Principles of Communications
ECS 332

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1. Intro to comm. system

Office Hours:
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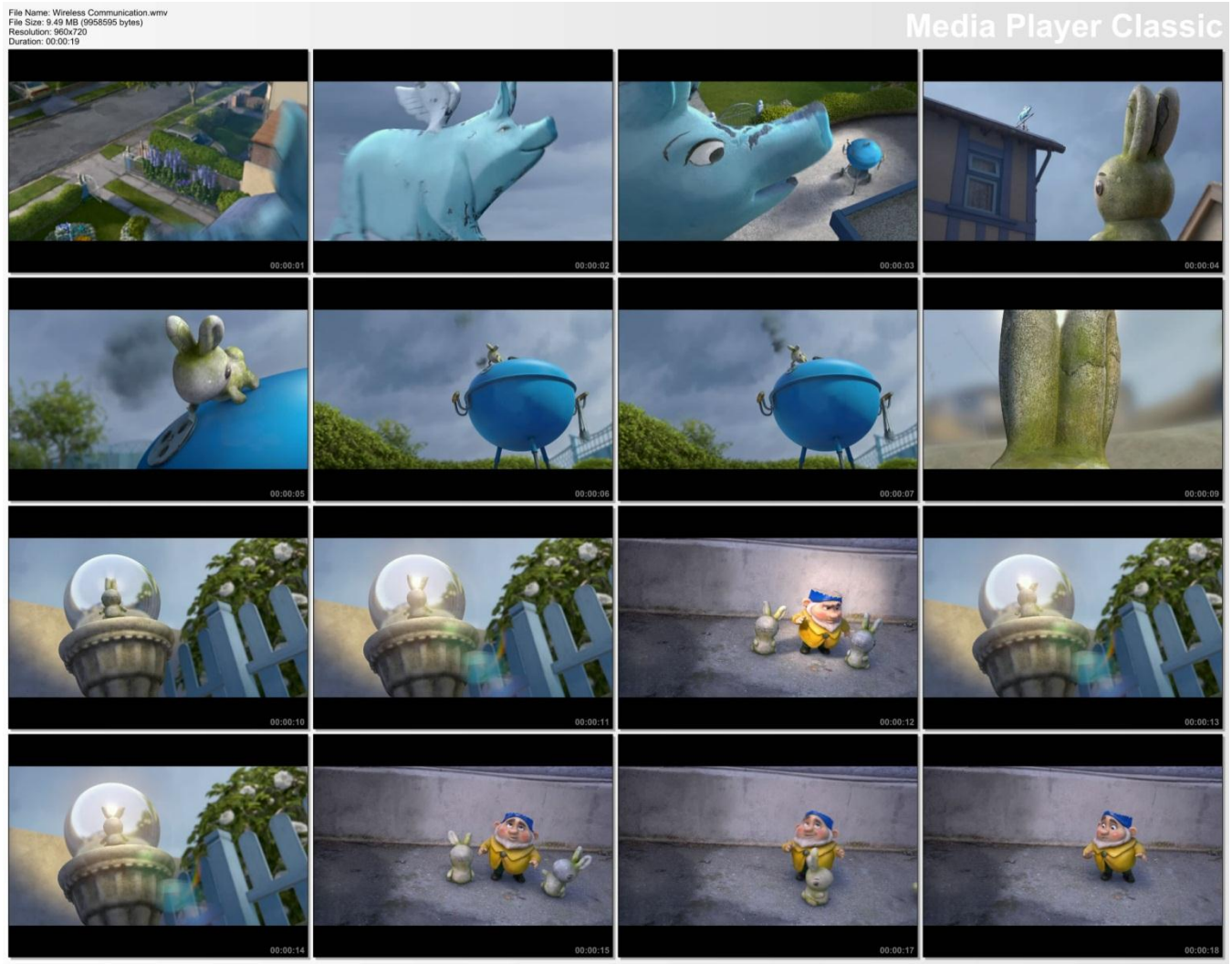
Monday	**14:40-16:00**
Friday	**14:00-16:00**

