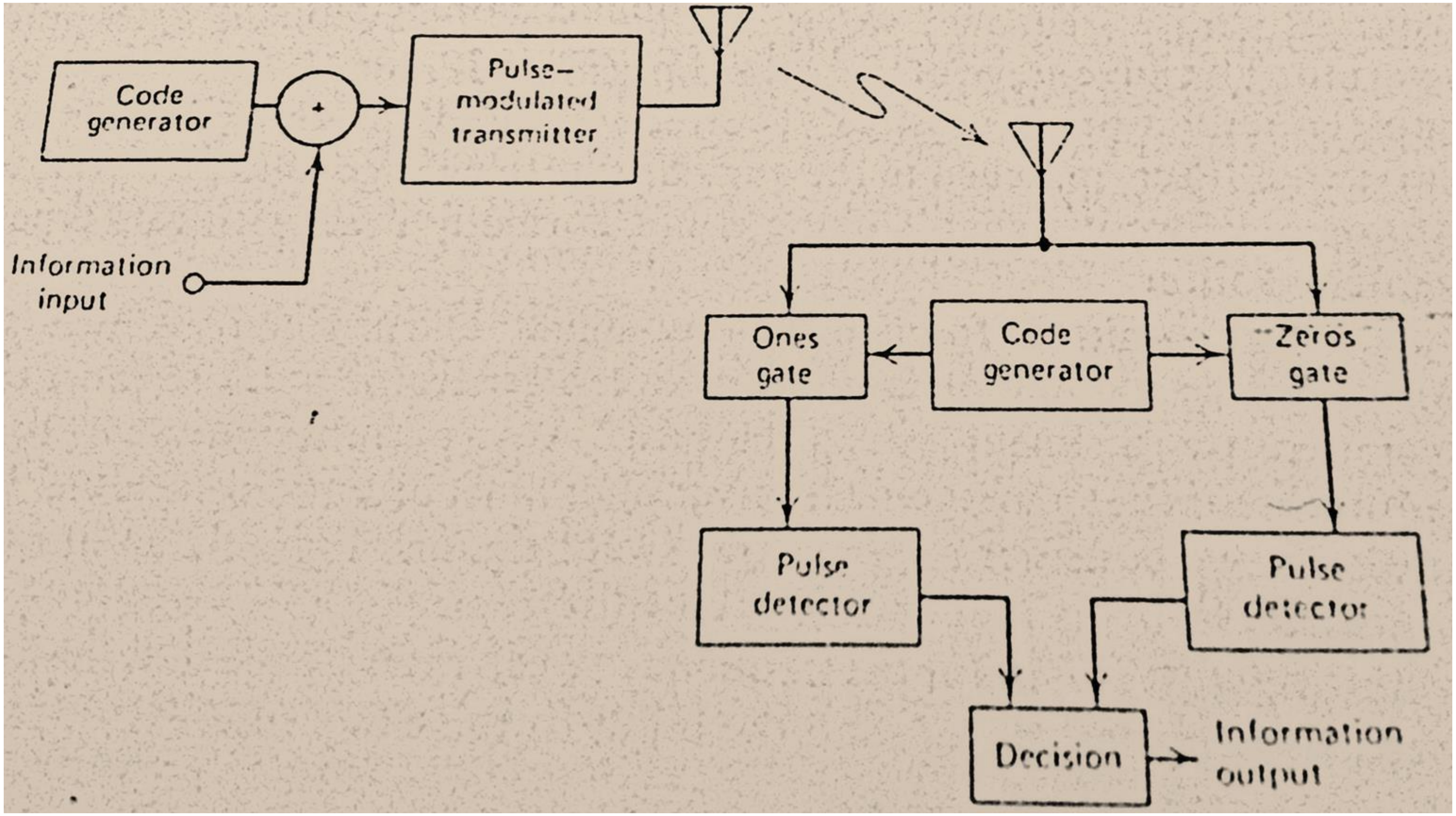
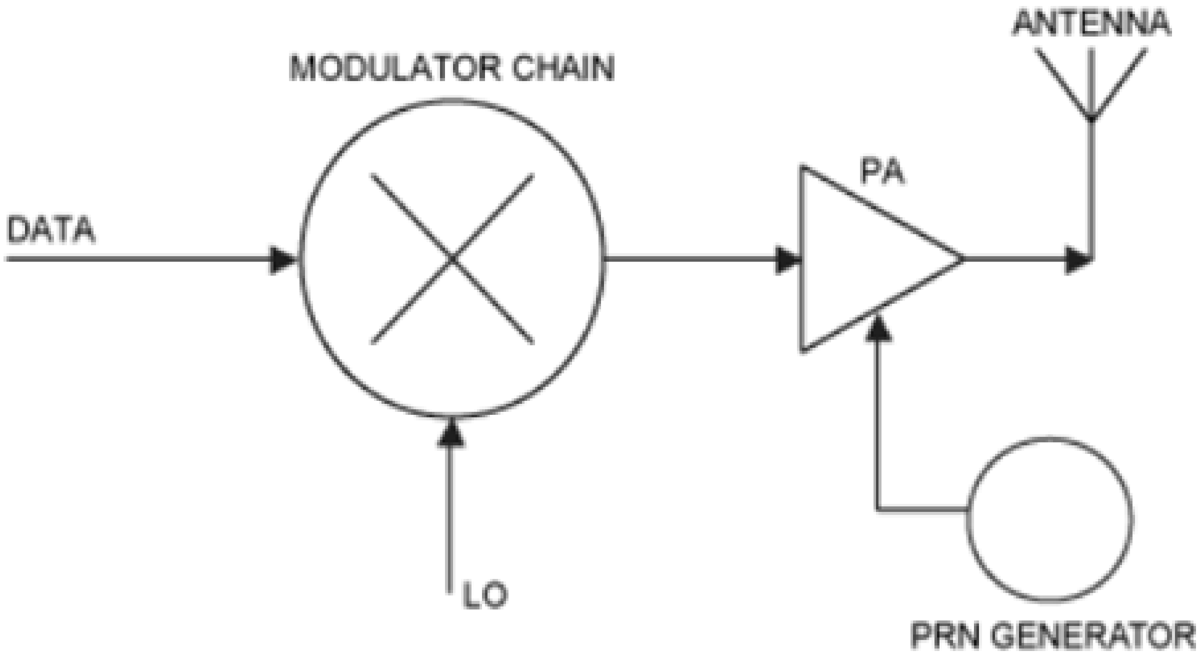
Time Hopping Spread Spectrum



