IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-10, Oct 2018 E-ISSN: 2347-2693

Analysis of Energy Consumption for a Distributed Database System Using Smartphone in Cellular Network

Nitin V. Wankhade[1*], S.P. Deshpande [2]

[1]PGDCST, DCPE, HVPM, Amravati, MS, India
[2]HOD, PGDCST, DCPE, HVPM, Amravati, MS, India

[*]*Corresponding Author: nitinvwankhade@gmail.com*

Available online at: www.ijcseonline.org

Accepted: 15/Oct/2018, Published: 31/Oct/2018

***Abstract*—** Fast advancement in the technology offering much smarter functionalities giving tremendous increase in Smartphone users. The battery powered Smartphone is being used to keep people engaged, communicate and remain online throughout the day, no matter where they are located so the scarcity of power is also increased. The technology advancement speed of offering functionalities in the Smartphone is much faster than that of the technology for development in batteries. Most of the applications waste energy in rest condition. The power consumption for a Distributed database system "SmartSource" using Smartphone in cellular network has been analyzed in this paper. The performance evaluation of the consumption of energy for the system is tested and presented.

***Keywords*—** Distributed Database, Smart phone, SMS

I. INTRODUCTION

Almost everybody has a Smartphone, a tablet, or both and these devices are being used to keep people engaged, communicate and remain online throughout the day, no matter where they are located. The applications for these devices are increasing rapidly which uses significant amount of data and power.

Power is the significant source of Smartphone [1]. Freedom of using Smartphone is solely dependent on its battery. The network consumes more memory than any other services [2]. These devices provides rich data rate services like video/audio conference, video on demand, faster internet and many others along with the basic audio call service [3]. Most of the applications waste energy in rest condition. Nowadays the users are trendier towards the faster services or applications but those are more power draining.

Mobile computing has transformed the way most of the people interact with applications using mobile phone [4]. The mobile data management differs from the conventional data management in terms of the mobility of the users, the accessing nodes connected to the system and the resource constraints such as wireless bandwidth and battery life [5]. The computational and networking power of mobile devices is still constantly increasing [6] and new technologies are integrated into them to support new functionalities, services and databases.

Several modern database management systems like SQLite, SQL Anywhere, IBM DB2 Everyplace, Oracle Database Lite, SQL Server Compact [7], etc. supports small-footprint databases that can be executed on mobile devices and admit disconnected computing and synchronization with a central.
Cellular network provides many ways of communication, Bluetooth, NFC, Wi-Fi and Internet. SMS, Bluetooth, and WAP have its advantages and disadvantages [8].

Bluetooth costs nothing to use but is limited by a transmission distance of up to 100 meters. In comparison, using SMS, a particular text or message can be sent to anyone anywhere without disturbing even if the receiver's device is offline, however, there is a cost for using the SMS but it is decreased up to the fraction of a penny. WAP costs more to use, but it can not only send text and multimedia messages but can also receive relevant information from the Internet through a mobile phone. Short Message Service (SMS) is the most successful [9] universal communication services in existing cellular networks with success delivery ratio more than 94.9% [10].

In the present state of art the businesses are using centralized or distributed mobile databases for storing and managing databases. The users are connecting form mobile devices to access the information from databases.

Distributed databases are used to increase the scalability and to increase the availability of data for the applications where

data and access of data are required to be of distributed in nature [11]. The examples of distributed database are the systems such as Airline reservations, weather forecast services, financial institutions, and automated manufacturing [12].

II. RELATED WORK

MAvBT consists of a server installed on a Bluetooth enabled computer, a mobile application installed on student's mobile phones [13]. The learning environment which signifies the anytime, anywhere learning uses a wireless network with both 3G and Wi-Fi to connect with the University server using Web [14].

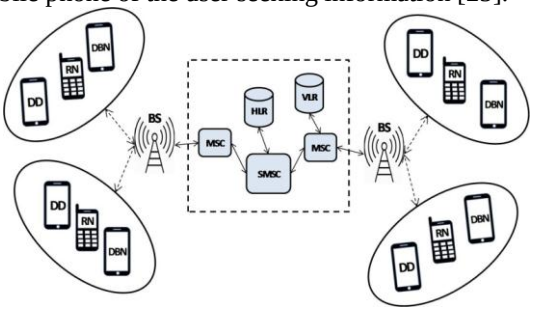
QOrder application utilizes Wi-Fi to easily reach to remote corner hotspot in the establishment [15]. Wi-Fi is used to send information to and retrieve data from an automated food ordering system [16]. In the Wireless Food Ordering System, Wi-Fi is used to establish wireless connections between a PDA client and a web server, and between a PDA client and wireless printers [17]. Wi-Fi network is used to implement WiFiRemote [18]. It is presumed that all ambulances will have fast wireless Internet access through a General Packet Radio Service (GPRS) or Worldwide Interoperability for Microwave Access (WiMAX) [19]. The implementation of iTrust is based on the HyperText Transfer Protocol (HTTP), which is most appropriate for desktop or laptop computers on the Internet [20]. In emergency system on the patient's notification, the Google Maps integrated with GPS service used to estimate the best route and the distance between the current location and the patient's location as well as the estimated time to pick up the patient [21].

