Broadband systems' features

Christoph Legutko
Wireless Standards and Regulations Manager
Intel Corporation, Global Public Policy

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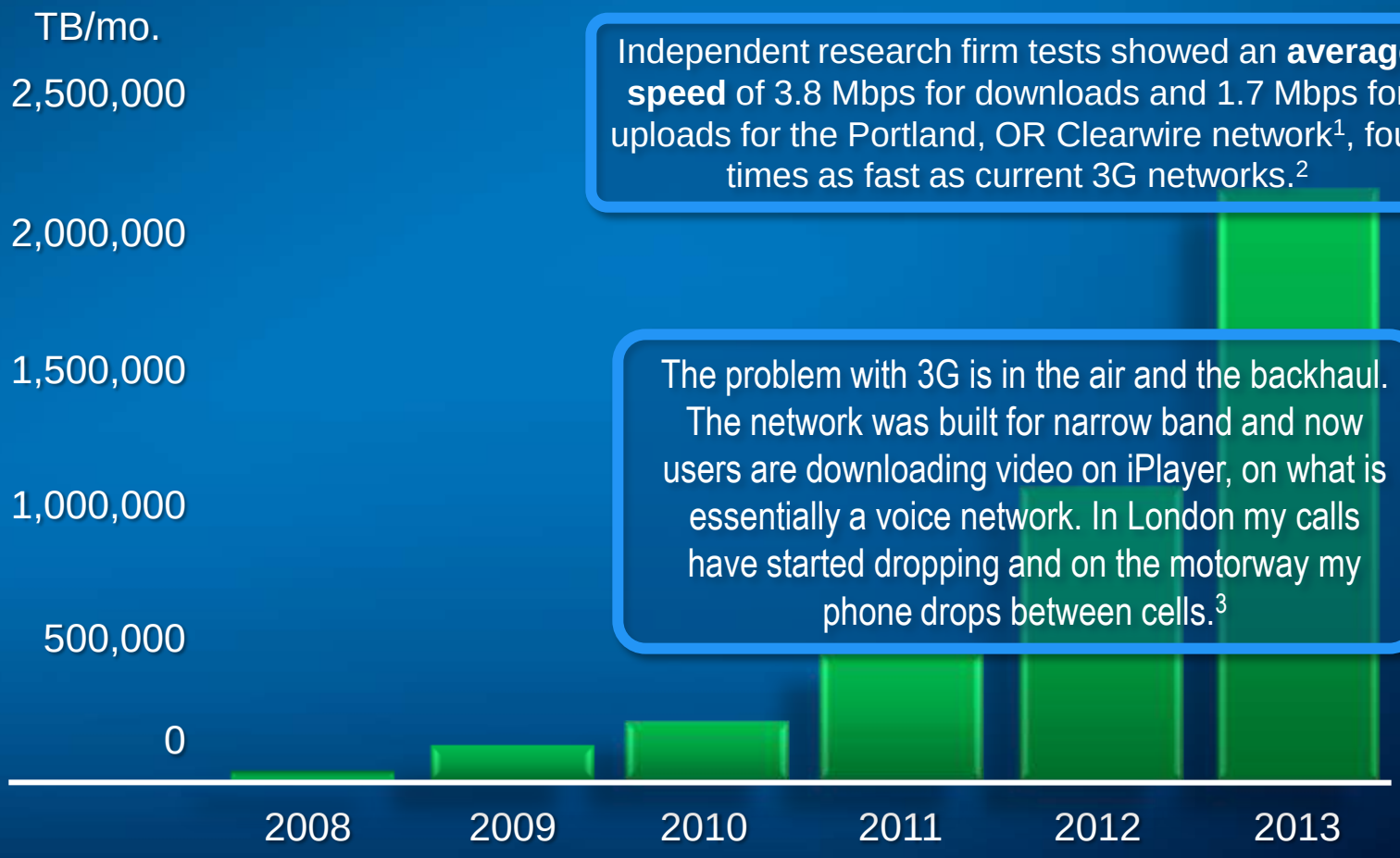
How Will Operators Meet Demand?

