Technology Trends in Access Networks

Wired and Wireless

Bob Sinclair, P.Eng

Member of the TELUS team

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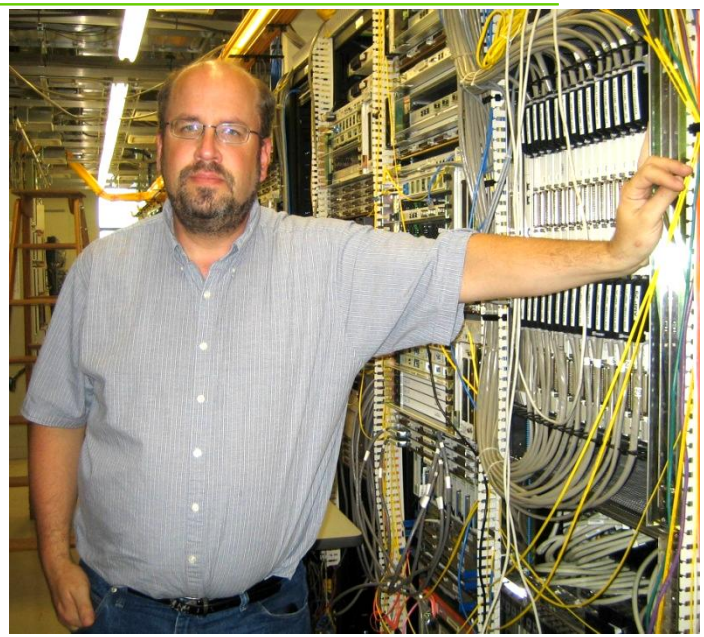
Richmond, BC

September 21, 2009

Who Am I?

- Long career experience especially at physical layer
- Almost a decade in TELUS setting standards and architecture for wired broadband access networks
- Currently managing a team providing guidance to TELUS on overall technology architecture



Here to talk about access technology in general, NOT TELUS specifics

Why Do I Like Access?

- The laws of physics (and economics) apply
- Claude Shannon 1916-2001

"There's no such thing as a free lunch"

$$C = BW \times \log_2\left(1 + \frac{S}{N}\right)$$

What Are We Trying To Accomplish?

Bandwidth Demanded by Services

- Consumers and business demanding more and higher bandwidth services
- Video a (the?) top driver
  - Bit rates from the hundreds of kbps to the multiple Mbps (HD)
  - Plus multiple users per home
- Plus all the other apps….
  - Extremely varied bandwidth requirements

How Do We Get This Bandwidth To Customers?

Choice #1: Dedicated or Open Communications Channel?

Existing Channels (copper)

- limited bandwidth (spectrum)
- cost to retrofit

New Channels (fibre)

Given This, What Developments Are There In Each Of These Branches?

Wireless

xDSL

Wired Access - xDSL

Existing Copper Plant

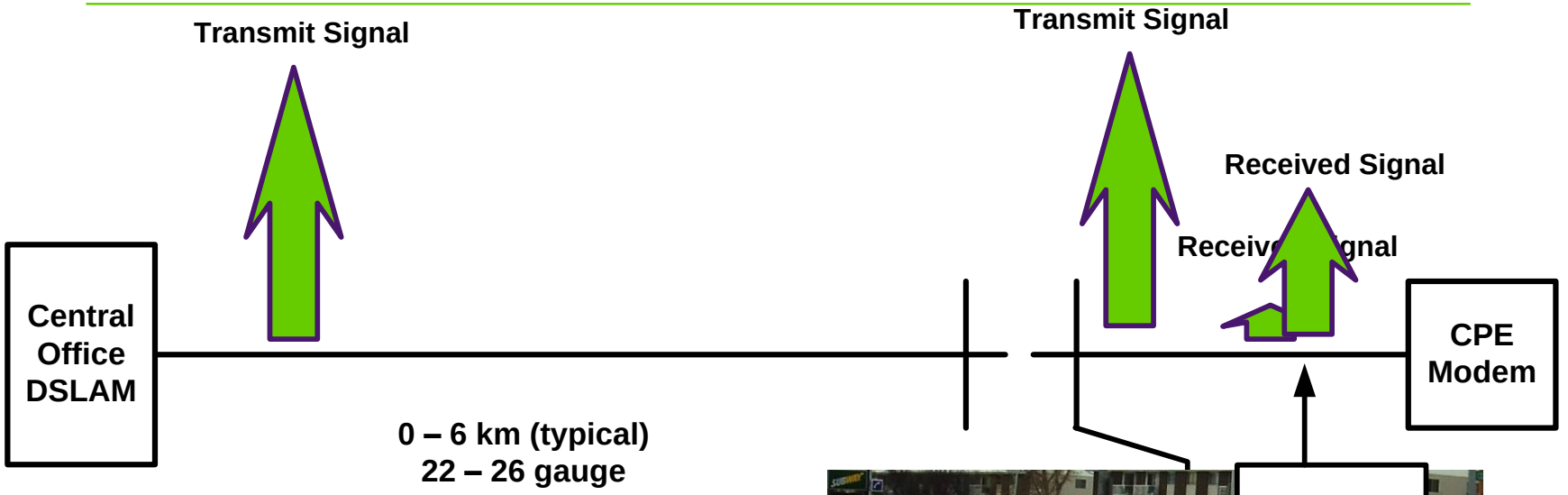
- Already in place!
- How could it be better?
- Look what the vendors say!

