IoT in Smart-City Auckland – Developing an Urban IoT Diffusion Framework

Kamal Dhawan[1], Maryam Mirzaei[2] and Kanat Sultanbekov[1]

1. School of Future Environments, Auckland University of Technology, Auckland, New Zealand
2. Business School, Auckland University of Technology, Tāmaki Makaurau Auckland, Aotearoa New Zealand

Corresponding author:
Kamal Dhawan, kamal.dhawan@aut.ac.nz

https://doi.org/10.34074/proc.250119

IoT in Smart-City Auckland – Developing an Urban IoT Diffusion Framework by Kamal Dhawan, Maryam Mirzaei and Kanat Sultanbekov is licensed under a Creative Commons Attribution-NonCommercial 4.0 International licence.

This publication may be cited as:

Dhawan, K., Mirzaei, M., & Sultanbekov, K. (2025). IoT in Smart-City Auckland – Developing an Urban IoT Diffusion Framework. In S. Varastehpour & M. Shakiba (Eds.), *Proceedings: AIOT Global Summit 2025: Economic Growth, 15–16 July* (pp. 106–113). ePress, Unitec. https://doi.org/10.34074/proc.250119

Contact:
epress@unitec.ac.nz
www.unitec.ac.nz/epress/
Unitec
Private Bag 92025, Victoria Street West Tāmaki Makaurau
Auckland 1142 Aotearoa New Zealand

ISBN: 978-1-99-118345-3

ABSTRACT

Smart cities integrate technology, sustainability and governance to address urbanisation challenges, employing IoT for real-time monitoring and efficiency. This study explores IoT adoption in Tāmaki Makaurau Auckland, examining benefits, challenges and diffusion patterns across transport, utilities and environmental sectors. Using Rogers' diffusion of innovations (DoI) framework, it analyses adoption drivers – relative advantage, compatibility, complexity, trialability and observability – through qualitative methods, including literature reviews, open-data analysis and stakeholder interviews. Findings aim to develop an urban IoT diffusion framework, offering insights for scalable, sustainable, smart city strategies. Tāmaki Makaurau initiatives, such as smart traffic systems and water management, highlight IoT's role in enhancing liveability, resource efficiency and economic growth, positioning it as a model for urban innovation.

INTRODUCTION

The smart-city paradigm: A multidimensional approach to urban development

Smart cities apply technology to urban challenges, advancing sustainability through integrated systems and inclusive governance (Fialová et al., 2021; Nam & Pardo, 2011). Informed by technological, human-centric and institutional theories (Anthopoulos & Fitsilis, 2010), the concept encompasses six dimensions: economic development, citizen engagement, governance, transport, ecology and quality of life (Estevez et al., 2016; Giffinger et al., 2007), while retaining interpretive flexibility (Albino et al., 2012). Implementation draws on collaborative models such as the triple and quadruple helix to align policy, innovation and stakeholder participation (Etzkowitz & Leydesdorff, 2000; Giffinger & Gudrun, 2010).

IoT adoption in Tāmaki Makaurau Auckland, Aotearoa New Zealand

Tāmaki Makaurau is deploying IoT technologies to address urban challenges and advance sustainability, efficiency and liveability. In collaboration with tech partners, IoT is integrated into transport, water, infrastructure and construction systems. Smart traffic signals and the AT Mobile app enhance transit efficiency (Auckland Transport, 2021; Bennett, 2025), while Watercare's smart meters support leak detection, resulting in water savings of up to NZ$28 million over a decade (Sustainability Matters, 2023; Watercare, 2023). In Wynyard Quarter, IoT facilitates smart parking, adaptive lighting and waste management (SparkNZ, n.d.c). Construction firms apply IoT for environmental monitoring and compliance (SparkNZ, n.d.a, n.d.b). These efforts reflect Tāmaki Makaurau's integrated IoT strategy for sustainable urban development.

BACKGROUND AND AIMS

Background

Connectivity, IoT and smart cities

Smart cities have transitioned from 1990s digital infrastructure to today's integrated sustainable urban systems (Anthopoulos, 2017). By synergising technology, community and ecology (Hurtado et al., 2021), they employ information and communication technology (ICT)-driven data analytics (Law & Lynch, 2019) through M2M networks and IoT frameworks for intelligent monitoring and control (Dobrilović, 2018).

