

# A Course on Multimedia QoS Networking: Development and Evaluation of On-Campus Offering

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**Abstract**—Multimedia networking applications are becoming increasingly popular and the ongoing research in this field is providing a progressively more sophisticated understanding of the underlying principles of providing Quality of Service (QoS) for networked multimedia applications. To provide education in this emerging area, which is of increasing importance for electrical, computer, and industrial engineers, a course on Multimedia QoS Networking has been developed at Arizona State University. To provide the students with a balanced education in the fundamental principles and in the current development trends the course structure has three components: 1) Lecture (40% of class contact time), in which the instructor presents the basic principles, 2) Topic Exploration (30% of contact time), which expands on the basic principles and explores current trends through student presentations, and 3) Paper Critique, in which the readings from the recent literature are critically evaluated and examined in instructor-led discussions (30% of contact time). The on-campus offering of the course was evaluated through the assessment of student work, student surveys, and student interviews. The assessment indicates the students were very positive toward the course structure, especially the paper critiques and their in-class discussions.

**Index Terms**—course development, multimedia, networking, paper critiques, paper discussions, topic exploration.

## I. INTRODUCTION

Multimedia networking applications, such as audio and video streaming over the Internet, are becoming increasingly popular and account for a growing portion of the Internet traffic. The ongoing research in this field is developing multimedia networking mechanisms for new and emerging applications that are expected to further dramatically increase the impact of multimedia networking on the Internet. Multimedia streaming applications typically require a stringent Quality of Service (QoS) from the network in order to function properly. The development and evaluation of these QoS networking mechanisms has been an active research area for over a decade and continues to be intensively researched. This research is providing a progressively more sophisticated understanding of the underlying principles of providing Quality of Service (QoS) for networked multimedia applications. To provide instruction in this emerging area, which is of increasing importance for electrical, computer, and industrial engineers [1], a course on Multimedia QoS Networking has been developed at Arizona State University.

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This paper presents (i) the course structure for the on-campus-only offering, and (ii) its evaluation. A companion paper [2] presents (iii) the transformation of the course to a hybrid on-campus/distance learning offering, and (iv) the evaluation of the transformation. A key challenge in developing a course on a rapidly evolving area, such as multimedia QoS networking, is to provide the students with balanced instruction in both the fundamental principles, and in the current development trends. To achieve this goal, the developed course structure has three components: 1) Lecture (40% of class contact time), in which the instructor presents the basic principles of the class material, 2) Topic Exploration (30 % of contact time), which expands on the basic principles covered in the lecture component and explores current trends and developments, and 3) Paper Critique, in which the students critically evaluate readings from the recent literature in terms of novel contributions, the benefits and drawbacks, and the grounding in the literature. The student paper critiques are examined in instructor-led discussions (30 % of contact time) in class.

## II. COURSE PHILOSOPHY

The main goal of the course development was to design a course that provides students with a balanced instruction in the basic underlying principles of multimedia QoS networking and the current trends and developments in this rapidly evolving area. Instruction in the basic principles is important as it provides the students with an understanding of the development constraints for multimedia QoS networking mechanisms and the main approaches and protocols that have become widely accepted in this area. The basic principles also provide a solid grounding for exploring and critically evaluating the current trends. There are existing courses that focus primarily on the basic principles of multimedia networking and the performance evaluation of networking mechanisms, see, e.g., [3]–[5].

Instruction in the current trends and developments in multimedia QoS networking is important as it provides the students with an up-to-date overview of the research and developments in the area. At the same time the students learn about the open issues in the area and are enabled to develop their own research topics. Several universities offer research seminars on multimedia networking that are primarily focused on surveying the current state of the art and initiating original research by the students, see, e.g., [6]–[9].

Our goal was to develop and assess a course structure that achieves a balance between basic principles and current trends. The course should be accessible to students that have completed

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an introductory networking course covering the elementary networking mechanisms in the five layer Internet protocol stack at the level of the first five chapters of [10].

