Survey of Saving the Tail Time in 3G UMTS of Cellular Networks

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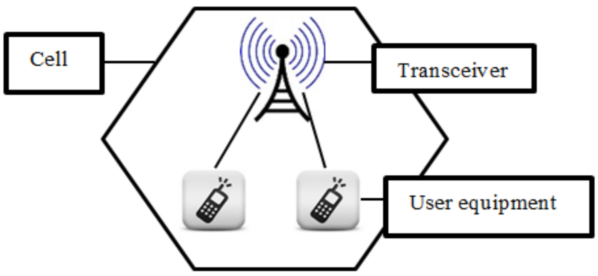
Abstract— **The paper surveys the demerits of the tail time in UMTS used in Smartphone's, defined as the timeout period of inactivity timers where radio resources are wasted. We include the merits and demerits on various techniques handled to save the radio resource and battery power in 3G network system. We discuss the overall idea of the various generations of internet and the average power consumption in mobile phones and UMTS. We also discuss the fast dormancy mechanism. We conclude with comparison result analyzed from various research paper and the possible directions for future work.**

Keywords—Universal Mobile Telecommunication Systems; Radio Resource Control Protocol; Tail Optimization Protocol; user equipment; Adaptive Fast Dormancy.

I. INTRODUCTION

Mobile phones have become an extensive device among people in their daily life; few limitations of mobile technologies are range and bandwidth, security standards, transmission interferences etc. As nowadays Smartphone's consume more power and radio energy during internet access especially in 3G and 4G technologies.

Cellular Networks or mobile networks consist of subdivided wide land areas in shape of hexagons called cells. Each cell is served by a trans-receiver called base station and the mobile devices in the cell use different frequency spectrum that has a fixed bandwidth, which provide communication and data transfer between two different UE's. Radio transmission starts at various kHz like the very low frequency, medium frequency, low frequency up to extremely high frequency. The Ultra High Frequency is used in mobile phones of analog technology (450-465 MHz).



a. Components of Cellular Network

Fig. 1.Cellular Network Architecture.

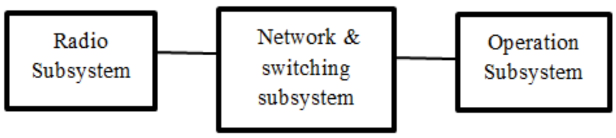
A. The generations in telecommunication technologies are:

1) 1G the First Generations

It provides narrow band wireless analog network which provides voice calls and send text messages. It provides services through circuit switching and can transfer 2.4 kbps of data. It is based on Frequency Division Multiple Access. The disadvantage of 1G is that we could only contact with the UE within the particular nation locally.

2) 2G the Second Generation

It provides narrow bands wireless digital network, it brought in more clearness to the circuit switching model. It can transfer 64kbps of data. It provides roaming facility and a semi- global facility. It is based on Time Division Multiple Access .It consists of some networking architectures like Global System for Mobile Communication architecture and CDMA- one, D-AMPS etc. The traditionally used architecture is GSM.



a. Divisions of GSM architecture

Fig. 2.GSM System Architecture.

GPRS (General Packet Radio Service) is a tremendous success to packet- oriented Internet. It offers point to point packet transfer and maintains a virtual circuit change of cell within the GSM network. (HSCSD) High Speed Circuit Switched Data available with a few providers that achieve high data rate by grouping up of channels for communication.

3) 3G the Third Generation

It provides wide band wireless network with increased clarity where data is sent through packet switching and voice calls that are interpreted through circuit switching. Its services include global roaming and apart from voice communication it provides fast communication and data transfer, high speed internet access, multimedia messages and 3D gaming etc. It can transfer up to 2000kbps terrestrial and 2500kbps in satellite of data. The architecture used by 3G is Universal Mobile Telecommunication System. It is based on Wideband Code Division Multiple Access with its bandwidth range of 5MHz.

4) 4G the Fourth Generation

The fourth generation provides access to very high speed data which is based on Long Term Evolution. They can transfer 100,000kbps of data. It is based on CDMA-2000 (Code Division Multiple Access) that uses orthogonal coding technique.

