OFDM for High Data Rate, High-Mobility, Wide-Area Wireless Communications

LAN data rates with cellular-like coverage

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AT&T Labs - Research

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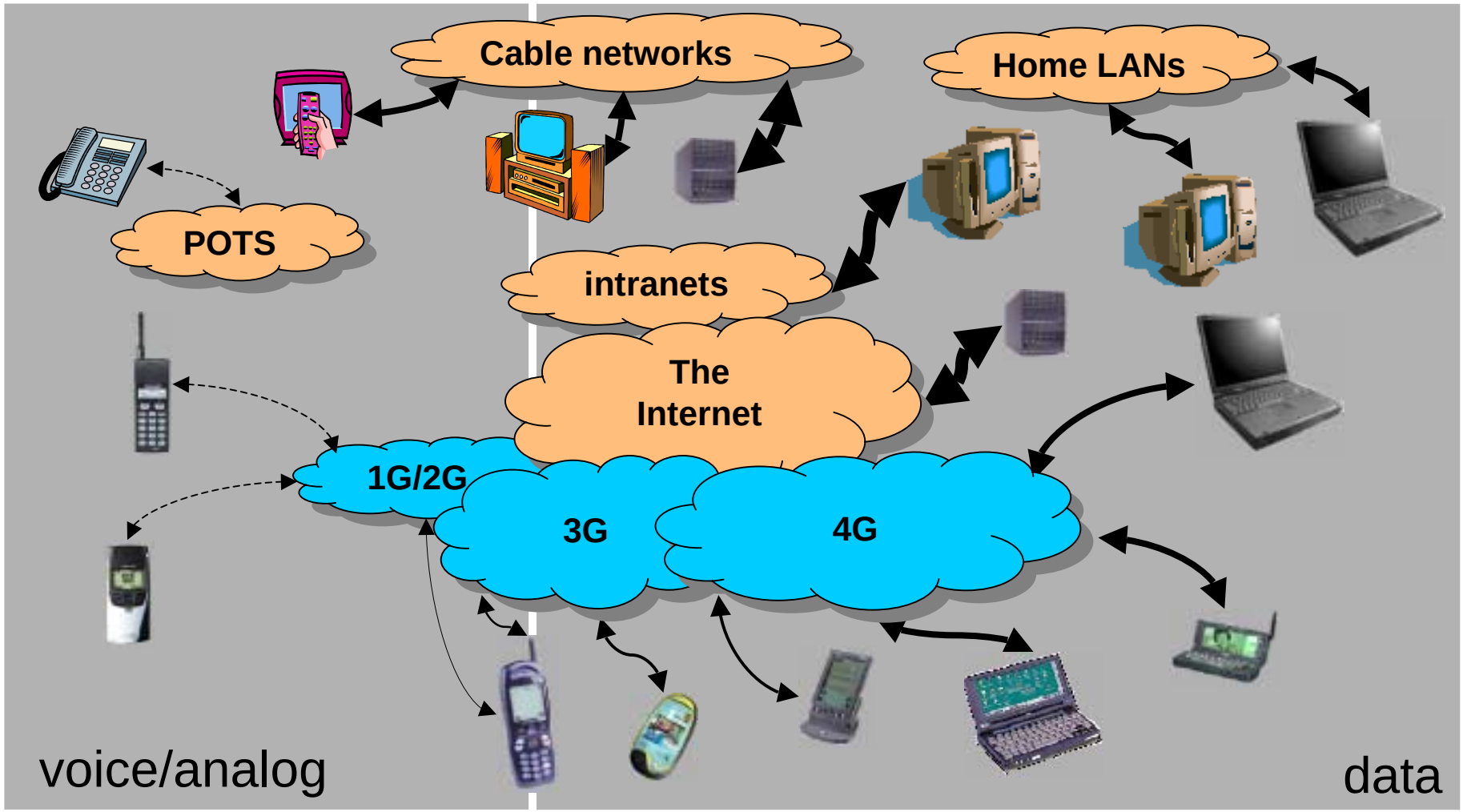
Fourth Generation (4G) Wireless Access



sophisticated wired data networking demand ↑
demand for mobility ↑
reliance on mobile computing/PDAs ↑

