IMN

Vehicular Communications – Part II
Interference Management in Networks

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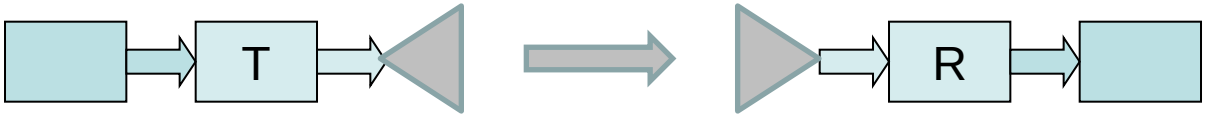
Outline

1. Interference
2. Communication Link with Interference: System Model
3. Link Performance (BER) of M-QASK with Interference
4. Capture Effect

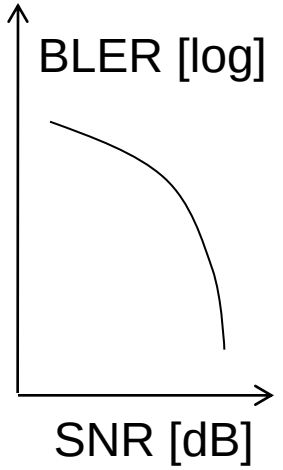
The scope of this lecture block is to introduce the fundamentals of digital transmission techniques for interference limited links.
The ultimate goal is the discussion of the concept of *capture effect*.