Example: Wireless Communication

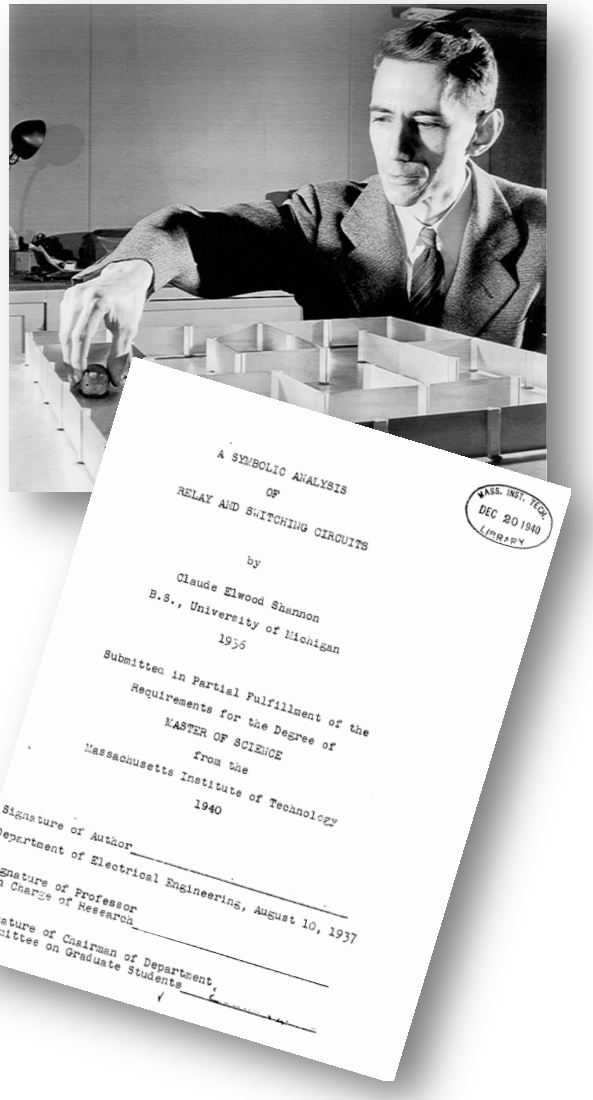


"The **fundamental** problem of **communication** is that of **reproducing** at one point either exactly or approximately a message selected at another point."

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

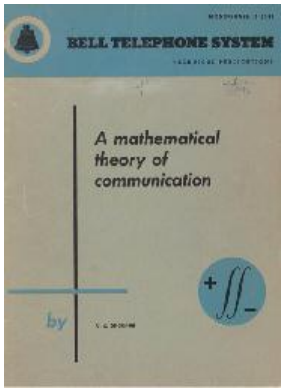
C. E. Shannon (1916-2001)

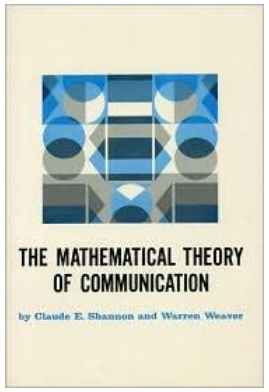
- 1938 MIT master's thesis: A Symbolic Analysis of Relay and Switching Circuits
- Insight: The binary nature of **Boolean logic** was analogous to the **ones** and **zeros** used by **digital circuits**.
- The thesis became the foundation of practical digital circuit design.
- The first known use of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

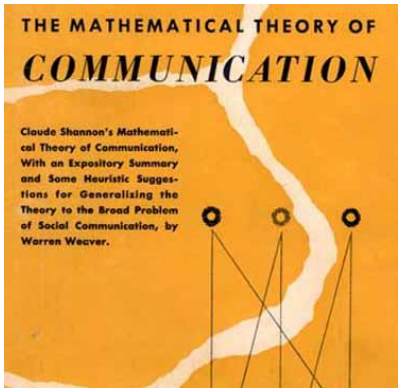


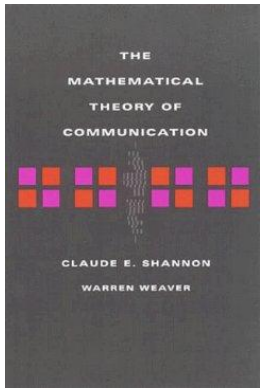
C. E. Shannon (Con't)

- 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.





