



ILLINOIS INSTITUTE
OF TECHNOLOGY



DEPARTMENT OF COMPUTER SCIENCE

Various Aspects of Network Modeling

Edward Chlebus

SB 226B

chlebus@iit.edu

http://www.iit.edu/csl/cs/faculty/chlebus_edward.shtml

“Network” (1755)

“Network: Any thing reticulated or decussated, at equal distances, with interstices between the intersections.”

Dictionary of the English Language, 1755

“Network” (1996)

“When I took office, only high energy physicists had ever heard of what is called the World Wide Web. Now even my cat has its own page.”

Bill Clinton, announcement of Next Generation Internet Initiative, 1996

Invention of the telephone

“The method of, and apparatus for, transmitting vocal or other sounds telegraphically by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound.”

*US Patent #174465 issued to Alexander Graham Bell
on March 7, 1876*

Future of telephony...

“This ‘telephone’ has too many shortcomings to be seriously considered as a means of communication.”

Western Union internal memo, 1876

Telephone network dimensioning

- How to measure telephone traffic?
- Given traffic A offered from source S to destination D , what's the capacity of the link between S and D to meet GOS requirements?
- Erlang loss formula

Basic works by Agner Krarup *Erlang*

- “The Theory of Probabilities and Telephone Conversations” (1919)
- “Solution of some Problems in the Theory of Probabilities of Significance in Automatic Telephone Exchanges” (1917)

“I think there is a world market for maybe five computers.”

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Thomas Watson, Chairman of IBM, 1943

Growth of the Internet

Date	Number of hosts
1969	4
1971	23
1984	1,000
1987	10,000
1989	100,000
1992	1,000,000
1996	10,000,000
July 2000	93,050,000
July 2010	770,000,000

“There is no reason for any individual to have a computer in his home.”

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*Ken Olson, president and founder of Digital Equipment Corp.,
World Future Society Convention, 1977*

Growth of the Internet (cont'ed)

Date	Number of users	% of world population
Dec. 1995	16 million	0.4%
Dec. 2000	361 million	5.8%
Dec. 2005	1,018 million	15.7%
June 2011	2,110 million	30.4%

Email statistics (2010)

Average number of email messages per day	294 billion
Number of email accounts worldwide	2.9 billion
New email users since the year before	480 million
Share of emails that were spam	89.1%

Website statistics (2010)

Number of websites in Dec. 2010	255 million
Added websites in 2010	21.4 million

Do they have anything to do with Internet research?

- Isaac Newton (1643-1727)
The universal law of gravitation
- Siméon Denis Poisson (1781-1840)
The probability distribution applied to the deliberations of juries (1838)
- Vilfredo Pareto (1848-1923)
Probability distribution of wealth, the 80-20 rule
- George Kingsley Zipf (1902-1950)
Statistical occurrences in different languages
- D. Lavalette
Statistical analysis of numerical values of the Journal Impact Factor

New applications for old laws

- Gravity models used to model the volume of $S \rightarrow D$ traffic in a network (PSTN, Internet)
- Poisson distribution: telephone call arrivals, packet arrivals, web transaction arrivals
- Zipf's law, Pareto distribution: file size distribution, Internet topology, file access requests, website visitors
- Modified Lavalette's law: wireless Internet access

Network modeling and teletraffic analysis

- Nondeterministic models
- Do we need a crystal ball?
- Probability distributions
- Measurement data

Sample projects

- Analysis of wireless Internet access sessions
- Synthesis of Internet traffic matrices
- Profiling various categories of Wi-Fi hotspot network users by applying clustering techniques
- Generation of cell dwell time residuum

Sample projects (cont'd)

- Website visitor traffic analysis
- Video on demand and time shifted TV traffic analysis

Teaching

- CS-455 Data Communications (Fall 2011, Spring 2012)
- CS-542 Computer Networks I (Fall 2011)
- CS-544 Computer Networks II (Spring 2012)

“There are three kinds of death in this world. There's heart death, there's brain death, and there's being off the network.”

Guy T. Almes, former Chief Engineer for the Internet2 Initiative

Enjoy studying at our CS Department!