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Understanding Security Requirements, Issues, and Challenges in Internet of Everything

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ABSTRACT
IoE is a concept that goes beyond the Internet of Things (IoT) by not only connecting devices and objects but also incorporating people, processes, and data into a cohesive intelligent network. It envisions a world where a vast number of “things”, or "objects," are equipped with sensors and other equipments that empower them to collect data, interact with their surroundings, and communicate with each other and with people. The growth of the Internet of Everything (IoE) continues to be a significant trend as new devices are developed and deployed in various environments. The advancement of technology and the increasing adoption of connected devices have donated to the expansion of IoE in many areas, such as consumer electronics, health-care, transportation, industrial automation, smart cities, and more. While IoE offers numerous advantages, it also offerings challenges linked to security, interoperability, confidentiality, and data governance. As the number of associated devices raises, addressing these challenges becomes increasingly important to ensure the continued growth and success of the IoE ecosystem. Due to the vast scale and distributed nature of IoE networks, security and confidentiality are major challenges in the Internet of Everything (IoE). We have identified, categorized, and discussed various security requirements, issues and challenges in Internet of Everything.

Keywords — Internet of Things(IoT), Internet of Everything(IoE), things, objects

I. INTRODUCTION

The Internet of Things (IoT) has witnessed continuous improvement and has gained significant popularity, attracting an increasing number of people from various domains. The continuous improvement and increasing adoption of IoT indicate that this technology has become an integral part of our daily lives and business operations. The number of connected devices in the IoT ecosystem is indeed growing quickly. As per the predictions from Strategy Analytics, the number of connected objects is projected to rise significantly over the subsequent years.

According to their forecast, the number of associated devices is predictable to reach more than 38 billion by the end of 2025. This indicates a substantial increase in the deployment of IoT devices across various industries and consumer applications. Furthermore, the growth trend is expected to continue, with Strategy Analytics predicting that the number of connected objects will surpass 50 billion by the year 2030. This further emphasizes the continued expansion of the IoT ecosystem and its increasing impact on our daily lives, industries, and the global economy. The three main challenges in the Internet of Things (IoT) are indeed data collection, data transmission, and data security.

A. Data Collection

Challenge: IoT devices produce enormous quantities of data from sensors, actuators, and various sources. Collecting and handling this information efficiently is a significant challenge, particularly when dealing through a large number of devices and diverse data formats.

Importance: Effective data collection is crucial for providing valuable insights, analytics, and informed decision-making. Without proper data collection, the potential of IoT to provide real-time, actionable information may not be fully realized.

B. Data Transmission

Challenge: Transmitting the collected data from IoT devices to the cloud or central servers can be challenging, particularly in environments with limited network connectivity, high latency, or intermittent connectivity.

Importance: Reliable data transmission is essential for timely data analysis, response, and overall system performance. Delays or data loss during transmission can hinder critical processes and applications.

C. Data Security

Challenge: Security is a paramount distress in the IoT environment. With the proliferation of connected devices and the sensitivity of the data they collect, ensuring data security is a complex task.

Importance: Data security is vital to protect sensitive information, prevent unauthorized access, and safeguard against cyber attacks. Breaches in data security can lead to severe consequences, both for individuals and organizations.

II. IoT ARCHITECTURE

The IoT refers to a vast network that connects various physical entities or "things" embedded with sensors, actuators, and microcontrollers. These entities can range from routine daily devices, appliances, and automobiles to manufacturing equipments, infrastructure elements, and wearable gadgets.

The concept of the IoT[1] is a relatively recent development and represents a distinct evolution from its antecedents, including traditional internet networks, mobile networks, and sensor-based networks. While these earlier networks provided the foundation for IoT, IoT stands out due to its unique characteristics and capabilities:

