Volume: 6 Issue: 4 Pages: 2409-2413 (2015) ISSN: 0975-0290

Improved EPRCA Congestion Control Scheme for ATM Networks

Dr. M.Sreenivasulu
Department of CSE, K.S.R.M.College of Engineering, Kadapa, Andhra Pradesh, India.
Email: mesrinu@rediffmail.com

---ABSTRACT---
Traffic management and congestion control are major issues in Asynchronous Transfer Mode(ATM) networks. Congestion arises when traffic in the network is more than offered load. The primary function of congestion control is to ensure good throughput and low delay performance while maintaining a fair allocation of network resources to users. In this paper, Enhanced Proportional Rate based Congestion Avoidance (EPRCA) scheme proposed by ATM forum has been considered. But this scheme has limitation of higher cell drop problem for the bursty traffic. Improvements to EPRCA scheme have been proposed to reduce cell drop problem and results of improved EPRCA schemes were analyzed with basic EPRCA scheme.

Keywords**: ATM networks, EPRCA, IEPRCA, NIST ATM Network Simulator.**

Date of Submission: November 27, 2014 Date of Acceptance: January 7, 2015

1. Introduction

Broadband Integrated Services Digital Network (B-ISDN) can offer high speed data transport, multimedia communication, high quality video conferences, video telephony, etc [17]. The Asynchronous Transfer Mode (ATM) has emerged as a standard technology for supporting gigabit BISDN services [18-20]. Using ATM, the information is usually transmitted in fixed size units called cells. The ATM technique is designed to provide fast packet switching at variable rates from 1.54 Mbps to 2 Gbps and even beyond.

Traffic Management and congestion control are major issues in ATM networks [1-6]. Congestion arises when incoming traffic to specific link is more than outgoing link capacity. When congestion problem arises, cells are discarded without being processed. The design of congestion control mechanism is essential not only for regulating traffic to prevent congestion but also for providing efficient and fair bandwidth allocation [9,15]. Among various congestion control mechanisms, rate base mechanisms are proved efficient than other mechanisms. Rate based congestion control schemes are end-to-end feedback mechanisms, and the cell transmission rate of each source end system is regulated according to congestion feedback information returned by the network [8,12,13].

In this paper, Enhanced Proportional Rate Control Algorithm (EPRCA), which is a rate based scheme for controlling congestion in ATM networks, has been considered. The improvements to EPRCA scheme is also presented in this paper. The basic and improved schemes were implemented using NIST ATM network simulator. This paper is organized as follows: The importance of Resource Management (RM) cell and its fields are presented in Section 2. The basic EPRCA mechanism, the simulation environment and results analysis of EPRCA are presented in section 3. The improvements to EPRCA schemes, with results are presented in section 4. Finally the conclusion of paper is presented in section 5.

2. Resource Management (RM) Cell

In rate based congestion control schemes, source end system periodically sends a Resource Management (RM) cell for every 31 data cells. The RM cell is used to carry control and flow information over the connection between source and destination end systems [11]. The destination end system sends an RM cell with an indicator showing the status of traffic back to the source end system. The intermediate switches may simply forward these RM cells or specify the explicit rate in RM cell based on functionality of different rate based congestion control schemes. The source end system then uses the information in the RM cell for specifying the transmission rate until a new RM cell is received.

The RM cell is used for finding status of congestion, if any, in the network. Every RM cell has the header of five bytes width. The payload type indicator (PTI) in cell header is set to a 3 bit binary, 110, as the default value, to indicate a RM cell. The protocol ID field, which is one byte long, is set to one for Available Bit Rate (ABR) application connections. The direction (DIR) bit distinguishes between forward and backward RM cells. The backward notification (BN) bit is set only in switch generated RM cells. The congestion indication (CI) bit is set by a switch to indicate presence of congestion. The no increase (NI) bit, is set by a switch to indicate moderate congestion in the network. The sequence number field value is set by source end system to indicate the current sequence number for the RM cell and the queue length field value is set by a switch in the network. The Explicit Rate (ER) field indicates the maximum rate allowed to the source and this field value is set by the switch. When the source receives the backward RM cell from the network,

Volume: 6 Issue: 4 Pages: 2409-2413 (2015) ISSN: 0975-0290

it adjusts its transmission rate using the ER, CI, and NI values in the received RM Cell.

