



Lahore University of Management

CS 678/EE 672 – Topics in Internet Research

Spring 2024

Subject to Change

Instructors	Dr. Zafar Ayyub Qazi, Dr. Zartash Afzal Uzmi, Dr. Ihsan Ayyub Qazi
Room No.	SBASSE 9-G24A (Zafar), SBASSE 9-319 (Zartash), SBASSE 9-G14A (Ihsan)
Office Hours	4pm-5pm on Monday or by Appointment (Ihsan)
Email	zafar.qazi@lums.edu.pk , zartash@lums.edu.pk , ihsan.qazi@lums.edu.pk
Telephone Ext	3323 (Zafar), 8202 (Zartash), 8368 (Ihsan)
Class Timings	1
Class Venue	
Course URL	http://lms.lums.edu.pk

Course Basics			
Credit Hours	3 credit hours		
Lecture(s)	2 per week	Duration	75 minutes per lecture

Course Distribution	
Core	None
Elective	All
Open for Student Category	All

COURSE DESCRIPTION	
<p>CS678 is a graduate-level course on computer networking research. It involves lectures, paper readings, discussions, and a semester-long research project. CS678 will focus on the following 4 key areas in networking research:</p> <ul style="list-style-type: none">Cloud Computing and Systems for Machine LearningCellular NetworksWeb, Video Streaming, and ICT for DevelopmentInternet Censorship & Privacy <p>For each of these areas, we will read classical research works as well as explore the state-of-the-art. Students will be required to write paper summaries and participate in class discussions. In addition, students will be expected to make presentations on assigned papers and participate in a semester-long research project.</p>	

Course Prerequisite(s)	
<ul style="list-style-type: none">	CS382 (Net-Centric Computing) or CS471 (Computer Networks) or CS4713 (Introduction to the Internet: Architecture and Protocols)

Course Objectives	
<ul style="list-style-type: none">	<p>To become familiar with state-of-the-art in computer networking research</p> <p>To understand how to analyze and critique research works</p> <p>To engage in networking research through a semester-long research project</p>

Learning Outcomes	
<ul style="list-style-type: none">	<p>To develop an understanding of principles behind state-of-the-art network protocols and architectures</p> <p>To gain experience in critically analyzing research works</p> <p>To conduct networking research by carrying out an independent research project</p>

Grading Breakup and Policy	
<ul style="list-style-type: none">Class Participation & Attendance: 20%Paper Reviews: 10%Paper Presentation(s): 5%Quizzes: 15%Project: 50%	



Lahore University of Management

- Proposal: 5%
- Midterm Report/Review: 15%
- Final Report/Presentation: 30%

Research Project

The semester-long research project is one of the most important components of the course. The goal is to carry out novel research that by the end of the semester would be publishable in a good quality workshop or a conference. Past research projects in this course have been quite successful. Here are some papers that started out as course projects:

