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A MULTILEVEL CLOUD ARCHITECTURE FOR PROCESSING SENSOR NETWORK QUERY TO INCREASE LIFETIME OF SENSOR NETWORK

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ABSTRACT

These days WSNs are being used in different areas like medical services, defense, such as military target tracking and surveillance, government and environmental services like natural disaster relief, hazardous environment exploration, and seismic sensing, and so forth. The data and information provided by these sensors are used to screen and control their deployed environment. The amount of information in sensor system is immense, heterogeneous and multidimensional in nature. Integration of cloud computing with a sensor system takes care of the issue of vast amount of capacity and computation power necessity of this type of system. This paper proposes a cloud based multilevel architecture for processing sensor network query to expand the lifetime of the target sensor network.

KEYWORDS: Sensor network, cloud computing, absolute validity, relative validity, hybrid database, Case Base Reasoning (CBR).

I. INTRODUCTION

The progression and utilization of wireless sensor networks become an unbeatable trend into the various industrial, environmental and commercial fields. A WSN contains spatially dispersed self-governed sensors that cooperatively screen the ecological conditions, like sound, temperature, pressure, movement, vibration and contamination [1, 2]. At present WSNs are used to provide different types of services in several areas like healthcare and defense. These services include military target tracking and surveillance, natural disaster relief operation, hazardous environment exploration like earthquake monitoring and so forth. The data provided by these sensors are used to monitor and control their deployed environment. Large amount of memory and computation power is needed to process huge amount of different types of multidimensional data of the sensor network. But resource constraints and design constraints obstructed the processing of information within sensor network. The resource constraint includes computation power, memory and storage capacity, communication bandwidth. Design constraints depend on two factors; one is nature of the application and the other is deployed environment [6]. Cloud computing becomes the computing paradigm of future [3]. It basically provides three types of services which are IaaS, PaaS and SaaS [5]. The limitation of a sensor network is now overcome with the integration of cloud computing's theoretical infinite amount of computation power and storage.
Data processing in cloud computing is done using two approaches which are as follows

- First sensor network sense data and forward it to the cloud for processing [7, 12].
- Cloud data processing system first process query, subdivide the query and forwards into sensor network. In response of query sensor nodes sends only required data [13]. In [10] author uses TinyDB as one of the sensor database and TinyDB is an acquisitional query processing system for sensors [14].

This paper proposes a cloud based multilevel architecture for processing sensor network query to expand the lifetime of the target sensor network. The novelty of this approach basically relies on two key aspects, one is reformation of the query so that only those portions of the query will be executed in WSN which cannot be fulfilled from the cloud storage and another is selection of the optimal set of sensors instead of accessing of whole WSN.

II. RELATED WORK

The limitation of WSN is surmounted through the integration of cloud especially for data processing. “CLOUDVIEW”, a framework dedicated for fault data prediction is used to process the data collected from sensors attached with industrial machines. The embedded sensors sense data and transmit this data in cloud for processing [7]. This system uses CBR and distributed Hadoop and Map-Reduce approach to process streaming time series data. But the disadvantage of this system lies in the use of the batch processing style of Hadoop.

In [8] authors concentrate on maintaining the isolation and consistency property of sensor transaction. Sensor query processing has 2 parts- one is one-time processing part and another is continuous query execution part. The problem occurs when multiple continuous part are executed on sensor network. Temporally Nested Query approach is used for Isolation and timestamp based validation based Protocol is used for Concurrency and consistency Management of query processing. To implement above approaches two assumptions are made, first at most one validation phases can execute at a time and secondly Validation and commit occur in a critical section. But the problem is if one validation and commit is used at a time, then how system will grant access to multiple users, especially when data volume is huge and streaming in nature and the network is failure prone. Again system would not be able to handle large no of transaction. This also leads to lack of scalability. There is no transaction prioritization scheme. Again the transactions are more involved in the conflict checking process rather than execution.

Sensor data can be categorized into two types, one is semi organized and the other is unstructured. In [9] Apache Hadoop and Map-Reduce is used to process this data.

