ECS455: Chapter 4

Multiple Access

4.8 IS-95

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Tuesday	14:20-15:20
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Evolution of cellular network

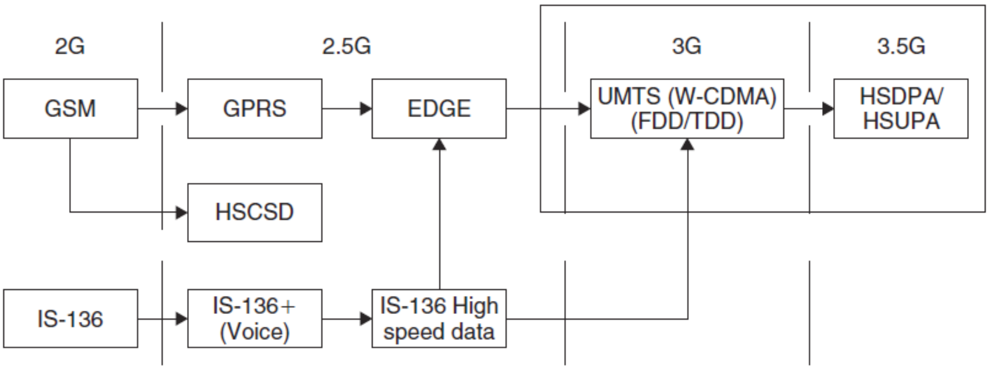


Figure 1.1 *Evolution of 2G networks based on TDMA technology.*

[Abu-Rgheff, 2007]

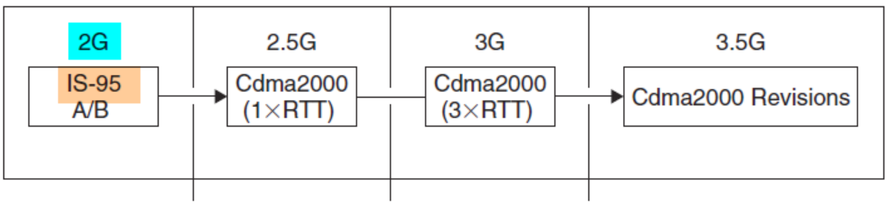


Figure 1.2 *Evolution of 2G networks based on CDMA technology.*

The first CDMA demo

[https://www.youtube.com/watch?v=1X9wWnnXcZc]

IS-95 System

- Based on direct sequence CDMA (**DS-CDMA**)
  - **First** CDMA-based digital cellular standard.
- The brand name for IS-95 is cdmaOne.
  - Also known as TIA-EIA-95.
- Proposed by Qualcomm in 1989 and adopted in 1993.
  - North America
- Replaced by IS-2000 (CDMA2000)
- **1.25 MHz Channel BW**
- 1.228 Mb/s chip rate
- WH sequences of order 64 are extensively used in the IS-95 system.
- Remarks
  - IS-95B = cdmaOne
    - Upgrade IS-95A
  - Can carry data at rates up to **14.4 kbps** for IS-95A and **115 kbps** for IS-95B.

