SMART CITY AND IIoT IMPLICATIONS

WHITE PAPER

CONTENT

Introduction to Smart Cities

Over the last few decades, there has been a paradigm shift instigated by technological advancements, which is a phenomenon that has influenced globalization trends. Accordingly, with the growing integration of technology worldwide, the concept of smart cities h-as gained prominence. The spectacle of a smart city is best described as a multidisciplinary concept that integrates urbanization, technology, and innovation in a global growth context (Zawislak et al., 2017). Zawislak et al. (2017) postulated that such cities are essential, ideal urban development models that allow the transformation and adaptation o-f urban environments to evolve with contemporary trends of sustainable socioeconomic and environmental growth. Alternatively, it is the application of ICT to sense, analyze an--d incorporate the essential data of core systems in the management of cities (Harmon et al., 2015).

In addition, the smart city concept entails attracting and retaining innovative people and leveraging their skills and expertise to influence urban fabric changes (Manisha et al., 2021). Therefore, a smart city can be considered an urban fabric that holistically integrates technology into its associative functions from a multidimensional perspective, incorporating the entire urban fabric, including its constituents.

Concurrently, understanding smart city development requires acknowledging

the technological and historical transition be-ginning with the water and steam-powered machines, advancing to the

development of electricity in the 20th century, and ultimately the conception of computers in the latter years of the 20th century (Sathyabama IST, n.d.).

Subsequently, the concept has evolved, supported by the dynamic advancements of technology as the industrial revolution transitions into Industry 4.0 root-ed in Industry Internet of Things (IIoT) which forms the basis of the report.

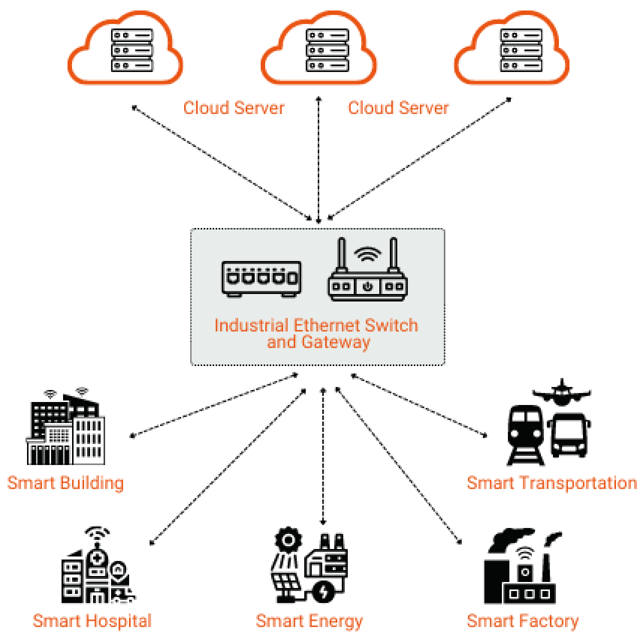

Figure 1: Smart City Conceptual Image

The Necessity for Smart City Development

Concurrently, the subject of urbanization has been a prevailing challenge in the world as the rates of urban expansion proliferate. The concept has been the subject of research over the last few decades as its impact on the world's sustainability was criticized. Arguably, the global urbanization rates have been a cause for caution as the United Nations documented that the world urban population was rapidly increasing to over 55% of the total global population (UN-Habitat, 2020). Existentially, the projected trends highlight its significance as estimates indicate that by 2050 the urban areas of the world will accommodate over 70% of the global population (Syed et al., 2021). These magnitudes of people-e pose a risk to sustainability due to urban expansion trends and their impacts on the environment. Moreover, the effects of urbanization are magnified by the conception of climate change tied to expansion.

Developed industries contributed to climate change by emitting harmful gases into the atmosphere. Moreover, human activity has increased the dilapidation of urban environments through the increased application of machinery that harms the environmental sphere (Axon, 2010). The challenges sparked a radical intervention from the conceptualization of sustainability and associated with the United Nations Sustainable Developments Goals of 2030 (SDGs) (Syed et al., 2021). The concept has progressively instigated a transition to enhance anthropogenic activities in reducing the impacts on environmental spheres. Thus, this report reiterates the significance of adaptation and change to smart cities and the innovative application of technology to alleviate such effects of human activity.