### III. LECTURE

The lecture component of the course was primarily focused on providing students with the fundamental underpinnings of multimedia QoS networking. In addition, educational modules on research methods were provided to facilitate the paper critique component and the intellectual growth of the students toward active contributors to research in the area. The lecture outline was roughly aligned with the five-layer Internet protocol stack and proceeded in top-down manner.

The lecture component constituted approximately 40% of the class contact time. The material to be covered in the lecture component was selected so as to provide the students with the basic underlying principles of the field of multimedia QoS networking and to enable them to comprehend the materials that they encounter in the topic exploration and paper critique components. The outline of the material covered in the lectures throughout this course was as follows:

- 1) Research methods: literature search methods, technical writing in multimedia networking research.
- 2) General multimedia networking concepts: QoS requirements of multimedia content, timing constraints of multimedia stream delivery and playout.
- 3) General QoS networking concepts: Integrated Services paradigm, Differentiated Services paradigm, Content distribution networks (CDNs) and multimedia caching.
- 4) Application layer: Real-Time Protocol (RTP), RTP Control Protocol (RTCP), Real-Time Streaming Protocol (RTSP), Session Initiation Protocol (SIP).
- 5) Transport layer: Stream Control Transmission Protocol.
- 6) Network layer: multicast routing, traffic engineering, multiple protocol label switching (MPLS).
- 7) Link layer: packet scheduling disciplines, weighted fair queueing and related QoS guarantees, relationship with Resource Reservation Protocol (RSVP), as well as IntServ and DiffServ paradigms, wireless link modeling for multimedia transport, wireless link scheduling.

While there are many books on multimedia, networking, and QoS, we could not find a book that would be a suitable text book for the course (requiring the students to purchase multiple books was not feasible). The existing books were either focused on the multimedia signal processing and compression aspects, e.g., [11], or not entirely up-to-date, e.g., [12]–[14]. One promising text [15] appeared too late to allow for assessment before the course offerings considered in this paper. The instructor prepared class notes from a wide range of books and research papers and presented the lecture material on the black board. The instructor also prepared practice problems that reinforced the main principles and were worked out jointly by the students and instructor during the lectures.

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### IV. TOPIC EXPLORATION

The topic exploration component which took up of 30 % of the class contact time, served to some limited extent to expand on the basic principles covered in the lecture component and to a larger extent explored current trends and developments. Each student conducted one topic exploration. The students selected the topic according to their own research interest in consultation with the instructor, who provided a list of suggested topics at the beginning of the class.

A topic exploration consisted of (a) a topic exploration paper, (b) a student presentation, (c) instructor-led discussion and feedback on student presentation, and (d) topic exploration review and assessment. The topic exploration paper required the student to work independently to write a survey of the research in a specific topic area. The survey was to provide an authoritative comprehensive overview of the research in the topic area and was to be based on an exhaustive set of references on the topic.

Each student presented her/his topic exploration to class in a 22–25 minutes long professional presentation. The student presentations were scheduled so that they were fairly equally spaced out over the semester. Typically there were no presentations during the first few weeks of the semester and then one to two presentations each week for the remainder of the semester. Each student posted her/his topic exploration paper and presentation slides three days prior to the in-class presentation on the class web site.

Each presentation was immediately followed by the instructor-led discussion, in which the main points of the presentation were put in the context of and related to the underlying principles presented in the lecture component. Also, the instructor initiated discussions on the topic through follow-up questions to the entire class. This discussion phase lasted typically 5-8 minutes.

Each student prepared a review set (quiz) on the material covered in her/his topic exploration. The presenter's fellow students completed the review set after the follow-up discussion on the presentation. The review set typically took 5 minutes to complete. The presenting student collected the completed review sets, graded them, and delivered them to the instructor before the next class meeting.

