In the name of GOD

Advanced Theory of Communications

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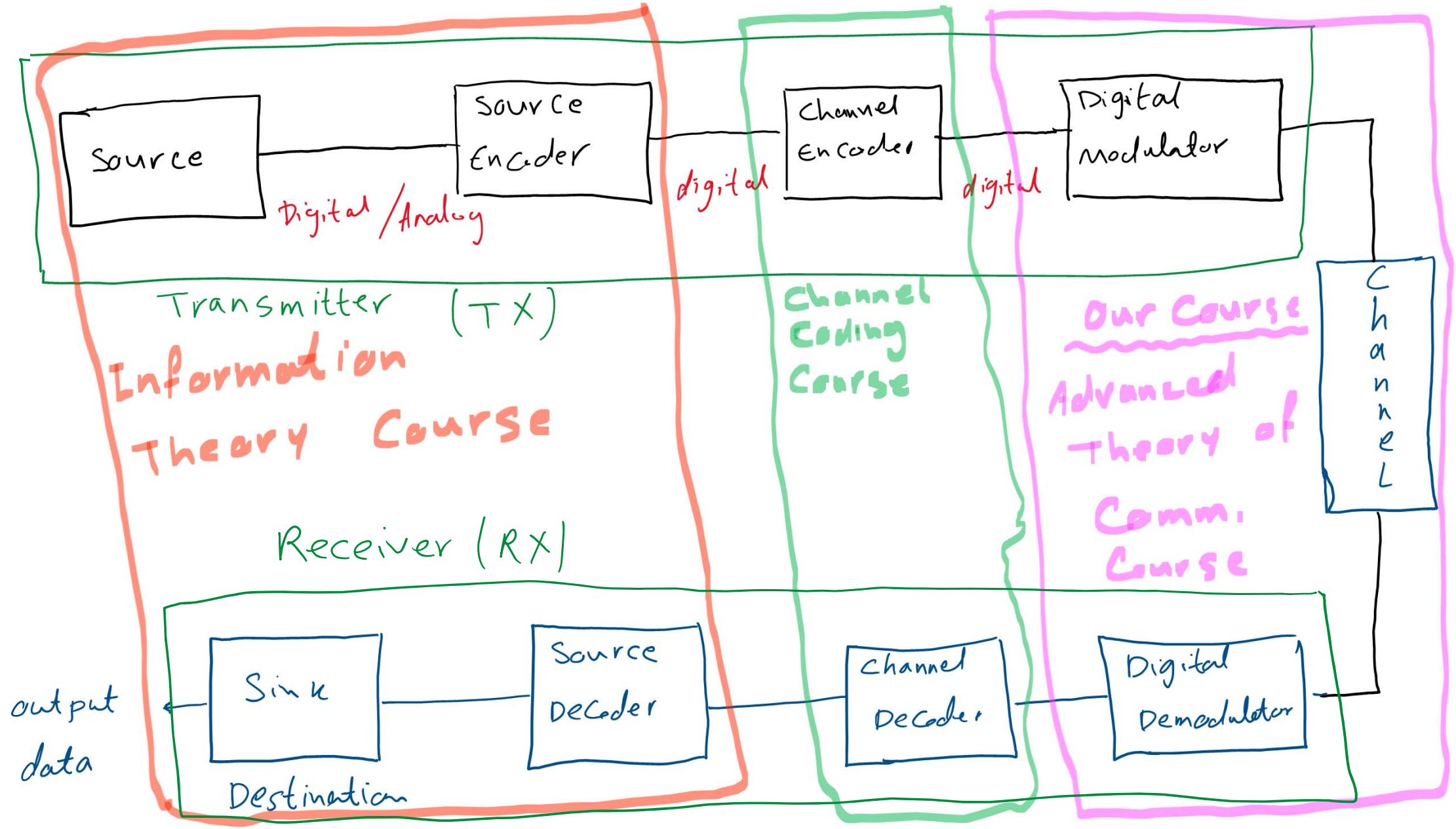
In this session we will talk about the basic block Diagram of any Digital Communication System.

1. Source : It is the source of Data or information we want to transmit to one or more Destinations. The output of the Information source may be digital or analog. For Example $\underbrace{\text{data produced by the Computers}}_{\text{Digital Data}}$

or $\underbrace{\text{Voice or Video}}_{\text{Analog}}$.