B. Universal Mobile Telecommunication System

UMTS was developed by 3rd Generation Partnership Project, 3G technologies that is based on WCDMA (Wide band Code Division Multiple Access) that uses orthogonal variable spreading factor codes and the bandwidth is 5MHz that is divided into 15 slots. The frequency bands for UMTS are 1885- 2025 MHz uplink and 2110-2200MHz downlink. The mobility support is low to high and its applications are voice and data. It coverage is local and wide. The deployment cost for wide coverage is very high. The UMTS is combined with GSM and EDGE. There are a few components of this architecture they are base trans-receiver, Radio Network Controller which is responsible for the release of radio resource, media gateway.

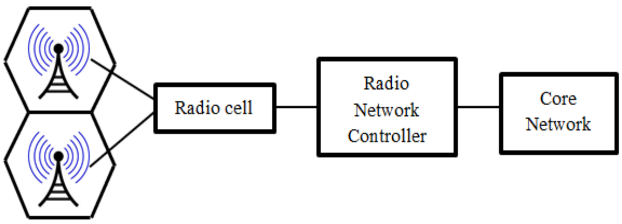


Fig. 3.UMTS System Architecture.

C. UMTS system architecture

It consists of the UE the UTRA Network consists of several RNS (Radio Network Subsystems) that does ciphering and deciphering, handover control, radio resource management etc. where each are controlled by RNC (Radio Network Controller) it consists of several components called Node B. The core network that comprises of the gateway to the other network, offers inter system handover and performs location management if there is connection between the equipment and the UTRAN. The UMTS has subdivided architecture domains the *user equipment domain* assigned to single user and provides all functions needed to access the services, mobile equipment used for radio transmission, *infrastructure domain* offers all UMTS services, *access network domain* that performs the access network dependent functions, *serving network domain* functions used by user for accessing UMTS services, *transit network domain* and *home network domain*.

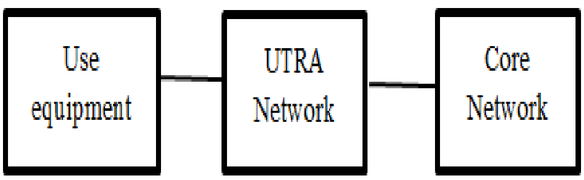


Fig. 4.UMTS System Architecture.

II. PROBLEM DESCRIPTION

A. Impact of InactivityTimers

The inactivity timer consists of two timers a timer and b timer, which plays a vital role in implementing *promotion* refer to transfer of high power state to low power state and *demotion* refers to transfer of high power state to low power state. Energy is wasted for t seconds in each state when the reset and timeout of inactivity timers occur is known to be the tail time.

B. State Transitions in RRC protocol

The RRC protocol is used to release the radio resource for the UE to communicate. There are three different state machine of the RRC in 3G to be mounted when the mobile traffic is detected. The three states are *CELL_DCH*, *CELL_FACH* and *IDLE* state. The CELL_DCH to CELL_FACH and CELL_FACH to IDLE and IDLE to CELL_DCH states consumes high power. CELL_FACH to CELL_DCH and CELL_DCH to IDLE states consumes low power.

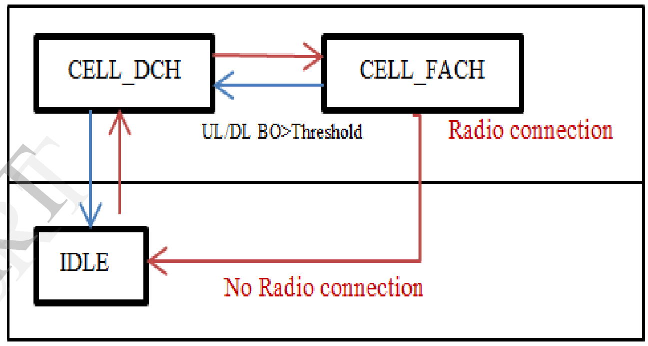


Fig. 5.Transition states of RRC protocol.

