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A Survey On Energy Efficiency And Energy Management In Mobile Sensing Applications And Devices

A.Sunil Samson[1], Dr.N.Sumath[2]

[1]*Research Scholar, Dept. of Computer Science Ramakrishna college of Arts and Science Coimbatore, India*
[2]*Professor and Head, Dept. of Information Technology Ramakrishna college of Arts and Science Coimbatore, India*

Abstract: With fast development of mobile and wireless devices in world, energy efficiency of devices became one of the important issues among devices. Amidst many applications such as green technology, energy saving methods, a new problem is arising with energy management in mobile sensing devices. Energy sensing applications in different modes such as active/sleep modes, transmission of signal in need etc. did not give a good solution to those devices. In this the problems are with various research papers and a survey for energy saving in mobile sensing applications is produced. The Key challenge is, minimizing the energy that is consumed by mobile sensing application, due to increase of latest versions with powerful sensors, wi-fi, light sensors etc. Mobile sensing devices could provide a large number of applications with various survey as different technology and methods. The computing implementations are classified into two categories such as community monitoring and personal sensing applications. Many categories of mobile sensing are based on both, but the major problem facing by the mobile sensing application is energy efficiency. The widespread use of smartphones, wearables, and Internet of Things (IoT) devices has already transformed many aspects of our daily lives, enabling ubiquitously connected machine-to-machine communication, machine-to-human communication, and human-to-human communication, paving the way for the realisation of smarter environments in our homes and across the domains of medical care and transportation, energy grids, industry automation, and defence. This article examines the state of the art in energy management solutions for mobile and Internet of Things devices, with the goal of maximising performance and quality-of-service while working within the various resource limitations imposed by these devices.

1. INTRODUCTION

1.1. Background study

The growth of mobile devices is equipped with more powerful sensors to give progressive development in mobile technology. The enhanced computing methodologies and mobile sensing makes devices catchier and makes updated in sensing applications. One the other hand Artificial Intelligence also makes devices smarter, self-operated network, acting by individual, sensing applications etc., the survey is made in order to analyze the problem in mobile sensing applications. All Mobile Applications Energy Efficiency is important factor, without energy the smart phones or sensing application don't meet its requirements, for example when buying a new mobile one of the important attribute seen is see is battery consumption. Currently very sophisticated sensors are available on mobile devices which are designed to perform automated operations. For example, GPS is location based service it is used in 90% of the applications in mobile. Very particularly it needs sensors to sense the location and track the services etc. Thus smart phones and mobile sensing devices is surrounded around the environment accomplish the work very smarter and the time consumption is also less. Moreover the mobile sensing applications are used in health sector to sense and gather information of patient health record such as heart beat, pressure and more. The mobile sensing applications are numerous according to users need. Accelerometer and GPS acquires geographic information system to provide facilities to users in physical level. Wi-Fi is another application that is used by sensing application by users in more, nowadays mobile sensing applications are numerous in nature, each and every person has minimum one sensing device but the sensing applications don't make the services in energy efficiency, since the users use the devices for different applications. Thus the energy is efficient for one type of user and on the other side the same energy is not efficient for another type of user. Totally the energy is one of the most important topics which in the field of mobile sensing devices even though numerous technologies are developed.

All mobile devices, as well as the vast majority of Internet of Things devices, are portable and need a battery to function. This is due to the fact that such gadgets often have tiny form factors, which restricts the amount of the battery that can be utilised in them. Lithium-ion rechargeable batteries are the most commonly utilised batteries in these de- vices because of their high capacity. This battery technology has evolved just little over the last several decades, and there has yet to be discovered a much superior alternative that is significantly more energy dense than it. As a consequence of the limited energy available from these batteries, the capabilities of components that may be utilised in these devices, such as sensors, CPUs, wireless interfaces, memory, and displays, are severely restricted. This is a significant issue, particularly considering the increasing need for IoT and mobile devices to perform ever-more demanding applications, such as deep learning inference, augmented and virtual reality, and high quality video processing, among others.