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Need for sophisticated, high-speed *wireless* data

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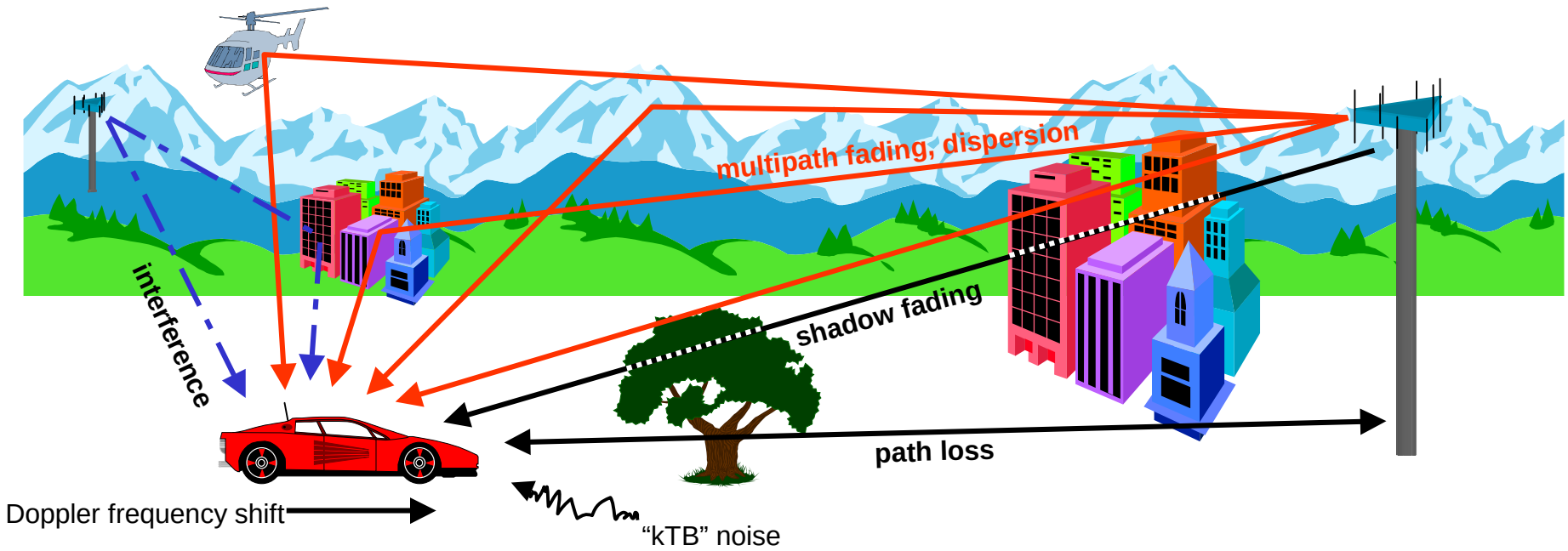
Fourth Generation Wireless:

High Speed Data Networking in a High Mobility, Wide Area, Cellular-like Environment

The Challenge:



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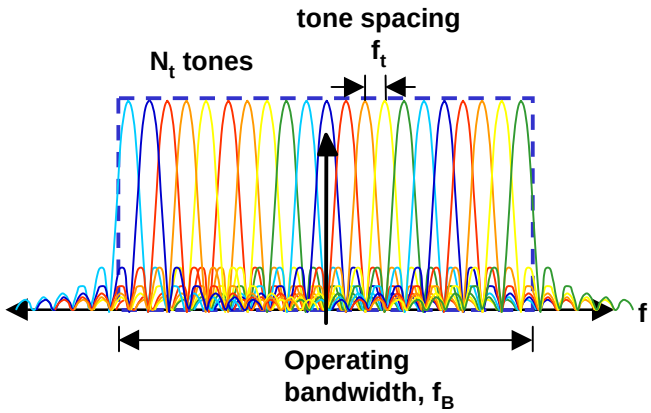
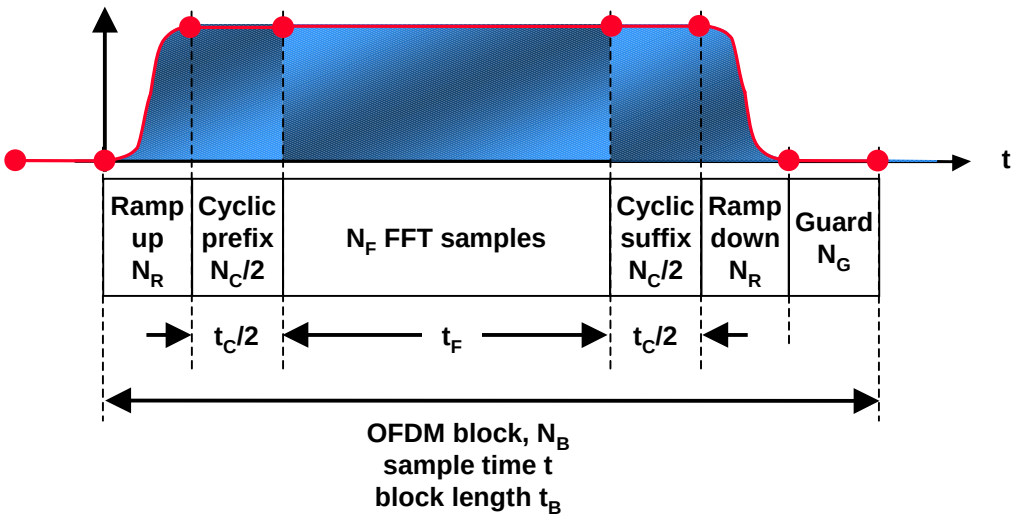
OFDM Basics