3. Basic EPRCA Scheme

The Enhanced Proportional Rate Control Algorithm (EPRCA) is a rate based scheme, in which switch explicitly specifies the rate at which transmission should be made at the source [14,16]. In this scheme, each switch in the path between source and destination end systems maintains a queue or buffer, with two congestion thresholds namely, thresholds QT (i.e. to indicate normal congestion) and DQT (i.e. to indicate severe congestion). Each switch in the network periodically computes mean allowed cell rate (MACR) that should ideally be the mean of all source end systems ACRs. The MACR value is used for computing explicit rate in RM cell.

3.1. EPRCA Algorithm

Before transmission of data by the source end system, the connection or route to be established between source and destination end systems. The route comprising of source, destination end systems, intermediate systems, and switches. The behaviour of source, destination end systems, and intermediate switch are mentioned below [10]:

Source End System behaviour

1. At the beginning of transmission, the source transmits an RM cell. The allowed cell rate (ACR) or current cell rate (CCR) is initially set to peak cell rate.

2. The source sends data cells and after every 31 data cells transmitted, one RM cell is followed.

3. The source continuously decreases its ACR until it receives an RM cell returned from the destination. Upon receipt of every RM cell, the source increases its ACR by no greater than ER.

Destination End System behaviour

1. The destination returns an RM cell upon receiving each RM cell.

Switch behaviour

1. In the network, each switch periodically computes a mean allowed cell rate (MACR) using the following formula:

MACR = (1 – AV) * MACR + AV * ACR,

where AV is the Average Factor, which is set to a default value of 0.0625.

If the queue length is less than QT, then there is no congestion in the network. When non-congested switch receives a RM cell from a source end system and if ACR is less than MACR, then there is no need to adjust its MACR. If ACR is greater than or equal to MACR, it means that MACR is not adequately large enough, then MACR needs to be increased by using the above formula.

2. If the queue length exceeds DQT, indicating that the switch is said to be in severe congestion state, then ER needs to be replaced in RM suitably, as follows:

ER = min (ER, MACR * MRF)

Where MRF is Major Reduction Factor, set to a default value of 0.95

If queue length exceeds QT, the switch is said to be in congestion state, then only those source end systems whose ACR is more than MACR is need to reduce their ACR value by replacing ER in RM cell given by the formula:

ER = min (ER, MACR*ERF)

Where ERF is Explicit Reduction Factor, set to a default value of 0.9375.

3.2 Simulation Environment

The basic EPRCA scheme described in previous section was implemented using NIST ATM Network Simulator for a sample network configuration shown in fig 1 [7].

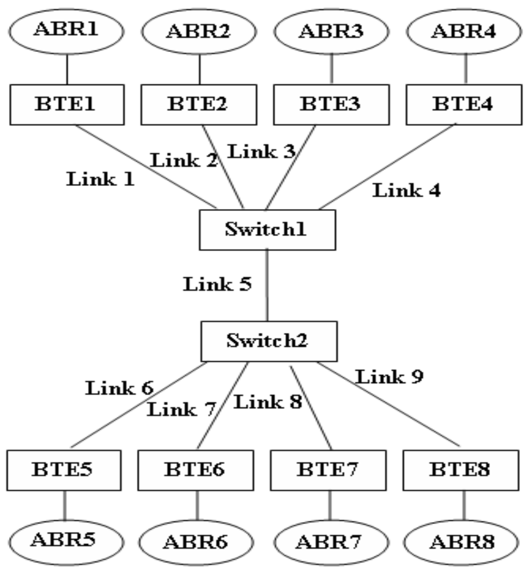

Fig.1: A Sample Network Configuration

The network shown in fig.1, consist of four source end systems (BTE1 to BTE 4 – Broadband Terminal Equipment), four destination end systems (BTE5 to BTE8), nine communication links (link1 to link 9), two switches (switch1 and switch2), four applications (Available Bit Rate applications ABR1 to ABR4) running on source end systems and another four applications (ABR5 to ABR8) running on destination end systems. The ABR applications are attached to source and destination terminals for sending and receiving data respectively. For example, in given network configuration, four virtual channels have been considered for explanation. The first Virtual Channel (VC1) can be established is through BTE1, Switch 1, Switch 2, and BTE 5. The Second Virtual Channel (VC2) is through BTE 2, Switch 1, Switch 2, and BTE 6. The Third Virtual Channel (VC3) is through BTE 3, Switch 1, Switch 2, and BTE 7. The Fourth Virtual Channel (VC4) is through BTE 4, Switch 1, Switch 2, and BTE 8.