$G_P=1/T_d$

Where T_d is transmit duty cycle

THSS



Pulse modulation; PN is used to key the transmitter on-off.

- Using pulses with low duty cycle having a wide frequency response, spreading of the spectrum is caused.
- TH often used to form hybrid spread-spectrum (SS) systems; TH-FH
- **TH** can be used to achieve low probability of intercept when the transmission time is changed randomly by varying period and duty cycle of the pulse using a PN sequence.
- It also refer to pulse-position modulation

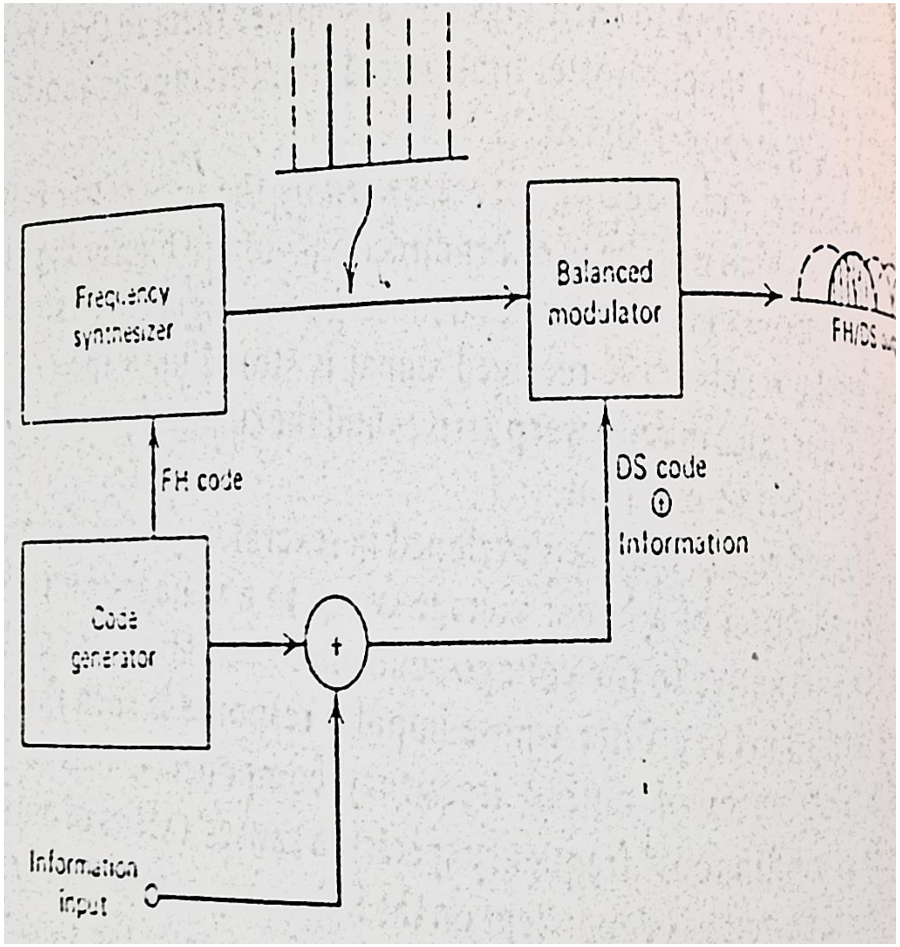
Advantages and dis….

