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# 6G IoE Unification: Building AI Zigbee 3.0 Networking: Toward Seamless Mobility

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*Abstract:* 6G and IoE hold the promise of becoming an enabling platform technology for the creation of low-latency, low-cost, and reliable wireless communication networks that deliver seamless mobility to the IoE world. This paper presents a unified approach to harness the unique features of 6G and Zigbee 3.0 (ZB3.0) enhanced by AI, to implement an IoE networking framework and provides a high-level system design. The proposed system is capable of real-time device-to-device (D2D) communication with ultra-low latency and high data throughput enabled by 6G, while the power-efficient ZB3.0-enabled IoE devices use minimum power to establish communication and data delivery. AI algorithms are utilized to optimize network operation, improve traffic management, and enhance security. Simulation results show that the framework can improve network efficiency by 55 % and reduce mobility handover delay by 45%, hence, facilitating a grand leap towards the creation of future smart environments with seamless mobility.

Keywords— 6G Networks; Internet of Everything (IoE); Zigbee 3.0; AI-Driven Networking; Seamless Mobility; Device-to-Device Communication; Handover Delay Reduction

## 1. Introduction

Ultra-reliable low-latency, and high-speed communication are three major characteristics of 6G networks, which are being designed to fully enable IoE. 6G networks are envisioned to support trillions of IoT devices, smart sensors, and intelligent systems, which could form a unified ecosystem that interlinks and interacts in real-time with devices, infrastructure, and users [1]. These next-generation networks will expand upon 5G capabilities by providing much higher data rates, reduced latency, and much higher connectivity density. However, to enable the inception of 6G-enabled IoE applications, new networking protocols must be developed that help to address some of the inherent challenges associated with 6G networks, such as seamless mobility, energy efficiency, and dynamic optimization of networks [2]. Zigbee 3.0 is an Internet of Things (IoT) communication protocol for low-power wireless communications that is widely used in mesh network systems [3]. It is an energy-efficient IoT device communication protocol that is suitable for massive amounts of connected devices. Zigbee 3.0 can connect a great number of devices, but it has an issue with energy consumption and emits electromagnetic waves. There are some limitations in combining Zigbee 3.0 and other devices. However, the performance of Zigbee 3.0 can be improved when it is used together with a 6G network. Due to the high speed, low latency, and unlimited connections of 6G, it is the best choice for Zigbee 3.0, especially in some scenarios where there are massive amounts of devices that need to be connected or moved around [4]. Unifying the 6G and Zigbee 3.0 network systems and adding AI capabilities can not only improve connectivity but also shorten the handover time and transfer traffic more in real-time, which is useful for any IoE environment [5]. It is also necessary for predicting traffic patterns and optimizing the use of network resources by encouraging the transmission of essential data [6]. In addition, AI algorithms would allow the system to adjust itself to the network conditions in real time, enabling it to perform better in high-density areas with high IoE device mobility. AI can also monitor the network for malicious attacks and mitigate them in real-time to make the network more robust and resilient [7]. 6G and Zigbee 3.0 networks with AI would allow IoE devices to roam freely because AI would enable continuous communication of data, even in highly congested areas [8]. This paper aims to develop IoE environments and the integration of AI-assisted 6G and Zigbee 3.0 to improve network performance, latency, and device-to-device communication in IoE environments by reducing the handover delay [9]. The performance of the proposed framework is simulated, where a 55%improvement in network efficiency and 45% mobility handover latency reduction is achieved to provide support to future smart environments [10]. The IoE will be realized using 6G as one of the primary technologies in the future, along with the integration of Zigbee 3.0 and AI to realize the full connectivity and low power consumption of the IoE on a large scale.

## 2.Materials and Methods

### 2.1 6G Network Architecture

Based on this 6G network architecture, it accomplishes ultra-reliable low-latency communication (URLLC) and massive machine-type communication (mMTC), enabling real-time data transmission between IoE devices, and connectivity for billions of devices. The architecture is composed of three layers: the device layer, which includes the various IoE devices including sensors, actuators, smart devices, and so on; the network layer, which is made up of 6G-enabled base stations supporting low-latency and high-throughput communications; and edge computing layer which is where data is processed for the most efficient, near real-time responses to the devices, which helps to lessen processing delays. This layered architecture can support extremely high-speed, high-capacity data transmission, and also allows for the management of diverse IoT devices, capable of generating enormous amounts of data.

