CDMA Systems

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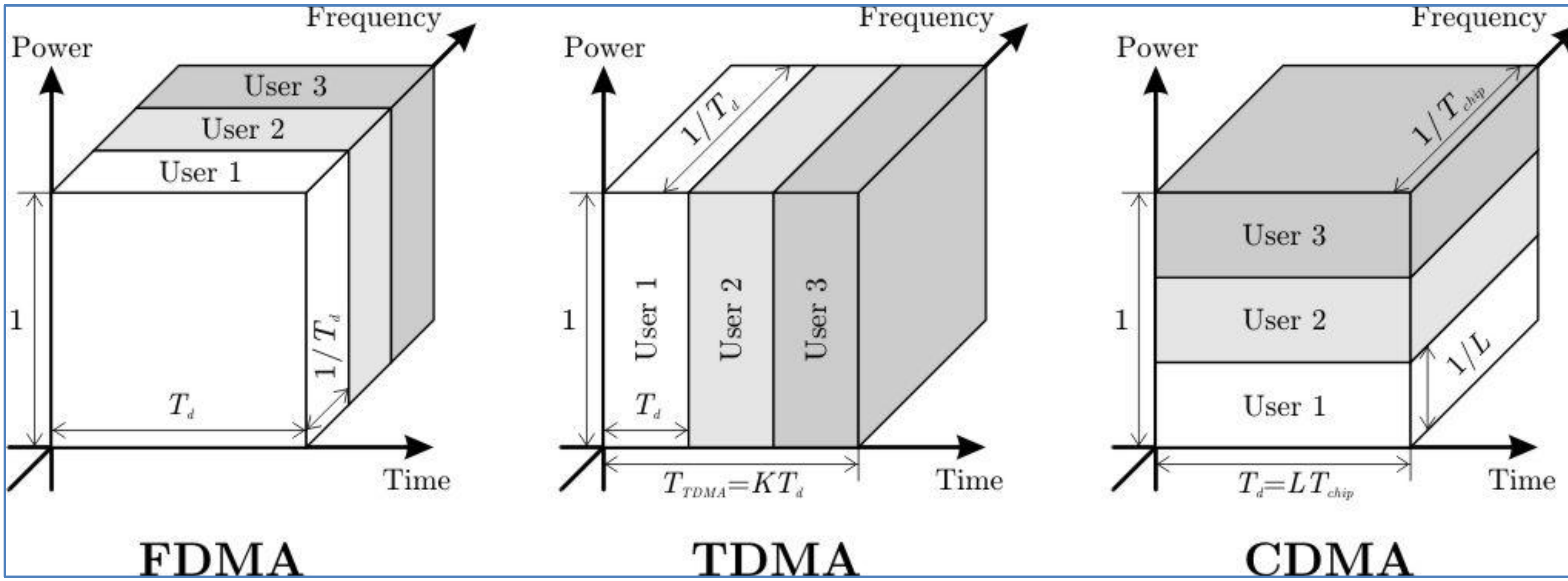
Multiple Access Techniques

