Provisioning Multimedia QoS in Wireless Networks- The Meta-Analysis

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***Abstract*: Providing Quality of Service for multimedia contents in wireless networks is the hot issue among recent researches. Most of the work already has been done in this field but no such article provides conclusive results. This is the major motivation to do Meta–analysis research in this field, to provide some conclusive results based upon previous knowledge base. Thirty-six journal articles have been selected and reviewed, the subject area found are: Call Admission & Control, Bandwidth Management, Resource Reservation/Allocation, Cross-Layer Design, Routing and Traffic Management. The research models, methodologies, variables and subject area, used by each article are identified. Finally results have been concluded on the basis of this knowledge base. On the basis of these results the new framework is proposed, which would be helpful for upcoming researcher to initiate the research in the field of wireless network to provide QoS for multimedia contents.**

Keywords:
Quality of Service, Wireless Networks, Multimedia, Meta-Analysis and Framework

I. INTRODUCTION:

Wireless is an omnipresent technology, and is a universal remedy. Wireless communication brings fundamental changes to data networking and Telecommunications. To relay information to and from our computer, wireless network uses radio waves instead of cables. Due to high speed Internet and Multimedia applications, future wireless communication are expected to support multimedia traffic such as voice, video and text with a variety of Quality of Service (QoS) requirements and make efficient use of radio resources.

An important issue in wireless networks related to QoS is the support for Multimedia Services; many scheduling strategies have been developed to carry out multimedia traffic. [1] Focus on managing downlink traffic in both wireless ATM and WiFi scenarios, referring to an infrastructure wireless access network where a central coordinator takes scheduling decisions for the mobile users in its cell. Many different protocols are introduced to provide assured QoS multimedia traffic. [2] Uses the embedded Markov chain and supplementary variable methods and obtained the queue-length distribution as well as the loss probability and the mean waiting time for each type of customer.

The objective of this paper is to develop taxonomy of how different researchers are providing QoS in wireless networks since the last decade considering different aspects based upon literature review.

II. TAXONOMY OF SUBJECTS:

Different subject areas related to QoS provisioning for Multimedia in Wireless Networks are identified and examined how researchers use them. These subject areas are listed in Table 1.

Furthermore, all the research papers are examined and sorted out according to the usage of models, variables and research methodologies. The taxonomy of models and research methodology is depicted from [3].

TABLE – 1
QoS provisioning Subject Areas Taxonomy

Number	Subject Area
1	Call admission Control (CAC)
2	Bandwidth Allocation / Reservation
3	Resource Allocation / Reservation
4	Cross-Layer Design
5	Routing
6	Traffic Management

A. Call Admission Control (CAC)

The call admission control scheme is able to provide statistical QoS guarantees for real-time and streaming traffic. [4] Proposes CARC (Call Admission & Rate Control) scheme. In CAC the first criterion is to admit a new real-time flow only if the requested resource is available and the second criterion is that the QoS provided for the currently existing real-time flows is not affected. The rate control (RC) scheme must also ensure two things. First, it should not affect the QoS level of the admitted real-time traffic. Second, best effort traffic should have access to the

residual bandwidth left by real-time traffic in order to efficiently utilize the channel.

In [5] the call admission control (CAC) with QoS-provisioning is run against each EVL entry and results show that it eliminates the need of prior resource reservation.

A simple M/M/1/k scheme to provide a QoS on call dropping in mobile multimedia networks with mixed-call types is described in [6]. The scheme is robust, simple and efficient to implement.

B. Bandwidth Allocation / Reservation

In order to avoid a sudden degradation in QoS, [7] presents an overload control method for TDMA systems to reduce the source rate requirements to a sustainable level. [8] Also considers the rate-based control to achieve the fairness and smoothness.

A location-aware bandwidth pre-reservation mechanism is designed in [9], which takes advantage of each mobile node's geographic location information to pre-reserve bandwidth for such high priority connections and thus greatly reduces potential scheduling conflicts for transmissions.

[10] Introduces a novel adaptive bandwidth allocation scheme which estimates dynamically the changing traffic parameters through local on-line estimation.

C. Resource Allocation / Reservation

Resource management scheme presented in [11] envisages an AP in each cell that is able to perform adaptive scheduling on the basis of channel state estimate for each user.

[12] Focuses on the MAC/PHY layer and considers three different types of scheduling: CDMA with opportunistic scheduling used in UMTS/HSDPA, CSMA/CA is used in IEEE802.11 WLAN and OFDMA are in IEEE802.16 WiMax.

The module that estimates the future QoS according to the current scheduling where as the controller parameters are tuned according to the system status to achieve dynamic scheduling is described in [13]. Results show that it outperforms in terms of service delay and system utilization.

