ISSN No:-2456-2165

Minimization of Power Consumption in Smartphone during Web Browsing by Reorganization of Browser's Computation Sequence

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Abstract:- Nowadays almost everyone has a smartphone which provides amazing features to users. A most common activity on smartphone is the web browsing which billion of users going to perform on daily basis. Web browsing using smartphone uses large amount of power and results in low battery. As downloading of webpage uses the features of 3G radio interface a lots of power get consumed. So battery utilization of smartphone must be noticed while browsing the web. In this paper, this power consumption issue is resolved using two different techniques. In first techniques, we change the computation sequence of web browser by separating computation which will generate new data transmission and remaining computation is executed later. In second technique, prediction of user reading time is performed using data mining techniques.

Keywords **:-** *Web Browser, Wireless Radio Interface, Gradient Boosted Regression Tree, Energy Consumption.*

I. INTRODUCTION

A smartphone is used by almost everyone as it provides variety of services and applications to users. Among these applications web browsing is basic functionality on smartphone. We often notice that while performing web browsing on smartphone, phone battery getting low earlier. This is because, smartphone contains such many applications which unfortunately consumes more energy saved in battery. So, battery usage must be noticeable when handling a smartphone.

Here, we work on the concept of power consumption while browsing the web. In order to resolve power consumption issue research on various interfaces of smartphone have been done such as display, WiFi, Bluetooth etc. We study the different characteristics of wireless radio interface like 3G, 4G LTE and identify power consumption issues.

To resolve power consumption issue of smartphone here we use two techniques. First, we change the order in which web browser execute the webpage. Second technique is to predict user reading time of webpage using data mining technique called Gradient Boosted Regression Trees (GBRT). This prediction is used to decide if the smartphone should switch to IDLE. So, minimize power and delay of webpage loading during web browsing.

II. LITERATURE SURVEY

There are various techniques and ideas are applied to smartphone in order to optimize the power consumption. Cat-nap[3], propose a system that offer higher bandwidth by combining smaller packets into meaningful sleep intervals. This causes NIC as well as the device to doze off so the mobile client is sleeping for the duration of data transfer results in saving of energy.

Scheduling technique used by Bartender [4] for power consumption purpose. It first calculate the signal strength and relate it with power consumption then it uses a scheduling algorithm and schedule an optimal communication that leads to power saving.

F. Qian, Z. Wang [5] proposed an algorithm called TOP(Tail Optimization Protocol). Here tail means a timeout value. TOP perform interaction between the phone and the radio access network and help to remove tail. So, TOP saves energy and perform better resource utilization.

As we know Wi-Fi consumes much more power in smartphone when it is active. So,Eric Rozner [6] uses a technique NAPman: Network-Assisted Power Management for WiFi devices. He develops a new energy-aware fair scheduling algorithm to minimize radio wake up time and unnecessary retransmissions.

So, power consumption is done in various ways like J.Sorber focuses on the components of smartphone such as display, Wifi, bluetooth to save power. Qian [7] uses caching

ISSN No:-2456-2165

technique and Zhao et al. [2] uses virtual-machine based Proxy (VMP) to save power and delay for web browsing in 3G networks. Also speculative parsing, Google SPDY, layout caching, web task scheduling among group of users etc. techniques are used for power consumption earlier. Different from them, this approach focuses on reorganizing the computation sequence to reduce the total data transmission time to save power.

III. PROPOSED WORK

To access the radio resources of backbone network a Radio Resource Control (RRC) protocol define three states as follows:

- *IDLE State*

This state consumes very little amount of power. Smartphone can't send user data as it don't have any signaling connections with backbone network.

- *DCH State*

In this state, smartphone can send user data as it has dedicated transmission connection to the smartphone, it require more power.

- *FACH State*

Smartphone don't have dedicated transmission connection in this state, so it can transmit data only through common shared channel. FACH consumes half power that of DCH state.

In order to transmit data a smartphone must be in DCH state. So when a smartphone is in IDLE state and wants to transmit data it has to be moved in DCH state. To establish connection to backbone network it uses number of message exchanges. It first establishes signaling connection to the backbone network and then obtains dedicated channel for transmission. When to release the allocated transmission channel to smartphone by the backbone network is determined by using timer.

A. Rearranging the Computation Sequence of the Web Browser

To change the execution sequence of web browser, we must know about how a web browser processes a webpage. First request is made for document. The web server then provides the page to the web browser. Now web browser parses the page in the form of html data. The web browser looks at the entire html document and looks for any css, javascript and images that are referenced by the page and download them. DOM tree is build which represents each resource element separately. The style and layout properties are applied to each element in DOM tree. Now web browser can render those elements correctly on the screen.

So, in processing a web page, a web browser first fetch all the content of webpage as a document and carry out some local computations. We classify these computations into two categories based on whether they will generate new data transmission or not such as,

- The data transmission computation
- The layout computation

As shown in Fig. 1, a web browser consist two types of computations. Data transmission computation includes HTML and CSS file parsing and JavaScript code execution which generates new data transmissions. Layout computation that does not cause data transmission and used to layout webpage such as image decoding, style formatting, page layout calculation and page rendering, which is known as the layout computation.

In our energy-aware approach we group all data transmission together, so the objects of a webpage can be downloaded earlier. As we seen in Fig.1 data transmission mainly comes from three resources such as HTML, CSS, and JavaScript. Now we fetch elements such as images, css and javascript using url of each object separately.