Global Mobile Data Traffic Growth



Independent research firm tests showed an **average speed** of 3.8 Mbps for downloads and 1.7 Mbps for uploads for the Portland, OR Clearwire network[1], four times as fast as current 3G networks.[2]

The problem with 3G is in the air and the backhaul. The network was built for narrow band and now users are downloading video on iPlayer, on what is essentially a voice network. In London my calls have started dropping and on the motorway my phone drops between cells.[3]

Source: Cisco Visual Networking Index, July 2009. Forecast, 2008 -2013

[1] Signals Ahead Research, Volume 5, No. 11, 9 September, 2009.
[2] **Saul Hansell, Sprint Banks on WiMax to Win Back Market Share**, **New York Times**, 27**September 2009**
[3] "U.S. 3G Networks Deliver Less Than Expected," Phillip Redman, Gartner Research, 22 January 2009.

Mobile Voice vs. Mobile Internet

Traffic Equivalents*

1 Smartphone = 30 Handsets

1 Laptop = 450 Handsets

~ 10 Kbps Constant Rate

A network optimized for mobile voice cannot handle high numbers of mobile internet users

1-5 Mbps Burst Traffic

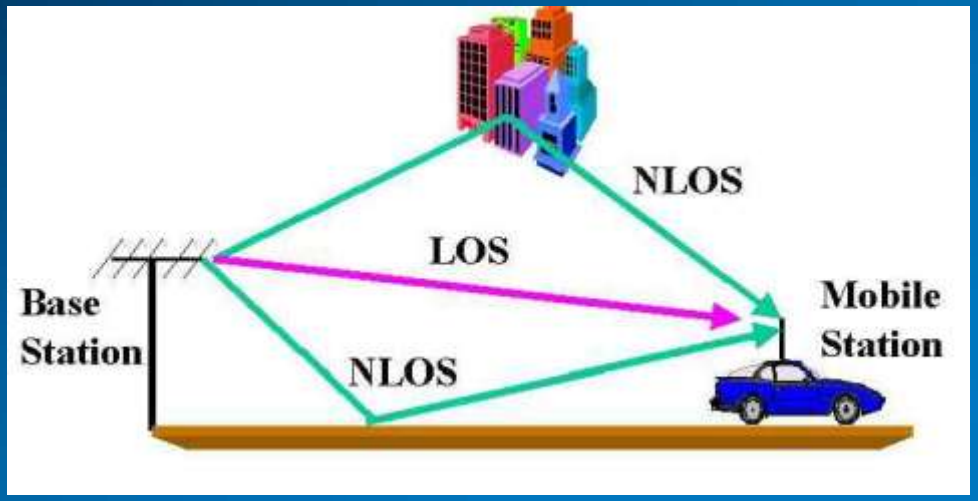
More Spectrum Needed

More Backhaul And Different Network Architecture Required

Mobile Internet Requires a Technology Revolution

* Source: Cisco Visual Networking Index, July 2009

Broadband Wireless Channel Challenges

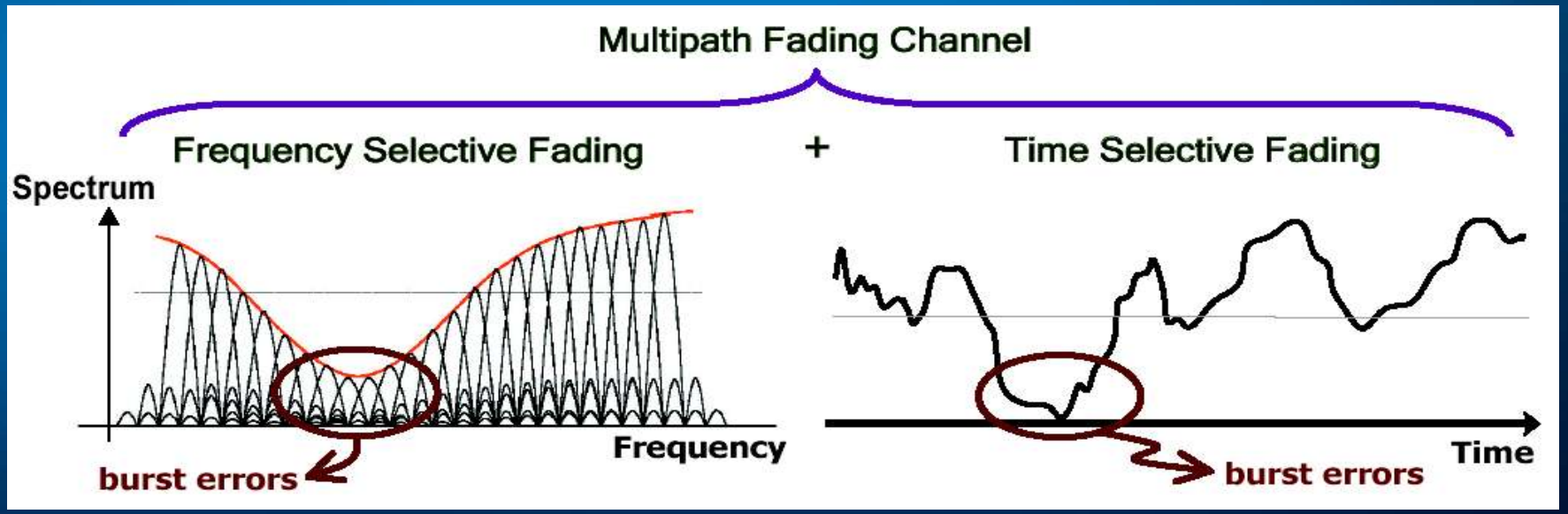


Frequency variation:

- Multipath delay spread at Receiver

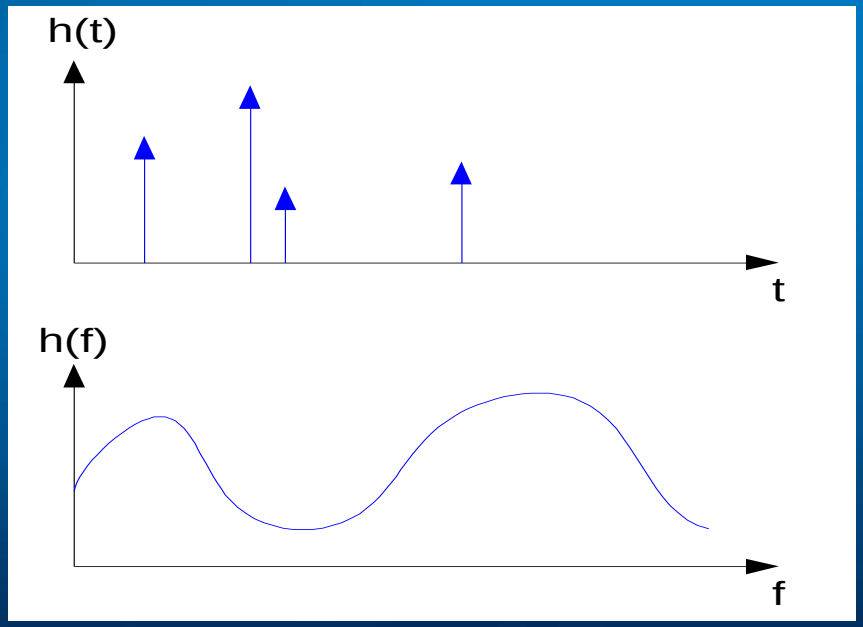
Time variation:

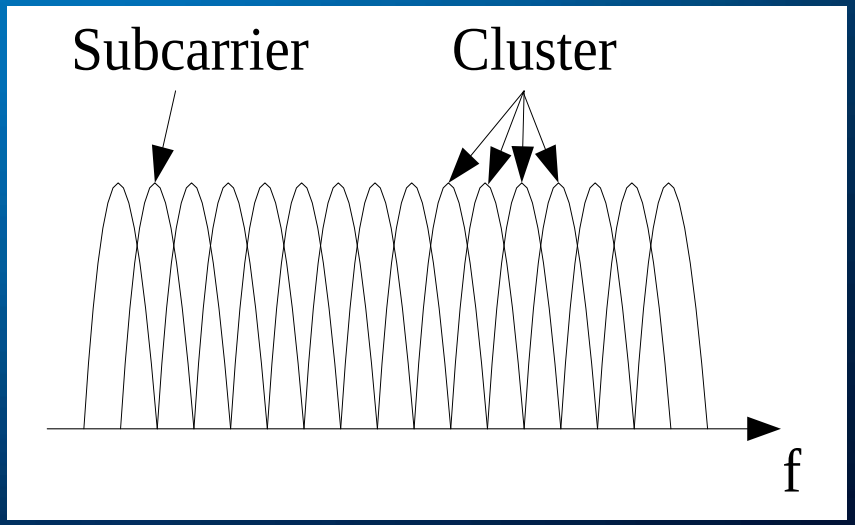
- Mobile stations



OFDM Basics

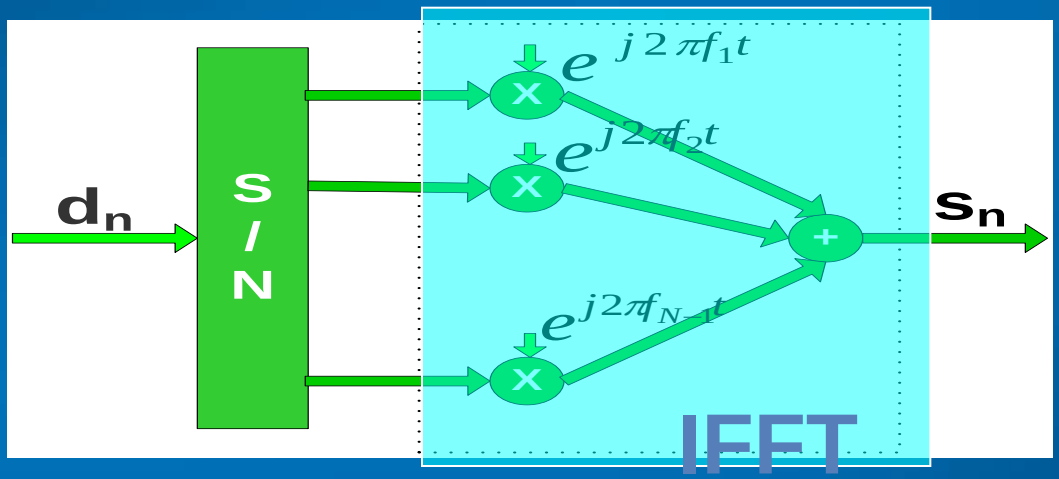
- Orthogonal frequency division multiplexing
- Frequency-selective wideband channel → Parallel orthogonal flat narrowband channels





Why OFDM ?

- TDMA and CDMA suffers in high delay spread channels
- How to combat frequency selective fading? → parallel orthogonal flat narrowband channels



