



ECS455: Chapter 4

Multiple Access

4.8 IS-95



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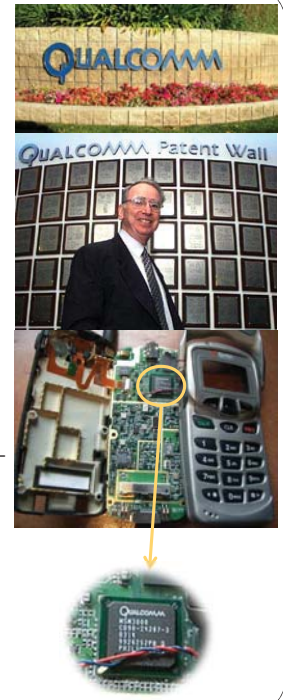
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Wednesday 14:20-15:20
Friday 9:15-10:15

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IS-95 System cdmaOne

- Based on direct sequence CDMA (DS-SS-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.



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Evolution of cellular network

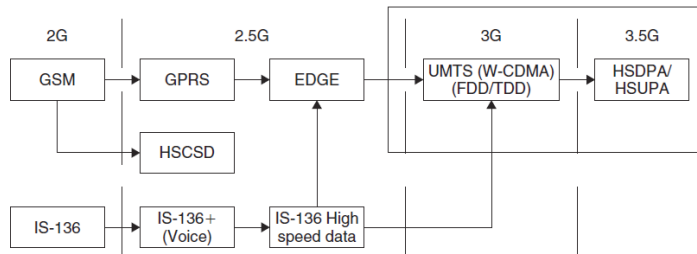


Figure 1.1 Evolution of 2G networks based on TDMA technology.

[Abu-Rgheff, 2007]

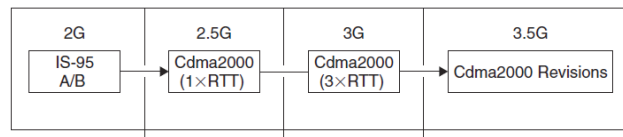


Figure 1.2 Evolution of 2G networks based on CDMA technology.

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Walsh and WH Sequences of order 64 as indexed in IS-95