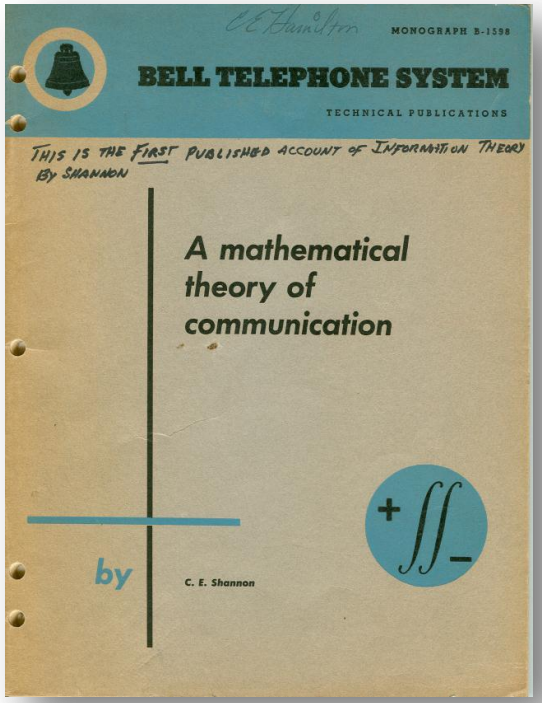


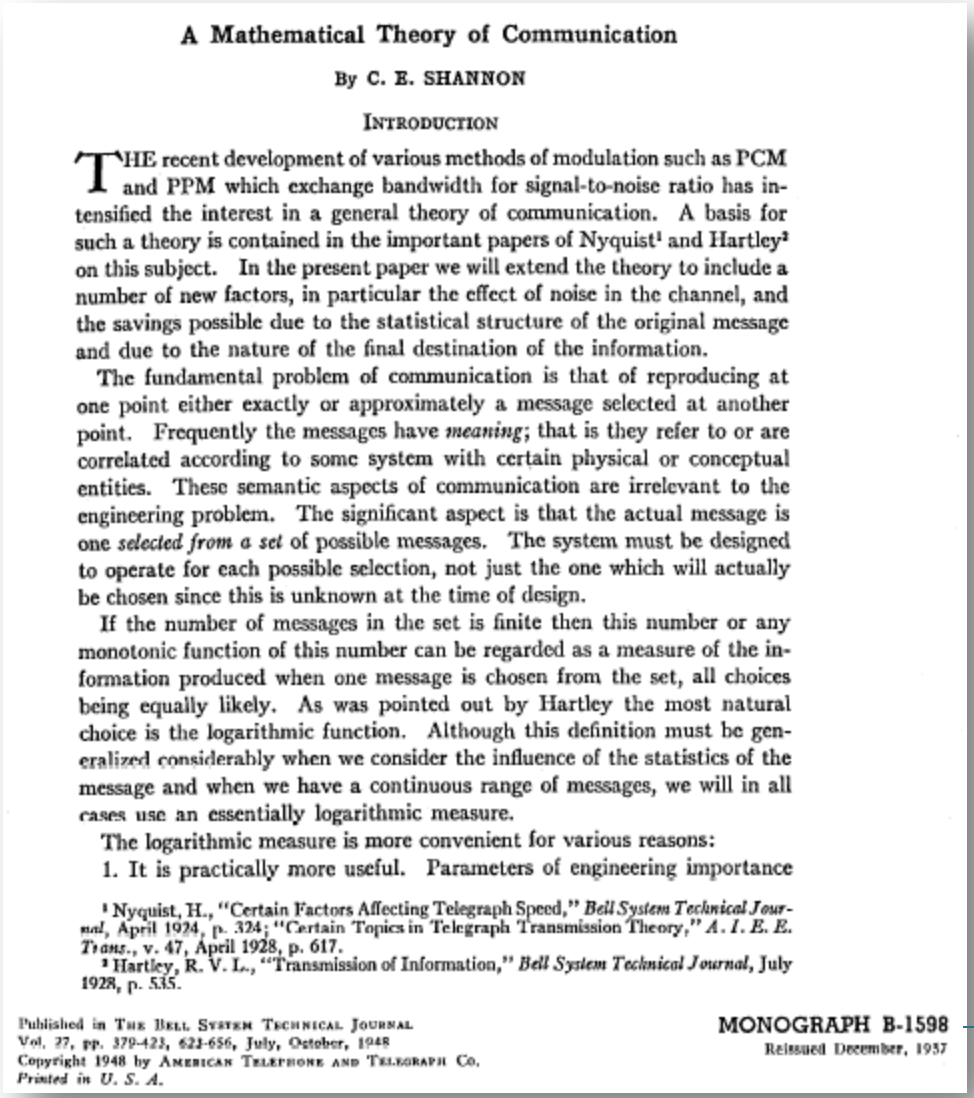


- Invent **Information Theory**: Simultaneously founded the subject, introduced all of the major concepts, and stated and proved all the fundamental theorems.

