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Performance Improvements of the Umts Systems for Messages Transfer

TarigShawgiAbdelrahman[†], Amin Babiker A. Mustafa[†], and Ismail El-Azhary[††]
†Dept. of Telecommunications, Faculty of Engineering, Al Neelain University, Khartoum, Sudan
††Dept. of Computer Engineering, Faculty of Engineering, Al Neelain University, Khartoum, Sudan

Abstract: *This paper addresses the improvement of the Universal Mobile Telecommunication System (UMTS) performance in the transmission of short messages over Random Access Channel and dedicated channel. In addition to call origination and registration messages,Random Access Channel (RACH)can carry traffic including short message service packets. Throughput for message data transmission is evaluated as a function of the offered network load. Two mathematical models are implemented,dedicated channel model1 which is used to analyze the dedicated channelthroughput, and the proposed model which is used to analyzeRACH and dedicated channel throughput, in the first model Random Access Channel only carry requests for transmissions over dedicated channel, in the second model Random Access Channel carry either messages or requests of transmission, so increasing the number of the received messages.*

I. Introduction

Universal Mobile Telecommunication System (UMTS) is one of the major third generation mobile communication system developed by ETSI. UMTS mark the move into the third generation of mobile networks and isexpected to address the growing demand of mobile and internet applications for increasing capacity and higher data rates that were the shortcoming of 2G and 2.5G (GPRS) [1]. UMTS supports multimedia and various other applications like http, ftp, email, voip, sms , by the side of voice. UMTS supports a wide range of data rates from 64kbps to 2 Mbps in the indoor and outdoor environments [1].

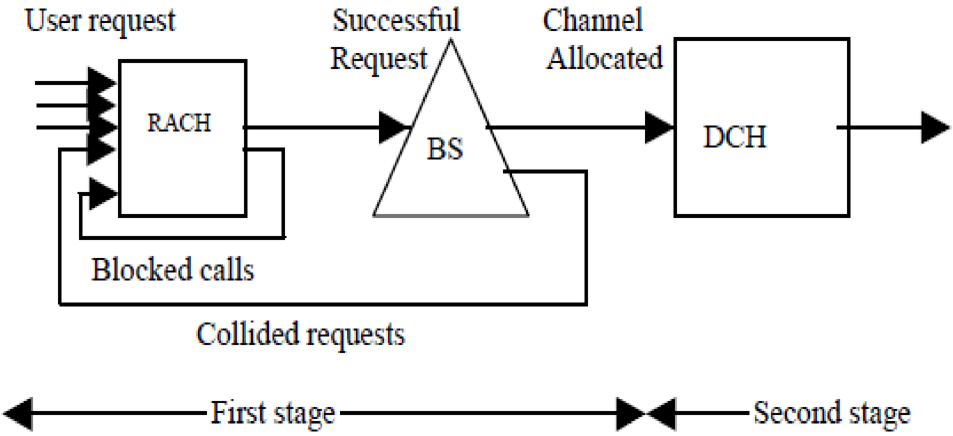
UMTS provides channels for services of non-real time applications, also provides channels for services of real time applications. UMTS standard provides various channels for different types of traffic services, Dedicated Channel (DCH), Downlink Shared Channel (DSCH) and the Forward Access Channel (FACH) transmits packets in the downlink direction. DCH, Uplink Shared Channel (USCH) and Random Access Channel (RACH) transmit packets in the uplink direction.

Dedicated channel can be used in two modes: one is the dedicated channel mode and the other is the multiplexing mode. Dedicated channel mode guarantees the allocation of dedicated channel for the entire duration of a session or a call and used for transmission of real time applications, the other mode is the multiplexing mode in which the channel can be allocated to different packet users and used for transmission of non-real time applications [1].

Investigating the UMTS system performance over dedicated channel based on buffer length allocation and dynamic allocation control procedures was proposed in [1].Details of random access procedure is proposed in [3] and [4]. Throughput of slotted aloha p persistence RACH and a detailed specifications of Radio Resource Control (RRC) protocol are well discussed in [2]. Calculation of the throughput of RACH channel Common Packet Channel CPCH is the main focus of [5] in which the probability of successful transmission given at least one preamble transmission attempt was calculated first. Throughput analysis for Carrier Sense Multiple Access CSMS- type random access protocol for finite number of users has been presented in [6]. Pure and slotted aloha throughput was introduced in [7].