Walsh and WH Sequences of order 64

as indexed in IS-95

W_0	H_0	0000000000000000	0000000000000000	0000000000000000	0000000000000000
W_{63}	H_1	0101010101010101	0101010101010101	0101010101010101	0101010101010101
W_{31}	H_2	0011001100110011	0011001100110011	0011001100110011	0011001100110011
W_{32}	H_3	0110011001100110	0110011001100110	0110011001100110	0110011001100110
W_{15}	H_4	0000111100001111	0000111100001111	0000111100001111	0000111100001111
W_{48}	H_5	0101101001011010	0101101001011010	0101101001011010	0101101001011010
W_{16}	H_6	0011110000111100	0011110000111100	0011110000111100	0011110000111100
W_{47}	H_7	0110100101101001	0110100101101001	0110100101101001	0110100101101001
W_7	H_8	0000000011111111	0000000011111111	0000000011111111	0000000011111111
W_{56}	H_9	0101010110101010	0101010110101010	0101010110101010	0101010110101010
W_{24}	H_{10}	0011001111001100	0011001111001100	0011001111001100	0011001111001100
W_{39}	H_{11}	0110011010011001	0110011010011001	0110011010011001	0110011010011001
W_8	H_{12}	0000111111110000	0000111111110000	0000111111110000	0000111111110000
W_{55}	H_{13}	0101101010100101	0101101010100101	0101101010100101	0101101010100101
W_{23}	H_{14}	0011110011000011	0011110011000011	0011110011000011	0011110011000011
W_{40}	H_{15}	0110100110010110	0110100110010110	0110100110010110	0110100110010110
W_3	H_{16}	0000000000000000	1111111111111111	0000000000000000	1111111111111111
W_{60}	H_{17}	0101010101010101	1010101010101010	0101010101010101	1010101010101010
W_{28}	H_{18}	0011001100110011	1100110011001100	0011001100110011	1100110011001100
W_{35}	H_{19}	0110011001100110	1001100110011001	0110011001100110	1001100110011001
W_{12}	H_{20}	0000111100001111	1111000011110000	0000111100001111	1111000011110000
W_{51}	H_{21}	0101101001011010	1010010110100101	0101101001011010	1010010110100101
W_{19}	H_{22}	0011110000111100	1100001111000011	0011110000111100	1100001111000011
W_{44}	H_{23}	0110100101101001	1001011010010110	0110100101101001	1001011010010110
W_4	H_{24}	0000000011111111	1111111100000000	0000000011111111	1111111100000000
W_{59}	H_{25}	0101010110101010	1010101001010101	0101010110101010	1010101001010101
W_{27}	H_{26}	0011001111001100	1100110000110011	0011001111001100	1100110000110011
W_{36}	H_{27}	0110011010011001	1001100101100110	0110011010011001	1001100101100110
W_{11}	H_{28}	0000111111110000	1111000000001111	0000111111110000	1111000000001111
W_{52}	H_{29}	0101101010100101	1010010101011010	0101101010100101	1010010101011010
W_{20}	H_{30}	0011110011000011	1100001100111100	0011110011000011	1100001100111100
W_{43}	H_{31}	0110100110010110	1001011001101001	0110100110010110	1001011001101001
W_1	H_{32}	0000000000000000	0000000000000000	1111111111111111	1111111111111111
W_{62}	H_{33}	0101010101010101	0101010101010101	1010101010101010	1010101010101010
W_{30}	H_{34}	0011001100110011	0011001100110011	1100110011001100	1100110011001100
W_{33}	H_{35}	0110011001100110	0110011001100110	1001100110011001	1001100110011001
W_{14}	H_{36}	0000111100001111	0000111100001111	1111000011110000	1111000011110000
W_{49}	H_{37}	0101101001011010	0101101001011010	1010010110100101	1010010110100101
W_{17}	H_{38}	0011110000111100	0011110000111100	1100001111000011	1100001111000011
W_{46}	H_{39}	0110100101101001	0110100101101001	1001011010010110	1001011010010110
W_6	H_{40}	0000000011111111	0000000011111111	1111111100000000	1111111100000000
W_{57}	H_{41}	0101010110101010	0101010110101010	1010101001010101	1010101001010101
W_{25}	H_{42}	0011001111001100	0011001111001100	1100110000110011	1100110000110011
W_{38}	H_{43}	0110011010011001	0110011010011001	1001100101100110	1001100101100110
W_9	H_{44}	0000111111110000	0000111111110000	1111000000001111	1111000000001111
W_{54}	H_{45}	0101101010100101	0101101010100101	1010010101011010	1010010101011010
W_{22}	H_{46}	0011110011000011	0011110011000011	1100001100111100	1100001100111100
W_{41}	H_{47}	0110100110010110	0110100110010110	1001011001101001	1001011001101001
W_2	H_{48}	0000000000000000	1111111111111111	1111111111111111	0000000000000000
W_{61}	H_{49}	0101010101010101	1010101010101010	1010101010101010	0101010101010101
W_{29}	H_{50}	0011001100110011	1100110011001100	1100110011001100	0011001100110011
W_{34}	H_{51}	0110011001100110	1001100110011001	1001100110011001	0110011001100110
W_{13}	H_{52}	0000111100001111	1111000011110000	1111000011110000	0000111100001111
W_{50}	H_{53}	0101101001011010	1010010110100101	1010010110100101	0101101001011010
W_{18}	H_{54}	0011110000111100	1100001111000011	1100001111000011	0011110000111100
W_{45}	H_{55}	0110100101101001	1001011010010110	1001011010010110	0110100101101001
W_5	H_{56}	0000000011111111	1111111100000000	1111111100000000	0000000011111111
W_{58}	H_{57}	0101010110101010	1010101001010101	1010101001010101	0101010110101010
W_{26}	H_{58}	0011001111001100	1100110000110011	1100110000110011	0011001111001100
W_{37}	H_{59}	0110011010011001	1001100101100110	1001100101100110	0110011010011001
W_{10}	H_{60}	0000111111110000	1111000000001111	1111000000001111	0000111111110000
W_{53}	H_{61}	0101101010100101	1010010101011010	1010010101011010	0101101010100101
W_{21}	H_{62}	0011110011000011	1100001100111100	1100001100111100	0011110011000011
W_{42}	H_{63}	0110100110010110	1001011001101001	1001011001101001	0110100110010110