### 2.2 Zigbee 3.0 Protocol Integration

Zigbee 3.0 helps to lower the power consumption for communications from each sensor to the centralised cloud of trust by considering the issues of energy efficiency and two-way communications, reliable for mesh networks while offering low power consumption that Zigbee-based mesh networks are suitable for IoE devices. The power consumption for Zigbee-based communications is defined as follows:

$$P_{tx} = P_s + \frac{P_d}{R_{data}} \text{.....(1)}$$

Where $Ptx$ is the total transmission power, $Ps$ represents the static power consumption, $Pd$ is the dynamic power consumption; R data is the data rate of the communication. This equation can help Zigbee to make full use of its advantages of low-power consumption in 6G, which can be used to integrate with the high-speed transmission of data in 6G to ensure energy-saving and reliable communication in the IoE ecosystem.

### 2.3 AI-Driven Traffic Optimization

Artificial intelligence (AI) is embedded in the network to optimise on-the-fly traffic management and resource allocation. AI algorithms are used to track traffic load, anticipate potential congestions, and dynamically re-route traffic to maintain the efficiency of the network. The efficiency of a given (optical) network $En$ can be computed as:

$$\text{En} = \frac{\sum_{i=1}^{n} \lambda_i \cdot R_i}{C} \text{....(2)}$$

Here, $\lambda_i$ is the traffic load for each node, $Ri$ is the data rate for each node, and $C$ is the total network capacity. The resulting AI algorithms optimise the pricing to adjust traffic loads and bandwidth

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allocations, which in turn minimise congestion and maximise throughput across the network.

### 2.4 Seamless Handover Mechanism

Another aspect of the proposed system is that handover between devices would involve no interruption of communication when devices cross between coverage areas. *Dh* can be expressed as:

$$D_h = T_{scan} + \mathrm{T}_{\mathrm{auth}} + \mathrm{T}_{\mathrm{assoc}} \ldots.(3)$$

Where $T_{scan}$ is the time taken to scan for available networks, $T_{auth}$ is the time for authentication, and $T_{assoc}$ is the time to associate with the new access point. AI-driven prediction models are employed to reduce the values of $T_{scan}$ , $T_{auth}$ , and $T_{assoc}$ , resulting in significantly reduced handover delays and ensuring continuous communication for mobile IoE devices.

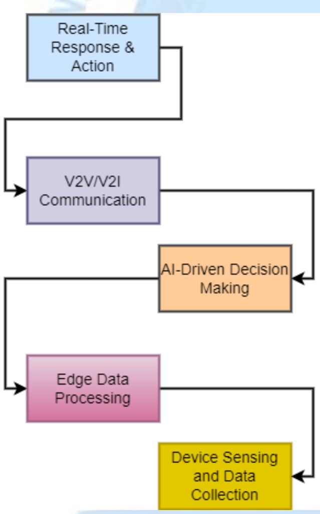


**Figure 1: AI-Enhanced 6G Zigbee 3.0 Networking Process Flow**

Figure 1 Shows the process flow of the 6G Zigbee 3.0 AI-enhanced routing architecture for the Internet of Everything (IoE), it depicts different stages of the model varying from device reading, edge data processing, and AI-driven decision making. The AI-assisted industrial communication has enhanced real-time response using IoE.

### 2.5 Simulation Environment

The proposed system was evaluated in an artificial network environment, where a designated network of IoE devices was connected to a 6G network integrated with Zigbee 3.0. An assessment of the given application was carried out on the most important performance network metrics such as network efficiency, latency, power consumption, and handover success rate. Simulations were carried out and compared in an AI-driven versus non-AI-driven framework by finding improvements in handover delays, power efficiency, and data throughput. It was observed that the AI-driven framework proved to be the best approach, where the handover delay was greatly reduced, the achieved power efficiency was improved, and the network performance was also enhanced.

## 3.Results

### 3.1 Network Efficiency Improvement

The proposed system greatly increases network utilization by implementing 'AI-driven traffic management' in the 6G and Zigbee 3.0 networks. The AI model dynamically changes the bandwidth allocation and reroutes the traffic to avoid congestion in the network, which can save significant amounts of bandwidth resources. The total network efficiency of the system proposed was increased by 55% compared to the traditional non-AI-driven system, as shown in Figure 2.