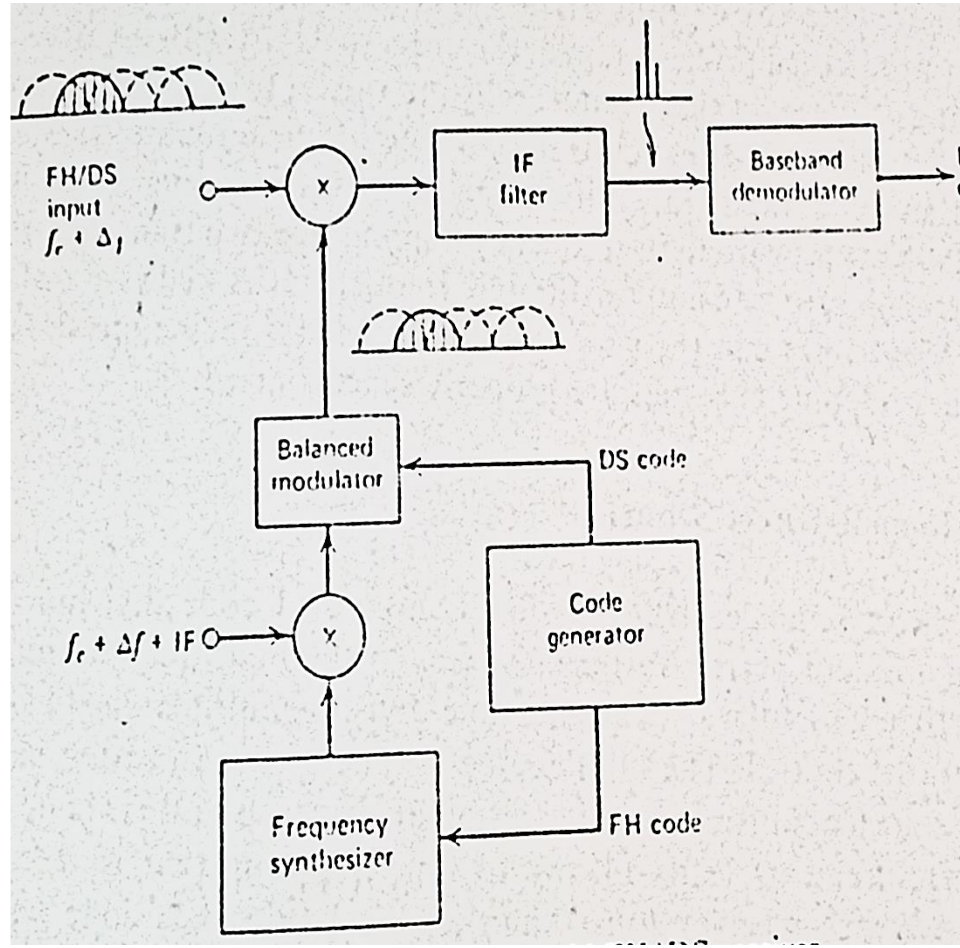
- **Advantages**
  - Has a high bandwidth efficiency as compared to FH and DSSS.
  - Its implementation is simpler than that of FHSS
  - Near-far problem can be avoided in a coordinated system
- **Disadvantages**
  - Also requires error correction
  - Offers a little of interference rejection: CW at single cenetr frequency (interference signal) can block communication effectively
- So, TH with FH for anti-jamming