A Mathematical Theory of Communication

- Link posted in the "references" section of the website.





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.

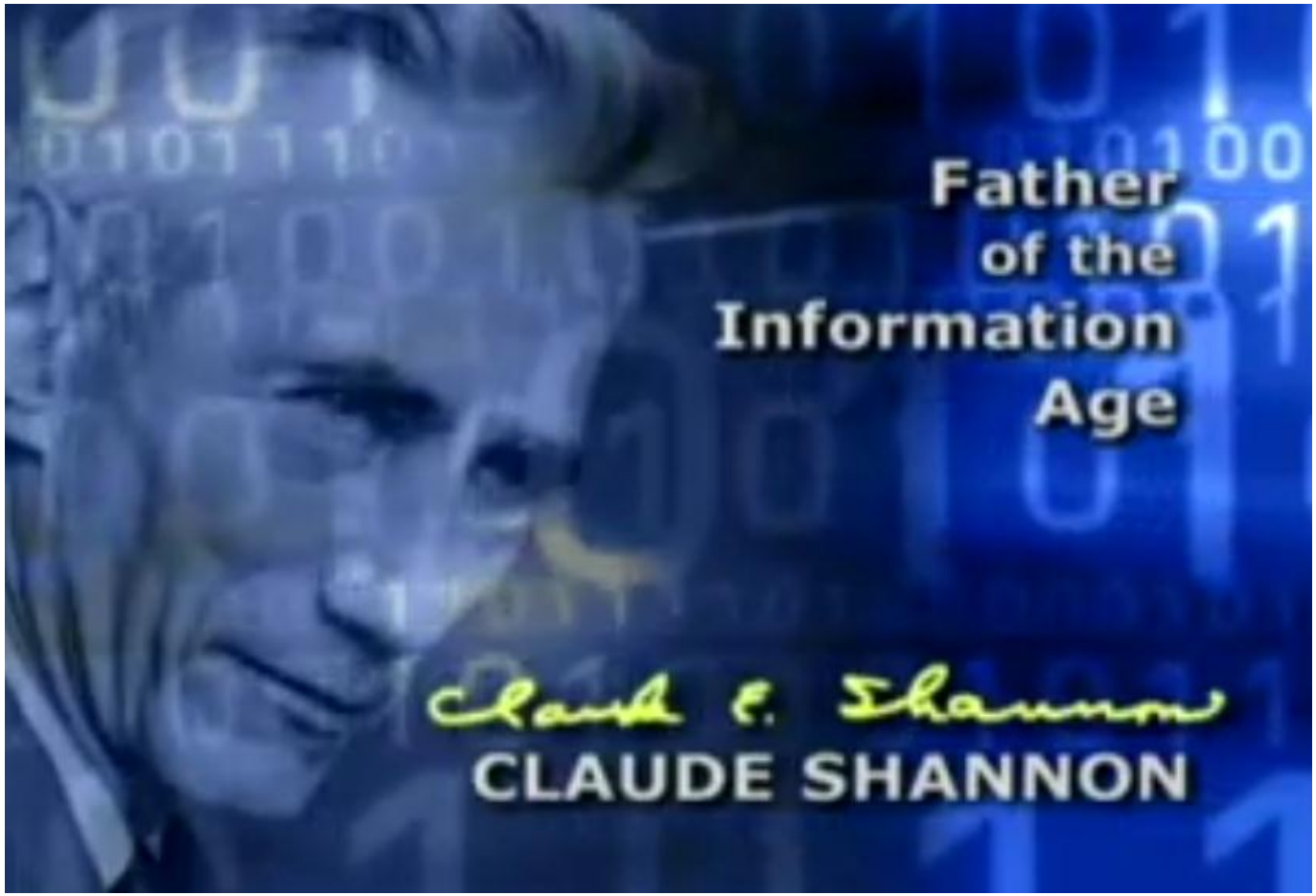
Published in THE BELL SYSTEM TECHNICAL JOURNAL
Vol. 27, pp. 379-423, 623-656, July, October, 1948

Printed in U. S. A.