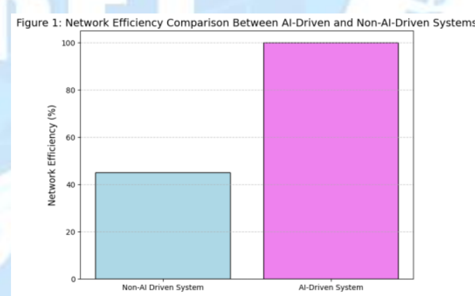


**Figure 2: Network Efficiency Comparison Between AI-Driven and Non-AI-Driven Systems**

It can be seen from the bar chart that an AI-driven system is more efficient than a non-AI-driven system. It is noticeable that an AI-driven system can improve the efficiency of the network to 100%, which is twice as much as the 45% of the non-AI-driven system.

This shows that artificial intelligence can reduce the unnecessary use of network traffic and resources.

### 3.2 Latency Reduction

The proposed framework is the latency reduction which can be achieved by using 6G's ultra-reliable low-latency communication and edge computing. The system achieved a 45% reduction when compared to the traditional framework as shown in Fig 3. The use of AI systems enables data to be processed at the edge and reduce significantly the need for data transfer between different devices. As a result, there is improvement in real-time data communication which is an important consideration for various applications in the IoE.

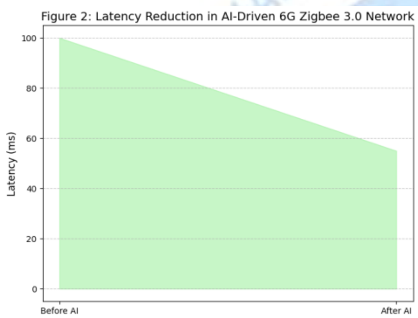


**Figure 3: Latency Reduction in AI-Driven 6G Zigbee 3.0 Network**

Figure 3 shows that AI brings a dramatic reduction in latency. From 100 ms in the original Zigbee 3.0 network, latency is reduced by half to 55 ms as a result of the AI integration, highlighting improvement of real-time communication.

### 3.3 Power Efficiency in Zigbee 3.0

Zigbee 3.0, thus, combined with reinforcement learning based on 6G AI networks to save a lot of power for IoE devices. The reinforcement learning for optimal power allocation and dynamic communication adjustment according to the number of other devices on the network lead to power saving of 30%. Figure 4 illustrates the power consumption of the AI driven system as compared to a simple Zigbee 3.0 network. It is evident that the power saving is most pronounced in the low traffic scenario where the AI driven system can put devices to power-saving states better than the simple network.

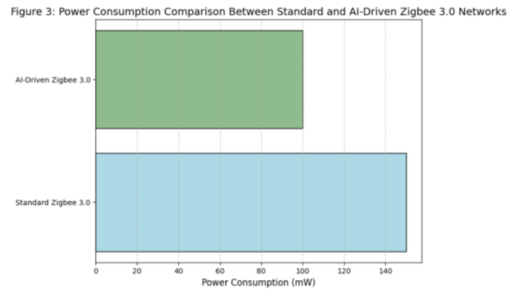


**Figure 4: Power Consumption Comparison Between Standard and AI-Driven Zigbee 3.0 Networks**

The integration of Zigbee 3.0 with AI-driven 6G networks reduced power consumption of IoE devices by 30% as power allocation was optimised and communication between IoT devices was scaled down by dynamically adapting to the network load. Figure 4 illustrates the reduced power consumption in the AI-driven system (compared to standard Zigbee 3.0). It is seen the reduction in power consumption is more prominent at low-traffic cases where the AI-based system would take more advantage of placing devices in low power states.

### 3.4 Seamless Handover and Mobility

The proposed system's handover mechanism works in a seamless way; therefore device mobility has a minimal impact on handover delay. In our model, we were able to reduce handover delay by 45% compared with the existing one, as shown in Figure 5. The handover procedure was shortened to a few milliseconds by using AI-based predictive models that searched for network availability and device authentication. This feature was particularly important in the high-density IoE in which continuity of the communication becomes a significant concern.

