Android Phone Performance Enhancement by Energy Efficient Web Browser

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***Abstract*— In today's era mobile applications have reached great heights. Processing power, available user memory and storage have seemingly increased. Considering all this, a concern about energy consumption is raised as all these require a significant amount of power consumption. Also keeping the battery backup of a smartphone in mind, the need to conserve and minimize Energy consumption comes to play. This power consumption is due to the characteristics of the wireless radio interface. Hence, in this paper the power consumption reduction will be achieved by addressing those issues of the wireless radio interface. For this, computations will be reorganized for the long processing time web page and prediction model will be used for the webpages which require short processing time in which reading time threshold will be considered for the state switching. This project will enhance the performance and network capacity by reduction of energy consumption of the Android phone web browser. Again the method of Prefetching will also be added to reduce latency of the web page loading.**

Keywords—Web Browser; Mobile Computing;Wireless Communication; Portable devices; prefetching; Reading time Threshold; Wireless radio interface; Reading time threshold.

I. INTRODUCTION

Smartphones are becoming a key element of our day-to-day life. We all are connected by the internet throughout the world. The survey says that there are 3% people worldwide who use the internet on mobile phones. And some of them use more than one smartphones for their own. Samrtphones have tremendous demand in the market because of its amazing applications. Though smartphones are doing well, there is one issue which must be focused and resolved. And that is, the energy consumption while browsing the web.

For resolving this issue, a lot of research has been done on various interfaces like, Wi-Fi, Bluetooth. But these have different characteristics than the wireless radio interface or the cellular interface like 3G, 4G LTE. The cellular interface characteristics, if studied, we come to know that these things consume much more power. So, here those special characteristics will be addressed and the issues on them will be identified.

For efficient utilization of the limited radio resource of the backbone network, the 3G Radio Resource Control(RRC) protocol defines the following three states for smartphones to control their wireless radio interface.

IDLE state: In this state the smartphone does not have any signaling connection with the backbone network, and hence it cannot transmit user data. The radio interface of the smartphone consumes very little power in this state.
DCH state: This is the dedicated channel state in which the backbone network allocates dedicated transmission channels (uplink and downlink) to the smartphone, so that the smartphone can transmit user data and signaling information at high speed. This consumes highest level of power.
FACH state: This is forward access channel state in which the smartphone no dedicated transmission channel. Hence, it can only transmit user data and signaling information through common shared transmission channels at low speed (up to a few hundred bytes/second). Data transmission in the FACH state requires about half of the power in the DCH state.

When the smartphone wants to transmit the data, it has to be switched from IDLE to the DCH state. It first establishes the signaling channel and then obtains the dedicated channel for the transmission. This process requires lots of message exchanges. To determine when to release the dedicated transmission channels allocated to the smartphone, the backbone network uses timers.

Smartphones can't do many computations. While loading a web page there are various computations such as HTML parsing, JavaScript code execution, image decoding, style formatting, page layout, etc. Based on whether they will generate new data transmissions from the web server, these computations generally belong to two categories i.e. Data transmission computation and layout computation. These two computations are mixed with current web browsing.

Again, there are two types of web pages based on the processing time, i.e. long processing time and short processing time. The web pages which require longer processing time, should separate the computations to reduce the power consumption. And those webpages which require shorter processing time, the reading time will be predicted so that the next data object should be prefetched.

Caching and prefetching techniques can also be used for the reduction of traffic overhead. These techniques will help the browser to prefetch the data objects distributed on the web pages in the local cache. And when a user is accessing the web page he will not have to wait for loading

the data objects as it was already prefetched in the cache. This will improve the user experience and reduce latency.

II. Literature Survey

Much research has been done to resolve the issue of power consumption. But many of the researchers have focused on the issue of power consumption on display. Some researchers have focused the interfaces like Wi-Fi or Bluetooth. The wireless radio interface, such as 3G, 4G LTE have different characteristics from other interfaces and they consume much more power. To resolve this issue, the two techniques are used [1] i.e. Reorganization of computing sequence for those web pages which require long processing time and prediction of user reading time for the web pages which require short processing time. These techniques help to reduce the power consumption, delay and to increase the network capacity. If the threshold value is not exceeded, the energy consumption will be more due to state switching. In the reorganization of computing sequence, the two computations are separated, i.e. data transmission computation and the layout computation. The main focus is on the data transmission computation. So, this data is parsed, which generate the new data transmissions, then the radio resources are kept in the low power state. And then the remaining layout computations are done. In this way, it enhances the performance of the smartphone in terms of power consumption, delay and network capacity.