Source
Source Encoder
Digital / Analog
digital
Channel Encoder
digital
Digital Modulator
Transmitter (TX)
Information Theory Course
Channel Coding Course
Our Course
Advanced Theory of Comm. Course
Channel
Receiver (RX)
Sink
Source Decoder
Channel Decoder
Digital Demodulator
output data
Destination

2 - Source Encoder : Any information soures produce some redundant information. By the use of source encoder we can omit these redundant information. So we have a better use of bandwidth. omitting these redundant information is based some proper algorithms in the way that we can detect the information at destination in a reliable manner. This is called also compressing the information.

(It is the content of Information Theory Course)

The output of source encoder is a digital stream of Data.

3- Channel Encoder: Based on Shanon's theorem, if we send the information in a rate smaller or equal to Channel Capacity, we can detect information reliably. But to reach this aim, we must have a mapping from signal space to another proper space. This mapping is called channel Encoding. Simply, channel Encoders add some redundant information to the transmitted signal, in a controlled manner. In the receiver (channel decoder) these controlled redundants are used to detect and correct the impairments happened in the channel.
(This is the content of channel Encoding Course)

4. Digital Modulator : As we said, signals are transmitted to destination via a Communication Channel. There are many impairments in the Channel that damaged our signals. Besides, Communication channel is a physical (analog) media. So, digital modulator is a interface between the digital blocks of Communication systems and physical channel that Prepare a suitable waveform to transmit data on the channel to destination.

5- Channel : Channel is a physical media used to transmit waveforms (signals) from a source to destination. For Example, free space (wireless Communications), Copper Cables (telephone), optical fibers (optical Communications), Water (Acoustic Com.), athmosphere layers such as unosphere or troposphere (Sattelite Comm.). All these physical media Cause some impuirments on the waveforms (signals) due to physical characterstics. For Example, attenuations, noises, interferences, shadowing, fading (due to multipath scattering), ..

So, in the transmitter we prepare a suitable signal to be sent on the channel.

In the receiver the dual operations of what are done in the transmitter are performed on the received waveform (signal) from the channel. It means that, firs a digital demodulator extract the digital signal from received waveform by the use of some proper algorithms. (we talk about it, in this course)

Then, Channel decoder by the use of redundant information of recovered signal, try to detect and Correct, errors that happened due to channel impairments. This is done based on some algorithms. (Discussed in Channel Coding Course)

Then, Source decoder by the use of some suitable algorithms, try to recover the primary information generated by the source. (This is the Content of Information theory Course)

Overally, the recovered data at the destination may have some errors. It is not exactly the same as the data generated by the source. But it is be noted that, these errors are under control and are small, due to the proper use of source encoder/decoder, channel encoder/decoder and Digital Modulator/Demodulator. The error rate performance of any Comm. systems, is one of the major parameters used to evaluate their performance.

In the bit level, we call it Bit Error Rate (BER)

in the symbol level, we call it Symbol Error Rate (SER)

in the frame level, we call it Frame Error Rate (FER)

a bit a bit

$$\underbrace{010}_{\text{Symbol}}\underbrace{001}\underbrace{110}\underbrace{001}10111$$

a 3-bit symbol

a group of symbols and some Control data, make a frame.

what are the parameters that affect the error rate performance of any Comm. systems?