In our simulation, the source end systems transmit cells at its given Allowed Cell Rate which is initially set to PCR with default value of 149 Mbps. The bandwidths of all links (i.e link 1 to link 9) were set to 155 Mbps. The default values for various control parameters of switches and source end systems are also set, as mentioned in Table 1 and Table 2 respectively.

Volume: 6 Issue: 4 Pages: 2409-2413 (2015) ISSN: 0975-0290

Table 1: Control parameters for Switch1 & Switch 2 for EPRCA scheme

Parameter	Value
Queue length (in cells)	1000
Low threshold (in cells)	600
Very Congested Queue Threshold (in cells)	900
Explicit Reduction Factor (ERF)	0.9375
Major Reduction Factor (MRF)	0.95
Average Factor (AV)	0.0625

Table 2: Control parameters of source end systems for EPRCA scheme

Parameter	Value
Initial Cell Rate (ICR)	7.49 Mbps
Minimum Cell Rate (MCR)	1. 49 Mbps
Peak Cell Rate (PCR)	149.76 Mbps

3.3 Results Analysis

The performance of EPRCA Scheme is measured based on cell drop percentage during transmission period of data cells. The graph showing cell drop percentage over transmission time is shown in figure 2.

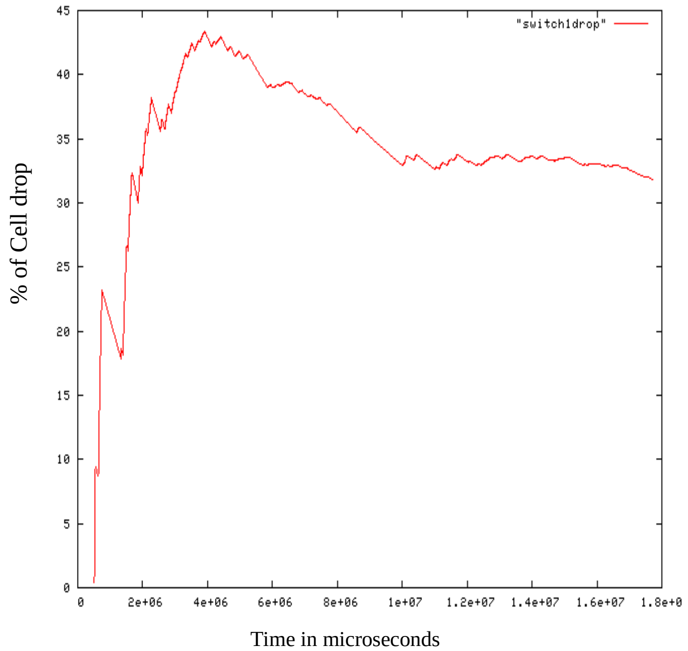

Fig: 2 Percentage of Cell drop Vs Time at Switch 1 for basic EPRCA Scheme

From the above graph, higher percentage of cell drop is noticed at the beginning of transmission, because ACR was set to PCR. The cell drop at switch 1 is approximately 33 % and need a mechanism to reduce.

4. Improved EPRCA Schemes

Improvements to EPRCA scheme have been proposed to reduce the cell drop problem by considering the following modifications to basic EPRCA scheme.

4.1. Improved EPRCA (IEPRCA) Scheme1

In this, the behavior of source end systems are modified by changing value of PCR to get reduced cell drops as well as optimal link utilization. In basic EPRCA scheme, a default value of 149.7 Mbps is set to PCR. This PCR value is assigned to Initial Cell Rate (ICR) and all source end systems start transmitting cells at higher rates (i.e. with PCR) initially, resulting high cell drops at switch1. The experimental tests have been conducted by varying values for PCR and able to notice that the maximum network efficiency can be reached by selecting PCR value at an optimal value equal to 100 Mbps.

The improved EPRCA with optimal PCR value (i.e. modified source end system behavior) was implemented and graph for percentage of cell drop at switch1 over transmission time is Fig. 3.