The main goal of this paper is to increase number of the received messages during busy hours, messages can be carried either over DCH or RACH. We attempt to investigate the impact of various parameters on the throughput such as offered network load and percentage of the offered network load on RACH and DCH. The paper is organized as follows: section two including throughput of the dedicated channel model1, in section 3 we discuss throughput of the proposed model, in section 4 throughputs of the dedicated channel model1 and the proposed model were compared and discussed, including effects of the variable values of the offered network loadand its distribution percentage on the throughput, finally we concluded in section-5.

II. Dedicated channel Throughput



Fig(1):Dedicated Channel Model1

The throughput of the dedicated channel is well discussed in [1]. The dedicated channel access mechanism is mathematically analyzed to study the performance in terms of throughput and access delay. The overall system is divided in two individual stages as shown in fig (1), the first stage being RACH slotted aloha channel and the other stage where in dedicated channel is allocated. As per the protocol users contend on the RACH channel and if its request is successfully granted, the packets are transmitted on dedicated channel. Since the stages are connected in cascade the throughput of both the stages are individually determined and multiplied to get the overall throughput.S_1 and $S_2$are throughput of first and second stage respectively. The first stage is asimple slotted aloha system and the second stage can be approximated to an M/M/m/m system [1].

2.1 RACH Throughput

RACH channel is the first stage of the model in fig(1) above. Before sending a short message over RACH each user transmits a short burst called a preamble during one access slot of 1.33 ms, the preamble is detected and acknowledged by the base station, each preamble is encoded by one of 16 signatures, the base station acknowledges signatures in the AI (Acquisition Indication) message sent a predefined time interval after the reception of the preamble[2]. The AI message does not acknowledge preambles individually, only signatures that were used. If the base station does not have a resource (demodulator) to serve the incoming message it sends a NACK for a particular signature [2]. In case signature was not used in a particular slot, or the preamble was not detected a NoACK feedback will be sent in the corresponding AI message for this signature. If a preamblereceived a NoACK feedback the user equipment assumes that the power was too low and preample is retransmitted at higher power level [2]. After the preample is acknowledged the message is sent at a predetermined time interval after the preample [2]. If a NACK feedback is received the message goes through a random backoffprocedure[2]. The normalized RACH throughput in fig(1) is calculated as a function of the average number of preamples sent per access slot (1.33ms),(G). Time can be represented as a sequence of idle and busy periods. Each busy period resulting in either success or collision is of the same length M= (Tm/1.33) slots [2].T_m is the total length of the preample and preample to message gab. M includes the overhead associated with sending the preample denoted by α [2]. In RACH specifications α can be 3 or 4 [2]. We assumesthatallpreamples are received at the power level above threshold, and we assumes that those transmitted during the busy period do not affect the ongoing successful packet reception [2]. Cycle is defined as an idle period followed by a busy period then according to poisson assumption consecutive cycles are independent[7]. In that case the average throughput is defined as:

$$S = \frac{E[u]}{E[I]+E[B]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where U defined as the length of a useful transmission during a cycle, can be M –α or 0 depending on whether the cycle results in a success or collision, respectively [2].

$$E[I] = \frac{e^{-G}}{1-e^{-G}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$E[B] = M \quad (3)$$

$$S = \frac{P_{succ}\,(M-\propto)(1-e^{-G})}{e^{-G}+M(1-e^{-G})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

P_{succ} of a single signature was introduced in [7]

$$P_{Succ} = P[1\ \text{pream. send}|\text{atleast 1 sent}] = \frac{Ge^{-G}}{1-e^{-G}} \ \ldots\ldots\ldots (5)$$

Throughput in case of single signature

$S_1 = \frac{Ge^{-G}(M-\alpha)}{e^{-G}+(1-e^{-G})M}$ ……………………….(6)

2.2 Dedicated Channel Throughput

For the second stage the call blocking probability of an M/M/m/m is derived in [1].

$$P_m = \frac{\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!}}{\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}} \quad \text{……………………….(7)}$$

Where m is the number of dedicated channels.The probability of request successfully reaching at the base station is

$P_{Succ} = 1 - P_m \ldots$ (8)

Throughput of the second stage is given by:

$S_2 = P_{Succ} * \frac{T}{\tau}$…….(9)