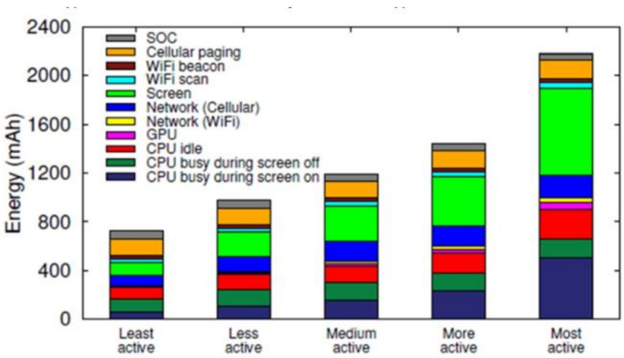

Figure 1 shows the split of average daily energy drain across five groups of 1520 users who were using the Samsung Galaxy S3 and S4 smartphones [1].

A breakdown of average energy use among 1520 users of the Samsung Galaxy S3 and S4 mobile handsets is shown in Figure 1 [1]. The users are split into five categories depending on the amount of activity they do in each day. It can be noted that the average energy consumption of the display (screen), processors (CPUs, GPUs), wireless network radios (Wi-Fi, cellular), and the system-on-chip (SoC) varies depending on the component. Energy (and power) savings across all of these components are highly desirable because they (1) allow mobile and IoT devices to operate for longer periods of time on a single battery charge (i.e., increased device uptime or battery lifetime); and (2) allow more sophisticated components such as faster CPUs, GPUs, and neural processing units to be selected if their energy and power footprint can be intelligently optimised.

1.2. Challenges

Mobile sensing devices are emerging pervasively. It is a going to be a major important application in future mobile technology. Proactive services requiring continuous monitoring of contexts, a major challenge came across sensing devices, it is energy efficiency. By continuously capturing, sensors get loaded both computationally and physically during the operation in sensing and the energy drains rapidly. Mobile sensing devices are feasible to employ all those sensors currently present. A real time example is that a latest smart phone in any brand, when the GPS is ON, phone battery is will get drained within six to seven hours; whereas same battery is lasts for more hours when it is used only for or telephonic conversations. Many studies have been made to save the energy with optimized level but still most of them resulted only with certain extend it is possible to reduce energy consumption while the mobile devices are using GPS and when they are involved in sensing the user activities. Therefore it is needed to build a good energy efficient methodology with a statistical models that is predefined feature extraction and classification. Though many of the problems are rectified, the challenges faced due to energy consumption is a major issue in the field. This paper gives a survey of energy efficiency management, problems, challenges faced, reasons for energy drain, survey of best methods and challenges faced by those methods and solution strategies given by researchers with drawback of those techniques.

1.3. Reasons for Energy Wastage of Mobile Sensing Application

In regards to the identification of energy draining in mobile sensing application, there are some factors which are to be note:
Interference: Each smartphone app needs to maintain the range of interference to what extend it reaches..
Distance: Distance is shortest one when the communication path is chosen.
Idle listening: Need a listening technique for idle channel to receive signals
Traffic : Need to reduce the traffic of signal transmission by making less interference of same channel.
Usage of unwanted applications: Need to close unwanted applications that tend to drain the battery.

1.4 Problem in Energy-Efficiency

The following are some general definitions of energy consumption:

$$E = AvP \times T \text{----} (1)$$

In this equation 1, E denotes energy and AvP denotes average power, both of which are measured in Joules and Watts, respectively, with 1 Joule equaling 1 Watt equaling 1 Second.
Energy efficiency is defined as the ratio of performance, measured as the rate of work done, to the amount of power used, and performance may be represented by the reaction time or throughput of a computer system, respectively.
The most important method to achieving energy efficiency is via effective power control. If we look at the first equation, there are two ways to improve energy-efficient computing: either by increasing performance while using the same amount of energy or by decreasing power usage without losing too much performance. While maximum performance for certain activities (or the

whole workload) is still desirable in some circumstances, energy-efficient systems must also guarantee that energy consumption is kept to a bare minimum. A computer system should use the least amount of energy possible while doing a job at its highest possible degree of performance.

