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ORIGINAL ARTICLE

An Adaptive Sensor Data Access Framework for Mobile and Web Environments

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ABSTRACT

Wireless Sensor Networks (WSNs) have emerged as an important and attractive area of research due to its significant role in transforming human lifestyle globally. Infact, WSNs have evolved as a technology that enables the collection and dissemination of real-time data from a variety of physical environments. The applications of WSNs are diverse ranging from environmental monitoring, smart agriculture to industrial automation and smart cities. However, the increasing complexity and dynamic nature of these applications pose significant challenges to efficient and adaptive data access in WSNs. The proposed research addresses the multifaceted landscape of WSNs, acknowledging their crucial role in numerous domains. Applications of WSNs range from monitoring environmental parameters such as temperature and humidity to more complex tasks like tracking healthcare metrics and managing smart infrastructure. Despite their versatility, WSNs face several challenges that hinder their optimal performance. These challenges include energy constraints of sensor nodes, the dynamic nature of the environment and the need for reliable and real time access to sensors' data. In particular, the adaptability of WSNs to changing conditions and user requirements remains a critical research challenge. The focus of this research is the development of an Adaptive Sensor Data Access Framework (ASDAF) that addresses the challenges. This framework is envisioned to seamlessly integrate with mobile and web environments, thereby providing a responsive and adaptive approach to accessing sensor data in real time. The proposed approach will encompass advanced algorithms and mechanisms for real-time adjustments to changing environmental conditions, varying network dynamics, and evolving user preferences. The integration with mobile and web applications is seamless, ensuring that the end-users experience a continuous and responsive flow of sensor data tailored to their specific needs. This research is positioned at the intersection of WSNs, mobile and web applications, and adaptive computing that aim to contribute significantly to the evolution of WSNs, making them more resilient, user-friendly, and adaptable to the constantly changing demands of modern WSNs applications in terms of sensors' data acquisition.

Keywords: Wireless Sensor, Networks, *Data, Adaptive, Realtime, Framework*

Author`s Contribution

[1,2] Data analysis, interpretation, and manuscript writing, Active participation in data collection
[2,4] Conception, synthesis, planning of research. Interpretation and discussion

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INTRODUCTION

Wireless sensor networks (WSNs) are composed of distributed, small, self-organized, autonomous and resource constrained devices that are deployed to seamlessly monitor some physical or environmental conditions like humidity, temperature, pressure, sound, motion or vibrations, etc. Wireless sensor networks are initially designed and developed for military applications, however later these networks have emerged/evolved into other domains for industrial and civilian applications. More precisely, wireless sensor networks comprising many cheap, small and resource constrained devices (usually called sensor nodes) that are densely installed or deployed to monitor some physical or environmental conditions [1, 2]. These tiny inexpensive sensor nodes can sense, storing, processing and wirelessly transmitting/communicating data to a central base station or sink node for further analysis and decision-making. Due to distributed nature, wireless sensor networks enable real time data collection over wide geographic areas, which make them highly significant in applications such as environmental monitoring, industrial automation, healthcare, and smart cities [3, 4]. Ongoing research in WSNs aims to enhance security [5], data accuracy [6], optimize query processing [7] and enable intelligent, self-organizing network behavior to meet demands of increasingly complex and large-scale applications [8].

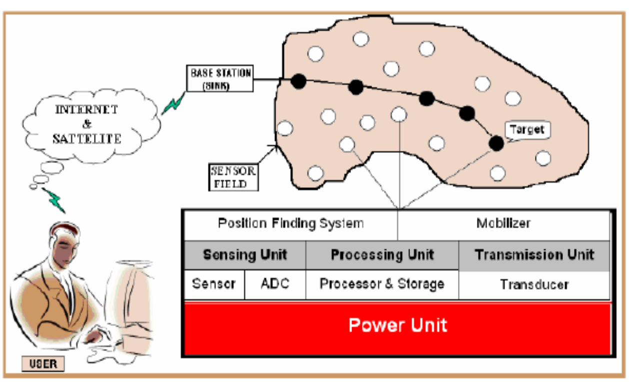

Figure-1: Communication Architecture of Wireless Sensor Networks (WSNs) [2]

A typical WSNs architecture (as shown in figure 1) consists of three main components, which are described below:

(i) Sensor Nodes: Sensor nodes are very tiny and inexpensive and resource constrained (i.e. limited storage, limited processing, limited battery and limited bandwidth/communication capabilities) devices that are used to sense, collect, process and communicate environmental data/conditions.