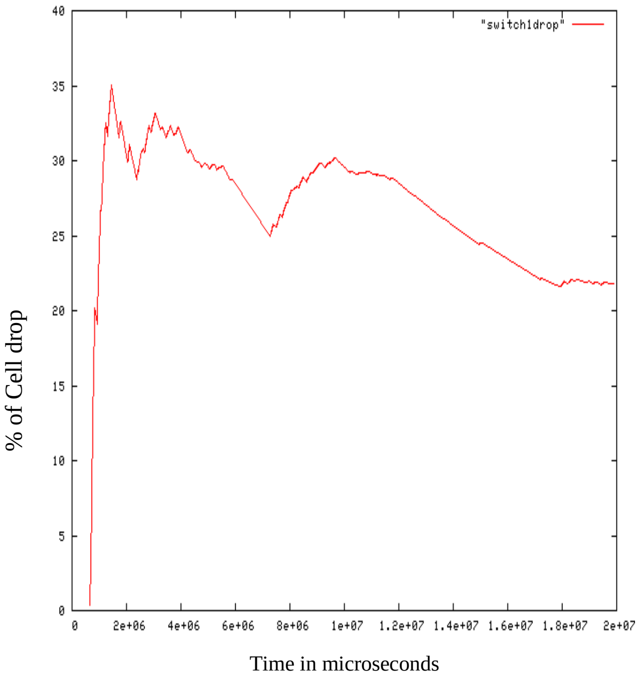

Fig.3: Percentage of Cell drop Vs Time at Switch1 for IEPRCA sheme1

From the graph, it has been noticed that, the IEPRCA scheme1 gives 21% cell drop, where as in the case of basic EPRCA scheme it is approximately 33%. So the IEPRCA scheme1 effectively reduces cell drop problem by selecting PCR value at optimum and hence better than basic EPRCA scheme.

4.2 Improved EPRCA (IEPRCA) Scheme2

The modification of switch behavior is also considered to improve the performance of EPRCA scheme. The modified switch behavior is given below.

1. When non congested switch receives forward RM cell from source end system, it computes mean ACR (MACR) using the following formula:

$$MACR = (1 – AV) * MACR + AV * CCR$$

Int. J. Advanced Networking and Applications
Volume: 6 Issue: 4 Pages: 2409-2413 (2015) ISSN: 0975-0290

The mean ACR is used for setting ER field of the RM cell and CCR is the Current Cell Rate.

2. When switch receives backward RM cell from the destination end system, it checks, if there is congestion at the switch. It compares the queue length with threshold value to detect congestion.

(i) If queue length exceeds threshold DQT, the switch is said to be in severe congestion state. Then it replaces ER in RM cell by min (ER, MACR * MRF) and reduced ER communicated to all source end systems via backward RM cell.

(ii) If queue length exceeds QT, the switch is said to be in congestion state. To relieve congestion in network, the switch reduces ER by replacing ER with min(ER, MACR * ERF) and this reduced rate is communicated by sending backward RM cell to all source end systems.

The IEPRCA scheme2 was implemented with modified switch behavior and graph showing percentage of cell drop at switch1 over transmission time is shown in Fig. 3.

From this graph, it can be observed that switch reduces explicit rate in backward RM cell, whenever it finds the queue length exceeds threshold value.

The source end system decreases allowed cell rate when it receives reduced ER in backward RM cell. When the switch1 gets relief from congestion, it increases ER field value in backward RM cell to allow source end systems to increase their allowed cell rate.

It can also easily noticed from the graph that, % cell drop fairly depends upon the cell transmission rate, and increases with the rate of transmission The % cell drop with IEPRCA scheme2 is 27%, as against 33% with basic EPRCA scheme. Hence IEPRCA scheme2 is proved to be better than basic EPRCA scheme.

