

# Space-Time Coding for Reliable and Covert Urban Communications

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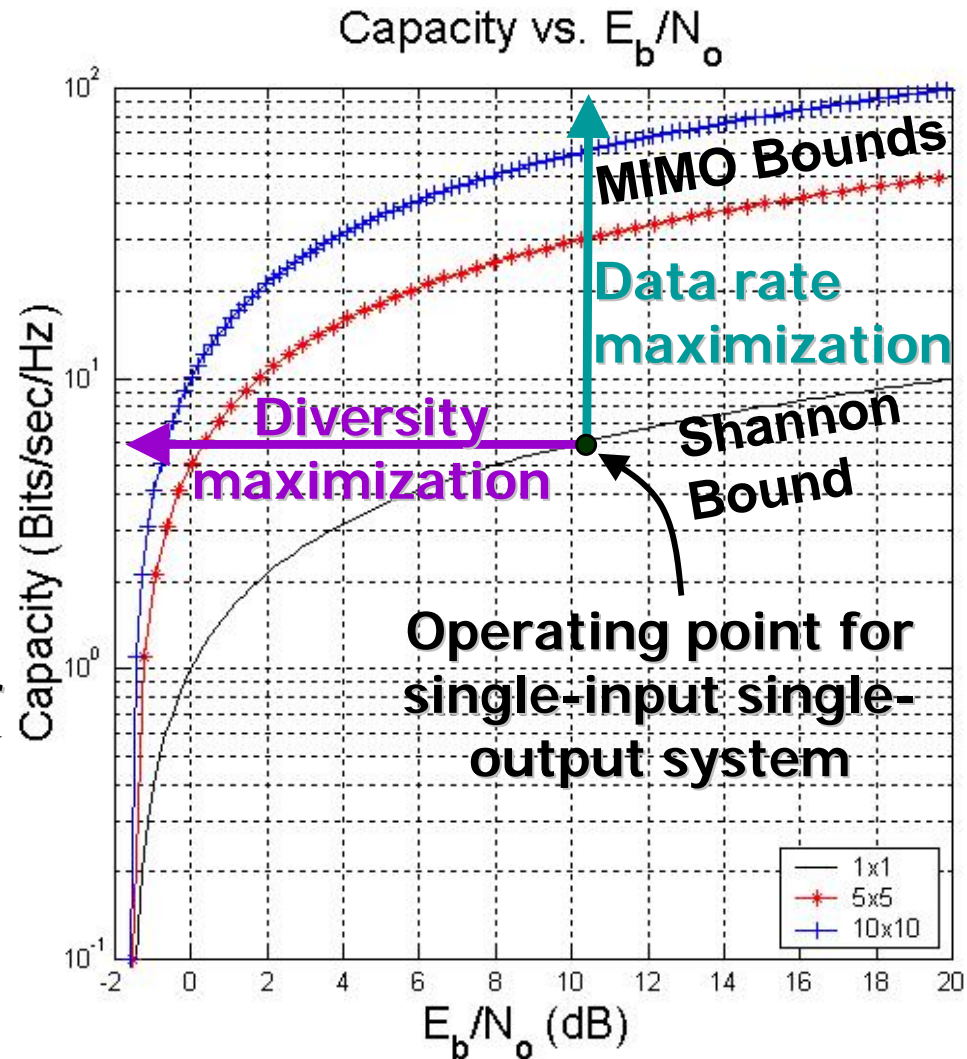
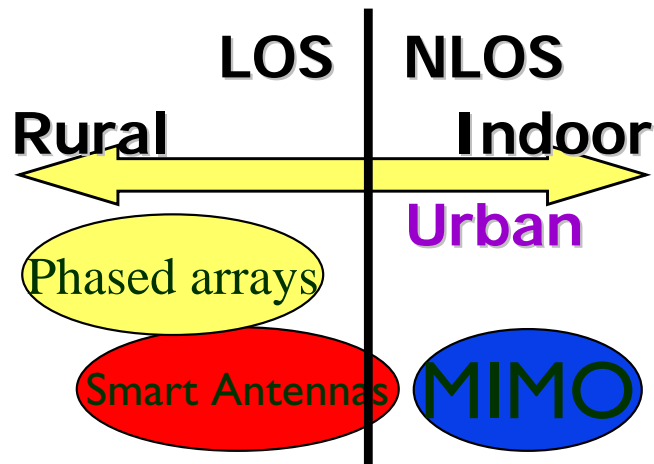
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# Problem