(ii) Sink Node/Base Station: Sink node or base station is a type of sensor node, which is more capable (in terms of power, storage, battery, etc) than other ordinary nodes within the sensor field. It is responsible for receiving data from ordinary sensor nodes and transmits it to external systems (like the end-user) or cloud platforms for further analysis and future use.

(iii) Communication Links: Wireless communication protocols like WiFi, Bluetooth and Zigbee, are used to exchange data between nodes and base stations, while internet and/or satellite technology is used to connect the sensor fields/base stations with the end user applications.

Jumping into more details, as shown in figure 1, a sensor node may consist of four major parts and two additional parts. The four major or compulsory parts of sensor node include sensing unit, processing unit, transmission unit and power unit, while the two additional parts include position finding system and mobilizer [2, 7]. Each of these components is described below:

a) Sensing Unit: The sensing unit is the core part of a sensor node. Its primary responsibility is to sense physical environment, such as temperature, pressure, humidity, or motion. The sensed data is converted into an electrical signal and then digitized, after which it is forwarded to the processing unit for further operations.

b) Processing Unit: The processing unit receives digital signals from the sensing unit and performs necessary computations and data processing tasks. It controls the functionality of other components and prepares the processed data for communication. In most sensor nodes, this unit consists of a microcontroller or microprocessor integrated with storage and memory.

c) Transmission Unit: The transmission unit is responsible for enabling communication between sensor nodes and the base station. It transmits processed data to other nodes or a base station using radio frequency (RF) communication protocols such as Zigbee, Bluetooth, or LoRa. Additionally, it receives data from neighboring nodes for collaborative processing or forwarding, which is essential for multi-hop communication in WSNs.

d) Power Unit: The power unit is one of the most important components of a sensor node, as it provides the necessary energy for all operations. Typically powered by batteries or energy-harvesting mechanisms, this unit determines the lifetime of the node. If the power unit fails, the entire sensor node becomes non-functional. Therefore, energy efficiency is a major research challenge in WSNs design, and several strategies, such as low-power communication and sleep scheduling, are implemented to optimize power consumption.

e) Position Finding System and Mobilizer: The position finding system and mobilizer are the two additional components of sensor nodes. Note that wireless sensor networks can be classified as static and mobile networks [16]. These two components are available in those sensor nodes, which are part of a mobile wireless sensor network and help in dealing with mobility management.

As stated earlier, WSNs have a wide range of applications in numerous fields such as healthcare (monitoring patient heartbeat, checking blood pressure, etc), military perspective (monitor battle field surveillance), fire-fighting (detecting fire outbreaks, trigger alarms and even shut down the main power supplies to prevent hazards.), in smart cities, smart transportation systems, smart grid station, agriculture, manufacturing, smart vehicle / object tracking system, and entertainment [8 – 13]. On the one hand WSNs offer great benefits, while on the other hand these still face many research issues and challenges including security, power consumption and data acquisition, etc. Security threats include provenance forgery [4], node replication [5], DoS, DDoS, selective forwarding, sybil, and spoofing attacks, etc [14 – 20]. The studies [14 – 20] demonstrate that these security threats can generate untrustworthy data, for which may adversely affect decision-making and lead organizations in erroneous direction. At the other hand from the perspective of power consumption, substantial research work has been carried out to minimize the energy consumption in WSNs [21 – 24]. Though all research challenges are significant, among them, the focus of this research work is on data acquisition and query processing challenges, more precisely, this research proposes an adaptive data acquisition framework for mobile and web environments.

The rest of the paper is organized/structured as follows: section II is literature review, which provides comprehensive overview of the relevant literature, section III provides the details of the proposed adaptive sensor data access framework, and section IV concludes the paper and provides future directions.