2. SURVEY ANALYSIS IN ENERGY EFFICIENCY RESEARCH IN MOBILE SENSING

The energy management on mobile devices are included in default but it is not an effective method to save those energy of sensing devices. This survey sketches out the methods that are available for energy efficiency by making comparative study analysis depicted in the table given below.

Paper	Methodology	Drawbacks	Usage
"Energy Consumption in Personal Mobile Devices Sensing Applications"	Motion detection methodology – controlled by periodic sampling analysis	Method does not percept the patterns presented in the battery	Balancing between sensing tasks effectiveness and saves the energy without compromise the collected data.
"Improving Energy Efficiency of Location Sensing on Smartphones"	Sensing Substitution (SS), Sensing Suppression (SR), Sensing Piggybacking (SP), Sensing Adaptation (SA).	Implementation model is very large.	Usage of GPS in various scenario makes user comfortable
"Less is More: Energy-Efficient Mobile Sensing with SenseLess"	SenseLess System	Implemented only on smartphones	Save energy in localization application effectively
"A Framework of Energy Efficient Mobile Sensing for Automatic User State Recognition"	Finite state automata theory	It is not applicable in complex sensing applications	Selectively turning on the minimum set of sensors to monitor user state and triggers new set of sensors if necessary to achieve state transition detection.
"Enhancing Energy Efficiency of Wireless Sensor Network through the Design of Energy Efficient Routing Protocol"	PRRP (Position Responsive Routing Protocol)	This protocol is designed as enhanced one, so it is fixed with in a network not more than in sensing applications.	Network lifetime improvement
"Improving energy efficiency of Wi-Fi sensing on smart	Wi-Fi Sense	False Triggering	Maximize the usage of Wi-Fi network in smart phone

phones”			
“Improve energy efficiency in wireless sensor networks through scheduling and routing”	“LEACH (Low Energy Adaptive Clustering Hierarchy) using TDMA Technique”	Improved energy efficiency but not implemented in FDMA technique	It is used in TDMA technique
“An energy efficient approach for routing in wireless sensor networks”	MODLEACH and MIEEPB	Source of energy is depleted when the problem faced by WSN nodes	Provide scalability along with extended network lifetime
“Energy management technique in modern mobile handsets”	Substitution-suppression, piggybacking and adaptation	Limited exclusively to mobile devices	Many methods but not standard one
“Energy efficient cooperative computing in mobile wireless sensor networks”	Multi-CN	Cross layer technique not considered	Joint optimization problem of computation

Table 2.1.: Comparative survey analysis of Mobile sensing devices energy efficiency techniques

From the above table, ten paper are analyzed for energy consumption based on mobile sensing applications. First paper, they depicts energy consumption is made through human motion detection analysis, but this solution works when the human motion analysis is worked in this devices, at the same time, the method experiments good solution to human based devices but not for non human based devices like automatic sensors.

Secondly, “Improving Energy Efficiency of Location Sensing on Smart phones” by Jacob John, Paul Rodrigues. States by giving four methods for energy efficiency of location based sensing on smart phones, implementation is very large due to four type of methods used such as Sensing Substitution (SS), Sensing Suppression (SR), Sensing Piggybacking (SP) and Sensing Adaptation (SA). According to signal received the substitution is made after that suppression and if the signal cuts piggybacking is done if signal receives it adapts. If it is used in smart phones, very high quality and implementation structure is large and also for computational analysis. It can be used in GPS based application alone.

