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Protecting Confidentiality in Data Consolidation within IoT

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ABSTARCT

The term "Internet of Things" (IoT) refers to a network of devices, both large and small, that are linked together and made available online. Because IoT devices may increase efficiency, accuracy, and financial advantage while decreasing the need for human intervention, they provide the greatest degree of adaptability and convenience in our day-to-day operations. The burden of safety, confidentiality, and communication There are also emerging issues in the Internet of Things. Several privacy-preserving data aggregation strategies have been proposed in recent years to combat this issue. One use case for the Internet of Things is the secure collection of data. Users' privacy can be safeguarded in large part through the use of privacy-preserving data aggregation.

In this study, we offer a high-level overview of a privacy-protecting data aggregation technique for the Internet of Things, with the dual goals of minimising privacy risks and communication costs. Many methods for protecting user privacy during data consolidation in low-resource sensor nodes are among the many that have been proposed as part of the Privacy-Preserving Data Aggregation (PPDA) field. In this study, we survey and evaluate contemporary PPDA methods. We have analysed the most modern methods in great detail, down to the smallest details. This survey also includes a detailed study of all the maths behind the various PPDA programmes. This research will aid developers of Internet of Things (IoT) apps in designing privacy-protecting features that are both computationally and energy-efficient.

Keyword: Internet of Things , Confidentiality , Privacy-Preserving Data Aggregation (PPDA)

I. INTRODUCTION

With the rapid development of Internet of Things (IoT) technology, numerous devices are interconnected to collect data and share it with various applications to perform complex tasks. This vast amount of data generated by these devices offers new opportunities for data-driven decision-making, machine learning, and artificial intelligence applications. However, privacy and security concerns are paramount as these devices may collect sensitive data about individuals and organizations.Data aggregation is a fundamental operation in IoT, which involves the collection of data from various devices to create a comprehensive view of the system. However, traditional data aggregation techniques are vulnerable to privacy and security attacks, as they require transmitting raw data to a centralized server, where the data is processed, analyzed, and stored. This centralized architecture is vulnerable to various attacks, including eavesdropping, data tampering, and data breaches.

Privacy-preserving data aggregation (PPDA) techniques have emerged to address these concerns, aiming to preserve privacy while still allowing data to be analyzed and utilized for various applications. PPDA involves encrypting data before transmitting it to a centralized server, and then aggregating the encrypted data without decrypting it, ensuring the privacy and confidentiality of the data. PPDA offers numerous advantages over traditional data aggregation techniques, including preserving the privacy and confidentiality of data, reducing the risk of data breaches, and enabling the secure and efficient sharing of data. PPDA has been widely adopted in various IoT applications, including smart homes, healthcare, and transportation, where privacy and security concerns are paramount.

In conclusion, privacy-preserving data aggregation is a critical technology that enables IoT devices to share data securely and efficiently, while preserving the privacy and confidentiality of sensitive data. PPDA has numerous advantages over traditional data aggregation techniques and has been widely adopted in various IoT applications, highlighting the importance of privacy and security in the development of IoT technologies.

REVIEW OF RELATED LITERATURE

"A Privacy-Preserving Data Aggregation Scheme for IoT Applications" by **A. K. Bharti and S. Srivastava (2016):** This paper proposed a privacy-preserving data aggregation scheme for

IoT applications, based on a modified ElGamal encryption algorithm. The proposed scheme ensures the privacy and confidentiality of data while enabling efficient data aggregation.

"Privacy-Preserving Data Aggregation Techniques in Wireless Sensor Networks: A Survey" by **P. Kumari and S. K. Rath (2014):** This paper provides a comprehensive survey of privacy-preserving data aggregation techniques in wireless sensor networks, which can be applied to IoT applications. The authors review various encryption and key management techniques used for PPDA in WSNs, and discuss their advantages and limitations.

"A Secure and Efficient Data Aggregation Scheme for Wireless Sensor Networks" by **N. R. Prasad, B. K. Panigrahi, and D. K. Sahoo (2015):** This paper proposes a secure and efficient data aggregation scheme for wireless sensor networks, which can be applied to IoT applications. The proposed scheme uses a hybrid encryption algorithm, combining symmetric and asymmetric encryption, to ensure the privacy and confidentiality of data.