IoT systems use sensors, actuators and cameras to transmit urban data via internet protocols, requiring interoperable frameworks, reliable power and high-speed connectivity (Grace et al., 2016; Jo et al., 2019; Rafiq et al., 2023). Secure deployment depends on strong privacy protections (Noor & Hassan, 2019), while scalability enables integration of varied devices (Zyrianoff et al., 2018). Unlike traditional systems, IoT facilitates intelligent machine–human interaction through full-stack architectures combining hardware, software and cloud analytics (Kranz, 2018; Woetzel et al., 2018). In smart cities, edge and cloud processing enable real-time monitoring of traffic, energy and safety, offering data-driven insights to improve efficiency and address urban challenges (Zaman et al., 2024).

IoT, as an advanced automation technology, supports smart cities by enhancing quality of life and enabling sustainable urban development. It improves efficiency in sectors such as commerce, transport, healthcare and tourism through optimised resource use, enhanced human–object interaction (Huang, 2020) and increased data accessibility (Brous et al., 2020). IoT also reduces emissions, energy use and infrastructure strain (Abbate et al., 2019; Bibri, 2018). Integration with cloud, fog and edge computing is vital for sustainability (Rejeb et al., 2022), while big data enables efficient processing and informed decision-making (Ge et al., 2018). Big-data analytics extract insights from IoT data to improve planning, resource use and real-time urban management (Bibri, 2019; Nie et al., 2020; Shah et al., 2019).

Cognitive cities: The next step

A systemic urban approach integrates sustainability, resilience and adaptive learning. Systems theory views cities as socio-technical systems shaped by evolving technologies, institutions and practices (Kaufmann & Portmann, 2015). While smart cities employ sensor networks for data-driven services (Mohammadi & Al-Fuqaha, 2018), traditional models often neglect complex agent interactions and ICT's role in collective learning (Finger & Portmann, 2016; Malone & Bernstein, 2015). Cognitive cities enhance this by integrating AI, IoT and machine learning to enable responsive systems and improved decision-making (Galal et al., 2023), fostering resilience through human–machine collaboration in adaptive, information-centric communities (Helbing, 2015; Mostashari et al., 2011).

Aims and research questions

The aim of this study is to develop an urban IoT diffusion framework through the context of implementation in Tāmaki Makaurau, by answering the following research questions:

- **RQ1.** What benefits and challenges are reported from current IoT deployments?
- **RQ2.** How do existing dashboards and open-data streams portray adoption rates across transport, environment and utilities?
- **RQ3.** Which diffusion-of-innovations attributes – relative advantage, compatibility, complexity, trialability, observability – most strongly shape those rates and how?

METHODOLOGY

Theoretical framework

Recent research reveals uneven digital-technology adoption in the public sector. A 2019 review of 59 studies showing rapid AI uptake in public services, economic affairs and environmental protection, but noted gaps in understanding adoption disparities (Sousa & Rocha, 2019). The diffusion of innovations (DoI) framework explains this as a socio-technical process influenced by stakeholder perceptions (Rogers et al., 2014). Smart city IoT studies corroborate DoI's applicability to municipal sensor networks (Leroux & Pupion, 2022). This study employs semi-structured interviews with Auckland Transport, Auckland Council and IoT providers, plus open data analysis, to examine IoT adoption patterns. Preliminary findings will be shared in a poster presentation.

RESEARCH DESIGN

This study adopts a sequential, multi-phase design, moving from smart-city analysis to a validated urban IoT diffusion model. The first phase integrates a literature review (Torraco, 2005; Webster & Watson, 2002) with qualitative analysis of open data from five global cities – Tāmaki Makaurau, Vancouver, Melbourne, Los Angeles and Tokyo – to develop a provisional Smart City Adoption Model, highlighting key technological, governance and socio-cultural factors (Creswell & Poth, 2016).