Orthogonal subcarriers → high spectral efficiency

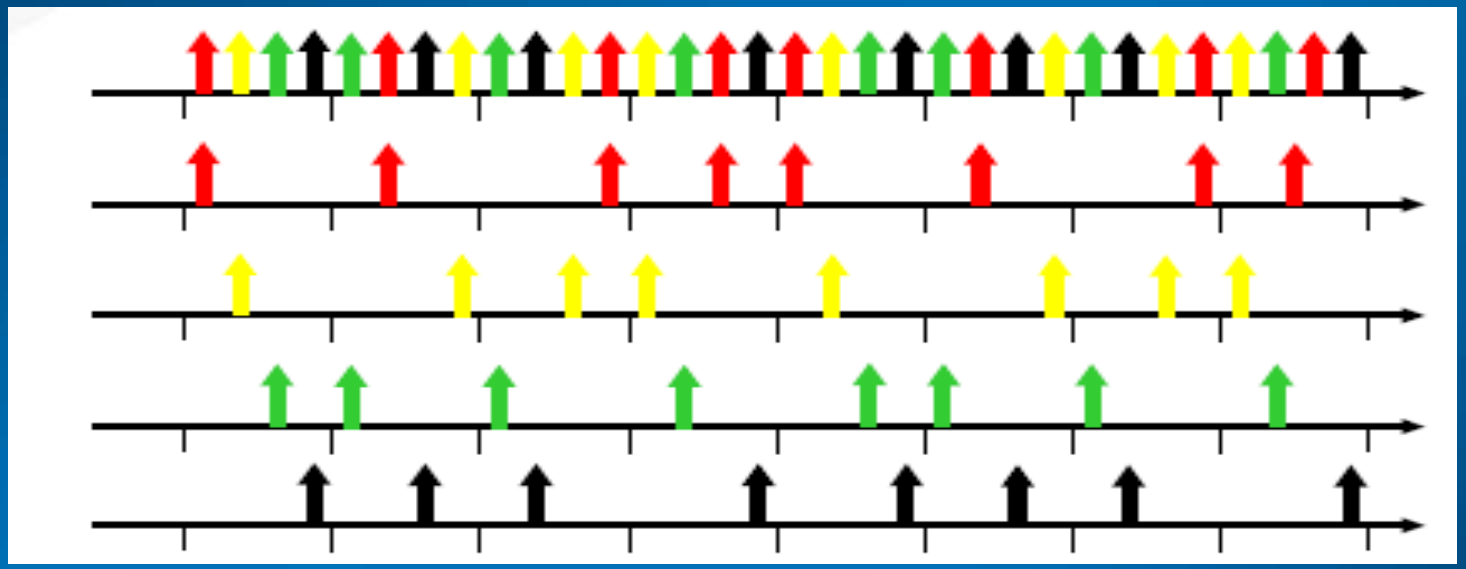
FFT fast algorithm → efficient implementation