- Embedded Intelligence: Unlike traditional internet networks, IoT devices are often embedded with intelligence through microcontrollers and sensors. This allows IoT devices to collect data, process it locally, and make autonomous decisions without relying solely on central servers or human intervention.
- Proliferation of Devices: IoT involves a vast number of interrelated devices, extending from minor sensors to complex industrialized machinery. This scale of interconnectivity sets IoT apart from traditional networks that primarily focused on human-to-human communication.
- Diverse Applications: IoT's scope extends beyond communication between people or information retrieval. It encompasses a wide variety of applications across different trades, including transportation, smart households, health-care, industrial computerization, agriculture, and more.
- Real-Time Data and Insights: IoT devices generate real-time information, providing immediate and valuable insights into various processes and systems. This real-time capability enables timely responses and optimizations in critical applications.
- Physical World Integration: IoT bridges the gap between the physical and digital worlds by connecting objects and systems in the physical environment to digital networks. This integration facilitates data-driven decision-making and enables better control and monitoring of physical processes.
- Interoperability: IoT relies on standardized communication protocols and data formats to ensure interoperability between miscellaneous devices and platforms. This standardization is essential to assist continuous communication and data interchange across the IoT ecosystem.
- Machine-to-Machine (M2M) Communication: IoT emphasizes machine-to-machine communication, where devices can interact and collaborate without human intervention. This opens up possibilities for automation, efficiency, and new services.
- Ubiquitous Connectivity: IoT devices can connect to the internet through various means, including Wi-Fi, cellular networks, Bluetooth, Zigbee, LoRa, and more. This ubiquity of connectivity enables IoT deployment in a wide range of environments.
- Data-Driven Decision-Making: The continuous flow of data from IoT devices enables data-driven decision-making, predictive analytics, and the ability to optimize processes based on real-world data.

Due to the lack of complete standardization in the Internet of Things (IoT) ecosystem, various IoT architectures have emerged to address specific use cases, requirements, and industry needs. Among the different architectures, two well-known and commonly referenced ones are the three-layer and five-layer architectures.

A. *Three-Layer IoT Architecture*

The three-layer IoT architecture is a simple and commonly used framework that organizes IoT components into three layers: Perception Layer, Network Layer, and Application Layer.

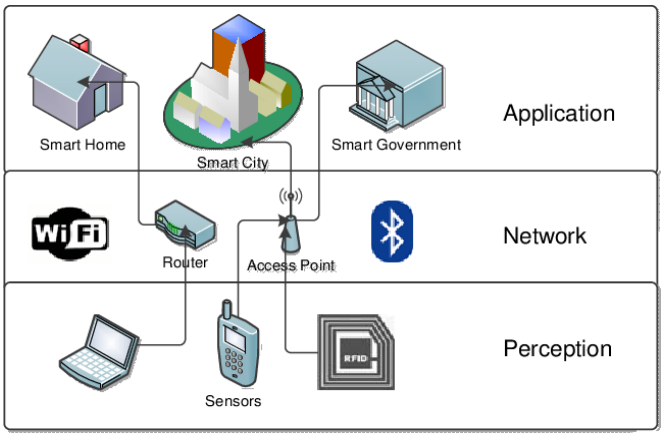

Fig. 1 Three-Layer IoT Architecture

- Perception Layer: This layer comprises IoT devices or "things" embedded with sensors, actuators, and microcontrollers. These devices collect data from the physical environment and send it to the Network Layer.
- Network Layer: The Network Layer is responsible for transmitting the collected data from IoT devices to the cloud or central servers. It includes innumerable communication tools, such as cellular networks, Bluetooth, or Wi-Fi, and more.
- Application Layer: At the top layer, the Application Layer processes and analyzes the data received from the Network Layer. It includes applications, user interfaces, and data analytics platforms that interpret the data and provide actionable insights to end-users or trigger specific actions.

B. *Five-Layer IoT Architecture*

The five-layer IoT architecture expands on the three-layer architecture by adding two additional layers: Processing Layer and Business Layer. This architecture is more comprehensive and enables more sophisticated IoT applications.

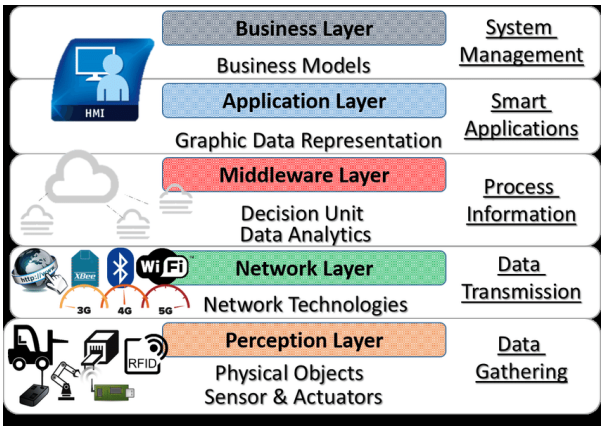

Fig. 2 Five-Layer IoT Architecture

- Perception Layer: This layer is related to the three-layer design, the Perception Layer contains of IoT devices with actuators and sensors.
- Network Layer: The Network Layer handles data transmission from IoT systems to cloud platforms or gateways.
- Processing Layer: The Processing Layer is an intermediate layer that performs data pre-processing, aggregation, and filtering tasks. It can also include edge computing capabilities, where data is processed closer to the source, decreasing latency and bandwidth necessities.
- Business Layer: The Business Layer is responsible for processing the analyzed data further and applying business logic or rules to generate actionable insights and responses.
- Application Layer: The Application Layer provides user interfaces, dashboards, and applications that permit end-users to intermingle with the IoT system and access the valuable information generated by the Business Layer.