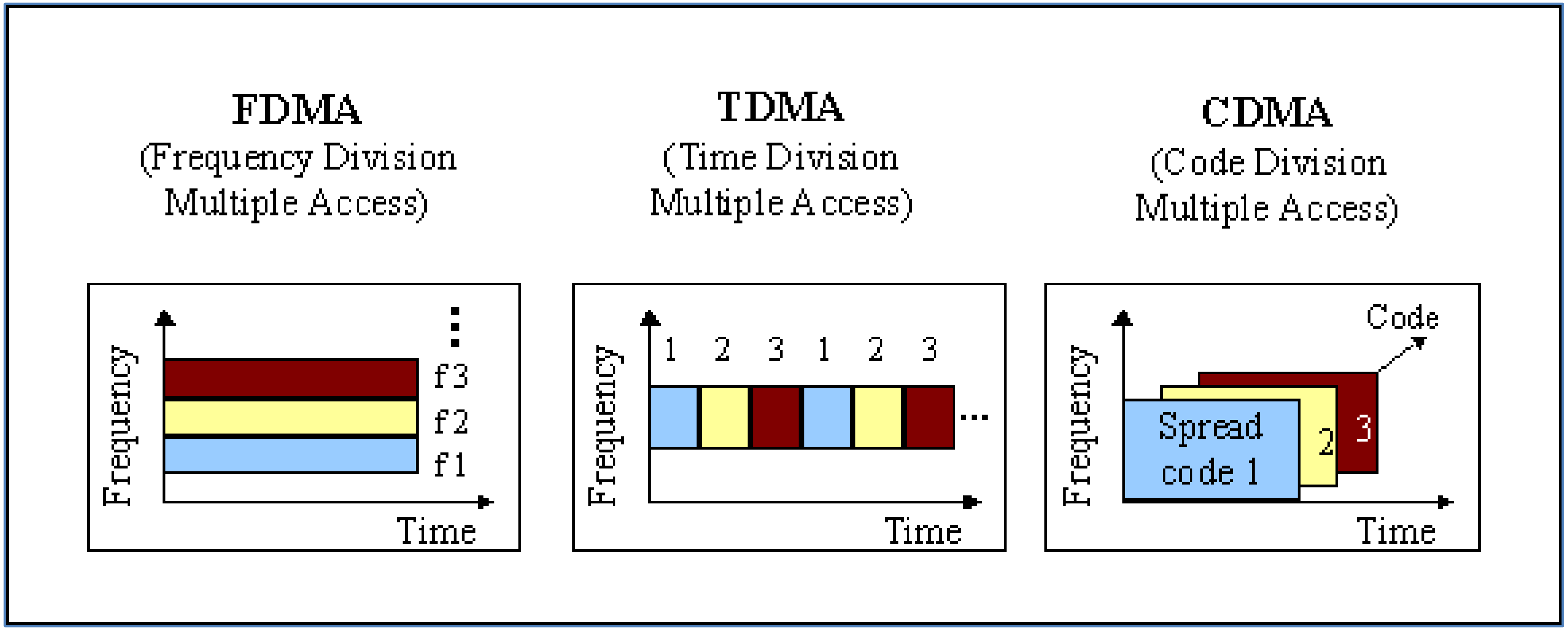
- In many wireless systems, multiple transmitters attempt to communicate with the same receiver.

- There are three widely-used policies:
  1. FDMA (Frequency Division Multiple Access)
  2. TDMA (Time Division Multiple Access)
  3. CDMA (Code Division Multiple Access)