A systematic review is underway, using Rogers' DoI attributes (Rogers et al., 2014) to refine search terms and code literature (2015–25). Findings will inform a provisional IoT-diffusion adoption model, further validated through semi-structured interviews with approximately 20 senior practitioners. Transcripts will undergo thematic analysis in NVivo, with triple coding to ensure inter-coder reliability (Clarke & Braun, 2017). Rigour will be ensured through triangulation, audit trails, member checking and contextual transparency (Guba & Lincoln, 1994), producing a robust validated framework for IoT diffusion in urban contexts.

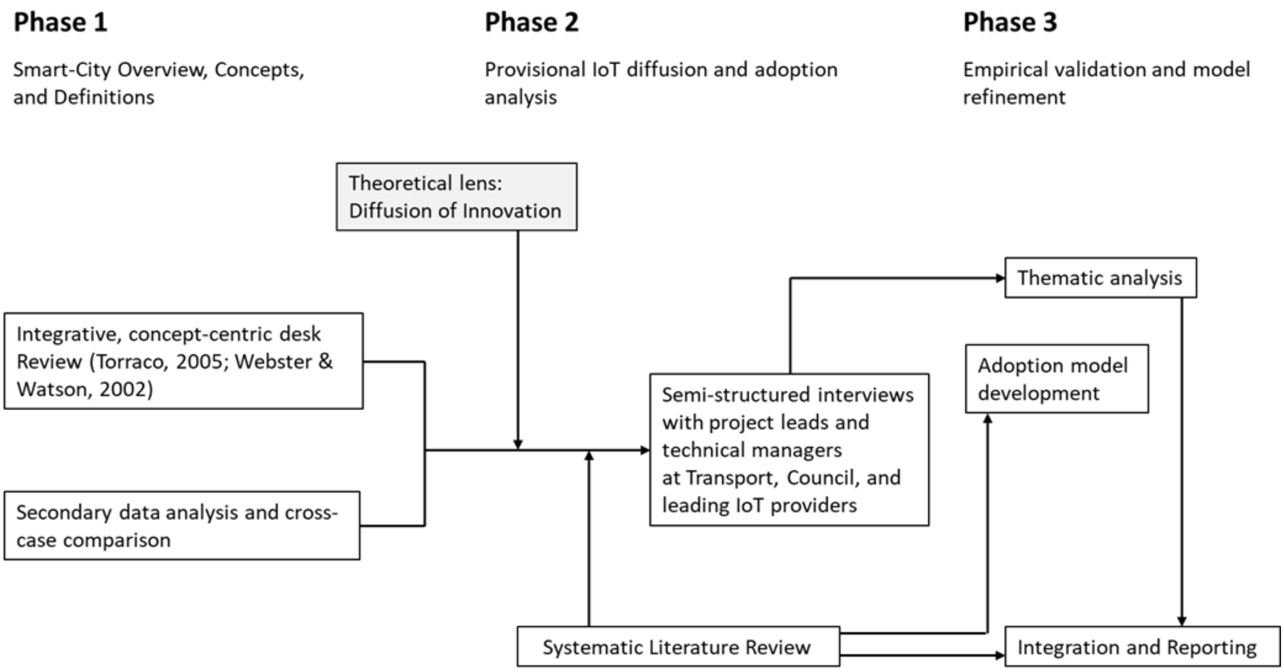

Figure 1. Research design.

Given the early stage of technology adoption, a standard ten-year typical 'S' curve diffusion is assumed, with 5% uptake in year one and peak growth between years five and six .

CONCLUSION AND IMPACT

Tāmaki Makaurau's smart-city programme targets six core outcomes: enhanced data-driven decision-making, strong data governance, resilient and cost-efficient infrastructure, attraction of global tech talent, improved international standing, and economic growth through sensor-based innovation (Scally-Irvine & Louisson, 2016). The strategy centres on advancing smart technologies, fostering local expertise and promoting collaboration to position Aotearoa New Zealand as a global innovation leader.

This study examines IoT implementation in Tāmaki Makaurau to develop a diffusion framework suited to Aotearoa's dispersed population, rural–urban dynamics and market context. Expanding on European and North American models, it prioritises localised connectivity, data sovereignty, agritech, resilience, sustainability and Māori engagement. Effective policy must embed privacy and security, support innovation, and address environmental impacts through clear guidelines and integrated design (Muller et al., 2017).

