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QoS Based Adaptive Admission Controller for Next Generation Wireless Networks

Ch. Sreenivasa Rao, K. Chenna Keshava Reddy, and D. Srinivasa Rao

Abstract—**In 4G networks admission control will need to deal with many heterogeneous networks and admit new sessions to a network that is most appropriate to supply the requested QoS. In order to avoid the degradation of the QoS of low priority sessions, in this paper we propose a QoS Based Adaptive Admission Controller (QAAC). The service request is classified into two types new or handoff and the traffic is classified as real-time and non real-time. Then depending on the traffic class and type of service, the request is finally classified into four categories and priorities are assigned for each category. The admission control algorithm manages the various service requests in their queues and adaptively schedules them as per their assigned priorities. The basic concept of the algorithm is to simultaneously provide transmission priority and space priority for the data flows of the same end-user. The algorithm tries to minimize the number of the sessions that are blocked due to insufficient resources in the target network. By simulation results, we show that our proposed technique yields better throughput with reduced delay.**

Index Terms—**Wireless networks, 4G networks, QoS, QoS based adaptive admission controller (QAAC).**

I. INTRODUCTION

There arises the need for a better understanding of fundamental issues in communication theory and electromagnetic and their implications for the design of highly-capable wireless systems as a result of the increasing demands and requirements for wireless communication systems. 4th generation

(4G) mobile technology is monitored by most of the service providers in the continuous development of mobile environments.4G acts as a solution to the inquiry and various standardization bodies standardize the vision and requirements [1] of 4G. It is a descendant to 3G and 2G and it is the known as the fourth generation of cellular wireless networks. It becomes the advanced strategy in world of wireless communications [2]. It provides interoperability with existing wireless standards [3]. It supports global roaming across multiple wireless and mobile networks [4]. A user is able to reconnect faultlessly to different networks and can access the network if he had large range of mobility [5].

QoS assigns priorities to different applications, users or data flows. It also guarantees a certain level of performance to a data flow. For example, it can guarantee a required bit rate, delay, jitter, packet dropping probability and/or bit error rate. The QoS guarantees are important if the network capacity is insufficient since these often require fixed bit rate and are delay sensitive, and in networks where the capacity is a limited resource [7]. Fourth Generation (4G) technologies have interconnection of various access networks and thus it enables the provision of faultless service to the end user. When more than two networks were needed to interoperate, the end-to-end service quality cannot be provided easily [9] as in the 4G market [8].

A. *QoS issues in 4G Networks*

- Real time applications require QoS guarantee. When the best-effort quality is acceptable, then the end user will require the QoS guarantee
- Lack of protocols for implementing an overall adaptive application QoS support in order to obtain optimal QoS performance.
- The problem of resource reservation and management for guaranteed QoS in a generic multi-system environment is not addressed efficiently.
- QoS suffers from the lack of access, location transparency, re-configurability and adaptability which became major shortcoming for the evolution towards the QoS of 4G mobile wireless network.
- Another challenge faced by the current internet is the streaming of multimedia content to different receivers across heterogeneous networks
- There are different standards adopted in different countries which led the major issues in realization and implementation of 4G networks today.
- Due to the intermittent quality degradation, QoS are difficult to maintain in wireless networks.
- Creating an adaptive application-level QoS set of parameters and attributes.
- Achieving the optimal mapping between application QoS parameters and system components.

In order to meet diverse user QoS requirements, 4G have to consider many service classes. The service classes considered may include different delay, throughput, and bit error rate (BER) characteristics. There could be services that should have higher priority due to the nature of the service classes. There are two requests new and handover (handoff) request based on the priorities.

In order to avoid the degradation of the QoS of low priority sessions, in this paper, we propose a QoS Based Adaptive admission controller. We concentrate to obtain transmission priority for real time flow and bandwidth priority to the non real time data flow of the same end-user, in order to prevent non real time flow starvation, without violating the real-time

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Ch. Sreenivasa Rao, Professor, Department of ECE, Vardhaman College of Engineering. (e-mail: sreenivasaraophd@gmail.com)

K. Chenna Keshava Reddy, Professor and principal, Jyothismathy College of Engineering and Technology, Hyderabad.

D. Srinivasa Rao, Professor, ECE Dept. , JNTU CE, Hyderabad.

flow QoS requirements.

The paper is organized as follows. Section 2 presents the related works done on the same topic. Section 3 gives the detailed description of the proposed QoS Based Adaptive Admission Controller. The simulation results are given in Section 4 and the paper is concluded in Section 5.

