1. Intro to Communication Systems

Office Hours:
BKD, 6th floor of Sirindhralai building
Wednesday 13:45-15:15
Friday 13:45-15:15
“The **fundamental** problem of **communication** is that of **reproducing** at one point either exactly or approximately a message selected at another point.”

Shannon: Father of the Info. Age

- Documentary
- Co-produced by the Jacobs School, UCSD-TV, and the California Institute for Telecommunications and Information Technology
- Won a Gold award in the Biography category in the 2002 Aurora Awards.

[http://www.uctv.tv/shows/Claude-Shannon-Father-of-the-Information-Age-6090]
[http://www.youtube.com/watch?v=z2Whj_nL-x8]
C. E. Shannon (1916-2001)

• 1938 MIT master's thesis: A Symbolic Analysis of Relay and Switching Circuits
• Insight: The binary nature of **Boolean logic** was analogous to the **ones** and **zeros** used by **digital circuits**.
• The thesis became the foundation of practical digital circuit design.
• The first known use of the term **bit** to refer to a “**binary digit.”**
• Possibly the most important, and also the most famous, master’s thesis of the century.
• It was **simple, elegant, and important.**
A SYMBOLIC ANALYSIS
OF
RELAY AND SWITCHING CIRCUITS

by
Claude Elwood Shannon
B.S., University of Michigan
1936

Submitter in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
from the
Massachusetts Institute of Technology
1940

Signature of Author

Department of Electrical Engineering, August 10, 1937

Signature of Professor
in Charge of Research

Signature of Chairman of Department,
Committee on Graduate Students

Library
Boole/Shannon Celebration

- Events in 2015 and 2016 centered around the work of
  - George Boole, who was born 200 years ago, and
  - Claude E. Shannon, born 100 years ago.

- Events were scheduled both at
  - the University College Cork (UCC), Ireland and
  - the Massachusetts Institute of Technology (MIT)

- http://www.rle.mit.edu/booleshannon/
An Interesting Book

- The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age
- by Paul J. Nahin
- ISBN: 9780691151007
C. E. Shannon (Con’t)

- 1948: A Mathematical Theory of Communication
- September 1949: Book published. Include a new section by Warren Weaver that applied Shannon's theory to human communication.
- Create the architecture and concepts governing digital communication.
- Invent Information Theory: Simultaneously founded the subject, introduced all of the major concepts, and stated and proved all the fundamental theorems.
A Mathematical Theory of Communication

- Link posted in the “references” section of the website.
C. E. Shannon

...with some remarks by Toby Berger.
Claude E. Shannon Award

Claude E. Shannon (1972)
David S. Slepian (1974)
Robert M. Fano (1976)
Peter Elias (1977)
Mark S. Pinsker (1978)
Jacob Wolfowitz (1979)
W. Wesley Peterson (1981)
Irving S. Reed (1982)
Robert G. Gallager (1983)
Solomon W. Golomb (1985)
William L. Root (1986)
James L. Massey (1988)
Thomas M. Cover (1990)
Andrew J. Viterbi (1991)
Elwyn R. Berlekamp (1993)
Aaron D. Wyner (1994)
G. David Forney, Jr. (1995)
Imre Csiszár (1996)
Jacob Ziv (1997)
Tadao Kasami (1999)
Thomas Kailath (2000)
Jack Keil Wolf (2001)
Toby Berger (2002)
Lloyd R. Welch (2003)
Richard Blahut (2005)
Rudolf Ahlswede (2006)
Sergio Verdu (2007)
Robert M. Gray (2008)
Jorma Rissanen (2009)
Te Sun Han (2010)
Shlomo Shamai (Shitz) (2011)
Abbas El Gamal (2012)
Katalin Marton (2013)
János Körner (2014)
Arthur Robert Calderbank (2015)
Alexander S. Holevo (2016)

[ http://www.itsoc.org/honors/claud-e-shannon-award ]
IEEE Richard W. Hamming Medal

1988 - Richard W. Hamming
1989 - Irving S. Reed
1990 - Dennis M. Ritchie and Kenneth L. Thompson
1991 - Elwyn R. Berlekamp
1992 - Lotfi A. Zadeh
1993 - Jorma J. Rissanen
1994 - Gottfried Ungerboeck
1995 - Jacob Ziv
1996 - Mark S. Pinsker
1997 - Thomas M. Cover
1998 - David D. Clark
1999 - David A. Huffman
2000 - Solomon W. Golomb
2001 - A. G. Fraser
2002 - Peter Elias
2003 - Claude Berrou and Alain Glavieux
2004 - Jack K. Wolf
2005 - Neil J.A. Sloane
2006 - Vladimir I. Levenshtein
2007 - Abraham Lempel
2008 - Sergio Verdú
2009 - Peter Franaszek
2010 - Whitfield Diffie, Martin Hellman and Ralph Merkle
2011 - Toby Berger
2012 - Michael Luby, Amin Shokrollahi
2013 - Arthur Robert Calderbank
2014 - Thomas Richardson and Rüdiger L. Urbanke
2015 - Imre Csiszar
2016 - Abbas El Gamal

“For contributions to Information Theory, including source coding and its applications.”
Information Theory

The science of information theory tackles the following questions [Berger]

1. What is information, i.e., how do we measure it quantitatively?
2. What factors limit the reliability with which information generated at one point can be reproduced at another, and what are the resulting limits?
3. How should communication systems be designed in order to achieve or at least to approach these limits?
Basic elements of communication

- **Information source**: produce a message
- **Transmitter**: operate on the message to create a signal (in an appropriate form) which can be sent through a channel

Analog (continuous)  Digital (discrete)
Basic elements (2)

- **Channel**: the medium over which the signal, carrying the information that composes the message, is sent
- **Channel impairments**: Unwanted undesirable effects which corrupt the message
Basic elements (3)

- **Receiver**: transform the received signal back into the message intended for delivery

- **Destination**: a person or a machine, for whom or which the message is intended
Elements of digital commu. sys.

Information Source → Source Encoder → Channel Encoder → Digital Modulator → Transmitted Signal → Channel → Received Signal → Digital Demodulator → Channel Decoder → Source Decoder → Destination

Message

Transmitter

Recovered Message

Receiver

Noise & Interference
Digital Communication

Waveform $\rightarrow$ sequence $\rightarrow$ symbols $\rightarrow$ bits

Input

Source Encoder

Know the probabilistic structure of the input source.

Channel Encoder

Binary data stream (sequence of data) without meaning (from channel viewpoint).

Take the bits from one place to another.

Output

Source Decoder

Channel Decoder

Binary Interface

Channel

+ noise & interference

This is the major layering of all digital communication systems.
Additional Reading

- A Brief History of Communications: IEEE Communications Society - a fifty-year foundation for the future
  - ประวัติย่อ “การสื่อสารโลก”: หัวสิบปีชมรมไฟฟ้าสื่อสาร—รากฐานสู่อนาคต
    - [http://www.ebooks.in.th/ebook/7880/ประวัติย่อการสื่อสาร](http://www.ebooks.in.th/ebook/7880/ประวัติย่อการสื่อสาร)

- Thai Telecommunications Encyclopedia (สารานุกรม โทรศัพท์มobil

- Links posted in the “references” section of the website.