THE ASIAN BULLETIN OF BIG DATA MANAGMENT
Vol. 3. Issue 1 (2023)
https://doi.org/10.62019/abbdm.v3i1.42

ASIAN BULLETIN OF BIG DATA MANAGEMENT
http://abbdm.com/
ISSN (Print): 2959-0795
ISSN (online): 2959-0809

Block-Chain based Trustful Data-Driven Cyber-Physical Social System Framework for Urban Air Mobility

Faheem Ahmed Abbasi *, Kamran Dahri, Zia Ahmed Shaikh, Muhammad Ali Memon, Muhammad Ali Nizamani, Muhammad Yaqoob Koondhar

Chronicle

Article history
Received: Sept10, 2023
Received in the revised format: October 7, 2023
Accepted: October 7, 2023
Available online: October 10, 2023

Faheem Ahmed Abbasi, Kamran Dahri, Muhammad Ali Memon & Muhammad Ali Nizamani are currently affiliated with Department of Information Technology University of Sindh,Jamshoro, Pakistan.
Email: faheem.abbasi@usindh.edu.pk,
Email: kamran.dahri@usindh.edu.pk
Email: muhammad.ali@usindh.edu.pk
Email: ma.nizamani@usindh.edu.pk

Zia Ahmed Shaikh is currently affiliated with Directorate of Information Technology Liaquat University of Medical & Health Sciences, Jamshoro, Pakistan.
Email: zia.shaikh@lumhs.edu.pk

Muhammad Yaqoob Koondhar is currently affiliated with Information Technology Center Sindh Agriculture University,Tando Jam, Pakistan.
Email: yaqoobkoondhar@sau.edu.pk

***Corresponding Author**

Abstract

This paper provides an overview of existing research on urban mobility issues. It highlights the importance of incorporating smart technologies, particularly in introducing air-based transportation, to enhance the efficiency of urban mobility systems. The integration of air mobility will increase complexities in managing urban transportation due to the growing volume of data, services, and infrastructure-governing bodies that must be handled. Urban air mobility infrastructure consists of interconnected and intricate systems that demonstrate the seamless integration of physical and software components. To address these complexities, the Cyber-physical social system (CPSS) is proposed as an effective approach to minimize complications within and between these subsystems. Establishing public-private partnerships and ensuring secure transactions are vital prerequisites for embracing current technological advancements and shaping the future of urban air mobility services. In this regard, block-chain technology emerges as a reliable protocol that guarantees the integrity of data exchanged among the decentralized network of stakeholders, eliminating the need for a trusted intermediary.

Keywords: Urban air mobility; multi-dimensional urban mobility; block-chain technology.

BACKGROUND

The economic attractiveness of cities has thus generated, through the ages, a steady increase in the urban population, leading policy-makers to rethink mobility to cope with the density of traffic, infrastructure renewal, sustainable development, and safety of the passengers (Utriainen et al, 2018). In this context, convergence tends to shift towards using digital platforms offering a variety of services, on-demand and more adapted to users' immediate needs. Private sector actors often develop these services with the expertise and the technology to deploy. Through intelligent mobility, the renewal of urban mobility has brought alternatives to usual travel, giving way to soft mobility, the reasoned use of personal vehicles, multi-modality, and international mobility. Its emergence has fostered the development of a new urban mobility economy, combining services from public and private sector providers. In addition to digital convergence, tariff convergence appears to be a critical factor in a successful implementation (Alyavina et al, 2020). However, expanding terrestrial networks to comply with the new needs and constraints is beginning to show its limits. It suggests the conquest of the air to diversify the mobility offer, as is already done in some large cities that have introduced an air transport mode (helicopters, small carriers, drones, etc.) for transporting both humans and goods (Elangovan et al, 2022). Decentralized systems, distributed ledgers, and an immutable, cryptographically laxed era are all components of Enterprise 4.0's new Internet of Things packages. This generation involves a succession of transaction lists that are exchanged and kept in sync by many firms or occasions (Ting et al, 2020). Because of the more patient-centric approach to healthcare technology and block-chain ability to connect different structures and increase the accuracy of digital health information, fitness care is one industry where it has exceptional potential (Gunasekeran et al, 2021). The Internet of Things (IoT), 5G telecommunication networks, and Artificial intelligence (AI), which uses deep learning and massive data analytics, have all emerged in the last ten years as some of the most cutting-edge digital technologies. These technologies might have significant uses and effects in healthcare (Whitelaw et al, 2020).

The COVID-19 pandemic has quickly advanced the development of digital technologies to meet, paralyzing access to global healthcare systems through hitherto unheard-of lockdowns and imposed physical distance. Various healthcare wishes globally (Sharma et al, 2020; Elangovan et al, 2022). Coordination of big-scale operations, including population-degree mass screening, rapid contact tracing, supply chain control for vaccines and capsules, telemedicine consultations, and e-commerce enlargement, has adopted a massive range of digital technologies (Gunasekeran et al, 2021). Block-chain is a foundational digital era that integrates a couple of other generations (appendix pp 2–four) (Kuo et al, 2017). In health care, block-chain may additionally want to serve instead of standard distributed database management systems, usually consumer-server databases with structured question Language or relational input (Smarsly et al, 2017).

Regardless of the developing adoption of cyber-bodily structures in structural health tracking and control applications, research investigating modelling methodologies for version-primarily based representation of cyber-physical systems can be very confined. There is an apparent lack of modelling strategies facilitating a unique model-based total absolute expression of records applicable to a CPS, such as facts at the sensor node design, attributes at the algorithms embedded into the sensor nodes, records on the configuration and topology of the sensor network, or information approximately the overall tracking and control strategies ("CPS-related statistics") (Sharma et al, 2020).