The multilevel data processing framework for sensor network consists of a coordinator and gateway to collect and store data from multiple sensor networks connected with the local server. The local server is responsible for the computation and backup of data collected from sensor networks. Map-Reduce parallel processing is used. But instead in cloud Map is executed at local server and reduces at cloud. This system uses different databases at a time. SQLite and TinyDB are used on gateways to store metadata of the sensor networks. MySQL is used on local servers to store sensor data and historical data. MongoDB and Cassandra are used to store application related data [10]. But this paper does not consider any load distribution strategy and do not specify how to deduce sensor data from existing data or maintaining data precision.

In [11] author incorporated ERP and sensor network to minimize the utilization of resources. The monitoring and controlling of sensor network uses three step approaches which includes collection of data from sensor networks, decision generation and use of decision to turn them on/off or adjust the transmission frequency of sensors of sensor network. This paper mainly focuses on the reconfiguration of the sensor network. At first system collects the data from sensor networks and with the help of middleware it converts data in XML format and send it to cloud-based ERP system. The ERP system processes the data and based on their prediction model it generate some decision or control information and forwards it back to sensor network for reconfiguration. But the approach used in this system incurs more power consumption due to the use of twice data transmission policy.

III. PROBLEM STATEMENT

The main problem of a sensor network is resource constraint. The limited computation power and limited storage restrict a sensor network to process heavyweight and continuous query, as it reduces the lifetime of the network. The approaches [7, 8, 9, 10, 11] discussed above concentrate mainly on the processing of a sensor query using different approaches and inclusion of all the sensors in a network. This motivates to propose a multilevel cloud based query processing architecture which is not only capable to slice the query and forward only those queries to the sensor network for which data is not available in the cloud data storage but also selection of an optimal set of sensors.

IV. PROPOSED SYSTEM

The proposed architecture consists of two modules which are query division module and sensor selection module. The two modules collectively slices the sensor query and selects sensor in such a way that not only those queries are forwarded in sensor network for which data is not available in cloud storage but also selecting the appropriate sensors capable to fulfill the query requirement. The overall system consists of other modules which facilitate to provide correct result corresponding to a sensor query and proper functioning of the system.

Query Division Module

Query Division module analyzes the query targeted to a sensor network and send only those queries which can’t be fulfilled from cloud storage. The purpose of this module is the reduction of sensor access rate to expand network lifetime. The working procedure of this module is divided into four stages which are as follows

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Stage1: The first stage of query division checks whether the query can be served using data stored in cloud by comparing sensor data or not by considering time duration of the required dataset. The steps are

Step1: Extract time duration (tr) of required data set.
Step2: Divide the tr into td and ts.
Step3: if tr<=td then
        Execute sensor query in cloud.
    else
        if td=0 then
            goto stage2.
        else
            Execute query for td in cloud and goto stage2.

Stage2: This stage focuses on query overlap among multiple queries. The parameter set for analyze this are specific to nature of sensor network. The steps are

Step1: Divide parameter sets of multiple queries into overlapping set and non-overlapping set.
Step2: Generate a single query for the parameters of overlapping set.
Step3: Generate separate query for each parameter of non-overlapping set.

Stage3: The stage is compare absolute validity and relative validity of linked data item of incoming query with data stored in cloud storage. Absolute validity parameter is set according sensor network updating ratio. The step is

Step1: if abvq=abvc and rvq =rvc then
        Prepare result set using the data available in cloud storage.
    Else
        goto stage4.

Stage 4: This stage checks whether the intended query is a one time or continuous. If one time query can be satisfied using part of continuous query forward only continuous query in sensor network. The steps are

Step1: categorize one time query and continuous query.
Step2: if one time query is a part of continuous query then
        Forward continuous query to module2.
    else
        Forward both one time query and continuous query to module2.