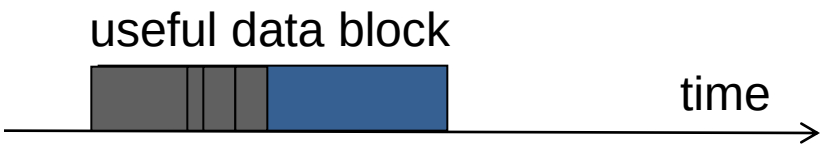
1. Interference

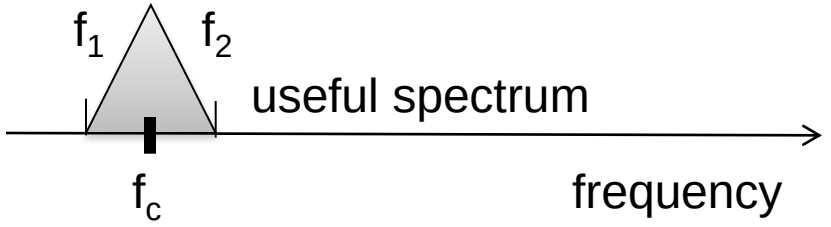
Interference



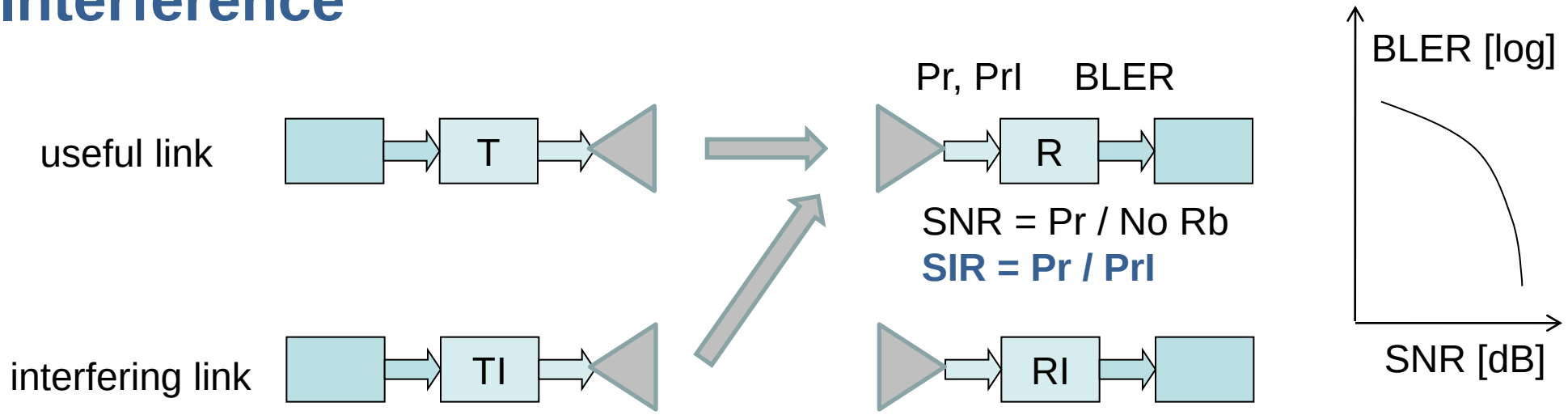
SNR = Pr / No Rb

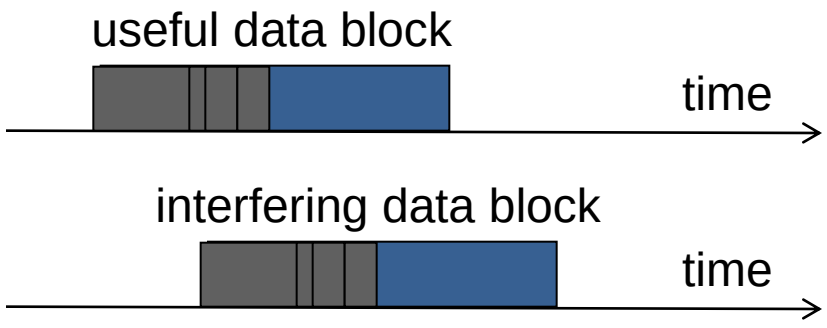




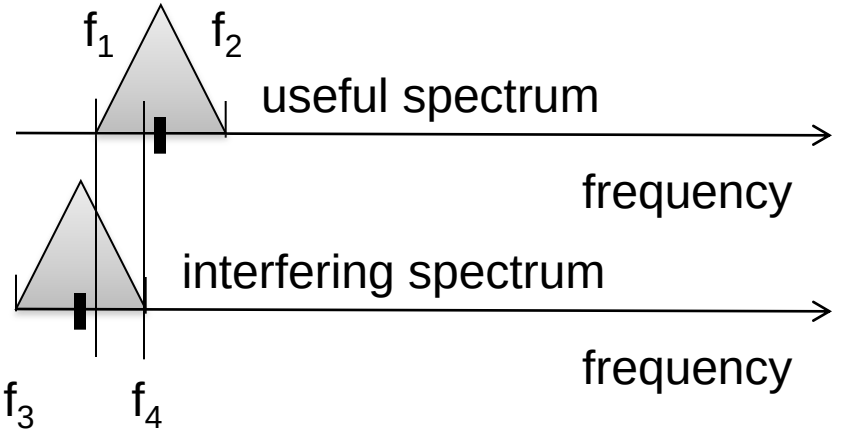


Interference

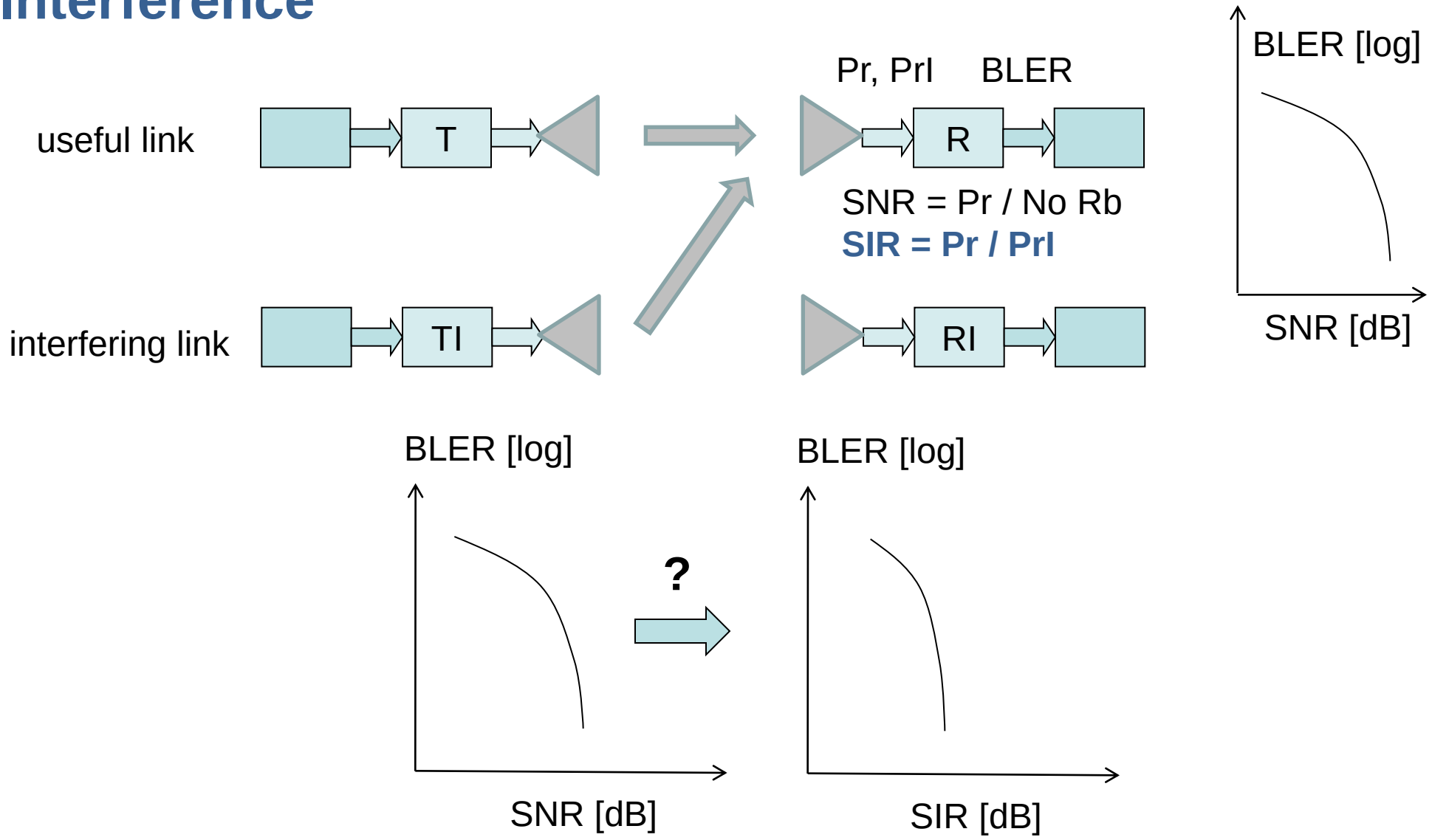




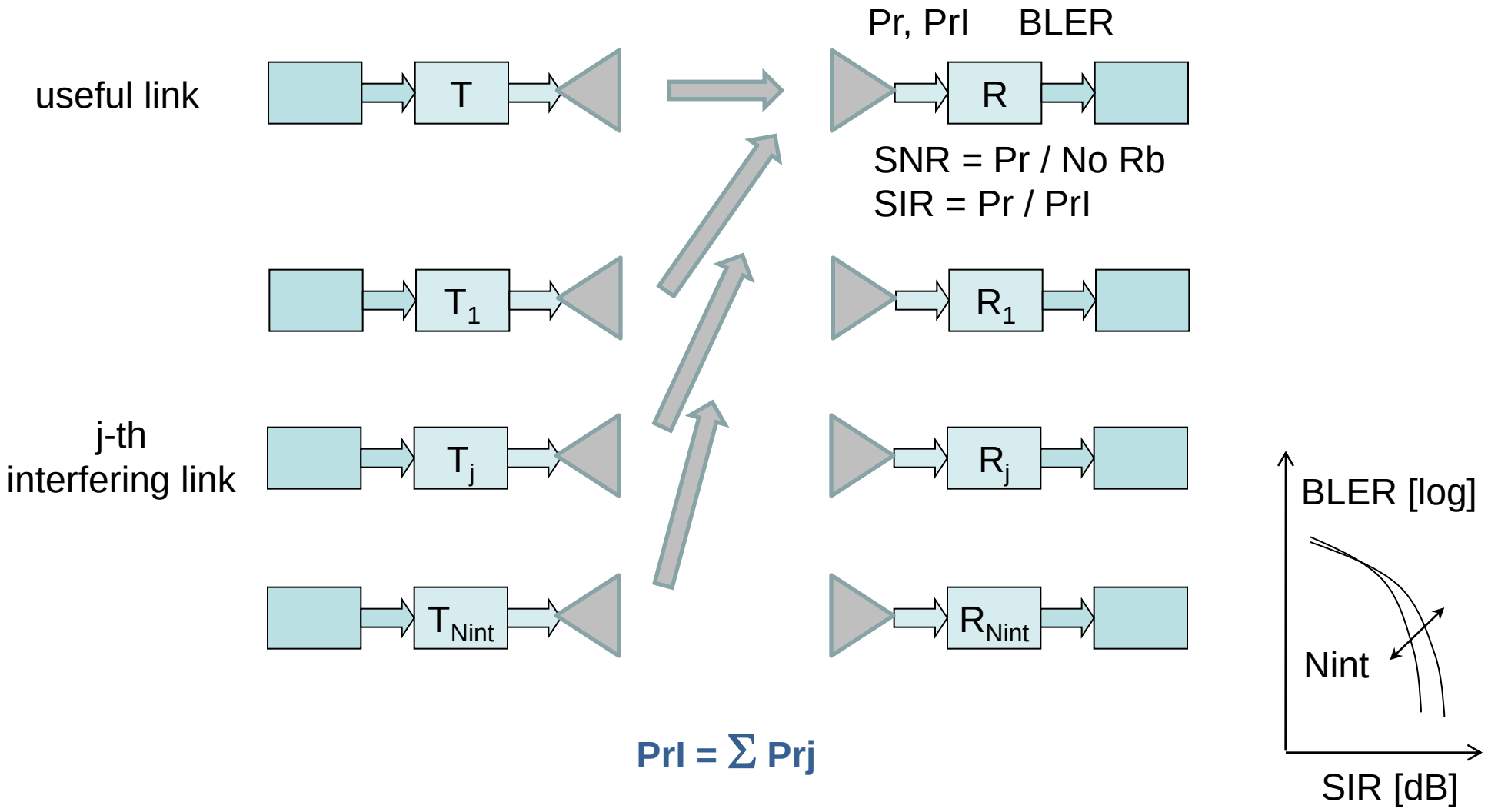
data blocks transmitted simultaneously on the same frequencies