1) IDLE

This state refers to the default state of a mobile phone when it is switched on to 3G internet, where no radio resource is allocated and UE is not connected to the RNC and it cannot transfer any data.

2) CELL_DCH

This channel is a dedicated channel, its a fixed and standard channel allocated for about 32 users and used for large and high speed transmission of data that consumes large amount of power.

3) CELL_FACH

They come under common control channel they do not have a fixed physical channel, only small quantities of data are transferred by using shared channel. Sometimes it happens when the user is in CELL_DCH state but when no channel is allocated the user has to move to CELL_FACH state during high power state.

C. InactivityState of Promotion and Demotion

The UE consumes less energy at demotion and more energy during promotion. In promotion state is initialized by the Buffer Occupancy Level. It is present in both downlink and uplink buffers in the Radio Link Control Layer. When the UE is in IDLE state and the BO value is greater than 0, promotion occurs from IDLE to DCH state. When the UE is in FACH state either value of the BO exceeds the threshold value, demotion occurs from FACH->DCH state. The two inactivity timer α timer and β timer controlled by RNC. During DCH state α timer is reset when high traffic occurs. When throughput is 0 or less than the threshold value α timer stops, and mounted to FACH state. Therefore in FACH state the β timer is reset when traffic occurs. When throughput is 0 or less than the threshold value β timer stops and state is mounted to IDLE state.

III. TECHNIQUES USED TO REDUCE THE TAIL TIME

We discuss the states where radio resource and power of the mobile device wasted during data transmission. The techniques used to save and eliminate tail time and other power consumption mechanisms.

A. *Leveraging the Tail Time*

The paper exposes the idea by utilizing the tail time to transfer and perfecting and batching request called Tail Theft scheme. It is focused on UMTS using RRC protocol. By scheduling the request using a scheduling algorithm called dual queue scheduling algorithm and use of virtual tail time method.

1) Tail Theft scheme

- An API is designed to distinguish the types of request by the network application in the mobile phone, and uses virtual tail time to identify the tail time.
- It then uses the virtual tail timer which plays the exact function of the inactivity timer that determines whether the tail time can be used to transfer and pre-fetch the request.
- Thirdly it uses dual queue scheduling algorithm that consists of two queues one for real time request and other for tail theft request all request are processed before the dead line of the timer set.

a) Merits

- Tail time can be utilized rather than eliminating the tail time.
- Saving significant battery energy and radio resource for sending request.

B. *Tail Optimization Protocol for Saving Energy*

Design TOP to eliminate the tail time whenever possible. It is interfaced with the phone and the Radio Access Network by analyzing the inter arrival time of the sessions and uses fast dormancy for the immediate release of radio resource release. Focused on UMTS architecture and implemented with application traces.

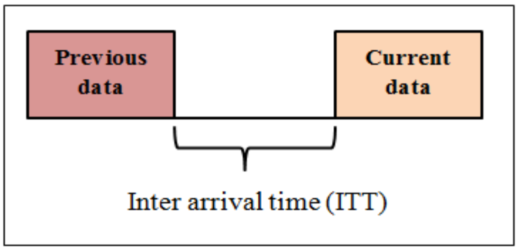


Fig. 6.Defining Inter arrival Time.

1) TOP Approach

- Predicting the tail time by analyzing the inter arrival time between the previous data packet and the currently sent packet of the next transfer.
- Tail removal is done when the inter arrival time is longer than the threshold known as Tail Threshold.
- Then invokes the fast dormancy for signal release, when it receives a T message from the application when it determines the tail time.

a) Demerits

- Poorly used fast dormancy includes node promotion and long delay of the users data transfer.
- Various versions of fast dormancy used may also increase the difficulty in implementation.
- Can be used for application that has limited users.
- Network characteristics and devices mobility causes change in inter arrival time and increase in signaling overhead.

C. *Adaptive Fast Dormancy Algorithm*

It discuss about the radio resource management technique by reducing the tail overhead. It uses an adaptive fast dormancy algorithm where it determines the traffic inactivity of the device and maximizes the signaling of fast dormancy. By controlling the false alarm by formulating the stochastic approximation approach for UMTS networks to save battery energy. The required size of the traffic traces varies upon the complexity use of the network application.