The working principal of the above module is depicted in fig. 1,2, 3,4 and 5

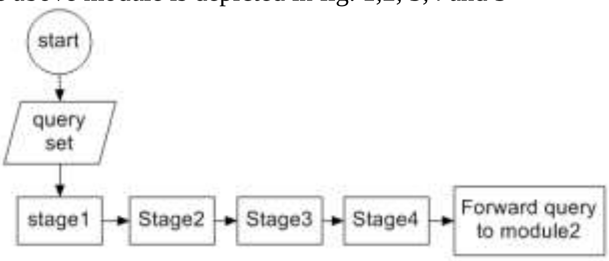

Fig. 1: Query Division Module

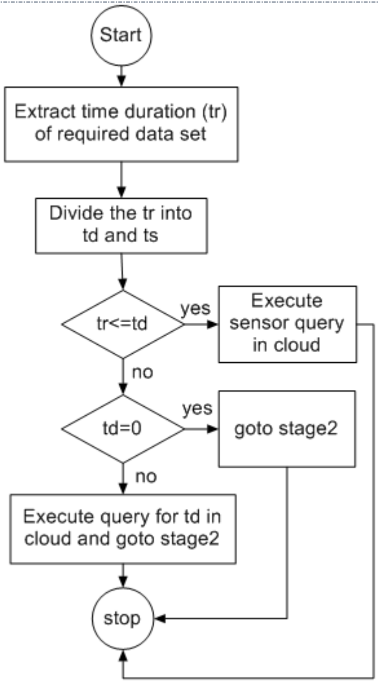

Fig. 2: Stage1

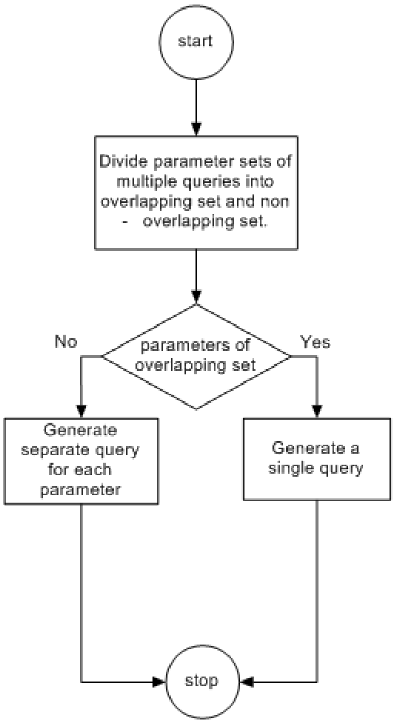

Fig. 3: Stage2

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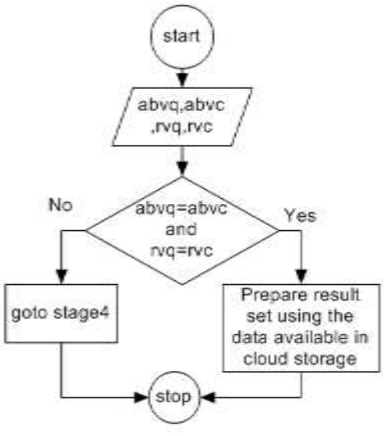

Fig. 4: Stage3

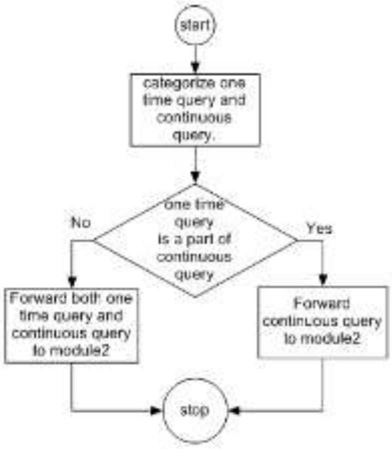

Fig. 5: Stage4

Sensor Selection Module

This module selects the sensors to which query is to be forwarded to collect data based on the following working principle. The steps are

Step1: Determine list of sensor which satisfy query.

Step2: Calculate resource requirement (CR) using the equation 1

$$CR = cpr + mr + V + tf \quad (1)$$

Step3: Calculate workload of the selected sensors (WR).

Step4: Refine sensor list based on CR & WR so that no sensors will be overloaded load.

Step4: Calculate query processing cost, data transmission cost and sensing cost (QDS).

Step5: Divide the sensors for processing, sensing and transmission.

Step6: Prepare optimal set of sensors based on adaptive weighted reservoir sampling. The weight is the distance of sensors from source of event.