W_0^*	H_0	0000000000000000 0000000000000000 0000000000000000 0000000000000000	W_{32}^*	H_{32}	0000000000000000 0000000000000000 1111111111111111 1111111111111111
W_1^*	H_1	0101010101010101 0101010101010101 0101010101010101 0101010101010101	W_{33}^*	H_{33}	0101010101010101 0101010101010101 1010101010101010 1010101010101010
W_2^*	H_2	0011001100110011 0011001100110011 0011001100110011 0011001100110011	W_{34}^*	H_{34}	0011001100110011 0011001100110011 1001100110011001 1001100110011001
W_3^*	H_3	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{35}^*	H_{35}	0110011001100110 0110011001100110 1001100110011001 1001100110011001
W_4^*	H_4	0000111000011111 0000111000011111 0000111000011111 0000111000011111	W_{36}^*	H_{36}	0000111000011111 0000111000011111 1111111111111111 1111111111111111
W_5^*	H_5	0101101001010101 0101101001010101 0101101001010101 0101101001010101	W_{37}^*	H_{37}	0101101001010101 0101101001010101 1010101010101010 1010101010101010
W_6^*	H_6	0011100001111000 0011100001111000 0011100001111000 0011100001111000	W_{38}^*	H_{38}	0011100001111000 0011100001111000 1000001110000011 1000001110000011
W_7^*	H_7	0110100101010001 0110100101010001 0110100101010001 0110100101010001	W_{39}^*	H_{39}	0110100101010001 0110100101010001 1001100110011001 1001100110011001
W_8^*	H_8	0000000011111111 0000000011111111 0000000011111111 0000000011111111	W_{40}^*	H_{40}	0000000011111111 0000000011111111 1111111111111111 1111111111111111
W_9^*	H_9	0101010101010101 0101010101010101 0101010101010101 0101010101010101	W_{41}^*	H_{41}	0101010101010101 0101010101010101 1010101010101010 1010101010101010
W_{10}^*	H_{10}	0011000111000100 0011000111000100 0011000111000100 0011000111000100	W_{42}^*	H_{42}	0011000111000100 0011000111000100 1000100110011001 1000100110011001
W_{11}^*	H_{11}	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{43}^*	H_{43}	0110011001100110 0110011001100110 1001100110011001 1001100110011001
W_{12}^*	H_{12}	0000111111110000 0000111111110000 0000111111110000 0000111111110000	W_{44}^*	H_{44}	0000111111110000 0000111111110000 1111111111111111 1111111111111111
W_{13}^*	H_{13}	0101101010100101 0101101010100101 0101101010100101 0101101010100101	W_{45}^*	H_{45}	0101101010100101 0101101010100101 1010101010101010 1010101010101010
W_{14}^*	H_{14}	0011100110001011 0011100110001011 0011100110001011 0011100110001011	W_{46}^*	H_{46}	0011100110001011 0011100110001011 1000001110000011 1000001110000011
W_{15}^*	H_{15}	0101010101010101 0101010101010101 0101010101010101 0101010101010101	W_{47}^*	H_{47}	0101010101010101 0101010101010101 1001100110011001 1001100110011001
W_{16}^*	H_{16}	0000000000000000 1111111111111111 0000000000000000 1111111111111111	W_{48}^*	H_{48}	0000000000000000 1111111111111111 1111111111111111 0000000000000000
W_{17}^*	H_{17}	0101010101010101 0101010101010101 0101010101010101 0101010101010101	W_{49}^*	H_{49}	0101010101010101 0101010101010101 1010101010101010 1010101010101010
W_{18}^*	H_{18}	0011000111000100 0011000111000100 0011000111000100 0011000111000100	W_{50}^*	H_{50}	0011000111000100 0011000111000100 1000100110011001 1000100110011001
W_{19}^*	H_{19}	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{51}^*	H_{51}	0110011001100110 0110011001100110 1001100110011001 1001100110011001
W_{20}^*	H_{20}	0000111111110000 0000111111110000 0000111111110000 0000111111110000	W_{52}^*	H_{52}	0000111111110000 0000111111110000 1111111111111111 1111111111111111
W_{21}^*	H_{21}	0101101010100101 0101101010100101 0101101010100101 0101101010100101	W_{53}^*	H_{53}	0101101010100101 0101101010100101 1010101010101010 1010101010101010
W_{22}^*	H_{22}	0011100011100010 0011100011100010 0011100011100010 0011100011100010	W_{54}^*	H_{54}	0011100011100010 0011100011100010 1000001110000011 1000001110000011
W_{23}^*	H_{23}	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{55}^*	H_{55}	0110011001100110 0110011001100110 1001100110011001 1001100110011001
W_{24}^*	H_{24}	0000111111110000 0000111111110000 0000111111110000 0000111111110000	W_{56}^*	H_{56}	0000111111110000 0000111111110000 1111111111111111 1111111111111111
W_{25}^*	H_{25}	0101010101010101 0101010101010101 0101010101010101 0101010101010101	W_{57}^*	H_{57}	0101010101010101 0101010101010101 1010101010101010 1010101010101010
W_{26}^*	H_{26}	0011000111000100 0011000111000100 0011000111000100 0011000111000100	W_{58}^*	H_{58}	0011000111000100 0011000111000100 1000100110011001 1000100110011001
W_{27}^*	H_{27}	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{59}^*	H_{59}	0110011001100110 0110011001100110 1001100110011001 1001100110011001
W_{28}^*	H_{28}	0000111111110000 0000111111110000 0000111111110000 0000111111110000	W_{60}^*	H_{60}	0000111111110000 0000111111110000 1111111111111111 1111111111111111
W_{29}^*	H_{29}	0101101010100101 0101101010100101 0101101010100101 0101101010100101	W_{61}^*	H_{61}	0101101010100101 0101101010100101 1010101010101010 1010101010101010
W_{30}^*	H_{30}	0011100011100010 0011100011100010 0011100011100010 0011100011100010	W_{62}^*	H_{62}	0011100011100010 0011100011100010 1000001110000011 1000001110000011
W_{31}^*	H_{31}	0110011001100110 0110011001100110 0110011001100110 0110011001100110	W_{63}^*	H_{63}	0110011001100110 0110011001100110 1001100110011001 1001100110011001