In the first section, the general context of this research work was introduced that motivates to solve the general issues related to urban mobility. The rest of the paper is structured as follows: In section 2, we present state-of-the-art on urban mobility concerns for sustainable development and their key challenges and related work in literature, taken as the frame in which the new mobility paradigm should be designed. Section 3 highlights the main research objective and proposes a trustful data-driven cyber-physical social system framework that allows a decision support system to help decision-makers in cities better manage the renewal of services for urban air mobility infrastructure and anticipate users' new needs. Finally, the conclusion and future perspectives of the ongoing research conclude the paper.

LITERATURE REVIEW

Urban Mobility Concerns

As stated earlier, the rapid growth of urbanization spawns a variety of urban mobility concerns that must be tackled timely, such as traffic congestion, infrastructure, the safety of the passengers, and environmental pollution, as shown in Fig. 1.

Figure 1.
Different urban mobility concerns for sustainable development

Congested Traffic

Traffic congestion is exacerbated by urbanisation. Congestion has proven to be a major concern. Indeed, if the number of vehicles continues to rise while the road system and parking lots stay unchanged, the commute will grow more onerous. This is most prevalent in urban areas, yet the congestion problem cannot be solved simply by launching infrastructure projects such as bridges, highways, railway networks, etc. Technology has emerged as a tool for solving human issues and making lives easier, and it is extremely beneficial in reducing congestion (Afrin et al, 2020). Other elements contributing to traffic congestion, such as accidents, maintenance work, poor transportation systems, and so on, must be addressed individually and as part of the overall solution. (Evans et al, 2018).

Infrastructures

Transportation is made easier by a network of highways, pathways, airport terminals, and other infrastructural developments. Planning for these must take into account the anticipated demands of each community. Revitalization or, at least, maintenance projects can be carried out where new projects are not feasible to ensure that the systems function as intended and help prepare for increased or decreased flow appropriately (Hamid et al, 2019).

Protection of the Travellers

There have been more accidents as a result of growing traffic. In urban locations, accidents, injuries, and fatalities are frequently more likely to occur the more congested the traffic is. Some nations have experimented with laws limiting the kind of vehicles permitted on the road, such as those with odd or even registration numbers. However, by purchasing numerous vehicles, many get around these rules. The perception of security among commuters has also declined (Janjevic et al, 2016).

Environmental Pollution

Urban mobility has radically raised energy usage. As a result, pollution has grown. Pollution, which harms human health, has made urban life miserable for residents, especially when combined with irritating noise (Silva et al, 2018). City planners (public authorities) are under enormous pressure to provide a solution to the various needs of the residents (users) and mobility suppliers (providers) to address the aforementioned urban mobility challenges (Kalghatgi, 2019).Public authorities must tackle different kinds of pressures timely for the needs of the end-users and providers, as shown in Fig. 2.

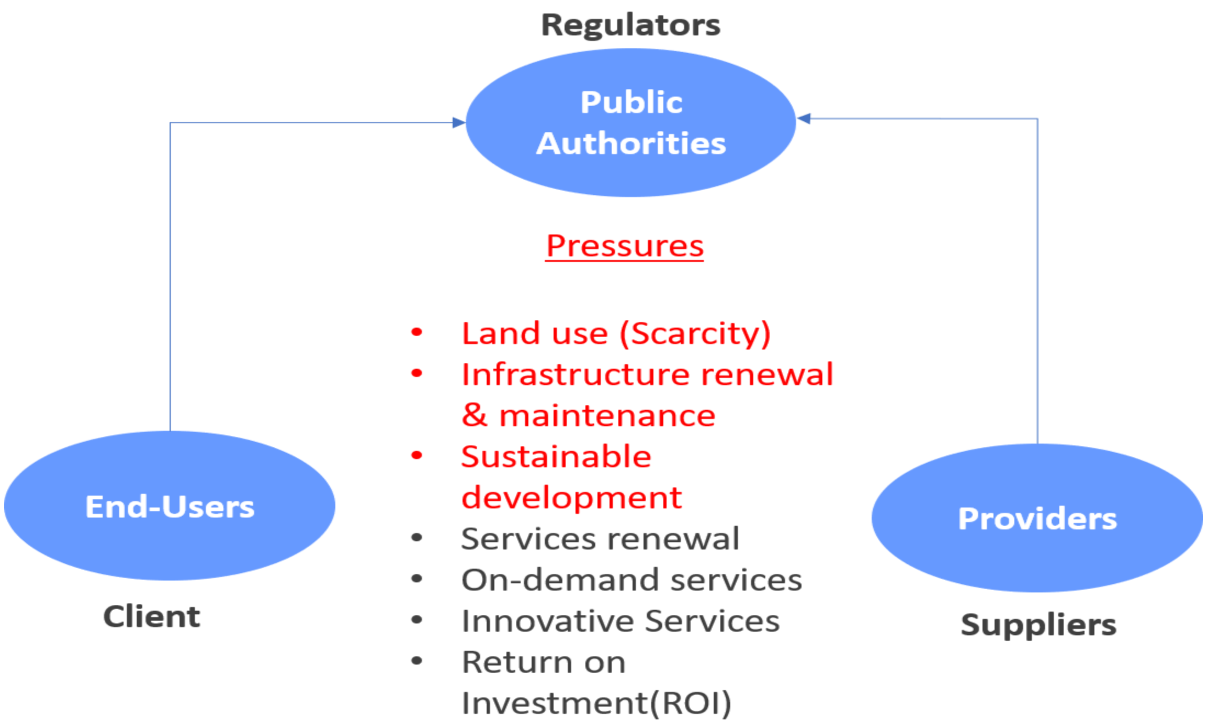

Figure 2.
Different kinds of pressures on public authorities

Key Stakeholders of the Urban Mobility Systems

Key stakeholders of Urban Mobility Systems are given here under.