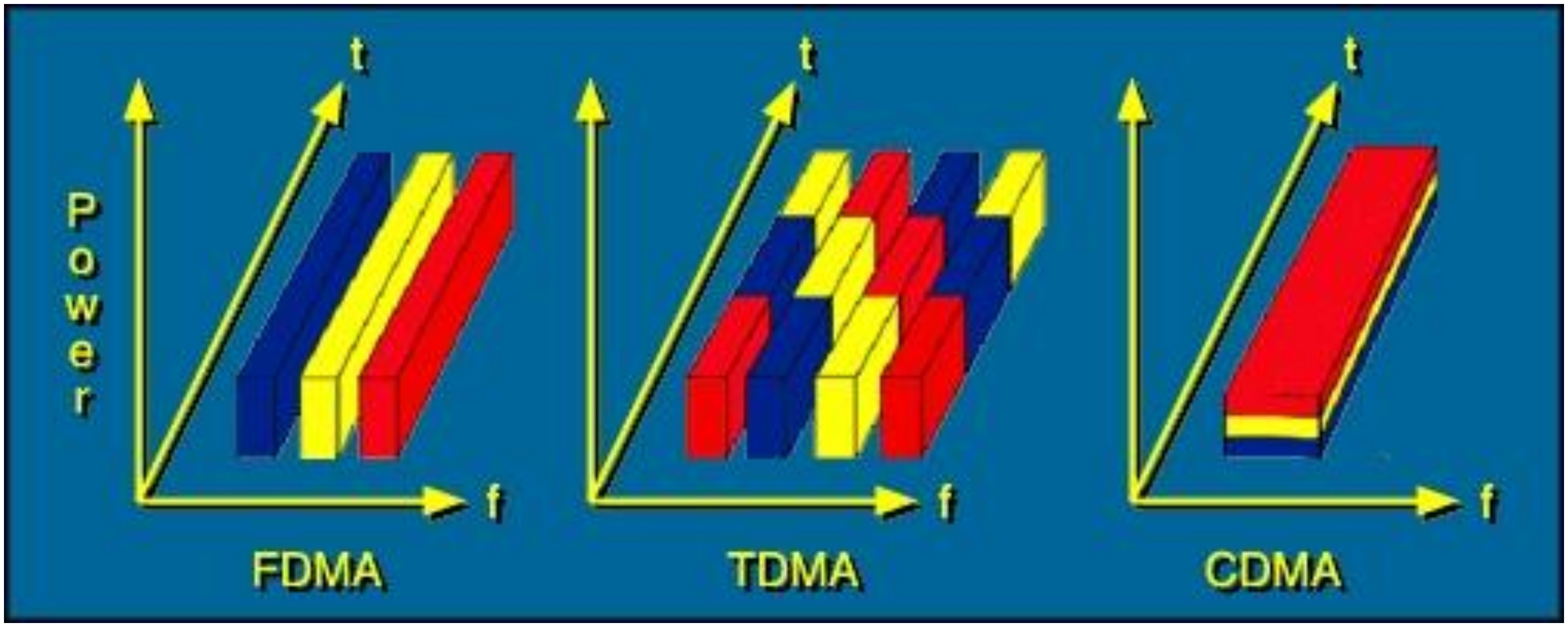
Multiple Access Techniques



Multiple Access Techniques

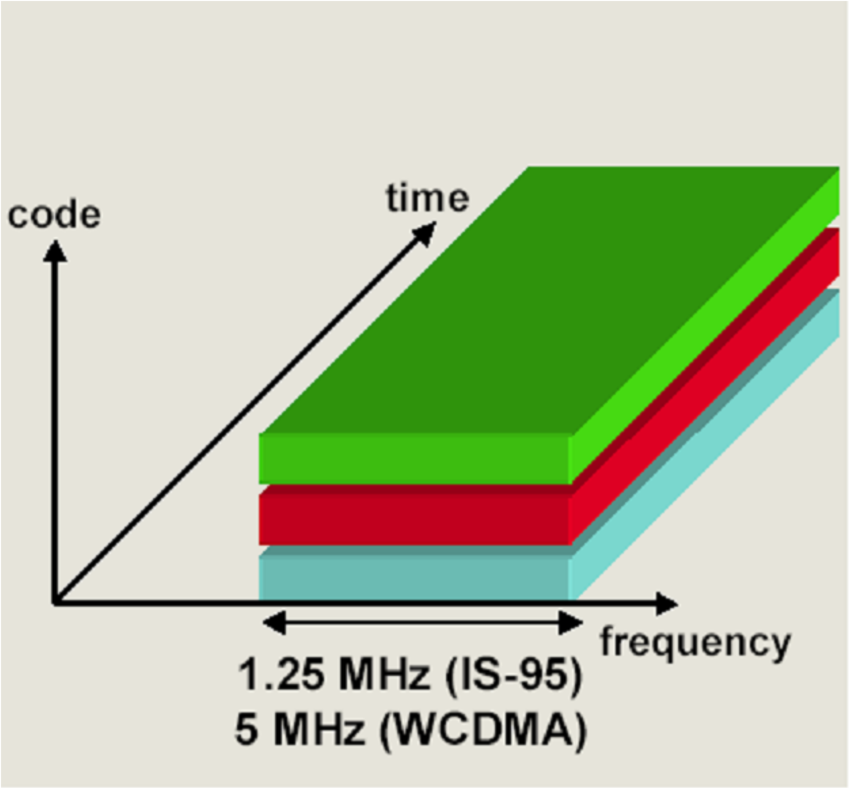


Multiple Access Techniques

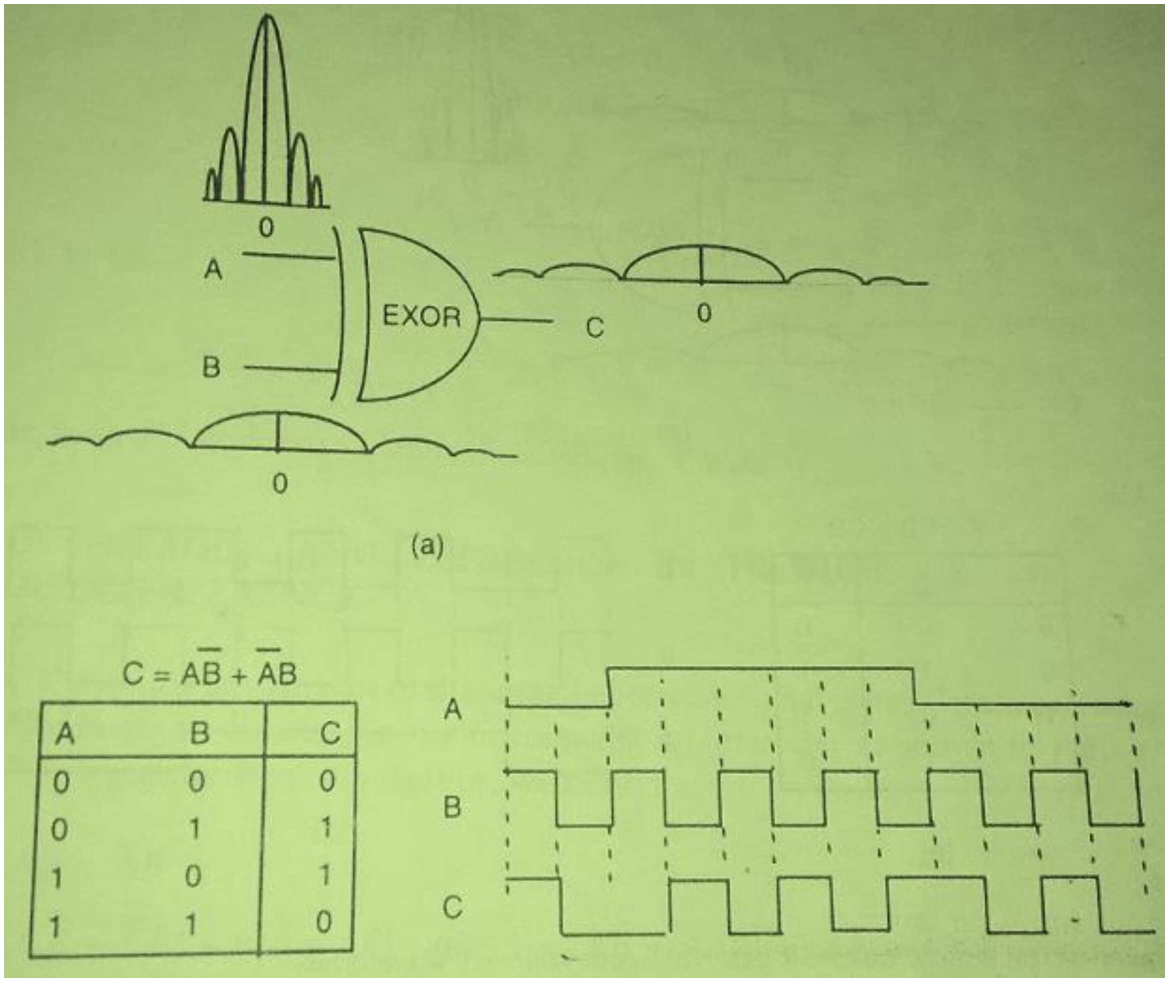


CDMA

- **Definition:**
- CDMA is a technology that allows multiple users to share the whole spectrum at all the time unlike TDMA and FDMA.
- CDMA has wider bandwidth compared to TDMA & FDMA.
- Requires digital transmission



