular number of vehicles. Each IoT device that has a record of its vehicle usage and offers services to various vehicles can be utilized to store mining data over a block. Intruders may manipulate or alter information communication in devices or vehicles, which may change past interactions or history and further penalize the devices or vehicles by blocking or lowering their ratings (Rathee et al., 2019).

3. Methods

A. Implementation blockchain technology

In smart cities with the use of cutting-edge technology and blockchain technology as the potentiality for the addition of complexity in the infrastructure of the smart cities for evaluation of long-term and short-term impacts. Most of the blockchain potential consequences are safe for the implementation in smart city. Greatest difficulties in the infrastructure can be overcome through blockchain with future adaptability and complexity. Even though, more than 600 global companies are involved in block chain either directly or indirectly it is proved that it is more safe and reliable solution for the challenges that are made by the smart city. The most crucial thing is security that can be satisfied only through blockchain there is enough security bridge is extremely lowered in this technology implementation in smart city ecosystem first stop the complete implementation of block chain in the complex system has returned the investment of 590% age which are reduced by the unnecessary complexities and redundancy that are at present (Alnahari&Ariaratnam., 2022).

TABLE I. DIFFERENT TYPES OF BLOCKCHAIN IMPLEMENTATION IN SMART CITY

S. No	Blockchain implementation in smart cities	
	<i>Blockchain technology</i>	<i>Implemented in smart city</i>
1	Smart Banking	95%
2	Private Messages	88%

3	Pollution tracking	70%
4	Smart energy system	75%
5	Smart Parking	80%
6	Autonomous vehicles	68%

Infrastructure sustainability and the complex future nature can be addressed with resource and security management with priorities with the convenience of user based upon their requirements, secured financial activities data monitoring in the improved and secured way. The framework of smart city ecosystem can be implemented with block chain technology with the integration of city infrastructure and the operations which would likely be the future smart city. With sharing of electricity and self-consumption within the community of consumers according to the security models using blockchain technologies can be more profitable for the consumers by trading off with one another and they should be aware of the retailer and the middle man. By using the fundamental steps of the smart city ecosystem which includes citizens, governance, local and public administration. Blockchain deployment in the regular use offers more security in administration and privacy among the people of the city. Due to the crowded nature, it is not possible for looking after every house and every citizen. So that block chain technology offers the most secured way for transaction and transmission of data and financial services among the cities due to the development of Internet of Things and ICT. The highlights of the study analyse the implementation of block chain in smart cities in every aspect and key areas which includes banking transportation pollution management and energy management. smart parking services help in digitalised level of parking in the crowded areas with time allocation and parking allotment of the vehicles. Transmission of private messages protects against the threats and attacks with blockchain.