MONOGRAPH B-1598
Reissued December, 1957

[An offprint from the Bell System Technical Journal]

Shannon - Father of the Info. Age



[http://www.youtube.com/watch?v=z2Whj_nL-x8]

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)

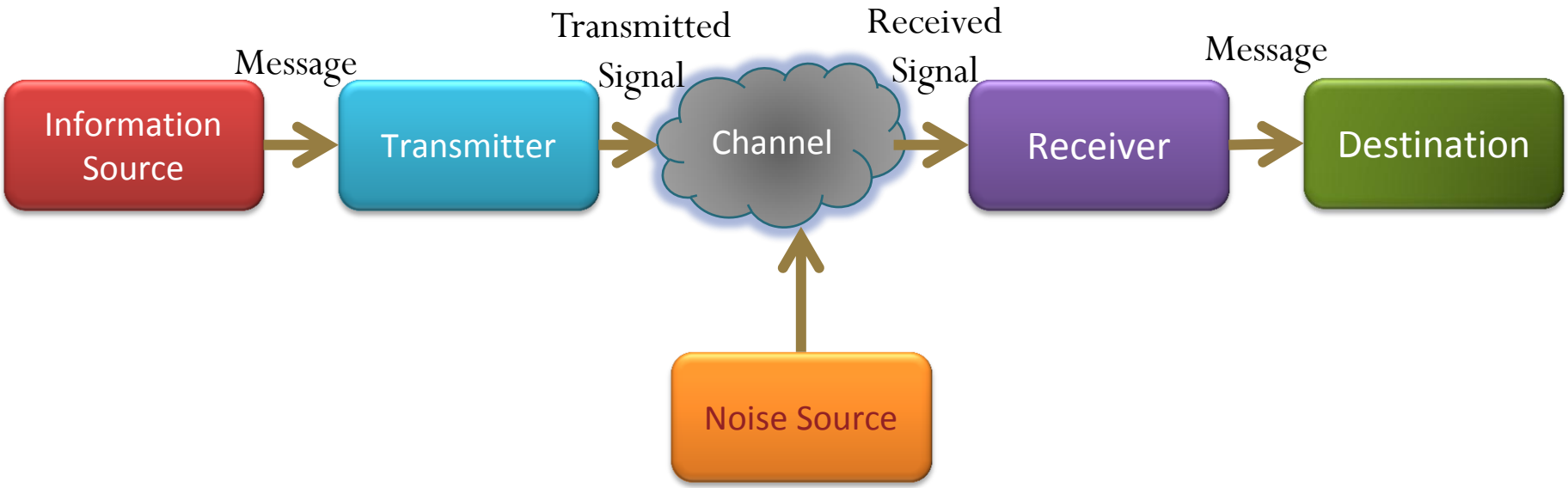
Information Theory

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?