Both the three-layer and five-layer architectures are prevalent and offer valuable insights into structuring IoT deployments. The choice of architecture depends on the specific requirements of the IoT application and the complexity of the system. As the IoT ecosystem evolves and standardization efforts continue, more refined and standardized architectures may emerge to further streamline and enhance IoT deployments.

III. CHALLENGES OF IoT SYSTEM

IoT characterizes various challenges that need to be addressed to fully realize its potential and ensure its responsible and secure deployment. These challenges[2] span technical, security, ethical, and regulatory aspects. Here are some of the key challenges of IoT:

- Security and Confidentiality Concerns: IoT system often gather and transfer sensitive data, rising concerns about data security and privacy. Susceptibilities in IoT devices can be demoralized by attackers to acheive unauthorized access, compromise data, or disrupt services.
- Interoperability and Standardization: The lack of uniform standards for communication protocols, data formats, and device interfaces can hinder interoperability between different IoT devices and platforms. Achieving seamless integration and data exchange is essential for IoT's success.
- Scalability and Complexity: As the number of IoT devices grows exponentially, managing and scaling IoT networks becomes increasingly challenging. Handling the complexity of interconnected systems requires robust and efficient management solutions.
- Data Management and Analysis: Dealing with vast amounts of data produced by IoT system poses data management and analytics challenges. Efficiently processing and deriving actionable insights from large datasets are critical for IoT's effectiveness.
- Power and Energy Efficiency: Many IoT devices operate on limited power sources, such as batteries. Maximizing power efficiency and optimizing energy usage are vital to extend the lifespan of devices and reduce environmental impact.
- Edge Computing and Fog Computing: The increasing adoption of edge and fog computing in IoT introduces challenges related to data processing, security, and management at the network edge.
- Reliability and Resilience: IoT applications often serve mission-critical functions in industries like healthcare, transportation, and industrial automation. Certifying the reliability and resilience of IoT systems is crucial to prevent potential disruptions.
- Regulatory and Ethical Concerns: The deployment of IoT devices in various domains raises ethical concerns about data ownership, agreement, and potential misuse of data. Developing clear regulatory frameworks is essential to address these issues.
- User Awareness and Education: End-users may lack awareness of IoT security best practices, making them vulnerable to attacks. Educating users about potential risks and safety measures is vital for creating a more secure IoT ecosystem.
- Cost and Return on Investment (ROI): The cost of deploying and maintaining IoT infrastructures can be a barrier to entry for some organizations. Demonstrating a clear ROI is essential for encouraging wider adoption of IoT technologies.
- Environmental Impact: The proliferation of IoT devices can donate to electronic excess and environmental concerns if not managed responsibly.

Talking these challenges needs collaboration among stakeholders, comprising governments, industry leaders, researchers, and end-users. Technological advancements, standardization efforts, data governance frameworks, and responsible design practices will play critical roles in overcoming these challenges and enabling IoT to deliver its transformative potential.

IV. SECURITY CHALLENGES OF IoT

The security challenges of the IoT can indeed be categorized into two main classes: security challenges and technological challenges. These challenges represent the complex and multifaceted nature of securing IoT devices, networks, and data.

A. Security Challenges

Security challenges in IoT are related to the vulnerabilities and risks that arise due to the interconnected and often resource-constrained nature of IoT systems and networks. Some key security experiments include:

Device Vulnerabilities: Many IoT devices have inadequate processing power and memory, making it difficult to enhance strong security mechanisms. This can leave devices vulnerable to exploits and attacks.

Inadequate Authentication and Authorization: Weak authentication and authorization mechanisms can lead to unauthorized access to IoT devices and networks.

Lack of Encryption: Data transferred between IoT system and cloud platforms may be exposed to eavesdropping if not encrypted properly. Default Credentials and Hardcoded Passwords: Many IoT devices come with default credentials or hardcoded passwords that attackers can easily exploit if not changed by the users. Firmware and Software Updates: IoT devices may not receive regular security updates, leaving them vulnerable to known exploits.