Therefore, the demand for sustainable urban environments and mitigation of anthropogenic effects influences technology integration in urban management. Applying technology and innovation in urban spheres generates radicalized ideas and concepts rooted in innovative technology. Technology in recent years has expanded into machine automation of urban processes and services, resulting in the modernization of multiple sectors influencing city stakeholders (Bellini et al., 2021). Combining such features with sustainability models and principles has led to adapting cities and urban areas to changing times o-f high demand for goods and services. As such, contemporary practice has leveraged the application of technology to alleviate urban challenges such as impacts and encourage sustainable development. As such, the smart city concept has become the epitome of urban management and planning approaches that integrate technology, advancing into artificial intelligence.

Industrial Internet of Things and Smart City

Distinguishing IoT and IIoT

Applying IoT to industrial automation processes has been embraced internationally in recent years. Accordingly, the resultant outcome has been the development of the industrial internet of things, which has grown substantially. It has been adopted to support the trend toward innovative transitions of economic processes as governments and organizations seek to enhance the quality of life and promote value addition (Zawislak et al., 2017). In addition, Mirani et al. (2022) argued that the changes in the application have been characterized by the evolution of industrial function that has caused the adoption of industry 4.0, which is marked as the next industrial revolution. As such, there is a distinction between IoT and IIoT, as the former is known to have preceded the latter, allowing the evolution of the international industrial field (Karmakar et al., 2019).

Accordingly, Manisha et al. (2021) postulate that the systems were developed to support increased commercial sector efficiency, boosting manufacturing and Blockchain supply profitability. However, the progressive advantages tied to its application were acknowledged to serve the criteria of sustainable growth systems. Moreso, the application of intelligent devices reiterated the proliferating trend of smart technology and, concurrently, smart cities. Manisha et al. (2021) presented that the public good offered by the IIoT stimulated a new framework for economic data gathering, public utility technology, and decision-making. Hence, IIoT has significantly been integrated into global networks radicalizing the process of urban adaptation and considered an enhanced application of IoT to the industrial revolution. Mirani et al. (2022) consider its intricate features to offer substantive application of intelligent analytics, remote sensing, and control of industrial function. It transforms the industrial process into optimal operational efficiency, especially when integrated with information technology and CPS.

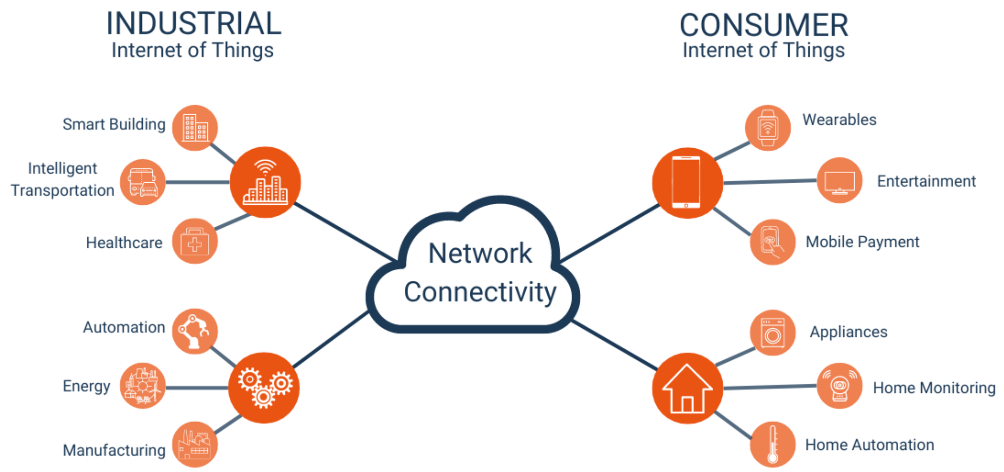

Figure 2:Distinguishing IoT and IIoT

IIoT Architecture and Infrastructure

IIoT systems possess a grouping of components that form a framework for the operationalization deemed the infrastructure or architecture of IIoT (Karmakar et al., 2019). The infrastructure network includes the devices and the industrial control system representing the software and hardware combination that facilitate control of vital infrastructures such as SCADA, PLCs, RTUs, IEDs, HMI, and control servers (Karmakar et al., 2019). Moreover, devices are also intricate components that include the sensors, translators, or interpreters that communicate with the ICS of an industrial system allowing machine-machine, human-machine, and human-machine interaction. Further, Karmakar et al. (2019) indicated that the transient stores are adopted as slave components that store data, securing the data in the transient form and temporarily reassuring the systems' durability. Applications were also marked as essential features allowing real-time feedback for staff to regulate devices and their interactions to process and manipulate data, detect problems and decide on the most effective action. Thereafter, the processors and channels allow data transfer into collectors and processors (Karmakar et al., 2019). Such systems handle big data volumes that may require longtime storage and are concurrently secure. These features support the adaptability of intelligent systems to changes in network frameworks and data sources.