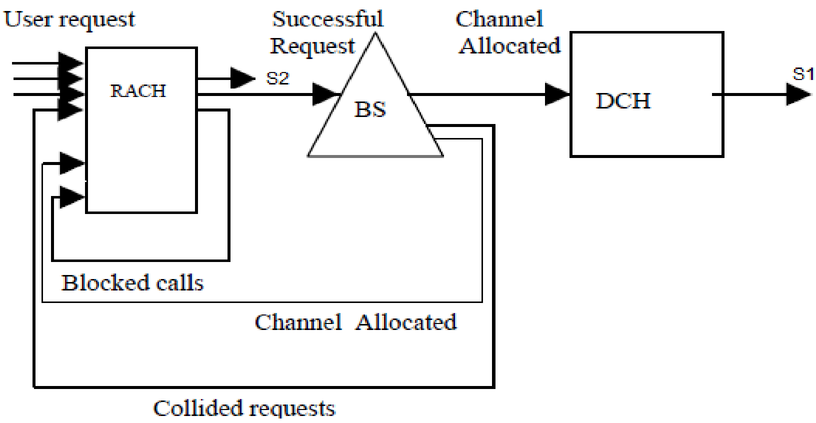
Whereτ is the request transmission time, T is the time granted for each request,λ is the arrival rate of the successfully received requests at the base station, and μ is the request service time = 1/T (10)

the throughput of the second stage is

$$S_2 = \left(1 - \frac{\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!}}{\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}}\right) * \frac{T}{\tau} \quad \text{………………………..(11)}$$

The overall throughput of the model in fig (1) S $= \frac{Ge^{-G}(M-\alpha)}{e^{-G}+(1-e^{-G})M} * \left(1 - \frac{\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!}}{\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}}\right) * \frac{T}{\tau}$ (requests/time slot)………… (12)

III. Proposed model



Fig(2): The Proposed Model

As shown in fig (2), the total throughput of the proposed model is composed of S1 and S2, $S_{tot} = S_1 + S_2$ (13). In the proposed model RACH channel carry requests for transferring messages either over itself or over dedicated channel. Every request successfully received at the base station granted transmission for time T over dedicated channel or RACH channel.

$$S_1 = \frac{XG\ e^{-XG}\ (M_1-\alpha)}{e^{-XG} + M_1(1-e^{-XG})} * \left(1 - \frac{\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!}}{\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}}\right) * \frac{T}{\tau} \quad \text{……… (13)}$$

Here $M_1 = 4.5a$ ……………………………………(14)

a(time slot) = 1.33 ms………………………………(15)

$S_2 = \frac{(1-X)G\ e^{-(1-X)G}\ (M_2-\alpha)}{e^{-(1-X)G} + M_2(1-e^{-(1-X)G})}$ ……………….. (16)

$M_2 = 34.5*a$…………………………………..(17)

$$S_{total} = \frac{XG\ e^{-XG}\ (M_1-\alpha)}{e^{-XG}+M_1(1-e^{-XG})} * \left(1-\frac{\frac{\left(\frac{\lambda}{\mu}\right)^m}{m!}}{\sum_{k=0}^{m}\frac{\left(\frac{\lambda}{\mu}\right)^k}{k!}}\right) * \frac{T}{\tau} + \frac{(1-X)G\ e^{-(1-X)G}\ (M_2-\alpha)}{e^{-(1-X)G}+M_2(1-e^{-(1-X)G})} \text{ (req/time slot)}.......(18)$$

X is defined as the percentage of requests for transmission of SMSover the dedicated channel, $0 \leq X \leq 1$. Where (1 - X) is defined as the percentage of requests for transmission of SMS over RACH channel.