D. Cross-Layer Design

A cross-layer model for adaptive wireless links, which enables derivation of the desired QoS metrics analytically from the typical wireless parameters across the hardware-radio layer, the physical layer and the data link layer, is presented in [14]. Results show that the proposed solution is simple, scalable and backward compatible.

To decrease the number of control blocks used for RLC (Radio Link Control) acknowledgment mechanism [15] proposes the Non-Selective Repeat (NSR) mechanism for point-to-point communications, thus reduces the delay requested for a packet delivery.

E. Routing

Positional Attribute based Next-hop Determination Approach (PANDA) to improve the performance of flooding-based route discovery in MANETs, presented in [16], using positional attributes of the nodes. Simulation result shows that PANDA can find paths with less energy, achieves improved path optimality and end-to end delay

An extended depth-first-search (EDFS) algorithm is proposed by [17] to solve the multi-constrained path (MCP) problem in QoS routing, solves the general k-constrained MCP problem with pseudo-polynomial time complexity $O(m^2 \cdot EN + N^2)$, where m is the maximum number of non-dominated paths maintained for each destination, E and N are the number of links and nodes of a graph, respectively.

F. traffic management

The traffic management techniques include high-level protocols for traffic monitoring, with subsequent pertinent guidelines for dynamic capacity allocation to heterogeneous multimedia traffics. [18] Proposes Traffic Monitoring Algorithm (TMA). A Framed Time-Domain Based (FTDB) technique and a Framed CDMA (FCDMA) technique is compared, results show that the TMA-FTDB combination is better to the TMA-FCDMA combination

Rest of the paper is organized as: SECTION – II illustrates the research method adopted for this study, SECTION – III describes the results showing the subject areas trends, models and methodologies used by sample articles, SECTION – IV presents the proposed framework and SECTION – V concludes by discussing the limitations for this study and then wrap-up results with future trends for up coming researchers in this field.

III. RESEARCH METHOD FOR THIS STUDY:

Extensive content analysis was conducted for the particular study. In this study research papers are reviewed and previous work is analyzed. Based upon the Computer Science Journal Ranking by [19], thirty-six journal articles are selected for meta-analysis from the leading Journals. The leading journals reviewed for this study are represented in Table 2:

TABLE-2
Selected Journals used in this Study

Wireless Networks
Computer Communication

The articles reviewed in this Study lie between the time periods of 1997-2007. Articles from these selected journals were chosen, reviewed and analyzed using the research method "Content Analysis"

> *"A method of analysis in which text (notes) is systematically examined by*

identifying and grouping themes and coding, classifying and developing categories" [3]

Table-3 depicts the frequency of selected articles from the related leading journals. Frequency of articles in Wireless Networks is very high, because most of the articles related to provisioning of Quality of Service were found in this journal.

In each articles, the category of topic (i.e. subject area), variables, research model, research methodology and research questions were identified. Occasionally, there were more than one research model in each article, and more than one research methodologies were adopted.

Different research methodologies are defined by [3]. The research methodology is basically the procedure of conducting a research. The most frequently used research methodologies in selected articles are listed in Table–4

IV. RESULTS:

Based upon extensive contents analysis, following results have been drawn:

A. Subject Usage:

Table – 5 presents the subject frequency for different subject areas in the selected articles. Some of the articles have more than one subject area but is counted in the category on which article is more emphasized.

The major contribution of the work done previously, to provide Quality of Service (QoS) in wireless networks is the Resource Reservation and Call Admission & Control. A lot of work has been done so far in this field.

Most of the researchers have not much considered the field of *Cross-Layer Designing, routing* and *traffic management* for the provisioning of QoS. Only 5.55 % of the papers have focused the research in routing and traffic management.

B. Model Usage:

The Research Model Taxonomy is defined by [3] is the result of hundreds of research articles. The most frequently used research models in the selected articles are listed in Table – 6 with their usage percentage.

Most of the research papers present Mathematical Model, according to the coded articles (58 %) research articles use Mathematical model. Multi-Tier Influence Diagram and Temporal Influence Diagrams are at (16.66 % & 13.88% respectively), and rest of the models have only (2.77 %) of usage.

C. Subject Usage Trends:

If we analyze the data according to time period of study from 1997 to 2007, we have very interesting results.