II. RELATED WORK

Gordana Gardaševic *et al.* [10] have identified the key adaptation issues and proposed the architectural framework for application level QoS adaptation. This framework was established as a set of entities, where each of them performs specific tasks. Those entities were dealing with traffic characterization, estimation, application policy and QoS syntax.

Francesco Benedetto *et al.* [11] have presented a cooperative network-aware processing of multimedia content for dynamic quality of service management in wireless IP networks. Their technique can be also used for quality control in UMTS environments, exploiting the tracing watermarking recently introduced in literature. In the work, they used the transmitted video sequences to monitor the QoS in a videoconference call. Thus it became a solution to the lack of access and location transparency as well as of re-configurability and adaptability capabilities maintained.

Isabella Cerutti *et al.* [12] have proposed an adaptive cross-layer (ACL) strategy that jointly optimizes PHY and MAC parameters of an OFDM based network to meet users' QoS. ACL strategy was based on a queueing theory model. ACL strategy was tested on different scenarios of user mobility. But further studies were required on this topic to account for delayed or inaccurate CQI, impact of other QoS requirements (e.g., jitter, maximum delay) and different service flow characteristics (more accurate traffic models), practical implementation constraints (e.g., limited buffer size), and more sophisticated ARQ protocols.

Elias Z. Tragos *et al.* [13] have presented the fundamentals of access-network-based admission control, an overview of the existing admission control algorithms for 2G and 3G networks, and finally gave the design of a new admission control algorithm suitable for future 4G networks and specifically influenced by the objectives of the European WINNER project. They also demonstrated how an algorithm that was indented on satisfying multiple criteria could perform well in both light and heavy traffic.

Mostafa Zaman Chowdhury *et al.* [14] have proposed a priority order of QoS parameters based on protocol layers and service applications. They presented the relation among the QoS parameters those influenced the performance of other QoS parameters. The proposed soft-QoS scheme was found to be very much effective to reduce the dropped call rate which was the most important parameter for all types of services. That scheme could also reduce blocked call rate up to medium traffic condition if bandwidth was not sufficient to accept a requested call.

III. QOS BASED ADAPTIVE ADMISSION CONTROLLER (QAAC)

A. Overview

In QoS Based Adaptive admission controller technique, the channel quality is measured and separate queues are maintained for each class of service. The service request is classified into two types new or handoff. Depending on the class of service (real-time or non real time) and type of service, four categories are formed as:

Category 1: A handoff request with real time traffic
Category 2: A handoff request with non-real time traffic
Category 3: A new request with real time traffic
Category 4: A new request with non-real time traffic

Our objective is to simultaneously provide transmission priority for the real time flow, and bandwidth priority to the non real time data flow of the same end-user. In order to prevent non real time flow starvation, without violating the real-time flow QoS requirements.

Transmission priority is given for category 1 and 3 (priority TP) to fulfill delay, since they involve delay-sensitive and loss-tolerant real-time (RT) flows. Bandwidth priority is given for category 2 and 4 (priority BP) to provide loss minimization, since they involve loss-sensitive but delay tolerant non real-time (NRT) flows.

QoS Based Adaptive admission controller manages the various service requests in their queues and schedules them according to their priorities. The derived algorithm for future network aims to maximize the number of admitted or in-session traffic sessions supported over the networks, while guaranteeing their QoS requirements and ensuring that a new session does not violate the QoS of ongoing sessions.

The TP flow packets are queued ahead of the BP flow packets of the same user for the priority scheduling on the shared channel. The BP packets get bandwidth priority in the user's buffer queue because of their loss sensitivity, and lower transmission priority due to their delay tolerance [13].T is the threshold which restricts the maximum number of queued RT packets but the flow of requests under category 1 has unrestricted access to the entire buffer space.

B. Adaptive Admission Control

This technique uses a trade-off mechanism to exchange transmission priority to the NRT flow, but there will be a slight degradation of the priority BP within certain constraints. Queuing will prevent the potential priority BP flow starvation at the radio interface, satisfying the QoS requirements. A hybrid priority queuing mechanism is used to queue priority TP and BP for the same user.

1) Queue Management for Real-time Packets

Let a_t and b_t be the number of RT and NRT packets in the queue at time t. From queuing principle, $0 < a_t < T$ and $0 < b_t < N$ at any given time t where T is the threshold for queued RT packets and N represents the total number of packets in the queue.