Low data rate on each subcarrier → low ISI – Inter Symbol Interference

Combing with advanced FEC – Forward Error Correction →reducing burst errors

Cost-effective broadband wireless technology

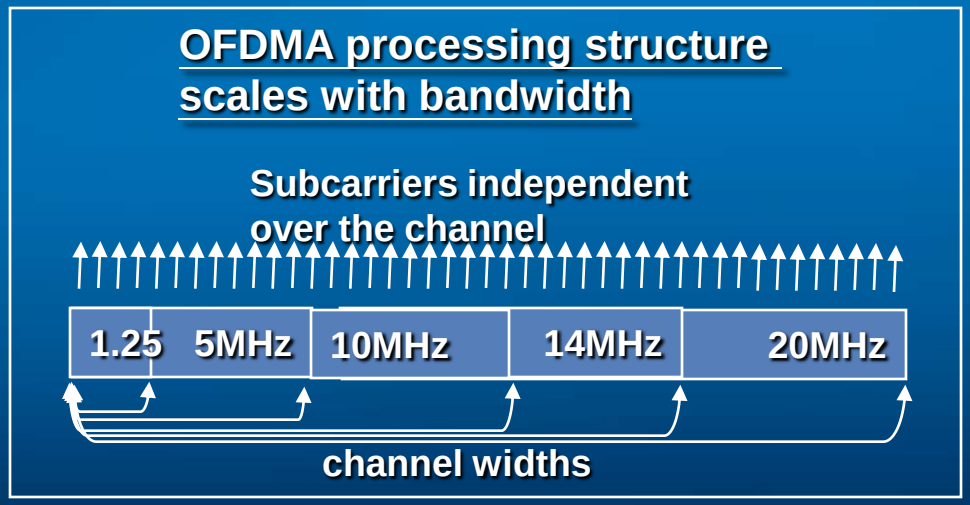
OFDMA – Multi User Access

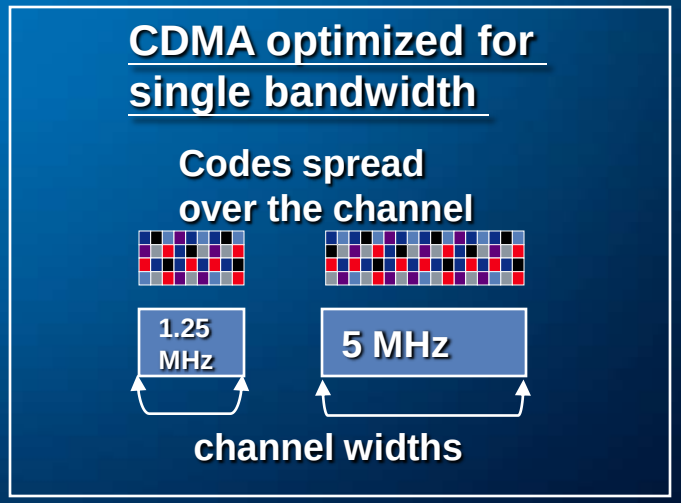


- Multiple users keep orthogonal sub-channels during multiple access
- Flexible sub-channelization
  - Pseudo-random permutation for diversity
  - Contiguous permutation for selectivity
- High granularity bandwidth allocation
- Scalable structure

OFDMA Scalability

- CDMA does not scale well with multiple channel bandwidths
  - CDMA 2000 = 1.25MHz channels
  - WCDMA/HSDPA = 5 MHz channels
- OFDMA allows for optimal operation in varying channel widths
  - OFDMA = 1.25 MHz, 2.5, 5, 10, 14 and 20 MHz channels





Summary

- physical layer uses OFDMA and is optimized for mobile broadband
  - Robust against frequency-selective fading
  - Robust against ISI – Inter Symbol Interference
  - Multi-user access
  - High data rate in both downlink & uplink
  - Efficient implementation
  - Flexible & scalable architecture
  - Diversity, AAS - Advanced Antenna System, and MIMO

Glossary

AAS – Advanced Antenna System

AMC – Adaptive Modulation and Coding

AMS – Adaptive MIMO Switching

ARQ – Automatic Repeat Request

BS – Base Station

BTS – Base Station Transceiver

CC – Convolution Coding

CDMA – Code Division Multiple Access

CP – Cyclic Prefix

CQICH – Channel Quality Indication Channel

CTC – Convolutional Turbo Code

CSI – Channel State Information

CSN – Connectivity Service Network

DL – Down Link (BS to MS)

FCC – Federal Communications Commission

FDD – Frequency Division Duplex

FEC – Forward Error Correction

FFT – Fast Fourier Transform

FUSC – Fully used sub carrier

HARQ – Hybrid Automatic Repeat Request

ISI – InterSymbol Interference

LA – Link Adaptation

LOS – Line Of Sight

LTE – Long Term Evolution

MCS – Modulation-coding scheme

MIMO – Multiple-Input, Multiple-Output (Antenna system)

MME – Mobility Management Entity

MS- Mobile Station

NLOS – Non Line of Sight

OFDM – Orthogonal Frequency Division Multiplexing

OFDMA – Orthogonal Frequency Division Multiplexing (Multiple Access)

PHY – Physical Layer

PUSC – Partially used sub carrier

QoS – Quality of Service

RRM – Radio Resource Management

RX - Receiver

SM – Spatial Multiplexing

SNR – Signal-t0-Noise Ratio

STC – Space-Time Coding

SISO – Single Input Single Output

TDD – Time Division Duplex

TX - Transmitter

UL – Up Link (MS to BS)

WWAN – Wireless Wide Area Network


Thank You
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