End-Users: End-users want to move from location A to B, e.g., Schools, Work, Leisure, etc. So, he required mobility-on-demand, fast and innovative services to commute, personalized services, etc.

*Providers:*Providers are called mobility operators (public and private) and solution providers (technology companies). Who invested their money and expected a Return on investment (ROI).

*Public Authorities:*Users and financial benefits to service providers. They are considering other pressures such as Land utilization (scarcity), Infrastructure renewal and maintenance, i.e., roads, bridges, railway stations, airports, etc. Including all these pressures, public authorities are more concerned with sustaining all the above needs since urban mobility causes negative impacts on the environment, such as the emission of CO_2 pollutants and noise nuisance (Trivedi et al, 2021). Therefore, while making policies to handle the pressures mentioned above, public authorities should consider these pressures in the context of sustainable development.

The stakeholders use different methods and tools to cater to all these urban mobility concerns and pressures, as stated in the literature review section below.

Sustainable Urban Mobility

Mobility can be defined as an attribute related to the movements made by individuals in their study, work, leisure, and others. It is a process that combines three essential dimensions: environmental, economic, and social, establishing a correlation between these three poles, guaranteeing economic efficiency and protection of the environment without losing sight of the social goals, which are the fight against poverty, inequalities, exclusion and the pursuit of equity (Silva et al, 2018). Sustainable development in transport planning is associated with a balance between environmental, economic, and social aspects in the present and future urban interventions. The balance between these three components will fulfil people's needs regarding the quality of life of every citizen (Nikitas et al, 2019).

So, understand that when it comes to sustainable urban mobility, one can think of a strategy, in the long term, for the future development of urban areas, including transport infrastructure and mobility services. However, current urban growth and development policies have not favoured using more sustainable means of transport (such as cycling, walking, and public transport). In what consequence of the indiscriminate use of the automobile in urban areas: increased congestion, energy consumed in the transport sector, and noise and toxic gas emissions? The increasing spatial dispersion is another problem visibly identified in urban areas that directly influences mobility planning.

In some cases, dissociation exists between urban planning and transport operators, particularly in urban land use planning. These issues have contributed to widening disparities in the supply of services to the various urban segments, directly impacting urban mobility (Nieuwenhuijsen et al, 2020). The traditional planning process, in which each urban problem must be solved separately, can no longer be used to solve the current issues (Linder et al, 2022). There is a need to take policy measures to reduce ground-based transport and land use travel distance by increasing technological innovation. These factors have motivated researchers and decision-makers to seek new ways to minimize, discuss and find solutions to these urban issues. Below, Tab. 1 describes and analyses different papers based on the literature on urban mobility issues.

The issues presented in Tab. 1 can be categorized by different domains associated with urban mobility, such as planning, governance, policies, environment, safety, legislation, crowd-sourcing, social aspects, and technology-based. We analyzed the literature that the urban mobility concept is linked to different domains and stakeholders. Therefore, effective integration and engagement of stakeholders are required for a sustainable urban mobility paradigm and multimodal solutions (Nijland et al, 2017; Baptista et al, 2014).

Table 1.
Categorization of the different domains associated with urban mobility

#	Quantity	Conversion from Gaussian
1	Semantic integration for supporting visualization	Visualization-oriented Ontology (Thiago Sobrala et al.,2017)
2	Knowledge-assisted integration and visualization of data	Visualization-oriented Urban Mobility Ontology (VUMO) (Thiago Sobral et al., 2020)
3	Road pricing	Simulation. Agent-based modelling (Van Duin et al., 2012)
4	Urban freight flows	Simulation (Comi and Nuzzolo 2014, 2016)
5	Assess the impact of shared, autonomous electric vehicles	Simulation and Combining analytics (Oliver Dlugoscha et al.,)
6	Service network design	Mixed-integer linear programming (MILP) (Crainic et al.,2016)
7	Passenger transition dynamics	MLP analyses (Afsaneh Moradi et al., 2018)
8	Multiple trips, zones, time windows	An adaptive large neighborhood search (ALNS) (Grangier et al., 2016)
9	Location of pickup points	Clustering (Wu et al., 2015)
10	The multi-trip vehicle-related problem with time windows and release date	Genetic algorithm (Cattaruzza et al., 2016)
11	Identify and quantify the factors affecting the adoption and use of UAM	Technology acceptance model (TAM) and automation acceptance model (AAM) (Christelle Al Haddad, et al.,2020)
12	Designing UMSs	Traveler eXperience Conceptual Model (TXCM) (Ouail Al Maghraoui et al.,2019)
13	Urban land use and climate change mitigation	Developed & analyzed a theoretical model (Benjamin D. Leibowicz,2020
14	Congestion and emissions	Review (Browne et al., 2012)

.