The hybrid priority queuing mechanism is explained as follows:

```
1. For each arriving request frame from the network for the packet, determine the flow priority TP or BP.
2. If flow belongs to TP, for each packet in the payload, then
   2.1 If $(a_t < T)$, then
           2.1.1 Store the packet at RT queue tail
       Else
           2.1.2 Drop the packet and update TP loss
       End If
   End if
3. If flow belongs to BP, for each packet in the payload, then
   3.1 If $(a_t + b_t) < N$, then
           3.1.1 Store the packet at queue tail
       Else
           Drop the packet and update BP loss
       End if
   End if
```

2) Admission Control Algorithm

The admission control algorithm is described as follows

```
When a new request comes
1. Check its characteristics.
2. If target network not exists, then
       2.1 reject the session.
   Else
       2.2 Check whether the request is a TP or BP.
           If TP, then,
               2.2.1 Check for transmission priority
               2.2.2 If $(a_t < T)$ then,
                       2.2.2.1 Accept the request
                     Else
                       2.2.2.2 If can be served by another network, then,
                           2.2.2.2.1 Repeat from 2.2.1
                         Else,
                           2.2.2.2.2 Reject the request
                         End if
                     End if
         Else
             2.3.1 Check for bandwidth priority
             If $(a_t + b_t) < N$
                 2.3.1.1 Accept the request
             Else
                 2.3.1.2 If another suitable network exists, then
                         2.3.1.2.1 Repeat from section 2.3.1
             Else
                 2.3.1.2.2 Reject the session.
             End if
           End if
       End if
End if
```

Supposing that we are not dealing with emergency calls and user grouping after selecting the target network, the algorithm checks if the session is new or from handover. If it is a new session, if there are other sessions waiting in the queue it will be rejected; otherwise, it goes to the next step. The next step of the algorithm is to check if it satisfies the condition, $(a_t < T)$ in that network for the session to be served. If the resources of the particular target network are insufficient, the first thing to check is whether the session can be served by another network, since it is more desirable to perform intersystem handovers than degrading the QoS of some users in a network. Then check for the bandwidth priority condition, $a_t + b_t < N$, if the condition is met, then repeat again from the time priority session else repeat the same. If the session is a handover or a new high-priority session, it is not rejected in the target network, but is first checked for whether it can be served by another network. If not, degrade the session. If it is a new session, then check whether it can be served by another network and if the condition satisfies, then again check the condition, $(a_t < T)$ and proceed. And if it does not satisfy, then degrade the session.

The session will remain in the queue until:

- The needed resources become available
- The session leaves the cell or the session is completed.
- The session is terminated due to timeout a user should not wait forever to receive service, so the calls are assigned an admission timeout variable.

The above algorithm tries to minimize the number of the sessions that are blocked due to insufficient resources in the target network. Another advantage of the algorithm is the efficient use of each network's resources by sending to each network traffic that can be best served by that network according to its technical capabilities.