There are various prefetching and caching techniques to reduce the latency of web page loading. But most of them rely on the history for prefetching the objects of web pages and it can increase the traffic. So, congestion problem occurs. Hence, optimal prefetching [2] is needed to be done. The algorithm based on the current content of the web documents is used so that there is no requirement of maintaining the past history of the users and is also beneficial for first retrieval of access to web resources. The algorithm very intelligently fetches only those hyperlinks which are required by the user. For this, the two modules are used, i.e. prefetch module and prediction engine. The prefetch module consists of two parts, one is the extraction module and the other one is prefect module. The prefetch module receives the request from the client and serves the request to the client. As per the request of the client it prefetches the hyperlinks according to the list of hyperlinks supplied by the prediction module and puts them into the prefetch cache. The extraction module collects the keywords from the user specified list of keywords. Then the list of all hyperlinks which contain the user specified keywords is done by this module. Prediction module compares the keywords in the user specified keyword-list with the list of keywords describing the hyperlinks on the actual HTML page using the optimal perfecting algorithm and sends the list of the hyperlinks to the prefetch module.

OLED (Organic Light emitting diode) technology is used on many mobile phone displays. But the OLED display are not so efficient to display bright colors and it consumes different power for showing different colors. For reduction of power consumption on display web pages, Chamelon [3] (A Color-Adaptive Web Browser for Mobile OLED Displays) technique is used. This web browser renders web pages with the power-optimized color schemes under the constraints which are user-supplied. Chameleon gives user to choose the preference for color transformation using 4 different algorithms which gives 4 formats of web pages as dark, green, arbitrary and inversion. This technique is able to reduce average system power consumption for web browsing by 41% and is able to reduce display power consumption by 64% without introducing any noticeable delay. But, it only works on energy consumption on display only.

As we know mobile phones have low computation power, to reduce the computational burden, some techniques should be used to reduce the computational burden. Hence, Bo Zhao has proposed the technique which shifts the burden of computation from smart phones to VMP (Virtual machine based proxy) [4]. A proxy is added between the web server and the smartphones, and a new client is added on the side of the smartphone which interacts with the proxy. Hence the request is sent to the proxy instead of sending it to the web server, and the proxy sends that request to the web server. The proxy can reduce the resource consumption by running different optimization techniques at the smartphone. It reduces the delay by more than 80% and reduces the power consumption during web browsing by more than 45%. Although this approach has low cost, public cloud may not meet the security level.

III. Proposed Methodology

A. Reorganization of the computation sequence

Since today's web browser has to process various script code like JavaScript embedded in HTML documents, Cascading Style Sheets (CSS), which describes the presentation semantics and the style rules of a web page such as, color fonts and layout. Document Object Model (DOM) is an interface that allows programs and scripts to update the content, structure and style of HTML documents.

There are two types of computations i.e. Data transmission computation and the layout computation as shown in the fig.1. These two computations are mixed in the current browser design. Because of which the computation burden on the web browser increases. Hence, here these two computations will be separated to minimize the computation burden and to reduce energy consumption

To retrieve all data in the web page as fast as possible the computation sequence of the web browser will be reorganized. In the original web browser design, the data transmission computation and the layout computation are mixed. So to reduce the energy consumption these computations will be separated. So, the focus of this approach will be on the data transmission computation. When the new data transmissions are completed, the wireless radio interface will change its state to IDLE, so that

the energy consumption will be saved. And then the layout computation will be done.

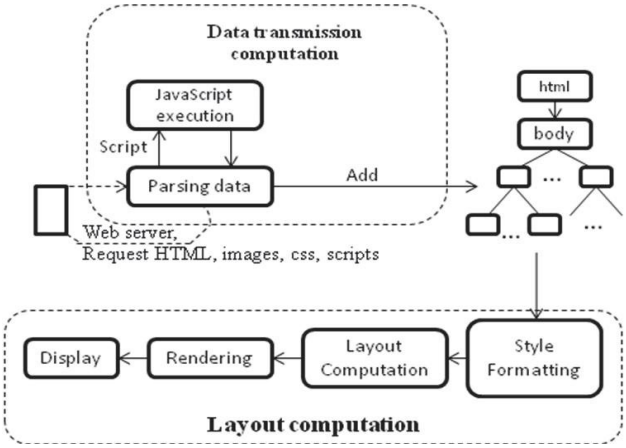

Fig.1. Webpage processing workflow in smartphone web browser.