REFERENCES

Abbate, T., Cesaroni, F., Cinici, M. C., & Villari, M. (2019). Business models for developing smart cities. A fuzzy set qualitative comparative analysis of an IoT platform. *Technological Forecasting and Social Change*, *142*, 183-193. https://doi.org/10.1016/j.techfore.2018.07.031

Albino, V., Berardi, U., & Dangelico, R. M. (2012). Smart cities: Definitions, dimensions, and performance. *Journal Of Urban Technology*, *1*(22), 1723-1738. https://doi.org/10.1080/10630732.2014.942092

Anthopoulos, L., & Fitsilis, P. (2010). From digital to ubiquitous cities: Defining a common architecture for urban development. 2010 Sixth International Conference on Intelligent Environments, Kuala Lumpur, Malaysia. *IEEE Xplore*. https://doi.org/10.1109/IE.2010.61

Anthopoulos, L. G. (2017). Governing a smart city. In *Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick?* (pp. 215-262). Springer. https://doi.org/10.1007/978-3-319-57015-0

Auckland Transport. (2021). *AT projects finalists in Smart City Awards*. https://at.govt.nz/about-us/news-events/at-projects-finalists-in-smart-city-awards/

Bennett, B. (2025). Auckland's smart traffic signs cut congestion, promote public transport use. *New Zealand Herald*. https://www.nzherald.co.nz/business/business-reports/project-auckland/aucklands-smart-traffic-signs-cut-congestion-promote-public-transport-use/DMPF4XQ32BF2VJZ4DXA3NLU5BI/

Bibri, S. E. (2018). The IoT for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability. *Sustainable cities and society*, *38*, 230-253. https://doi.org/10.1016/j.scs.2017.12.034

Bibri, S. E. (2019). On the sustainability of smart and smarter cities in the era of big data: an interdisciplinary and transdisciplinary literature review. *Journal of Big Data*, *6*(1), 25. https://doi.org/10.1186/s40537-019-0182-7

Brous, P., Janssen, M., & Herder, P. (2020). The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations. *International journal of information management*, *51*, 101952. https://doi.org/10.1016/j.ijinfomgt.2019.05.008

Clarke, V., & Braun, V. (2017). Thematic analysis. In C. Willig & W. S. Rogers (Eds.), *Encyclopedia of quality of life and well-being research* (pp. 6626-6628). Springer.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications.

Dobrilović, D. (2018). Networking technologies for smart cities: An overview. *Interdisciplinary Description of Complex Systems: INDECS*, *16*(3-A), 408-416. https://doi.org/10.7906/indecs.16.3.13

Estevez, E., Lopes, N., & Janowski, T. (2016). *Smart sustainable cities: Reconnaissance study*. United Nations University. https://collections.unu.edu/eserv/UNU:5825/Smart_Sustainable_Cities_v2final.pdf

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From national systems and "Mode 2" to a triple helix of university–industry–government relations. *Research policy*, *29*(2), 109-123. https://doi.org/10.1016/S0048-7333(99)00055-4

Fialová, J., Bamwesigye, D., Łukaszkiewicz, J., & Fortuna-Antoszkiewicz, B. (2021). Smart cities landscape and urban planning for sustainability in Brno City. *Land*, *10*(8), 870. https://doi.org/10.3390/land10080870

Finger, M., & Portmann, E. (2016). What are cognitive cities? In E. Portmann & M. Finger (Eds.), *Towards Cognitive Cities: Advances in Cognitive Computing and its Application to the Governance of Large Urban Systems* (pp. 1-11). https://doi.org/10.1007/978-3-319-33798-2_1

Galal, H., Chowdhary, R., Vessali, K., Paul, V., Jaisinghania, G., & Kabbara, M. (2023). *Cognitive cities: A journey to intelligent urbanism*. PricewaterhouseCoopers. https://www.pwc.com/m1/en/publications/documents/cognitive-cities-a-journey-to-intelligent-urbanism.pdf

Ge, M., Bangui, H., & Buhnova, B. (2018). Big data for internet of things: A survey. *Future Generation Computer Systems*, *87*, 601-614. https://doi.org/10.1016/j.future.2018.04.053