Hybrid Spread Spectrum System

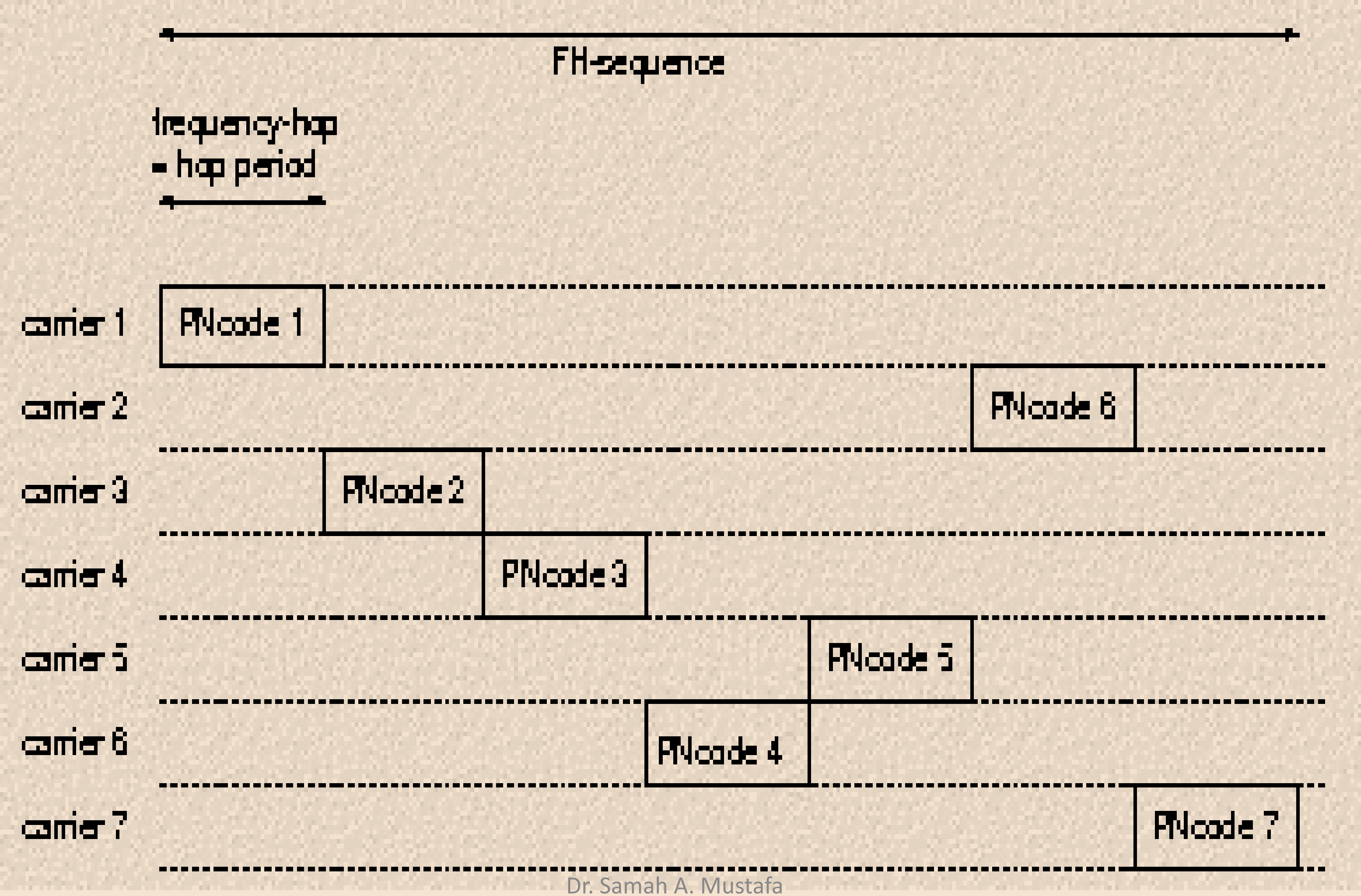
Hybrid DS/FH Spread Spectrum

- The DS/FH Spread Spectrum technique is a combination of DS and FH.
  - To get characteristics that are not available by one of them
- One data bit is divided over frequency-hop channels (carrier frequencies).
  - DS code is normally faster than the rate of Freq. hopping
- In each frequency-hop channel one complete PN-code of length is multiplied with the data signal.


Frequency synthesizer
Balanced modulator
FH/DS
FH code
DS code
⊕
Information
Code generator
+
Information input


FH/DS input
×
IF filter
Baseband demodulator
Balanced modulator
DS code
Code generator
×
FH code
Frequency synthesizer

Hybrid System: DS/(F)FH



As the FH-sequence and the PN-codes are coupled, an address is a combination of an FH-sequence and PN-codes.

$$G_P = G_{P(DS)} + G_{P(FH)}$$
$$= 10 \log N_{FH} + 10 \log(BW_{DS}/Bw_{infor})$$

An interference signal whose power falls wholly within one sector of the RF band is spread by only the bandwidth of DS signal whenever the interferer hops into that sector

i.e the interferer won't spread by the FH/DS RF band that means less power of interference signal is required to jam the SS signal → loss in M_J

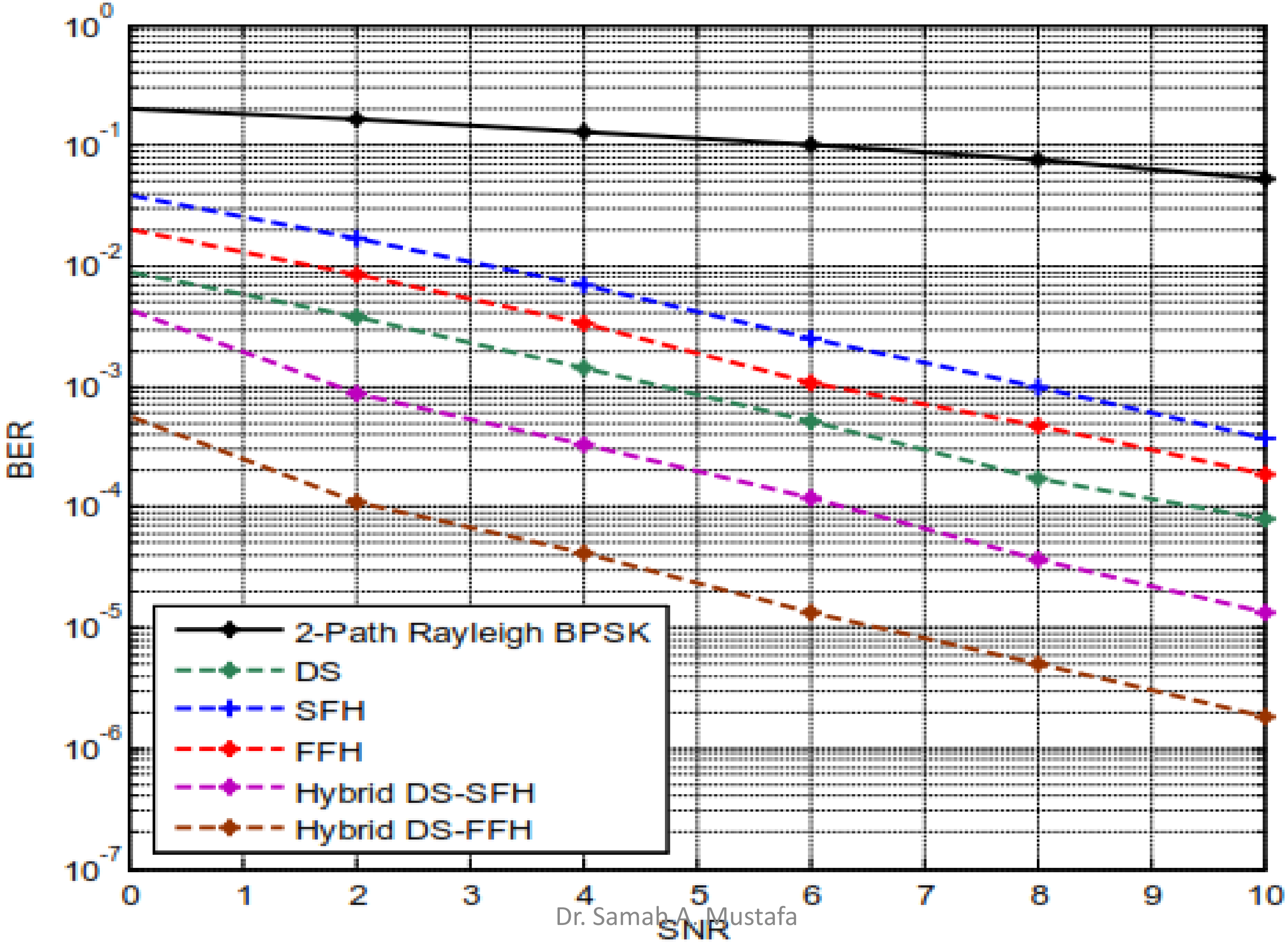
The relation between G_P and M_J introduced earlier is not necessarily applied here.