"Privacy-Preserving Data Aggregation in Internet of Things" by A**. Mishra, N. K. Sharma, and A. K. Mishra (2017):** This paper presents a privacy-preserving data aggregation scheme for IoT, based on homomorphic encryption. The proposed scheme enables data aggregation without decrypting the data, ensuring the privacy and confidentiality of sensitive data.

"Privacy-Preserving Data Aggregation Techniques in IoT: A Review" by **S. R. Selvi and K. Thangavel (2020):** This paper provides a comprehensive review of privacy-preserving data aggregation techniques in IoT, focusing on the various encryption and key management techniques used for PPDA. The authors also discuss the challenges and future directions in this field.

"Privacy-Preserving Data Aggregation in Industrial IoT using Blockchain" by A**. Jain, A. Mittal, and R. Agarwal (2020):** This paper proposes a privacy-preserving data aggregation scheme for Industrial IoT using blockchain technology. The proposed scheme ensures the privacy and confidentiality of data by encrypting the data before transmitting it to the blockchain, enabling secure and efficient data aggregation.

"Privacy-Preserving Data Aggregation in Multi-User IoT Environments: A Review" by **R. Bharti and A. K. Dhaka (2018):** This paper provides a comprehensive review of privacy-preserving data aggregation techniques in multi-user IoT environments, where multiple users contribute data to a central server. The authors review various encryption and key management techniques used for PPDA, and discuss their advantages and limitations.

"Secure and Efficient Privacy-Preserving Data Aggregation in IoT using Fog Computing" by **M. K. Sharma and N. Gupta (2019):** This paper proposes a privacy-preserving data aggregation scheme for IoT using fog computing. The proposed scheme enables secure and efficient data aggregation by encrypting the data before transmitting it to the fog node, ensuring the privacy and confidentiality of sensitive data.

In this research, we present a method for aggregating IoT data that is both effective and secure. Here, we discuss how to get data from IoT devices without compromising users' privacy.

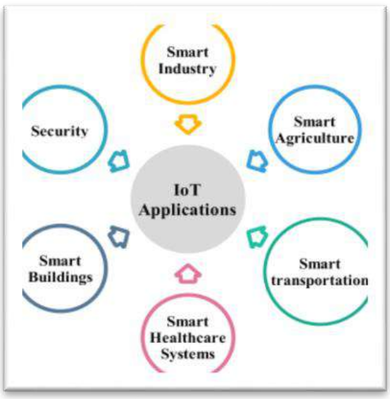

Fig.1. Data Aggregation in IoT

We have looked at the newest methods, and we have analysed the privacy and security problem. You should also be familiar with Data Aggregator, which does the aforementioned task without requiring access to the original data sources. This is the most recent thread on the topic of these PPDA solutions, as far as we can tell. Methods for PPDA in sensor nodes with limited resources are discussed in Section 2 of this paper. In Section 3, we analyse the methods, and in Section 4, we wrap things up.

II. DATA AGGREGATION METHODS THAT PROTECT INDIVIDUAL PRIVACY

A certified level of security and privacy is required by nearly all IoT applications. Maintaining data privacy while providing efficient data aggregation is a significant challenge in wireless sensor networks. Several methods have been developed for aggregating data from WSNs and smart grids while protecting users' privacy. We take a look at various PPDA approaches and evaluate how well they function. The procedures are described below.

To protect WSN data from intrusion, Bista et al. devised a solution. In comparison to the current techniques cluster-based private data aggregation and Slice-Mix-AggRegaTe , the suggested scheme has low communication overhead and low power consumption.

Using additively homomorphic encryption, Li et al. offer a fantastic sum aggregation technique and build a highly efficient Min computation protocol from it. In order to prevent collusion attacks and effectively manage users' dynamic joining and departing, the protocols developed by Li et al. utilise a very delicate key system on top of their good efficiency and clever designs.

Using Incremental Hashing Function, Yip et al. offer a system for Smart Grid power management and broadcasting that is both privacy-protecting and cheat-resistant (PPCR) (SG). Smart metres with limited resources can benefit from IHF. Low data storage and processing power are required for IHF. Smart metre data is aggregated and hashed by this system. The system is highly private and secure. If information is intercepted at the device layer, this system will not produce a result.