IV. PERFORMANCE EVALUATION

A. Simulation Model and Parameters

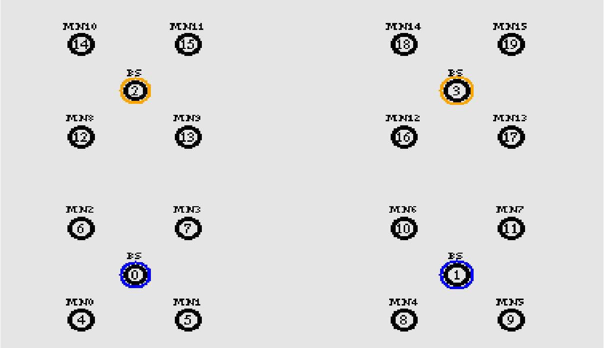
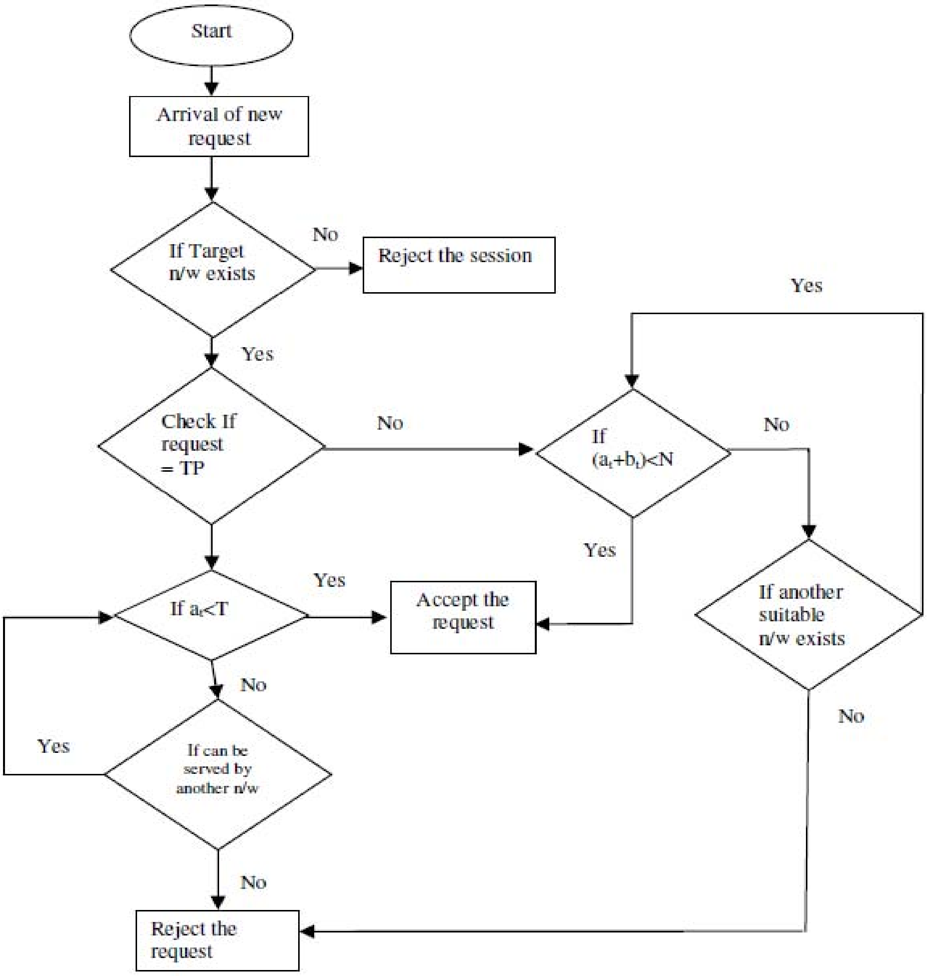


Fig. 2.Simulation Topology

To simulate the proposed scheme, network simulator (NS2) [15] is used. In the simulation, clients (SS) and the base station (BS) are deployed in a 1000 meter x 1000 meter region for 50 seconds simulation time. It consists of 4 base stations among which, 2 are based on 802.16 WiMax and remaining 2 are based on 802.11 WLAN. The base stations marked with orange circle belongs to 802.11 WLAN and the base stations marked with blue circle belongs to WiMax 802.16 network. Each network contains 4 mobile nodes (refer fig. 2). All nodes have the same transmission range of 250 meters. In the simulation, both the CBR and Video traffic are used. Among the flows, category 1 to 3 has one flow each and category 4 has 3 flows. In our simulation, Mobile node 9 and 3 perform horizontal and vertical handoff, respectively.



Fig, 1.Flow chart of Admission Control Algorithm

The simulation settings and parameters are summarized in table 1.

TABLE.I: SIMULATION SETTINGS AND PARAMETERS

Area Size	1000mtsX 1000mts
Mac	802.16 and 802.11
Base stations	4
Clients	16
Radio Range	250m
Simulation Time	50 sec
Routing Protocol	DSDV
Traffic Source	CBR and Video
Video Trace File	JurassikH263-256k_trace.dat
Physical Layer	OFDM
Packet Size	100 bytes
Frame Duration	0.005
Rate	50 to 250 kb
Time	35 seconds

A. *Performance Metrics*

We compare our proposed QoS based adaptive admission controller (QAAC) based algorithm with the Admission Control for QoS Support (ACQ) in Heterogeneous 4G Wireless Networks [13]. We mainly evaluate the performance according to the following metrics:

Throughput: It is the amount of traffic (real time or non-real time) that is received in the destination, represented in Megabits / second.

Delay: It is the average end to end delay occurred at the destination for all flows.

B. *Results*

1) Based on Rate

In the initial experiment, we vary the rate of each traffic flow from 50kb to 250kb and measured the performance for real time (RT) and non-real time (NRT) traffic.