LITERATURE REVIEW

A substantial body of research has been conducted on data collection and data gathering techniques in Wireless Sensor Networks (WSNs). This section provides a comprehensive review of the relevant approaches with a particular focus on adaptive sensor data collection mechanisms, highlighting their key advantages and inherent limitations. In addition, a concise comparative summary of the reviewed approaches is provided in tabular form for clarity and ease of analysis.

In [7] Malkani et al. have proposed a query processing and data acquisition approach for wireless sensor networks, which is mainly based on structured query language (SQL). Authors [7] have tested and validated the proposed approach empirically using web technology/interface, however it is not tested using mobile platforms. Additionally, this approach [7] is an effective and easy solution from data access point of view, but it becomes inefficient when it is applied to resource constrained and densely deployed sensor nodes, because SQL is not an efficient solution for resource constrained devices like sensor nodes.

In [21] Liu et al. have proposed an intelligent and smart data fusion approach for WSNs, which is based on hybrid delay-aware adaptive clustering scheme. It is noted that in [21], authors have conducted a theoretical analysis of delay and energy consumption for single-layer clusters and multi-layer clusters at different fusion rates. The proposed algorithm dynamically forms cluster structures using a linear weighted sum method, thereby achieving an effective trade-off among energy consumption and delay. A limitation of this approach is that when number of nodes reaches 55 (n=55) or above, the delay increases significantly.

In [25] Yee Wei Law et al. have proposed an adaptive sampling algorithm can reduce sampling (sampling which refers to the action or process of sensing) by 24% to 49% a specific dataset used in simulations. This algorithm improves energy efficiency by decreasing sampling. However, the major drawback is that it is tailored to specific datasets used in simulations, so changing the dataset(s) may impact the algorithm's performance.

In [26] Chao Wang et al. the main focused reducing communication costs compared to the SAF scheme. The proposed scheme utilizes spatial and temporal correlation to minimize communication costs, thereby reducing energy consumption. The key advantage of the proposed scheme is that it minimizes communication or transmission cost for data acquisition with a guaranteed error bound. By exploiting the temporal correlation through a linear rend component, the estimation capability is enhanced. However, a limitation of proposed Approximate Data Collection (ADC) scheme is that the maximum error of ADC is slightly larger, with the error bound Δ (the error bound increasing with application-specific requirements). This means that as Δ (delta) increases the error of ADC also increases which directly impacting the data quality. i.e. if Δ=0.4, the communication cost of ADC is higher as the message paths used by ADC are longer than Similarity-based Adaptive Framework (SAF).

In [27] Xia Yang et al. have proposed a data acquisition scheme for wireless sensor networks, which involves compressing sensory readings in real time by leveraging the opportunistic routing. They utilized a Nonuniform Sparse Random Projection (NSRP) model for data collection process and introduced an NSRP-based estimator which uses high probability, to guarantees optimal (small) estimation errors, while consuming less energy to extend (prolong) the network lifetime. A major limitation of this approach is its inability to handle anomaly readings such as sensor faults or outliers.

Li Luo [28] highlights the advantage of the proposed approach, which focuses on IPv6 addressing over other technologies such as 3G/4G/GPRS, Bluetooth and ZigBee, etc. The use of IPv6 addressing provides a huge number of addressing, making it applicable for large scale applications like smart campus data collection and query processing systems. The authors [28] leverages the features of IPv6 over Low-Power Wireless Personal Area Network (6LoWPAN) technology to design and implement the smart campus for data acquisition. This technology offers IPv6 addressability, low power consumption, as well as large network capacity. Choosing GPRS/3G, or 4G wireless network communication has major drawback, such as a restricted network size and maximum of 32 Wi-Fi network nodes. Whereas Bluetooth technology is primarily used for short-range point-to-point data communication and collaboration. In inquiry mode, the server sends query instructions after receiving data, leading to increased communication/transmission load in the data collection process and hence reduces data collection efficiency.

