Intelligent Antennas and BLAST for 3G-CDMA



Mobility Solutions

Join Lucent on the Road to Higher Spectral Efficiency

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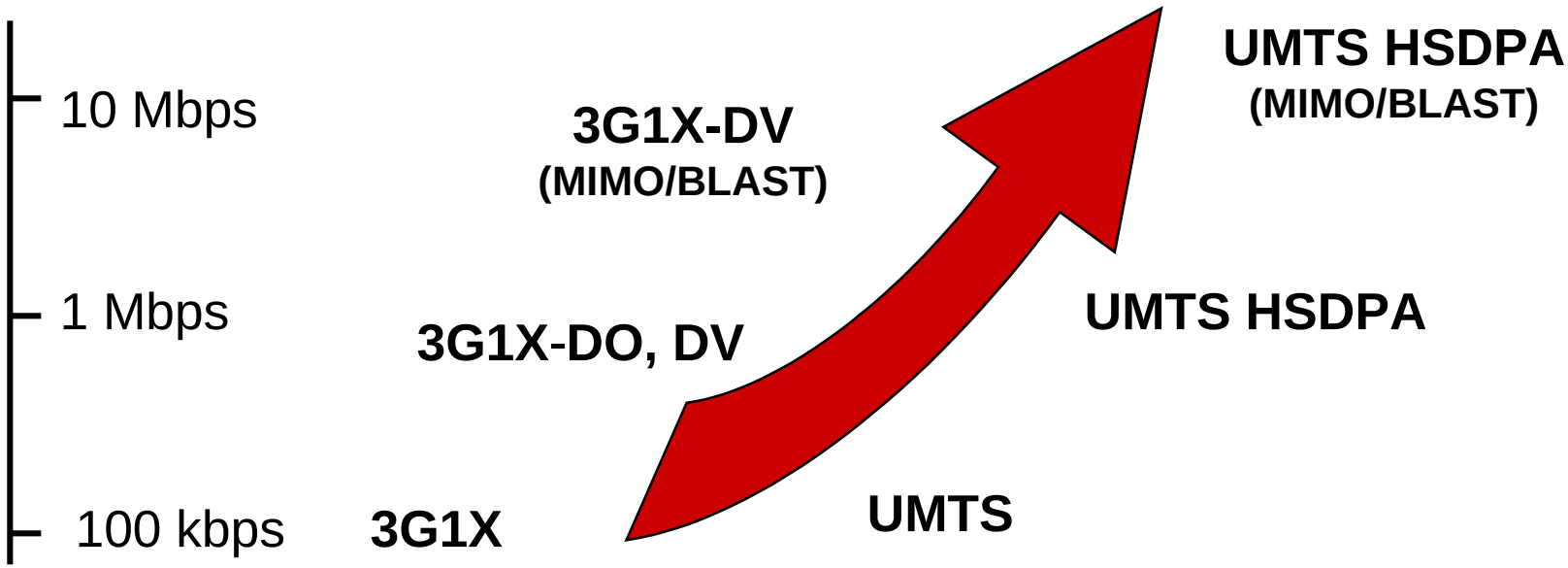
Data Technology Evolution



- **Rate-adaptive shared channels provide first access to market for high data-rates.**
- **3G-CDMA provides a smooth migration path to these high rates. All evolutions supported by Lucent products.**
- **Migration path includes hybrid-ARQ and MIMO (Multiple-Input Multiple-Output)/BLAST extensions**
- **Intelligent Antenna technology will be applied to all evolution steps**

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Why do we need high data-rates?

Consumer Gaming
High-Resolution video







Secure Mobile VPN, Enterprise Apps

Free up voice capacity

- **3G promises very high data-rates enabling ubiquitous connectivity and substantially improving the user experience.**
- **This stresses the network through severe cell-breathing and requires a spectrally efficient air-interface.**

Intelligent antennas and BLAST increase data rate much more efficiently than increasing the constellation size.

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Lucent Intelligent Antenna Solution

- ***Cell capacity and data throughput*** **are determined by** ***channel quality*** **and** ***interference level***

- **Lucent's Intelligent Antenna technology uses** ***multiple antennas*** **and** ***extensive signal processing*** **to obtain:**
  - **significant improvement in channel performance**
  - **reduction in interference level**

The system level result is ***increased capacity***.