When it comes to protecting user privacy and data integrity during the data aggregation process, Kumar and Madria have developed a revolutionary energy-efficient technique. In this implementation of Recursive Secret Sharing (RSS), k2 additional bits of information are stored in exchange for shares of the data d. If a node has at least k shared connections, it can readily recover the k1 bits of secret data. In this way, the unknowable information is protected from being reconstructed and retrieved by a single node that controls all of the shares. Power consumption, memory savings, data transfer, and runtime all benefit greatly from the use of this technique. The method for sustaining variables in sensor nodes is not discussed in this algorithm.

Othman et al. create a system that increases transmission efficiency while maintaining data privacy through grouping. Based on homomorphic symmetric encryption, this technique uses homomorphic signatures to guarantee the authenticity of transmitted data. For security and confidentiality, Othman et al. devised a method of data aggregation that uses little energy. Node cooperation attacks can compromise this strategy. It relies on Elliptic Curve Okamoto-Uchiyama (EC-OU) to keep information secret and on Elliptic Curve Digital Signature Algorithm (ECDSA) to keep it secure when gathering information from WSNs.

In this paper, we primarily provide a summary of modern privacy-preserving data aggregation techniques. Although either the user's private data or the intermediate information may be released, the current privacy preserving data aggregation approach provides privacy protection for both. In order to protect users' anonymity, we describe a wide variety of effective and realistic data aggregation strategies that involve data confusion.

III. REQUIREMENTS OF PRIVATE DATA AGGREGATION

Privacy-preserving data aggregation (PPDA) is a critical requirement for many IoT applications, especially those involving sensitive or personal data. PPDA refers to the process of collecting and aggregating data from multiple sources while ensuring the privacy and confidentiality of the individual data points. Here are some of the key requirements of PPDA:

Data Privacy: The primary requirement of PPDA is to ensure the privacy and confidentiality of individual data points. This can be achieved using various encryption and key management techniques that enable data aggregation without revealing the underlying data.

Data Integrity: PPDA also requires that the aggregated data is accurate and reflects the true values of the underlying data points. This can be achieved using various techniques such as data validation and error correction, to ensure that the aggregated data is free from errors or tampering.

Scalability: PPDA systems should be able to handle large volumes of data from multiple sources in real-time. This requires efficient data storage and processing techniques, as well as distributed data aggregation algorithms that can handle the scale and complexity of IoT data.

Efficiency: PPDA should be designed to minimize computational and communication overheads, to enable efficient data aggregation without compromising privacy or accuracy. This can be achieved using techniques such as data compression and optimization, as well as parallel processing and distributed data storage.

Flexibility: PPDA systems should be flexible and adaptable to different types of data and use cases. This requires a modular and extensible architecture, as well as the ability to support different types of data sources and data formats.

Trustworthiness: PPDA systems should be trustworthy and secure, to ensure that the aggregated data is not vulnerable to unauthorized access or tampering. This requires strong authentication and access control mechanisms, as well as robust security protocols and monitoring systems.

Anonymity: PPDA systems should provide some level of anonymity to data sources to protect the identity of users or devices providing the data. Anonymity can be achieved using techniques such as data masking, randomization, or differential privacy.

Selective data Sharing: PPDA systems should provide fine-grained control over which data is shared and with whom. This requires access control mechanisms and data sharing policies that can be customized for different users or groups.

Data Provenance: PPDA systems should provide information on the origin and history of the aggregated data to enable auditing and accountability. This requires the ability to track data sources and the processing steps applied to the data.

Regulatory Compliance: PPDA systems should comply with relevant data protection regulations and standards, such as GDPR or HIPAA. This requires ensuring that the processing and storage of data meet the necessary security and privacy requirements.

Resource Constraints: PPDA systems deployed in IoT environments often face resource constraints, such as limited bandwidth, processing power, or energy. This requires optimizing the PPDA algorithms and protocols to reduce resource consumption without compromising the privacy or accuracy of the data.

Interoperability: PPDA systems should be able to interoperate with other systems and data sources to enable data sharing and collaboration. This requires standardization of data formats and protocols, as well as the ability to integrate with existing data management and analytics systems.

