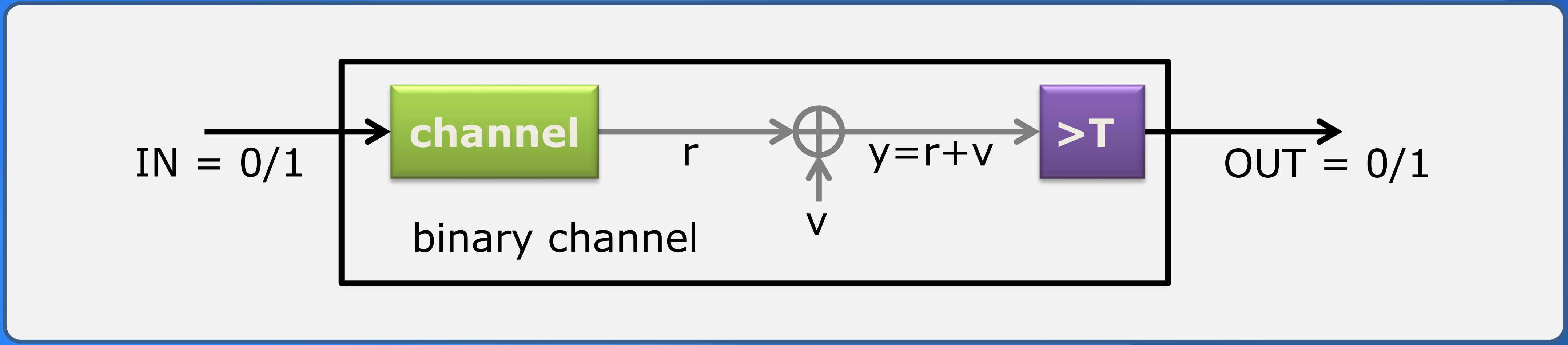
The Binary Channel and Calculating BER

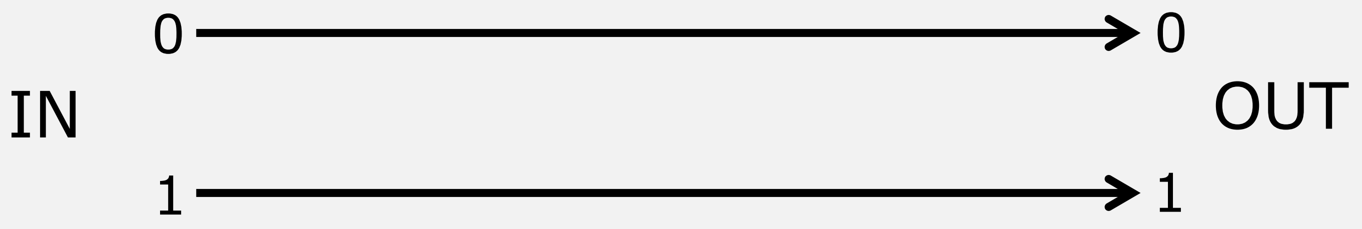
Binary Channel Model

- **To start with, we will further simplify the model**
  - **We ignore details about the noise and received signal levels r_{min}/r_{max}**
  - **We look only at the input and output bits**
- **Binary channel: both input and output have possible two values, 0 or 1 ("bi" = two).**