B. Technological Challenges

Technological challenges[5] in IoT security arise from the unique characteristics of IoT systems, including the scale, heterogeneity, and dispersed nature of the ecosystem. Some key technological challenges contain:

- Scalability: Securing a massive number of interconnected devices in IoT requires scalable security solutions that can holder the rising number of devices and data.
- Interoperability: IoT devices come from various manufacturers and may use different communication protocols, making it challenging to establish consistent security measures across the ecosystem.
- Edge Computing Security: As edge computing becomes more prevalent in IoT deployments, securing the edge devices and data processing at the edge becomes critical.
- Confidentiality Concerns: IoT devices often collect sensitive data, rising confidentiality distresses regarding data ownership, usage, and consent.
- Complexity of Systems: The complexity of IoT[6] systems and their interactions increases the difficulty of identifying potential vulnerabilities and mitigating risks effectively.
- Addressing these security and technological challenges[4] requires a complete and multi-layered method to IoT security. It includes industry-wide collaboration, strong security standards, device manufacturers' responsibility, user education, and continuous research and development of security technologies. As IoT continues to grow and evolve, addressing these contests will be crucial to confirming a secure and trustworthy IoT ecosystem.

V. SECURITY ISSUES IN EACH LAYER OF IOT

Security is a serious concern in the Internet of Things IoT eco-system, and it needs to be addressed at each layer of the IoT architecture to ensure a secure and reliable deployment. Here are some common security issues that may arise in each layer of the IoT:

A. Perception Layer (Sensing Layer)

- Device Vulnerabilities: IoT devices in this layer may have limited computing power and memory, making them susceptible to various attacks, such as buffer overflows, code injections, and privilege escalation.
- Insecure Communication: Lack of encryption or weak authentication mechanisms in data transmission between IoT devices and gateways can expose sensitive data to eavesdropping and interception.
- Default Credentials: Many IoT devices come with default credentials or hardcoded passwords, which can be exploited by attackers if not changed by users during the setup process.

B. Network Layer

i. Man-in-the-Middle Attacks: Attackers can intercept and modify data exchanged among IoT system and gateways, compromising the reliability and confidentiality of the transferred information.

ii. Denial-of-Service (DoS) Attacks: IoT n/w may be susceptible to DoS attacks, where an attacker floods the link with traffic, causing service disruptions and impacting the availability of IoT devices.

iii. Network Spoofing: Attackers can impersonate IoT devices or gateways, gaining unauthorized access to the network and potentially causing security breaches.

C. Gateway Layer

- Security Misconfiguration: Improperly configured gateways may have exposed ports or weak security settings, providing an entry point for attackers to access the broader network infrastructure.
- Data Aggregation Vulnerabilities: Gateways aggregating data from multiple IoT devices can become attractive targets for attackers seeking to compromise a huge quantity of devices at once.

D. Data Processing and Analytics Layer

- Data Integrity and Trustworthiness: Ensuring the integrity and authenticity of data processed in this layer is crucial to prevent malicious data from influencing critical decisions and analytics.
- Insufficient Access Controls: Insufficient access controls could permit unauthorized users to access sensitive data or analytics, leading to potential data leaks or unauthorized actions.

E. Application Layer

- Weak Authentication and Authorization: Insecure authentication and authorization mechanisms in IoT applications may allow unauthorized access to sensitive functionalities or data.
- Insecure APIs: Vulnerabilities in application programming interfaces (APIs) be able to demoralize by attackers to achieve unauthorized access or manipulate IoT devices remotely.
- Lack of Secure Software Development Practices: Insecure coding practices in IoT[3] applications can lead to various software vulnerabilities, including buffer overflows, injection flaws, and cross-site scripting.

F. Management and Control Layer

a) Firmware and Software Updates: Inadequate security updates for IoT devices can leave them vulnerable to known exploits and attacks.
b) Device Provisioning and Decommissioning: Improper device provisioning and decommissioning processes can result in unauthorized access to devices or data.

Addressing these security issues requires a comprehensive approach that includes robust encryption, protected communication protocols, strong authentication, consistent software updates, user education, and adherence to industry security best practices. Additionally, a proactive and collaborative effort from all stakeholders, including device manufacturers, service providers, and end-users, is essential to ensure the security and privacy of IoT systems throughout their lifecycle.

