EE 597 1/24/12

Recap. Lecture 5

2 perspectives on fading :

1. Power-delay profile of the channel due to multipath → ISI

2. Impact of mobility on the dynamics of the fading

	Flat	Frequency Selective	
Slow	Can we channel State Information/ Learning	Equalization	ISI
Fast	"Averaging effect"	OFDM CDMA Rake Receiver	

Channel Coding : a key technique to deal with the high error rates encountered in wireless fading channels.

Intuitively : careful addition of redundant bits in order to detect & correct errors.

BLOCK CODES & CONVOLUTIONAL CODES

Block codes : static mapping from k bits of information to a codeword of n bits

$n > k$.

k/n — code rate

e.g. Hamming code (7,4)

code rate 4/7

As k is kept fixed, increasing n reduces the code rate, but gives a better error performance

Block Codes :

Linear Block Codes

Hamming

BCH

Reed-Solomon code

(Prof. Irving Reed)

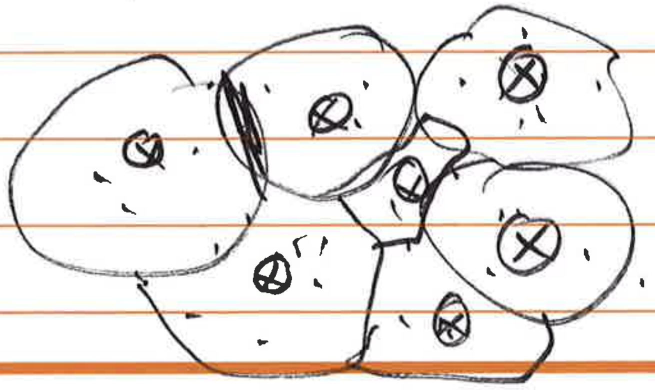
a nonbinary block code

e.g. ~~the~~ (7, 4) Hamming code.

$$\underset{1\times 7}{C} = \underset{1\times 4}{U} \cdot \underset{4\times 7}{G} \longleftarrow \text{generator matrix}$$

The general principle in decoding is to identify the "nearest" codeword to what was received.

In this example, only 16 codewords out of 128 possible 7-bit received sequences.



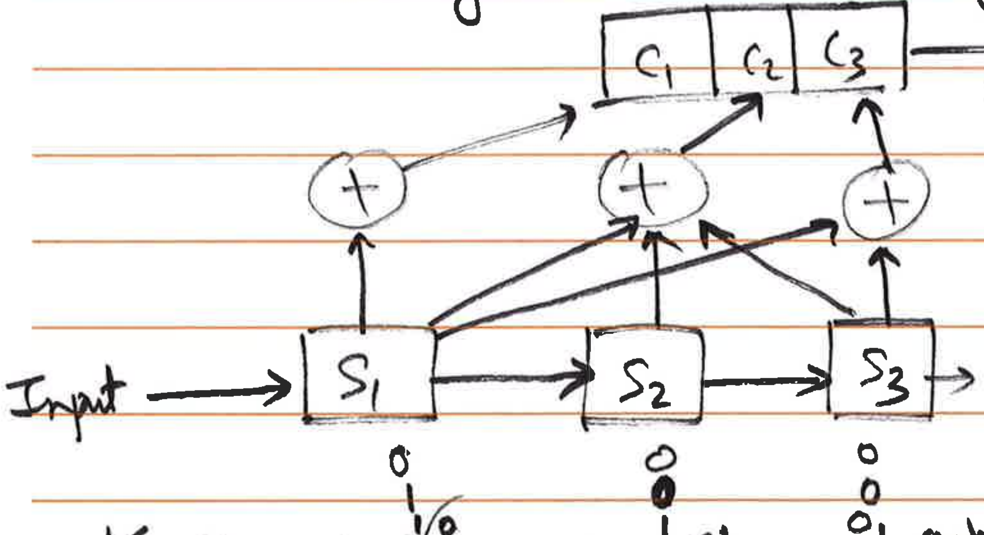
Another tradeoff: keeping code rate k/n fixed, while increasing n yields better error rates tending to 0.

Here the tradeoff is increased complexity & delay.

Convolutional Codes

110. . . .