- Ammar Tahir, M. Tahir Munir, Shaiq Munir Malik, Zafar Qazi and Ihsan Qazi. *"Deconstructing Google's Web Light Service"* in *WWW 2020*, Taiwan
- Ihsan Qazi, Fahad Dogar, Ali Raza Tariq, Ghulam Murtaza, Abeer Ahmad, Nathan Stocking. *"MissIt: Using Missed Calls for Free, Extremely Low Bit-Rate Communication in Developing Regions"* in *ACM CHI 2020*, USA
- Arsalan Jumani, Fizza Zafar, Zafar Qazi, Ihsan Qazi. *"Device-Aware Adaptive Video Streaming"* in *ACM SIGCOMM 2019*, China (poster)
- Arsalan Jumani, Fizza Zafar, Zafar Qazi, Ihsan Qazi. *"Unraveling Poor Video Streaming Experiences in the Developing World"* in *ACM IMC 2018 (poster)*, USA
- Aqib Nisar, Aqsa Kashaf, Ihsan Qazi, Zartash Uzmi. *"Incentivizing Censorship Measurements via Circumvention"* in *ACM SIGCOMM 2018*, Hungary
- Hira Javaid, H. Kamran Khalil, Zartash Afzal Uzmi, Ihsan Ayyub Qazi. *"Online Advertising under Internet Censorship"* in *ACM HotNets 2017*, USA
- Tooba Ahsen, Fatima Tariq, M. Tirmazi, Ifrah Idrees, Zafar Qazi, Ihsan Qazi, Zartash Uzmi. *"DRIBS: Flow Scheduling over Asymmetric Datacenter Topologies"* in *NSDI 2017*, USA (poster paper)
- Kamran Nishat, Farrukh Javed, Saim Salman, Nofel Yaseen, Ans Fida, Ihsan Qazi, *"SlickFi: A Service Differentiation Scheme for High-Speed WLANs using Dual Radio APs"* in *ACM CoNEXT 2016*, Irvine, USA
- Aqib Nisar, Aqsa Kashaf, Zartash Uzmi, Ihsan Qazi, *"A Case for Marrying Censorship Measurements with Circumvention"* in *ACM HotNets 2015*, USA
- H. Pirzada, M. R. Mahboob, Ihsan Qazi, *"eSDN: Rethinking Datacenter Transports Using End-Host SDN Controllers"* in *ACM SIGCOMM 2015*, UK (poster)
- Ruwafa Anwar, Kamran Nishat, Mohsin Ali, Zahaib Akhtar, Haseeb Niaz, and Ihsan Qazi, *"Loss Differentiation: Moving onto High-Speed Wireless LANs"* in *IEEE INFOCOM 2014*, Canada
- Aisha Mushtaq, Asad Khalid Ismail, Abdul Wasay, Bilal Mahmood, Ihsan Qazi, and Zartash Uzmi, *"Rethinking Buffer Management in Data Center Networks"* in *ACM SIGCOMM 2014*, USA (poster paper)
- Ali Munir, Ihsan Qazi, Zartash Uzmi, Aisha Mushtaq, Saad Ismail, M. Safdar Iqbal, and Basma Khan *"Minimizing Flow Completion Times in Data Centers"* in *IEEE INFOCOM 2013*, Italy

Paper Reviews

Each class will have one or two assigned readings that we will all read prior to class. All students are expected to have thoroughly read the papers, and come to class ready to discuss them in detail. This is essential to get the most out of the class! Before each class, students must submit a short written review (max 1/2-page) of the required readings on LMS. Reviews will be accepted by 6pm the night before the class. The review is expected to cover the following points:

1. What problem is the papersolving and why is it important?
2. What is the main idea of the paper?
3. Identify any limitations of the paper.
4. How would you improve the paper or build on it in future work?

Project Proposal

The project proposal is due 5pm on Friday, February 7th in the form of a written document (max 2 pages). The proposal should at least have the following sections:

- Introduction
 - What is the problem you plan to address? Why is it important to solve?
- Related Work
 - What are the most related works? (analyze prior works and cite related papers)
- Proposed Approach
 - What is your proposal and how does it differ from prior work?
- Timeline and Division of Work
 - Mention a timeline and a division (if there are 2 or more members in the project) of the project tasks

Midterm Review/Report

Students are expected to make substantial progress before the midterm review and are expected to submit a report (max 2 pages) on the milestones achieved (e.g., experiments conducted, initial results and hypothesis, and any preliminary design) and a list of future tasks to be carried out. The report will be submitted on LMS.