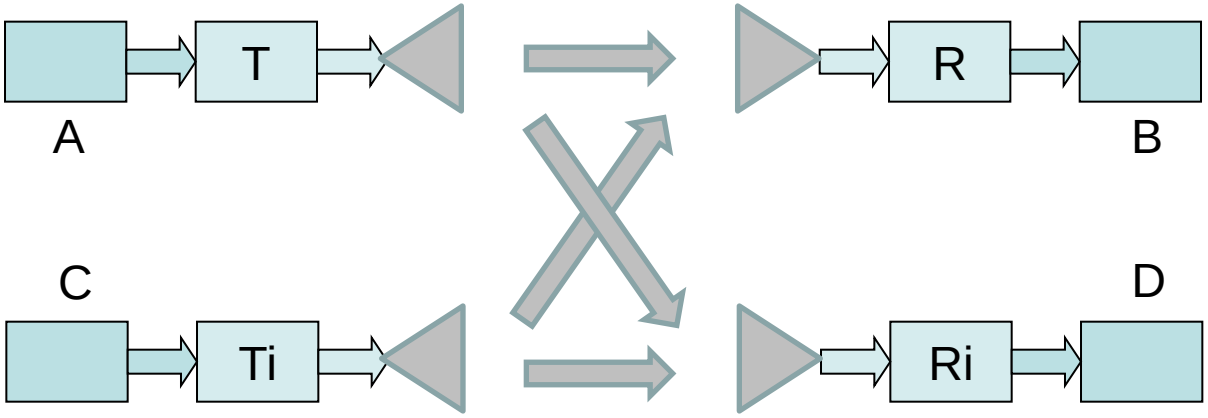
Interference



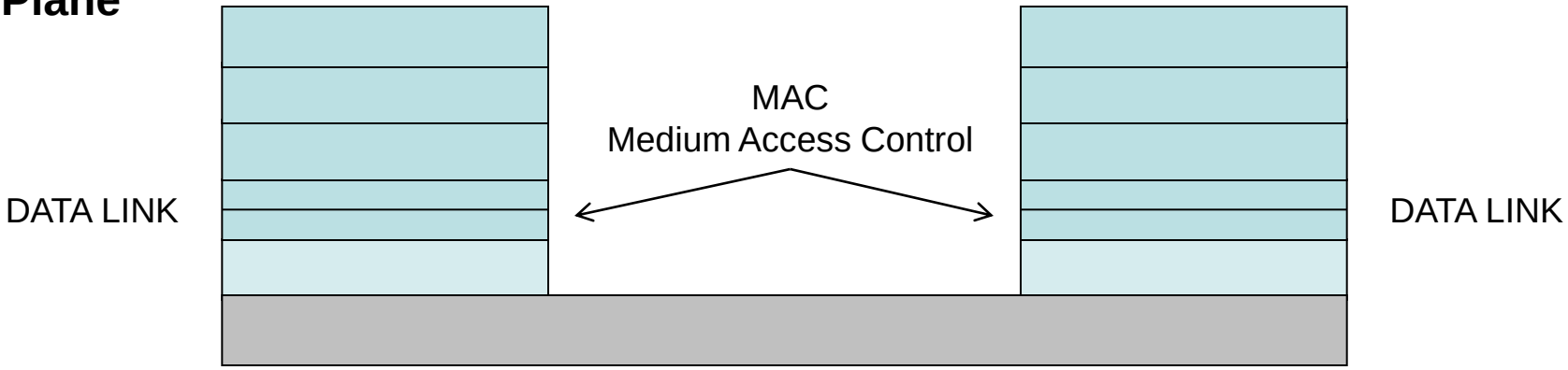
Interference



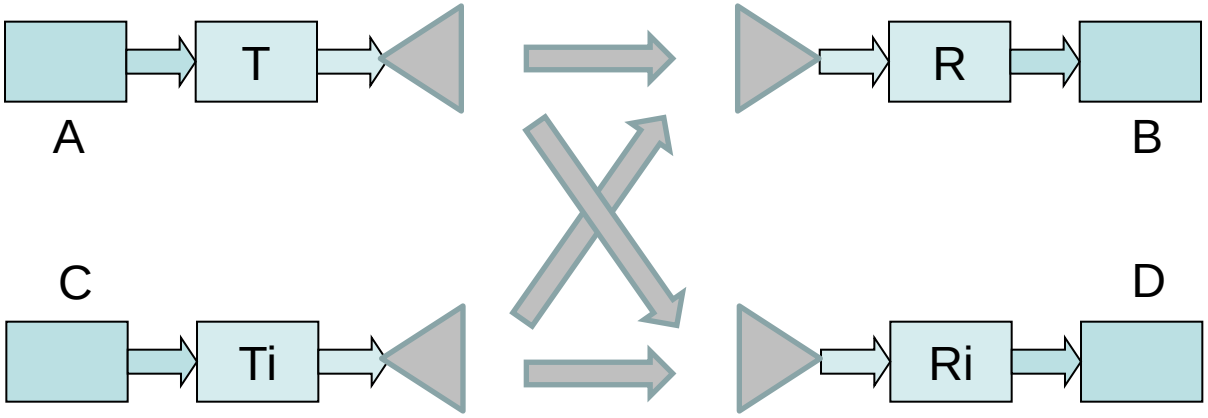
Interference



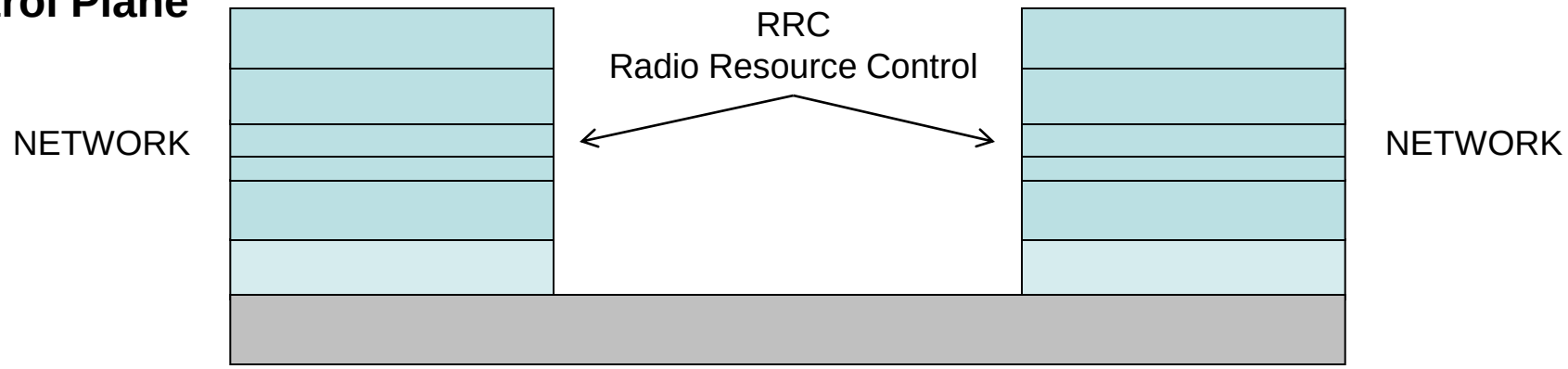
User Plane



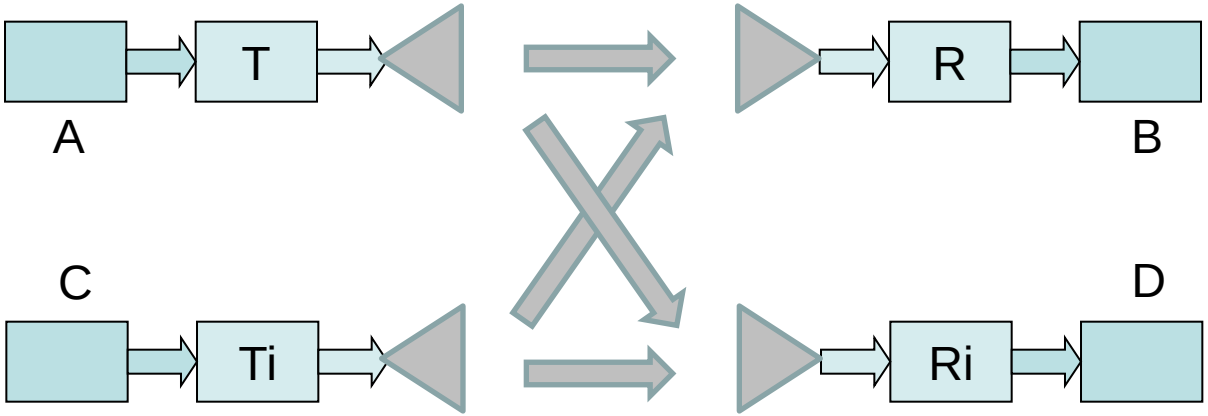
Interference



Control Plane



Interference

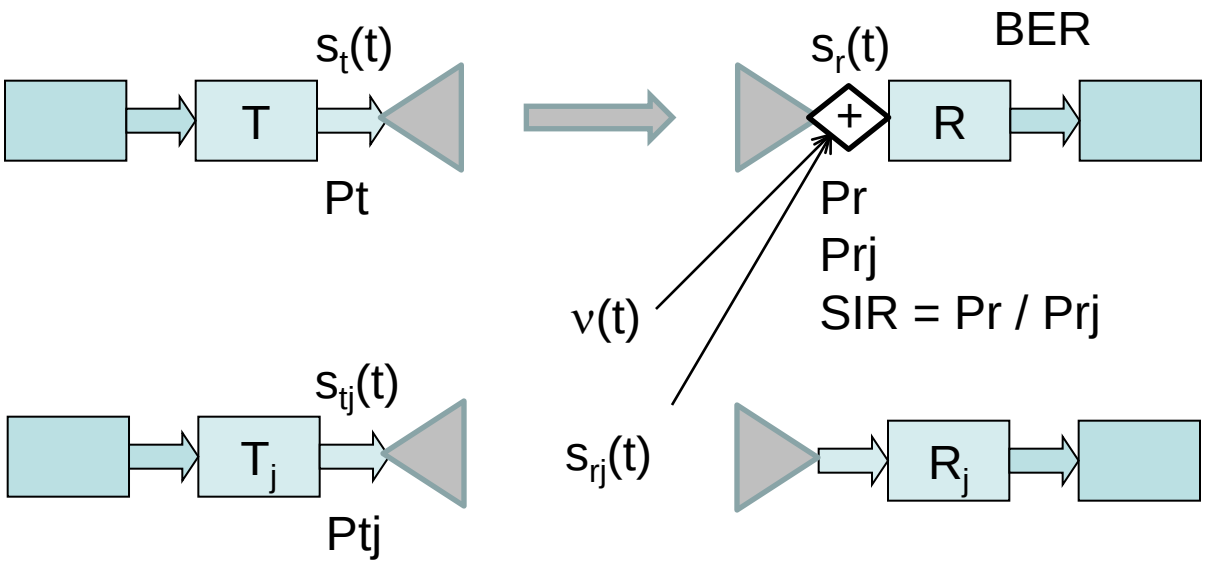


Interference Management is a key Issue:

- **Interference Avoidance → PHY or DATA LINK or NETWORK Layer**
- **Interference Averaging → PHY or DATA LINK Layer**
- **Interference Rejection → PHY Layer**
- **Collision Resolution → DATA LINK Layer**

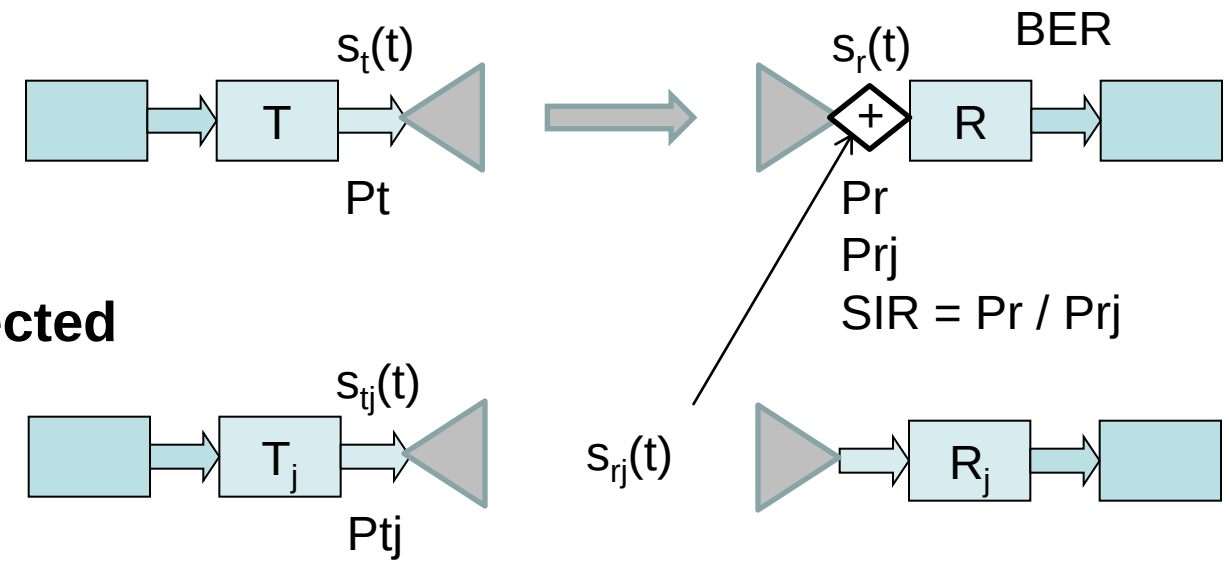
2. Communication Link with Interference: System Model