- **Phased approach will add Multiple Antennas:**
  - **initially at the basestation (Intelligent Antenna technology)**
  - **finally at the terminal (MIMO/BLAST)**

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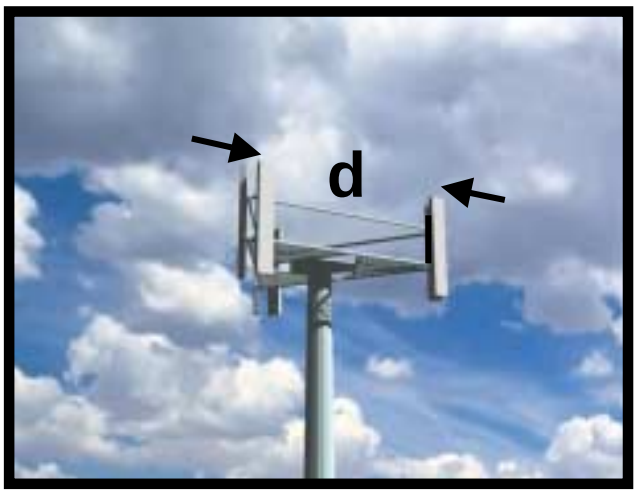
Antenna configurations



Choice of *antenna configuration* determines signal processing techniques available to combat fading effects and reduce interference.

Technology

Diversity: d large (> wavelength)

Diversity (Rx: MRC , MMSE, etc
Tx: Phase-Swept, Space-Time, etc)

BLAST

Phased Array: d small (< wavelength)

Switched beams

Steered beams

Increasing capacity

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Lucent Intelligent Antenna Solution

Approach

- **Simplified Architecture for high-performance and low-cost**
- **Lucent solution is *integrated* into the basestation (not an applique)**
- **All *IA signal processing* done at baseband in *channel-element ASIC*. No adjunct processing required.**

Performance

- **Maintain diversity antennas as integral part of our solution**
- **Benefits**
  - **Maintain largest gains for worst-case channel environments (single-path flat-fading at low mobile speeds)**
  - **Allows migration by hardware upgrade from *1 -> 2 -> 4* transmit paths per sector giving performance gains and incremental costs.**
  - **Provides *balanced gains* in the forward and reverse links.**
  - **Supports *migration to* future methods of providing very high speed packet data using *BLAST***

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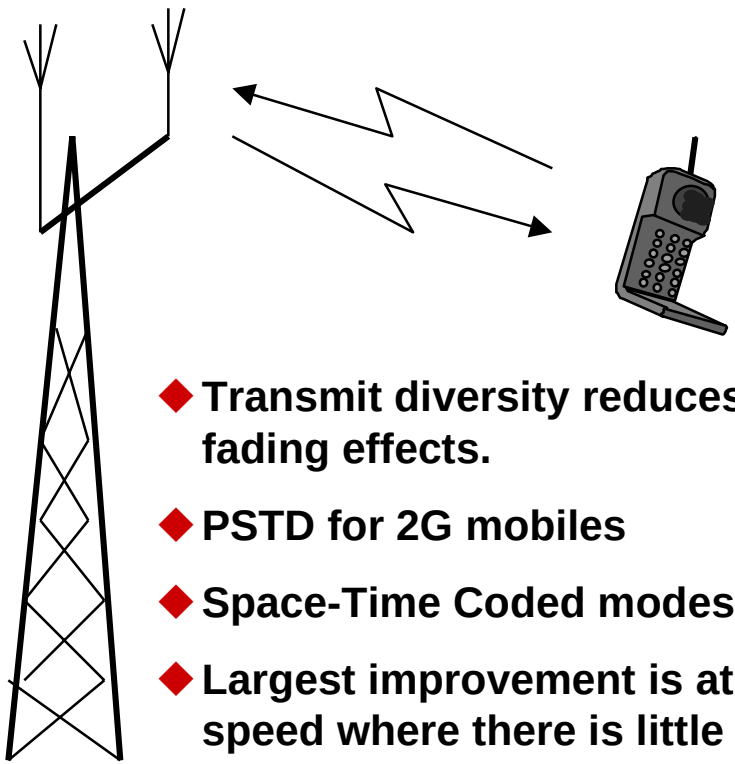
Phase 1 of 3: Transmit Diversity

Receive: 2-Branch MRC
Transmit: Multiple-Mode Diversity
- Phase-Swept
- Space-Time coded ...