Lahore University of Management

Final Report

The final report should be structured as a conference/workshop paper and should include (i) description of the problem, (ii) problem motivation, (iii) your solution/idea, (iv) discussion of related works, (v) evaluation of your solution, and (vi) a conclusion. We strongly suggest that you write your final report using LaTeX. It is the de-facto tool in which most CS/EE research papers are written. While it has a small start-up cost, it is much easier to collaboratively write research papers using LaTeX than using Word. We highly suggest using an online LaTeX editor such as OverLeaf (<https://www.overleaf.com>). You may alternatively install a local version of LaTeX on your computer and use the following a sample LaTeX template (<http://www.cs.cmu.edu/~dga/15-744/S07/sample.tar.gz>) or a MS Word template (sample file: <http://conferences.sigcomm.org/sigcomm/2016/doc/word-acm-10pt-on-12pt-7.0x9.25.doc>) for ACM SIG proceedings).

Source Code Control

You are required to use GitHub, version control platform for performing source code control for your project as well as for the paper/report you are writing. Please share a link of your public repository by the project proposal deadline.

Paper Presentations

Students will be expected to deliver one or more presentations (max 15mins including Q/A, max 10 slides) in the course. We will assign papers to the students randomly. In some circumstances, two students may be assigned to make a joint presentation. It will be expected that the presenters will be prepared to answer any related questions.

Class Participation (CP)

Students will be expected to actively participate in the class in the form of questions, critique of the paper, new ideas, etc. CP may include a short (oral) summary of the paper at the start of each class, for which students will be chosen *randomly*. Grading of CP will also include attendance as a component.

Policies

- All deadlines are hard
- All assigned work must be done individually (unless specified otherwise)
- Re-grading can be requested within 2 days after grade reporting

Examination Detail

Midterm Exam	Yes/No: No (Instead there is a midterm project report)
Final Exam	Yes/No: No

	Session	Author(s)	Lead Faculty
1	<p>[Introduction] <i>Introduction & Overview of Networking Research</i></p> <p>[Optional] “How to Read a Paper” in ACM SIGCOMM CCR 2007 [Optional] “How to build research network systems in your spare time” in SIGCOMM CCR 2010 [Optional] “Logical Fallacies” Purdue online writing lab</p>	S. Keshav R. Mahajan	Ihsan Ayyub Qazi Zartash Afzal Uzmi Zafar Ayyub Qazi
<h2 style="text-align: center;">Background</h2> <h3 style="text-align: center;">Internet Architecture, Software Defined Networking, and Network Functions Virtualization</h3>			
2	<p>[Internet Architecture] “The Design Philosophy of the DARPA Internet Protocols” in ACM SIGCOMM 1988</p> <p>[Optional] “End-to-end Arguments in System Design” in ACM Transactions on Computer Systems</p>	Clarke et al. Saltzer et al.	Zartash Afzal Uzmi
3	<p>[Programmable Control Planes: SDN] [Video] “The future of networking and the past of protocols”, talk by Scott Shenker at the Open Networking Summit, 2011</p> <p>[Optional] “The Road to SDN: An intellectual history of programmable networks” in ACM Queue 2013 [Optional] “Ethane: taking control of the enterprise” in ACM SIGCOMM 2007</p>	Scott Shenker Feamster et al. Casado et al.	Ihsan Ayyub Qazi