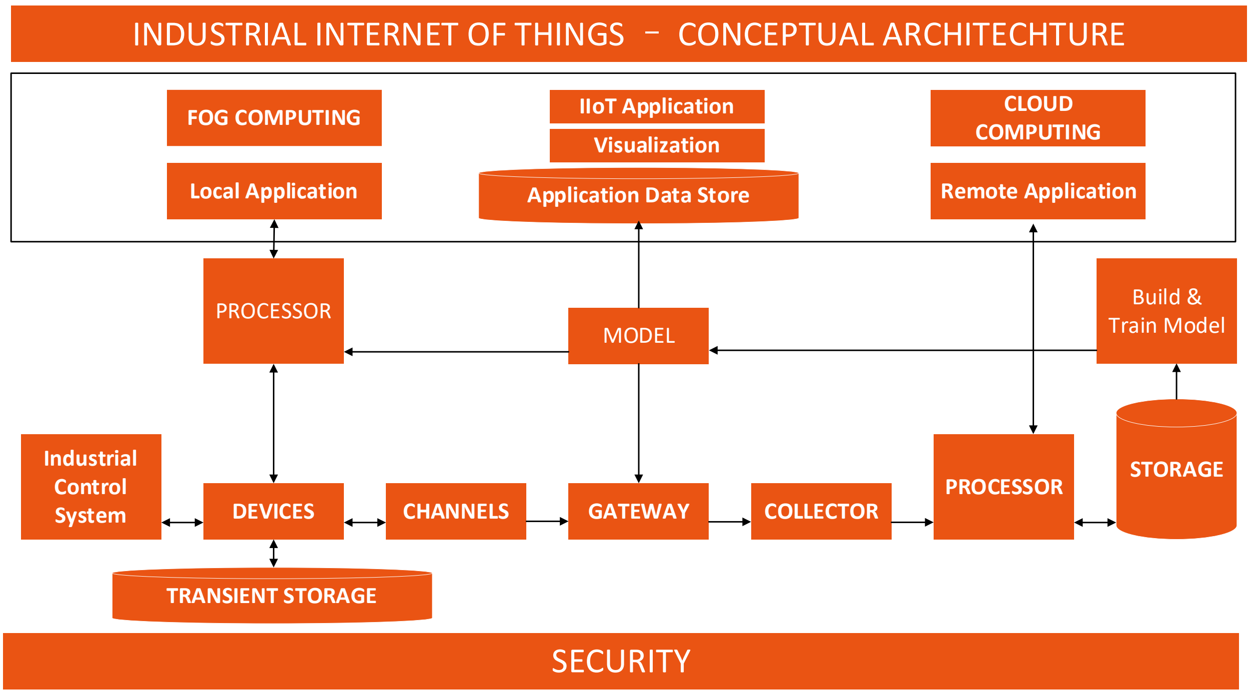

Figure 3: IIoT Conceptual Architecture

Smart City Solutions and Applications

Significantly, smart city has influenced a change in urban management, presenting a shift in infrastructure and service provision to sustain the ever-growing population. Smart city development is applied to enhance the efficacy of resource exploitation, optimizing the capacity of urban consumption (Goundar et al., 2021). This implies the global impact urban activities have on the environment, such as global warming that develop-s urban heat islands. Artificial intelligence is the contemporary achievement of techno-logical advancements instigating the transition as smart cities integrate big data and IoT components as the fundamental elements (Tiwari, 2016).

As presented in figure 4 below, the integration of ICT in urban management is integral to smart city domains that leverage interconnectedness through the internet. The combination supports the application of automated services in multiple fields, enhancing the concept of automation and machine learning, and decision-making processes. Tiwari (2016) presents its application in home management systems, automated industrial process management, intelligent traffic management, smart grids, energy management, and medical disciplines such as geriatric care. Thus, smart cities offer a multidisciplinary application resulting in improved service delivery for the urban population.