Total bandwidth $f_B = N_t f_t$

Tone spacing vs active block time $f_t = \frac{1}{t_F}$

$$N_B = 2N_R + N_C + N_G + N_F$$

Block efficiency $\eta = \frac{N_F}{N_B} = \frac{N_F}{N_F + N_C + 2N_R + N_G}$

Tolerance to delay spread $\approx t_C \propto N_C$

Raw capacity for M-ary tone modulation $N_t M$

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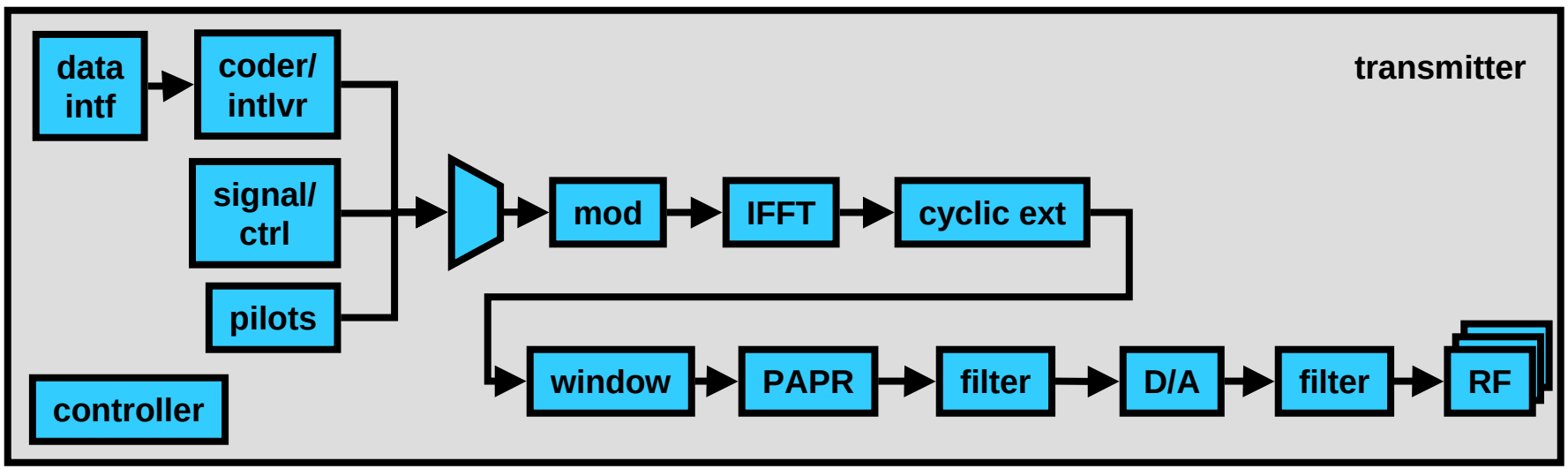
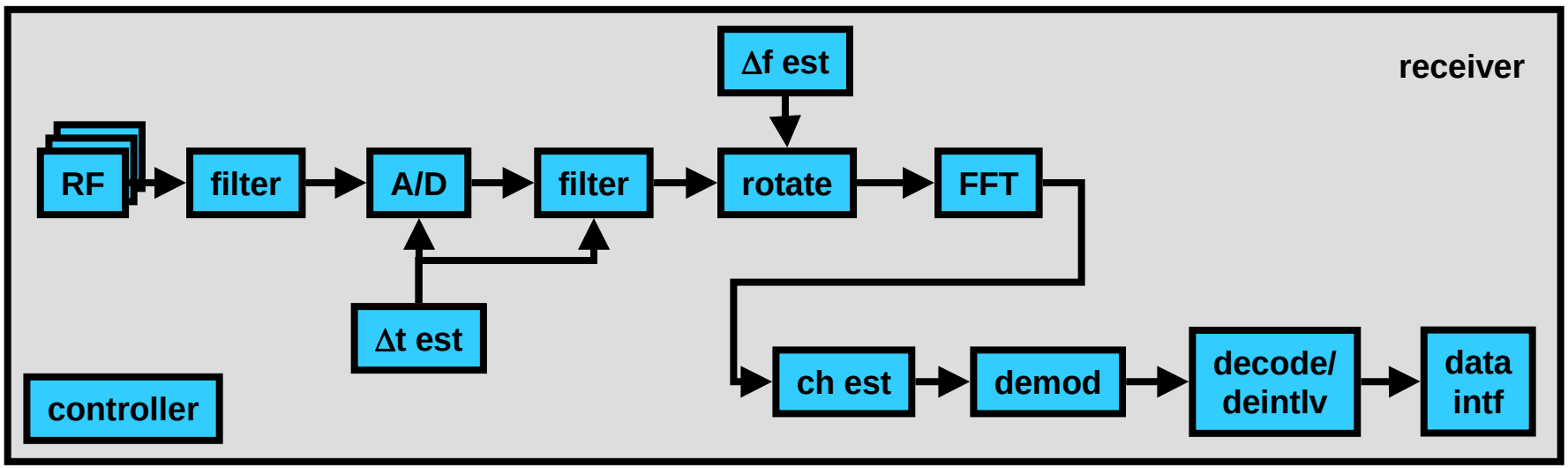
OFDM Transmitter



