Digital Communication Systems
ECS 452

Asst. Prof. Dr. Prapun Suksompong

prapun@siit.tu.ac.th

Overview of Digital Communication Systems

Office Hours:
BKD 3601-7

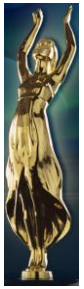
Monday	**14:00-16:00**
Wednesday	**14:40-16:00**

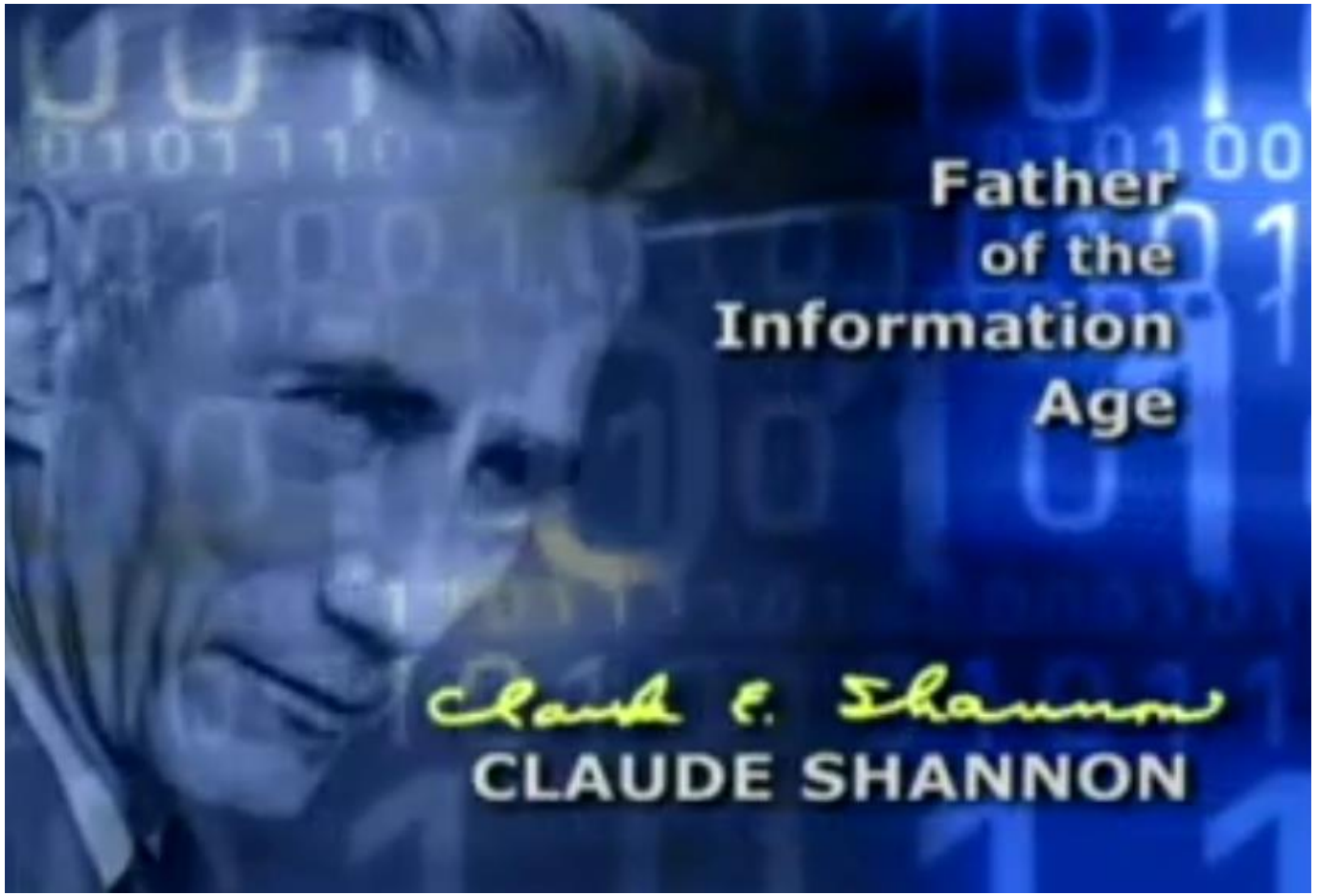
"The **fundamental** problem of **communication** is that of **reproducing** at one point either exactly or approximately a message selected at another point."

Shannon, Claude.
A Mathematical Theory Of Communication. (1948)

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.