Lahore University of Management

4	<p>[SDN Use Case: Middlebox Management] “SIMPLifying middlebox policy Enforcement” in ACM SIGCOMM 2013</p> <p>[Optional] “B4: Experience with a Globally-Deployed Software Defined WAN” in ACM SIGCOMM 2013</p>	<p>Zafar et al.</p> <p>Sushant et al.</p>	Ihsan Ayyub Qazi
5	<p>[Network Function Virtualization] “NetBricks: Taking the V out of NFV” in OSDI 2016</p> <p>[Optional] “Network Function Virtualization” (white paper)</p>	<p>Panda et al.</p>	Zafar Ayyub Qazi
Cloud Computing and Systems for Machine Learning			
6	<p>[Cloud Computing] “A Guided Tour through Data-center Networking” in Communications of ACM, 2012</p> <p>[Optional] “The Tail at Scale” in Communications of the ACM, 2013</p>	<p>Abts et al.</p> <p>Satya et al.</p>	Ihsan Ayyub Qazi
7	<p>[Systems for AI] “TensorFlow: A System for Large-Scale Machine Learning” in OSDI 2016</p> <p>[Optional] “PyTorch: An Imperative Style, High-Performance Deep Learning Library” in NeurIPS 2019</p> <p>[Optional] “Storm @Twitter” in SIGMOD 2014</p>	<p>Abadi et al.</p>	Zafar Ayyub Qazi
8	<p>[DC Transports] “Friends, not Foes – Synthesizing Existing Data Center Transport Strategies in PASE” in ACM SIGCOMM 2014</p> <p>[Optional] “Data Center TCP (DCTCP)” in ACM SIGCOMM 2010</p> <p>[Optional] “Minimizing Flow Completion Times in Data Centers” in IEEE INFOCOM 2013</p>	<p>Qazi et al.</p> <p>Alizadeh et al. Munir et al.</p>	Zartash Afzal Uzmi
9	<p>[Edge Computing] “The Emergence of Edge Computing” in Computer, vol. 50, no. 1, pp. 30-39, Jan. 2017.</p>		Zafar Ayyub Qazi
10	<p>[Privacy Preserving ML] “Towards Federated Learning at Scale: System Design” in SysML 2019</p> <p>[Optional] “Federated Optimization for Heterogeneous Networks” in Adaptive & Multitask Learning Workshop 2019</p> <p>[Optional] “It's Time for Low Latency” in ACM HotOS 2011</p>	<p>Bonawitz et al.</p> <p>Rumble et al.</p>	Ihsan Ayyub Qazi
11	<p>[Video Analytics at the Edge] “Scaling Video Analytics on Constrained Edge Node” in SysML 2019</p> <p>[Optional] “Machine Learning at Facebook: Understanding Inference at the Edge” in HPCA'19</p>	<p>Canel et al.</p> <p>Wu et al.</p>	Zartash Afzal Uzmi
Cellular Networks			
12	<p>[Introduction to Cellular Networks] (1) A brief background of cellular networks (2) Introduction to 5G</p>		Zafar Ayyub Qazi
13	<p>[Role of Cellular Control Plane] “A Control Plane Perspective on Reducing Data Access Latency in LTE Networks” in MobiCom 2017</p>	<p>Y Li et al.</p>	Zartash Afzal Uzmi
14	<p>[Scaling Cellular Control Plane] “Scaling the Cellular Control Plane for Future Mobile Access” in ACM CoNEXT 2014</p>	<p>Arjit et al.</p>	Zafar Ayyub Qazi
15	<p>[Re-architecting Cellular Core] “PEPC: A high performance cellular packet core” in ACM SIGCOMM 2017</p>	<p>Zafar et al.</p>	Ihsan Ayyub Qazi
16	<p>[Moving the Core to the Edge] “Moving Core to the Edge for Untethered and Reliable UAV-based LTE Networks” in ACM MobiCom 2018</p> <p>[Optional] “Experiences: Design, Implementation and Deployment of CoLTE, a Community LTE Solution” in ACM MobiCom 2019</p>	<p>Mehrdad et al.</p> <p>Spencer et al.</p>	Zartash Afzal Uzmi



