Aalto University
School of Science
and Technology

T-110.6120 (Per I, Fall 2012)
Special Course in Data Communications Software

Topic: Future Internet

Background

For over 30 years, the Internet has been coping with ever increasing traffic and new applications, including voice and video, while retaining its original architecture drafted over 40 years ago.

Despite its enormous success, the Internet is suffering from several key shortcomings that stem from a design that appears increasingly unfit to support current (unanticipated) usage trends.

Some of these shortcomings include…

- The **send-receive communication paradigm**, which inherently causes an imbalance of powers in favor of the sender of information, who is overly trusted.
- **Locator-identifier aggregation**, whereby a node's topological locator (i.e. it IP address) also serves as its unique identifier, leading to severe limitations on mobility.
- **Host-centric design**, which emphasizes the topological location of content as opposed to the content itself.
- A **lack of built-in multicast and caching solutions**, resulting in wasted network resources and sub-optimal content delivery.
- A **lack of built-in security and other critical functionalities**, with most features being added as afterthoughts in response to new usage requirements (e.g. VPN, DNS, MIP, HIP, IPv6, PGP, DHTs, DiffServ/IntServ, BGPSec, DNSSec, IPSec, SSL/TLS etc.)

etc.

Some unanticipated usages include…

- Mass usage (billions of devices and users, multiple devices per user and multiple users per device)
- The need for human-friendly naming conventions and interaction
- Mass content storage, retrieval, and delivery
- Secure site-to-site transport, secure user-to-user messaging
- Varying degrees of quality-of-service
- Mobility, multi-homing, multi-casting etc.
- Unified IP architectures for audio, video etc.

etc.

The worst consequence is that **the full range of possibilities offered by the Internet is not being exploited and trust in its proper operation has been lost.**

Course description

In this course, we will…

1) Review the beginnings of the Internet and its evolution and attempt to understand how and why it evolved into its current form. Technology trends and evolving usage demands are of key importance.
2) Examine the key problems which have resulted due to the mismatch between usage demands and the Internet's increasingly ossified architecture.
3) Review evolutionary solutions that have been proposed and enacted to resolve the Internet's problems.
4) Examine the end results of the aforementioned improvisations on the Internet's functionality and usability.

The items above will account for approximately **25%** of the course content.

The remaining **75%** will consist of in-depth investigations of prominent evolutionary and revolutionary future Internet architectures, which seek to redefine the Internet's core design so as to adapt its overall functionality to fit current and future usage trends.

We will conclude with an architectural demonstration and panel discussion.

* NOTE: This will be an intensive course i.e. 4 ECTS in 6 weeks. You should be prepared to work hard and absorb a lot of material. However, motivated participants will likely find that the course structure is more appealing and easy to complete than that of most other graduate and postgraduate courses.

The basics

Language

- The course will be held in **English.**

Credits

- **4 ECTS** (i.e. approximately 110 hours); see breakdown in "Course format, credit breakdown, and assessment" section

Schedule

- Teaching period I (weeks 37 – 42), fall 2012
- The regular lecture times are **Monday and Tuesday, 16:15 – 18, hall T5**

Prerequisites

There are no mandatory prerequisites for the course. **We are targeting senior students, particularly graduate and postgraduate candidates,** as well as anyone who has a strong understanding of Internet technologies and a desire to investigate the future of the Internet in-depth. **You must have completed your Bachelor's degree in order to attend the course for credit.**

Lecturers

D.Sc. Arto Karila
Principal Scientist
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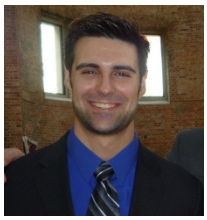
Arto Karila is the Coordinator of the PURSUIT future Internet project (http://www.fp7-pursuit.eu) and a part-time Principal Scientist at HIIT. Previously he has been (among other things) a professor of computer networks at the Helsinki University of Technology (1995 to 2001), Director of Nordic Operations for Wellfleet Communications (later a part of Nortel Networks, from 1992 to 1994), Director of Telecom Finland (now Sonera, from 1988 to 1992, where he was starting commercial Internet services in 1988), a board member of the Finnish University Network (FUNET), a consultant for many large IP networks (ministries, banks, defense, cities, regional networks etc.) and Fujitsu Labs. He has been on the boards of many startups, including three publicly traded companies. He holds a D.Sc. degree from HUT and M.S.I.C.S. from Georgia Tech.



