SoA on CDMA multiple-access interference mitigation technology

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UALG
MESTRADO EM ENGENHARIA INFORMÁTICA

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Screening Process

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- Because the codes are orthogonal, it's possible to retreive the original message of each user

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MAI (Multiple-Access Interference)

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Near-Far problem

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- Loss of orthogonality occurrs.

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Near-Far problem (example)

User chips:
User 1: $[+1, -1, +1, +1]$
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- This might actually result in $(2 + 0.1 - 5) = -2.9$ at the receiver.

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- It results in $(1 + 1 + 1) = 3$.

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Multipath channel distortion

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- This interacts with the signals and causes interferance.

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- Waves become higher frequency in front of the transmitter.
- Waves become lower frequency behind the transmitter.
- This creates a continuously changing phase shift.
- As the phase keeps changing, it seems as if the signal is "spinning" to the receiver.

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- Usually extremely easy to make work flawlessly.

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- Users have different locations, velocities and different amplitude transmitters.
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- Data is completely incoherent and impossible to decode by the central station.
- Core limitation of CDMA, where MAI comes into play very destructively.

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Solutions

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CDMA Rake

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- The PN code is uniformly random in such a way that the average is 0, as each bit is encoded between 1 or -1.

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$$C_i = (C_{i\cdot n}, C_{i\cdot n+1}, \ldots, C_{(i+1)\cdot n-1})$$

and a 0 data bit will be encoded to $-C_i$. The next data bit sent, will already be encoded into C_{i+1}, and so on and so forth.

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- Each "echo" has a different weight proportional to it's amplitude and correlation (probability of it being of the same signal).
- Finally the combiner takes each "echo" and does their weighted sum.

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- Diminishes the doppler effect as it tracks out of phase and lower amplitude replicas.

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Space-time coded (STC) CDMA systems

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Space-time coded (STC) CDMA systems

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- Introduces structured redundancy in both space and time.
- The redundancy is structured in such a way that we get signal gain by listening to more antennas.
- We can also decode messages when other antennas are obstructed

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example

	Antenna 1	**Antenna 2**
$t = 0$	c_0	c_1
$t = 1$	c_1	$-c_0$

Table 1: Individual antenna transmission at time t with 2 antennas.

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- The reason for the negation is to make the sending space orthogonal.
- If each user has a multi-antenna system, STC CDMA neutralizes the near-far problem.

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Multiuser detectors (MUD)

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- The algorithm is extremely inefficient ($O(2^k)$, when k is the number of users transmitting simultaneously.

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- They mitigate the near-far problem.
- They mitigate problems that come with having quasi-orthogonal codes (PN codes).

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Common downlink solution

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- STC can also be used as long as the station has multiple antennas, in order for users to receive higher fidelity data.

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- Users with STC CDMA systems (multi antennas) whenever possible.
- Users and (especially) stations employing MUDs.
- Power Control to further mitigate the near-far problem.

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Conclusions

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- For downlink transmission there is essentially no transmission issues, using welsh codes to generate orthogonal chip vectors.

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