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. J. (2007). *Smart cities. Ranking of European medium-sized cities. Final report*. Vienna University of Technology. https://repositum.tuwien.at/bitstream/20.500.12708/153435/1/Giffinger-2007-Smart%20cities.%20Ranking%20of%20European%20medium-sized%20cities.%20Fin...-vor.pdf

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: An effective instrument for the positioning of the cities? *ACE: architecture, city and environment*, *4*(12), 7-26. https://www.researchgate.net/profile/Rudolf-Giffinger/publication/228915976_Smart_cities_ranking_An_effective_instrument_for_the_positioning_of_the_cities/links/02e7e5253ccb0ea795000000/Smart-cities-ranking-An-effective-instrument-for-the-positioning-of-the-cities.pdf

Grace, P., Pickering, B., & Surridge, M. (2016). Model-driven interoperability: engineering heterogeneous IoT systems. *Annals of telecommunications*, *71*, 141-150. https://doi.org/10.1007/s12243-015-0487-2

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (Vol. 2, pp. 105). Sage Publications.

Helbing, D. (2015). *Thinking ahead: Essays on big data, digital revolution, and participatory market society*. Springer.

Huang, X. (2020). Multi-node topology location model of smart city based on Internet of Things. *Computer Communications*, *152*, 282-295. https://doi.org/10.1016/j.comcom.2020.01.052

Hurtado, P., Hitchings, B. G., & Rouse, D. C. (2021). *Smart cities: Integrating technology, community, and nature*. American Planning Association.

Jo, J., Joo, I.-H., & Lee, K.-W. (2019). Constructing national geospatial big data platform: Current status and future direction. 2019 IEEE 5th World Forum on Internet of Things (WF-IoT), Limerick, Ireland.

Kaufmann, M., & Portmann, E. (2015). Biomimetics in design-oriented information systems research. In B. Donnellan, R. Gleasure, M. Helfert, J. Kenneally, M. Rothenberger, M. Chiarini Tremblay, D. VanderMeer, & R. Winter (Eds.), *At the Vanguard of Design Science: First Impressions and Early Findings from Ongoing Research* (pp. 53–60). https://cora.ucc.ie/server/api/core/bitstreams/42dd0940-bdd1-4b52-b74c-eb1c1645a6a8/content

Kranz, M. (2018). *6 ways the Internet of Things is improving our lives*. World Economic Forum. https://www.weforum.org/stories/2018/01/6-ways-the-internet-of-things-is-improving-our-lives/

Law, K. H., & Lynch, J. P. (2019). Smart city: Technologies and challenges. *It Professional*, *21*(6), 46-51. https://doi.org/10.1109/MITP.2019.2935405

Leroux, E., & Pupion, P.-C. (2022). Smart territories and IoT adoption by local authorities: A question of trust, efficiency, and relationship with the citizen-user-taxpayer. *Technological Forecasting and Social Change*, *174*, 121195. https://doi.org/10.1016/j.techfore.2021.121195

Malone, T. W., & Bernstein, M. (2015). *Handbook of collective intelligence*. MIT Press.

Mohammadi, M., & Al-Fuqaha, A. (2018). Enabling cognitive smart cities using big data and machine learning: Approaches and challenges. *IEEE Communications Magazine*, *56*(2), 94-101. https://doi.org/10.1109/MCOM.2018.1700298

Mostashari, A., Arnold, F., Mansouri, M., & Finger, M. (2011). Cognitive cities and intelligent urban governance. *Network Industries Quarterly*, *13*(3), 4-7.