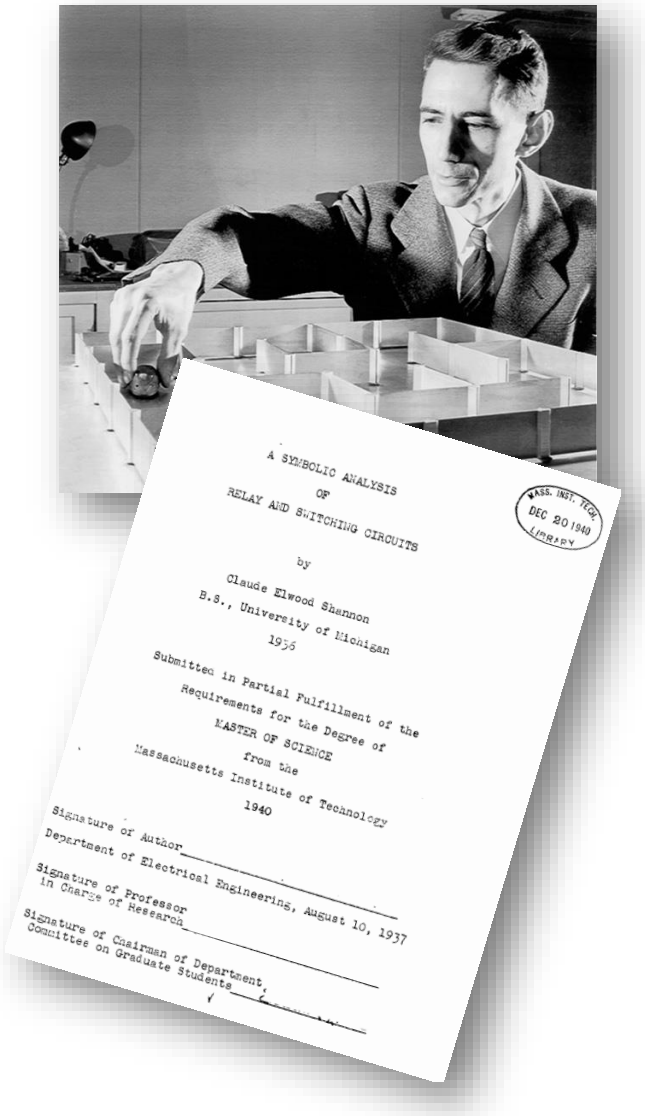


uctv UNIVERSITY of CALIFORNIA TELEVISION

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

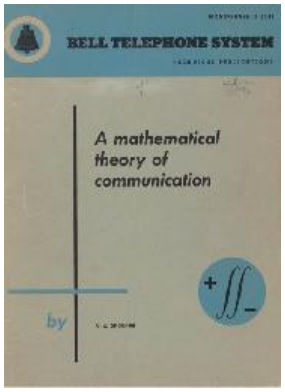
C. E. Shannon (1916-2001)

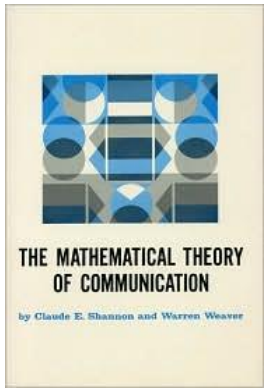
- 1938 MIT master's thesis: A Symbolic Analysis of Relay and Switching Circuits
- Insight: The binary nature of **Boolean logic** was analogous to the **ones** and **zeros** used by **digital circuits**.
- The thesis became the foundation of practical digital circuit design.
- The first known use of 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*.

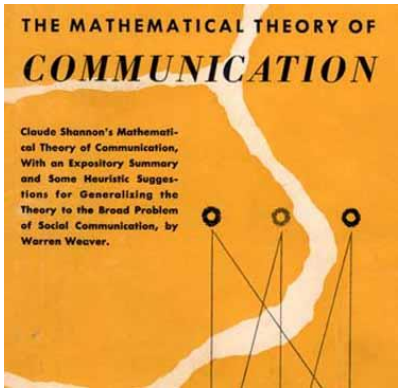


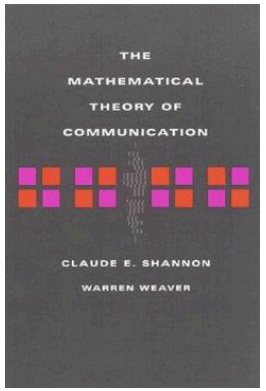
C. E. Shannon (Con't)

- 1948: A **Mathematical Theory of Communication**
  - Bell System Technical Journal, vol. 27, pp. 379-423, July-October, 1948.
- 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.



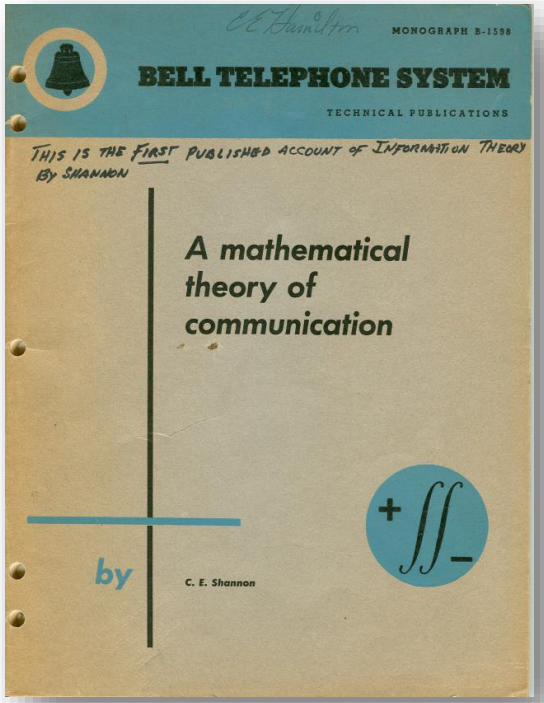






- Invent **Information Theory**: Simultaneously founded the subject, introduced all of the major concepts, and stated and proved all the fundamental theorems.