Lahore University of Management

17	<p>[Congestion Control in Cellular Networks] “Adaptive Congestion Control for Unpredictable Cellular Networks” in SIGCOMM CCR 2015</p> <p>[Optional] “Rethinking Congestion Control for Cellular Networks” in ACM HotNets 2017.</p>	Zaki et al.	Ihsan Ayyub Qazi
Web, Video Streaming, and ICT for Development			
18	<p>[Understanding Modern Websites] “Understanding Website Complexity: Measurements, Metrics, and Implications” in IMC 2011</p>	Butkiewicz et al.	Zafar Ayyub Qazi
19	<p>[Page Load Performance] “Demystifying Page Load Performance with WProf” in USENIX NSDI 2013</p>	Xiao et al.	Ihsan Ayyub Qazi
20	<p>[Impact of Device on Mobile QoE] “What-If Analysis of Page Load Time in Web Browsers Using Causal Profiling” in ACM SIGMETRICS 2019</p> <p>[Optional] “Impact of Device Parameters on QoE for Internet Applications” in IMC 2018 [Optional] “A View from the Other Side: Understanding Mobile Phone Characteristics in the Developing World” in ACM IMC 2016</p>	Pourghassemi et al. Dasari et al. Ahmad et al.	Zartash Afzal Uzmi
21	<p>[Proxy Design for the Mobile Web] “Deconstructing Google’s Web Light Service” in WWW 2020</p> <p>[Optional] “Flywheel: Google’s Data Compression Proxy for the Mobile Web” in NSDI 2015</p>	Zafar Qazi et al.	Zafar Ayyub Qazi
22	<p>[Video Streaming Characteristics] “Performance Characterization of a Commercial Video Streaming Service” in ACM IMC 2016</p> <p>[Optional] “Confused, Timid, and Unstable: Picking a Video Streaming Rate is Hard” in ACM IMC 2012</p>	Ghasemi et al. Huang et al.	Zartash Afzal Uzmi
23	<p>[Optimizing Video Streaming] “Neural Adaptive Video Streaming with Pensieve” in ACM SIGCOMM 2017</p> <p>[Optional] “Oboe: Auto-tuning Video ABR Algorithms to Network Conditions” in ACM SIGCOMM 2018</p>	Mao et al. Zahaib et al.	Ihsan Ayyub Qazi
Internet Censorship and Privacy			
24	<p>[Measuring Internet Censorship] “Incanting censorship measurements via circumvention” in ACM SIGCOMM 2018 “Encore: Lightweight Measurement of Web Censorship with Cross-Origin Requests” in ACM SIGCOMM 2015 (just read the abstract and intro)</p> <p>[Optional] “Global Measurement of DNS Manipulation” in USENIX Security 2017 [Optional] “Geneva: Evolving Censorship Evasion Strategies” in ACM CCS 2019</p>	Nisar et al. Burnett et al. Pearce et al. Bock et al.	Zartash Afzal Uzmi
25	<p>[Censorship Resistance & Anonymity] “LASTor: A Low-Latency AS-Aware Tor Client” in IEEE/ACM Transactions on Networking’14</p> <p>[Optional] “SoK: Towards Grounding Censorship Circumvention in Empiricism” in IEEE Symposium on Security & Privacy, 2016</p>	Akhoondi et al. Tschantz et al.	Zafar Ayyub Qazi
26	<p>[Web tracking] “Detecting and defending against third-party tracking on the web” in NSDI 2012</p> <p>[Optional] “Exploring ADINT: Using Ad Targeting for Surveillance on a Budget – or – How Alice Can Buy Ads to Track Bob” in WPES 2017 [Optional] “Cookies that give you away: Evaluating the surveillance implications of web tracking” in WWW’15</p>	Roesner et al. Vines et al. Englehardt et al.	Zartash Afzal Uzmi
27	<p>[Privacy and Advertising] “Online Advertising under internet censorship” in ACM HotNets 2017</p> <p>[Optional] “If you are not paying for it, you are the product: How much do advertisers pay to reach you?” in ACM IMC 2017</p>	Javaid et al. Papadopoulos et al.	Zafar Ayyub Qazi
28	<p>[Privacy Regulation Compliance] “GDPR Compliance by Construction” in Poly 2019 workshop at VLDB 2019</p>	Schwarzkopf et al.	Ihsan Ayyub Qazi



Lahore University of Management

	“The Seven Sins of Personal-Data Processing Systems under GDPR” in HotCloud 19	Shastri et al.	
29	Project presentations		