1) Fast Dormancy Algorithm Approach

- The fast dormancy request sent from the mobile can detect the end of connection. Once the inactivity timer expires the algorithm makes a request to the network that maintains two timers for each application.
- Stochastic approximation framework tool used to find the zero of a function to control false alarm.
- In network AFD will reduce the connection duration to save battery where small duration takes more radio resource.

D. *Performance –aware Energy Optimization*

This work designed an efficient online scheduling algorithm to save maximum amount of energy during tail time and during transmission time called PerES algorithm to evaluate a better performance to save energy in phones.

1) Scheduling process and Design

- The scheduling decisions are made for each time slot to gain a long time of benefit as it requires no future information of the traffic activity.
- In-order to schedule the applications, they are grouped by their profile type or by their weight or user preference.
- Applications are fixed with deadlines and thus use a queue management to solve the delay.

E. Radio Jockey

This paper uses program execution state which predicts the recently transferred packet over the cellular network that happens to be the last packet in the currently active session. Then it invokes fast dormancy.

1) Radio Jockey function

- It learns the application level behavior and predicts that the behavior consists of Radio Jockey's learning engine that implements rule matching and invoking the fast dormancy.
- The intuition of the approach is that by identifying the code paths, defined as the set of code paths run applications using network, and other codes are executed when application stops using the network. By identifying the code paths we can predict the end of network behavior.
- In active session when two consecutive packets transmission time occur more than a t seconds then it can be used to predict the end of session.
- Other method is rule learning mechanism, uses decision tree classifier with information that outputs a set of rules that indicate when a session is in an ACTIVE or EOS (End of Session) state.

a) Demerits

- Fixed value for inactivity timer in which packets are transferred immediately after the timer has expired that causes the radio resource to wake up immediately that increases the signaling overhead.
- Channels change dramatically in case of mobility and packets are delayed due to low latency. If idle timers are used in such cases may lead to increase in signaling load.
- When the predicted delays are small it is not beneficial to utilize or eliminate the tail time. Therefore it is difficult to handle.

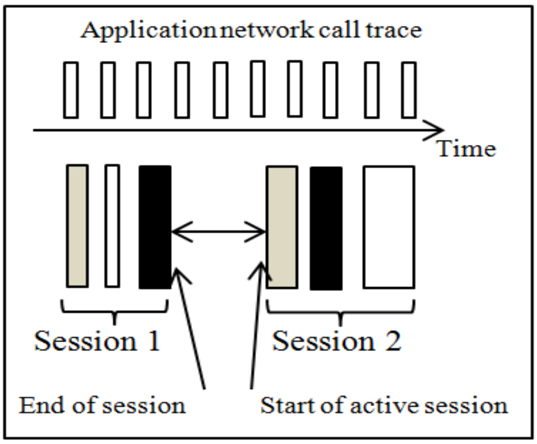


Fig. 7.Defining the end of session traces.

F. Traffic aware Techniques

Like 3G/LTE are also drains the battery in mobile devices. Battery power is wasted when the mobile devices are in unwanted active state when there is no traffic. The paper presents the technique for studying the traffic pattern of the network traffic patterns and determining the start and end of burst time of the traffic. It is implemented with the design of two algorithms implemented for two carriers known to be Active and Idle algorithm.

1) Algorithm Approach

- The contribution of the paper is traffic-aware implementation of design for the control system of the RRC state transitions and also determining the energy taken by the device, latency and signaling overhead.
- The design of two algorithms Make Idle helps to predict the end of session. Make Active algorithm to delay the start of a new session by activating multiple sessions that can decrease the amount of signaling overhead.
- The main design is to put the radio state into idle mode when more bursts are predicted.
- The system design consists of a control module inside the device to predict the burst. One path connected with the Fast Dormancy and other path with socket layer connected in turn with the mobile application.