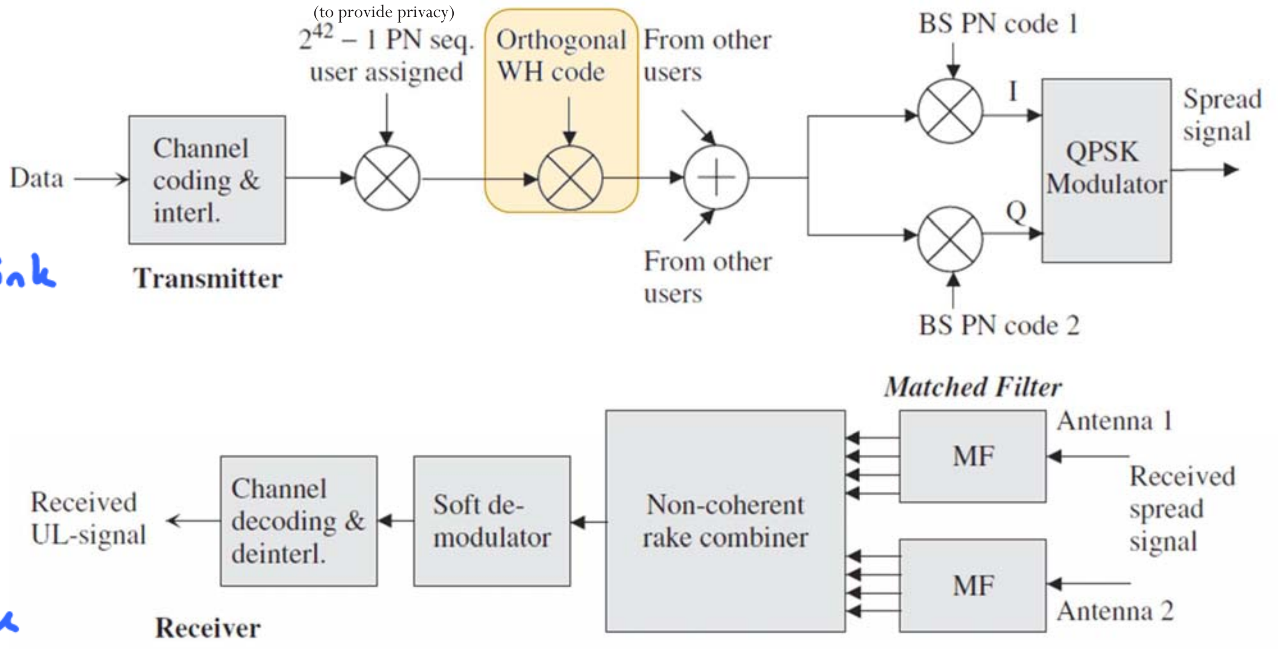
[Lee and Miller, 1998, Table 5.8]

WH Sequences in IS-95

- **Forward link (Downlink)**
  - QPSK with a chip rate of 1,228,800 per second.
  - The **multiple access scheme** is accomplished by the use of 64-bit spreading orthogonal **WH sequences** (functions).
    - The (coded and interleaved) traffic channel signal symbols are multiplied with distinct repeating WH sequences that are assigned to each channel for the duration of the call.
  - Every base stations is synchronized with a GPS receiver so transmissions are tightly controlled in time.
- **Reverse link (Uplink)**
  - The WH sequences are employed as an **orthogonal modulation code**, which depends only on the data pattern (not channel), forming a 64-ary orthogonal modulation system.