### V. PAPER CRITIQUE

A paper critique required the students to critically evaluate a research paper. A paper critique consisted of:

- 1) a one paragraph summary of the paper
- 2) a one paragraph discussion of the contributions of the paper (what does the paper add to the previously known state-of-the-art?)
- 3) a one paragraph discussion of the strengths of the paper
- 4) a one paragraph discussion of the weaknesses of the paper
- 5) a list of at least 3 additional references that the paper could/should have cited plus a justification for each reference why it could/should have been cited.

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Paper critiques were assigned each week. The papers for critiquing were selected by the instructor to highlight a representative cross-section of the current research and development in the field of multimedia QoS networking (also a few seminal papers on underlying principles were critiqued). The instructor timed the assignment of the papers so that the papers related to the materials that had just been covered in the lecture and topic exploration components. This ensured that the students had the necessary basic background to comprehend the research paper and be in a position to critique. The papers were selected from both journal articles and conference proceedings papers. Each student worked independently on his/her critique.

Each critiqued paper was discussed in detail in class, whereby about 30% of the weekly class contact time (i.e., about 45 minutes per critiqued paper) was devoted to these discussions. The discussion on a given paper was aligned with the structure of the paper critique as given above. For each of the five parts of the paper critique the instructor selected one student to initiate the discussion on the part. The selected student made an opening statement outlining his/her main views on that particular aspect of the critiqued paper. The instructor and the other students then commented on the opening statement by bringing up additional considerations, elaborating on the main points, asking follow-up questions, or challenging comments from the other students. The instructor directed the discussion on the contribution aspect of the critiqued paper to clearly bring out (i) the relationship of the critiqued paper to the existing literature, and (ii) the distinguishing features of the critiqued paper against the backdrop of the literature. These distinguishing features were then further discussed and examined in the discussion of the strengths of the paper, focusing on the intellectual and practical significance, technical thoroughness, and presentation of the paper. The discussion of the weaknesses of the paper was directed by the instructor to not only bring out the weaknesses in significance, technical thoroughness, and presentation, but also to examine the limitations of the work presented in the critiqued paper. In particular, the instructor encouraged the students to identify areas and questions that remained unexplored in the critiqued paper (as well as the additional papers that could/should have been cited) and could lead to worthwhile topics for new research. The additional paper references from all the critiques were compiled—and if key references had been overlooked, added by the instructor—into a literature list that was distributed to the students.

## VI. EVALUATION

### A. Overview

The developed course was offered as EEE598/CSE591 Multimedia QoS Networking at Arizona State University in the fall 2003 and fall 2004 semesters. The fall 2003 offering was an on-campus only offering in the traditional classroom format. The fall 2004 offering was a hybrid on-campus/distance learning offering [2]. This section presents the evaluation of the general course aspects across the two offerings. There were a total of eight students enrolled in the fall 2003 offering and twelve

in the fall 2004 offering. The course was assessed through an extensive student survey (henceforth referred to as course survey) developed by the authors for assessing this course, the regular student course evaluation survey conducted by the Fulton School of Engineering for all classes (henceforth referred to as FSE survey), student interviews, and the evaluation of student work.

The assessment of student performance and the grading was based on (i) the topic exploration paper (27%), (ii) presentation of topic exploration (10%), (iii) review set on topic exploration (10%), (iv) weekly paper critiques (38%), (v) class participation (10%), and (vi) class portfolio (5%).