To bound the hit-chance (the chance that two users share the same frequency channel in the same time) the frequency-hop sequences are chosen in such a way that two transmitters with different FH-sequences share at most two different frequencies at the same time (time-shift is random).

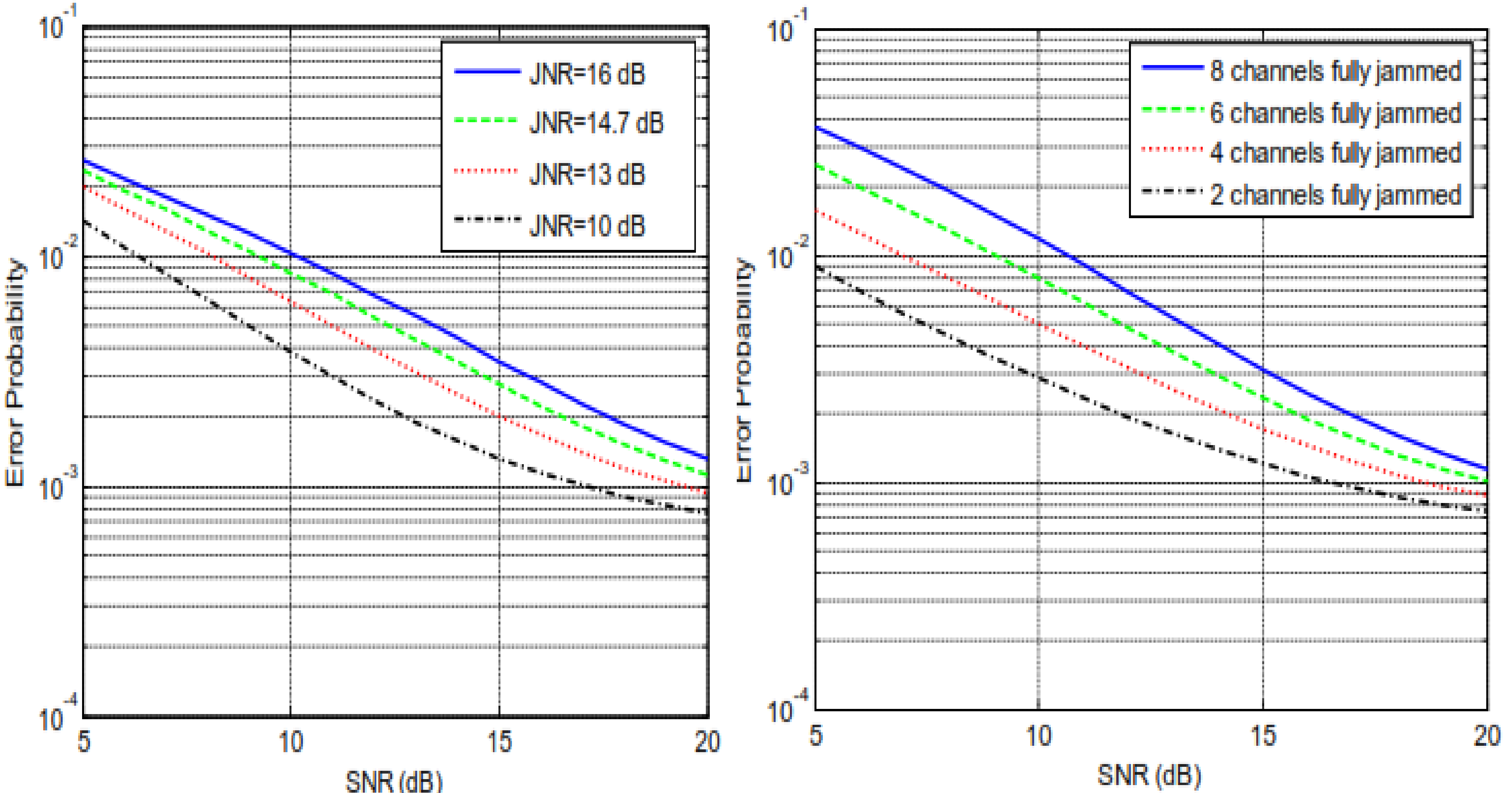
In multi user system, to prevent a user from being completely lost, change the order of channel use.