IV. FAST DORMANCY AND POWER CONSUMPTION ANALYSIS

An application mechanism that uses a signaling technique by sending a RRC control signal called Signaling Connection Release Indication to the RNC to demotion state from CELL_DCH to the IDLE state.

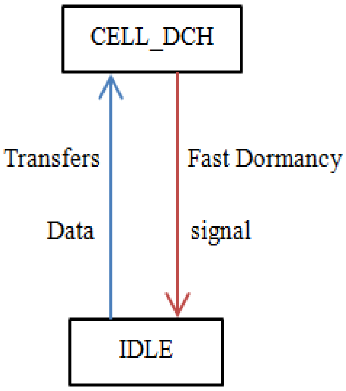


Fig. 8.Fast dormancy mechanism.

A. Few factors that affect smartphones power

1) Radio consumption: The radio energy is a major power consumer in today's smartphones and the traffic determines the power management.

2) Packet Loss: Packet loss is also one of the main factor that decreases the throughput of smartphone traffic. Too much of traffic generated also ends in bottleneck and overflow of uplink and downlink buffers may also lead to high power consumption.

3) Idle energy: The radio signal quickly resumes transfer of packet exchange if it takes too long time, power is unnecessarily wasted when there is no transmission. Energy is also wasted due to wake up cost of each state.

As the user equipment sends a request signal for fast dormancy to the RNC to immediately mount to IDLE state when there is no transmission taking place. Instead of waiting for the inactivity timer to timeout the energy is wasted. Poor performance of fast dormancy may lead to high power consumption and also long delays of the process.

B. Power consumption in different technologies

Power consumption depends on the usage of mobile device. Smartphone's uses Lithium (Li-ion) battery. Power may also decrease due to packet loss, range etc. Taking three different mobile networking systems 3G, GSM, Wi-Fi as we compare the tail energy defined to be the time spent when radio energy is wasted and ramp energy defined to be the energy spent while IDLE state is mounted to high power state. Compared to the three systems Wi-Fi is an efficient energy consumer.

TABLE I. DIFFERENCE BETWEEN MOBILE NETWORKING SYSTEMS

Networking systems	Difference
3G	• Energy wasted in tail time and small amount of ramp energy. • Consumes high power to transfer large data.
GSM	• Tail time is less when compared to 3G. • No ramp energy. • Low power consumed for low data rate and high power consumed for high data rate is transferred. • Data size has high impact on energy cost.
Wi-Fi	• Tail energy is comparable to 3G tail energy. • Low data rate transferred that consumes low power and high data rate also consumes low power.

V. COMPARISION RESULT

A small comparison of the papers discussed in Section. III applied their own algorithm and methods and the percentage of energy saved.

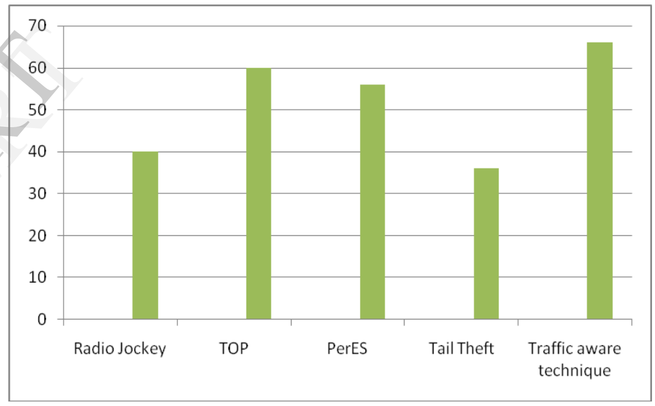


Fig. 9.Comparision of result of various techniques for saving energy.

VI. CONCLUSION

As we see 3G network system provides enormous amount of data access. Along with more power consumption that drains the battery of the mobile device that is a significant problem. We discussed the energy consumption of mobile phones and the energy wastage during the tail time. Performance mechanism analyses of various techniques were classified. Includes algorithms that are been implemented with various techniques handled in other research papers to leverage the wasted radio resource. The other projects developed to conserve energy in mobiles are Green Radio, EARTH, OPERA -net etc.

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