SI 541/741
Prof. Paul N. Edwards
University of Michigan, Winter 2008
Monday, 1-4 PM, 311 West Hall

Systems, Networks, and Webs:

History and Theory of Infrastructure

This course offers historical, comparative, and theoretical perspectives on the evolution of major infrastructures from the 19th century to the present. We will focus especially on information infrastructures: the Internet, the World Wide Web, and scientific cyberinfrastructures.

To set the stage, we will compare their historical trajectories with those of older transportation, electric power, and communication infrastructures. For example, transportation infrastructures face their most difficult challenges at the interface between different transport modes, as in ports (where shipping connects with trucking and rail) and airports (where air transit connects with automobile, truck, bus, subway, train, and pedestrian modes). These *intermodal* problems in transport networks find significant parallels in information infrastructures. For example, data conversion (from analog to digital, or from one digital format to another) creates difficult problems for system designers and users; connecting networks built on different standards motivated early Internet research.

The course looks at how infrastructures form, how they change, and how they shape (and are shaped by) social systems. A major focus will be the role of standards (e.g. railroad track gauge, alternating current voltages, TCP/IP, HTTP, HTML) and standard-setting bodies in creating "ground rules" for infrastructure development. Concepts such as "technological momentum" (the tendency of large technical systems to become increasingly resistant to change), "load factor" (maximizing the use of available system capacity), and "interdependence" (among components and between connected infrastructures) will be explored. We will try to articulate the differences between systems, networks, and webs (or internetworks) as both technological and social phenomena.

Prerequisites: none.

Requirements and assignments

This course is "front-loaded" with reading that will prepare you for four weeks of research and writing at the end of the course. Please budget your time carefully.

Students in the masters-level version of the course (541) have a different set of requirements from doctoral-level (741) students.

Requirements for all students

- ***Class participation*** (20 percent of course grade). This is a discussion seminar, so you are expected to participate actively in all class discussions. This requirement includes at least one in-class presentation of course readings. (Depending on the number of students in the course, you may be asked to do two or more presentations.) Presentations are not graded separately, but their quality is taken into account as part of the class participation grade. See "Presentation Guidelines" and "How to Give an Academic Talk" (CTools). Attendance at all classes is expected.

- ***Group/pair project.*** Working in groups of two to four, students will create case studies comparing the development of two dissimilar infrastructures. This project should be based on your term paper research.

  The project will culminate in 2 products:

  1. A class presentation, delivered during one of the last three class sessions (10 percent of course grade).

  2. A medium-length paper (2500-3500 words for pairs, 3000-4000 words for triples) OR a website (or other new media product) including the same amount of text. While this paper should be considerably different from the term paper — focusing on comparative analysis — you need not research an entirely different topic. Due in class April 20 (25 percent of course grade). NO LATE PROJECTS.

Additional requirements for 541 students:

- A ***1200-1600 word "think piece"*** (10 percent of course grade). Due in class Feb. 16.

- ***Term research paper*** (35 percent of course grade). A 3000-4000 word paper on an infrastructure issue of your choice. This can be a traditional paper, or a hypermedia project (must include the same amount of text). 541 students may use course texts as the primary basis for this project, but must conduct at least some additional research as well (guideline: at least five additional high-quality sources). The assignment has three parts.

  (a) A 400-500 word *prospectus,* clearly describing your topic, your approach, and the sources you plan to use, is due March 2.

  (b) An *extended prospectus* (1000-2000 words), further elaborating your topic and showing evidence of additional research, is due March 23.

  (c) A *final version,* thoroughly revised and proofread, is due by midnight on Thursday, April 23. NO LATE PROJECTS.

Additional requirements for 741 (doctoral) students:

- ***Additional required readings*** (see schedule).

- A ***2000-3000 word essay*** on theories of infrastructure development (20 percent of course grade). Due in class February 16.

- ***Term research paper*** (35 percent of course grade). A 4000-5000 word paper on an infrastructure issue of your choice. This can be a traditional paper or a new media project.

In addition to course readings, 741 students must conduct substantial independent research (at least fifteen additional high-quality sources). Use of original historical sources is encouraged, but not required. The assignment has three parts.

(a) A 500-word *prospectus,* clearly describing your topic, your approach, and the sources you plan to use, is due March 2.

(b) A *extended prospectus* (minimum 1500-2500 words), further elaborating your topic and showing evidence of research, is due March 23.

(c) A *final version,* thoroughly proofread, is due by midnight on Thursday, April 23. NO LATE PROJECTS.

Required Texts (books available at Shaman Drum):

Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger* (Princeton University Press, 2006)

Stephen B. Goddard, *Getting There: The Epic Struggle between Road and Rail in the American Century* (New York: Basic Books, 1994).

Alfred Dupont Chandler and James W. Cortada, eds., *A Nation Transformed by Information* (New York: Oxford University Press, 2000)

Stephen Graham and Simon Marvin, *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition* (New York: Routledge, 2001)

Manuel Castells, *The Internet Galaxy: Reflections on the Internet, Business, and Society* (Oxford ; New York: Oxford University Press, 2001)

Janet Abbate, *Inventing the Internet* (Cambridge, MA: MIT Press, 1999)

Articles and web-based readings on CTools

Copies of all course books are on 4-hour reserve at the Shapiro Library desk.

