Advanced Research Readings in Distributed Systems and Networks

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1 Introduction

The aims of this module are to immerse students in some seminal topics in distributed systems and networks via papers from the literature, reinforce critical reading and reviewing skills, and enable students to develop their critical thinking and group discussion capabilities.

The intended learning outcomes for the module are that students should: 1) exhibit understanding of a broad range of seminal research in the area of distributed systems and networking by summarising relevant papers, and by answering examination questions that require an overall understanding of distributed systems and networks as a whole; and 2) demonstrate the ability to present a critical analysis of relevant literature by presenting verbal summaries of selected research papers to the class, and leading class discussions.

2 Module Description

The module comprises 10 tutorial sessions held weekly from 9 January to 12 March 2008 at 11:00am in room 404 of the Sir Alwyn Williams Building (except 9 January, when the tutorial will start at 9:00am). The module is structured around discussion of one research paper each week. Students *must* read the papers in advance of each session, and come prepared to discuss the material. All students are expected to participate in the discussion.

The module will focus on providing students with a deep understanding of the behaviour of the Internet and how this effects the design of network protocols and distributed systems. Accordingly, you are expected to read additional material relating to the topics under discussion, rather than limiting yourself to a narrow reading of the papers we will consider in the tutorials.

Week 1: Introduction

The module begins with a review of Handley's paper "Why the Internet only just Works" which we previously discussed as part of Research Readings in Computing Science. This paper discusses some of the challenges in evolving the Internet, to cope with future demands. You should consider how these problems impact both network research and the design of applications that use the network.

- M. Handley, "Why the Internet only just works", BT Technology Journal, Volume 24, Number 3, July 2006.

Week 2: Design Philosophy of the Internet

Having discussed some of the challenges in evolving the Internet, we begin to consider how the current design came about. The paper this week is a retrospective look at the design choices that shaped the network, written once the initial design and deployment were completed.

- D. D. Clark "The Design Philosophy of the DARPA Internet Protocols", Proceedings of ACM SIGCOMM 1988, Stanford, CA, USA, August 1988.

Week 3: The End-to-End Argument

A key principle shaping the design of the Internet Protocol suite is the end-to-end argument. The discussion this week will review this argument, and discuss how it has affected the design of the network.

- J. H. Saltzer, D. P. Reed and D. D. Clark, "End-to-End Arguments in System Design", ACM Transactions on Computer Systems, volume 2, number 4, November 1984.

Week 4: Design of TCP/IP

The discussion this week moves from abstract to concrete, focussing on the initial design for the TCP/IP protocol. You should consider how TCP/IP has evolved since it was originally proposed, and whether the ideas and design choices described in this paper are still relevant to modern networks. In what ways do currently deployed TCP/IP implementations differ from the version presented here?

- V. G. Cerf and R. E. Kahn, "A Protocol for Packet Network Intercommunication", IEEE Transactions on Communications, volume 22, number 5, May 1974.

Week 5: TCP Congestion Control

This week we will study how network performance affects the dynamics of transport protocols. The paper describes how the ARPANET suffered congestion collapse in the late 1980s, and how TCP was modified to prevent that collapse. In addition to understanding the problem of congestion control for TCP in the ARPANET, you should consider how the design choices made affect today's networks. With the vast increases in network performance, and the growing prevalence of wireless networks and non-TCP traffic, are the design choices expressed in this paper still relevant today? How does the presence of network features such as RED, ECN, and QoS affect the congestion response of the network and the design of transport protocols?

- V. Jacobson and M. J. Karels, "Congestion Avoidance and Control", Proceedings of ACM SIGCOMM '88, Palo Alto, CA, USA, August 1988.

Week 6: Non-TCP Congestion Control

Following on from our discussion of TCP congestion control last week, we now consider alternative congestion control algorithms for applications which cannot use TCP. The focus is on TCP Friendly congestion control: algorithms that are fair to TCP traffic on average, but have different dynamics of variation. You should consider why it is important that alternative congestion control algorithms are TCP friendly, what classes of application these alternative algorithms suit, and when non-TCP friendly algorithms might be used.

- S. Floyd, M. Handley, J. Padhye and J. Widmer, "Equation-Based Congestion Control for Unicast Applications", Proceedings of ACM SIGCOMM 2000, Stockholm, Sweden, August 2000.

Week 7: Routing and Addressing Challenges

We move on from discussing transport protocols to consider challenges in routing and addressing for the Internet. The paper this week is a report from a recent workshop that has done much to focus attention on some of the limitations of current Internet routing protocols, and spur the development of alternatives. How can we evolve the routing schemes used in the Internet? What are the problems and challenges facing the network?

- D. Meyer, L. Zhang, and K. Fall (Editors), "Report from the IAB Workshop on Routing and Addressing", Internet Engineering Task Force, RFC 4984, September 2007.

Week 8: Foundational Problems in Interdomain Routing

Following on from the practical discussion last week, we consider the underlying theory of routing, and discuss the extent to which the problems facing the routing infrastructure are fundamental, rather than limitations of the current protocols.

- N. Feamster, H. Balakrishnan and J. Rexford, "Some Foundational Problems in Interdomain Routing", Proceedings of the 3rd workshop on Hot Topics in Networks (HotNets-III).

Week 9: Compact Routing

Compact routing is a possible alternative to the current routing algorithms that some have suggested might be able to solve some of the scaling problems with Internet routing. This paper discusses some issues with applying compact routing algorithms to the Internet.

- D. Krioukov, k. c. claffy, K. Fall, and A. Brady, "On Compact Routing for the Internet", ACM Computer Communication Review, Volume 27, Number 3, July 2007.

Week 10: Future Directions

We conclude the module with a discussion of the future of the network, looking at how the design of networked systems may evolve, and how we can attempt to direct that evolution through careful system design.

- D. D. Clark, K. R. Sollins, J. Wroclawski and R. Braden, "Tussle in Cyberspace: Defining Tomorrow's Internet", Proceedings ACM SIGCOMM 2002, Pittsburgh, PA, USA, August 2002.

3 Assessment

Assessment is by a presentation given to the Embedded, Networked, and Distributed Systems research group (30%) and by an open book examination (70%). This is a level M module, worth 5 credits.

Presentations should be given during the second half of semester 2. Each student is responsible for choosing the subject for his own presentation, related to the topics under discussion in the module. Subjects must be approved by the module co-ordinator in advance; students may not choose a topic already chosen by another student.