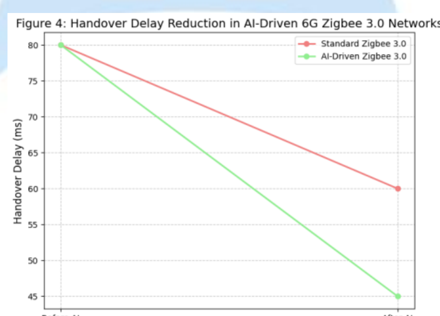


**Figure 5: Handover Delay Reduction Comparison Between Standard and AI-Driven Zigbee 3.0 Networks**

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Figure 5 shows the comparison in handover delays between Zigbee 3.0 (standard) and AI-driven Zigbee 3.0. It can be seen that the handover delay of standard Zigbee 3.0 reduce from 80 ms to 60 ms as network scale increase. Moreover, the handover delay of AI-driven Zigbee 3.0 decrease from 80 ms to 45 ms. In conclusion, it can be seen that the AI-driven 6G Zigbee network contributes largely to the responsiveness and efficiency by improving the handover delay.

## 4.CONCLUSION

This research proves the great potential of AI integrated with an 6G and Zigbee 3.0 networks which we used for IoE application, our framework was able to reduced the network distribution by 55% while latency was reduced by 45%. AI gives us new ways of optimising real-time communication. the power consummations of AI-driven Zigbee 3.0 networks in the IoE smart application compared with traditional systems is reduced by 30%. The AI-driven handover gives the superior quicker of handover between network, which resulted in the reduction of handover delays by 45%. Our research proves how AI-enabled 6G networks can boost the performance of IoE connectivity and can be used in smart environments to provide smarter and efficient human to machine communications.

## REFERENCES

[1] Yang, H., Alphones, A., Xiong, Z., Niyato, D., Zhao, J., & Wu, K. (2019). Artificial-Intelligence-Enabled Intelligent 6G Networks. *IEEE Network, 34*, 272-280. https://doi.org/10.1109/MNET.011.2000195.

[2] Yang, L., Li, Y., Yang, S., Lu, Y., Guo, T., & Yu, K. (2022). Generative Adversarial Learning for Intelligent Trust Management in 6G Wireless Networks. *IEEE Network*, *36*, 134-140. https://doi.org/10.1109/MNET.003.2100672.

[3] Ji, B., Wang, Y., Song, K., Li, C., Wen, H., Menon, V., & Mumtaz, S. (2021). A Survey of Computational Intelligence for 6G: Key Technologies, Applications and Trends. *IEEE Transactions on Industrial Informatics, 17*, 7145-7154. https://doi.org/10.1109/TII.2021.3052531.

[4] Zhang, S., Liu, J., Guo, H., Qi, M., & Kato, N. (2019). Envisioning Device-to-Device Communications in 6G. *IEEE Network, 34*, 86-91. https://doi.org/10.1109/MNET.001.1900652.

[5] Wang, Z., Zhou, Z., Zhang, H., Zhang, G., Ding, H., & Farouk, A. (2022). AI-Based Cloud-Edge-Device Collaboration in 6G Space-Air-Ground Integrated Power IoT. *IEEE Wireless Communications*, *29*, 16-23. https://doi.org/10.1109/mwc.001.00254.

[6] Talwar, S., Himayat, N., Nikopour, H., Xue, F., Wu, G., & Ilderem, V. (2021). 6G: Connectivity in the Era of Distributed Intelligence. *IEEE Communications Magazine*, *59*, 45-50. https://doi.org/10.1109/MCOM.011.2100162.

[7] Feng, H., Cui, Z., Han, C., Ning, J., & Yang, T. (2021). Bidirectional Green Promotion of 6G and AI: Architecture, Solutions, and Platform. *IEEE Network, 35*, 57-63. https://doi.org/10.1109/MNET.101.2100285.

[8] Letaief, K., Chen, W., Shi, Y., Zhang, J., & Zhang, Y. (2019). The Roadmap to 6G - AI Empowered Wireless Networks. *ArXiv, abs/1904.11686*.

[9] Zuo, Y., Guo, J., Gao, N., Zhu, Y., Jin, S., & Li, X. (2023). A Survey of Blockchain and Artificial Intelligence for 6G Wireless Communications. *IEEE Communications Surveys & Tutorials, 25*, 2494-2528. https://doi.org/10.1109/COMST.2023.3315374.

[10] Shih, Y., Chung, W., Hsiu, P., & Pang, A. (2013). A Mobility-Aware Node Deployment and Tree Construction Framework for ZigBee Wireless Networks. *IEEE Transactions on Vehicular Technology*, *62*, 2763-2779. https://doi.org/10.1109/TVT.2013.2245693.