VI. IOT SECURITY REQUIREMENTS

Ensuring the security of the IoT is essential to protect users, data, and critical infrastructure from potential threats and cyberattacks. IoT security requirements encompass a set of measures and best practices that must be implemented across various layers of the IoT ecosystem. Here are some key IoT security requirements:

- Strong Authentication: IoT devices and users should undergo robust authentication methods, for instance two-factor authentication (2FA) or multi-factor authentication (MFA), to verify their identity before accessing the network or sensitive data.
- Secure Communication: Data transferred between IoT system and cloud servers or gateways must be encrypted by robust encryption procedures (e.g., TLS/SSL) to protect against eavesdropping and unauthorized access.
- Access Control: Implement strict access controls to confirm that only authorized users or devices can utilize specific functionalities, data, or networks within the IoT ecosystem.
- Firmware and Software Updates: Regularly issue security updates and patches for IoT system to address known susceptibilities and improve the overall security posture of the devices.
- Secure Boot and Firmware Integrity: Employ secure boot mechanisms to ensure that IoT devices start with trusted firmware, and verify firmware integrity during runtime to prevent tampering.
- Data Protection and Privacy: Implement measures to shield data at rest and in transfer. Confirm compliance with data protection guidelines, and allow users to control their data and provide informed consent for its use.
- Secure APIs: Ensure that APIs used by IoT applications and services are secure and properly authenticated to prevent unauthorized access or manipulation of data.
- Physical Security: Deploy physical security measures to protect IoT devices from tampering or unauthorized physical access.
- Edge Security: Secure edge devices and edge computing infrastructure to protect data processing and analytics at the network edge.
- Security Monitoring and Incident Response: Set up seamless observings and instance response competencies to identify and react promptly to security incidents or anomalies in the IoT ecosystem.
- End-User Education: Educate end-users about IoT security best performs, password management, and the risks associated with insecure IoT[7] practices.
- Vendor Security Guidelines: Encourage manufacturers to follow secure development practices and provide IoT devices with necessary security features.
- Regulatory Compliance: Conform with applicable security guidelines, industry ethics, and privacy laws to maintain a high level of security assurance.
- Secure Device Decommissioning: Develop secure procedures for decommissioning or disposing of IoT devices to prevent data exposure.
- Addressing these security requirements is an ongoing process, as the IoT landscape and cybersecurity threats continue to evolve. Collaboration among IoT stakeholders, including device manufacturers, service providers, policymakers, and end-users, is essential to build a robust and secure IoT eco-system.

VII. CONCLUSION

Addressing these security requirements, issues, and challenges requires teamwork among several stakeholders, together with device constructers, service providers,

policymakers, and users. Implementing security measures from the design phase and keeping up with the latest security practices can help create a safer IoE ecosystem.

REFERENCES

[1] "Internet of Things Security and Privacy: A Survey" by M. M. Hassan, et al. (IEEE Communications Surveys & Tutorials, 2015) Link: https://ieeexplore.ieee.org/abstract/document/7320454

[2] "Internet of Everything: A Survey" by J. Chakraborty and S. S. Chowdhury (IEEE Internet of Things Journal, 2017) Link: https://ieeexplore.ieee.org/abstract/document/7892790

[3] "Internet of Everything: Securing the Path to Value" by Cisco Link: https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoE_Ebook_April14.pdf

[4] "Internet of Everything (IoE) Security: Technologies, Challenges, and Solutions" by S. N. Oke and O. A. Ayo (International Journal of Computer Applications, 2017) Link: https://www.ijcaonline.org/archives/volume168/number6/oke-2017-ijca-914491.pdf

[5] "Internet of Everything (IoE) Security: A Comprehensive Survey" by R. Meenakshi and R. N. Uma (International Journal of Computer Applications, 2016) Link: https://www.ijcaonline.org/archives/volume136/number11/meenakshi-2016-ijca-910334.pdf

[6] "Internet of Things Security: A Top-down Survey" by K. Roman, et al. (IEEE Internet of Things Journal, 2013) Link: https://ieeexplore.ieee.org/abstract/document/6521075

[7] "IoT Security: Ongoing Challenges and Research Opportunities" by A. Mosenia and N. K. Jha (Journal of Cybersecurity, 2017) Link:https://academic.oup.com/cybersecurity/article/3/2/115/3824037

[8] Satish, Karuturi S R V, and M Swamy Das. "Multi-Tier Authentication Scheme to Enhance Security in Cloud Computing." IJRAR (International Journal of Research and Analytical Reviews) 6, no. 2 (2019): 1-8, 2019.