- **Severe multipath fading and non-line-of-sight environments cause link failure for many terrestrial communication systems.**
- **Conventional coding and modulation schemes (even those used on multi-antenna systems) treat multipath as a hindrance.**
- **Multiple-input multiple-output (MIMO) systems exploit multipath to create new theoretical capacities which break the classical Shannon bound.**
- **Space-time coding is the means by which these new capacities are obtained.**

# Background

- 1995 **BLAST** (first MIMO system for **data rate maximization**)
- 1998 **Space-time coding** (first MIMO system for **diversity maximization**)



# Objective

- Design optimal space-time coding (STC) algorithms in software to achieve:
  - minimum bit error rate for fixed SNR and fixed data rate (**reliable communications**)
  - minimum SNR for fixed BER and fixed data rate (**covert communications**)
- Develop STC algorithms in hardware to:
  - Demonstrate performance gains
  - Analyze real-world effects

# Activities

- We've implemented in both **software and hardware** a **2x2 space-time block code (STBC)** and **unitary space-time modulation (USTM)** algorithm.
- We've implemented in software a **2x2 STBC**, **USTM**, **Grassmannian beamformer (a.k.a. maximum ratio transmission)**, **Bell Labs Layered Space-Time (BLAST)**, and **Space-Time Trellis Code (STTC)**.
- We've built a simulation test bed with a graphical user interface for development.