B. *Power save on Intermediate Display*

A cell phone can't afford much computation whereas a reflow costs more computation resources because it involves changes that affect the layout of the whole page. By reorganizing the computation sequence, this method draws the final display at the end of web page loading, and thus it saves the computation on redrawing or reflowing intermediate display.

C. *Predicting the Reading Time for state switching*

The reading time will be predicted for the user. If that reading time is greater than the data transmission time, the energy consumption will be reduced because the state switching will be done from DCH to IDLE. The prediction of reading time will be based on the Gradient Boosted Regression Tree (GBRT) model. These models are used for the prediction of the value of future data. Interest threshold is also considered. To match the user interest, some features are needed to be evaluated as described in the table below:

TABLE I. FEATURE DETAILS

Features	Description
Reading time	The duration from the webpage is completely opened to the time when user clicks to open another page
Transmission time	Data transmission time
Webpage size	The data size of webpage without considering the figures
Download objects	The no. of total downloaded objects
Download Java script files	The no. of downloaded java script files
Download figures	The no. of downloaded figures
Second URL	The no. of secondary URLs
Page height	The height of webpage
Page width	The width of webpage
Figure size	Size of total downloaded figures

D. *Network Capacity Analysis*

While downloading the web page, the backbone network switches the state to DCH and then to IDLE. This approach consumes more energy in state switching. Hence, here the DCH will first switch to the FACH and then to IDLE. With this approach, smartphones will exit the DCH state quickly, and thus the dedicated transmission channels can be quickly released and being used for supporting more users. This will increase the network capacity.

E. *Prefetching and caching*

Web traffic reduction techniques are necessary for accessing the web sites efficiently with the facility of existing networks. Web prefetching techniques and web caching reduces the web latency that we face on the internet today. Hence For this the various prefetching and caching techniques can be used to predict the web object to be pre-fetched and what are the issues and challenges involved when these techniques are applied to a mobile environment. These methods involve the extraction module and the prediction module.

a) Extraction module

When the user inputs the hyperlink keywords, the module will keep that keyword into the user specified keyword list. It will create a list of hyperlinks that contains the keywords of the user specified list by scanning. This module will produce the list of hyperlinks which will be containing all the keywords of user specified keyword list.

b) Prediction module

This module will compare the keywords of the user specified keyword list with the list of keywords of the hyperlinks on the actual HTML page and will send the list of the hyperlinks to the prefetch module.

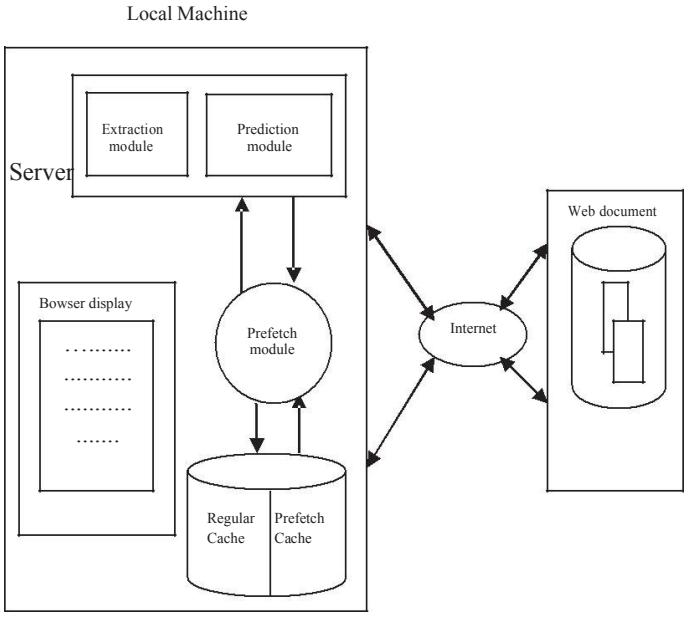

Fig.2. Optimal prefetching

IV. SYSTEM ARCHITECTURE

System architecture involves the following components:

Fig.3. Data flow diagram

A. Developing a model for analysis of web traffic

Web traffic, here deals with data traffic only. So, GBRT (Gradient boosted regression tree) model is used for predictive data mining, which is used for constructing statistical decision tree models from historical data. The decision tree is a decision support tool that uses a treelike graph or model of decisions and their possible consequences.