TABLE – 3
Scope of the study

Journals	**Frequency**
Wireless Networks	27
Computer Communication	9
Total:	**36**

TABLE – 4
Research Methodologies Used

Number	Methodology Identified
1	Framework model
2	Laboratory Experiment
3	Field Experiment
4	Quantitative Analysis
5	Secondary Data Analysis
6	Mathematical Analysis
7	Simulation

TABLE – 5
Subject Frequencies

Subject	Frequency	Percentage
Call admission Control	11	30.55%
Bandwidth Allocation / Reservation	9	25.00%
Resource Allocation / Reservation	11	30.55%
Cross-Layer Design	3	8.33%
Routing	2	5.55%
traffic management	2	5.55%
Total:	**36**	**100 %**

TABLE – 6
Research Models used

Model	Frequency	Percentage
No Model	1	2.77%
temporal Influence Model	5	13.88%
Mathematical Model	*21*	58.33%
Multi-tier Influence Diagram	6	16.66%
Listing of variables and implicit relationship	1	2.77%
Listing of variables and levels	1	2.77%
Venn Diagram	1	2.77%
Total:	**36**	**100 %**

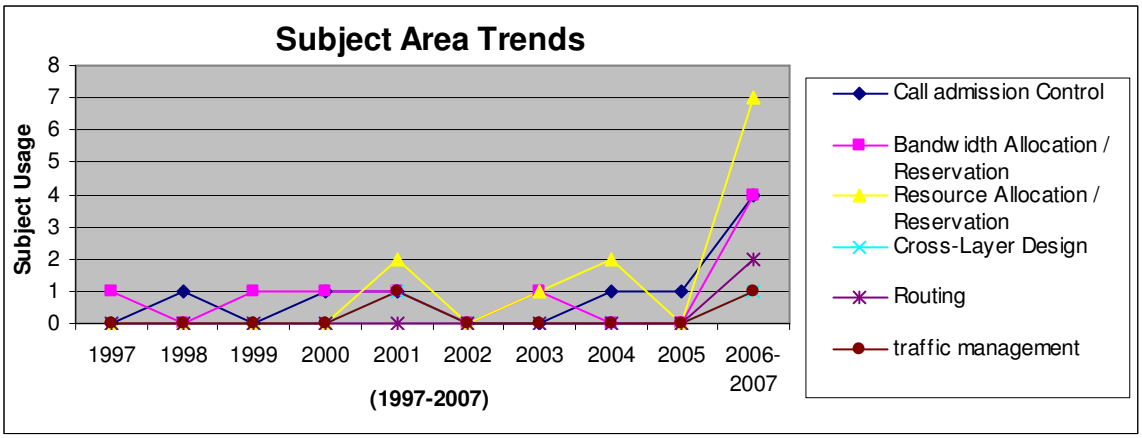


Fig.1 Subject Area Trends

On the whole, results show that, most of the articles have presented the subject area of Resource Reservation / Allocation particularly in 2006-2007. But still we can see in Fig.1 that, in recent year traffic management and cross layer design has not been exemplified as compared to other subject areas.

This pictorial representation can be a motivation for the new researcher in the field of Wireless networks to provide Quality of Service.

D. Subjects by Journals:

Table–7 demonstrates the distribution of various research Subject areas for a specific journal, in the wireless network to provide QoS. In both journals but especially in the Wireless Networks, the field "Resource Reservation" is clearly dominant to all others. Second most popular subject area in almost both journals is "Call Admission and Control".

TABLE – 7
Subjects and Journal Comparison

Journal: / **Subject**	Computer Communications	Wireless Networks	Total:
Call admission Control	2	7	9
Bandwidth Allocation / Reservation	2	7	9
Resource Allocation / Reservation	4	8	12
Cross-Layer Design	0	2	2
Routing	0	2	2
traffic management	1	1	2
Total:	9	27	36

E. Methodology by Journal:

Table–8 depicts the comparison of methodologies adoption by different journals. With this analyzed material, it can be concluded that the Journals of Wireless Networks use Simulation and Mathematical Model most frequently. Where as Computer Communication also has more emphasis on the Mathematical Model.

F. Subject by Methodology:

Table–9 depicts the representation of how the subject area exploits the different research methodologies. In this table, the analyzed material shows that, Mathematical Analysis and Simulation Research Methods are used by most of the researchers in the Call Admission & Control (CAC) and Resource Reservation to provide QoS.

G. Research Methodology by Research Models:

Table–10 represents the relationship between the research models used and the research methodology adopted. With this distribution, we can analyze that Simulation Research method has strong relationship with the mathematical model. Most of the papers uses Mathematical model but the methodology can be different as we compare the eighth column. But Multi-Tier Diagram and Temporal Influence Diagram are also catching significant use.

