Network Coding and Packet Erasure Coding

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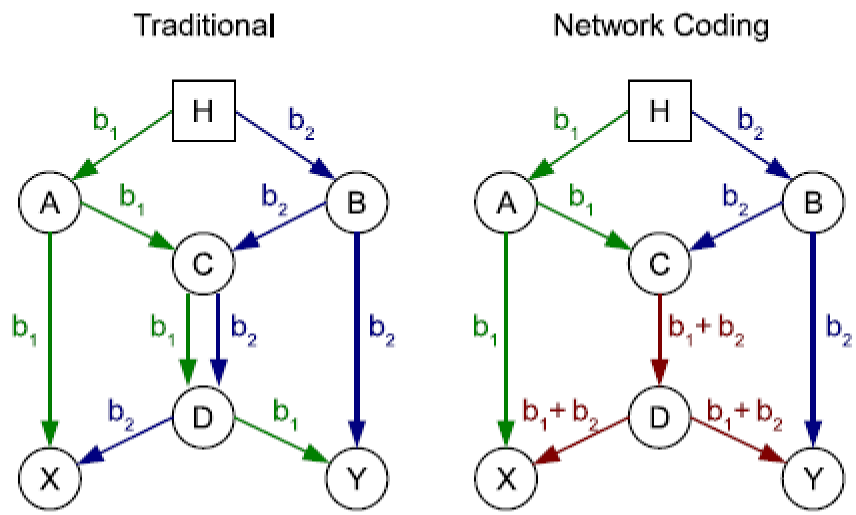
Outline

- Network Coding(NC)
- Effect of Link Error
- Packet Erasure Coding(PEC)
- Combination of NC and PEC
- Discussion
- Q&A

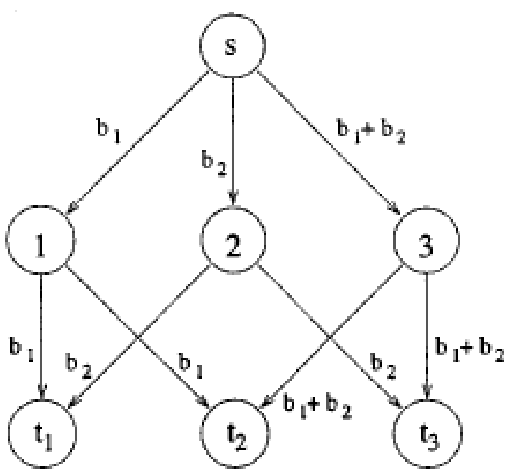
Network Coding

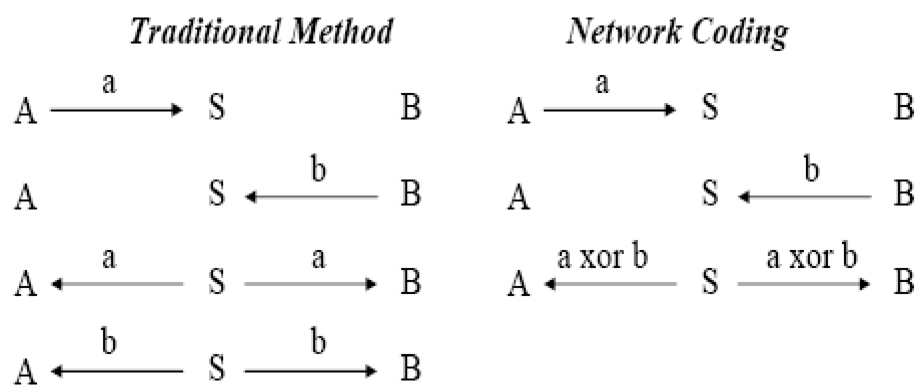
- error free transmission usually assumed
- Packet Encoding used to reduce the number of packets sent



Normal routing and NC on a butterfly network

- You don’t need to only think about butterfly networks...!