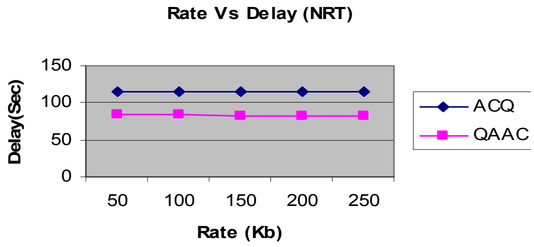


Fig. 3.Rate Vs Delay

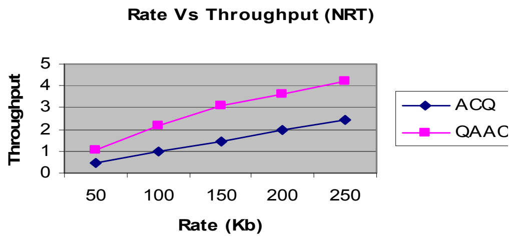


Fig. 4.Rate Vs Throughput

Figures 3 and 4 show the delay and throughput for the NRT traffic. Clearly we can see that our QAAC technique is better than ACQ when the rate is increased. This is because our QAAC technique provides bandwidth priority for NRT flows.

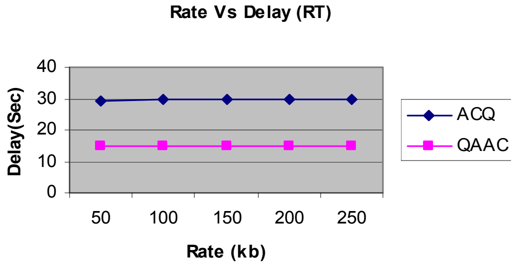


Fig. 5.Rate Vs Delay

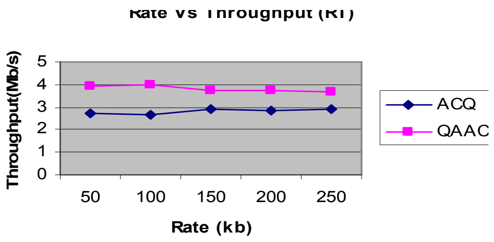


Fig. 6.Rate Vs Throughput

Figures 5 and 6 show the delay and throughput for the RT traffic. It can be observed that our QAAC technique yields better results than ACQ when the rate is increased. This is because our QAAC technique provides transmission priority for RT flows.

2) Based on Time

In the second experiment, we measure the performance for real time (RT) and non-real time (NRT) traffic, during various intervals of the whole simulation time. The traffic rate is fixed as 250Kb.

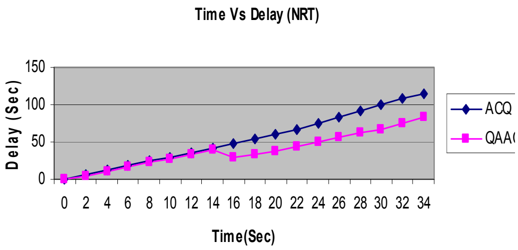


Fig. 7.Time Vs Delay

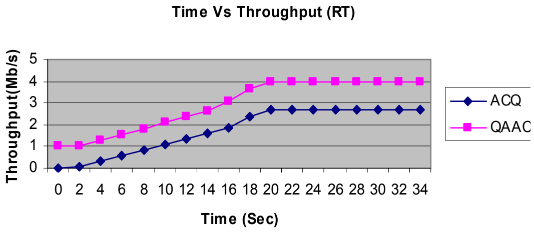


Fig 8: Time Vs Throughput

Figures 7 and 8 show the delay and throughput for the NRT traffic. Clearly we can see that our QAAC technique is better than ACQ for increasing time interval, since our QAAC technique provides bandwidth priority for NRT flows.

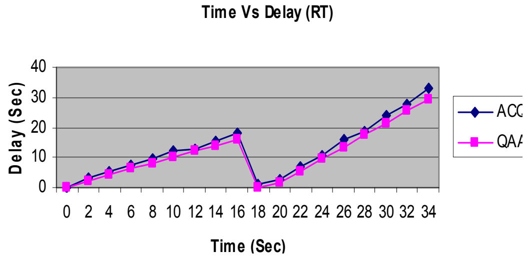


Fig. 9.Time Vs Delay

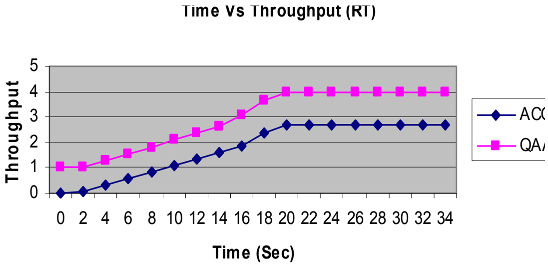


Fig. 10.Time Vs Throughput

Figures 9 and 10 show the delay and throughput for the RT traffic. It can be observed that our QAAC technique is better than ACQ for increasing time interval, since our QAAC technique provides transmission priority for RT flows.