IV. COMPARATIVE ANALYSIS

Here, we evaluate the efficiency of currently available algorithms for aggregating IoT data in a way that protects users' privacy. TheComputational Cost, communication overhead, privacy level, and privacy against the aggregator IoT sensor node are the most crucial performance criteria.

Computational Cost: The algorithms will be evaluated based on their computational complexity (CC).

Communication Overhead: Communication overhead refers to the total amount of packets that must be transported from one node to another.

Privacy preservation Level and Privacy against Aggregator: Protect information from prying eyes. Below, we examine and summarise Table 1's technique comparison.

Table1. Comparative analysis of Privacy preserving data aggregation Techniques for IoT

Technique	Privacy preservation efficiency	Communication overhead	Aggregation accuracy	Computational overhead	Privacy against aggregator
CPDA	Excellent	Fair	Good	Fair	Yes
SMART	Excellent	Large	Good	Small	Yes
PPCR	High	Very Small	-	Medium	No
PIP	Medium	Medium	-	Medium	Yes
SPDA	-	Light-weighted	Very High	-	Yes
EC-OU & ECDSA	High	Small	-	Very High	Yes

The accompanying table compares these cutting-edge methods across a variety of useful metrics. In the IoT, these are the most desirable characteristics of any privacy algorithm.

SUGGESTIONS FOR FUTURE WORK

Develop new PPDA Techniques: While there are many existing PPDA techniques, there is still room for developing new and more efficient techniques. Future work can focus on developing novel PPDA techniques that can handle different types of data and use cases, while preserving the privacy and accuracy of the data.

Evaluate PPDA Techniques in Real-World Scenarios: Most of the existing research on PPDA techniques has been conducted in controlled laboratory environments. Future work can focus on evaluating PPDA techniques in real-world scenarios, such as smart cities, healthcare, or industrial IoT, to assess their performance and effectiveness in practical settings.

Address Scalability and Efficiency Challenges: Scalability and efficiency are critical challenges in PPDA, especially when dealing with large volumes of data from multiple sources. Future work can focus on developing new algorithms and protocols that can handle the scalability and efficiency challenges of PPDA, while ensuring privacy and accuracy.

Consider the Ethical Implications of PPDA: PPDA techniques have important ethical implications, such as the potential for privacy violations or discrimination. Future work can focus on developing ethical guidelines for PPDA, as well as evaluating the social and ethical impacts of PPDA on different stakeholders.

Enhance Interoperability and Standardization: PPDA techniques must be interoperable with other systems and data sources to enable data sharing and collaboration. Future work can focus on enhancing interoperability and standardization of PPDA techniques, through the development of common data formats, protocols, and APIs.

Address Resource-Constrained Environments: PPDA systems deployed in resource-constrained environments, such as low-power IoT devices, may face significant challenges in terms of resource consumption. Future work can focus on developing PPDA techniques that can operate efficiently in resource-constrained environments, while preserving privacy and accuracy.

CONCLUSION

Privacy-preserving data aggregation is an essential approach to address the privacy concerns that arise when data is collected from IoT devices. In this approach, data is aggregated in a way that preserves the privacy of individual device owners, while still providing useful insights to data analysts.Various privacy-preserving data aggregation techniques have been developed, including encryption-based techniques, randomized techniques, and differential privacy-based techniques. Each technique has its own strengths and weaknesses, and the choice of technique depends on the specific use case and requirements.

However, despite the effectiveness of these techniques, privacy-preserving data aggregation is still an active area of research. As IoT devices become more ubiquitous, there is a growing need for more efficient and effective privacy-preserving data aggregation techniques that can handle large amounts of data and provide even stronger privacy guarantees. Privacy-preserving data aggregation is a crucial technique for ensuring the privacy of sensitive data collected from IoT devices while still providing useful insights. However, there are several issues and challenges that must be addressed when designing such systems. In this review, we analyzed existing privacy-preserving data aggregation protocols in IoT sensor nodes and compared them based on different performance parameters. This critical analysis provides new insights and research strategies for expanding existing systems and implementing new, secure and efficient privacy-preserving data aggregation techniques.

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