### B. Structure of Course Survey

The course survey developed by the authors consisted of eight parts that asked for the students' evaluation of and attitudes toward (1) the course activities, (2) the course structure, (3) the course delivery, (4) the learning resources, (5) the content, (6) the course instructor, (7) the student peers in the course, and (8) the course workload in the multimedia QoS networking course. The specific survey items for the first seven topic areas are listed in Table I. The survey item on the course workload is not included in the table due to space constraints and discussed in the following. Each survey item consisted of a statement about an aspect of the multimedia QoS networking course accompanied by a 5-point Likert-type rating scale on which the students indicated their level of agreement with each statement from strongly agree (scored as 5) to strongly disagree (scored as 1). The rating scale for the survey items on the course structure ranged from <10% (scored as 1) to >80% (scored as 5). The survey item on the course workload asked the students to select from the options (i) the course required little effort/time (scored as 0), (ii) the course required about the right amount of effort/time (scored as 1), and (iii) the course required too much effort/time (scored as 2). In addition, the students were asked for open-ended comments on the aspects they liked the best/the least about the multimedia QoS networking course, and ways to improve the course. The instructor asked the students in the last week of classes to fill in the survey, which was to be completed anonymously through a web interface.

### C. Results from Course Survey

Table I reports the descriptive statistics of the responses for the fall 2003 course offering (for which six completed surveys were received) and the fall 2004 offering (for which eleven completed surveys were received).

1) *Course Activities*: The results indicate that overall the students had the strongest and most consistent (as indicated by small standard deviations) preferences for writing the paper critiques and the topic exploration paper. The next highest preferences were for the instructor lecture and the discussion of the paper critiques. The students were somewhat less enthusiastic (but still positive) toward the student presentation of the topic exploration papers. Similarly, the students were less enthusiastic about designing the review set and solving the

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TABLE I

MEANS  $M$  AND STANDARD DEVIATIONS  $SD$  FROM COURSE SURVEYS FROM FALL 2003 ( $N = 6$ ) AND FALL 2004 ( $N = 11$ ) COURSE OFFERINGS AND OVERALL ( $N = 17$  STUDENTS)