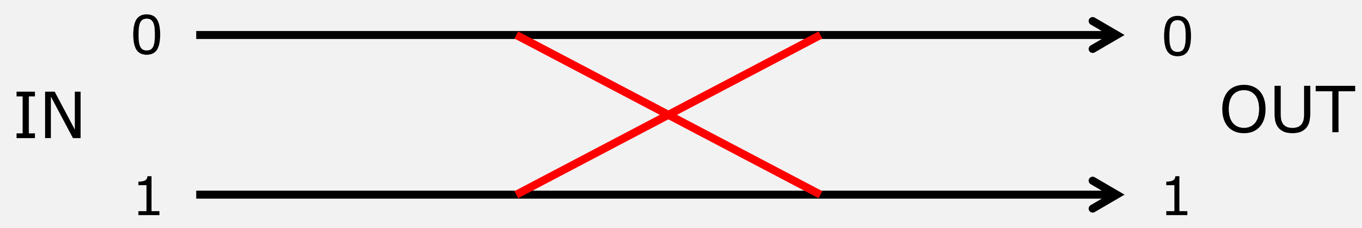


Binary Channel Behavior

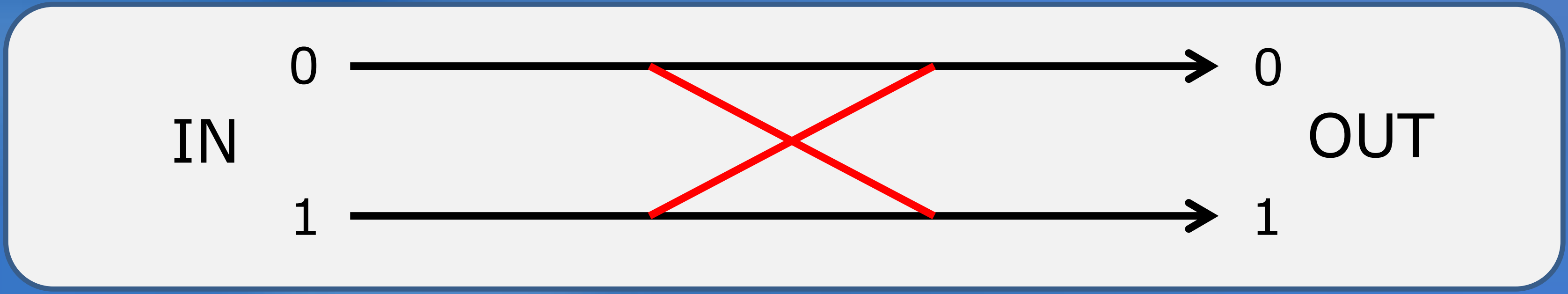
- **Ideally, (when IN=0, OUT=0) and (when IN=1, OUT=1). In this case, the BER = 0.**



- **Unfortunately, due to noise, sometimes (IN=0 but OUT=1) or (IN=1 but OUT=0). In this case, BER > 0.**



Probabilistic Analysis



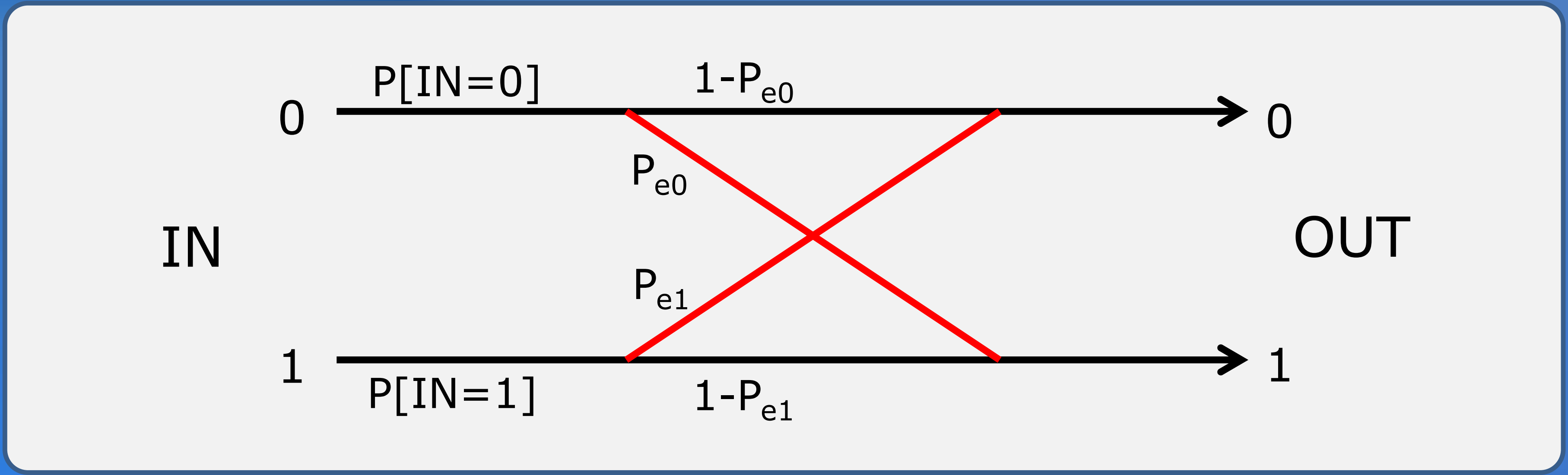
- The BER depends upon
  - "How often" IN = 0, but OUT = 1
  - "How often" IN = 1, but OUT = 0
  - "How often" IN = 0.
  - "How often" IN = 1.
- We quantify this notion of "how often" using probability theory.
- Intuitively, the probability of something happening (i.e. IN=0) is the percentage of time that thing happens. For example,