Third paper “Less is More: Energy-Efficient Mobile Sensing with SenseLess” by Fehmi Ben Abdesslem, Andrew Phillips and Tristan Henderson, depicts SenseLess Method is used in this paper to saving energy in localization application but these are only implemented in smartphones alone not in all mobile sensing applications.

Paper “A Framework of Energy Efficient Mobile Sensing for Automatic User State Recognition” by Yi Wang, Jialiu Lin, Murali Annavaram, Quinn A. Jacobson, Jason Hong, Bhaskar Krishnamachari and Norman Sadeh, in here they use finite state automata, it has finite number of states in any given time by this method researcher make a framework for saving energy by produce a states given in applications to use and not use of energy in a specific situations and selectively turns set of sensors and trigger to achieve state transition detection.

Fifth paper "Enhancing Energy Efficiency of Wireless Sensor Network" by Noor Zaman, Low Tang Jung, and Muhammad Mehboob Yasin through the Design of Energy Efficient Routing Protocol" line out a routing protocol used in wireless sensor devices. PRRP method makes a good responsive protocol that fix a sensing applications and improve lifetime efficiency of energy in networks.

In Sixth paper "Improving energy efficiency of Wi-Fi sensing on smartphones" by Kyu -Han Kim, Alexander W. Min, Dhruv Gupta , and Jatinder Pal Singh, with their "Wi-Fi Sense, it makes adaptive sensing technique and made energy consumption upto 79%.

In Seventh Paper "Improving energy efficiency in wireless sensor networks through scheduling and routing" by Rathna. R and Sivasubramanian. A, is analysed for TDMA Technique got energy consumption in given time slot, but in small extent the time delay is reduced.

In Eighth Paper "An energy efficient approach for routing in wireless sensor Networks" by Maya M. Warrier and Ajay Kumar, MODLEACH and MIEEPB, keeping sensors alive for long period to fulfill the application requirements.

In Ninth paper "Energy Management Techniques in Modern Mobile Handsets" by Narseo Vallina-Rodriguez and Jon Crowcroft, from this approach will need to face new trust schemes, access control policies, security mechanisms, privacy and possibly incentive schemes

In Tenth paper "Energy efficient cooperative computing in mobile wireless sensor networks" by Zhengguo Sheng, Chinmaya Mahapatra, Victor C. M. Leung, and Pratap Kumar Sahu, the potential to have a broad impact acrros a range of areas including IoT and Mobile computing, it makes multiple node selection strategies and serve as an effective methods.

Table 3: Methodology for mobile platforms using various power management

Ref	Method	Evaluation Platform	Single-threaded	Multi-Threaded	Gaming
[1]	Policy Iteration	Event-driven simulation	□	X	X
[2]	Heuristic	OdroidnXU+E	X	X	□
[3]	Heuristic	Odroid XU3	□	□	X
[4]	Control-theoritic	Baytrail SoC	X	X	□
[5]	Multivariate Regression	Linear OdroidnXU3	□	□	X

[6]	Logistic Regression	Odoid XU3			X
[7]	Reinforcement Learning	Simulation		X	X
[8]	Reinforcement Learning	Odoid XU3			X
[9]	Imitation Learning	Gem5			X
[10]	Imitation Learning	Odroid XU3			