	F '03, $N = 6$		F '04, $N = 11$		Ov. $N = 17$	
	$M$	$SD$	$M$	$SD$	$M$	$SD$
<b>COURSE ACTIVITIES: A Course in Multimedia QoS Networking should include:</b> (SA = 5, A = 4, N = 3, D = 2, SD = 1)						
Delivery of Instructor Lecture	4.83	0.41	4.64	0.67	4.71	0.59
Writing of Student Topic Exploration Paper	4.67	0.52	4.82	0.40	4.76	0.44
Presentation of Student Topic Exploration Paper	4.83	0.41	4.36	1.29	4.53	1.07
Peer-review of Topic Exploration Paper of Fellow Student	4.50	0.55	3.82	0.60	4.06	0.66
Design of Topic Exploration Review/Assessment Set	4.17	0.75	4.00	1.26	4.06	1.09
Solving of Topic Exploration Review/Assessment Set	4.00	0.89	4.00	1.18	4.00	1.06
Writing of Critiques of Journal/Conference Papers	4.67	0.52	4.91	0.30	4.82	0.39
Discussion of Critiques of Journal/Conference Papers	4.50	0.55	4.73	0.65	4.65	0.61
Solving Practice Problems Posed by Instructor	4.00	0.89	4.27	0.90	4.18	0.88
<b>COURSE STRUCTURE</b>						
The fraction of total instructional time (< 10% = 1, 20–40% = 2, 40–60% = 3, 60–80%, >80% = 5) of a course in Multimedia QoS Networking that should be devoted to:						
Instructor-Delivered Lecture	2.50	0.55	2.36	0.67	2.41	0.62
Topic Exploration Student Presentations	2.00	0.63	1.91	0.70	1.94	0.66
Review and Assessment Activities	1.67	0.52	1.36	0.92	1.47	0.80
Paper Critique Discussions	2.00	0.00	2.00	0.77	2.00	0.61
Practice Problem Solving	1.50	1.22	1.45	0.52	1.47	0.80
<b>COURSE DELIVERY</b>						
The optimal delivery method for a graduate course in Multimedia QoS Networking should be: (SA = 5, A = 4, N = 3, D = 2, SD = 1)						
Exclusively Face-to-Face Classroom Activities	3.17	0.41	2.73	0.79	2.88	0.70
Emphasize Face-to-Face Classroom Activities with Online Readings and Assignments	3.83	0.75	4.09	1.14	4.00	1.00
Half Online Activities and Half Classroom Activities	2.50	1.22	3.27	1.27	3.00	1.27
Emphasize Online Activities with Classroom Meetings	2.17	0.98	2.64	1.12	2.47	1.07
Entirely Online (Class Never Meets Face-to-Face)	1.33	0.52	1.73	1.01	1.59	0.87
<b>LEARNING RESOURCES</b>						
What types of materials/strategies would help you in learning?						
Textbook	3.67	1.03	3.82	1.25	3.76	1.15
Handout of Course Notes	4.00	0.00	4.55	0.52	4.35	0.49
Instructor Slides (Content)	3.83	0.75	4.36	0.81	4.18	0.81
Annotated Reading Guides for Additional Reading	4.00	0.89	3.91	0.70	3.94	0.75
Collection of Sample Paper Critiques	4.17	0.41	4.27	0.90	4.24	0.75
Collection of Practice Problems	3.83	0.75	3.73	1.27	3.76	1.09
Solution Guide to Practice Problems	4.00	0.63	3.55	1.04	3.71	0.92
List of Topics for Exploration	3.83	0.41	4.00	0.63	3.94	0.56
<b>CONTENT</b>						
(SA = 5, A = 4, N = 3, D = 2, SD = 1)						
I learned a lot in this class.	4.33	0.52	4.64	0.50	4.53	0.51
The content learned is useful for future work employment.	4.33	0.82	4.27	0.65	4.29	0.69
The content learned is useful for future research (e.g., M.S./Ph.D. thesis).	4.67	0.52	4.45	0.82	4.53	0.72
This was a worthwhile class.	4.50	0.55	4.82	0.40	4.71	0.47
I would recommend this class to others.	4.33	0.82	4.82	0.40	4.65	0.61
I enjoyed the opportunities to interact with the content.	4.17	0.98	4.64	0.50	4.47	0.72
It was easy to access the class content.	4.50	0.55	4.45	0.52	4.47	0.51
<b>INSTRUCTOR</b>						
The instructor was knowledgeable.	4.83	0.41	5.00	0.00	4.94	0.24
The instructor was supportive.	4.83	0.41	4.91	0.30	4.88	0.33
The instructor was interested in students as individuals.	4.67	0.52	4.73	0.65	4.71	0.59
The instructor was enthusiastic about teaching.	4.67	0.52	4.91	0.30	4.82	0.39
The instructor communicated the content clearly.	4.50	0.55	4.45	0.69	4.47	0.62
I enjoyed the opportunities to interact/communicate with the instructor.	4.67	0.52	4.82	0.40	4.76	0.44
It was easy to interact/communicate with the instructor.	4.83	0.41	5.00	0.00	4.94	0.24
The overall quality of instruction was good.	4.67	0.52	4.82	0.40	4.76	0.44
<b>PEERS/FELLOW STUDENTS</b>						
I enjoyed the discussions with peers.	4.33	0.82	4.00	0.45	4.12	0.60
I learned a lot from interactions with peers.	3.83	0.41	3.27	1.35	3.47	1.12
I enjoyed the opportunities to interact/communicate with peers.	4.33	0.52	3.91	0.54	4.06	0.56
It was easy to interact/communicate with peers.	4.33	0.52	3.64	1.12	3.88	0.99
Peers were helpful in my learning.	4.00	0.00	3.27	1.27	3.53	1.07

Key: Strongly Agree = SA = 5, Agree = A = 4, Neither Agree nor Disagree = N = 3, Disagree = D = 2, Strongly Disagree = SD = 1.

review sets designed by fellow students. Also, the peer review of the topic exploration papers by the fellow students and the solving of practice problems (which both were not part of the designed course but included in the survey to assess potential student interest) were viewed with relatively little enthusiasm. Overall, the survey results indicate that the designed course provided the activities that are perceived most positively by the students.