An intelligent database program for an interactive auto-responsive opinion poll system is designed based on SMS [5]. An application is developed for school usage using SMS [22]. A complete integrated solution developed for sending information using SMS from web to mobile number and reverse from mobile to web [23]. Location-aware query is sent via SMS to mobile phone connected to a stationary server [24].

The power and energy consumption for different actions to use various technologies is presented for Smartphone running Symbian OS 9.2 on Nokia N95 device [2]. Power consumption for various services using GSM and UMTS is presented in [3]. Component level energy usage is discussed and presented in [1].

III. ARCHITECTURE

A distributed database system architecture in Figure 1 consists of collection of mobile devices such as Smartphone performing the role of Database Directory (DD) and Database Nodes (DBN). RN, the requesting node is any mobile phone of the user seeking information [25].



Architecture of distributed database using Smart phones

The Requesting Node (RN) starts the communication by sending a request to DD containing information about desired attribute(s) for particular region with the particular format specified by the system. The DD acknowledge to RN if the request can be satisfied or not. Figure 2,3,4 shows the flow of service when one, two and three nodes are involve in the service.

Working:
The Requesting Node (RN) starts the communication by sending a request to DD/DBN containing information about desired attribute(s) for particular region with the particular format specified by the system.

The DD/DBN acknowledge to RN if the request can be satisfied or not. The DD/DBN extracts the attributes and if the DD/DBN satisfies the request alone, executes the request and respond to RN. If not then find out the participating DBN required for processing the request. Each request has validity period called WaitTime.

The participating DBNs are prioritized and stored in a DBNQueue for each request ReqID. The query is forwarded to the DD/DBN in the DBNQueue. The DD/DBN processes the request. If the DD/DBN is in network, after processing the request, DBN generates a response and sends back to the RN otherwise after WaitTime the DD sends the query to the next DBN listed in DBNQueue.

Update Protocol:
The modified Peer-to-Peer update strategy for asynchronous replication is used. The write request is always set highest priority, than the read request.

A DBN which initiates the update (INSERT/UPDATE/DELETE) transfers the update log to all DBN containing replicas and to DD. The node holding replica acknowledge to DD if they perform the update. The DD mark updated nodes and further queries routes to updated nodes only.

In the system if any node is out of network of switch off it will receive the update whenever it will switch on or enter enters into the network.

IV. IMPLEMENTATION

The system uses three DD node and five DBN node. Smart phones running Android OS has been chosen as operating platform. Energy efficient database SQLite which is most popular, cross platform, ACID compliance, small footprint and faster database for smart phones has been used for data management. The data communication technology used is SMS. SMS is connectionless communication technology which uses least energy.

Two android applications DDApp and DBNApp have been developed using Android ADT. DDApp have been installed on three smart phones and DBNApp on five smart phones. The entries for attributes in the particular region are added for each service using DBNApp. The replica of each DBN is placed on three distinct nodes.

V. RESULTS

After sending request messages from different cell phones from different locations for different services to all the nodes in the system the power measurements has been collected and analyzed.

The energy consumed for sending an SMS is 950 µAh [26]. SQLite database consumes very low energy. The average energy consumption for various operations such as INSERT, UPDATE, DELETE and SELECT are 0.025µAh, 0.015µAh, 0.025µAh and 0.006µAh respectively. [27] which is shown in Table I.

TABLE I. ENERGY CONSUMPTION FOR SMS AND SQLITE QUERIES

Sr. No.	Activity	Value	Unit
1	Energy consumed for SMS	950	µAh
2	Energy consumed for Insert	0.025	µAh
3	Energy consumed for Update	0.015	µAh
4	Energy consumed for Delete	0.025	µAh
5	Energy consumed for Select	0.006	µAh

The energy consumed for SMS messages for processing the request when single, Two, Three and Four nodes are involved are shown in Table II and Figure 2.

TABLE II. ENERGY CONSUMED FOR SERVICE RESPONSE (IN µAH)

No. of Nodes	DD	DBN1	DBN2	DBN3	Total Energy
1	986.436	-	-	-	986.436
2	986.436	986.436	-	-	1972.872
3	986.436	986.436	986.436	-	2959.308
4	986.436	986.436	986.436	986.436	3945.744

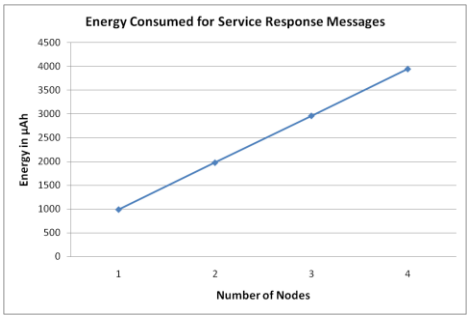


Figure 1. Energy consumed for messaging

SQLite consumes 0.025µAh for insert and 0.015µAh for update. The energy consumption for replica update for an INSERT, UPDATE and DELETE operations are shown in Table III, IV and V. Replica update at all locations including update in database directory consumes 0.0120µAh of energy when an INSERT is initiated by any DBN, when UPDATE and DELETE is initiated, consumes 0.090µAh and 0.0120µAh respectively as shown in Figure 3.