encoding a stream of bits



K stages

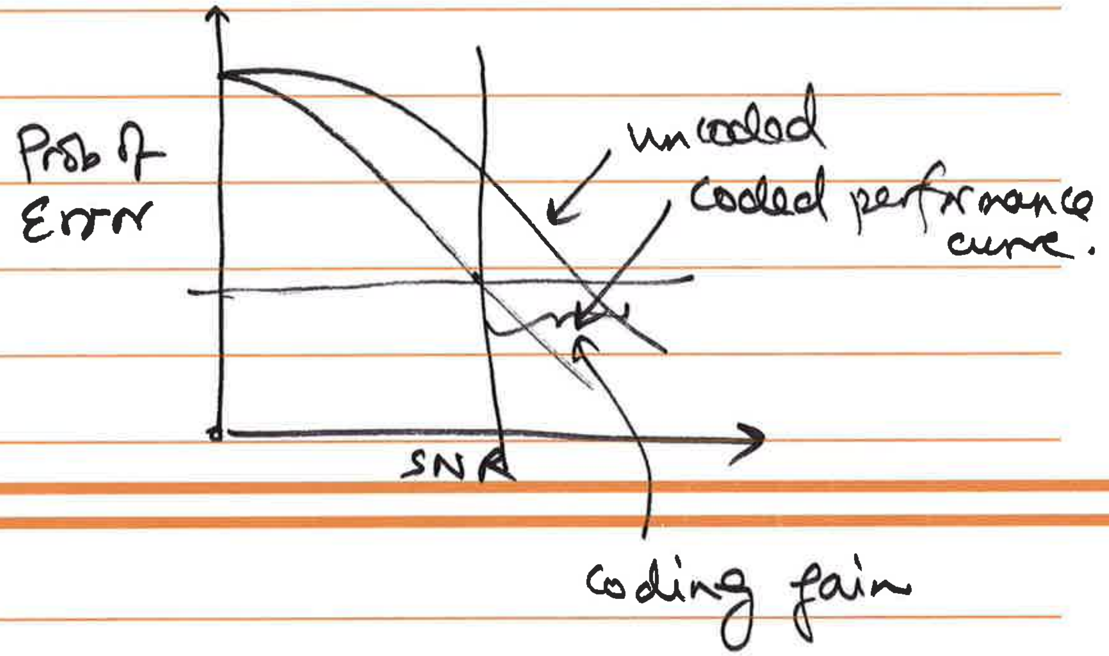
k bit input yields n output bits

K=3, k=1, n=3

111101001

Conv. codes are very commonly used

The most widely used decoding algorithm is the Viterbi Algorithm.



Advance Coding Techniques

Turbo Codes : parallel convolutional codes

LDPC codes

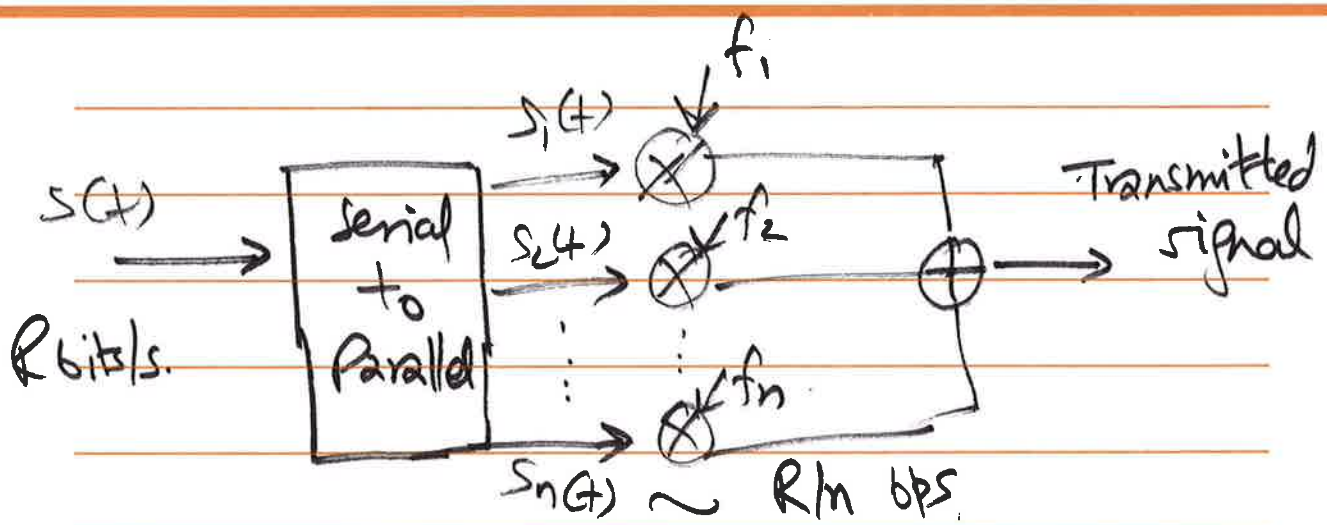
→ new class of iterative decoding based schemes that give near-optimal performance

