FEC
(Forward Error Control)
is Not Overhead

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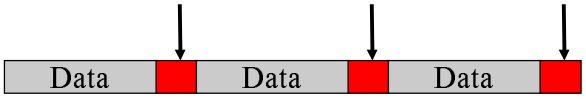
Overhead

- Subtracts from the primary goal of transmission:
  - reliable conveyance of user information (messages from transmitter to receiver)



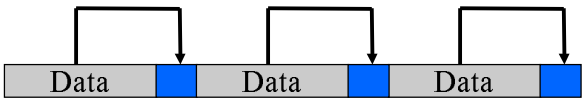
Examples of Overhead

- a frame synchronization in a packet system
- a packet preamble
- a pilot tone

- These functions help with higher level objectives or for estimation and tracking of channel parameters

Redundancy

- Adds to the primary goal of transmission
  - reliable conveyance of user information



The Distinguishing Feature

- Overhead is independent of the data
  - It helps with auxiliary functions, yet subtracts from resources
    - Power
    - Bandwidth
    - Data Rate
- Redundancy is a function of the data
  - It help with the primary function, it enhances the utilization of resources

FEC is considered as "overhead" when applied as a "Band-Aid"

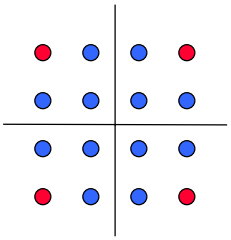
- A communications system is designed without coding, it is not robust enough
- An ECC (error control code) is used to "fix" the system
  - improvement of reliability
  - loss in rate ("overhead")
- This approach is a mistake in the design of a fresh system!

How to Correctly Design an FEC

- Fix a data rate (user rate) R
- Define a large signal set that generates more than 2^{R*T} signals in T seconds
- Judiciously select a subset of 2^{R*T} signals from the large set
  - Maximize noise immunity
    - Keep distinct signal well separated (Energy)

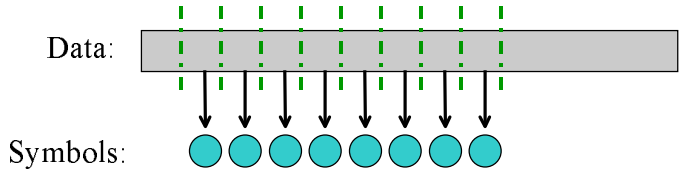
The "Overhead" of QPSK as a Coding of QAM

- Rate = 2 bits/symbol
- Overhead = 2 bits/symbol ???



Uncoded Modulation

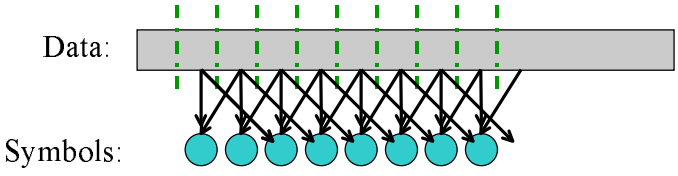
- Break data stream into small pieces
  - map onto independent dimensions



  - Noise occasionally causes symbol error
    ==> data error

Coded Modulation

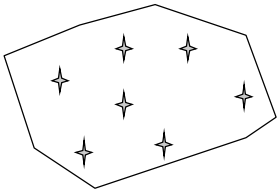
- Have each bit of data affect many symbols



- Average out the noise with the decoding

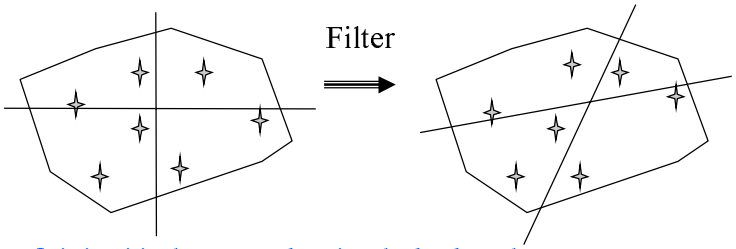
Making Signals Robust

- Maximize energy that differentiates distinct signals
- AWGN (Additive White Gaussian Noise)



Robust Signals

- Multipath



– It is intuitively correct that signals that have large energy separation at the input of a filter are better distinguishable at the output of the filter.