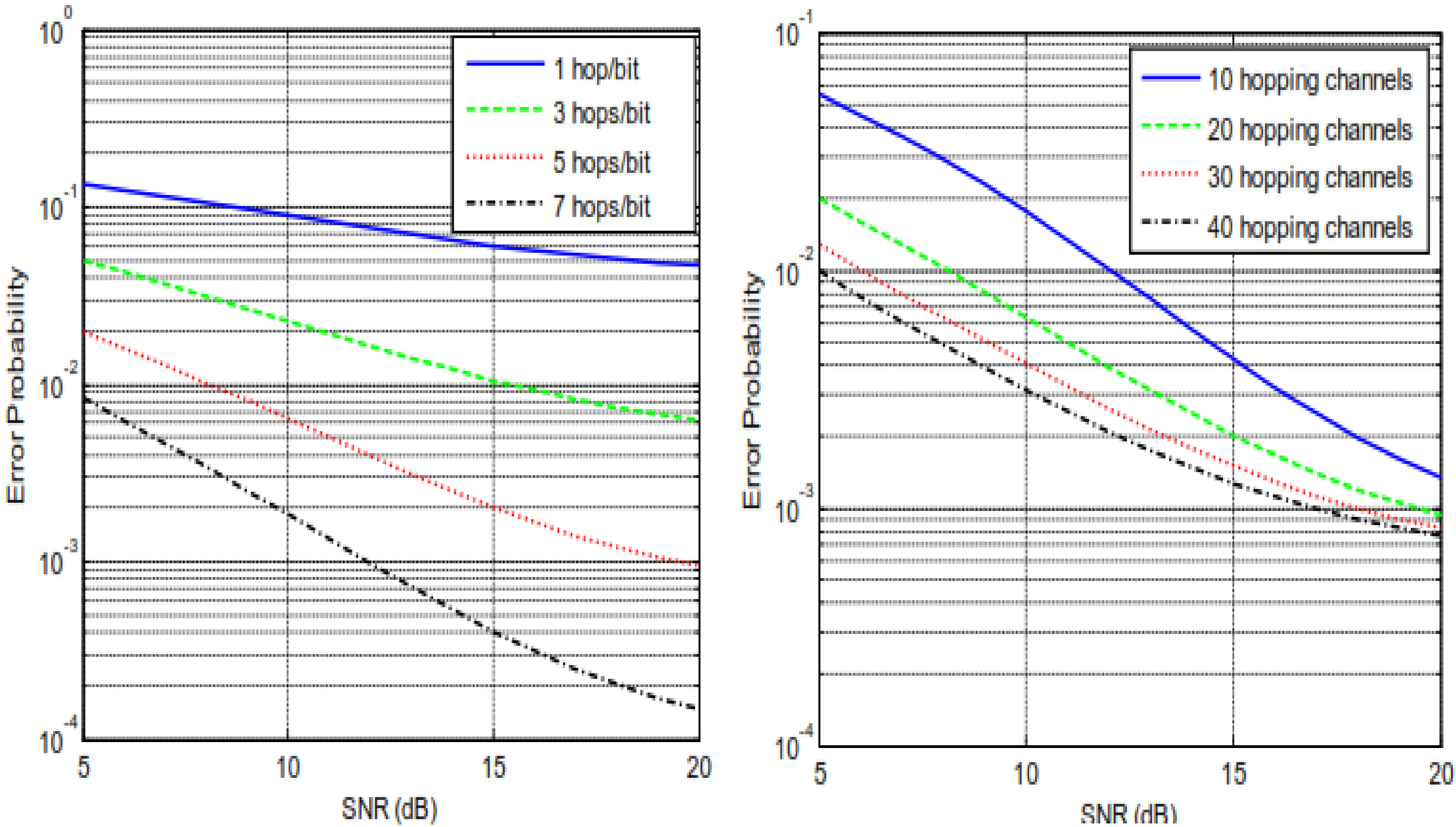
For N_{FH} channels and users and one jammer hits one channel, that channel would be affected by $1/20^{th}$ of the time and each user by $1/400^{th}$ of the time (if all users share all the 20 channels)