V. CONCLUSION AND FUTURE WORK

In this paper, we have developed an algorithm which tries to minimize the number of the sessions that are blocked due to insufficient resources in the target network. The basic concept of dynamic time-space priority is utilized in the algorithm to simultaneously provide transmission (time) priority for the priority TP flow, and space priority to the priority BP data flow of the same end-user. The technique utilizes a trade-off mechanism to switch transmission priority to the NRT flow at the expense of slight degradation of priority BP within the allowable constraints. The admission control of QoS Based Adaptive algorithm for future networks aims to maximize the number of admitted or in-session traffic sessions supported over the networks, while guaranteeing their QoS requirements and ensuring that a new session does not violate the QoS of ongoing sessions. Another advantage of the algorithm is the efficient use of each network's resources by sending traffic requests to each network that can be best served by that network according to its technical capabilities. By simulation results, we have shown that our proposed technique yields better throughput with reduced delay. As a future work, we wish to analyze the network performance on bandwidth reservation and develop an effective bandwidth management technique for both real-time and non real-time traffic flows.

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Ch. Sreenivasa Rao received The B.Tech degree (ECE) from Nagarguna University in1996, M.Tech (DSCE) from JNTU in 2004. From 1997 to 2000, he served in A.P.Trans Co, as Assistant Engineer. Since November 2000, he has been with Dept of ECE, Vardhaman College of Engineering, Shamshabad, Hyderabad. Presently he is working as Professor in the Department of ECE, Vardhaman College of Engineering.

He worked in the field of Electronics, particularly in Electronic Devices and Analog Electronics. He has 5 publications in various National, International Conferences. He is carrying research work since 2007 in the area of QoS in Wireless Networks at JNTUH under the guidance of Dr. K.Chenna Keshava Reddy, Principal, Jyothismathy college of Engineering and Technology, Hyderabad & Dr. D. Srinivasa Rao, Professor, Department of ECE, JNTU College of Engineering, Hyderabad.

Dr.K.Chenna Keshava Reddy received the B.E degree, M.Tech degree from Regional Engineering College (REC), Warangal in 1973 and 1976 respectively, PhD from JNT University, Hyderabad in 2001. He served in the Department of Electrical Engineering, REC Warangal for 1.5years as Research Associate in Problem Oriented Research Lab (P.O.R.L). He was with JNTU, Ananthapur from 1977 to1979. He served in the Dept of ECE, JNTU Hyderabad from 1979 to 2001 at various levels. From December 2001 to September 2006, he was the Deputy Director of UGC Academic Staff College, JNTU Hyderabad. He worked as Director of Evolution at JNTU Hyderabad from 2006 to 2007. Dr.Chenna Keshava Reddy was principal for JNTU College of Engineering, Jagityal, Karimnagar from May 2007 to June 2009. Presently he is working as professor and principal at Jyothismathy College of Engineering and Technology, Hyderabad. He has published 70 research papers at National and International levels.

Dr. D. Srinivasa Rao received the B.Tech degree (ECE) from Nagarjuna University in 1986, M.E (Digital Systems) from Osmania University in 1994 and Ph.D (Computer Communication Networks) from University of Hyderabad in 2004. His research interest is in the area of communications and computer networks. Presently 12 research students are working under his guidance. He has 22 publications in various National, International Conferences and Journals.

He has 20 years of teaching experience. He worked at CBIT as Lecturer in ECE Department for 6 years during 1988 – 1994. He worked at ECE Department of JNTU, Ananthapur in various capacities for 11 years during 1994-2005. Presently he is working as Professor in ECE Dept. of JNTU CE, Hyderabad. He has chaired sessions at various national conferences. He is advisory committee member for GNIT, Hyderabad. He is also governing body member for Syed Hashim College of Science & Technology, member of JNTU forum for Science & Society and Coordinator for campus networking at JNTU CE, Hyderabad.