Communication Link with Interference: System Model



$s_{tj}(t)$ with respect to $s_t(t)$	has different	symbols
		carrier phase
		symbol synchronisation
	and possibly	transmit power
		MCS
		carrier frequency

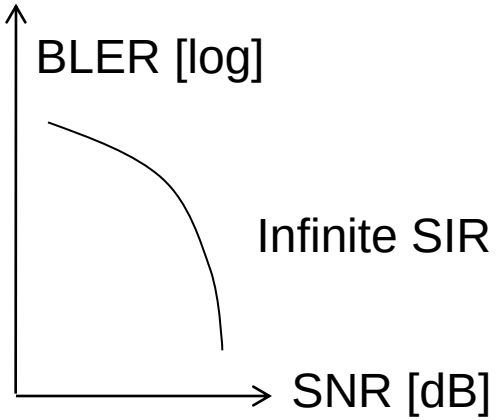
Communication Link with Interference: System Model

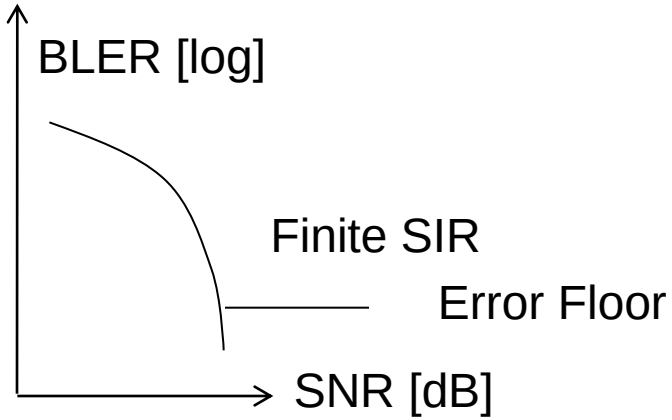


Noise neglected

Communication Link with Interference: System Model

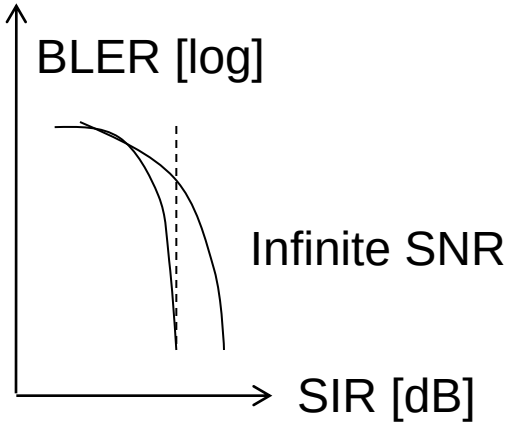
Noise limited system

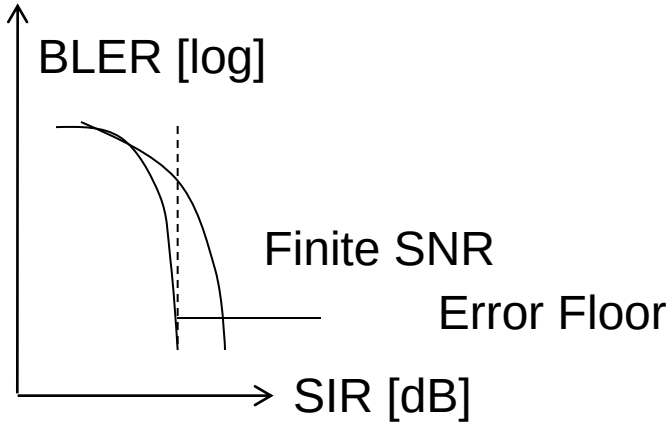




$$C = Bc \log_2 [1 + SNR]$$

Interference limited system

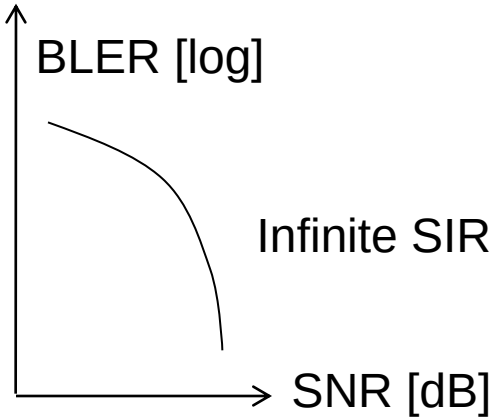




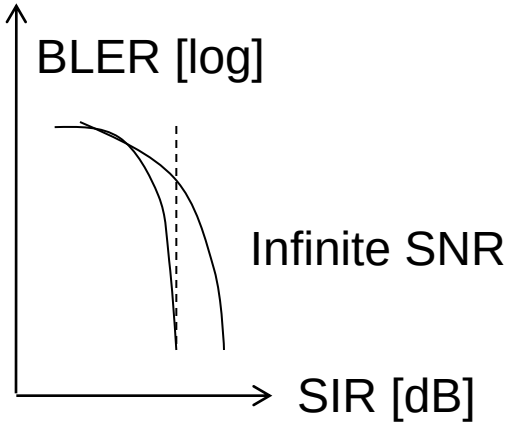
$$C \approx Bc \log_2 [1 + SIR]$$

Communication Link with Interference: System Model

Noise limited system



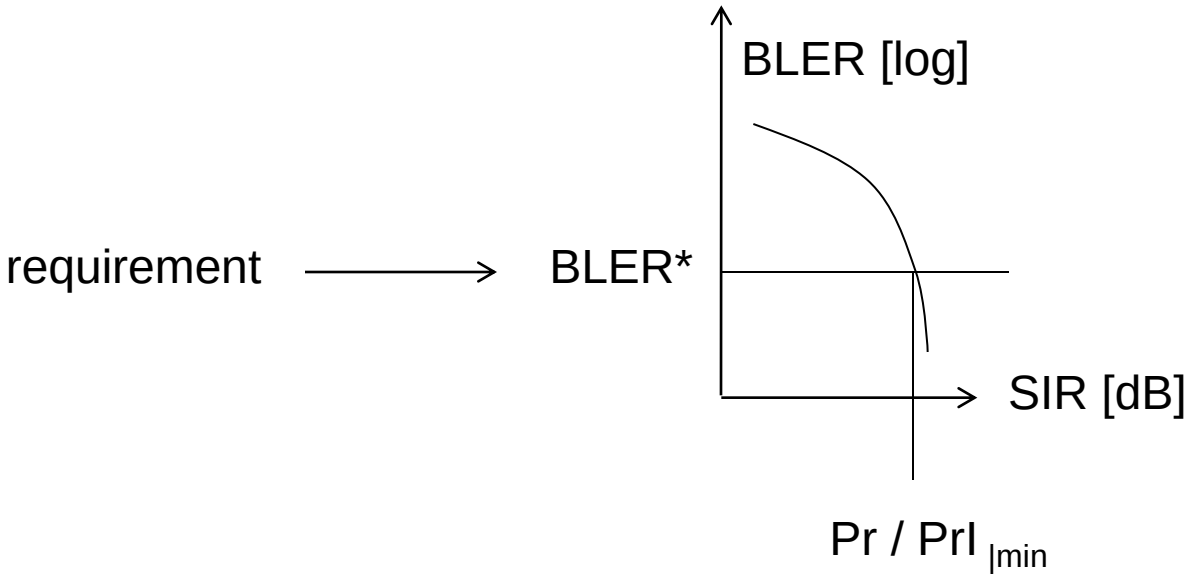
Interference limited system



… SINR = Pr / (Pn + Prl)

Interference is not Gaussian!