In [29] Rao Yuan et al. have proposed a framework for integrating two forms (of data processing: Compressed Sensing and prediction-based). The major advantage of this approach is its high accuracy in forecasting, which can lead to reduction in transmission by 30-80% through this may vary depending on the application. This framework offers lower sampling frequency, improved flexibility, and enhanced sensing ability for critical events by addressing the limitations of arbitrarily predefined deviation tolerance. Additionally, it includes more data points in the switching mechanism between CS and prediction-based modes compared to SWIFTNET. However, a drawback of this framework is that there are more data points in the prediction-based mode than CS. This may result in frequent changes in data gathering mode due to fluctuations around the prior threshold. Furthermore, there is a narrower range of perception switching in soil moisture compared to air humidity. However, another drawback of this scheme is that when sampling rate falls below one-fifth (1/5), the reconstruction accuracy adversely affected.

In [30] S. Diwakaran et al. proposed a scheme that utilized an Autoregressive Integrated Moving Average (ARIMA) prediction model combined with the Principal Component Analysis (PCA) reduction algorithm to reduce power consumption. The main advantage of this scheme is its lower power consumption, allowing all nodes to remain active up-to 2900th round. It offers a 50% increase in node longevity compared to spatial and temporal methods. Where nodes typically fail at the 2100th and 1800th rounds respectively. However, a drawback of this approach is that all nodes fail (die) by the 3000th round, impacting the network overall lifespan.

In [31] Hidaya Liazid et al. proposed an enhancement to the adaptive Dual Prediction Schemes (DPS) algorithm, achieving a 99% reduction in communication without sacrificing accuracy. The proposed scheme aims to avoid using a history table when updating the model. The main advantage of this approach is that its leading to improved performance by reducing the number of transmissions compared to the standard (ordinary) adaptive DPS. However, a limitation of the proposed scheme it that it is specifically suitable for a ring model. The accuracy of the scheme relies on the prediction accuracy of the sensor node; if the sensor node compromised from a security perspective, the scheme may not deliver satisfactory results. Additionally, the use of Machine Learning Artificial Neural Networks (ML ANN) is not feasible in Wireless Sensor Networks as it requires more extensive computation for training on large datasets, leading to increase energy consumption.

In [32] Najem Naji et al. proposed an approach for data acquisition called Energy Aware Context Recognition Algorithm. This approach aims to minimize energy consumption in Wireless Sensor Networks (WSNs). The main advantage of this approach is that it reduces the data packet size, leading to increased the sleep mode time for both the Arduino Nano programming board and the ZigBee RF module. As a result, this approach helps in reducing energy consumption.

In [33] Aiping Pang et al. proposed a Path-based Equalization Algorithm Based on Ratio (PEABR) that focuses on routing strategy and path planning to optimize data collection and balance energy consumption within a network. The approach involves dividing the network model into equal areas, each mentioned by clusters. Multiple mobile nodes act as data collectors, moving through each cluster node. As the number of sensor nodes increases, more mobile nodes are added leading to redivision. The main optimization objective is to minimize the path length of mobile nodes. However, the approach may not suitable for sensitive areas like military or medical domains as it relies on cluster heads waiting for mobile nodes (data collector).

In [34] Tain Wang et al. proposed parallel algorithm (DCF) aimed to achieve the minimum cost schedule between voronoi areas to maximize throughput and minimize latency from wireless sensor networks to the cloud. They developed an energy-efficient routing algorithm for all sensors in routing layer, considering factors such as hops and energy consumption. The simulation results demonstrate a significant reduction in both transmission delay and energy consumption. However, a drawback of this scheme is potential data loss if the sink or sensor is busy during schedule data transmission, as they do not update each other about sending/receiving data.

In [35] Guanghua Liu proposed Q-learning-based frequency-selective routing scheme. This feature is achieved by utilizing a kernel regression method to monitor the underwater environment. The advantage of this approach is that it uses multifunction sensor node (Multif-Sor) in bidirectional projection-based topology to enhance network reliability.

In [36] Rachit Manchanda et al. proposed a framework called Novel Framework Energy-

Efficient Compressive Data Gathering (NFECG) protocol, which consists of four phases such as Cluster Head (CH) selection (based on energy, distance node density) sleep scheduling for cluster members. Data compression at CH, and Data recovery at the sink. The efficiency analysis was conducted using ECDA and Energy-adjusted High-level Data Tool (EHDT) protocols, which are the main advantages of NFECG. It reduces redundant node participation, leading to decreases in the number of transmissions to the Cluster Head (CH) and alleviates hot-spot issues from network. However, a limitation is that it only works within a specified network area, such as 100 * 100 m^2 and the sink is located outside the network. In Case-II the network area is expanded to 300 * 300 m^2 with 100 and 200 nodes connected, respectively. Increasing the number of nodes can impact network performance. Similarly, if the network area is increase proposed, the approach may not perform as effectively as desired.

