* Purpose: Send Information of a source to one/multiple destinations

* The Information signal is acquired by the transducer device, e.g. a microphone if speech or music is recorded.

* TX: The TX is going to transform the source signal into a waveform appropriate for transmission through the channel.

* RX: Reverse process of TX

  Continuous waveform → Digital Bits → DAC
Transmitter (TX):

* Signal acquisition
  1) Sample the signal \(\rightarrow\) ADC
  2) Quantization

* Source encoding
  (Compression tools, remove any form of information redundancy)

* Encryption

* Channel encoding
  (Introducing extra bits to protect your information bits)

* Multiplexing

* Pulse shaping

* Modulation
  (Multiplying with \(\cos(2\pi f t)\))

* Amplification and filtering

Channel: Physical - medium used to send a signal from the TX to the RX

Typical Channels:

- Wireline
  - Electrical
  - Optical

- Wireless
  - Optical
  - RF
  - Acoustic (Underwater)
**Disrbusi:**
1) Additive  \(\rightarrow\) Thermal noise and interference
2) Non additive  \(\rightarrow\) Attenuation, phase shifts, delays, ...
   Spectral modifications

**Receiver:**
* Frequency translation
* Amplification and filtering \((\text{Remove attenuation and noise})\)
* Demultiplexing
* Channel decoding and error correction
* Deciphering
* Reconstruction
* Decoding
* Filtering \(\rightarrow\) DAC

**Mathematical Models of Communication Channels:**
* Different physical channels have different models

1) The additive noise channel
2) Linear time-invariant filter channel
3) Linear time-variant filter channel
1) **Additive Noise Channel**:

\[ S(t) \xrightarrow{a} a \cdot S(t) \xrightarrow{n(t)} r(t) \]

\[ |a| < 1 \]

Received signal: \( r(t) = a \cdot S(t) + n(t) \)

* For the special case where the noise is Gaussian, the channel is called **Additive White Gaussian Noise (AWGN)**.

2) **Linear time-invariant filter Channel**:

\[ S(t) \xrightarrow{c(t)} y(t) \xrightarrow{r(t)} \]

\[ r(t) = S(t) \ast c(t) + h(t) \]

Convolution

\[ = \int_{-\infty}^{\infty} S(t-\tau) c(\tau) d\tau + h(t) \]

* Accounts for noise
* Models finite Bandwidth Channels
* Accounts for Spectral distortion, in amplitude and phase
Example:

\[ G(f) \]

3) Linear time-varying filter channel:

\[ S(t) \rightarrow C(t; T) \rightarrow Y(t) \]

* Channel is time-variant but it is linear

\[ Y(t) = S(t) * C(t; T) + h(t) \]

\[ = \int_{-\infty}^{+\infty} s(t - \tau) c(t; T) d\tau + h(t) \]

Example:

\[ C(t; T) = a_1(t) \cdot \delta(t - T_1) + a_2(t) \cdot \delta(t - T_2) + a_3(t) \cdot \delta(t - T_3) \]

\[ R(t) = \int s(t - \tau) \cdot \left( c(t; T) + h(t) \right) d\tau = \sum_{i=1}^{3} a_i(t) \cdot S(t - T_i) + h(t) \]