Communication Link with Interference: System Model

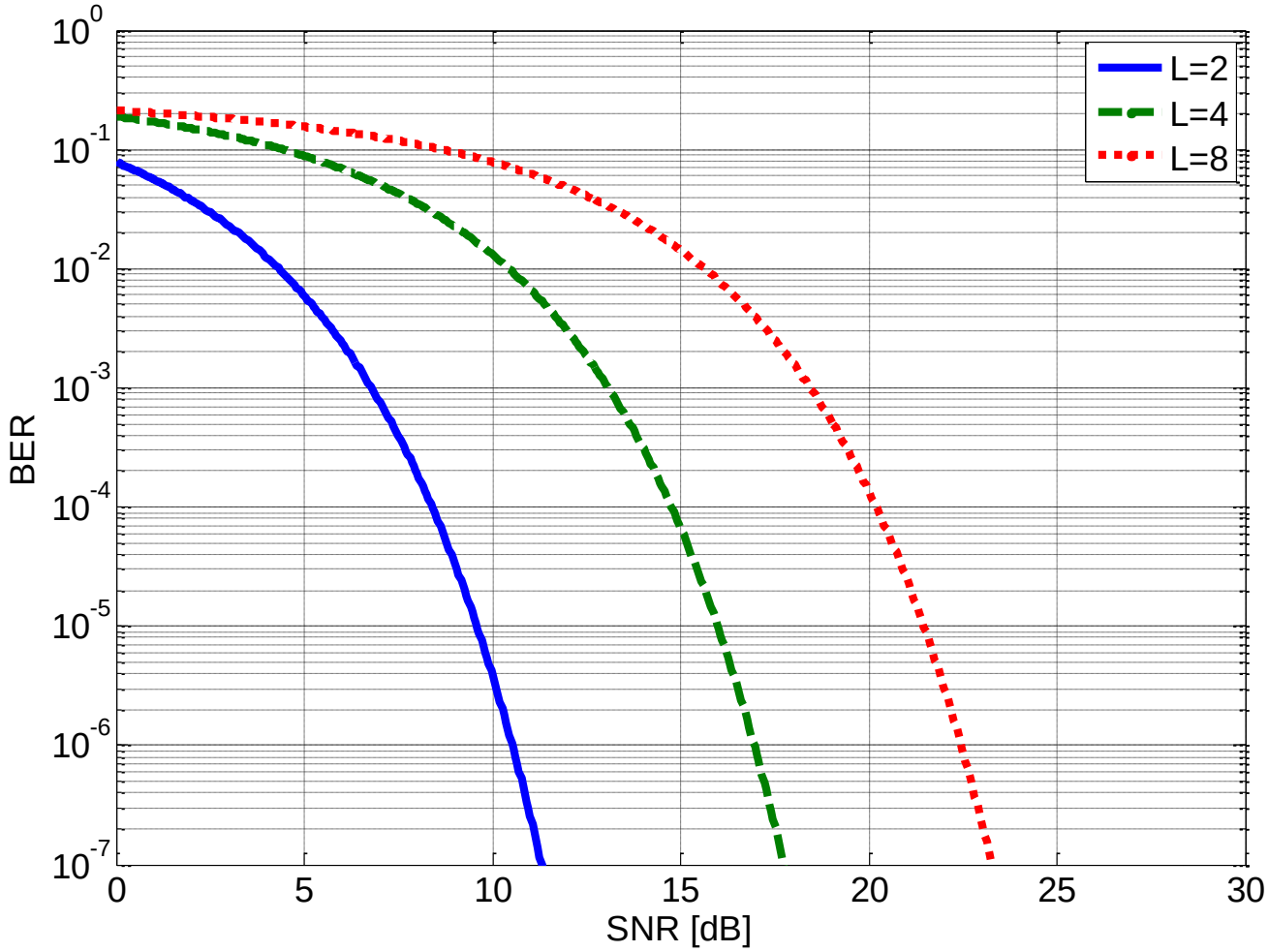


denoted as **protection ratio** ρ

3. Link Performance of M-QASK With Interference

Link Performance of M-QASK with Interference

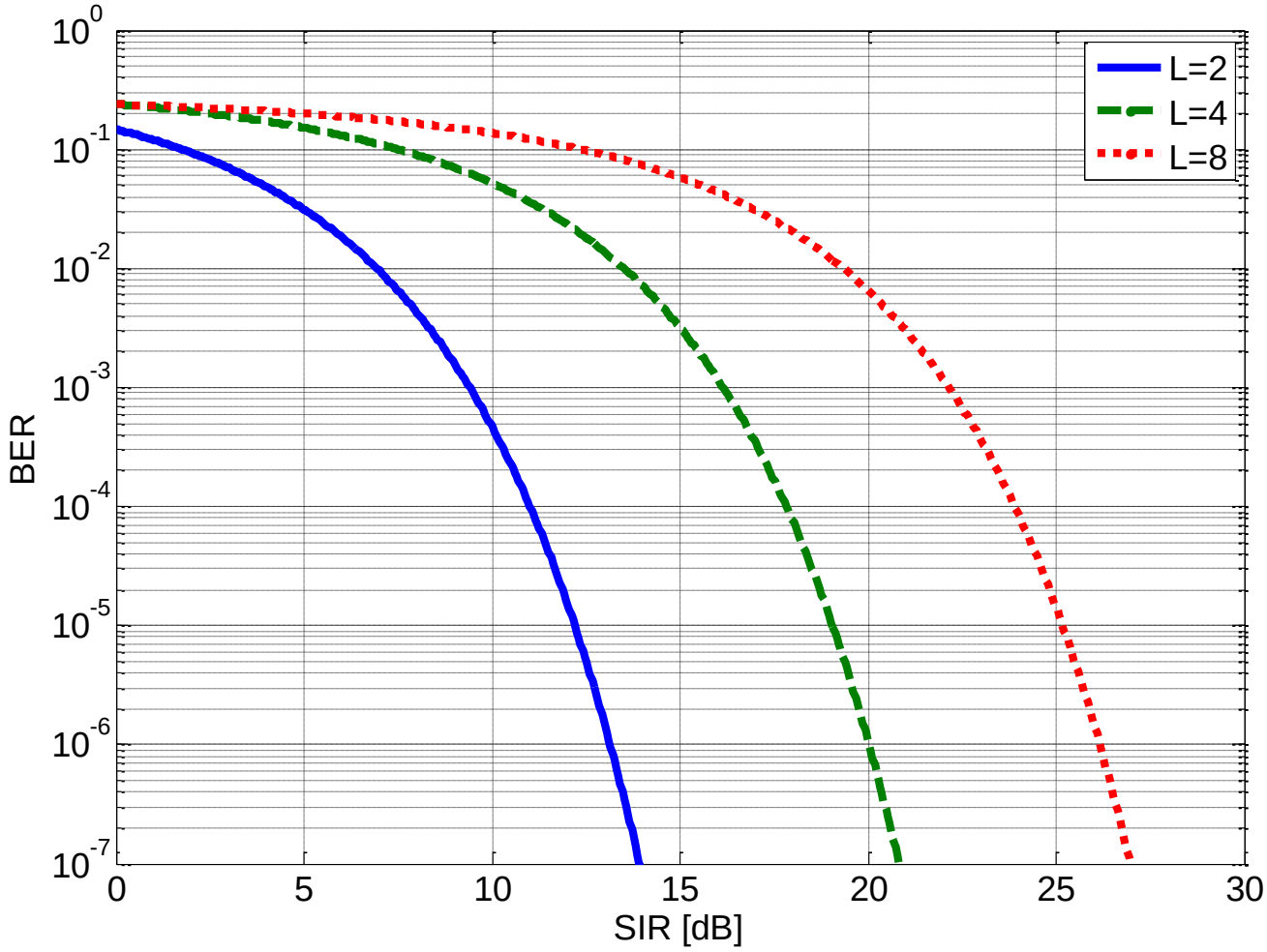
Mathematical Derivation



Link Performance of M-QASK with Interference