IV PROPOSED FRAMEWORK:

The proposed framework I-QoS (Integrated-Quality of Service) represents the integrated architecture for the provision of QoS in Wireless Networks, as shown in Figure–2. I-QoS module will get the information from the outside environment, and will make decision to provide what kind of QoS is required, then the control will be transferred to that module and after execution of that module control will be back to the I-QoS module for further decisions.

TABLE – 8
Comparison of Methodology by Journals

Journal / **Methodology**	Computer Communications	Wireless Networks	Total:
Framework Model	1	2	*3*
Mathematical Analysis	**5**	**7**	*12*
Simulation	1	**12**	*13*
Quantitative Analysis	1	2	*3*
Secondary Data Analysis	1	2	*3*
Laboratory Experimental Research	0	1	*1*
Field Experiment	0	1	*1*
Total:	*9*	*27*	*36*

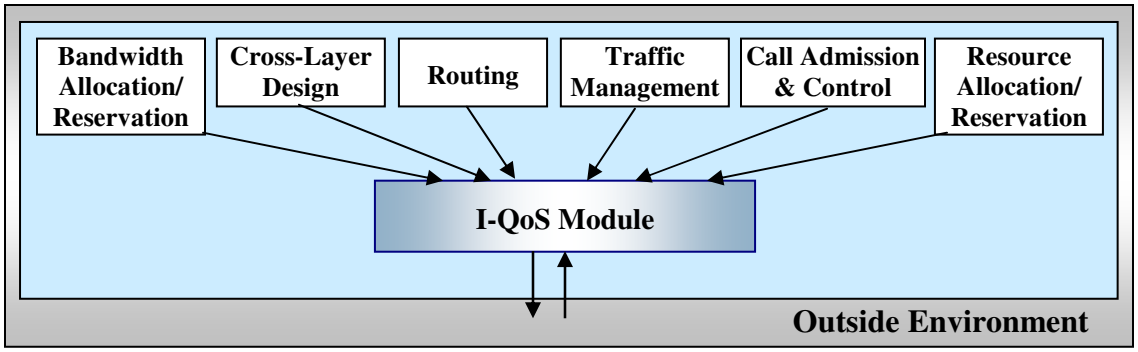
TABLE – 9
Subject Area Frequency and methodology

Methodology: / **Subjects**	Framework Model	Mathematical Analysis	Simulation	Quantitative Analysis	Secondary Data Analysis	Laboratory Experimental Research	Field Experiment	Total
Call admission Control	2	4	3	0	0	0	0	9
Bandwidth Allocation / Reservation	0	2	4	2	0	0	1	9
Resource Allocation / Reservation	1	3	4	1	2	1	0	**12**
Cross-Layer Design	0	2	0	0	0	0	0	2
Routing	0	0	2	0	0	0	0	2
traffic management	0	1	0	0	1	0	0	2
Total	3	**12**	**13**	3	3	1	1	36

TABLE – 10
Comparison of Subject Area with Research Models

Model / **Methodology**	No Model	temporal Influence Model	Mathematical Model	Multi-tier Influence Diagram	Listing of variables and implicit relationship	Listing of variables and levels	Venn Diagram	*Total*
Framework Model	0	0	2	1	0	0	0	*3*
Mathematical Analysis	0	3	**5**	3	1	0	0	*12*
Simulation	0	1	**10**	1		0	1	*13*
Quantitative Analysis	0	1	2	0	0	0	0	*3*
Secondary Data Analysis	1		1	0	0	1	0	*3*
Laboratory Experimental Research	0	0	0	1	0	0	0	*1*
Field Experiment			**1**					*1*
Total:	*1*	*5*	*21*	*6*	*1*	*1*	*1*	*36*

Fig.2: I-QoS proposed framework



V. DISCUSSION:

A. *Limitations:*

Before discussing the overall results, it is necessary to illustrate the limitations of the study. The core limitation is the scope of the study only two journals were selected for study and only 36 journal-articles have been selected, related to the Wireless Networks for the provisioning of QoS. The important fact is that, all the selected journals are the leading ones. [19]

The meta-analysis of the top-layer journals can be considered as a strong suit for this study, because it's collective information representing the best practices in the field of Wireless Networks to provide QoS.

B. *Results And Future Trends:*

Results illustrate that to provide Quality of Service in Wireless Networks; most of the work already has been done in the subject area of "Call Admission & Control" and "Resource Reservation". The frequency of usage in the "Resource Reservation" and "Call Admission & Control" for QoS provisioning in Wireless Networking is the 30%, where as for "Bandwidth Management" its 25%. The field of Routing, Cross-Layer Design and Traffic Management deserves further research. Also further work can be done to correlate different types of traffic in the field of "Traffic Management".