M.Sc. Mark Ain
Project Specialist
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Mark is a project specialist at HIIT and an independent management/ICT consultant. He has worked in the industry throughout North America and the Nordics dealing predominantly in project and process management and ICT engineering. His main projects have included commercial wireless deployments, MPLS core network designs, and managing the development of operator-grade telecom software solutions; Mark has also participated in the PSIRP (http://www.psirp.org) and PURSUIT (http://www.fp7-pursuit.eu) future Internet projects. He holds an M.M.Sc. in the Management Sciences from the University of Waterloo, an M.Sc. in Security and Mobile Computing from the NordSecMob Programme (NTNU/TKK), and a postgraduate Diploma in Operational Research (D.O.R.) from the Canadian Operational Research Society.

* NOTE: Guest lecturers may be called in at various times during the course.

Course format, credit breakdown, and assessment

The bolded arrowpoints indicate the grading method and associated requirement for passing the course. Remember, 1 ECTS = ~ 27hrs.

Lectures (1 ECTS)

The course is 6 weeks long with 2 lectures per week; each lecture is approximately 2 hours long with a short break in the middle. This yields approximately 24 hours of lecture time in total.

- ➔ **PASS/FAIL: Lecture attendance is mandatory. You must attend *all* lectures to pass the course.**
- ➔ **(33%) GRADED COMPONENT: Your final mark will be influenced by your participation in lecture discussions and the level of your contributions.**

Reading assignments & annotations (2 ECTS)

You will be required to read and annotate 2-3 publications per week. We highly recommend that you take the time to write up notes of the key points presented in each paper. We expect that this will take 3-4 hours per paper and you should expect to spend at least 6 hours per week on reading and annotating (NOTE: this should constitute the majority of your time spent studying for the final exam!).

- ➔ **PASS/FAIL: You should read and annotate all papers to successfully pass the course.**

Presentation (0.5 ECTS)

You will be required to make a ~60min lecture presentation of one of the future Internet architecture publications assigned in the course. You will give the lecture to your classmates, answer questions, and lead a discussion during the remaining lecture time. You should plan to leave ~30 mins for discussion after your presentation although this may vary according to how much discussion takes place during the presentation. Depending on how many students are enrolled, you may work in groups.

- ➔ **(33%) GRADED COMPONENT: Your presentation will be graded based on its completeness, the quality of the slides, the quality of ensuing discussions, your ability to answer questions and lead discussions etc. You will NOT be penalized for superficial reasons (e.g. failing to recall an obscure detail).**

Final Exam (0.5 ECTS)

The final exam format has not been decided but it is likely to consist of a combination of multiple-choice, true/false, and short-answer (e.g. 2-3 sentences) questions, and an essay. **You are allowed to bring all of your course notes (including the slides).** The exam will be approximately 2 hours long. The exam will cover all lectures and readings, including student presentations and future Internet architecture publications.

- ➔ **(33%) GRADED COMPONENT: You must pass the final exam with a 1 or above in order to pass the course. If you have attended all lectures, read all papers, and taken the appropriate notes, you shouldn't have any problems.**

*** NOTE: Everything above is MANDATORY. You may NOT choose to partially complete requirements and receive partial credit!**

Your final mark will be from 0 to 5 and depend EQUALLY on the three graded components (i.e. contributions to lecture discussions, quality of your presentation, final exam):

5	Excellent	90 – 100%
4	Very good	80 – 89%
3	Good	70 – 79%
2	Fair	60 – 69%
1	Poor	50 – 59%
0	FAIL	< 50%

Tentative course schedule

The course is lectured at lecture hall T5 of the T building, Konemiehentie 2, Espoo. The regular lecture times are **Monday and Tuesday, 16:15 – 18**. **Attendance is mandatory!**