B. As per the web traffic, the energy profiles of user will be generated by tracking user activities.

By the term energy profile, the dependency of total power P (in watts) consumed by switched on BTS is considered. And after the evaluation of web traffic, energy profiles of user will be generated by tracking the user activities on the web page.

C. Based on web usage, we would activate the given energy profile.

An energy profile will be made for the user. As per the profiles the prediction is done. A model will be trained for this.

D. Implement the prototype and collect real traces which are used to validate the effectiveness of the proposed energy-efficient approaches.

The prototype will be implemented and deployed on the Android smartphone. Then the real traces are used to validate the effectiveness of the proposed energy-efficient approaches. The measured voltage is exported to an application, which performs power calculations and plots power consumption profiles in real time. The traces captured are important for analyzing the website content for testing and verification purposes.

E. Optimization of system.

Result Analysis will be done, which will show the comparison between the energy efficient browser and other browsers.

V. RESULTS

A. Data usage tracking module

The data usage tracking module calculates the total bytes in the form of transmitting and received data bytes. This will be notified on an Android phone. The time will be displayed in GMT format with the date as shown in the snapshot.

Fig.4. A window showing list of transmitted and received bytes

B. The power efficient browsing module

This module shows the state switching of the wireless radio interface. In which there are three states which can be described as follows:

This will first analyze the state of the webpage when we enter any website name.

Fig.5. A window analyzing state of webpage

If the new data transmissions are to be generated, then it will be using a dedicated channel at a high speed and if that webpage is already being fetched then the FACH state used by the browser. If we enter a new website for example www.w3schools.com, it will notify us that the data

transmission state is DCH because new data transmissions are done.

Fig.6. A window showing DCH state for new data transmission

As, the www.w3schools.com is already fetched, the data is stored into the cache and when we enter the same website next time, the browser will use the FACH state. This state switching will save our battery power.

Fig.7. A window showing FACH state for prefetched webpage

Once we are done with the data transmission, the webpage will be kept on the IDLE state. To switch the states, the user's interest is to be evaluated. As, IDLE state is the lowest power state, and the user need not do new data transmissions, this browser will use the IDLE state to save the power.

Fig.8 Final webpage on IDLE state

C. *Keyword based prefetching module*

In this module, the keyword based optimal prefetching is done. When we enter the keywords into the textbox, it will get stored into the database and then if we enter the same keyword into the text box for searching, it will be seen in the suggestion list even if we don't have the internet connection. As compared to other browsers, like Firefox, it doesn't show the suggestion list when we are offline. This module will basically help the device to save energy by not making background calls for fetching data which intern would contribute towards saving a bit of energy. This is shown in the figures given below:

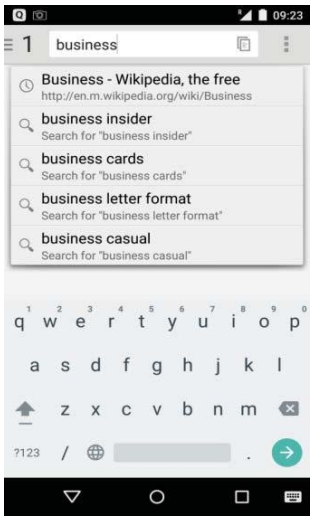

Fig.9. Energy efficient browser shows the suggestions offline

D. *Settings*

There are various settings given in the browser which includes the following settings as shown in the figure:

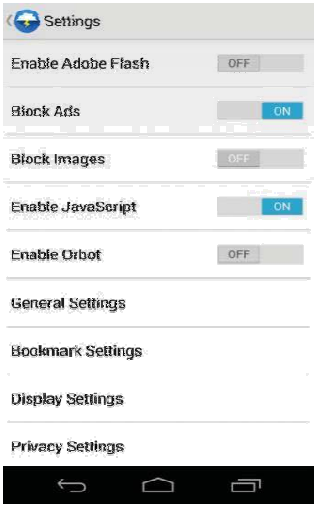

Fig.10. Settings

VI. CONCLUSION

As the demand of Android smart phones is increasing day by day, Use of software which will improve the performance of the android smartphone in terms of energy consumption, loading time and network capacity are also needed. For this purpose this paper has proposed the different techniques which will deal with the wireless radio interface to reduce the Power consumption of smart phone. Again, a technique of prefetching and caching will also be combined with the existing work to reduce time and web latency.

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