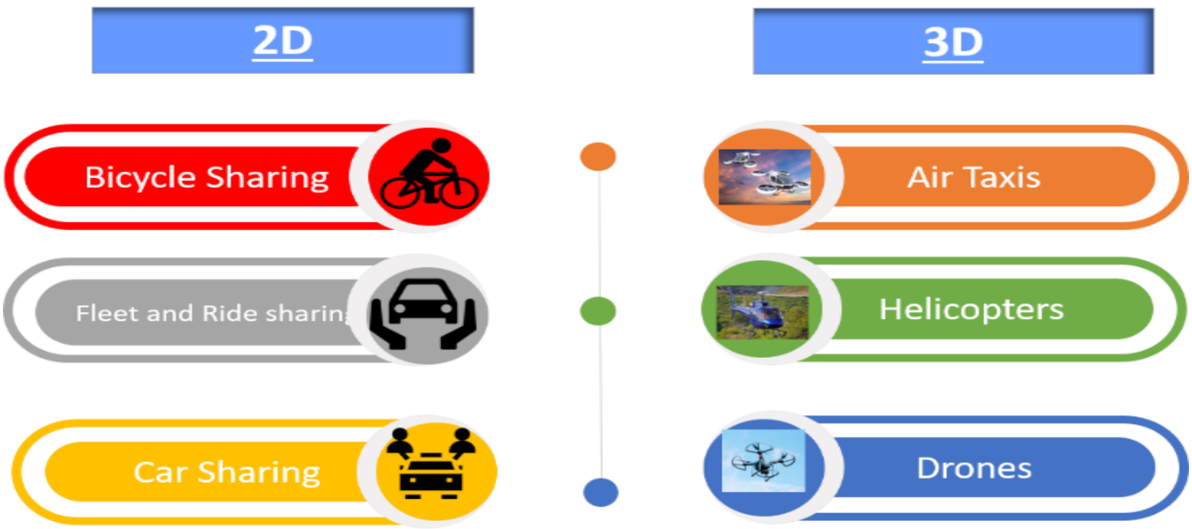

Figure 3.
Multi-dimensional urban mobility

Currently, the concept evolved as a multi-dimensional urban mobility delivery model in which a user's primary mobility needs are met through different urban mobility modes offered by a service provider and have been anticipated as a viable solution for sustainable urban mobility (Thipphavong et al, 2018; Ting et al, 2020).

Multi-Dimensional Urban Mobility

The expansion of terrestrial networks to comply with the new needs and constraints is beginning to show its limits. It suggests the conquest of the air to diversify the mobility offer, as is already done in some large cities that have introduced an air transport mode (helicopters, air taxis, drones, etc.) for transporting both humans and goods, as shown in Fig. 3 With the expansion of terrestrial networks, mobility services are moving to a new dimension to reduce the load on ground-based transportation networks. Researchers and companies all over the world (e.g., airbus vahana, ehang 184, volocopter) are working on air-bound mobility solutions (e.g., autonomous air taxis) for the intro and interurban passenger transport (Otte et al, 2018). As already done in some cities that have introduced an air transport mode (helicopters, small carriers, drones, etc.) for transporting humans and goods (see Fig. 4, Uber is planning on-demand service from Lower Manhattan to Kennedy International Airport).

Figure 4.

Future Urban Mobility

According to the estimation of Roland Berger, a German company of almost 100 cities will have a UAM operation in 2050 worldwide, as shown in Fig. 5 (Straubinger et al, 2020). These operations include Intercity flights, Air taxis, and airport shuttles. This drone passenger forecast clearly shows that Urban Air Mobility will soon be considered another way to move within cities.Due to the increased data, services, and infrastructures the organizing authorities will have to deal with due to the advent of air mobility, managing urban mobility will become more difficult (Karim et al, 2016). Therefore, to allow this third-dimension transport mode to operate within a city, decision-makers need data on existing infrastructure and services to make appropriate decisions for Urban air mobility (UAM) infrastructure renewal.

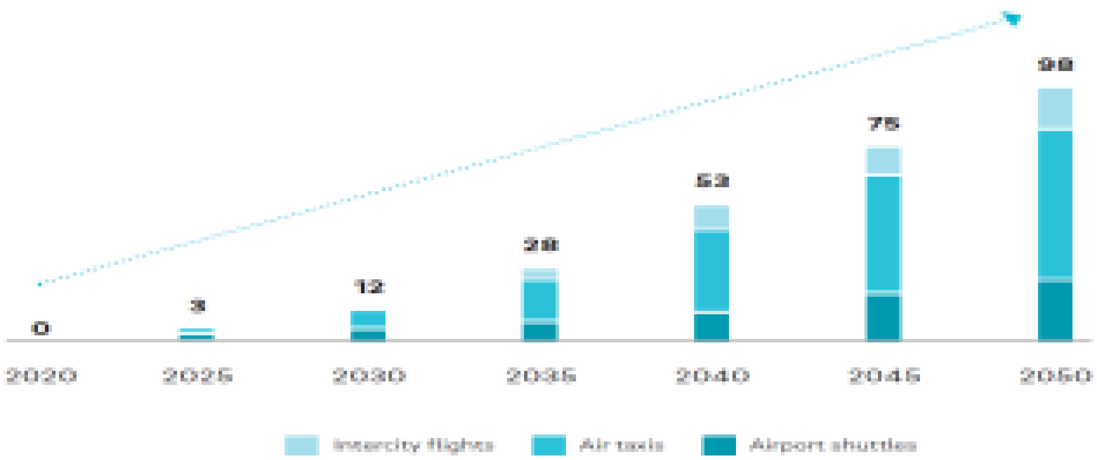

Figure 5.