  P[IN=0]=0.5 implies that the input bits are zero half the time

- Since there are only two possibilities,

$$P[IN=0]+P[IN=1]=1 \Longrightarrow P[IN=1]=1-P[IN=0]=0.5$$

Modeling the Binary Channel



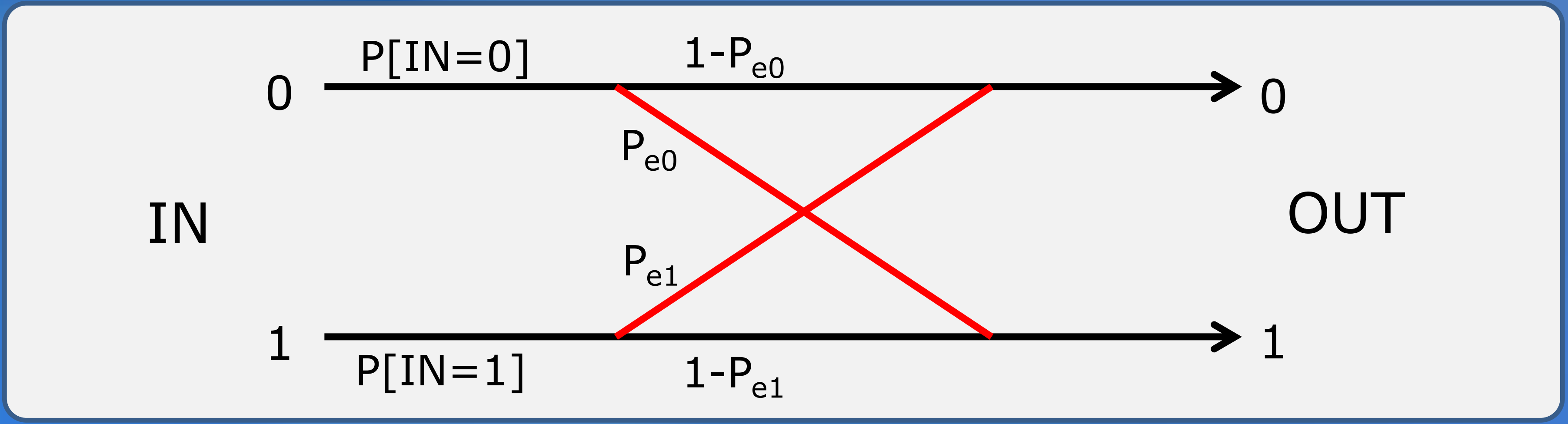
P[IN=0] = probability (% of the time) that IN=0

P[IN=1] = probability (% of the time) that IN=1

P_{e0} = probability (% of the time) there is an error when IN=0
= probability (% of the time) that OUT=1 when IN=0

P_{e1} = probability (% of the time) there is an error when IN=1
= probability (% of the time) that OUT=0 when IN=1

Computing the BER



The BER is the probability of error, P_e

$$BER=P_e=\underbrace{P_{e0}\cdot P[IN=0]}_{\text{probability that OUT=1 and IN=0}} + \underbrace{P_{e1}\cdot P[IN=1]}_{\text{probability that OUT=0 and IN=1}}$$

Two types of errors!