Network Coding

- Greatly enhances data throughput especially in multicast scenarios
- Has been applied ad-hoc sensor network, peer-to-peer networks, even in the area of network security

Effect of link error

- Adding a Packet Loss Rate(PLR) to point-to-point link(with same for every link):

$$\text{q} = (1 - \text{p}) \text{ --> is the Pr. of successfuly transmit a packet over a link}$$

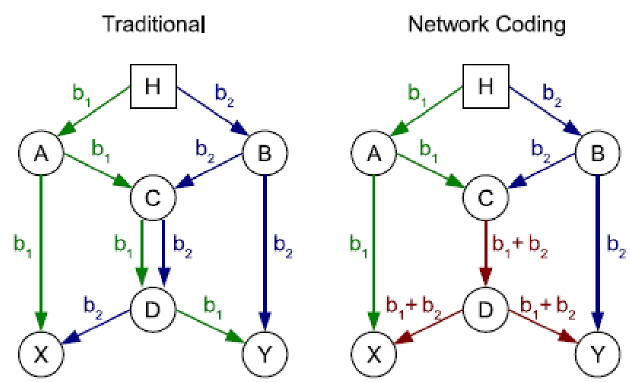
$$\Pr(b_1 \text{ arrives at node X}) = (1 - p)(1 - p) = q^2$$

$$\Pr(b_2 \text{ arrives at node X}) = (1 - p)(1 - p).\{(1 - p)(1 - p)[(1 - p)^3] + \ldots$$

$$(1 - (1 - p)(1 - p))[(1 - p)^2]\}$$

$$= q^4 + q^7 - q^6$$

- If p = .05, the two previous formulae will give us $Pr(b_1 \rightarrow X) = .9025$ and $Pr(b_2 \rightarrow X) = .7778$.
- Note that is we don't use network coding we get $Pr(b_2 \rightarrow X) = q^4 = .8145$!!

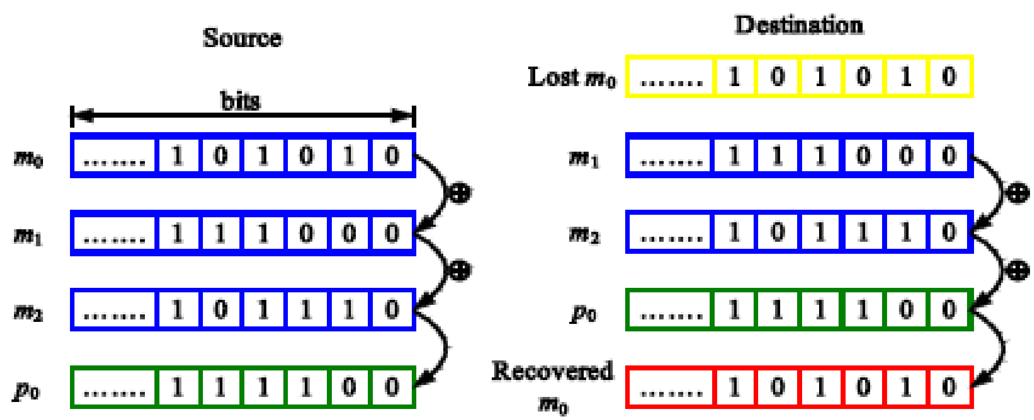


Packet Erasure Coding(PEC)

- Sender generates redundancy packets
- Generally accomplished by grouping “k” message packets and (n-k) redundancy packets to get “n” packets → (n, k, t)
- Recover some patterns of lost packets without any retransmission
- In real-time multimedia multicast or ad-hoc