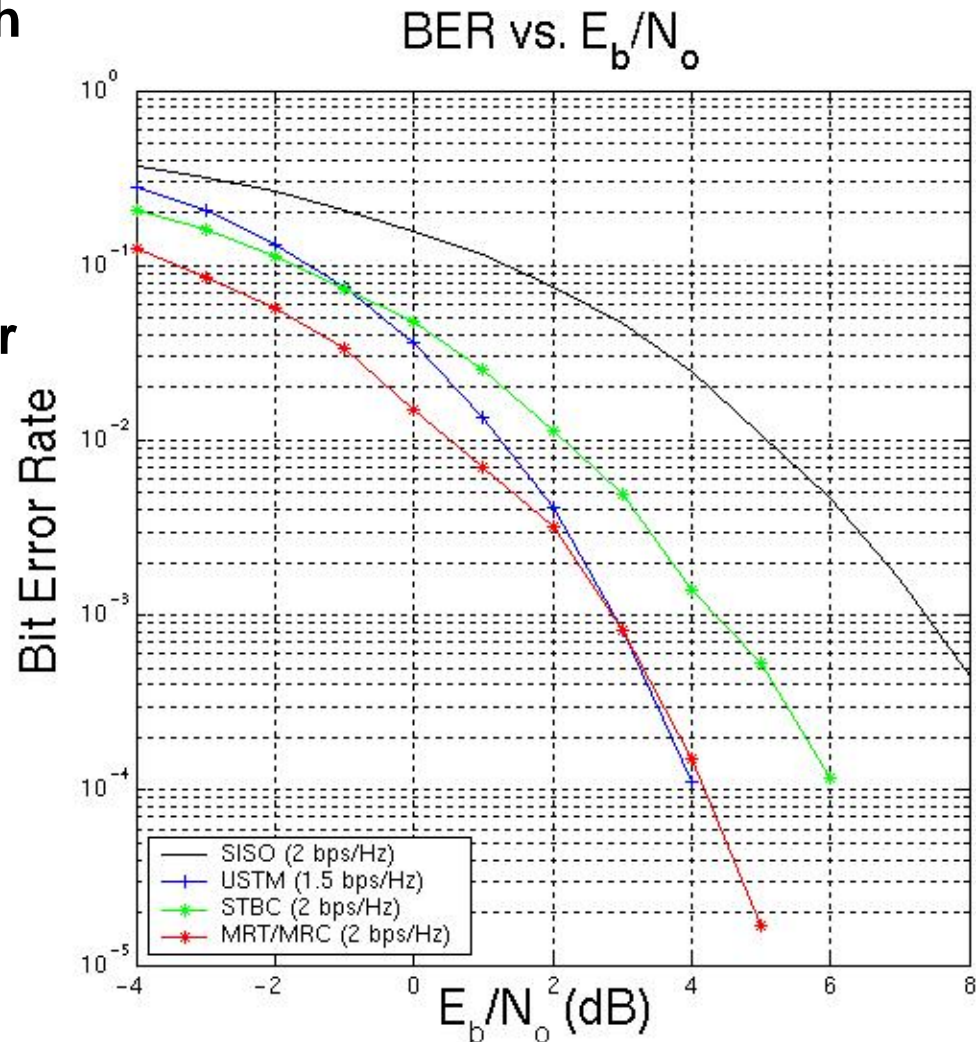
# Highlight

- 2x2 MIMO systems Rayleigh flat-fading compared to 1x1 (SISO)

- **Space-time block coding (STBC)** for informed receiver

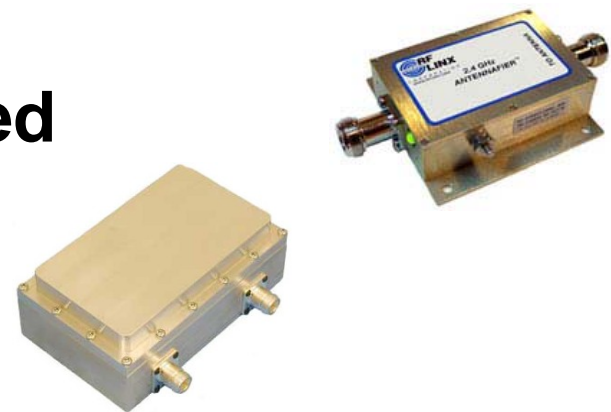
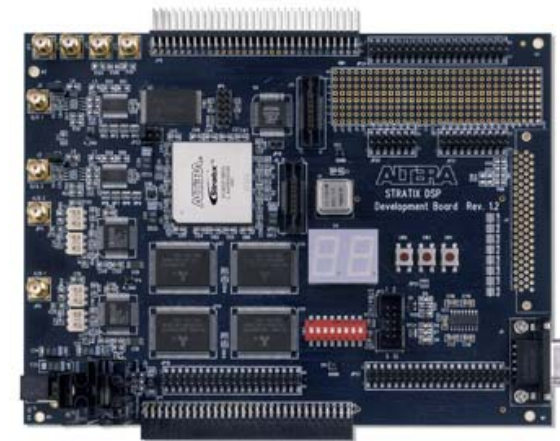
- **Maximum-ratio transmission/combining (MRT/MRC)** for informed transmitter and receiver

- **Unitary space-time modulation (USTM)** for uninformed transmitter and receiver



# Demonstration

- Digital modems are implemented using Altera FPGA development boards. Boards are programmed to implement space-time codes, symbol/carrier recovery loops, bit error rate testers, etc.
- RF front ends are implemented using discrete parts such as filters, amplifiers, mixers, attenuators, etc.



# Impacts

- **Army, Marines, and DARPA need reliable communications for urban warfare—potential application in a mobile ad hoc network.**
- **Intelligence agencies need low probability of detection/intercept—MIMO allows for much lower transmit power and can use channel exploitation to defeat eavesdroppers.**
- **Netted sensor benefits include lower power consumption, anti-jamming capability, and interference suppression.**
- **Conference and journal papers will follow.**

# Future Plans

**Unification of space-time coding theories to work in most general conditions**