Mathematical Derivation

$\alpha = 0.35$

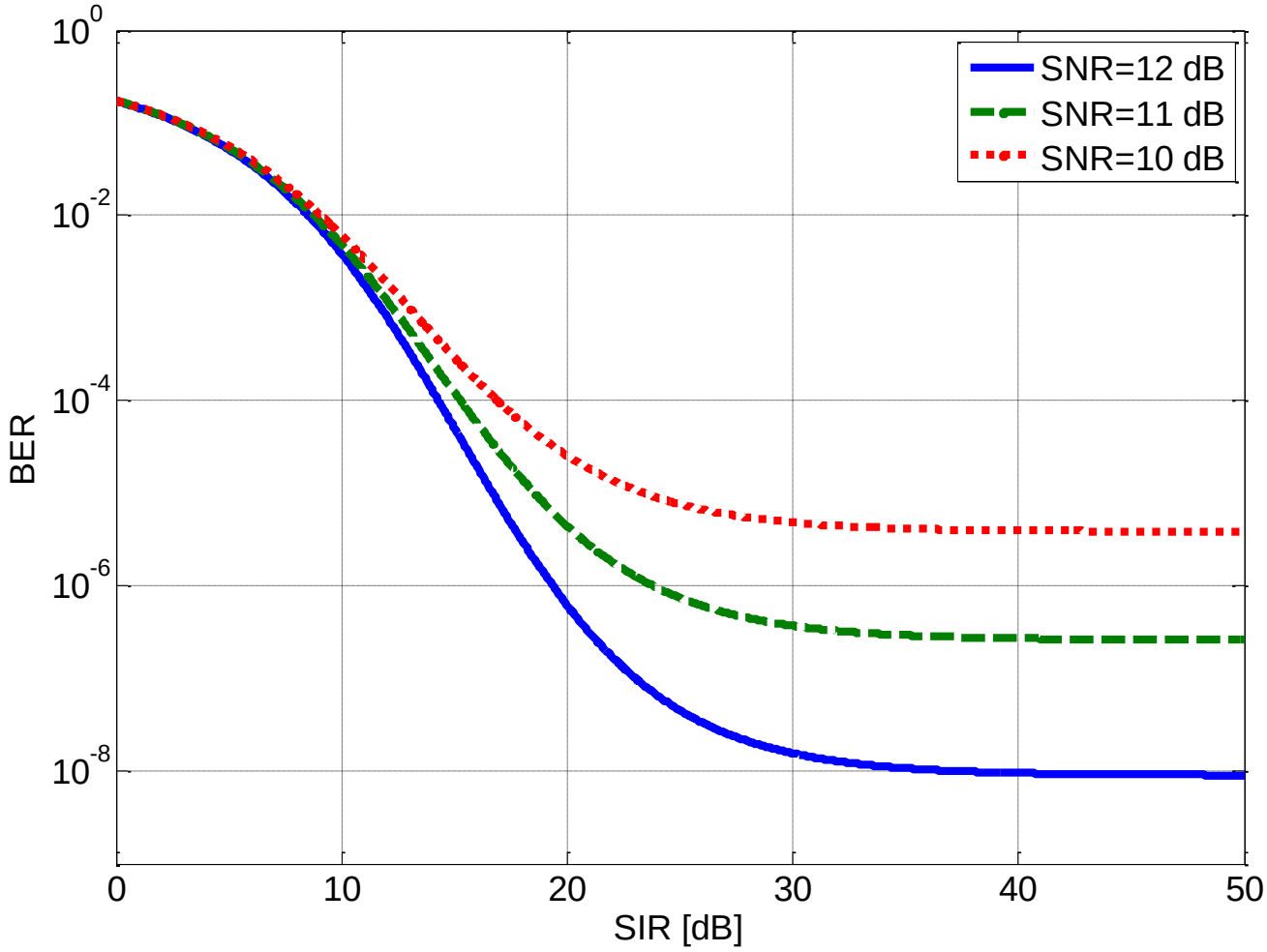


Link Performance of M-QASK with Interference

Mathematical Derivation

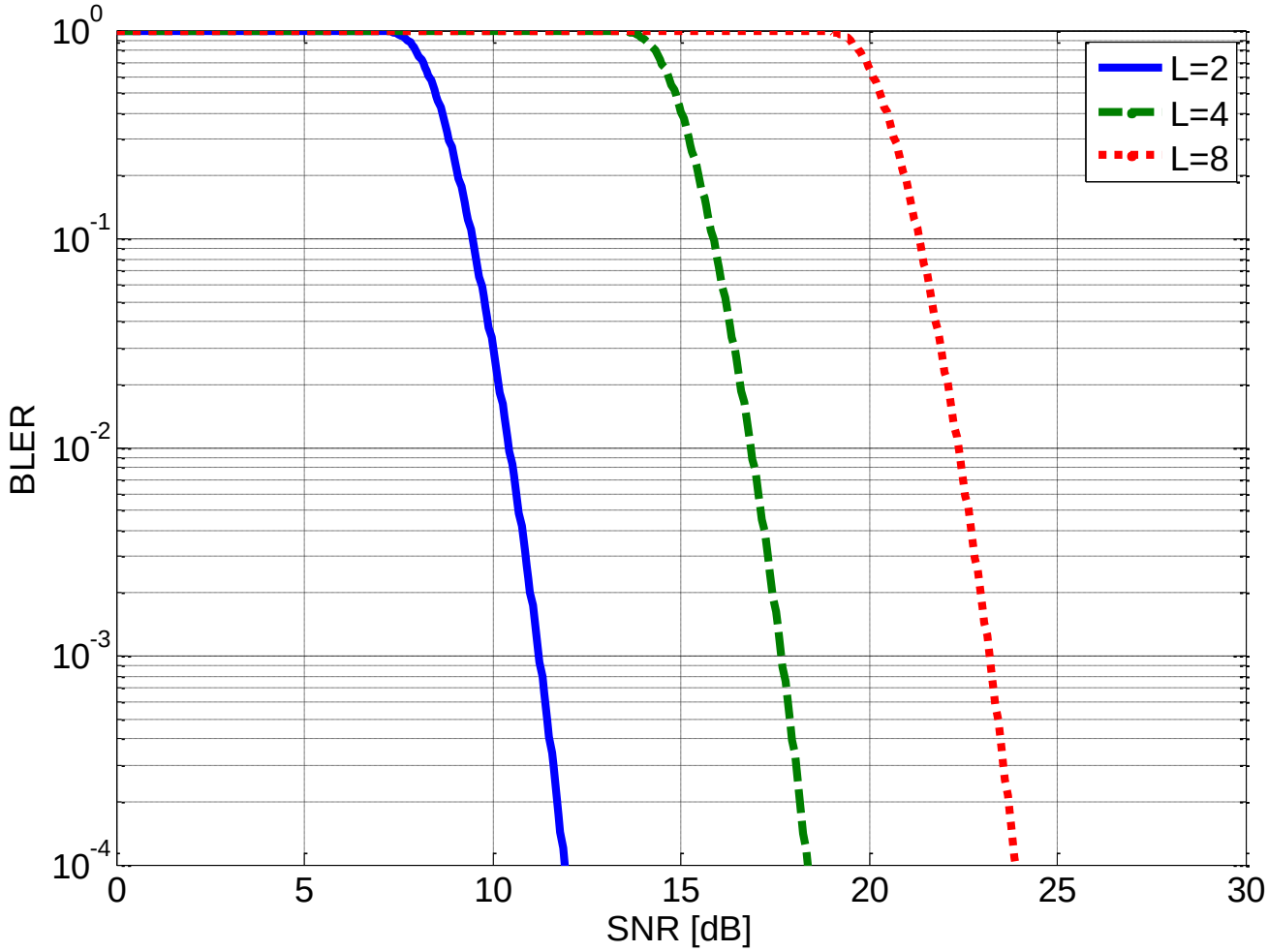
$\alpha = 0.35$

$L = 2$



Link Performance of M-QASK with Interference

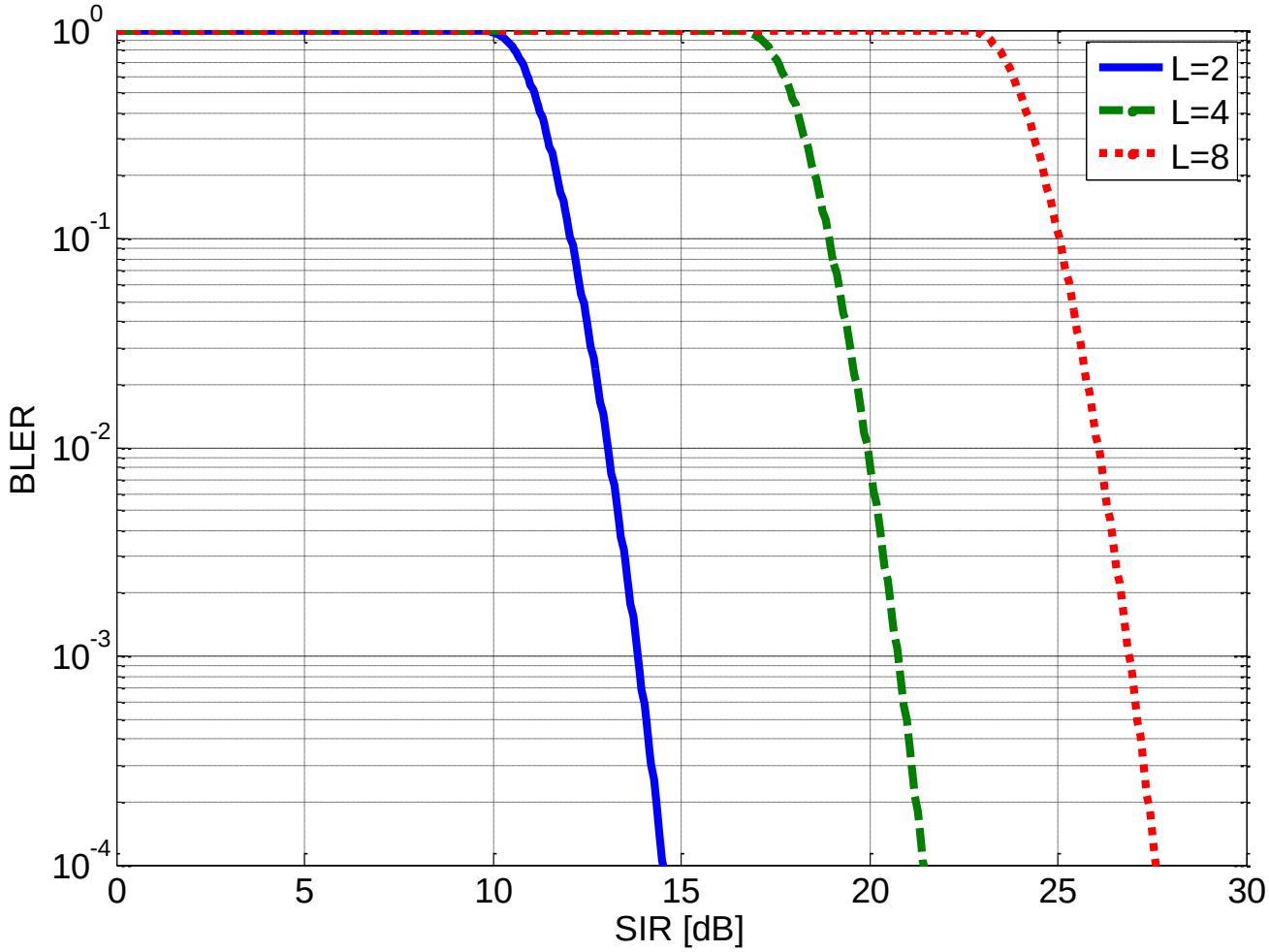
Mathematical Derivation