Automatic Repeat Request (ARQ) can be further investigated in the field of Cross-Layer Design. To cater for precautionary measures in cases of handoff and prediction of user movement, based on the notion of 'mobile' network services as well as appropriate mobility prediction algorithms can be introduced.

Development of algorithms for online computation of indices and also some policies can be established to determine the arrival and departure of index policies. Some QoS metrics can be defined to select access gateways and authentication mechanism and integrated security mechanism.

Extensions also include the demonstration of the framework on various video and other real time flow. Design of adaptive and robust scheduling algorithms for error-prone and to derive an optimum sub-carrier bit-allocation algorithms that consider the overall power constraint of an OFDM in the field of Resource Reservation.

REFERENCES

[1] P. Fiengo, G. Giambene, and E. Trentin, "Neural-based downlink scheduling algorithm for broadband wireless networks", Computer Communications, Vol.30 pp. 207–218, 2007

[2] D. Choi, T. Kim, and Lee, S. "Analysis of a queuing system with a general service scheduling function, with applications to telecommunication network traffic control", European Journal of Operational Research, Vol.178 pp. 463–471, 2006

[3] P. Palvia, V. Midha and P. Pinjani, Research Models in Information System, in: *Communication of AIS* Vol. 17 (2006) 1042-1063

[4] H. Zhai, X. Chen and Y. Fang, "A call admission and rate control scheme for multimedia support over IEEE 802.11 wireless LANs", Wireless Networks, Vol.12 no.4 pp.451–463, 2006

[5] O. B. Akan and B. Baykal, "Handoff Performance Improvement with Latency Reduction in Next Generation Wireless Networks", Wireless Networks, Vol.11 no.3 pp.319–332, 2005

[6] I. T. Li-Jin and X. L. Yuan, "A Robust M/M/1/k Scheme for Providing Handoff Dropping QoS in Multi-Service Mobile Networks", Wireless Networks, Vol.10 no.3 pp.301–309, 2004

[7] M. Borri, M. Casoni and M. L. Merani, "Effectiveness and issues of congestion control in 802.11g wireless LANs", Wireless Networks, 2006

[8] I. P. Nikos, and F. M. Lazaros, "A rate-based overload control method for the radio channel in PCN", Wireless Networks, Vol.3 no.4 pp.257–265, 1997

[9] X. Chen, W. Liu, H. Zhai and Y. Fang, "Location-aware resource management in mobile ad hoc networks", Wireless Networks, Vol.12 no.6 pp.797–812, 2006

[10] B. Li, L. Yin, K.Y. Michaelwong and S. Wu, "An Efficient and Adaptive Bandwidth Allocation Scheme for Mobile Wireless Networks Using an On-Line Local Estimation Technique", Wireless Networks, Vol.7 no.2 pp.107–116, 2001

[11] F. Pasquale, G. Giovanni and T. Edmondo, "Neural-based downlink scheduling algorithm for broadband wireless networks", Computer Communications, vol. 30, pp. 207–218, 2007

[12] D. Mariana, T. Chadi and C. Tijani, "Cross-layer modeling of capacity in wireless networks: Application to UMTS/HSDPA, IEEE802.11 WLAN and IEEE802.16 WiMAX", Computer Communications, 2007

[13] J. Chen and N. Chen, "Feedback Closed-Loop Scheduling Discipline for QoS Guarantee in Mobile Applications", Wireless Networks, Vol.12 pp.223–232, 2006

[14] Q. Liu, S. Zhou, B. Georgios and Giannakis, "Cross-layer modeling of adaptive wireless links for QoS support in heterogeneous wired-wireless networks", Wireless Networks, Vol.12 no.4 pp.427–437, 2006

[15] W. Ajib and P. Godlewski, "Acknowledgment Procedures at Radio Link Control Level in GPRS", Wireless Networks, Vol. 7 pp.237–247, 2001

[16] J. Li and P. Mohapatra, PANDA: "A novel mechanism for flooding based route discovery in ad hoc networks", Wireless Networks, Vol.12 no.6 pp.771–787, 2006

[17] Z. Li and J. J. Garcia-Luna-Aceves, "Finding multi-constrained feasible paths by using depth-first search", Wireless Networks, 2006

[18] A. Burrell and P. P. Kazakos, "A Comprehensive Approach to Signaling, Transmission, and Traffic Management for Wireless ATM Networks", Wireless Networks, Vol. 7 pp.385–400, 2001

[19] *Computer Science Journal Rankings* (2006) CUHK Department of Computer Science & Engineering, [Internet], Available from: <http://appsrv.cse.cuhk.edu.hk/~chhoi/jrank.htm>, [Accessed 15 December 2006]