IV. Results and Discussion

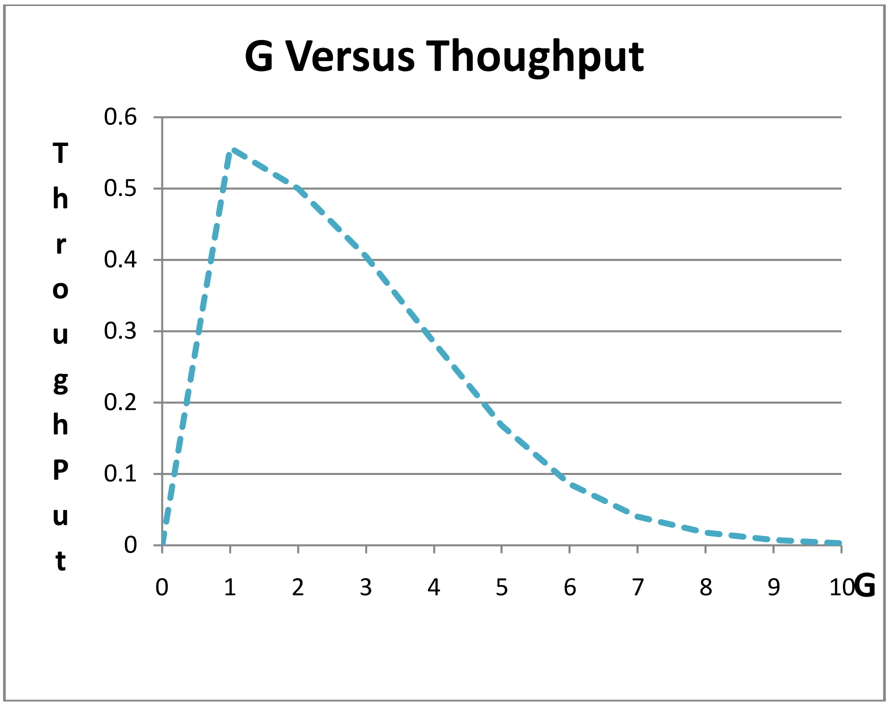


Fig (3):Throughput versus offered load of the dedicated model1.

Fig (3) shows the throughput versus the offered load (G) of the dedicated channel in model1,throughput is rapidly increased from 0 which is minimum throughput value at (G=0) up to 0.557which is the maximum throughput obtained at (G=1), then throughput declared with increasing the offered load G.

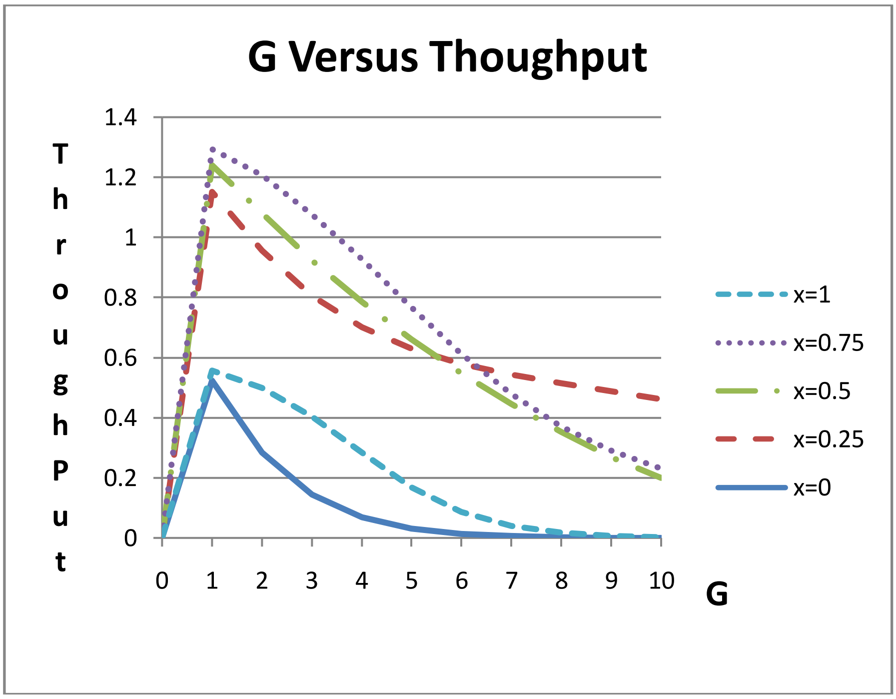
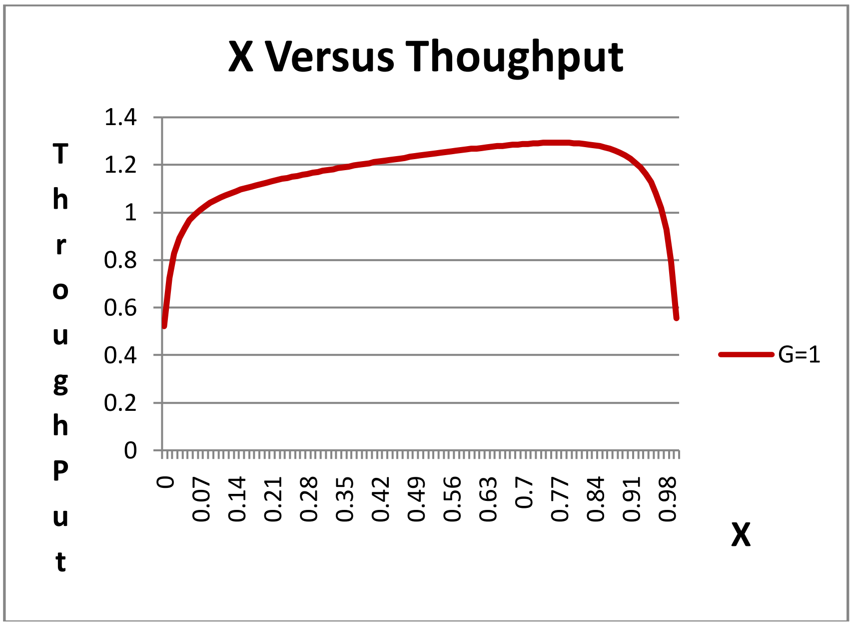