2) *Course Structure*: The results show that overall the students preferred the instructor delivered lecture as the largest course component. One interpretation of the average score of 2.41 across the two course offering is to associate the score of 2 with 30% (i.e., the mean of the associated 20–40% range) and the score of 3 with 50% of the instructional time. This interpretation gives approximately 38% of the instructional time as the preferred portion to be allocated to the lecture component, which is very close to the actual 40% allocation in the designed course. The students preferred the paper critique discussions closely followed by the topic exploration student presentations as the next largest course components. Following the interpretation that associates the survey scores with the means of the corresponding percentage intervals, the students preferred to devote about 30% of the class time to paper critique discussions and slightly less than 30% for the topic exploration presentations. These results are rather interesting in that they—in conjunction with the survey results for the course activities—underscore that students preferred to devote very significant portions of the class time to the discussion of the critiqued papers. Apparently the students greatly enjoyed and derived significant benefit from assessing research papers in the area of the class topic jointly with fellow students and the instructor who is an expert in the area and can provide immediate corrections, confirmations, and elaborations on the points raised by the students during the discussions.

3) *Course Delivery*: The survey results indicate that overall the students most strongly preferred a delivery mode that emphasizes traditional face-to-face classroom activities complemented with online readings and assignments. The student preferences dropped off quite rapidly toward the extreme ends of an exclusive face-to-face delivery method and delivery methods that emphasize or exclusively rely on online activities. These results indicate that the students were generally skeptical toward a distance learning delivery that would rely heavily on online class activities, as examined in [2] in more detail.

4) *Learning Resources*: The results indicate that overall the students would prefer handouts of the course notes and sample paper critiques most strongly as learning resources. Neither of these resources were provided in the developed course; rather the instructor presented the lecture material on the black board for the students to take their own notes. From a student learning perspective it may be debatable whether the students taking their own notes from an instructor lecture presented on the board, or handouts of course notes or slides complemented with instructor lecture are preferable. Since the purpose of the lecture component was to impart a carefully selected set of

the most fundamental underpinnings, the instructor preferred to employ the traditional black board lecture-student taking their own notes mode. This issue would clearly be an interesting topic for refining and reassessing the course. As far as the paper critiques are concerned, the instructor provided the students with guidelines on how to structure these, as detailed in Section V, and then carefully evaluated and provided feedback on the submitted critiques. This process “converged” typically after a few paper critiques to very well structured, technically sound, and well written critiques. Providing samples of excellent paper critiques as samples at the beginning of the course may accelerate this convergence process, which should be assessed in the future.

Interestingly, an annotated reading guide for additional reading on the topics covered in the course is also fairly strongly preferred by the students and should be considered as an addition to the course materials for future offerings. The list of topics for the topic exploration papers, which was provided to the students, was a welcomed learning resource. Interestingly, a course textbook was the learning resource with one of the lowest levels of preference by the students.

5) *Content, Instructor, and Peers*: The students were overall consistently (as indicated by the small standard deviation) very positive about the content aspects of the course. They agreed especially strongly with the class having been worthwhile and useful for their own future research, such as research leading to a Masters or Ph.D. thesis. The instructor was also perceived as very knowledgeable and supportive; and the interaction and communication with the instructor was rated very highly.

The students were somewhat less positive about the interactions with their peers. While the students enjoyed the opportunities to interact with their peers, as well as the actual interactions, they were only moderately positive about the peers being helpful in their learning.

The responses for the survey item on the course workload (not included in the table due to space constraints) were  $M = 1.00$  ( $SD = 0.00$ ) for the fall 2003 offering and  $M = 1.27$  ( $SD = 0.65$ ) for the fall 2004 offering. This appears to indicate that the workload was overall perceived as appropriate, with a slight tendency toward being too high in the 2004 offering. This may be related to the hybrid (on-campus/distance learning) format of the 2004 offering (examined in the companion paper [2]), which required the students to conduct a larger portion of the class activities online.