A Mathematical Theory of Communication



A Mathematical Theory of Communication

By C. E. SHANNON

Introduction

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist[1] and Hartley[2] on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design.

If the number of messages in the set is finite then this number or any monotonic function of this number can be regarded as a measure of the information produced when one message is chosen from the set, all choices being equally likely. As was pointed out by Hartley the most natural choice is the logarithmic function. Although this definition must be generalized considerably when we consider the influence of the statistics of the message and when we have a continuous range of messages, we will in all cases use an essentially logarithmic measure.

The logarithmic measure is more convenient for various reasons:

1. It is practically more useful. Parameters of engineering importance

[1] Nyquist, H., "Certain Factors Affecting Telegraph Speed," *Bell System Technical Journal*, April 1924, p. 324; "Certain Topics in Telegraph Transmission Theory," *A. I. E. E. Trans.*, v. 47, April 1928, p. 617.
[2] Hartley, R. V. L., "Transmission of Information," *Bell System Technical Journal*, July 1928, p. 535.

Published in The Bell System Technical Journal
Vol. 27, pp. 379-423, 623-656, July, October, 1948

MONOGRAPH B-1598
Reissued December, 1957

[An offprint from the Bell System Technical Journal]

Information Theory

The science of information theory tackles the following questions

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?

[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)
Neil J. A. Sloane (1998)
Tadao Kasami (1999)
Thomas Kailath (2000)
Jack Keil Wolf (2001)
Toby **Berger** (2002)
Lloyd R. Welch (2003)
Robert J. McEliece (2004)
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)

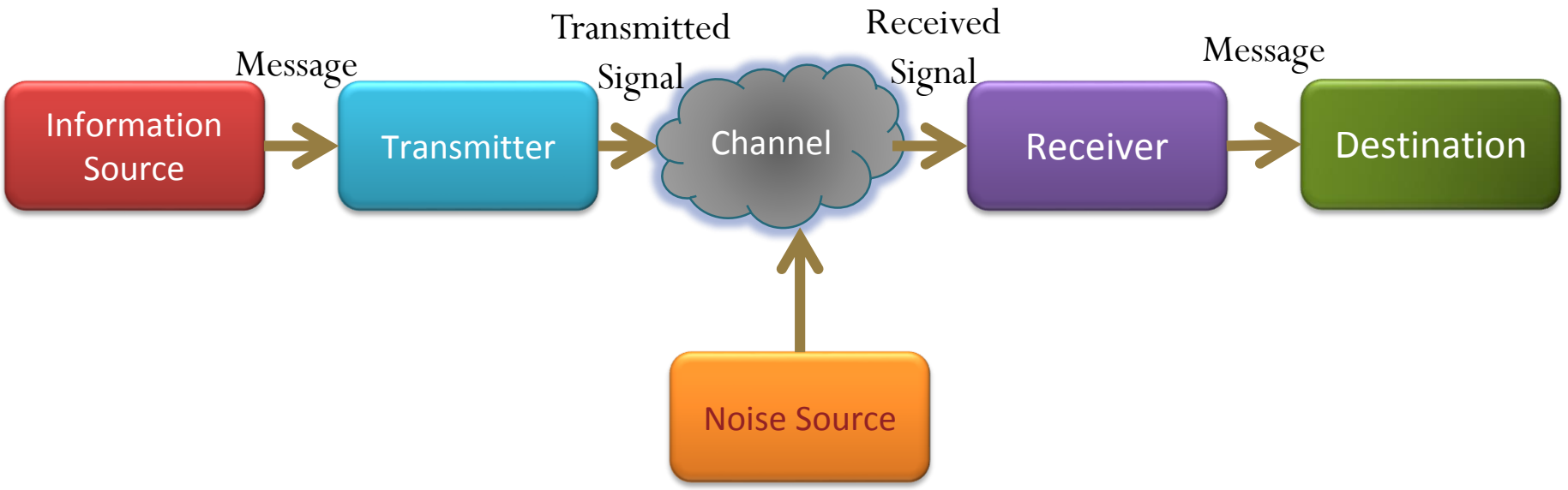
[http://www.ieee.org/documents/hamming_rl.pdf]

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

"For contributions to Information Theory, including **source coding** and its applications."

Elements of communication sys.



Elements of digital commu. sys.