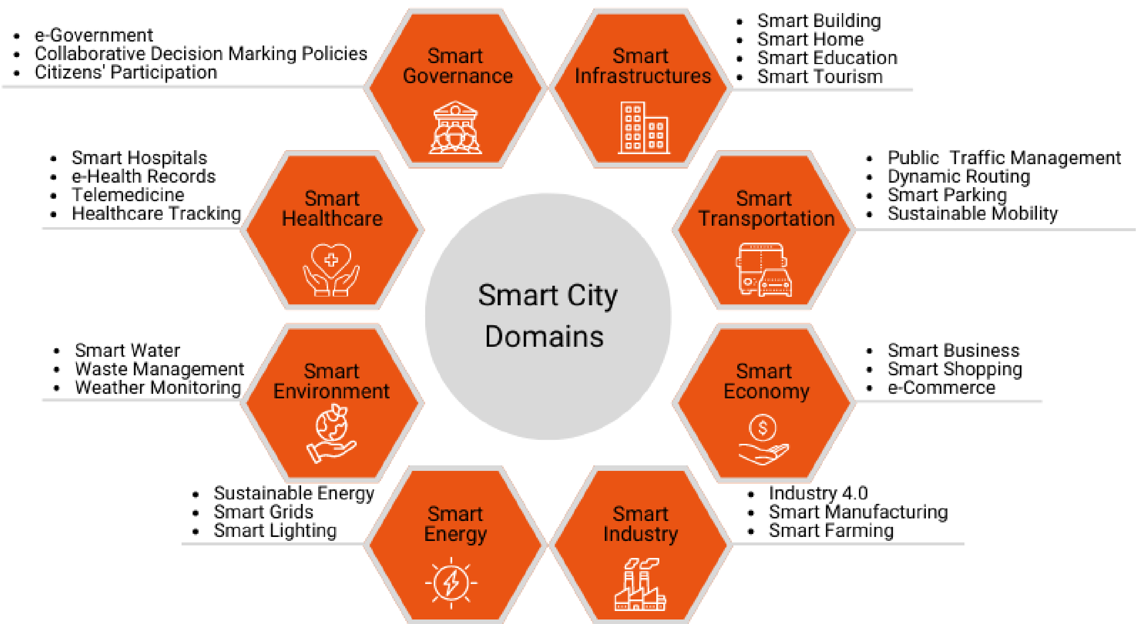

Figure 4: Smart City Domains and Associated Components

IIoT and the Evolution of Smart City

Smart Logistics Management

IIoT substantially influences logistics management, integrating technology to supply chain systems in the economic sector. Bhargava et al. (2021) contextualized such applications by examining the incorporation of IIoT for automated vehicular logistics, which involves significant decision-making. of IIoT to transportation systems, particularly the adoption of AI in vehicular systems. IIoT is employed to enhance logistics and supply chain management in this frame of thought, with increasing demand for cheaper logistics (Bhargava et al., 2021). Thus, the development of intelligent logistics is prioritized to improve the processes in a competitive industry.

As such, Bhargava et al. (2021) identified that the IIoT can be tamed to suit supply chain systems of an industrial environment enabling the application of fast internet, blockchain technology, and AI. In this sense, vehicles are enhanced to have the capacity to track and map the movement of shipments. The application, combined with AI systems, allow supply chain systems to predict and track the shortest, most efficient routes for movement (Bhargava et al., 2021). The intricate application of such techniques to smart cities allows the transportation systems of goods to be optimized, reducing delays for essential goods. Therefore, smart cities are generated in terms of advancement of their commercialization, enhancing their capacity towards globalization. It allows a competitive advantage for developing the industrial sector and related economic benefits. The outcomes translate to the economic element of sustainability that is part of the sustainable pillars of development.