ARQ, 10KB



Link Performance of M-QASK with Interference

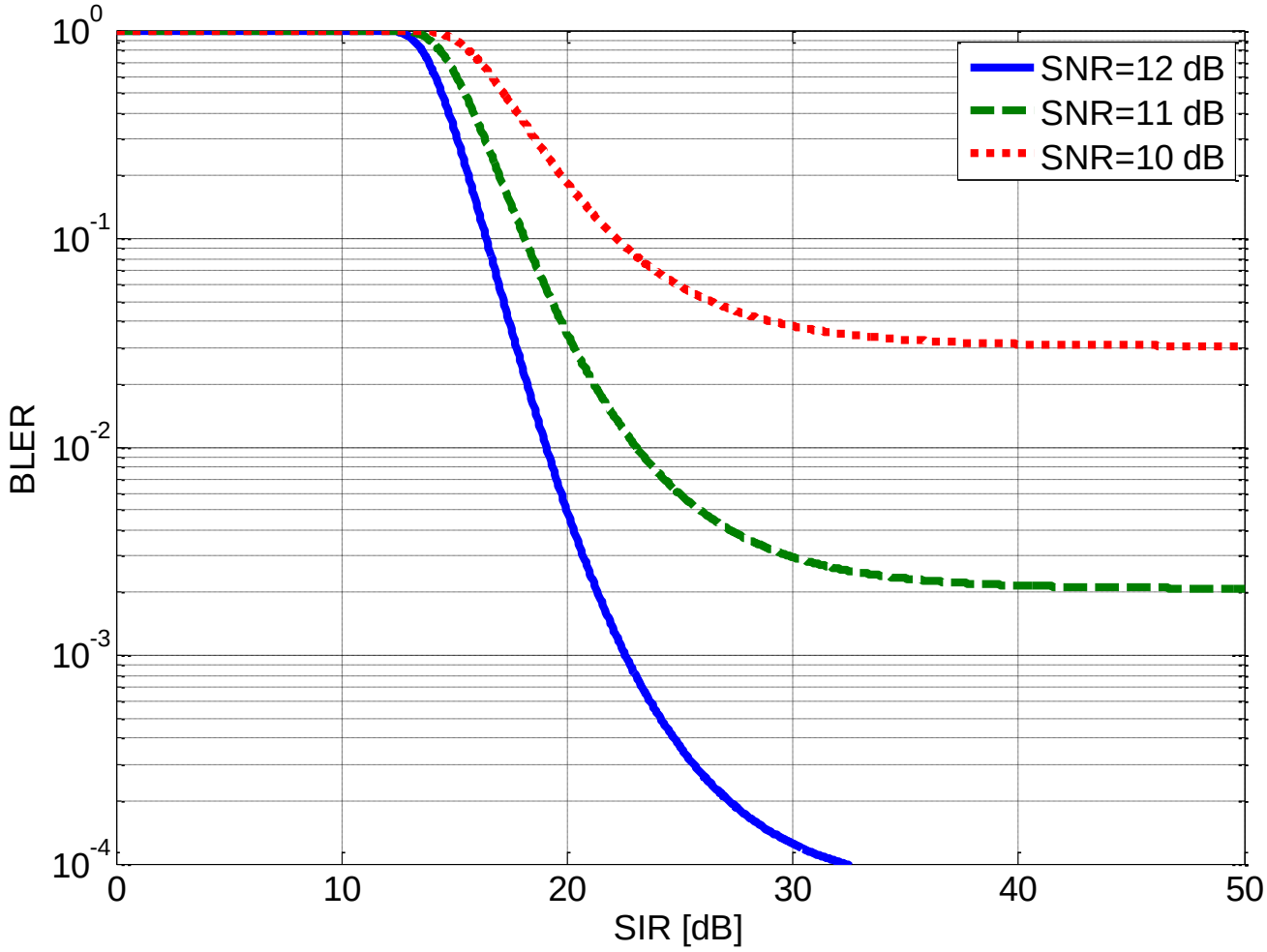
Mathematical Derivation

ARQ, 10KB, $\alpha = 0.35$



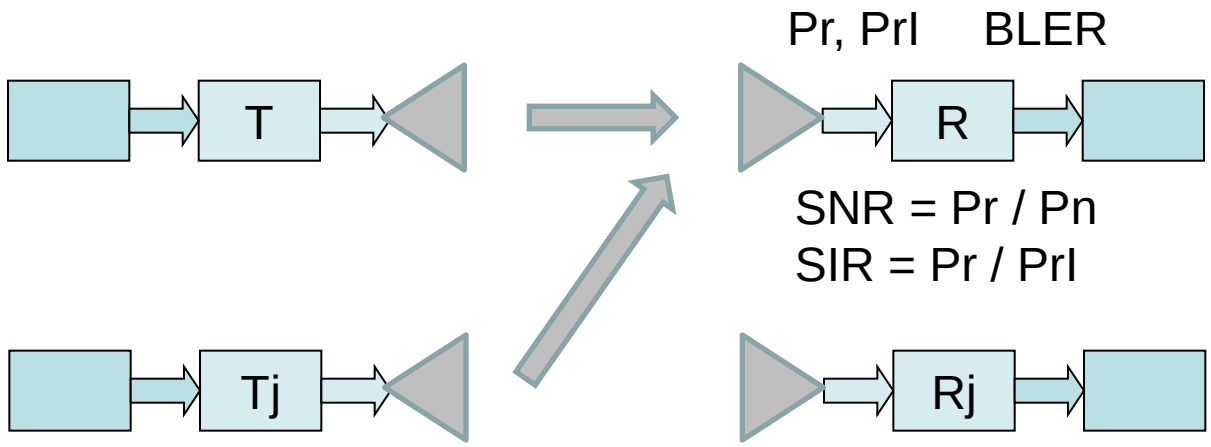
Link Performance of M-QASK with Interference

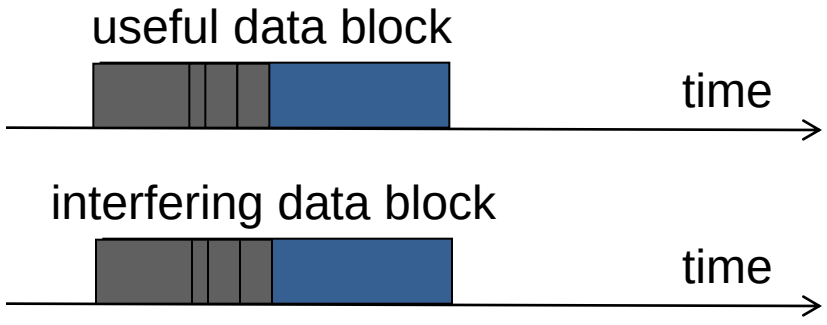
Mathematical Derivation
ARQ, 10KB, $\alpha = 0.35$
L = 2