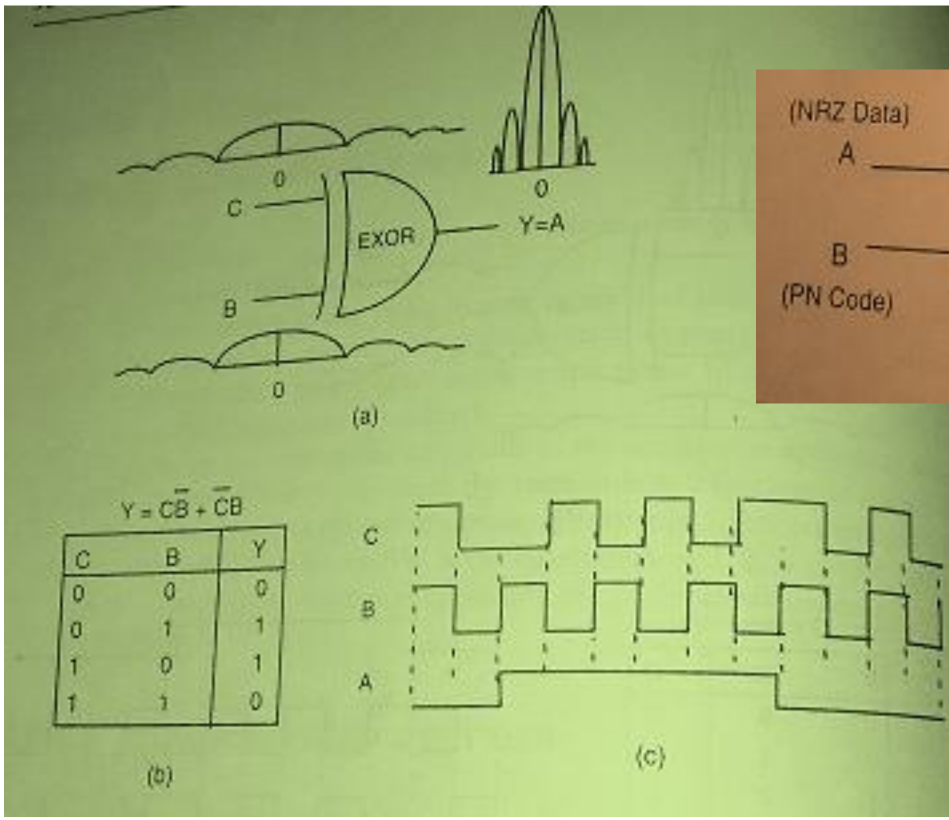
DS Spectrum Spreading

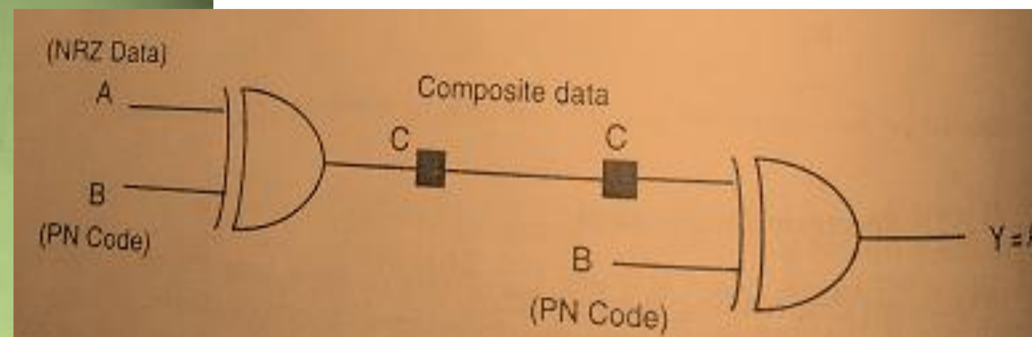


A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

DS-Direct Sequence

DS Spectrum Despreding





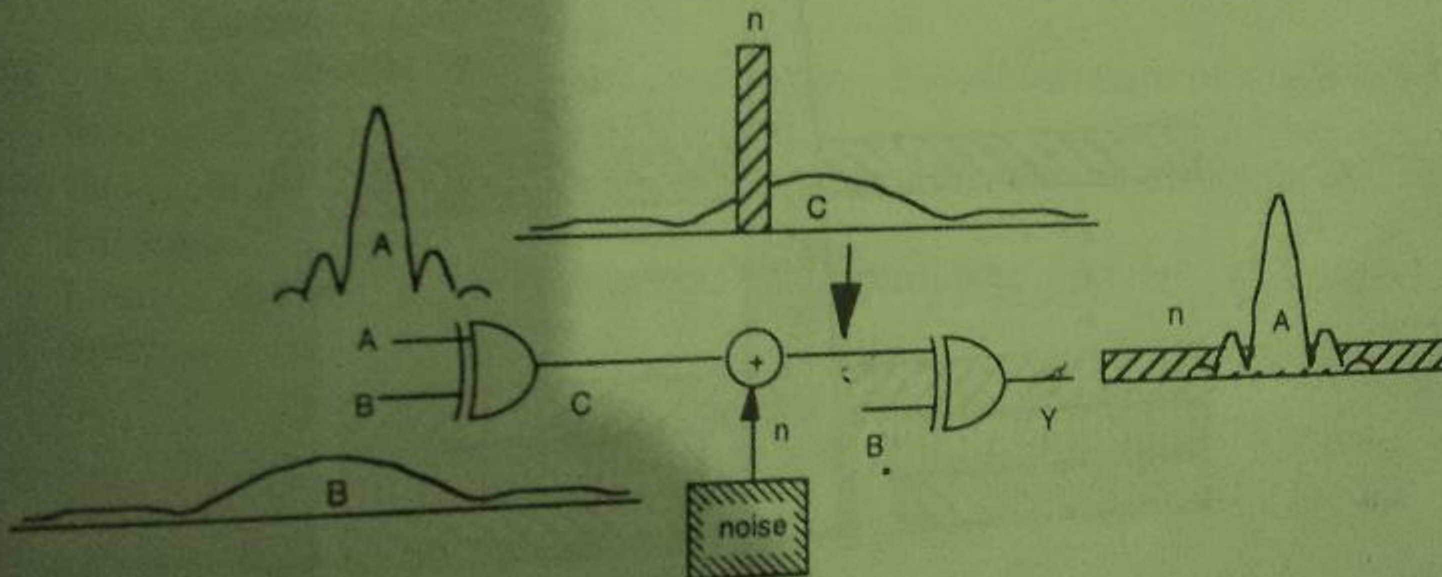
Spreading/Despreding w. Interference