#	Date	Lecturer	Topic
1.	Mon 10.09	AK	• Practical arrangements • Internet foundations • Internet evolution (part 1)
2.	Tue 11.09	AK	• Internet evolution (part 2)
3.	Mon 17.09	AK	• Why the Internet only just works
4.	Tue 18.09	AK	• Van Jacobson's NNC: a prominent evolutionary FI architecture
5.	Mon 24.09	AK	• Future Internet architecture presentations and group discussions
6.	Tue 25.09	AK	• Future Internet architecture presentations and group discussions
7.	Mon 1.10	AK	• Future Internet architecture presentations and group discussions
8.	Tue 2.10	AK	• Future Internet architecture presentations and group discussions
9.	Mon 8.10	AK	• Future Internet architecture presentations and group discussions
10.	Tue 9.10	AK	• Future Internet architecture presentations and group discussions
11.	Mon 15.10	AK	• FIA demo (Blackadder, LIPSIN) and discussion
12.	Tue 16.10	AK	• Panel discussion and closing remarks
F	(1) Tue 23.10, 9 – 12 (2) Tue 18.12, 13 - 16	-	• Final exam

See the next section for required readings.

Course material

You should read and annotate the papers BEFORE the lecture for which they are assigned, except during weeks 39 – 41 (i.e. presentations, lectures 5 – 10)

Lecture 2

- D. Clark. 1988. The design philosophy of the DARPA internet protocols. *SIGCOMM Comput. Commun. Rev.* 18, 4 (August 1988), 106-114. DOI=10.1145/52325.52336 http://doi.acm.org/10.1145/52325.52336

Lecture 3

- M. Handley. 2006. Why the Internet only just works. *BT Technology Journal* 24, 3 (July 2006), 119-129. DOI=10.1007/s10550-006-0084-z http://dx.doi.org/10.1007/s10550-006-0084-z

Lecture 4

- Van Jacobson, Diana K. Smetters, James D. Thornton, Michael F. Plass, Nicholas H. Briggs, and Rebecca L. Braynard. 2009. Networking named content. In *Proceedings of the 5th international conference on Emerging networking experiments and technologies* (CoNEXT '09). ACM, New York, NY, USA, 1-12. DOI=10.1145/1658939.1658941 http://doi.acm.org/10.1145/1658939.1658941

Lectures 5 – 10

The following papers will not be directly covered in the lectures but they **will be covered on the final exam**. We highly recommend that you read these during weeks 39 – 41.

- David D. Clark, John Wroclawski, Karen R. Sollins, and Robert Braden. 2002. Tussle in cyberspace: defining tomorrow's internet. In *Proceedings of the 2002 conference on Applications, technologies, architectures, and protocols for computer communications* (SIGCOMM '02). ACM, New York, NY, USA, 347-356. DOI=10.1145/633025.633059 http://doi.acm.org/10.1145/633025.633059
- Jennifer Rexford and Constantine Dovrolis. 2010. Future Internet architecture: clean-slate versus evolutionary research. *Commun. ACM* 53, 9 (September 2010), 36-40. DOI=10.1145/1810891.1810906 http://doi.acm.org/10.1145/1810891.1810906
- Marjory S. Blumenthal and David D. Clark. 2001. Rethinking the design of the Internet: the end-to-end arguments vs. the brave new world. *ACM Trans. Internet Technol.* 1, 1 (August 2001), 70-109. DOI=10.1145/383034.383037 http://doi.acm.org/10.1145/383034.383037

Lecture 11

- Petri Jokela, András Zahemszky, Christian Esteve Rothenberg, Somaya Arianfar, and Pekka Nikander. 2009. LIPSIN: line speed publish/subscribe inter-networking. In *Proceedings of the ACM SIGCOMM 2009 conference on Data communication* (SIGCOMM '09). ACM, New York, NY, USA, 195-206. DOI=10.1145/1592568.1592592 http://doi.acm.org/10.1145/1592568.1592592