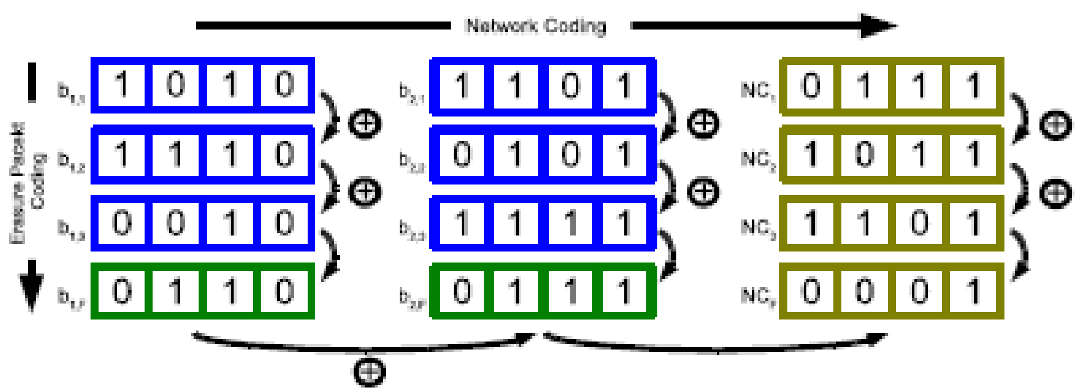
PEC

- Simple erasure packet coding by XOR-ing (note that the code is (k+1, k, 1))



NC & PEC (recovery at every hop)

- Source does the PEC and error correction(recovery) occurs at every hop



PEC

- We have average end-to-end PLR

$$PLR_{corr} = \frac{1}{n}\sum_{i=t+1}^{n} i \binom{n}{i} PLR_{ee}^{i}(1 - PLR_{ee}^{i})$$

$PLR_{ee} = 1 - (1 - p)^{M}$ -> end-to-end PLR without packet erasure recovery

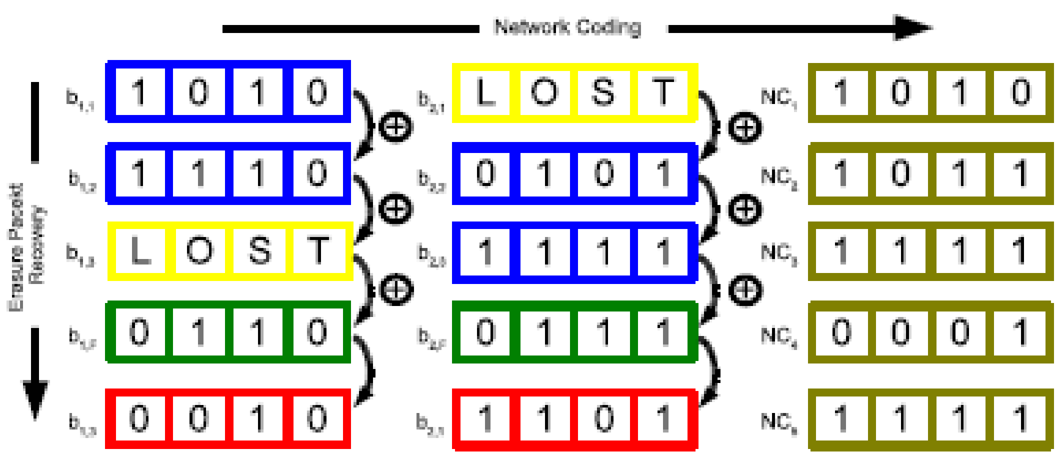
M -> # of links between the source and the node where recovery occurs

- With every hop packet recovery we get

$Pr(b_1 \rightarrow X) = .9858$ and $Pr(b_2 \rightarrow X) = .9650$

NC & PEC(recovery at some hops)

- Combining NC and PEC



- Do recovery in nodes C, D, X, Y and we get Pr(b_1 → X) = .9742 and Pr(b_2 → X) = .9136

NC & PEC - Discussion

Trade-off available:

- Packet loss recovery

- Packet processing complexity at the intermediate nodes and the destinations
- Protocol overhead
- Possible delays

End of my presentation...

Thanks for your attention.

Q/A?