Passenger drone operation forecast

METHODOLOGY

This study's primary benefit is providing a decision-support tool to public authorities for the renewal of sustainable UAM Infrastructure without affecting land use. Fig. 6 illustrates the combination of models offered by the existing mobility solutions in a decision support system that can assist city policy-makers in effectively managing the pressures listed below. A Decision support system (DSS) is a computerized information system that contains domain-specific knowledge and analytical decision models to assist the decision-maker by presenting information and interpreting various alternatives (Ghaffarzadeh, 2015). DSS has several common characteristics, namely: (i) provides support for decision-makers mainly in semi-structured and unstructured situations; (ii) attempts to improve the effectiveness of decision-making; (iii) can handle a large amount of data; (iv) focuses on a very domain-specific; (v) operates as an interactive system; and (vi) supports optimization and heuristic approach (Zheng et al, 2018).

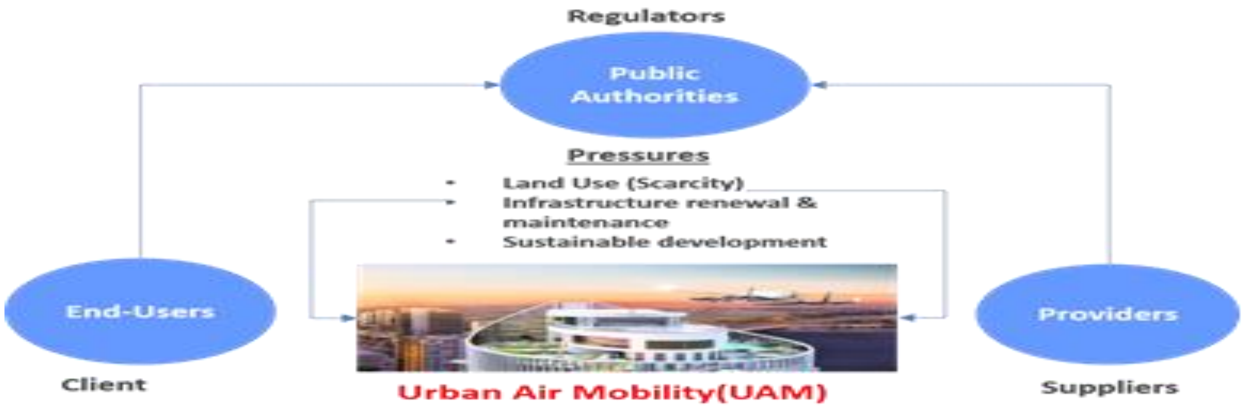

Figure 6.
UAM infrastructure

An interactive DSS aims to help city planners use existing urban mobility infrastructure efficiently for UAM by accessing the large volumes of information generated by various urban mobility stakeholders.

Figure 7.
Cyber-physical social system

As mentioned, the UAM infrastructure consists of a series of more complex systems, and a wide range of components are involved, including different modes of transportation, such as cars, bikes, buses, and air taxis, as well as physical transportation infrastructure, such as highways, bridges, subway lines, and airports, as well as digital infrastructures, such as sensors and actuators, mobility providers (operators), mobility services, such as car sharing, bike sharing, payment gateways, and user These systems exhibit the tight integration of hardware and software, gradually becoming more complicated, and are developing extremely co-related systems of connected-technologies. (Thipphavong et al, 2018; Liu et al, 2017). As a result, we believed that CPSS was one of the greatest methods for reducing complexity within and across these subsystems. One of the foundational elements of the Industry 4.0 revolution is CPSS. CPSS is a revolutionary method for controlling interconnected systems' physical resources and computational power. To generate fresh, cutting-edge information, technical proficiency, and improved quality of life, CPSS connects society, networking, and computing with physical systems. Information from the social and physical worlds can be extracted by CPSS, which can then be processed online. The CPSS must comprise three worlds (Utriainen et al, 2018).

The initial one is the material world, where physical components like sensors are used as a data source; the second is the cyber world, where computational systems operate in a network; and the third is the social world, where humans are involved in some capacity, such as as a data source, an actuator, or a decision-maker (Ghaffarzadeh, 2015), as shown in Fig. 7. Decision-makers (public authorities) can encourage other stakeholders, i.e., mobility providers and end-users, to collaborate through a trusted network (in the neutral platform) for data sharing and guaranteeing equity between the stakeholders. New ways of collaborating are enabled by technology. A new block-chain technology provides a viable method for trusted collaboration between stakeholders without a central authority. Block-chain technology is a trust protocol that ensures the integrity of the data exchanged among a decentralized network of stakeholders without going through a trusted third party (Tapscott et al, 2017).

The result is that stakeholder trust will increase and help develop new mobility as a services ecosystem. Fig. 8 shows block-chain technology has the potential to address the data level interoperability challenges currently present in information systems and to be the technical standard that enables individuals, service providers, other government entities, and researchers to share electronic data securely (Tariq et al, 2020; Abbasi et al, 2020, Memon et al, 2017; Alrizaq et al, 2020; Memon et al, 2021). Thus, the purpose of Block-chain technology is to maintain trust in a decentralized network.