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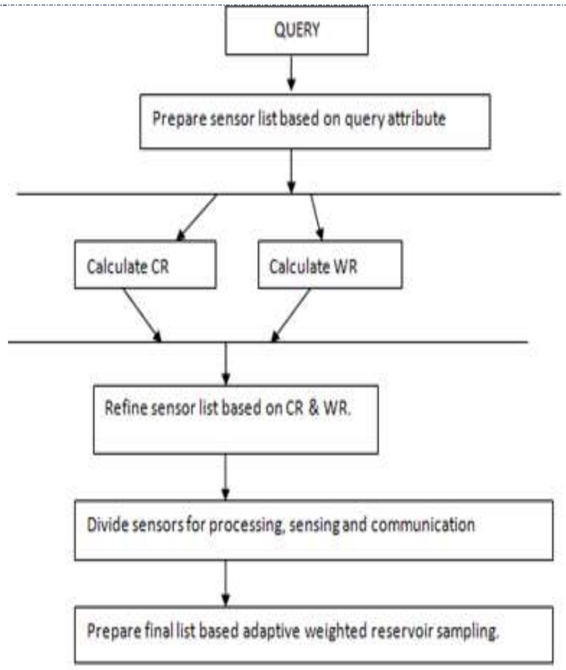

Fig.6. Sensor selection module

V. OVERALL SYSTEM ARCHITECTURE

The proposed architecture contains the modules which facilitate the proper functioning of the system and serves as additional modules.

User Interface Module

This module provides graphical user interface to accepts user query and forward it to data processing module.

Visualization Manager

The visualization manager generates maps and charts based on the collected data according to user requirement.

Cloud Resource Manager

This module is responsible to create, delete and management of Virtual machines to serve multiple query at a time.

Storage Manager

This module maintains two storages, one is for sensors known as sensor storage and other is for storing cloud middleware data known as Cloud Middleware Storage.

Sensor Manager

This module allows user to register, delete and manage WSN.

Cloud Sensor Gateway

This module implemented in cloud gateway provides actual access to sensors and implements sensor specific method to collect data. It acts as a link between the proposed cloud based query processing framework to actual WSN(s).

The architecture of the proposed system is demonstrated using the fig 7

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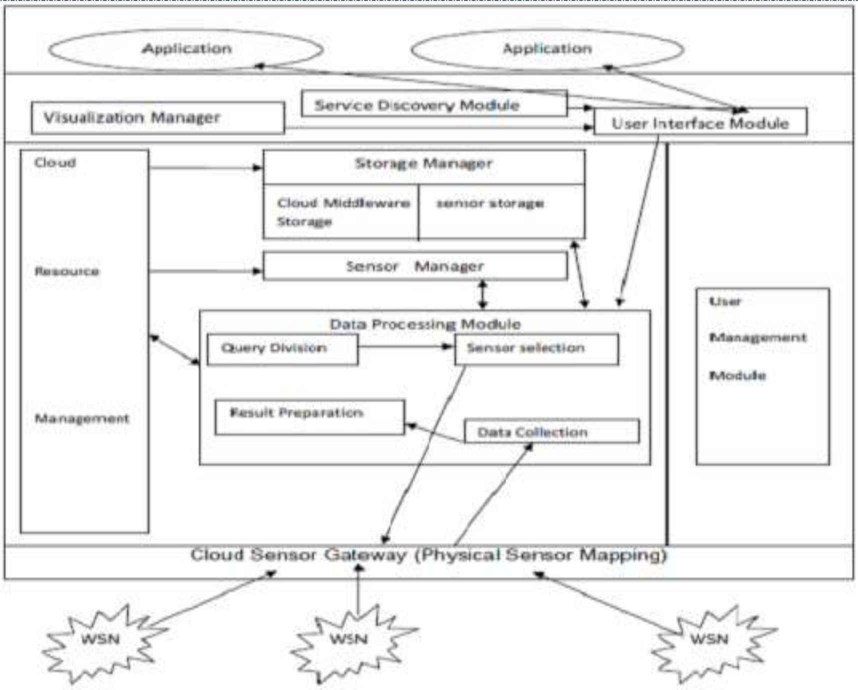

Fig. 7. Proposed System Framework

VI. CONCLUSIONS

The proposed cloud based multilevel query processing framework increases the lifetime of sensor networks by reducing the sensor access rate. There are different existing query processing frameworks which only consider the analysis of query overlap and use of query caching. But this paper not only considers those things, but it also uses absolute validity and relative validity parameter to answer a sensor query from the existing query result stored in the cloud. The novelty of this architecture not only lies in the slicing of a query for a sensor network, but also selection of an optimal set of sensor to overcome the problem of low sustainability of the sensor network.

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