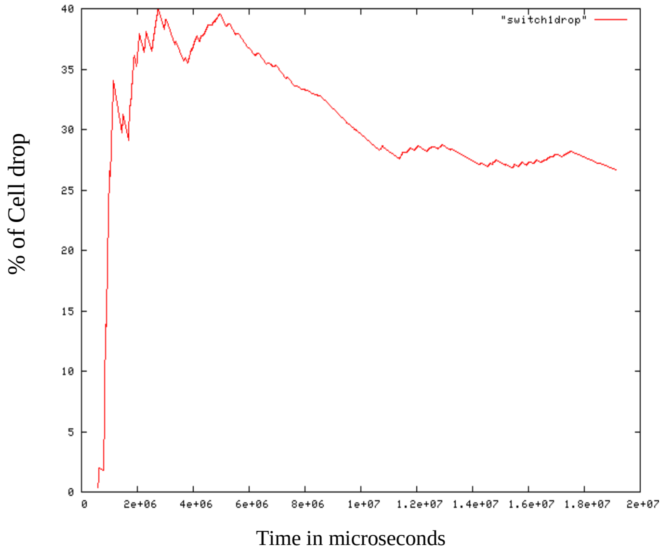

Fig.4: Percentage of Cell drop Vs Time at Switch1 for IEPRCA scheme2

4.3 Improved EPRCA (IEPRCA) Scheme3

To reduce the cell drop still further, the effects of method 1 and method 2 have been combined to achieve yet another improved scheme, called, IEPRCA scheme3. In this scheme3, the optimal value of 100 Mbps is set to PCR for source end system and also switch behavior is modified as in IEPRCA scheme2. The IEPRCA scheme3 was implemented and results are shown in form of graph for % cell drop vs time at intermediate switch1 in shown in Fig 5.

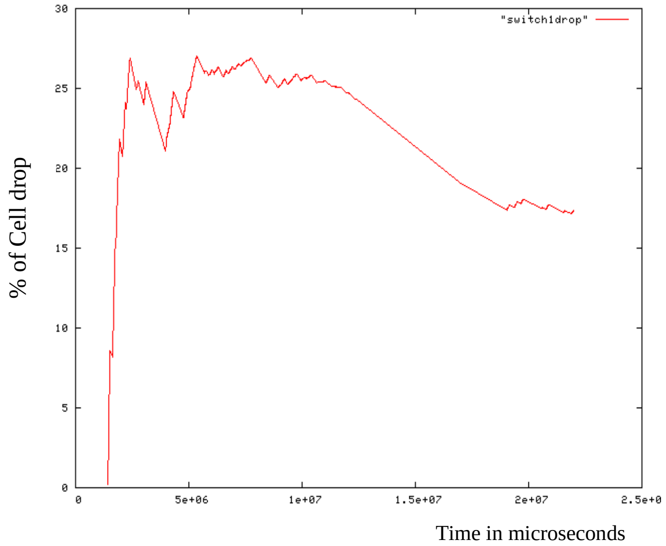

Fig.5: Percentage of Cell drop Vs Time at Switch1 for IEPRCA scheme3

From this graph, % cell drop is 17% noticed at switch1, which is considerably less than that of basic EPRCA scheme as well as IEPRCA scheme1 and scheme2. Hence it can be concluded that IEPRCA scheme3 is far better than basic EPRCA scheme.

4.4 Performance Comparison of EPRCA and improved EPRCA schemes

The performance of IEPRCA schemes and basic EPRCA can be compared by considering the amount of % cell drop at intermediate switch1 and it was tabulated in table 3.

Table 3: Percentage of cell drop for EPRCA and IEPRCA schemes

Sl. No.	Scheme	% cell drop
1.	EPRCA	33
2.	IEPRCA Scheme1	21
3.	IEPRCA Scheme2	27
4.	IEPRCA Scheme3	17

From the above the table, it has been noticed that, IEPRCA shceme3 results with 17% cell drop which is considerably less than that of basic EPRCA scheme as well as IEPRCA scheme1 and scheme2. Hence it can be concluded that IEPRCA scheme3 is far better than the basic IEPRCA scheme.

5. Conclusion

In this paper, 3 methods have been proposed to enhance the performance of basic EPRCA scheme, (i) by setting PCR to optimal value (IEPRCA scheme1), (ii) by modifying the switch behavior (IEPRCA scheme2), and (iii) by setting optimal PCR value and modified switch behavior (IEPRCA scheme3). The IEPRCA scheme3 found to achieve the best results when compared to basic EPRCA scheme as well as over other improved schemes IEPRCA scheme1 and IEPRCA scheme2.

References

[1] R.S.Deshpande, Dr. P.D. Vyavahare, "Recent Advances and a survey of congestion control mechanisms in ATM networks", *IE(I) Journal, Vol. 88*, pp. 47-54, , 2007 .

[2] W Li, Z Che, Y Li, "Research on the congestion control of Broadband Integrated Service Digital Network based on ATM", *Proceedings of the fifth international conference on Machine Learning and Cybernetics, Daliaan,* pp 2510-2512, 2006.