3. RELATED WORK

Consumers have some concerns about the cession of their location, according to Consolvo et al., who discovered that users are confused about why this information is required. Indirectly connected to their personal lives, smart phones are continuously indicating users' whereabouts, putting them at risk of losing their privacy. Kapadia and colleagues address these issues by outlining the difficulties and addressing potential solutions in detail. Among the systems shown by Shin et al. is the AnonySense system, which the authors define as "a privacy-aware system for developing applications based on opportunistic collaborative sensing in personal mobile devices." However, as recent findings from certain studies have shown, it is almost difficult to ensure the privacy of users in today's world. The movement patterns of a person may be determined either directly via GPS samples or indirectly through Wi-Fi access points and GSM base stations, depending on the situation. Occasionally, users of a collaborative sensing system choose to enable their personal gadget to be used to further the goals of the system without getting any kind of compensation and without giving up any of their privacy. Nonetheless, in order to maximise and sustain the number of participants over time, it is essential to develop a compelling incentive model that will attract and keep a sufficient number of players. The nature of the incentive may range from monetary compensation to access to a particular service. If the incentive is appealing, the user may be ready to give up their privacy in exchange for it. This kind of approach is used by social networking sites and other businesses. Furthermore, there is a technical challenge that makes it difficult for people to adhere to mobile sensing applications: the use of some mobile device interfaces for sensing tasks, such as the GPS, Wi-Fi, and Bluetooth, results in high energy consumption, which has a significant impact on the device's autonomy. Despite the fact that users may charge their devices on a regular basis, the high energy consumption of sensing apps for smart phones means that they are doomed from the start. Users are willing to give up their privacy without any significant concerns as long as the return is worthwhile, but they are not willing to give up their gadgets' autonomy. The majority of smart phone users are very hooked to their devices, therefore if an application significantly decreases the autonomy of the device, rendering it inaccessible or requiring the user to charge the device on a continuous basis, the programme will be deleted.

3.1 Software optimization

Hardware-based methods are just a portion of the whole solution set up. When you take into account the heterogeneity of hardware and the limited number of power control knobs that most hardware currently provides, data management software will play an important part in energy efficiency as well. Because of their physical data independence and query optimization, database management systems (DBMSs) provide for more software-level control over power-performance tradeoffs.

Harizopoulos and colleagues classified three types of software-based methods for decreasing energy consumption in relational database management systems.

It is possible to obtain the most energy-efficient configuration for the underlying hardware by using existing system-wide knobs and internal query optimization settings, which is known as energy-aware optimization. Xu and colleagues developed a method for identifying query strategies that use the least amount of electricity. The power profile for each fundamental database activity in query processing is established and kept as system parameters in database management systems (DBMSs) in order to do this. Through an iterative approach, the power cost may be calculated from the specifications of hardware components and divided by the anticipated period for which they are to be used. Calculating the power cost of a plan is possible using the higher-level operations, which include such fundamental activities as CPU power cost per tuple/indexed tuple, power cost for reading/writing a single page without buffering, and so on. For accessing a single relation using a variety of methods and join operations, it is possible to build a variety of power cost functions that are optimised for each method and join operation.

Specifically, resource usage consolidation refers to the process of moving communication and migrating data in order to condense resource consumption in both time and space. When system resources are not completely used, the system may enable other concurrent activities to make use of the resources, or the system may allow the resource to enter a suspended or reduced power state in order to save electricity.

Design software components to use as little energy as possible, decrease code bloat, and sacrifice some characteristics (or enable them to underperform in particular measures) in order to achieve greater energy efficiency. A QED (Improved Query Energy-efficiency by Introducing Explicit Delays) mechanism, for example, was developed by Lang et al., which makes use of query aggregation to exploit common components of queries in a workload. Query processing in QED is delayed and queries are put into a queue on ar- rival. A specific threshold is reached when the queue contains enough queries to warrant examination of all of the inquiries in the queue to see whether they can be aggregated into a limited number of groups so that the queries in each group may be assessed together. QED reduces CPU energy usage by 54 percent on a workload including simple selection queries in MySQL, while improving the average query response time by 43 percent on the same task.

4. PERFORMANCE ANALYSIS OF VARIOUS ENERGY EFFICIENT METHODS

The survey is taken from the respondents that energy efficiency creates an evaluation for demand side or supply side investments. It felts troubled by sensing energy efficiency consistently to be more stringent. The table 4.1 given below depicts the activity of including factors that has been doubled the standard of energy that needs a support in energy management. According to the Consortium for Energy Efficiency (CEE), state demand-side management expenditures in the United States totalled an anticipated $2.6 billion in 2018, representing a 13 percent increase from 20052. (CEE 2006, 1). In tandem with the increase in expenditures for energy-efficiency programmes, there is an increasing emphasis on the necessity of performing assessments to ensure that the money are used appropriately. In addition to learning what works and what doesn't work, it is critical to use assessment to determine what works and what doesn't work so that money are spent effectively and higher levels of energy-efficiency investment may be justified.