- Transmit diversity reduces the fading effects.
- PSTD for 2G mobiles
- Space-Time Coded modes for 3G
- Largest improvement is at low speed where there is little coding gain

Benefit:

- 1 to 6 dB improvement
- Impact is greatest on low mobility or stationary user (typical high-speed data user)

Hardware:

- Antennas: No Change (standard 2-antenna configuration)
- Duplex 2nd transmit path on the 2nd receive antenna

Signal Processing:

- Performed in Channel Element ASIC

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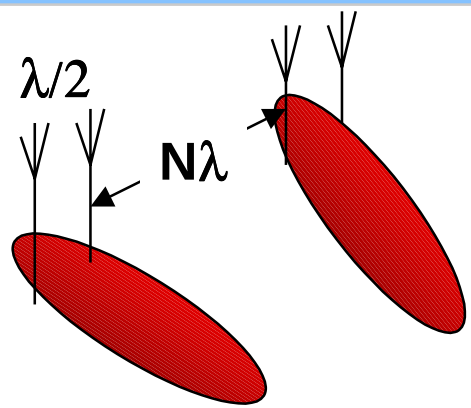
Phase 2 of 3: Intelligent Antennas

Receive: 4-Branch Adaptive

Transmit: Diversity with Beam Steering





- Use closely-spaced pair of antennas for beam-steering.
- Separate antenna pairs for diversity
- 4-Branch fully adaptive processing on uplink
- Angle-of-arrival information on the uplink provides beam direction for the downlink.

Benefits:

- 2 to 8 dB improvement for mixed high-speed data and voice traffic
- Adaptive uplink reduces impact of high-speed data users on voice capacity.

Hardware:

- Antenna: Same appearance as conventional antennas (one radome per antenna pair => minimal width increase).
- Provision two new RF paths

Signal Processing:

- Performed in Channel-Element ASIC

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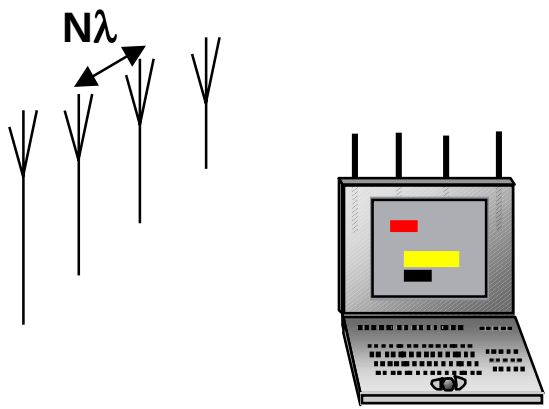
Phase 3 of 3: BLAST

Receive: 4- Branch Diversity

Transmit: 2- 4 Branch Diversity



- Antenna elements configured for four-branch diversity.
- Data is de-multiplexed so that different data streams appear at each antenna.
- Spatial characteristics of the radio link act as additional CDMA codes. Allows code-reuse for higher spectral efficiency

Benefits:

- Four fold increase in the data throughput.
- High data rates are achieved without increasing the interference or power => more simultaneous users.

Hardware:

- Basestation Antennas: Same appearance as conventional antennas
- Add more antennas to terminal

Signal Processing:

- Performed in BTS and terminal Channel-Element ASICs

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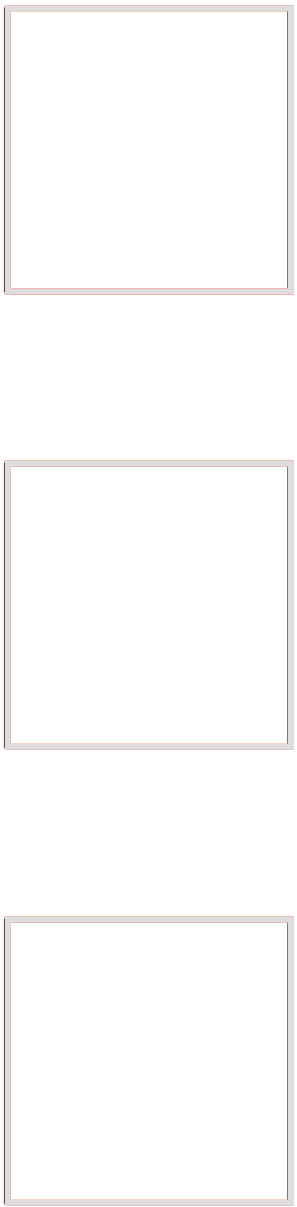
BLAST Example





- **Signals summed**
- **Noise subtracted**

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Lucent 3G CDMA System Evolution Summary

Forward Link

Largest gains (for low speed, flat fading, narrow angle spread)

Average

0%
Single Transmit

Up to 250%

20%-30%
Transmit Diversity

Up to 530%

80%-100%(2x)
IA Beam Steering

> 300%(4x)
BLAST Time-Space

Reverse Link

Average

0%
2 Antenna Diversity

2-Antenna

65%- 100%(2x)**
4-Antenna IA

> 300%
Multiuser Detection

*** Larger improvement is achieved for voice in the presence of strong interference from high-data rate users.*

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