$$C = A\overline{B} + \overline{A}B \tag{4.13}$$

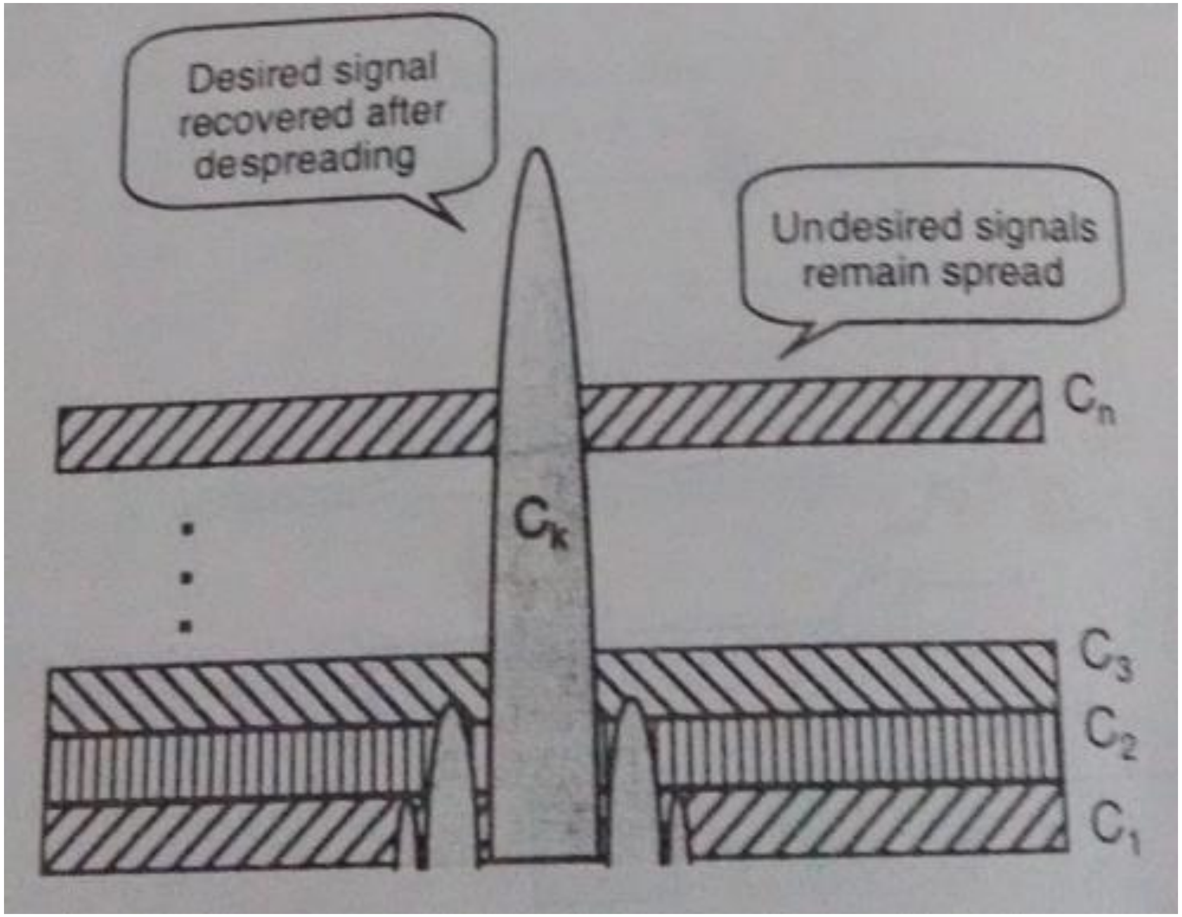
$$Y = (C\overline{B} + \overline{C}B) + (n\overline{B} + \overline{n}B) \quad \text{or} \quad Y = (A\overline{B} + \overline{A}B)\overline{B} + \overline{(A\overline{B} + \overline{A}B)}B + (n\overline{B} + \overline{n}B)$$