[Lee and Miller, 1998, Table 5.8]

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WH Sequences in IS-95

• Forward link (Downlink)

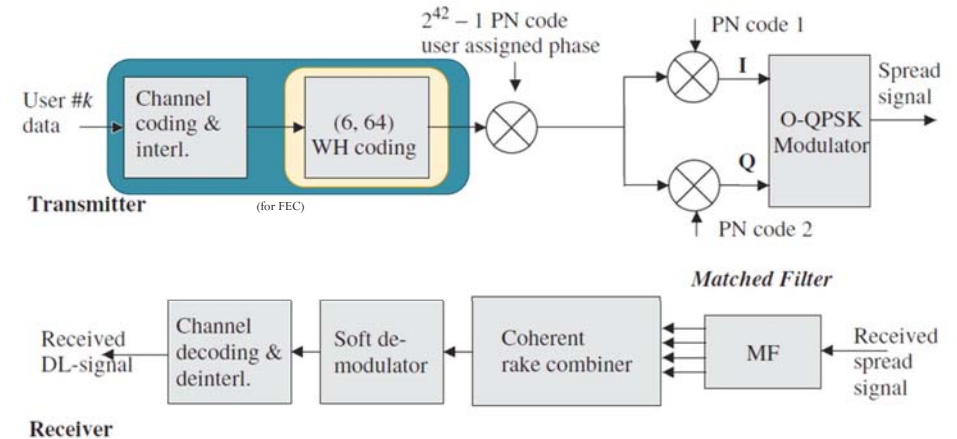
- QPSK with a chip rate of 1,228,800 per second.
- The **multiple access scheme** is accomplished by the use of 64-bit spreading orthogonal **WH sequences** (functions).
 - The (coded and interleaved) traffic channel signal symbols are multiplied with distinct repeating WH sequences that are assigned to each channel for the duration of the call.
- Every base station 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.

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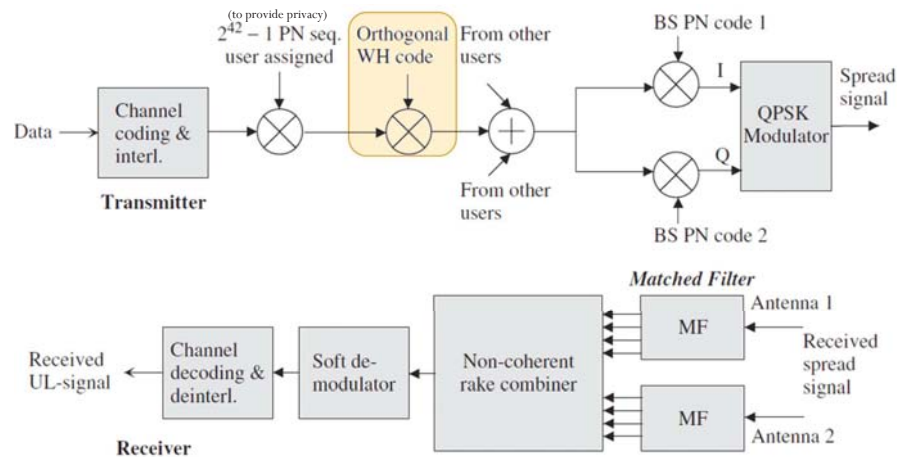
IS-95 terminal station transceiver



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

IS-95 base station transceiver



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

IS-95

- The **reverse link** 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.

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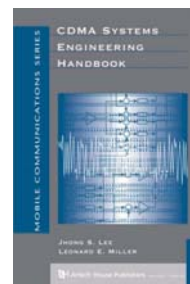
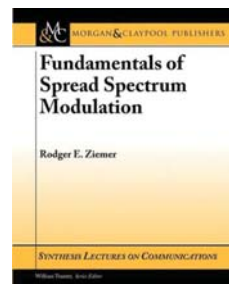
IS-95: Increased Spectral Efficiency

- 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.

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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]

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