OFDM Receiver



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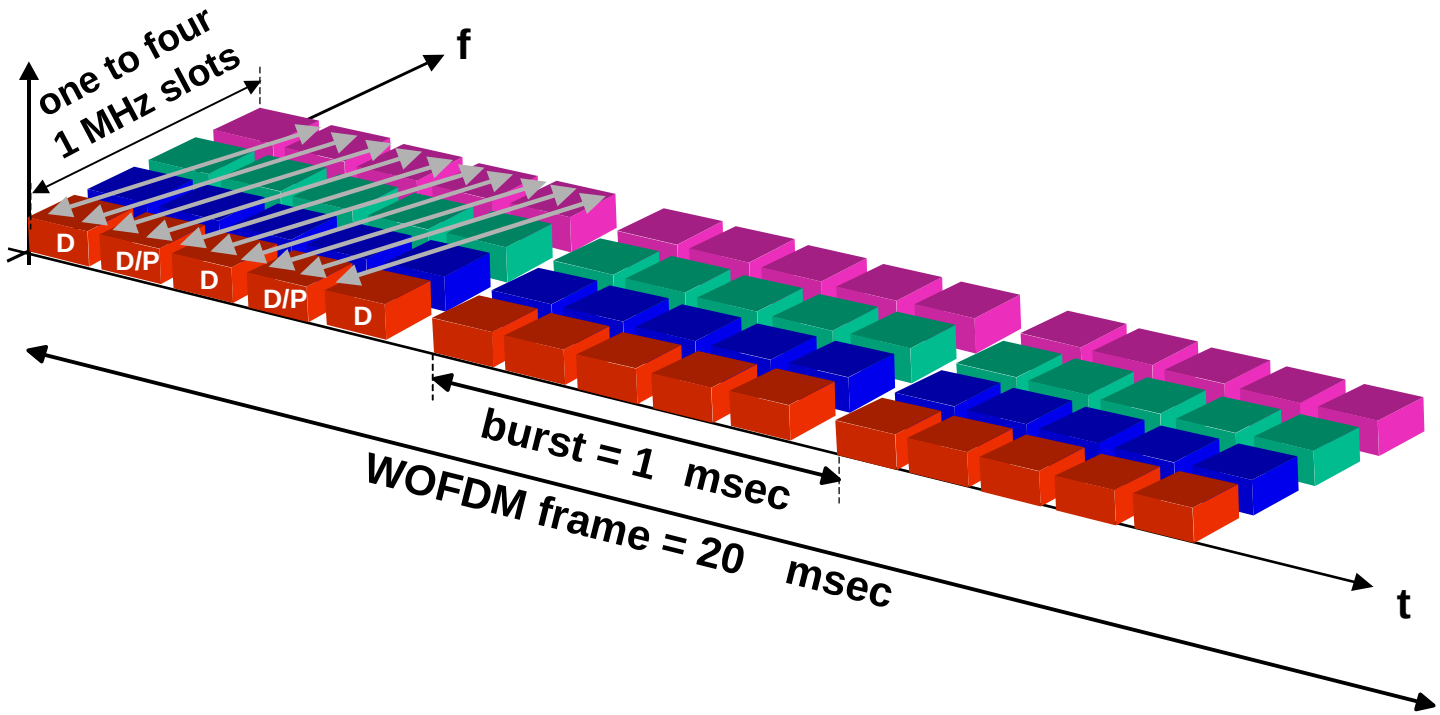
OFDM tradeoffs

	802.11a	4G	DVB-T 2k mode
Data rate	6, 9, 12, 18, 24, 36, 48, 54 Mb/s	2.56-8.96 Mb/s	4.98-31.67 Mb/s
Tone modulation	BPSK, QPSK, 16QAM, 64QAM	QPSK,16QAM	QPSK, “16QAM,” “64QAM”
Coding rate	1/2, 2/3, 3/4	1/2, 2/3, 3/4, 7/8	[1/2, 2/3, 3/4, 5/6, 7/8] + RS(204,88)
N_t	52	640	1705
t_B	4 μs	200 μs	231-280 μs
t_B-t_F	800 ns	40 μs	7-56 μs
f_t	312.5 kHz	6.25 kHz	4.464 kHz
f_B	16.56 MHz	4 MHz	7.6 MHz
f_{op}	~5 GHz	~2 GHz	~500 MHz

OFDM/TDMA Options



- Full peak data rates are achievable
- Dynamic Packet Assignment to base stations, mobiles is an option
- Portable terminals can process only relevant traffic for power savings