In [37] Ahmed Aziz et al. proposed the Chain Construction Algorithm (CCA) scheme / approach, which is used to construct the data aggregation path throughout the transmission and receiving process. To improve the reconstruction process, an efficient Reconstruction Algorithm (RA) is implemented to recover the original data from the compressed samples. The advantage of the proposed approach is that it reduces energy consumption, thereby increasing the network's lifetime. The proposed scheme yields satisfactory results compared to OMP, ROMP, and PEGASIS. It utilize Compressive Sensing (CS) with a seed estimation algorithm and the Chain Construction Algorithm to improve network lifetime. According to the literature, however, a major drawback is that it supports only 54 Mica2Dot sensor nodes, meaning that an increase in the number of nodes beyond 54 directly impacts network performance.

In [38] C Sureshkumar et al. proposed an Adaptive Adjacent Base Compressive Sensing (AACS) approach to enhance network lifetime, reduce distance, and reconstruct the network under specific conditions. The approach involves setting a threshold for sending or discarding packets and selecting the best forwarder node based on fuzzy logic considering mobility, energy, and fuzzy cost parameters. Temporal and spatial coordinates are utilized to enhance communication within a constrained (limited) time frame.

In [39] Jose Yeal Lopez Hernandez et al. proposed and implemented a prototype of an adaptive logging algorithm aimed at reducing the size of Comma Separated Values (CSV) file and improve energy efficiency. The algorithm designed to be reliable in a resource-constrained environment by reducing computational load, thereby extending battery life. However, a drawback of this approach is a 23.24% loss data during testing. It is worth noting that using a webpage can further increased data loss. Analysis of the CSV file, it relived that each request from webpage to the server caused in an average delay of 5s (s denoted second) resulting temporary halt data transmission.

In [40] Ping Hung proposed a distributed method based on non-linear regression that combines the time series relationship between data. The advantage of this approach is that it realis on wireless sensor networks for data acquisition and processing without considering network topology and other issues. However, a drawback of this approach is that the amount of data collected and transmitted decreases as the error threshold increases.

Table 1 presents the summary and comparative analysis of the literature review, which consists of eighteen studies from 2009 to 2024. Note that in table 1 NR means “Not Discussed” or “Not Reported by authors”. A key difference among the studies is adaptiveness, with only about half incorporating adaptive data collection strategies, while the remaining are using static methods. The evaluation and testing strategies reveal that vast majority of existing systems were evaluated solely through simulation tools like MATLAB, or Network Simulator-2, while very few approaches were evaluated or validated using real-world testbeds. Additionally, integration with mobile platforms and web services remain largely unexplored area, with

Table 1: Comparative analysis of the reviewed approaches

Reference No	Year	Adaptive?	Tested using mobile platform?	Tested using web service or web interface?	Evaluation and/or Data Acquisition Methodology
[7]	2023	N	N	Y	Customized / Proprietary testbed and structured query language (SQL) is used
[21]	2020	Y	N	N	Tested and evaluated using simulations; however the detail of simulation tool is not mentioned in the paper
[25]	2009	Y	N	N	Simulated using Project R, and 5000 samples are processed for each simulation experiment
[26]	2012	Y	N	N	Implementation and evaluation is carried out using mobile apps and declarative queries
[27]	2015	N	N	N	Evaluation is done by simulation, IntelLab, NBDC, CTD; dataset is collected from greenOrbs
[28]	2018	N	Y	N	Data acquisition system is tested and evaluated through a web based application that is developed using Python language in Django framework
[29]	2019	N	N	N	Compressed and Predication-based approach; evaluated using two datasets
[30]	2019	Y	N	N	Simulations using MATLAB
[31]	2019	Y	N	N	MATLAB/ SimuLink
[32]	2019	Y	N	N	Customized / Proprietary Testbed
[33]	2020	N	Y	N	Simulations using MATLAB
[34]	2020	N	N	N	Simulations using MATLAB
[35]	2021	N	N	N	Simulations are carried out; however simulators are not reported in detail
[36]	2021	N	N	N	The NFECG simulated in MATLAB version 2017a under two different criteria (i.e. network area and number of nodes)
[37]	2021	Y	N	N	Simulations are carried out; however simulators are not reported in detail
[38]	2023	Y	N	N	AACS is simulated in Network Simulator-2 (NS2)
[39]	2024	Y	Y	Y	Simulations using MATLAB
[40]	2024	N	N	N	Simulations using MATLAB