Fig 2. Blockchain implementation in Smart cities

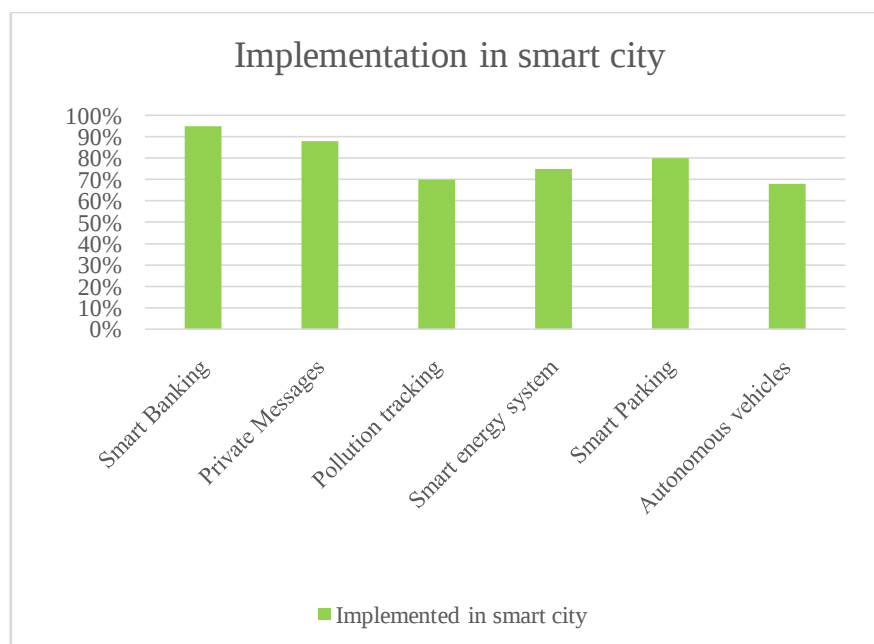
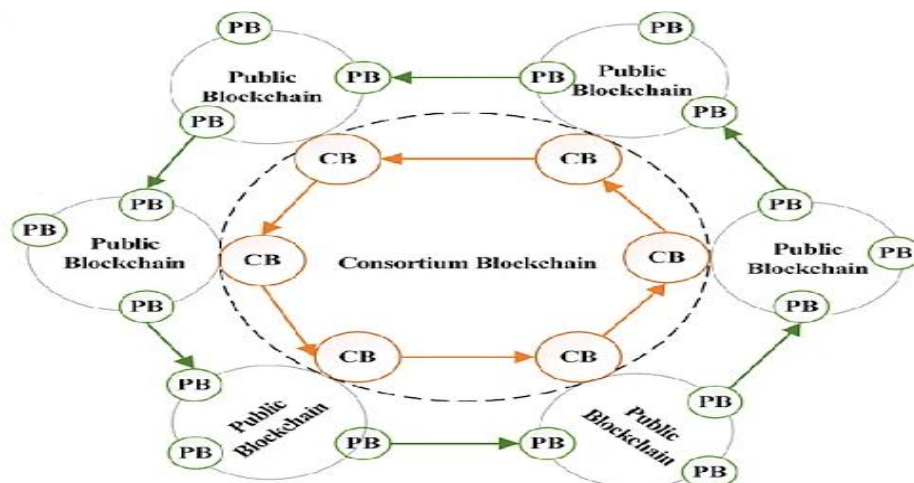


Fig 3. Blockchain implementation



4. Discussion

Rapid growth in the urban cities gave race for the new infrastructures and some challenges in the public administrations. When the cities are expanded and developed does more complex with management, governance and services. The cities should adopt the challenges in environment, engineering, society and economics. The city should face the challenges smartly. The digital platform for financial transactions and cryptocurrencies using blockchain technology is the most significant application in different areas in smart cities for the management of cities.

The components of the smart city depend on the collection and storage of data which is well supported by the infrastructure of specialist hardware. The most important aspect is considered as interoperability of the new applications when comparing with the existing ones. For improvement of quality as well as performance in the urban services for the city centre off smart city using digital technology. The application should be in the interactive way and guaranteed services should be provided for the smart city to access real time information. Local administration and the city officials in the smart city should be based on the block chain technology for the benefits of the complete connection with the visitors and the citizens in the city.

The implementation off the block chain technology in smart city for the data management has more impact find suitable for the management in the fast pace in various sectors of infrastructure first stop blockchain can transform the infrastructure entirely into the sustainable ecosystem which include smart banking, private messages, pollution tracking, smart energy system, smart parking and autonomous vehicles in the safe hands for the citizens of city.

References

- [1] Rotună, C., GHEORGHIȚĂ, A., Zamfiroiu, A., & SMADA ANAGRAMA, D. (2019). Smart City Ecosystem Using Blockchain Technology. *Informatica Economica*, 23(4).
- [2] Shilpi, S., & Ahad, M. (2020). Blockchain Technology and Smart Cities-A Review. *EAI Endorsed Transactions on Smart Cities*, 4(10).
- [3] Brandão, A., Mamede, H. S., & Gonçalves, R. (2018, October). A smart city's model secured by blockchain. In *International conference on software process improvement* (pp. 249-260). Springer, Cham.