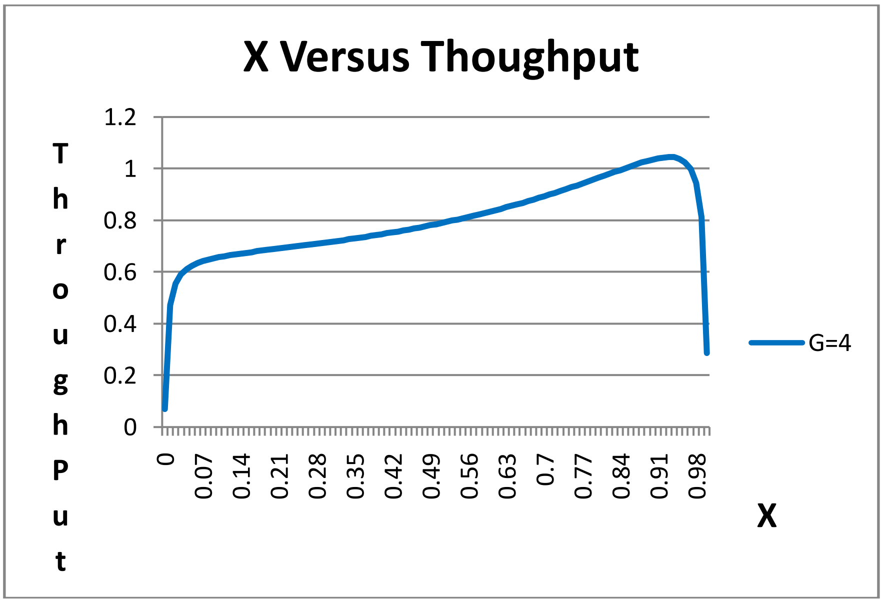
Fig (4): Throughput of the proposed model versus offered load (G) at different values of (X)

Fig (4) illustrates throughput of the proposed model versus offered load (G) at different values of (X), it have seen that the throughput of the proposed model is higher than model1 for all X values, except at X=1 at which throughputs of model1 and proposed model are equal and at X=0 at which the proposed mode throughput is lower than model1 throughput.Also it is clear that for decreasing X values the rate of throughput degradation decreases with increasing the offered load G,the optimum value of X for G≤6 is 0.75 and for G≥ 6is 0.25.
Fig (5), (6) and (7) illustrates the optimum (X) values to obtain maximum throughput, it is clear that the impact of X on throughput is more significant near 0 or 1.



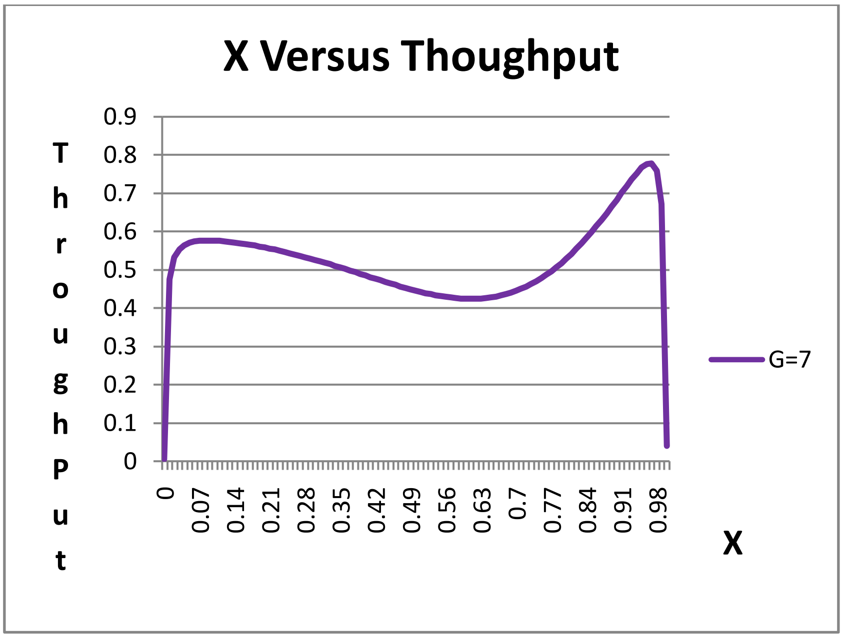
Fig(5): Throughput versus X at the offered load G = 1