Sl.No	Factors	Require more support in %
1.	"Data tracking and databases, tracking of evaluation results"	46%
2.	"Having adequate funding for EM&V"	40%
3.	"Emission factors"	35%
4.	"Training on EM&V issues"	35%
5.	"Measurements guidance"	5%

Table 4: Energy Management Gaps and Needs

S.No	Paper	Methodology	Percentage of Energy Consumption
1.	"Energy Consumption in Personal Mobile Devices Sensing Applications"	Motion detection methodology – controlled by periodic sampling analysis	70% According to human usage
2.	"Improving Energy Efficiency of Location Sensing on Smartphones"	Sensing Substitution (SS), Sensing Suppression (SR), Sensing Piggybacking (SP), Sensing Adaptation (SA).	75% longer compared to its existing system
3.	"Less is More: Energy-Efficient Mobile Sensing with SenseLess"	SenseLess System	Battery life from 9.2 to 22.5 hours using GPS.
4.	"A Framework of Energy Efficient Mobile Sensing for Automatic User State Recognition"	Finite state automata theory	75% longer compared to its existing system
5.	"Enhancing Energy Efficiency of Wireless Sensor Network through the Design of Energy Efficient Routing Protoc ol"	PRRP (Position Responsive Routing Protocol)	35% longer compared to its existing system
6	"Improving energy efficiency of Wi-Fi sensing on smart phones"	Wi-Fi Sense	79% compared to other wifi sensing methods
7	"Improve energy efficiency in wireless sensor networks through scheduling and routing"	LEACH (Low Energy Adaptive Clustering Hierarchy) using TDMA Technique	80% longer compared to all other techniques
8	"An energy efficient approach for routing in wireless sensor networks"	MODLEACH and MIEEPB	72% compared to other methods
9	"Energy management technique in modern mobile handsets"	Substitution-suppression,	78%

		piggybacking and adaptation	
10	"Energy efficient cooperative computing in mobile wireless sensor networks"	Multi-CN	80%

Table 5. Percentage of energy consumption for compared methodologies

4.2 Models and Metrics

The actual power consumption of a particular system is determined by a variety of variables, including the workload, system balance, and ambient conditions. In order to accurately measure power consumption, precise power and thermal models of specific components, systems, data and processing centres, and applications are required.

It is known that three distinct kinds of modelling methods exist in the literature: simulation-based approaches, detailed analytical approaches, and high level, black-box approaches.

Because it is difficult to acquire comprehensive information about the numerous components that make up a whole system, simulation-based methods aim to represent individual components rather than the entire system or a collection of systems via simulation.

Without the use of simulation, comprehensive analytical approaches are used to gather hardware and software metrics on a regular basis. For example, microprocessor performance counters to measure online the total power consumption of the whole system. According to the hypothesis that the peak power consumption of an entire system during the measurement interval is identical to the aggregate of the individual nameplate power consumption, Xu et al. presented a power model to accurately measure the energy costs of database query execution plans.

Models are constructed by fitting a model to the real-time metrics that are gathered via high-level black-box methods that do not need implementation knowledge. A power consumption model was developed by connecting alternating current power measurements with user-level system usage metrics at the system level, after which the model was validated. This power is derived from huge collections of servers that are used to run various types of applications over a long period of time.

5. CONCLUSION

In this survey the methodologies and protocols are compared that save energy with the factors and where it is used to save energy. Thus it is needed to choose an efficient method to save energy for mobile sensing applications and to give a good energy saving application. These challenges are faced in every network environment but it plays an important problem compared to other applications.

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