[3] E Al-Hammadi and M M Shasavari, "Engineering ATM networks for congestion avoidance", Mobile Networks and Application, *Vol. 5,* pp.157 – 163, 2000.

[4] Ching-Fong Su, Gustavo Do Vacianna, Jean Warland, "Explicit Rate Flow Control for ABR Services in ATM Networks", *IEEE/ACM Transactions on Networking*, *Vol. 8*, Issue 3, pp. 350-361, 2000.

[5] A Hac, H.Lin, "Congestion Control for ABR traffic in an ATM network", *International Journal of Network Management, Vol. 9,* pp. 249-264, 1999.

[6] K Siu, H Tzeng, "Intelligent Congestion Control for ABR service in ATM networks",*ACM SIGCOMM Computer Communication Review, Vol. 25*, Issue 2, pp. 81-106, 1994.

[7] N Golmie, F Mouveaux, L Hester, Y Saintillan, A Koenig, D.Su, "The NIST ATM/HFC Network Simulator Operation and Programming Guide", Dec 1998.

[8] H Ohsaki, M Murata, H Suzuki et al, "Rate based Congestion Control for ATM networks", *ACM SIGCOMM, Computer Communication Review, Vol. 25*, Issue 2, pp. 60-72, 1995.

[9] D Gaiti, G. Pujolle, "Performance management issues in ATM networks: traffic and congestion control", *IEEE/ACM transactions on networking, Vol. 4,* No.2, pp.249-257, April 1996.

[10] Raj Jain, Shivkumar Kalyanraman, Sonia Fahmy, Rohit Goyal, "Source Behavior for ATM ABR Traffic Management: An Explanation", *IEEE Communication Magzine*, pp. 50-55, 1996.

[11] Thomos M.Chen, Steve S. Lin, David Wang, Vijay K.Samalam, Michael J. Procanik, and Dinyar Kavouspour, "Monitoring and control of ATM networks using special cells", *IEEE network magazine*, pp.28-38, Sept/oct 1996.

[12] Anna Hac, Yingjun Ma, "A Rate based Congestion Control Scheme for ABR service in ATM networks", *International Journal of Network Management, Vol.8*, pp. 292-317, 1998.

[13] Lalita A. Kulakarni, San-qi Li, "Performance Analysis of a Rate-based Feedback Control Scheme", *IEEE/ACM Transactions on Networking, Vol. 6*, No. 6, Decemeber 1998.

[14] L Roberts, "Enhanced Proportional Rate Control Algorithm", ATM forum contribution, April 1994.

[15] Rama Krishnan, "Rate based Control Schemes for ABR Traffic – Design Principles and performance comparison",*Global Communication Conference Globecom96*, pp.1231-1235, 1996.

[16] Xinomel Yu, Doan B. Hoang, David D.Feng, "A Simulation Study of using ER feedback control to transport compressed video over ATM network", *Proceedings Workshop on Visualization*, 2001.

[17] William Stallings, "ISDN and Broadband ISDN with Frame Relay and ATM", (Fouth Edition, Pearson Education Asia, 2007).

[18] A Arulambalam, Xiaoqiang Chen, N. Ansari, "Allocating Fair Rates for Available Bit Rate Service in ATM Networks", *IEEE Communication Magazine, Vol. 34*, No. 11, pp. 92-100, 1996.

[19] Rainer Handel,Manfred N Huber,Stefan Schroder, "ATM Networks Concepts, Protocols,Applications' (Third Edition, Addison,Wesly,1999).

[20] J Y. Le Boudec, "The Asynchronous Transfer Mode: A Tutorial", *Computer Networks & ISDN Systems, Vol.24*, pp. 279-302, 1992.

Author's Biography

M. Sreenivasunlu received B.Tech degree in Computer Science and Engineering, from K.L. College of Engineering (K.L.University), Vaddeswarm, A.P. India, in 1990. He completed M.E. in Computer Science & Engineering, from Jadavpur University, Calcutta, India, in 1999. He received Ph.D. in Computer Science and Engineering, from J.N.T.University, Anantapur, A.P. India, in the year 2013. He is having 21 years of teaching experience. He is currently working as Professor & Head of Computer Science and Engineering Department, K.S.R.M.College of Engineering, Kadapa. He is member of IEEE, life member of IE(I), and ISTE. He published 15 papers in international journals and in the proceedings of National and International Conferences.