Fig(5) shows throughput versus X for the offered load (G = 1). As shown the minimum throughput is 0.522 which is obtained at X=0. For 0≤X≤0.07 throughput is rapidly increased from 0.552 up to 1.011, for 0.07≤X≤0.77 throughput is gradually increasing approximately in linear manner from 1.011 up to 1.294 which is the maximum throughput of G=1, throughput for 0.77≤X≤1 rapidly declared from 1.294 down to 0.557.



Fig(6): Throughput versus X at offered load G=4

Fig(6) shows throughput versus X at offered load(G=4). Throughput at 0≤X≤0.06 is rapidly increased from 0.068 which is the minimum throughput up to 0.633. At 0.06≤X≤0.93 throughput is gradually increasedfrom 0.633 up to 1.044 which is the maximum throughput. Throughput at 0.93≤X≤1 is rapidly decreased from 1.044 down to 0.283.



Fig(7): Throughput versus X at offered load G=7

Fig(7) illustrates throughput versus X at offered load G=7,it is shown that the minimum throughput is 0.005 which is obtained at X=0, throughput is rapidly increased from 0.005 up to 0.576 at X=0.09, at 0.09≤X≤0.61 throughput is gradually decreased from 0.576 down to 0.424, at 0.61≤X≤0.97 throughput increased from 0.424 up to 0.777 which is the maximum throughput, at 0.97≤X≤1 throughput is rapidly decreased from 0.777 down to 0.04.

V. Conclusion

In this paper the throughput of messages transferred by UMTS is improved. Two mathematical performance models are analyzed in terms of throughput. In dedicated channel model, RACH channel is solely used for requests transmission. In the proposed model RACH is used for requests and messages transmission, this led to increase number of the received messages.

For the proposed model, the impact of the offered load percentages (X) and (1-X) applied on the dedicated channel and RACH channel respectively, on the total system throughputis investigated. It is clearly shown that distributing the offered load with any percentage(0<X<1) results in increasing throughput compared with transmitting the whole offered load either on dedicated or RACH channel. According to the offered load G the optimum (X) value and maximum throughput could be obtained.

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**TarigShawgi**received his BSc in ElectronicEngineering from Military TechnicalCollege, Egypt in 1993.He did his MSc in Computer&NetworkEngineeringfrom Faculty of Engineering,AlgazeeraUniversity,Sudan in 2002.He is now doing his PhD research in the field of QoS with the Department of Telecommunications, Al Neelain University. Currently he is a Lecturer with Electrical Engineering Department, the Jordian Sudanese College.His research interest includes QoS in telecommunications.

 Amin Babiker A/Nabi Mustafa obtained his B.Sc. & M.Sc. from the university of Khartoum in 1990 & 2001 respectively. He obtained his Ph.D. from Alneelain University in 2007. He was the head of Computer Eng. Dept. from 2001 to 2004. Then he became the vice-dean. He has been the dean, Faculty of Engineering Alneelain University since 2009. His research areas includeQoS in Communication Systems, Traffic Engineering, Service Costing Disciplines & Networking. Associated Prof. Dr. Amin is a Consultant Engineer. He is a member of the Sudan Engineering Council. He is also a member of the Executive Committee of the Federation of Sudanese Engineers. Dr. Amin supervised or supervising more than 30 Ph.D. or M.Sc. students.Since 2002 up to April 2015 when he became the Secretary of Academic Affairs in Alneelain university.

**Ismail El-Azhary**received his BSc (Hons) degree from the University of Khartoum (Sudan) in1979. In 1989 he obtained his PhD degree from the University of Bradford (UK). He joined Omdurman Islamic University in 1992 as an assistant professor. Then, he moved to the Sudan University of Science and Technology as an associate professor in 1994. He became the Dean of the Faculty of Engineering, Al Neelain University from 2000 to 2005. His research interests include: QoS of networks, technical communication, digital typography, e-learning, antennas and propagation, and embedded systems. Dr El-Azhary is a Chartered Engineer and member of the IET. .