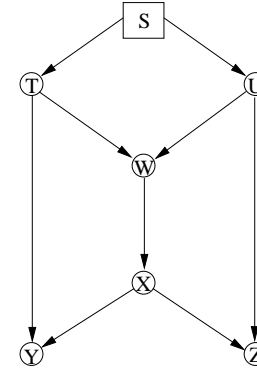## Background

In the basic coding framework, one assumes that there is one sender and one receiver, and if there are intermediate nodes in the network between the sender and the receiver, these simply forward the packets that they receive.

However, with more than one sender and/or more than one receiver, and a network of intermediate nodes processing packets actively, information can often be transmitted at a higher rate than in the basic store-and-forward setting. This topic has been coined **network coding**.

References

The term **network coding** was coined in

R. Ahlswede, N. Cai, S.-Y. R. Li, and R. W. Yeung, Network information flow, *IEEE Transactions on Information Theory* **46** (2000), 1204–1216.
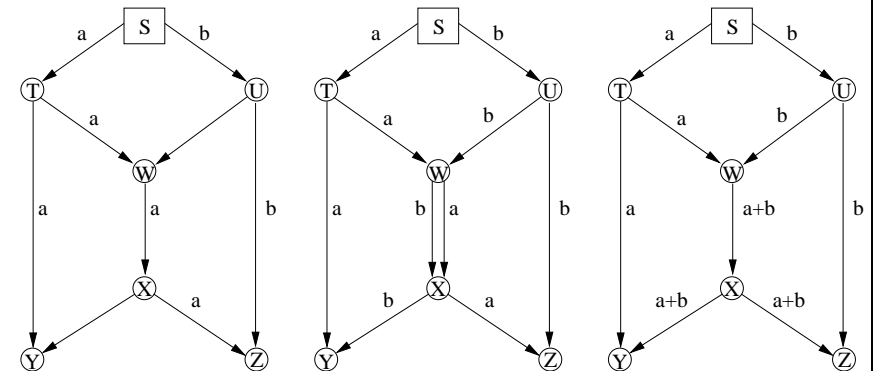
Introductory text to this topic can be found in

[**YLCZ**] R. W. Yeung, S.-Y. R. Li, N. Cai, and Z. Zhang, Network Coding Theory,

available electronically at

`http://iest2.ie.cuhk.edu.hk/~whyeung/publications/tutorial.pdf`

The Butterfly Network

The standard example network to demonstrate network coding is called the **butterfly network**.

Multicasting over a Communication Network

Properties of the Various Solutions

- The first method transmits 1.5 bits per receiver and transmission.
- The second and the third method transmit 2 bits per receiver and transmission.
- The second method uses 10 channels within the network, whereas the third method uses 9 channels.

Network coding minimizes energy consumption and maximizes bit rate.

Example: Satellite Communication

Two ground stations can communicate with each other through a satellite in the following way:

- The ground stations send the packets a and b, respectively to the satellite.
- The satellite sends $a + b$ back.
- The ground stations decode the unknown part.
- Simple coding, yet the downlink bandwidth can be reduced by 50%.

Another similar example with wireless relay stations can be found in [YLCZ, Fig. 1.3].