Performance Evaluation

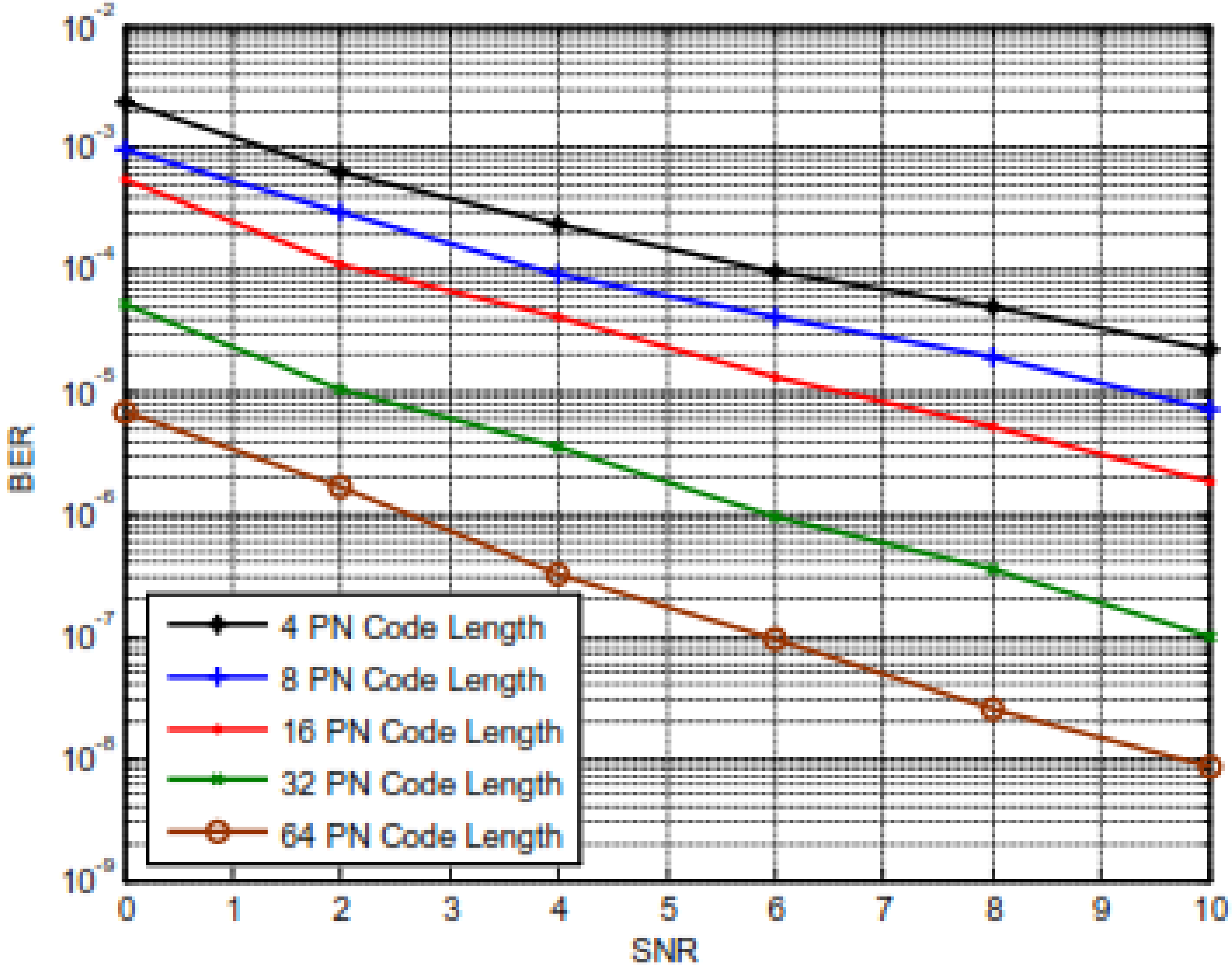


FH/DS performance





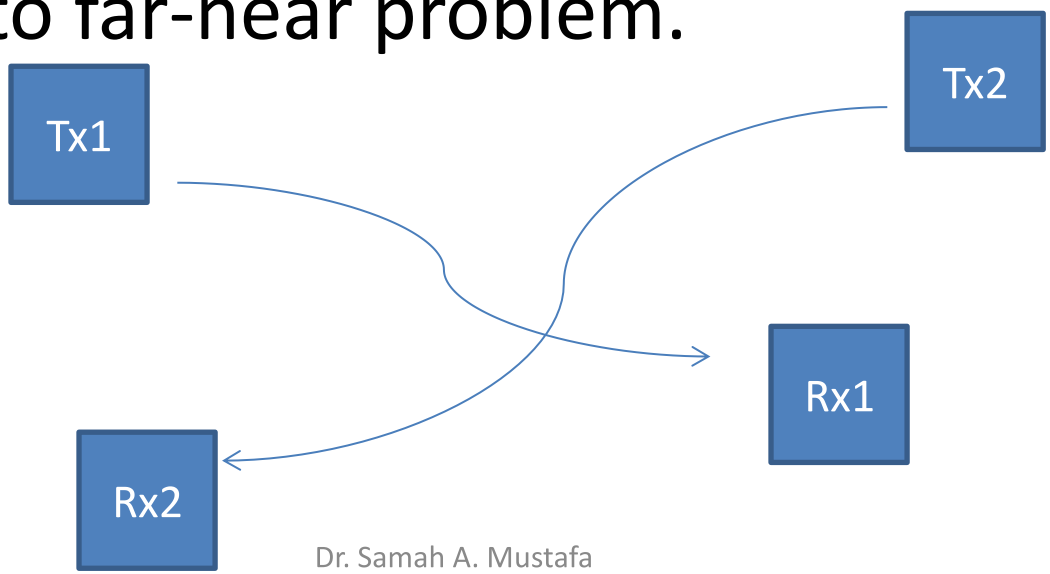
Error Probability
SNR (dB)
1 hop/bit
3 hops/bit
5 hops/bit
7 hops/bit
Error Probability
SNR (dB)
10 hopping channels
20 hopping channels
30 hopping channels
40 hopping channels