which reduces to

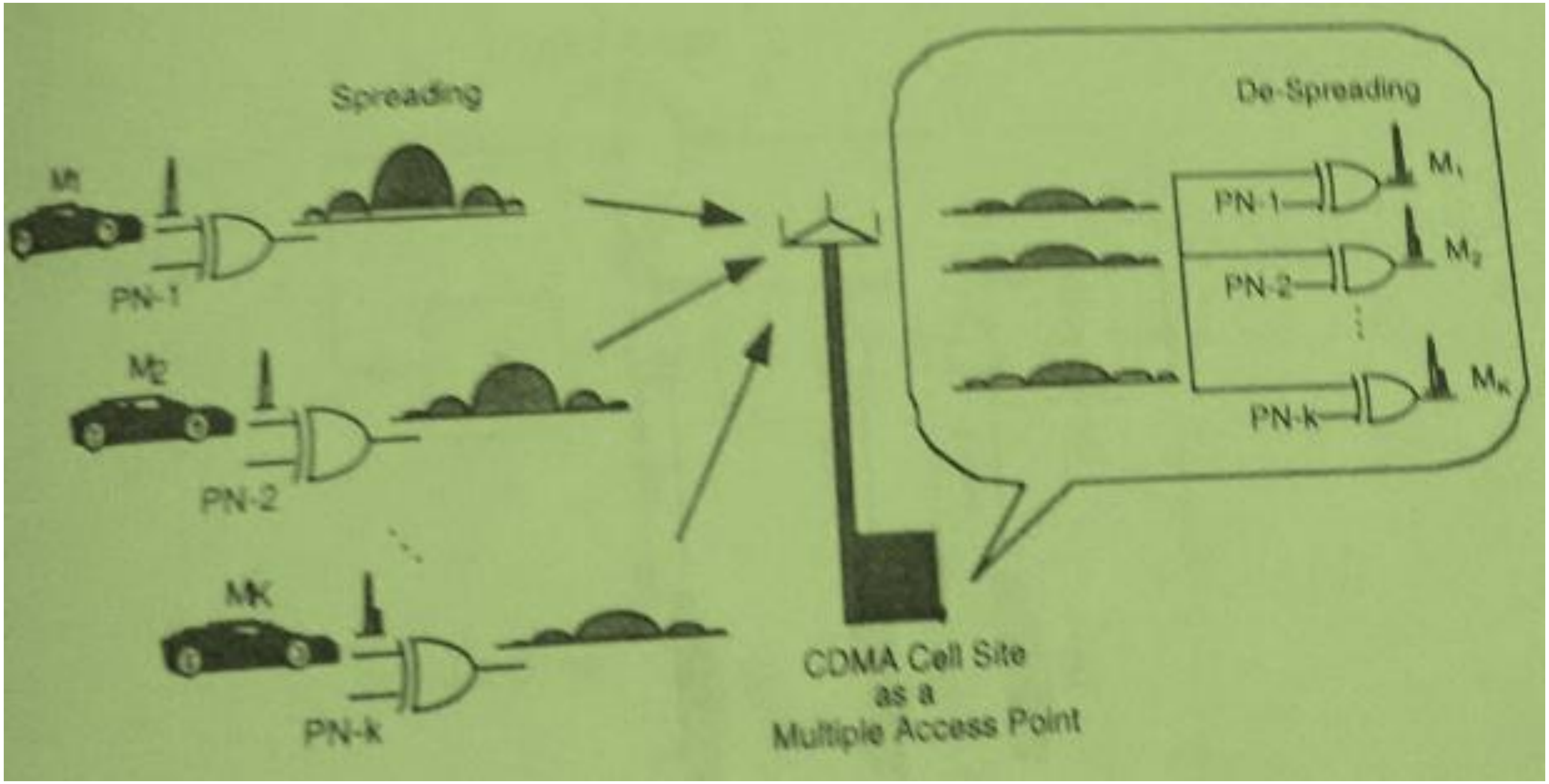
$$Y = A + (n\overline{B} + \overline{n}B) \tag{4.14}$$