1) Suitable Source Encoding/decoding algorithms

2) " Channel Encoding/decoding algorithms

3) " Modulation/demodulation algorithms

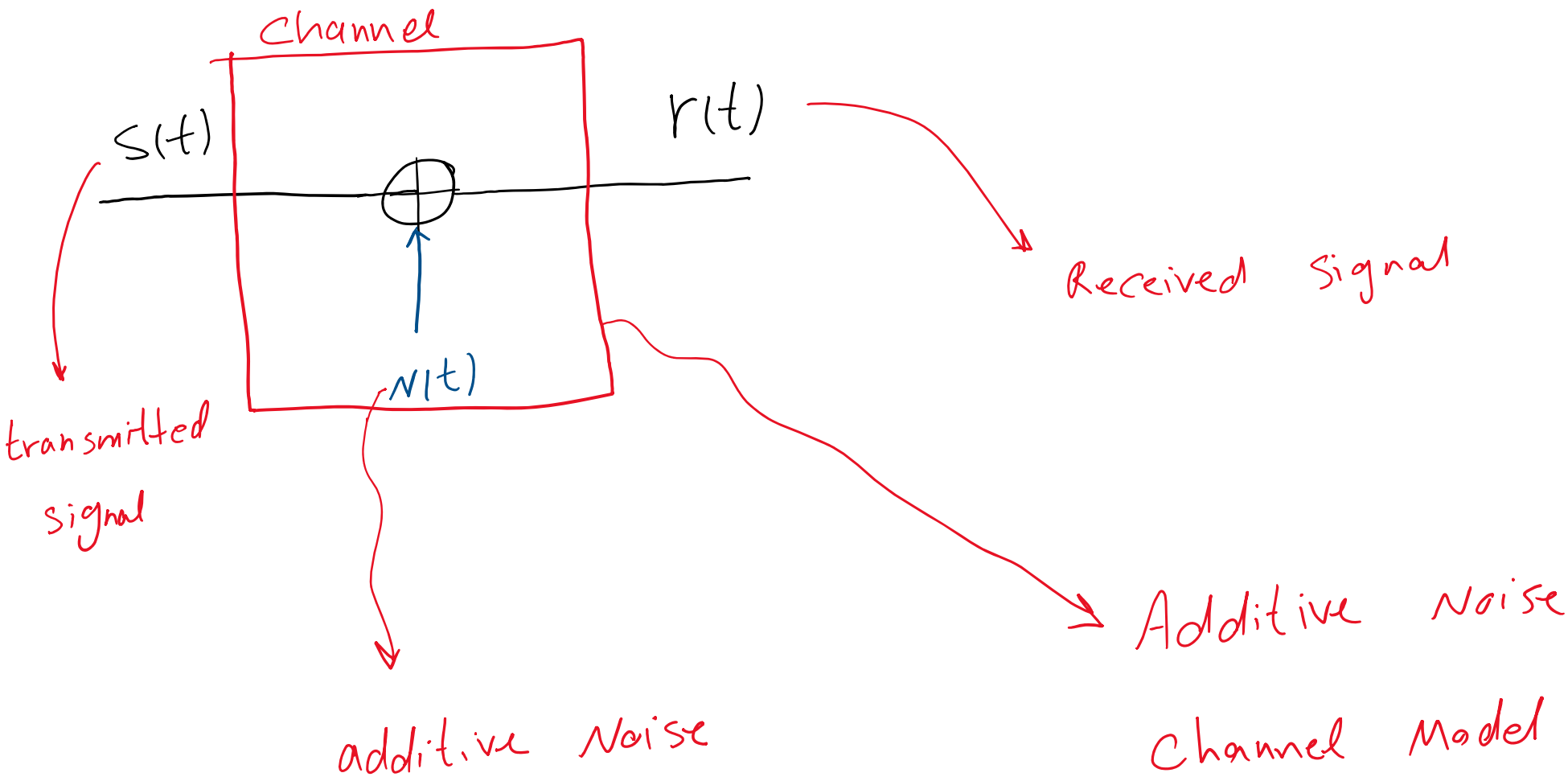
4) Channel impairments (Noise, Interference, fading, attenuation, ..)

5) Transmitted power (one of the main limitation of Comm. systems)

(Transmitted power) $\leftarrow P_{out} < P_o \rightarrow$ (a predefined level)

Another main limitation of any Comm. systems, is bandwidth. In the Comm. systems, we always have a power limitation ($P_{out} < P_0$) and a pre-defined frequency range and Bandwidth. We must note to these limitations for Comm. System design.

In this Course we will use the additive noise channel model to transmit our waveform from transmitter to receiver side.


Channel
s(t)
r(t)
n(t)
transmitted signal
Received signal
additive Noise
Additive Noise Channel Model

* Signals and systems characterstics

In the Comm. Systems, we use differnt kinds of signals to work.

For Example (1) based on stochastic chacterstics of signals we have, Deterministic signals and stochastic signals

(2) based on power, we have

Power signals : $P_s \neq 0, \infty$

Energy signals : $E_s \neq 0, \infty$

(3) based on time characteristics, we have

Continouse time signals

Discrete time signals

(4) based on amplitude cha., we have

Continouse state signals

Discrete state signals

(5) based on frequency Cha., we have

Lowpass (baseband) Signals

Bandpass Signals