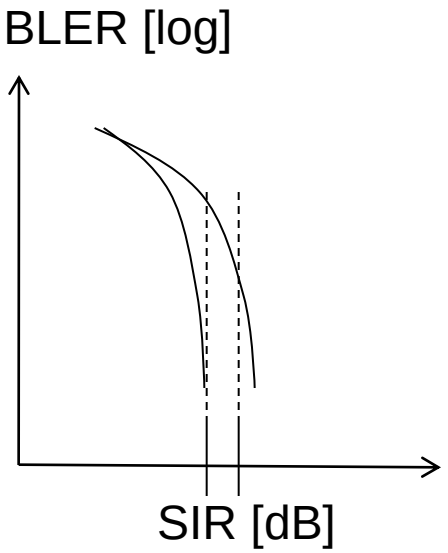
4. Capture Effect

Capture Effect

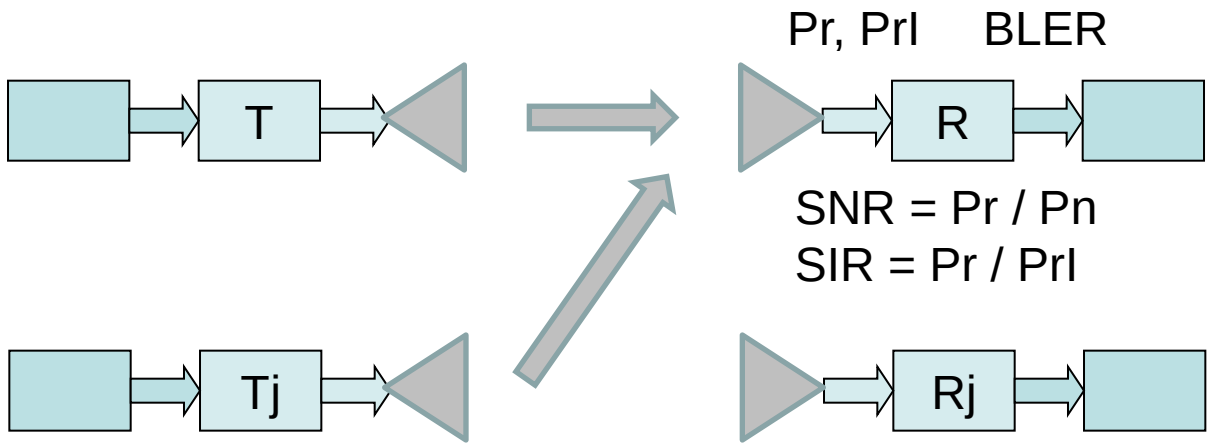


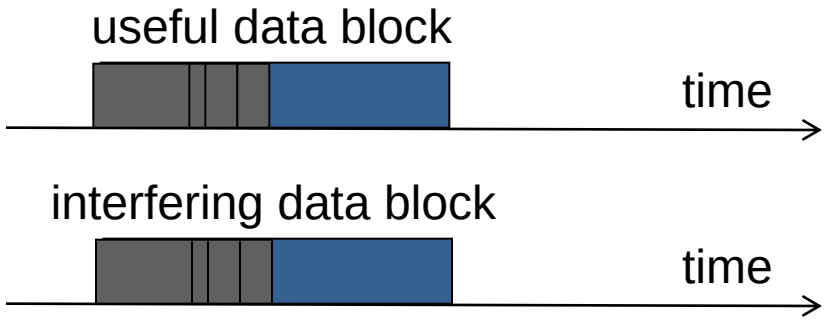


data blocks transmitted simultaneously
on the same frequencies



Capture Effect





data blocks transmitted simultaneously
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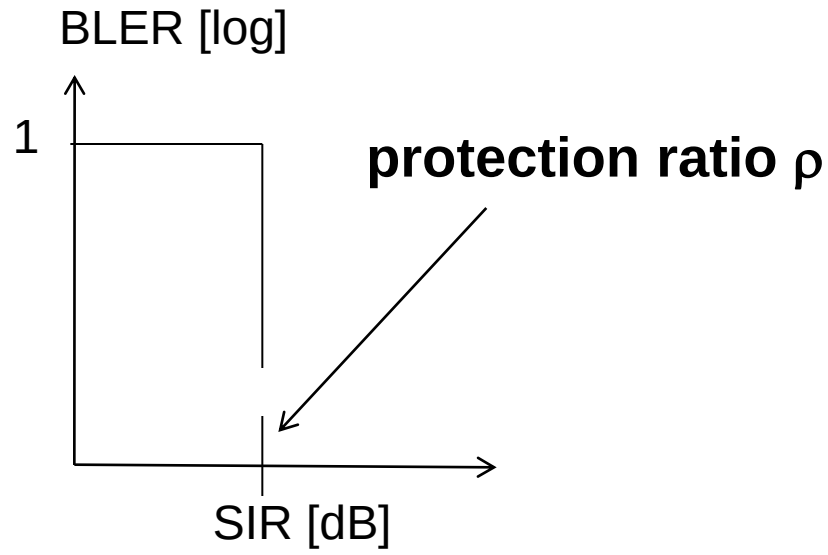
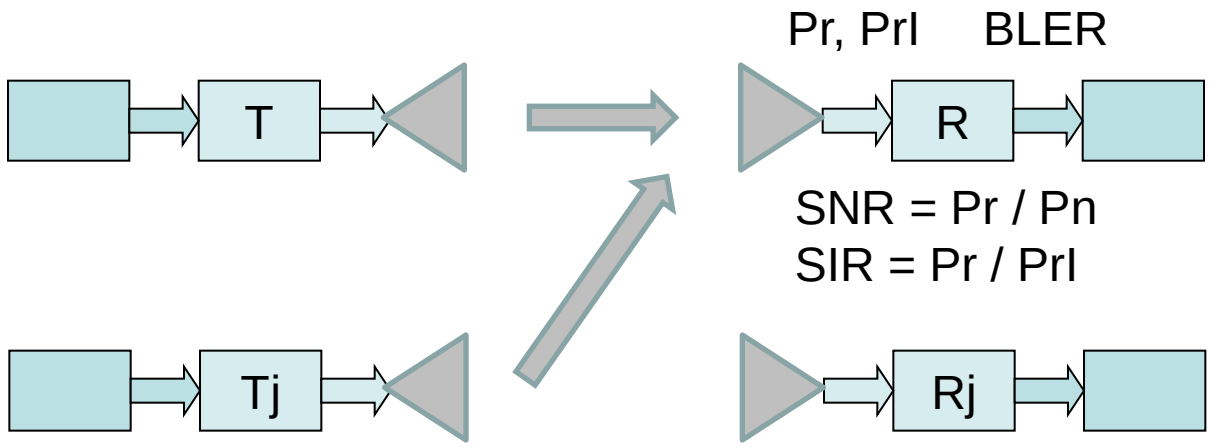
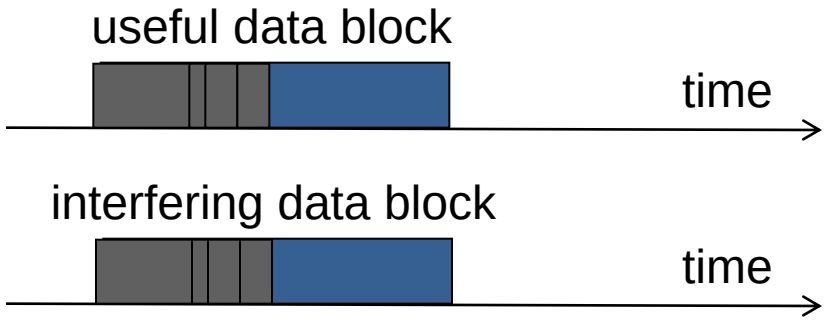


Capture Effect

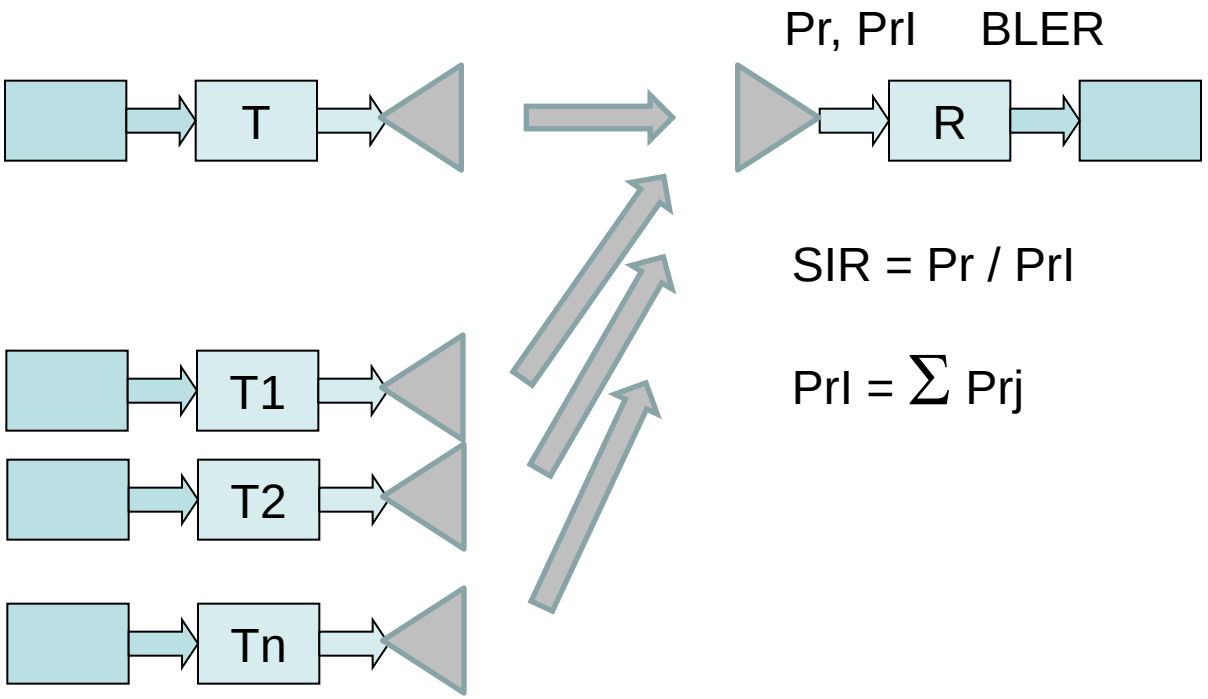




If SIR > α then data block is captured by receiver, otherwise lost

Capture Probability: Pc = Prob [SIR > ρ]

Capture Effect



With multiple interferers, the interference power is the sum of powers

If SIR > α then data block is captured by receiver, otherwise lost

Capture Probability: Pc = Prob [SIR > ρ]

Exercise IMN#1

A radio system uses QPSK over an AWGN channel with ARQ.
The system uses raised cosine filtering with roll-off factor 0.35.
Data blocks have size 1 Kbytes. The bit rate is 54 Mbit/s.
The channel bandwidth is 22 MHz, centred at carrier frequency 2.45 GHz.
The (monolateral) noise density power is 10^{-20} W/Hz.
Determine the protection ratio [dB] defined as
the minimum SIR ensuring BLER=0.01 in interference limited conditions, under Gaussian assumption.
Is it larger or smaller than the required SNR in noise limited conditions?

Compute the protection ratio for 16-QASK and 64-QASK under same conditions, and compare it with the required SNR in noise limited conditions.

Exercise IMN#2

A radio system uses QPSK over an AWGN channel with ARQ.
The system uses raised cosine filtering with roll-off factor 0.35.
Data blocks have size 1 Kbytes. The bit rate is 54 Mbit/s.
The channel bandwidth is 22 MHz, centred at carrier frequency 2.45 GHz.
The (monolateral) noise density power is 10^{-20} W/Hz.
Determine the protection ratio [dB] defined as
the minimum SIR ensuring BLER=0.01 in interference limited conditions, under Gaussian assumption.

Determine the minimum SIR ensuring BLER=0.01 with values of SNR equal to 12 dB, 11 dB, 10 dB.

Exercise IMN#3

A radio network uses QPSK over an AWGN channel with ARQ.
The system uses raised cosine filtering with roll-off factor 0.35.
Data blocks have size 1 Kbytes. The bit rate is 54 Mbit/s.
The channel bandwidth is 22 MHz, centred at carrier frequency 2.45 GHz.
The (monolateral) noise density power is 10^{-20} W/Hz.

Under free space conditions, with unitary antenna gains and connection losses, transmit powers set at 20 dBm, the network is composed of two simultaneously transmitting links. The first transmitter, T1, moves away from its receiver, R1, on a straight line. The second transmitter, T2, has fixed distance from R1 set at 7000 m. Compute the maximum useful distance compatible with a BLER requirement of 0.01.

Repeat the exercise with two interferers both located at 100 m from the useful receiver.