OFDM

orthogonal frequency division multiplexing

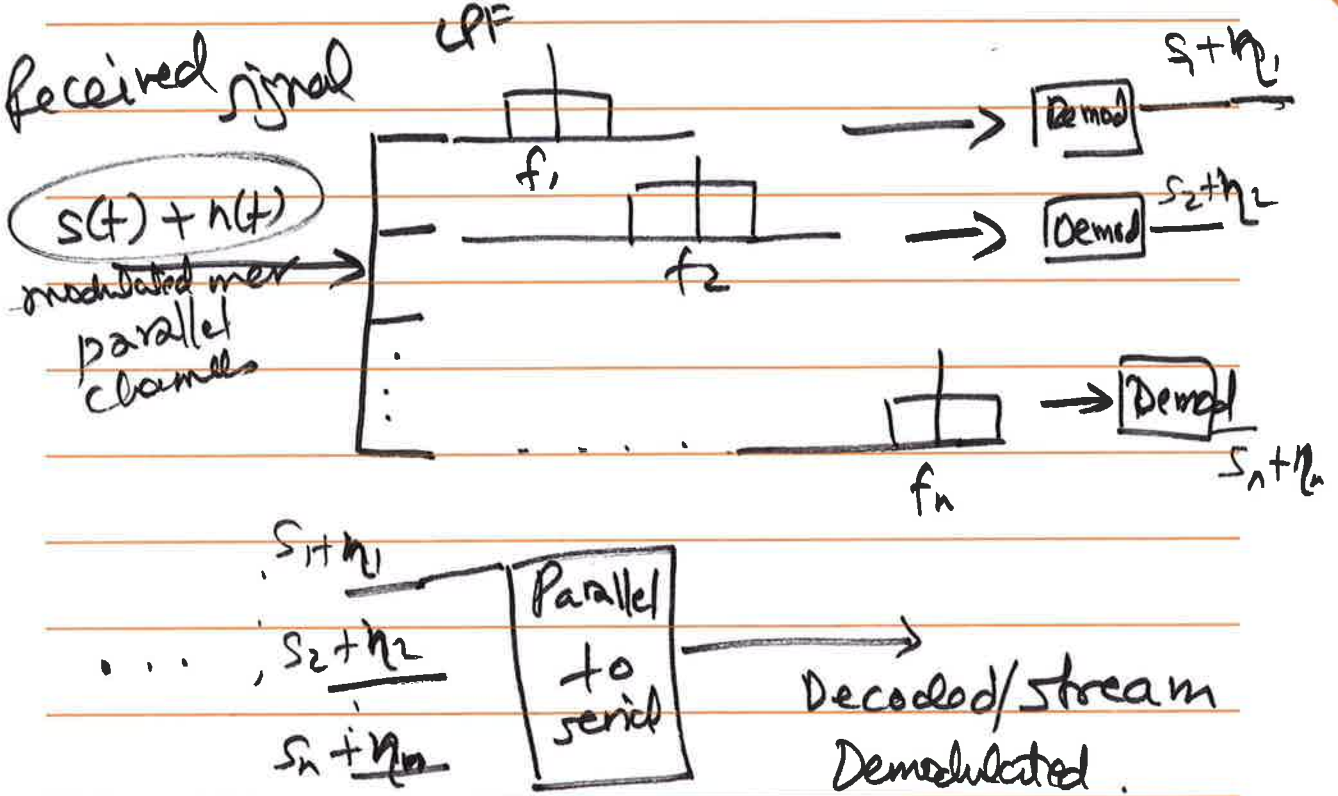
Divide the bit stream into multiple parallel subcarriers, each of which has a lower symbol rate.

$T_s \gg \sigma_D$



OFDM Xmitter Block Diagram

$f_1, f_2 \ldots\ldots f_n$ are orthogonal (spaced sufficiently apart)



On each subcarrier, the symbol rate is reduced by n, i.e. the symbol period is increased by a factor of n, yielding robustness to frequency selective fading (ISI).

Multiuser OFDM — different subcarriers are used to communicate w/ different nodes. e.g., WiMax.

OFDM is also used in IEEE 802.11 a to mitigate ISI

A look at IEEE 802.11a WLAN Standard.
(Sim. to IEEE 802.11g)

300 MHz of Spectrum in the 5 GHz unlicensed band.

Number of chanels : 12
Modulation schemes : BPSK, QPSK, MQAM (16 & 64 QAM)
OFDM System

uses convolutional coding
rate options : 1/2 , 2/3, 3/4

Maximum data rate : 54 Mbps
Range ~ 30 meters

CSMA/CA MAC layer

The 300 MHz of bandwidth is divided into 20 MHz channels, each

allocated to different users.

Channel Bandwidth B = 20 MHz.
OFDM w/ 64 subcarriers (n)

Subcarrier BW : $\frac{20}{64}$ MHz ~ 312.5 kHz

16 of used for int. suppression & pilot symbols.

64 subchannels.

(16 cyclic prefix symbols per OFDM symbol time)

∴ 80 samples per OFDM symbol time.

symbol time per subchannel : $\frac{80}{20\cdot 10^6} = \boxed{4\,\mu s}$

Rmin : 48 data subchannels

$\times \frac{1/2 \text{ bit}}{\text{coded bit}} \cdot \frac{1 \text{ coded bit}}{\text{symbol}} \cdot \frac{1 \text{ sub. symbol}}{4\,\mu s}$

BPSK

$= 6$ Mbps

convolution code rate

64 QAM

Rmax : $48 \times 3/4 \times 6 \times \frac{1}{4\,\mu s}$

$= 54$ Mbps

Next up: CDMA &
MIMO / multiantenna /
diversity.