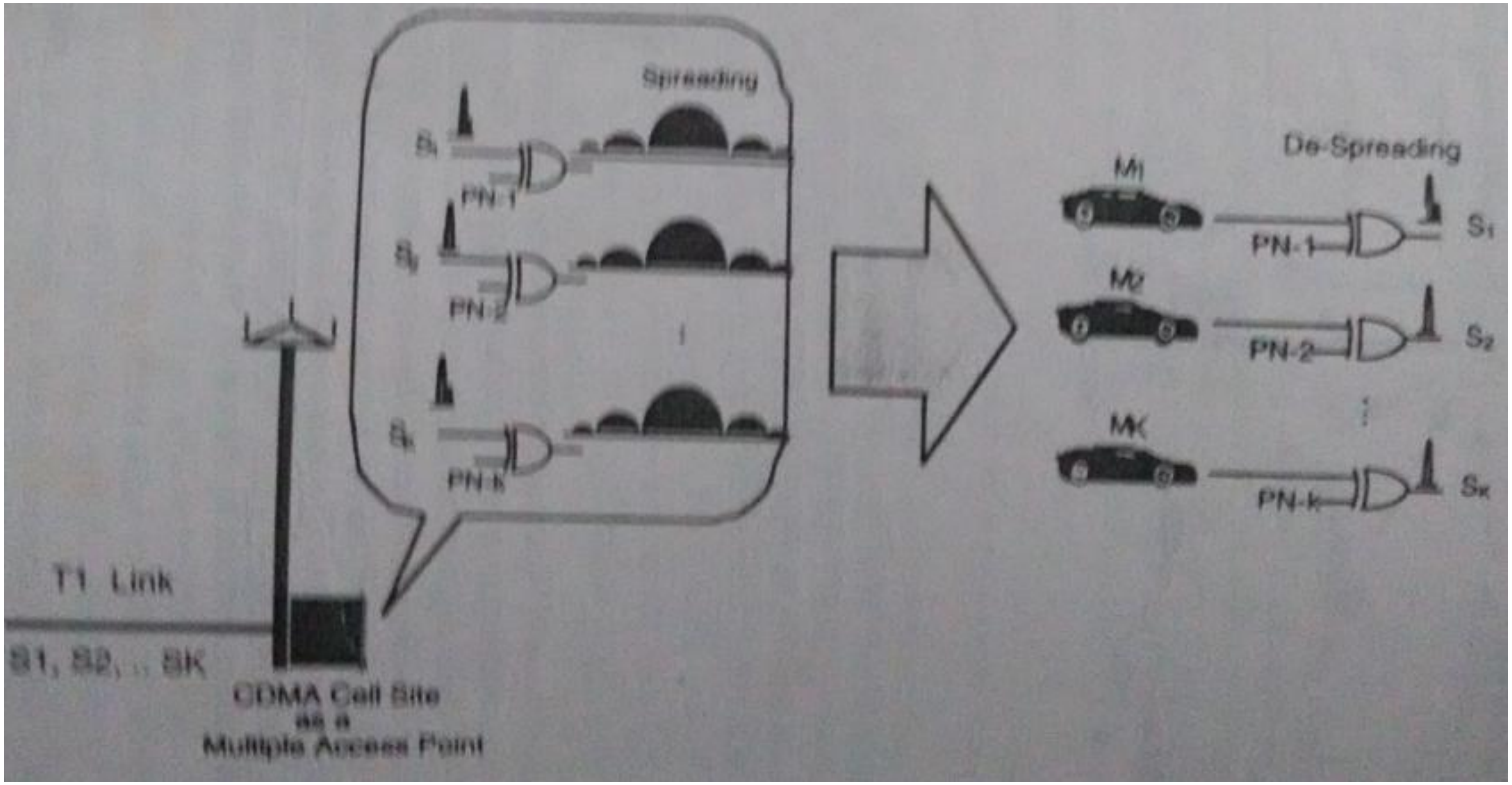
Recovering Desired Signal



Reverse Link DS-CDMA



Forward Link DS-CDMA



PN Sequence

- Pseudorandom Noise (PN) sequence widely used in digital communications
- Orthogonal codes for Cellular Communications
  - Have Zero Cross-correlation properties
- A pair of codes is said to be *orthogonal* if the cross-correlation is zero.

$$R_{xy}(0) = \sum_{i=0}^{m} x_i y_i = 0$$

PN Sequence

- x=0011, y=0110 (zero cross correlation)
- x=0101, y=0110 (zero cross correlation)
- x=0011, y=1100 (non zero)
- m-bit code has m-orthogonal codes
- An Orthogonal code has two basic properties
  - An equal number of 1s and 0s
  - Zero Cross-correlation property

Walsh Code

- Provides a complete set of orthogonal codes

$$\begin{array}{c|c} b & b \\ \hline b & \bar{b} \end{array} = \begin{array}{c|c} 1 & 1 \\ \hline 1 & 0 \end{array} \text{ or } \begin{array}{c|c} 0 & 0 \\ \hline 0 & 1 \end{array}$$

i.e. Code-1 = 1 1 or 0 0

Code-2 = 1 0 or 0 1

Walsh Code

$$\begin{array}{cc|cc} b & b & b & b \\ b & \bar{b} & b & \bar{b} \\ \hline b & b & \bar{b} & \bar{b} \\ b & \bar{b} & \bar{b} & b \end{array} = \begin{array}{cc|cc} 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 \\ \hline 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 1 \end{array} \text{ or } \begin{array}{cc|cc} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ \hline 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 \end{array}$$

where

Code-1 = 1 1 1 1 or 0 0 0 0

Code-2 = 1 0 1 0 or 0 1 0 1

Code-3 = 1 1 0 0 or 0 0 1 1

Code-4 = 1 0 0 1 or 0 1 1 0