IS-95 base station transceiver

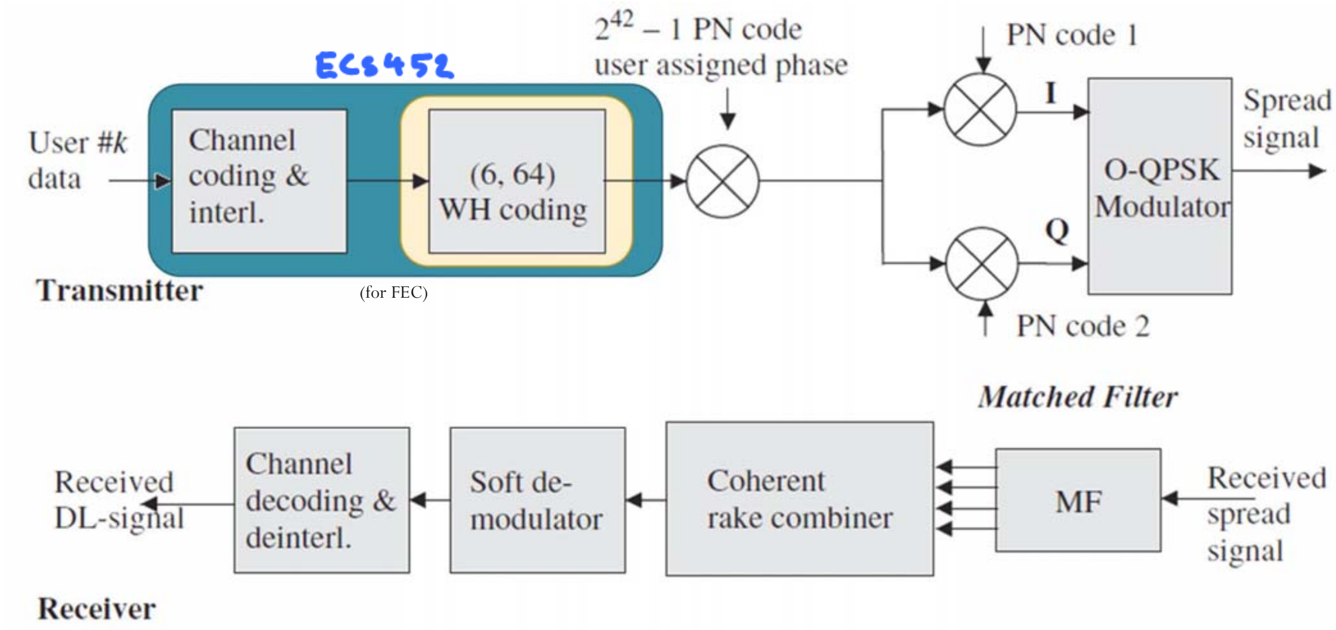
Downlink



Uplink

[Fazel & Kaiser, 2008, Fig. 1-13]

IS-95 terminal station transceiver



[Fazel & Kaiser, 2008, Fig. 1-14]

IS-95

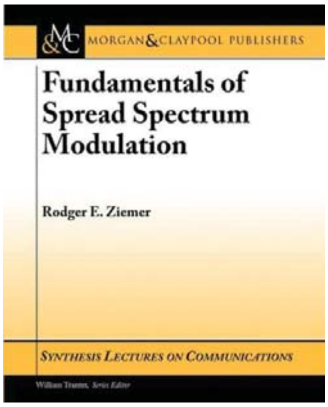
- The reverse link uplink is subject to near-far effects.
- More powerful **error correction** is employed on the reverse link.
  - A rate 1/2 constraint length 9 convolutional code followed by an interleaver on the forward channel
  - A rate 1/3 constraint length 9 convolutional code followed by an interleaver is used on the reverse link.
    - Also with WH(6,64)
  - Interleaving is utilized to avoid large burst errors, which can be very detrimental to convolutional codes.
- **Power control**.
  - Use a subchannel on the forward link
  - Every 1.25 ms the base station receiver estimates the signal strength of the mobile unit.
  - If it is too high, the base transmits a 1 on the subchannel. If it is too low, it transmits a 0.
  - In this way, the mobile station adjusts its power every 1.25 ms as necessary so as to reduce interference to other users.

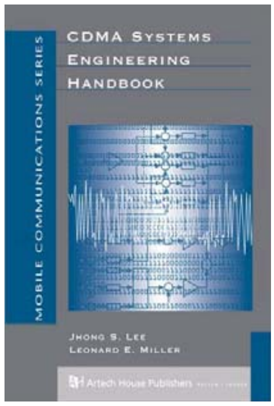
IS-95: Increased Spectral Efficiency

- Improve frequency reuse.
  - Narrow-band systems cannot use the same transmission frequency in adjacent cells because of the potential for interference.
  - CDMA has inherent resistance to interference.
    - Cluster size (N) = 1 (theoretically)
    - Although users from adjacent cells will contribute to interference level, their contribution will be significantly less than the interference from the same cell users.
    - Frequency reuse efficiency increases by a factor of 4 to 6.
- When used to transmit voice signals, CDMA systems may exploit the fact that voice activity typically lies at somewhat less than 40%, thus reducing the amount of interference to 40% of its original value.

References

- J. S. Lee and L. E. Miller, **CDMA Systems Engineering Handbook**, 1998.
  - Chapter 4 and 5
- R.E. Ziemer, **Fundamentals of Spread Spectrum Modulation**, 2007
  - Chapter 4





[TK5103.45 L44 1998]