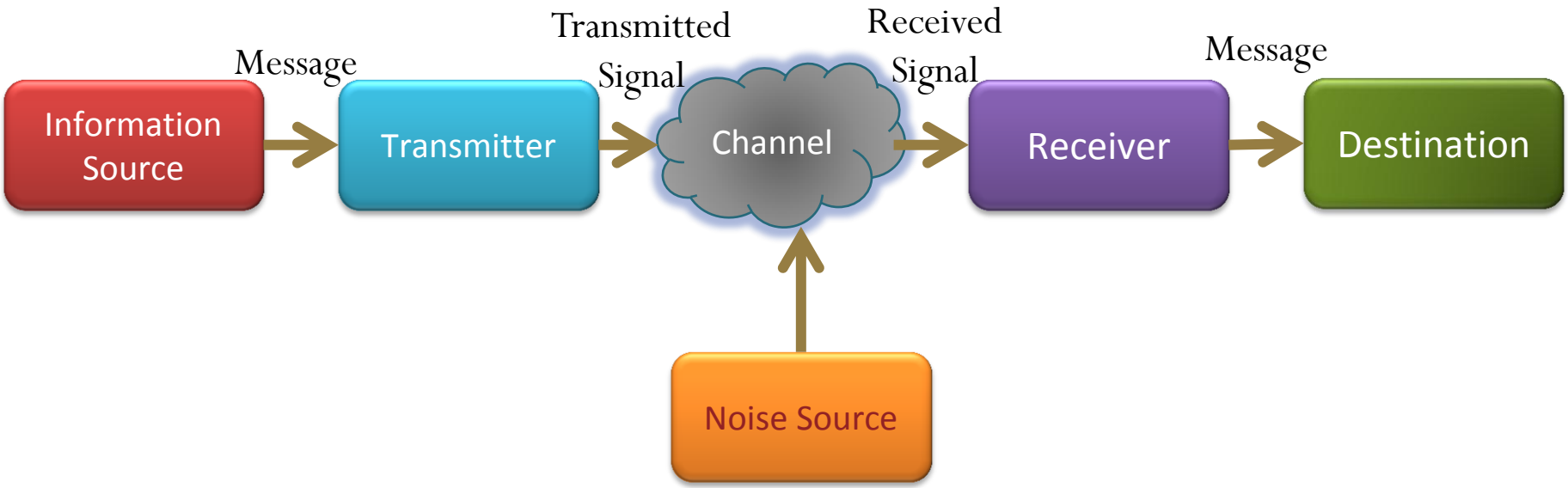
Basic elements of communication

- **Information source**: produce a **message**
- **Transmitter**: operate on the message to create a **signal** which can be sent through a channel



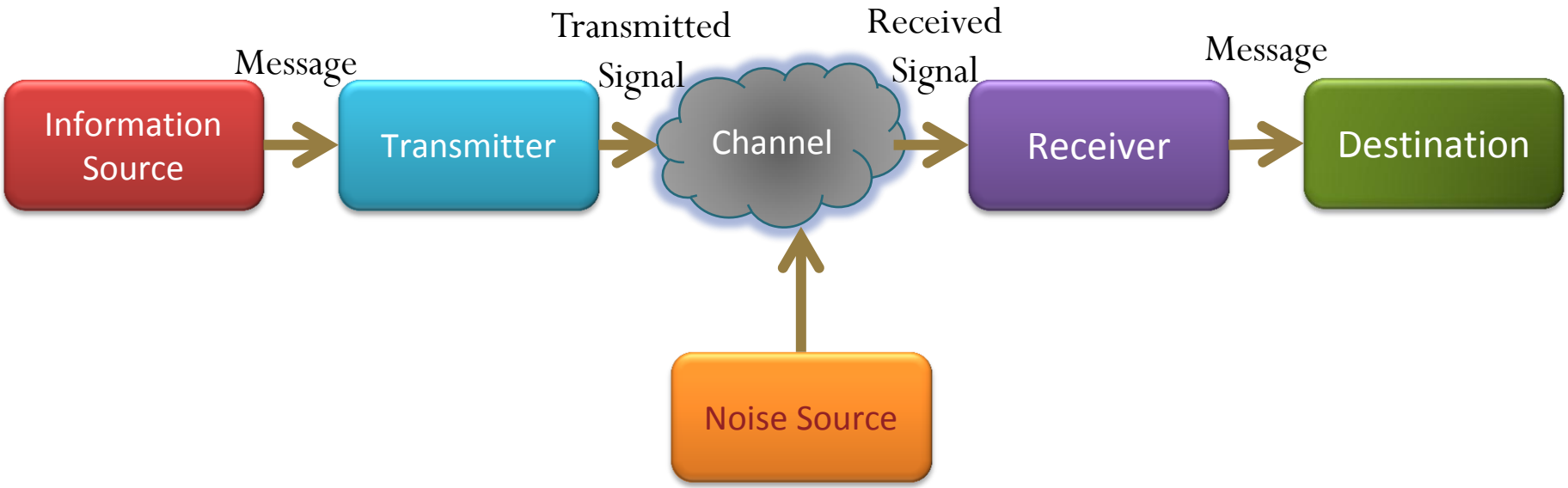
Basic elements (2)

- **Channel**: the medium over which the signal, carrying the information that composes the message, is sent
- **Receiver**: transform the signal back into the message intended for delivery