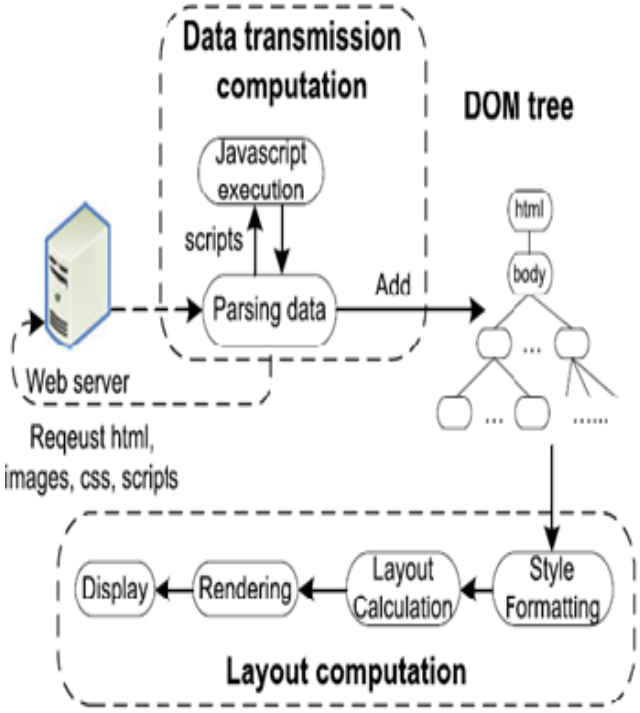

Fig 1:- Workflow of webpage processing

After fetching all data we download all these objects and store the statistics of each in memory rather than deliver it to the web browser. Thus, the web browser does not consume any resources on parsing them and generating the style rules. Then web browser can release radio resource by putting wireless radio interface into low power state. Now

web browser performs remaining layout computations which may take 40–70 percent of the processing time for loading webpage. Thus, a significant amount of power and radio resource can be saved.

B. Intermediate Display

The original web browser draws intermediate display while loading a webpage and updates it frequently to improve user experience. Fig. 2, shows computation sequence for opening a webpage and does comparison between two browser. Figure shows that original browser continuously process both data and layout computations until time slot 3 whereas our browser first complete all data transmission computation and then go for layout computations. Finally, both approaches have same DOM tree and display same webpage.

So, in energy aware approach, we save computations by avoiding redraw and reflows of intermediate display. Here we show only final display at the end of webpage loading by reorganizing the browser's computation sequence.

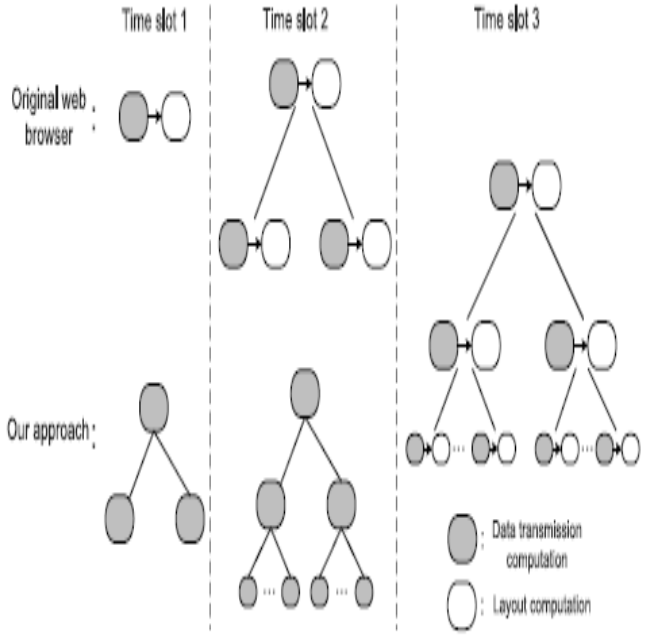

Fig 2:- The browser's sequence of opening webpage and building the DOM tree.

C. Predicting the User Reading Time of Webpage

The average reading time of each webpage is calculated using collected statistical data shown in Table 1. Gradient Boosted Regression Tree (GBRT) is a data mining technique used for prediction of future data. Here we predict the reading time of user after downloading of webpage using GBRT. After prediction of reading time we decide whether smartphone switch to idle state or not.

➢ *Algorithm For Energy Aware Approach*

- Request for a webpage
- Perform Data transmission computation
- Perform Layout computation
- Collect features x={x1,…….,x10} ……. Table 1
- Webpage is opened
- Wait for α second
- Get T_r from the prediction model with x
- if ($T_r > T_d$) or ($T_r > T_p$ AND mode == power) then
- Switch to IDLE state
- End

Where,

Parameters	Description
T_r	Predicted reading time (sec)
A	Interest threshold (sec)
T_d	Time duration threshold (T1 + T2) for delay driven mode
T_p	Time duration threshold for power driven mode
Mode	Power driven or delay driven

Table 1

Following features are collected during fetching the content of web page. These all features are used as input to GBRT algorithm to predict reading time of user.

Feature	Description
Reading time	The duration from the webpage is completely opened to the time when the user clicks to open another webpage
Transmission time	Data transmission time
Webpage size	The data size of the webpage without considering figures
Download objects	The number of total downloaded objects
Download javascript files	The number of downloaded javascript files
Download figures	The number of downloaded figures
Figure size	Size of the total downloaded figure
Javascript running time	The time for processing all the javascript code

Table 2:- Feature Details

IV. CONCLUSION

We proposed an energy-aware approach for web browsing in 3G based smartphones. We define a system which first reorganizes computation sequence of web browser at the time of loading webpage by separating the data which generates new data transmission. Web browser first process these data transmission computation, put 3G interface into IDLE and release radio resource. After completion of data transmission computation, web browser process remaining layout computation. Secondly we implement a low overhead prediction algorithm based on Gradient Boosted Regression Trees (GBRT) to predict user reading time when they read the content of webpage. The final results show that, as radio resource released earlier it can be used by another smartphone which increase network utilization and minimize power consumption of smartphone during web browsing as well as reduce the webpage loading time.

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