Plagiarism policy:

Plagiarism is the use of another person's words or ideas without attribution. In professional settings generally, plagiarism is an extremely serious matter. Professors, journalists, and other information professionals can (and regularly do) lose their jobs for this offense.

All writing assignments for this course must be your own, original work, written in your own words. You may incorporate excerpts from publications by other authors, but they must be clearly marked as quotations and properly attributed. You may obtain copy editing assistance, and you may discuss your ideas with others, but all substantive writing and ideas must be your own or else be explicitly attributed to another, using a citation sufficiently detailed for someone else to easily locate your source. *Bare URLs are insufficient as citations.*

It is your responsibility to understand exactly what plagiarism is and how to avoid it. All cases of plagiarism will be officially reported and dealt with according to Rackham policies. There will be no warnings, no second chances, no opportunity to rewrite; all plagiarism cases will be immediately reported to SI's Dean of Academic Affairs. ***Consequences can range from failing the assignment (a grade of zero) or failing the course to expulsion from the University.*** For additional information about plagiarism, see the "Academic and Professional Integrity Policy Statement" in the SI Master's Student Handbook, the Rackham pamphlet on Academic Integrity, and the Plagiarism document from the UM Libraries. Sweetland Writing Center has special help on plagiarism for international students.

Instructor:

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Course Schedule

Jan. 12 — **Introduction: What is Infrastructure? History? Theory?**

Edwards, Paul N., "How to Read a Book," www.si.umich.edu/~pne/PDF/howtoread.pdf

Geoffrey C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and its Consequences* (Cambridge, Mass.: MIT Press, 1999), 33-50 (CTools)

Richard O. Mason, James L. McKenney, and Duncan G. Copeland, "An Historical Method for MIS Research: Steps and Assumptions," *MIS Quarterly* 21:3 (1997), 307-320 (CTools)

Thomas Parke Hughes, "The Evolution of Large Technological Systems," in *The Social Construction of Technological Systems*, eds. Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, MA: MIT Press, 1987), 51-82 (CTools)

Susan Leigh Star and Karen Ruhleder, "Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces," *Information Systems Research* 7:1 (1996), 111-134 (CTools)

741 required/541 recommended:

Richard O. Mason, James L. McKenney, and Duncan G. Copeland, "Developing an Historical Tradition in MIS Research." *MIS Quarterly* 21 (1997) 257-278 (CTools)

James L. McKenney, Richard O. Mason, and Duncan G. Copeland, "Bank of America: The Crest and Trough of Technological Leadership." *MIS Quarterly* 21 (1997) 321-353 (CTools)

Jan. 19 — **MLK Day: class will not meet, but please read the items below**

Thomas Parke Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Johns Hopkins University Press, 1983), excerpts (CTools)

Stephen B. Goddard, *Getting There: The Epic Struggle between Road and Rail in the American Century* (New York: Basic Books, 1994), pp. 1-99, 151-206

741 required/541 recommended:

Patrick Feng, "Studying Standardization: A Review of the Literature," IEEE 3rd Conference on Standardization and Innovation in Information Technology (2003), 99-112

Jan. 26 — **Gateways**

Paul A. David and Julie Ann Bunn, "The Economics of Gateway Technologies and Network Evolution: Lessons From Electricity Supply History," *Information Economics and Policy* 3 (1988): 165-202 (CTools)

Tineke Egyedi, "Infrastructure Flexibility created by Standardised Gateways: The Cases of XML and the ISO Container," *Knowledge, Technology & Policy* 14, no. 3, 41-54 (CTools)

Marc Levinson, *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger* (Princeton: Princeton University Press, 2006). Focus on chapters 1-4, 7-9, and 13-14, but please skim the other chapters, esp. 5-6.

741 required/541 recommended:

Paul W. Forster and John Leslie King, "Information Infrastructure Standards in Heterogeneous Sectors: Lessons from the Worldwide Air Cargo Community," in Brian Kahin and Janet Abbate, eds., *Standards Policy for Information Infrastructure* (Cambridge, MA: MIT Press, 1995), 148-177 (CTools)

Feb. 2 — **Information Infrastructures**

Alfred Dupont Chandler and James W. Cortada, *A Nation Transformed by Information* (New York: Oxford University Press, 2000), chapters 1-9. Please read the entire book. You

may decide to spend less time on some chapters than on others, but everyone should read chapters 1-2, 6-7, and 9 carefully.

741 required/541 recommended:

Erik van der Vleuten, "Infrastructures and Societal Change: A View from the Large Technical Systems Field", *Technology Analysis & Strategic Management* 16:3 (2004), 395–414 (CTools)

Feb. 9 — **Cities as Infrastructure**

Stephen Graham and Simon Marvin, *Splintering Urbanism* (New York: Routledge, 2001). Read the Prologue and Chapters 1-5, focusing on chapters 1-3. Also read the table of contents, the lists of tables and figures, and the page of quotations just before the Prologue (but skip the acknowledgements).