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- [4] Aithal, P. S. (2020). Blockchain Technology: A Driving Force in Smart Cities Development. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 4(2), 237-252.
 - [5] Linde, L., Sjödin, D., Parida, V., & Wincent, J. (2021). Dynamic capabilities for ecosystem orchestration A capability-based framework for smart city innovation initiatives. *Technological Forecasting and Social Change*, 166, 120614.
 - [6] Ahlers, D., Wienhofen, L. W., Petersen, S. A., & Anvaari, M. (2019, June). A smart city ecosystem enabling open innovation. In *International Conference on Innovations for Community Services* (pp. 109-122). Springer, Cham.
 - [7] Mora, H., Mendoza-Tello, J. C., Varela-Guzmán, E. G., & Szymanski, J. (2021). Blockchain technologies to address smart city and society challenges. *Computers in Human Behavior*, 122, 106854.
 - [8] Mohammadinejad, H., & Mohammadhoseini, F. (2020). Privacy protection in smart cities by a personal data management protocol in blockchain. *International Journal of Computer Network and Information Security*, 11(3), 44.
 - [9] Lin, Y. P., Mukhtar, H., Huang, K. T., Petway, J. R., Lin, C. M., Chou, C. F., & Liao, S. W. (2020). Real-time identification of irrigation water pollution sources and pathways with a wireless sensor network and blockchain framework. *Sensors*, 20(13), 3634.
 - [10] Yuan, Y., & Wang, F. Y. (2018). Blockchain and cryptocurrencies: Model, techniques, and applications. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 48(9), 1421-1428.
 - [11] Rathee, G., Sharma, A., Iqbal, R., Aloqaily, M., Jaglan, N., & Kumar, R. (2019). A blockchain framework for securing connected and autonomous vehicles. *Sensors*, 19(14), 3165.
 - [12] Alnahari, M. S., & Ariaratnam, S. T. (2022). The Application of Blockchain Technology to Smart City Infrastructure. *Smart Cities*, 5(3), 979-993.
 - [13] V. Panwar, D.K. Sharma, K.V.P.Kumar, A. Jain & C. Thakar, (2021), "Experimental Investigations And Optimization Of Surface Roughness In Turning Of EN 36 Alloy Steel Using Response Surface Methodology And Genetic Algorithm" *Materials Today: Proceedings*, <https://doi.org/10.1016/J.Matpr.2021.03.642>
 - [14] A. Jain, A. K. Pandey, (2019), "Modeling And Optimizing Of Different Quality Characteristics In Electrical Discharge Drilling Of Titanium Alloy (Grade-5) Sheet" *Material Today Proceedings*, 18, 182-191. <https://doi.org/10.1016/j.matpr.2019.06.292>
 - [15] A. Jain, A.K.Yadav & Y. Shrivastava (2019), "Modelling and Optimization of Different Quality Characteristics In Electric Discharge Drilling of Titanium Alloy Sheet" *Material Today Proceedings*, 21, 1680-1684, <https://doi.org/10.1016/j.matpr.2019.12.010>
 - [16] A. Jain, A. K. Pandey, (2019), "Modeling And Optimizing Of Different Quality Characteristics In Electrical Discharge Drilling Of Titanium Alloy (Grade-5) Sheet" *Material Today Proceedings*, 18, 182-191 <https://doi.org/10.1016/j.matpr.2019.06.292>
 - [17] A. Jain, A. K. Pandey, (2019), "Multiple Quality Optimizations In Electrical Discharge Drilling Of Mild Steel Sheet" *Material Today Proceedings*, 8, 7252-7261 <https://doi.org/10.1016/j.matpr.2017.07.054>
 - [18] V. Panwar, D.K. Sharma, K.V.P.Kumar, A. Jain & C. Thakar, (2021), "Experimental Investigations And Optimization Of Surface Roughness In Turning Of EN 36 Alloy Steel Using Response Surface Methodology And Genetic Algorithm" *Materials Today: Proceedings*, <https://doi.org/10.1016/J.Matpr.2021.03.642>