BER
SNR
4 PN Code Length
8 PN Code Length
16 PN Code Length
32 PN Code Length
64 PN Code Length

Time-Frequency Hopping

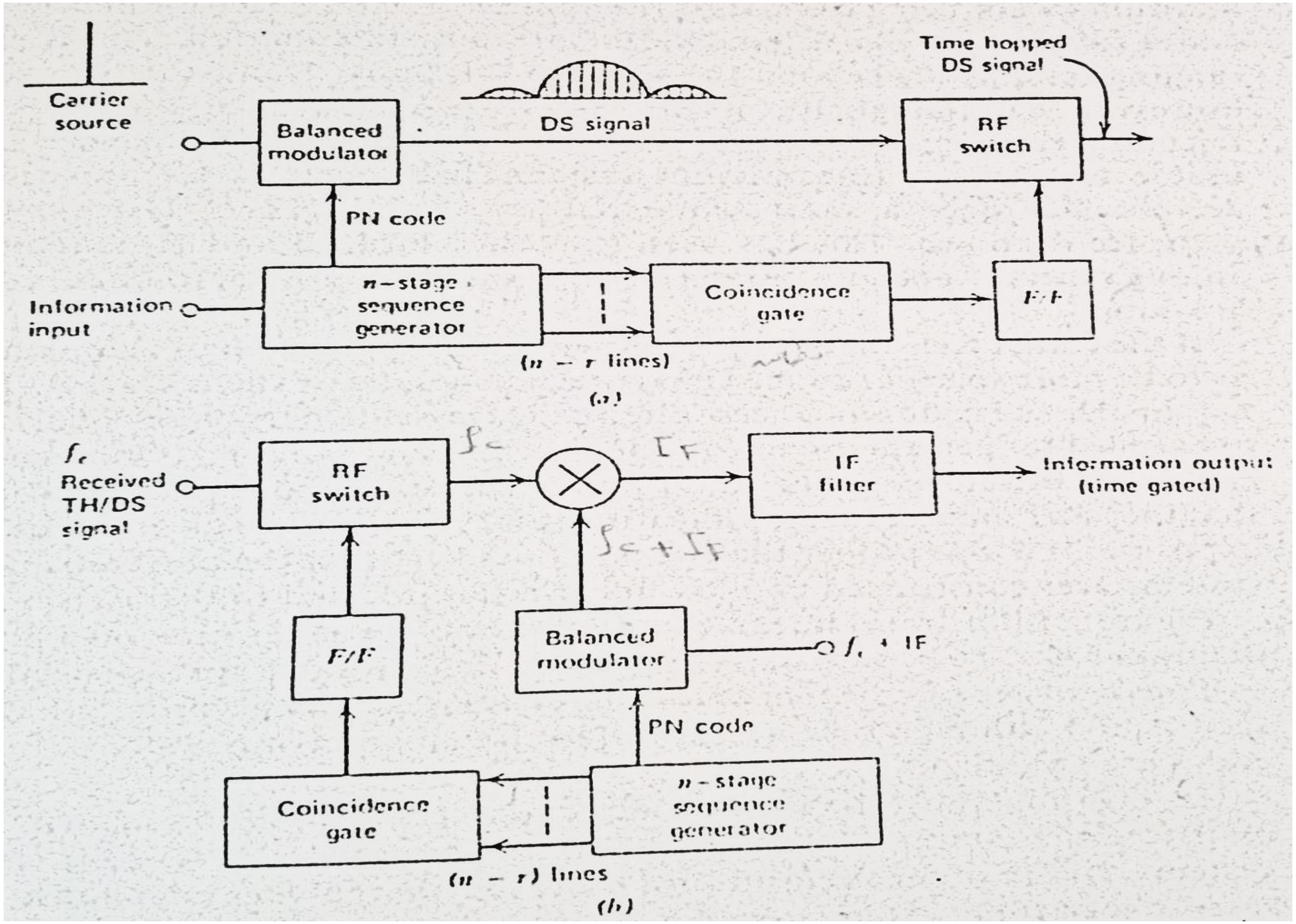
- When large of users with widely variable distances operate simultaneously in a single link.
- TH/FH system is one (if not the only) viable solution to far-near problem.
- Example:



- Anti-jamming of SS aids but is not enough
- Ex: near transmitter → signal attenuated by 40db and other far transmitter →signal attenuated by 63db so it looks we nee G_P=35db
- However, Process gain is not really the answer to near-far problem.
- A better solution is program the transmitters to not transmit at same time on same frequencies.

TH/DS

- when DS and CDMA don’t permit sufficient access
- TH adds TDM to aid in traffic control
- High degree of time synchronization between DS’s Tx and Rx support TDM operation
- Add time hopping TDM to DS system by on-off switching and control



- Average pulse occurrence for TH/DS transmission is $R_c\, 2^r / (2^{n+1} - 2)$