Bruno Latour, *Paris: Invisible City*, www.bruno-latour.fr/virtual/index.html

Feb. 16 — **The Internet**

Andrew L. Russell, "'Rough Consensus and Running Code' and the Internet-OSI Standards War," *IEEE Annals of the History of Computing* 28:3 (2006), 48-61 (CTools)

Janet Abbate, *Inventing the Internet* (Cambridge, MA: MIT Press, 1999)

741 required/541 recommended:

Jorge Luis Borges, "The Garden of Forking Paths" (short story, 1941). Full text at courses.essex.ac.uk/lt/lt204/forking_paths.htm, interesting hypertext adaptation and commentary at www.geocities.com/papanagnou/cover.htm

Recommended (all):

Rhonda Hauben, *Netizens: On the History and Impact of Usenet and the Internet.* A quirky, but interesting history of the early Internet (including especially its interaction with the history of Unix). The book exists in a print edition, but it is also available online at www.columbia.edu/~rh120/

— *541: "think piece" due in class* —

— *741: Essay due in class* —

Feb. 23 — **NO CLASS (Winter break)**

Mar. 2 — **Hypertext and the World Wide Web**

WB Rayward, "Visions of Xanadu: Paul Otlet (1866-1944) and hypertext," *Journal of the American Society for Information Science*, 45:4 (1994), 235-50 (CTools)

Alex Wright, "The Web Time Forgot," New York Times, June 17, 2008, www.nytimes.com/2008/06/17/science/17mund.html?_r=2&pagewanted=all

Vannevar Bush, "As We May Think," *Atlantic Monthly* 176: 7 (1945), 101-08 (CTools)

Browse the Project Xanadu website (xanadu.com), especially the history and archives pages, and Ted Nelson's website (old: xanadu.com.au/ted/, new: ted.hyperland.com):

Howard Rheingold, "Xanadu, Network Culture, and Beyond," Ch. 14 of *Tools For Thought* (online version of 1985 book), www.rheingold.com/texts/tft/14.html

Explore the CERN (European Laboratory for Particle Physics) web site on CERN and the history of the WWW. See especially the original proposal documents. www.cern.ch/Public/ACHIEVEMENTS/web.html

Read the Wikipedia entry, "History of the World Wide Web" (en.wikipedia.org/wiki/History_of_the_World_Wide_Web). Explore some of the links and sources.

741 required/541 recommended:

Tineke M. Egyedi and Ruben van Wendel de Joode, "Standards and Coordination in Open Source Software," *IEEE 3rd Conference on Standardization and Innovation in Information Technology* (2003), 85-97 (CTools)

— Term paper prospectus due (541 and 741) —

Mar. 9 — **The Internet as Infrastructure**

Manuel Castells, *The Internet Galaxy: Reflections on the Internet, Business, and Society* (New York: Oxford University Press, 2001), chapters 1-5

Graham and Marvin, *Splintering Urbanism*, pp. 219-248, 251-256

— Choose group/pair project partners —

Mar. 16 — **Information Infrastructure in the Developing World**

Matthew Zook, "The Geographies of the Internet," *Annual Review of Information Science and Technology* 40 (2006), 53-78. Also visit Zook's website, www.zooknic.com, and explore some of the maps and statistics.

Castells, *The Internet Galaxy*, chapter 9

Graham and Marvin, *Splintering Urbanism*, Chapter 7

Visit the website of the *Negotiating the Net* book project, www.cidcm.umd.edu/ntn/. Read the "Continent" study (last column on the right). Also choose and read at least two of the country studies. Note that these are drafts; the finished book (2006) is available.

Recommended (all):

Graham and Marvin, *Splintering Urbanism*, Conclusion and Postscript

— *Extended prospectuses due* —

Mar. 23 — **Cyberinfrastructure for the Sciences**

D Simberloff et al., *Long-lived digital data collections: enabling research and education in the 21st century* (Technical report NSB-05-40, US National Science Foundation, 2005) (CTools)

Visit the website of the NSF Office of Cyberinfrastructure, www.nsf.gov/dir/index.jsp?org=OCI. Choose and read at least one of the "CI+X" reports (on cyberinfrastructure in various sciences), www.nsf.gov/od/oci/reports.jsp

Paul N. Edwards, Steven J. Jackson, Geoffrey C. Bowker, and Cory P. Knobel, *Understanding Infrastructure: Dynamics, Tensions, and Design*. Report of the NSF Workshop on History & Theory of Infrastructure: Lessons for New Scientific Cyberinfrastructures (Ann Arbor: Deep Blue, 2007), http://hdl.handle.net/2027.42/49353

Mar. 30 — **Project Presentations**

April 6 — **Project Presentations**

April 13 — **Project Presentations**

April 20 — **Conclusion**

— *Group/pair project paper due in class. NO LATE PROJECTS* —

Thursday, April 23 — **Final draft of term project due**

Turn in on CTools and in my faculty mailbox (paper)

— *NO LATE PROJECTS* —