only small subset of approaches demonstrated such capabilities. Moreover, from the data given in table-1 several important research issues/gaps in existing data acquisition approaches are highlighted, which are discussed below:

- **Lack of adaptability:** Mostly, existing approaches are either static or partially adaptive and fail to respond dynamically to changing network conditions etc.
- **Limited practical validation:** A heavy reliance on simulations, without extensive real-world or testbed validation, raises concerns regarding scalability, robustness, and real-time applicability.
- **Insufficient data acquisition transparency:** The absence of clearly defined data acquisition techniques in many studies undermines reproducibility and restricts meaningful comparison across technologies.

Considering the facts, it is advocated that there is a strong need for comprehensive and adaptive framework for sensors' data access like the one presented in this paper.

PROPOSED FRAMEWORK

As stated table-1 presents a comprehensive summary of existing approaches for accessing and managing sensor's data in WSNs, however, these approaches face some limitations like firstly, these approaches are unable to adequately handle real-time and dynamic query processing efficiently, secondly, most of these approaches are less flexible and more application specific, and hence lack the generality feature and are also less scalable.

In this paper, we are proposing an adaptive sensor data access framework (ASDAF) to deal with research gap. Figure 2 presents the high-level architecture of the proposed Adaptive Sensor Data Access Framework (ASDAF) for wireless sensor networks. The proposed ASDAF is composed of four layers, which are listed below:

1. Application Layer
2. Access Management Layer
3. Processing and Storage Layer
4. Wireless Sensor Network Layer

Explanation of each of above listed parts of the proposed framework is given in subsequent sections below:

A) APPLICATION LAYER:

This is first layer of proposed framework, which serves as the interface enables end-user applications to submit request for accessing sensor data. Applications may include Android or iOS-based apps as well as web applications that operate through web browser or dedicated portals. This layer performs several key functions, including:

- Submitting request for sensor data.
- Defining access conditions (e.g. location, device-type etc.).
- Visualize real-time data or historical sensor data.
- Managing user interactions and feedback.

B) ACCESS MANAGEMENT LAYER:

This layer is further divided into two sub-layers. This layer plays a key role for data accessing and management. It enables system to adapt itself in dynamic environmental conditions in order to ensure uninterrupted data access. The adaptability feature is important for maintaining continuous access, as the system adjusts to changing conditions. This layer consists of two sub-components including context adaptation and policy-based access control components.

- **CONTEXT ADAPTATION:** The role of this subcomponent is to ensure the adaptability which means dynamically access permissions and data flow based on context (e.g. user location, time of day, network status, and energy level of sensors, etc).
- **POLICY-BASED ACCESS CONTROL:** As the name of this subcomponent indicates that it ensures access to sensor's data based on policies.