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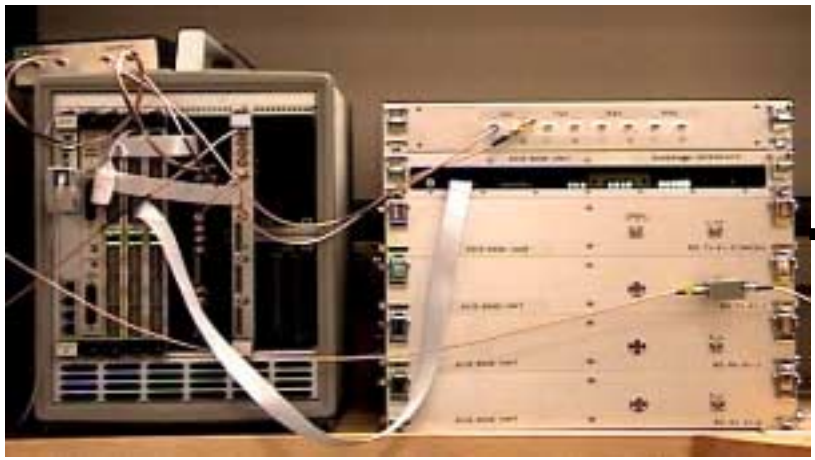
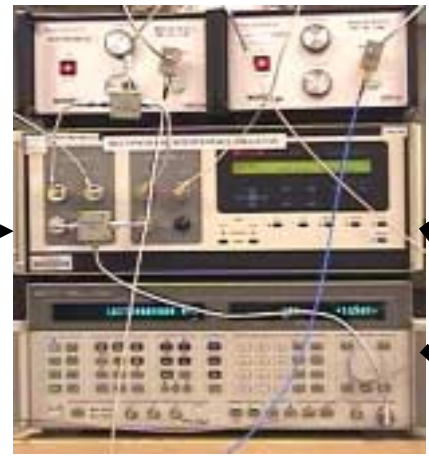
4G Wireless Research ϕ1 Prototype

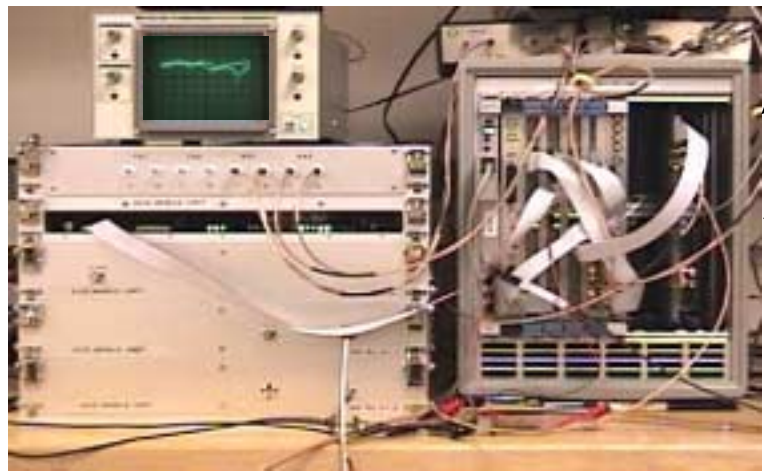


Base station



Channel simulator

- prototype designed with general purpose DSPs for flexibility
- two-branch receiver diversity implemented at 1900 MHz
- performance measured on typical mobile outdoor channels
- robust performance demonstrated



Mobile station

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Conclusions

- Real-time ϕ1 DSP prototype demonstrated:
  - performance within 1-2 dB of theory in AWGN
  - performance within .25 dB of idealized simulation for two-ray fading
  - robustness of OFDM against delay spread
  - OFDM can offer good performance even with straightforward receiver (e.g., simple combining, differential detection, (63,31) RS coder)
  - Two-branch receiver diversity provides 4 - 8+ dB performance gain for variety of channel conditions. Combined with coding across OFDM tones provides very effective diversity
- Wideband OFDM with improved modulation, coding, channel estimation can achieve excellent performance, even in low delay spread environments
- In combination with smart antennas, peak rates of 20-40 Mb/s in 5 MHz are feasible
- OFDM/TDMA offers advantages for portable terminals, dynamic resource assignment