Trustful Data-Driven CPSS Framework for UAM

This research work aims to develop a Blockchain-enabled CPSS decision support system. The associated main challenges and addressing the leading scientific research questions formulated above are also justified. The development of a framework allows policy-makers in cities to manage better the renewal of services for urban air mobility infrastructure and anticipate users' new needs by considering models provided by the existing mobility solutions shown in Fig. 9.According to the perspective of software architecture, the framework consists of the Physical space, social space, cyberspace,

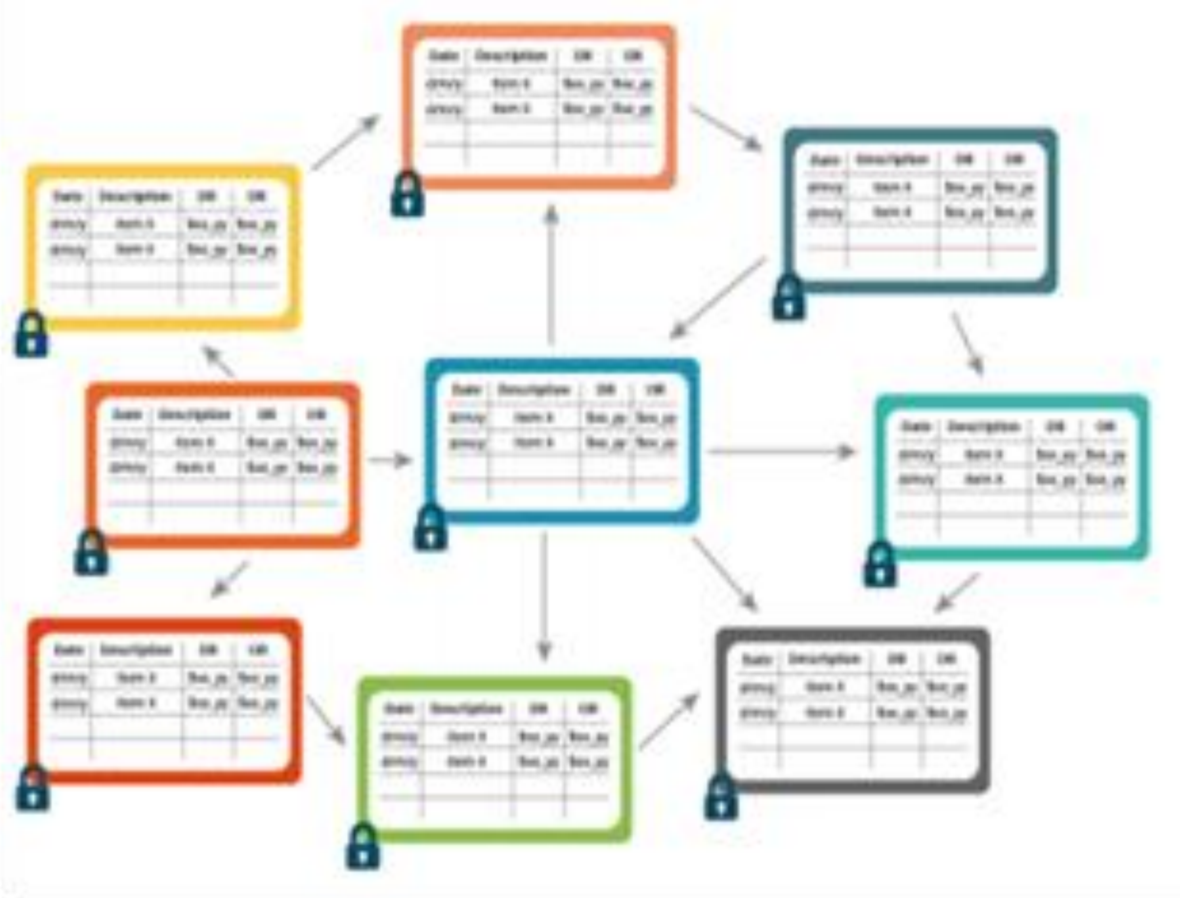

Figure 8. (Shaikh, 2023)
Block-chain

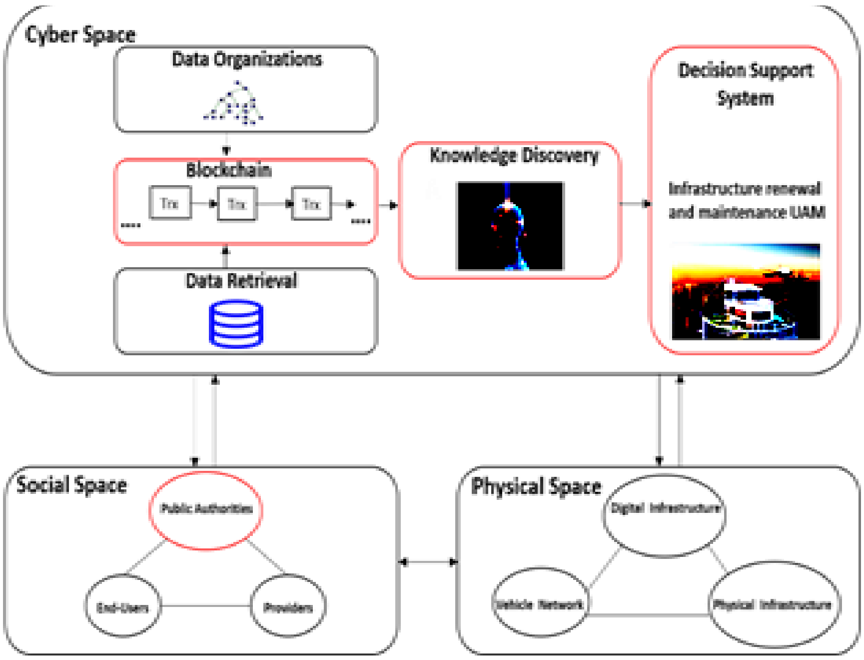

Figure 9.
Trustful Data-Driven CPSS Framework for UAM

However, the following components are part of cyberspace:

Data Organization Component:*Different physical and social space objects, such as Internet of Things (IoT) devices, vehicle networks, infrastructures, and various user types, such as governmental authorities, mobility providers, and customers, produce heterogeneous data. Ontologies must be used to organize and describe data meaningfully in this component (Alyavina et al, 2020).*

Data Retrieval Component:*This component solely retrieves run-time data from physical and social spaces.*

Block-chain Component:*Ensures the integrity of the transactional data comes from data organization and data retrieval components. Further, transfer that trusted data to the knowledge discovery component for the data analysis.*

Knowledge Discovery Component:*In the knowledge discovery component, we analyse trusted data from block-chain networks and convert insights into meaningful full knowledge for a decision support system, using different data analysing methods, i.e., Machine learning, etc.*

Decisions Support System Component:*DSS recommends and proposes different types of decision-based systems related to multi-dimensional urban mobility systems, for example, traffic prediction systems, parking systems, infrastructure renewal and maintenance, real-time simulation systems, etc.*

CONCLUSION

Due to the increasing rise in urbanization, this study has discussed the need for and transition of current urban mobility into urban air mobility and emphasized the pressures placed on governmental authorities to address related issues, such as transportation congestion, infrastructures, passenger safety, and environmental pollution. Studied existing urban mobility issues in literature and introduced an air mode as a third dimension mobility mode to propose a generic trustful data-driven CPSS framework for UAM to help public authorities in decision-making. We built the framework's general architecture and identified the methodological and technological approaches to implement it in this paper. In our upcoming work, we'll concentrate on the growth of each space and how to link them by controlling the data flows from various sources to applications for other user profiles, such as public authorities, service providers, and passengers (e.g., ticket reservation, trip planning, traffic prediction, infrastructure renewal and maintenance for UAM, etc.).

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the supervisors and their different affiliations.
Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant for his research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally to the creation of this work.
Conflicts of Interests: The authors declare no conflict of interest.
Consent to Participate: Not Applicable
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

REFERENCES

Abbasi, F. A., Karray, M. H., Houe, R., Memon, M. A., & Archimède, B. (2020). Towards a knowledge-driven framework of cyber-physical social system for multi-dimensional urban mobility. *Advances in Data Science and Adaptive Analysis*, *12*(03n04), 2041005.

Afrin, T. & Yodo, N. (2020), "A survey of road traffic congestion measures towards a sustainable and resilient transportation system," Sustainability, vol. 12, no. 11, pp. 4660.

Alrizq, M., Solangi, S. A., Alghamdi, A., Nizamani, M. A., Memon, M. A., & Hamdi, M. (2022). An Architecture Supporting Intelligent Mobile Healthcare Using Human Compute Interaction HCI Principles, *Comput. Syst. Sci. Eng.*, *40*(2), 557-569.

Alyavina, E., Nikitas, A. & Njoya E. T. (2020), "Mobility as a service and sustainable travel behaviour: A thematic analysis study," Transportation research part F: traffic psychology and behaviour, vol. 73, no. 1, pp. 362-381.

Baptista, P., Melo, S. & Rolim, C. (2014), "Energy, environmental and mobility impacts of car-sharing systems, empirical results from Lisbon, Portugal," Procedia-Social and Behavioral Sciences, vol. 111, no. 1, pp. 28-37.

Elangovan, D., Long, C. S., Bakrin, F. S., Tan, C. S., & Goh K. W. (2022), "The Use of Blockchain Technology in the Health Care Sector: Systematic Review," JMIR Medical Informatics, vol. 10, no. 1, pp. e17278.

Evans, J., O'Brien, J. & Ng, B. C.(2018), "Towards a geography of informal transport: Mobility, infrastructure and urban sustainability from the back of a motorbike," Transactions of the Institute of British Geographers, vol. 43, no. 4, pp. 674-688.

Ghaffarzadeh, S. A. M. (2015), "Decision making based on management information system and decision support system," Journal of Management Research and Analysis, vol. 2, no. 1, pp. 98-107.

Gunasekeran , D. V., Tseng, R. M. W. W., Tham, Y. C. & Wong, T. Y. (2021), "Applications of digital health for public health responses to COVID-19: a systematic scoping review of artificial intelligence, telehealth and related technologies," NPJ Digit Med, vol. 4, no. 1, pp. 40.

Hamid, S., & Davoud K. Z. (2019), "Road traffic injuries measures in the Eastern Mediterranean Region: findings from the Global Status Report on Road Safety–2015," Journal of Injury and Violence Research, vol. 11, no. 2, pp. 149.

Janjevic , M., Lebeau, P., Ndiaye, A. B., Macharis, C., & Mierlo, J. V. (2016)., "Strategic scenarios for sustainable urban distribution in the Brussels-capital region using urban consolidation centres," Transportation Research Procedia, vol. 12, no. 1, pp. 598-612.

Kalghatgi , G. (2019), "Development of fuel/engine systems—the way forward to sustainable transport," Engineering, vol. 5, no. 3, pp. 510-518.

Karim, R., Westerberg, J., Galar, D. & Kumar, U. (2016), "Maintenance analytics–the new know in maintenance," IFAC-PapersOnLine, vol. 49, no. 28, pp. 214-219.