TABLE III. ENERGY CONSUMPTION FOR INSERT (IN µAH)

Insert initiated By	DD1		DD2		DD3		DBN1	DBN2	DBN3	DBN4	Total Energy in µAh
	Insert In Replica	Update in DD	Insert In Replica	Update in DD	Insert In Replica	Update in DD	Insert In Replica	Insert In Replica	Insert In Replica	Insert In Replica	
DBN1	0.025	0.015	0.025	0.015	0.025	0.015					**0.120**
DBN2	-	0.015	0.025	0.015	0.025	0.015	0.025	-	-	-	**0.120**
DBN3	-	0.015	-	0.015	0.025	0.015	0.025	0.025	-	-	**0.120**
DBN4	-	0.015	-	0.015	-	0.015	0.025	0.025	0.025	-	**0.120**
DBN5	-	0.015	-	0.015	-	0.015	-	0.025	0.025	0.025	**0.120**

TABLE IV. ENERGY CONSUMPTION FOR UPDATE (IN µAH)

Update initiated By	DD1		DD2		DD3		DBN1	DBN2	DBN3	DBN4	Total Energy in µAh
	Update In Replica	Update in DD	Update In Replica	Update in DD	Update In Replica	Update in DD	Update In Replica	Update In Replica	Update In Replica	Update In Replica	
DBN1	0.015	0.015	0.015	0.015	0.015	0.015	-	-	-	-	0.090
DBN2	-	0.015	0.015	0.015	0.015	0.015	0.015	-	-	-	0.090
DBN3	-	0.015	-	0.015	0.015	0.015	0.015	0.015	-	-	0.090
DBN4	-	0.015	-	0.015	-	0.015	0.015	0.015	0.015	-	0.090
DBN5	-	0.015	-	0.015	-	0.015	-	0.015	0.015	0.015	0.090

TABLE V. ENERGY CONSUMPTION FOR DELETE (IN µAH)

Delete initiated By	DD1		DD2		DD3		DBN1	DBN2	DBN3	DBN4	Total Energy in µAh
	Delete In Replica	Update in DD	Delete In Replica	Update in DD	Delete In Replica	Update in DD	Delete In Replica	Delete In Replica	Delete In Replica	Delete In Replica	
DBN1	0.025	0.015	0.025	0.015	0.025	0.015		-	-	-	0.120
DBN2	-	0.015	0.025	0.015	0.025	0.015	0.025	-	-	-	0.120
DBN3	-	0.015	-	0.015	0.025	0.015	0.025	0.025	-	-	0.120
DBN4	-	0.015	-	0.015	-	0.015	0.025	0.025	0.025	-	0.120
DBN5	-	0.015	-	0.015	-	0.015	-	0.025	0.025	0.025	0.120

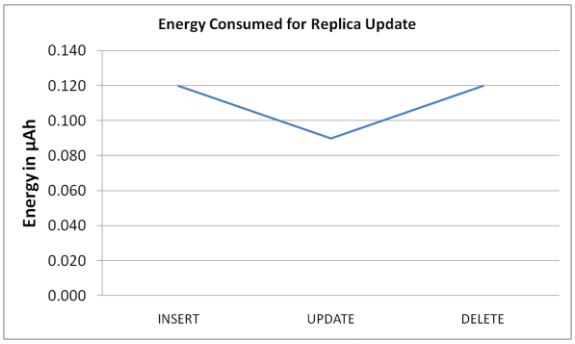


Figure 2. Energy consumption for Replica update

From the above it is found that the system consumes maximum of 0.120 µAh of energy for replica update at all nodes.

VI. CONCLUSION

The distributed database system utilizing the Smartphone battery at very rate. The SQLite database is energy efficient database for Smartphone and the communication technology SMS do not require constant connection which result in the minimum consumption of energy.

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Authors Profile

Mr. N. V. Wankhade pursed Master of Application from S.G.B.A.U., Amravati, MS, India in 2000. He is currently pursuing Ph.D. and currently working as Assistant Professor in P.G. Department of Computer Science and Technology, D.C.P.E., HVPM, Amravati, MS, India since 2005. He has 13 years of teaching experience.

Dr. S. P. Deshpande pursed Master of Application from S.G.B.A.U., Amravati, MS, India in 2000. He is currently pursuing Ph.D. and currently working as Associate Professor in P.G. Department of Computer Science and Technology, D.C.P.E., HVPM, Amravati, MS, India. He has 20 years of teaching experience and 6 years of Research Experience.