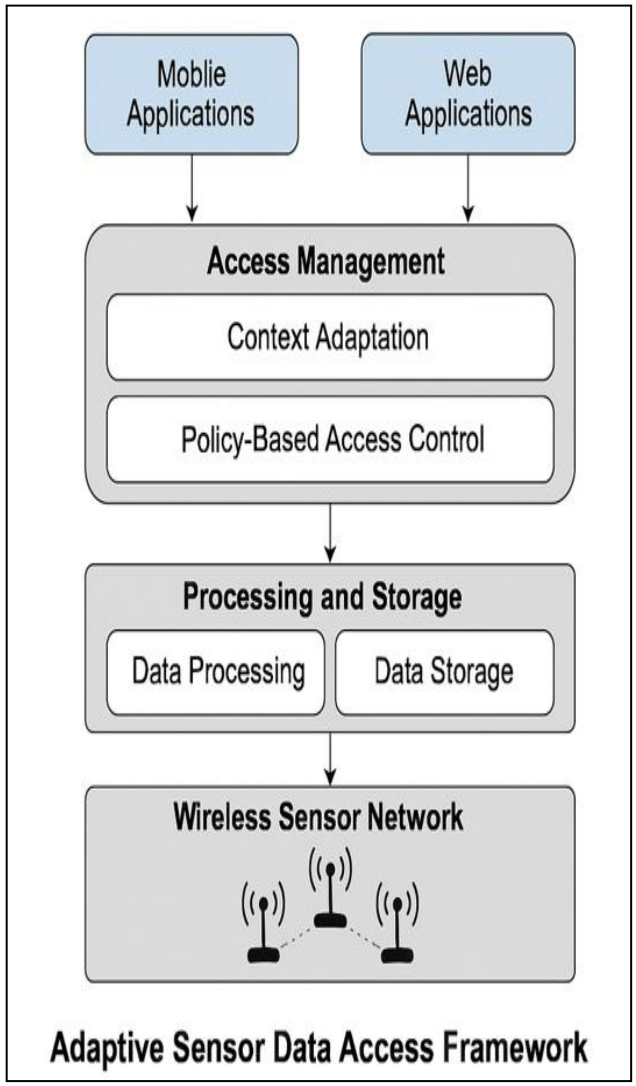

Figure – 2: High-level Architecture of the Proposed Approach

C) PROCESSING AND STORAGE LAYER:

This layer is further divided into two sub-components: data processing, and data storage. Its primary role is to process, store, and display sensors' data to the end-user. It is located closer to the sensors and is responsible for processing and storing data.

DATA PROCESSING: The primary focus of this sub-layer is to retrieve data from the sensors (e.g. LDR, motion, and humidity sensors, etc) that sense physical phenomena in real time and transmit the data for further processing.

DATA STORAGE: The fundamental responsibility of this layer is to store sensors' data/reading for future use, further analysis/examination and/or for decision making purposes. For storage, a database is utilized, with each data entry recorded along with its corresponding data and timestamp.

D) WIRELESS SENSOR LAYER:

This is final layer of the proposed framework, known as physical layer, which is directly connected to all sensor nodes (e.g. LDR, temperature, humidity, etc). The primary responsibility of this layer is to generate sensor readings/data. It reads sensor data in analog form, converts it into electronic format, and then transmits the generated data to the associated program/module for further processing and storage. The primary focus of the proposed framework is to ensure adaptability, as this is a key property that allows the system to behave and adjust dynamically.

In this paper, the theoretical details of the proposed adaptive sensor data access framework (ASDAF) have been presented. Currently, we are working on the real-world system implementation and testing of the proposed adaptive sensor data access framework (ASDAF). In system implementation, testing and evaluation, several hardware and software components are being used. Hardware components include Arduino and Wemos boards and several sensors like temperature and humidity sensors (i.e. DHT11), passive infrared (PIR) motion detection sensor, light dependent resistor (LDR), etc. At software level, Arduino and Python programming is being used. Arduino follows the C style programming for writing code for Arduino and Wemos boards, while Python programming is being used to write code for mobile and web applications that will be used to test and validate the proposed approach. The system implementation, testing and evaluation of the proposed framework will be presented in a separate publication/paper.

CONCLUSION AND FUTURE DIRECTIONS

In recent times, wireless sensor networks (WSNs) have got significant attention from industry and academia due to their useful and emerging applications. These networks play an important role in numerous fields, including healthcare, security, entertainment, object detection, military, smart agriculture, smart transportation, and smart grid stations etc. Extensive research has been done in wireless sensor networks from various perspectives, such as security, network coverage, energy efficiency, and data access and query processing, etc. Among those, the focus of this work is on sensors' data access and query processing. We advocate that real-time and adaptive sensors' data access is given less attention in wireless sensor networks. Therefore, our research focuses on this aspect to provide real-time data acquisition and propose a framework for mobile and web environments in wireless sensor networks. In the future, we plan to develop working prototypes of the proposed system and to evaluate it in real world and dynamic scenarios of wireless sensor networks.

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