6) *Responses to Open-Ended Questions and Student Interviews*: Table II reports the answers constructed by the  $N = 17$  students enrolled in the 2003 and 2004 class offerings for the open-ended questions. An interesting result is that the interactive paper discussions were noted by over half of the students as the best part of the course. Relatively fewer responses were constructed for the questions about the least liked aspects of the course and course improvements. Nevertheless, these items, which were constructed typically by one, at most by two students, provide useful directions for further refinements of the course.

TABLE II

CONSTRUCTED RESPONSES FROM  $N = 17$  STUDENTS FROM FALL 2003 AND FALL 2004 COURSE OFFERINGS TO THE OPEN-ENDED QUESTIONS (MULTIPLE RESPONSES ALLOWED)

Question and constructed responses	# of Res.
<i>What did you like best about this course?</i>	
In-class discussions of critiqued papers	9
Topic Exploration	4
Introduction to research methods	3
Overview of wide range of current research	3
<i>What did you like least about this course?</i>	
Scheduled class time (early morning)	2
Online communication aspects	2
Finding additional references for paper critiques	1
Preparing class portfolio	1
Poor presentation skills of some students	1
<i>Please suggest modifications/improvements for course.</i>	
More focus on system performance modeling	2
Offer research project	2
Popular vote on papers for critiquing	1
Add quiz on lecture material	1
Invite guest speaker from industry	1

One-on-one interviews were conducted with two randomly selected students from each course offerings to obtain additional insights into the student perceptions about the course. The interviews responses mainly elaborated on the points raised in the answers to the open-ended class survey questions. The students also expressed that aside from the technical course material they very much appreciated the “non-technical” instructional modules on searching the literature and technical writing in the networking area. They felt that these basic general research skills in conjunction with the broad range of current research that they were introduced to through the paper critique component, contributed significantly in maturing their research skills and outlook on their degree programs and careers.

#### D. Evaluation of Student Work

The assessment of the student work revealed that the topic exploration papers were rather comprehensive in the coverage of the selected topic. The main stumbling block for the students was to structure and categorize the existing literature. Most of the presentations were very good, some excellent, a few however, were mediocre, suggesting to incorporate an instructional module on presentation techniques into the lecture component.

In their first few paper critiques the students tended to focus extensively on summarizing the content of the paper (often times the summaries extended over more than one page) and to provide very limited discussions of contributions, strengths, and weaknesses. With the individualized instructor feedback all students developed into skilled reviewers giving proper attention to paper summary and its contribution, strengths, and weaknesses, which are commonly considered in the premier conferences in the multimedia networking area.

#### E. Structure and Results from School Survey

The FSE survey consisted of Likert-type items on the evaluation of the course (7 items), instructor (9 items), general

evaluation (2 items), general information (4 items), as well as open-ended questions similar to the course survey. Due to space constraints the detailed FSE survey structure and results can not be included here; the interested reader is referred to [16] for details. In summary, the results for the FSE survey largely reflect the results for the course survey; the highest rated items in the FSE survey were the value of the class assignments and the weight (in terms of grading) given to the assignments.

## VII. CONCLUSIONS

This paper presented the design and assessment of a course on multimedia QoS networking that strives to achieve a balance between the underlying principles and current research trends in this fast progressing field. The assessment indicates that the developed course structure, which devotes about 40% of the class time to lecture and 30% each to student presentations and discussion of research papers, is effective and very well received by the students. An interesting result was that the students were especially positive about the interactive in-class paper discussions and the significant portion of class time devoted to the discussions. These results provide valuable insights into the effective structuring of courses on emerging topics that require the integration of current research results into course offerings.

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