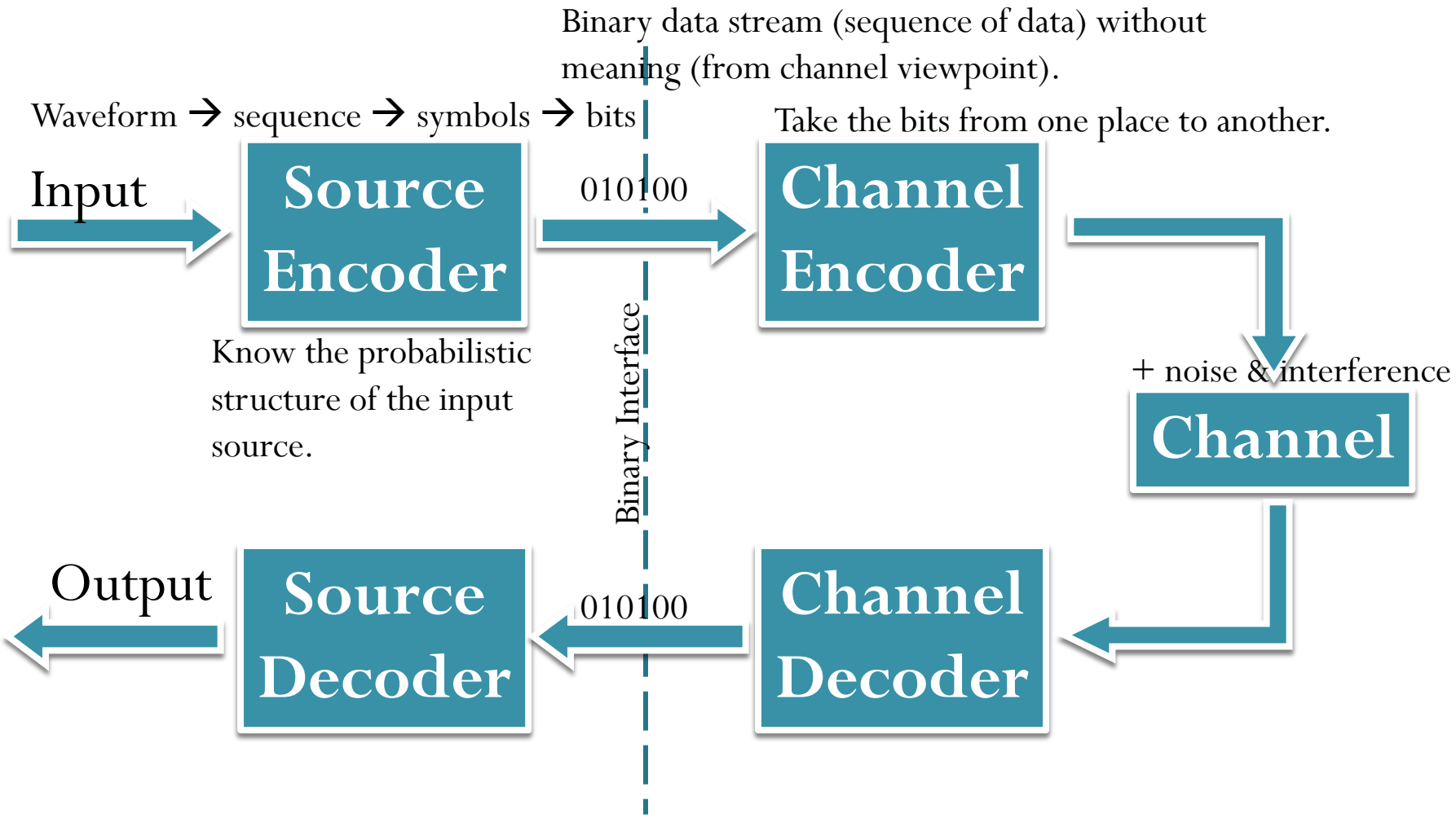


Basic elements (3)

- **Destination**: a person or a machine, for whom or which the message is intended



Digital Communication



This is the major layering of all digital communication systems.

References

- A Brief History of Communications: IEEE Communications Society - a fifty-year foundation for the future
  - ประวัติย่อ "การสื่อสารโลก": ห้าสิบปีชมรมไฟฟ้าสื่อสาร—รากฐานสู่อนาคต
- Thai Telecommunications Encyclopedia (สารานุกรม โทรคมนาคมไทย)
- Links posted in the “references” section of the website.