Muller, G., Collier, M., Wise, P., Minogue, S., Turner, V., Wright, A., MacGillivray, C., schiff, A., Glass, H., Laws, S., & Young, C. (2017). *Accelerating a connected New Zealand*. NZ IoT Alliance. https://iotalliance.org.nz/wp-content/uploads/sites/4/2018/09/Accelerating-a-Connected-New-Zealand-eBOOK.pdf

Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. *Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times* (pp. 282–291). ACM. https://doi.org/10.1145/2037556.2037602

Nie, X., Fan, T., Wang, B., Li, Z., Shankar, A., & Manickam, A. (2020). Big data analytics and IoT in operation safety management in under water management. *Computer Communications*, *154*, 188-196. https://doi.org/10.1016/j.comcom.2020.02.052

Noor, M., & Hassan, W. H. (2019). Current research on Internet of Things (IoT) security: A survey. *Computer Networks*, *148*, 283-294. https://doi.org/10.1016/j.comnet.2018.11.025

Rafiq, I., Mahmood, A., Razzaq, S., Jafri, S. H. M., & Aziz, I. (2023). IoT applications and challenges in smart cities and services. *The Journal of Engineering*, *2023*(4), e12262. https://doi.org/10.1049/tje2.12262

Rejeb, A., Rejeb, K., Simske, S., Treiblmaier, H., & Zailani, S. (2022). The big picture on the internet of things and the smart city: a review of what we know and what we need to know. *Internet of Things*, *19*, 100565. https://doi.org/10.1016/j.iot.2022.100565

Rogers, E. M., Singhal, A., & Quinlan, M. M. (2014). Diffusion of innovations. In D. W. Stacks, M. B. Salwen & K. C. Eichorn (Eds.), *An integrated approach to communication theory and research* (pp. 432-448). Routledge.

Scally-Irvine, K., & Louisson, O. (2016). *Evaluation of the Smart Cities Programme 2015-2016 - Final Report December 2016*. L. I. N. Zealand. https://www.linz.govt.nz/sites/default/files/sdp_smart-cities_report_20170322.pdf

Shah, S. A., Seker, D. Z., Rathore, M. M., Hameed, S., Yahia, S. B., & Draheim, D. (2019). Towards disaster resilient smart cities: Can internet of things and big data analytics be the game changers? *IEEe Access*, *7*, 91885-91903. https://doi.org/10.1109/ACCESS.2019.2928233

Sousa, M. J., & Rocha, Á. (2019). Digital learning: Developing skills for digital transformation of organizations. *Future Generation Computer Systems*, *91*, 327-334. https://doi.org/10.1016/j.future.2018.08.048

Spark NZ. (n.d.a). *Dempsey Wood customer story*. https://www.spark.co.nz/online/large-business-govt/why-choose-spark/customer-stories/dempsey-wood

SparkNZ. (n.d.b). *Smart benches customer story*. https://www.spark.co.nz/online/large-business-govt/why-choose-spark/customer-stories/innovation-precinct/smart-benches

SparkNZ. (n.d.c). *Smart parking customer story*. https://www.spark.co.nz/online/large-business-govt/why-choose-spark/customer-stories/innovation-precinct/smart-parking

Sustainability Matters. (2023). *Smart water meters rolled out across Auckland*. https://www.sustainabilitymatters.net.au/content/water/case-study/smart-water-meters-rolled-out-across-auckland-279899978

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples. *Human resource development review*, *4*(3), 356-367. https://doi.org/10.1177/1534484305278283

Watercare. (2023). *Rolling out a digital water meter solution to better service commercial properties*. https://www.watercare.co.nz/home/about-us/latest-news-and-media/rolling-out-a-digital-water-meter-solution-to-better-service-commercial-properties

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS quarterly*, xiii-xxiii. https://www.jstor.org/stable/4132319

Woetzel, J., Remes, J., Boland, B., Lv, K., Sinha, S., Strube, G., Means, J., Law, J., Cadena, A., & von der Tann, V. (2018). *Smart cities: Digital solutions for a more livable future*. McKinsey & Company. https://www.mckinsey.com/capabilities/operations/our-insights/smart-cities-digital-solutions-for-a-more-livable-future

Zaman, M., Puryear, N., Abdelwahed, S., & Zohrabi, N. (2024). A review of IoT-based smart city development and management. *Smart Cities*, *7*(3), 1462-1501. https://doi.org/10.3390/smartcities7030061

Zyrianoff, I., Borelli, F., Biondi, G., Heideker, A., & Kamienski, C. (2018). Scalability of real-time Iot-based applications for smart cities. *2018 IEEE Symposium on Computers and Communications (ISCC)*. IEEE. https://doi.org/10.1109/ISCC.2018.8538451