Kuo, T. T., Kim, H. E. & Machado, L. O. (2017), "Block-chain distributed ledger technologies for biomedical and health care applications," Journal of the American Medical Informatics Association, vol. 24, no. 1, pp. 1211-1220.

Linder N., Giusti, M., Samuelsson K. & Barthel, S. (2022), "Pro-environmental habits: an underexplored research agenda in sustainability science," Ambio, vol. 51, no. 3, pp. 546-556.

Liu, Y., Peng, Y., Wang, B., Yao, S. & Liu, Z. (2017), "Review on cyber-physical systems," IEEE/CAA Journal of Automatica Sinica, vol. 4, no. 1, pp. 27-40.

Memon, M. A., Karray, M. H., Letouzey, A., & Archimède, B. (2017). Semantic transportation planning for food products supply chain ecosystem within difficult geographic zones. Industrial Management & Data Systems.

Memon, M. A., Shaikh, A., Sulaiman, A., Alghamdi, A., Alrizq, M., & Archimède, B. (2021). Time and quantity based hybrid consolidation algorithms for reduced cost products delivery. *Computers, Materials and Continua*, pp 409-432.

Nieuwenhuijsen, M. J. (2020), "Urban and transport planning pathways to carbon neutral, liveable and healthy cities; A review of the current evidence," Environment International, vol. 140, no. 1, pp. 105661.

Nijland H. & Meerkerk, J. V. (2017), "Mobility and environmental impacts of car sharing in the Netherlands," Environmental Innovation and Societal Transitions, vol. 23, no. 1, pp. 84-91.

Nikitas, A., Njoya, E. T. & Dani, S. (2019), "Examining the myths of connected and autonomous vehicles: analysing the pathway to a driverless mobility paradigm," International Journal of Automotive Technology and Management, vol. 19, no. 1-2, pp. 10-30.

Otte, T., Metzner, N., Lipp, J., Schwienhorst, M. S., & Solvay A. F. (2018), "User-centered integration of automated air mobility into urban transportation networks," in Proceedings 2018 IEEE/AIAA 37th Digital Avionics Systems Conference (DASC), England, UK, pp. 1-10.

Shaikh, Z. A., Memon, A. A., Shaikh, A. M., Soomro, S., & Sayed, M. (2023). BLOCKCHAIN IN HEALTHCARE: UNLOCKING THE POTENTIAL OF BLOCKCHAIN FOR SECURE AND EFFICIENT APPLICATIONS FOR MEDICAL DATA MANAGEMENT-A PRESENTATION OF BASIC CONCEPTS. LIAQUAT MEDICAL RESEARCH JOURNAL, 5(2).

Sharmam A., Adhikary, A. & Borah, S. B. (2020), "Covid-19's impact on supply chain decisions: strategic insights from NASDAQ 100 firms using twitter data," Journal of Business Research, vol. 117, no. 1, pp. 443-449.

Silva, B. N., Khan, M. & Han, K. (2018), "Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities," Sustainable Cities and Society, vol. 38, no. 1, pp. 697-713.

Smarsly, K., Theiler, M. & Dragos, K. 2017, "IFC-based modeling of cyber-physical systems in civil engineering," in Proceedings of the 24th International Workshop on Intelligent Computing in Engineering (EG-ICE), Nottingham, UK, vol. 7, no. 10, pp..

Straubinger , A., Rothfeld, R., Shamiyeh, M., Büchter, K. D. & Kaiser, J. (2020), "An overview of current research and developments in urban air mobility–Setting the scene for UAM introduction," Journal of Air Transport Management, vol. 87, no. 1, pp. 101852.

Tapscott A. & Tapscott, D. (2017), "How block-chain is changing finance," Harvard Business Review, vol. 1, no. 9, pp. 2-5.

Tariq, N., Qamar, A., Asim, M. & Khan, F. A. (2020), "Block-chain and smart healthcare security: a survey," Procedia Computer Science, vol. 175, no. 1, pp. 615-620.

Thipphavong, D. P., Apaza, R., Barmore, B., Battiste, V., & Burian B. (2018), "Urban air mobility airspace integration concepts and considerations," in Proceedings 2018 Aviation Technology, Integration, and Operations Conference, Atlanta, Georgia, pp. 3676.

Ting, D. S. W., Lin, H., Ruamviboonsuk, P., Wong, T. Y. & Sim, D. A. (2020), "Artificial intelligence, the internet of things, and virtual clinics: ophthalmology at the digital translation forefront," Lancet Digit Health, vol. 2, no. 1, pp. e8-e9.

Trivedi, A., Jakhar, S. K. & Sinha, D. (2021), "Analyzing barriers to inland waterways as a sustainable transportation mode in India: a dematel-ISM based approach," Journal of Cleaner Production, vol. 295, no. 1, pp. 126301.
Utriainen, R. & Pöllänen, M. (2018), "Review on mobility as a service in scientific publications," Research in Transportation Business & Management, vol. 27, no. 1, pp. 15-23.
Whitelaw, S., Mamas, M. A., Topol, E. & Spall, H. V. (2020), "Applications of digital technology in COVID-19 pandemic planning and response," Lancet Digit Health, vol. 2, no. 1, pp. e435-e440.
Zheng, P., Lin, T. J., Chen, C. H. & Xu, X. (2018), "A systematic design approach for service innovation of smart product-service systems," Journal of cleaner production, vol. 201, no. 1, pp. 657-667.