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- [19] SK Hasane Ahammad, , D. K. J.Saini, Phishing URL detection using machine learning methods, *Advances in Engineering Software*, Volume 173, 2022,103288, ISSN 0965-9978, <https://doi.org/10.1016/j.advengsoft.2022.103288>
 - [20] Yadav, P, S. Kumar, and D. K. J.Saini. "A Novel Method of Butterfly Optimization Algorithm for Load Balancing in Cloud Computing". *International Journal on Recent and Innovation Trends in Computing and Communication*, vol. 10, no. 8, Aug. 2022, pp. 110-5, doi:10.17762/ijritcc.v10i8.5683.
 - [21] Jang Bahadur, D. K. , and L.Lakshmanan. "Enhancement of Quality of Service Based on Cross-Layer Approaches in Wireless Sensor Networks". *Journal of Theoretical and Applied Information Technology* ISSN: 1992-8645, 15th October 2022. Vol.100. No 19 .
 - [22] Jang Bahadur, D. K. , and L.Lakshmanan. "Virtual Infrastructure Based Routing Algorithm for IoT Enabled Wireless Sensor Networks With Mobile Gateway". *International Journal on Recent and Innovation Trends in Computing and Communication*, vol. 10, no. 8, Aug. 2022, pp. 96-103, doi:10.17762/ijritcc.v10i8.5681.
 - [23] Shailesh Kamble, Dilip Kumar J. Saini, Vinay Kumar, Arun Kumar Gautam, Shikha Verma, Ashish Tiwari & Dinesh Goyal (2022) Detection and tracking of moving cloud services from video using saliency map model, *Journal of Discrete Mathematical Sciences and Cryptography*, 25:4, 1083-1092, DOI: 10.1080/09720529.2022.2072436.
 - [24] Jang Bahadur, D. K. , and L.Lakshmanan "Improve Quality of Service in Optimization of Job Scheduling using a Hybrid Approach" *Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/ Journal of Xi'an Shiyou University, Natural Sciences Edition* ISSN:1673-064X Vol: 65 Issue 01 | 2022 DOI 10.17605/OSF.IO/DW57E.
 - [25] Jang Bahadur, D. K. , and L.Lakshmanan "Wireless Sensor Network Optimization for Multi-Sensor Analytics in Smart Healthcare System" *Specialusis Ugdymas*, ISSN NO: 1392-5369 Vol. 1 No. 43 (2022).
 - [26] Saini D., An IoT and fog computing enabled intelligent health care monitoring system to the cloud storage, *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* Vol12 No10(2021), 2085-2091(ISSN: 1309-4653) Scopus Indexed <https://turcomat.org/index.php/turkbilmat/article/view/4722>
 - [27] DOI: <https://doi.org/10.17762/turcomat.v12i10.4722>
 - [28] 9.Saini D, Novel Approach of Data Transformation for Privacy Assurance using Optimization of Genetic Algorithm, *Design Engineering (Toronto)* ISSN No:0011-9342 Scopus Indexed
 - [29] 10. D. K. Jang Bahadur Saini, P. Patil, K. Dev Gupta, S. Kumar, P. Singh and M. Diwakar, "Optimized Web Searching Using Inverted Indexing Technique," 2022 IEEE 11th International Conference on Communication Systems and Network Technologies (CSNT), 2022, pp. 351-356, doi: 10.1109/CSNT54456.2022.9787680.
 - [30] D. Siddharth, D. K. J Saini, P. Singh, An Efficient Approach for Edge Detection Technique using Kalman Filter with Artificial NeuralNetwork, *International Journal of Engineering, Transactions C: Aspects* Vol. 34, No. 12, (2021) 2604-2610
 - [31] "A comparative study on energy-efficient clustering based on metaheuristic algorithms for WSN", *International Journal of Advanced Technology and Engineering Exploration*, vol. 9, no. 86, 2022. Available: 10.19101/ijatee.2021.874823.