Smart energy management

Smart city development objective relates to the sustainability development trends that recognize a need to reduce energy consumption. Its implications are crucial to stimulating carbon footprint reduction as energy is predominantly generated from fossil fuel combustion. Goundar et al. (2021) stipulate that IIoT has enabled a series of energy management features, including automated detection and reduction of energy waste sources, production scheduling based on energy-aware mechanisms, and minimizing energy bills. Moreover, the incorporation of IIoT supports reduced oil spillage in the networks and the generation of carbon in the systems (Goundar et al., 2021). Consequently, the energy demand is significantly reduced from industries resulting from less power-intensive production and optimization of use. The approach is not only influential in industries as AI is implemented in house management systems that allow smart buildings to regulate and monitor energy consumption. The systems can tune HVAC systems on or off depending on the conditions rather than constantly running. Demystifying the need for 24/7 running machines enables targeted applications as modern houses can detect and store personalized data and exercise internal environment comfort.

Limiting Risk Factors

Despite the significant resilience and benefits of IIoT, a range of limiting factors challenge the application of the technology. These risk factors are denoted to influence the optimal performance of IIoT architecture affecting its relevance (Mirani et al., 2022). Accordingly, Mirani et al. (2022) suggested that the fundamental elements that pose risks include a system's interoperability, scalability, reliability, security, privacy, and low-network latency. The risk factors are necessary for contingency application to resolve the elements presenting increased efficiency. To provide the said resolutions understanding the factors is essential in expounding the concept of IIoT and its adaptation to these risks.

Therefore, interoperability relates to the capacity of the system devices to communicate data from varied components. However, the rate of advancements and development of indigenous technology produce a risk factor as heterogeneous devices impede data transfer and processing. Developing unique systems created a network of diverse components limiting AI unification. In addition, scalability is a risk factor affecting the application of IIoT in smart city environments. The implications rely on its ability to adapt to the increasing amount of data produced from IIoT and the capacity to process multiple data variations. Therefore, the rising heterogeneity of technology limit the application of IIoT as systems struggle to manage the big data analytics required for proper functionality (Mirani et al., 2021).

On the other hand, security is highlighted as a risk element of applying IIoT due to the associated handling of big data, which holds confidential and critical information in many cases. Thus, the applications present significant risks that imply insecure access to data from foreign individuals or organizations. The breaches can be classified into five, incorporating DOS attacks, malware attacks, man-in-the-middle attacks, and injection attacks that affect the IIoT network operationalization (Mirani et al., 2021). Research by Mirani et al. (2021) revealed that privacy issues are closely related to the case of security as it implies an individual or group controls or influences what information related to them may be collected, processed, and stored and by whom, and to whom that information may be disclosed. Thus, over the years, the increasing heterogeneity of systems has necessitated the introduction of blockchain systems and fog computing that support the protection of the IIoT data network (Mirani et al., 2021).

The system also requires contingencies on reliability which serves as a performance indicator appending the working ability of a system over a specified time. Mirani et al. (2021) presented the possibility of production interruptions as a risk factor in IIoT application. Hence, they advocated that a system is optimally reliable when all its elements are at an optimal reliability state. The implication presented is the need for a balance in the functionality of the devices and networks. Finally, the latency levels are among the potential factors that create a risk in the application of IIoT, influencing the duration taken for information packets to be transmitted from a source to the destination. Therefore, Mirani et al. (2022) hypothesized that IIoT faces the challenges of low latency because current systems are synonymous with handling big data volumes. The risk factor presents a risk factor in the application of smart cities as the systems may be inhibited in their network capacities. Research by Mirani et al. (2022) suggested that the applied resolutions for the latency challenge integrate the adoption of 5g and edge/fog computing. Consequently, these factors are essential to consider in applying smart city concepts to ensure the resilience of IIoT-based systems.

Conclusion

The findings provide insight into contemporary trends and acknowledge smart city development from its historical perspective, tied to the discovery of the computer in the last century, and indicate a continuing e futuristic approach. Extensively, the application of technology presents a paradigm shift from the negative connotations of climate change as advancements generate solutions to climate change challenges. Automation of services and energy optimization are essential factors of production and demand that are emphasized. However, the feature that stands out in smart city systems is the enhanced application of IIoT and support in upgrading the supply chain system that is more time, energy, and cost-efficient allowing urban areas to compete actively. These trends can be The integration of technology in this model of urbanization provides solutions to urban challenges economically, socially, and environmentally. The application of IIoT presents a new dimension of development linked to Industrial revolution 4.0 movements that emphasize automated industrial processes that are resource-friendly. The evolution supports the principles of sustainability that foster appropriate resource exploitation and prevent undermining future generations' capacity to satisfy their needs.

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