Ericsson demonstrates 500 Mbps over normal copper wiring

March 17, 2009 — 2:15am ET | By Paul Mah

... telecom equipment maker Ericsson has successfully demonstrated 500Mbps transmission speeds over ordinary phone-grade copper wiring. This is the same wiring used by DSL lines ….

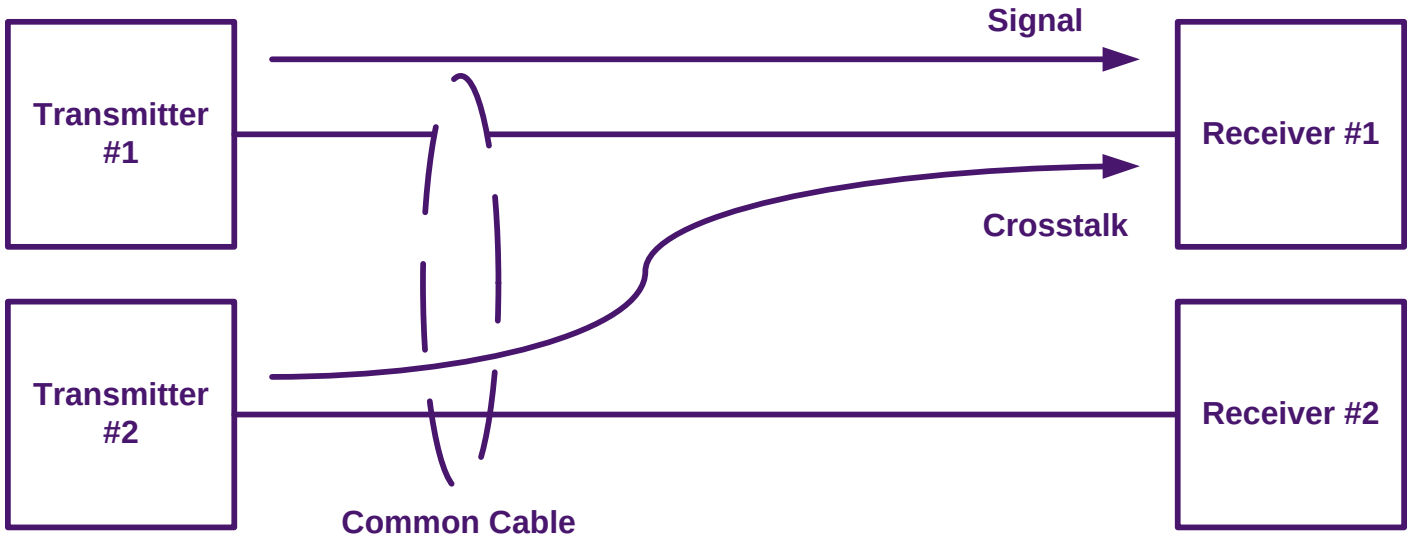
Define “The Same Wiring”

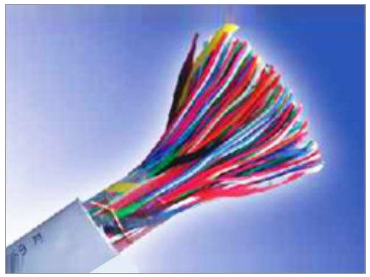


Sept 6, 2006

TELUS today announced a $600 million investment to enhance its broadband network in BC, Alberta and eastern Quebec...

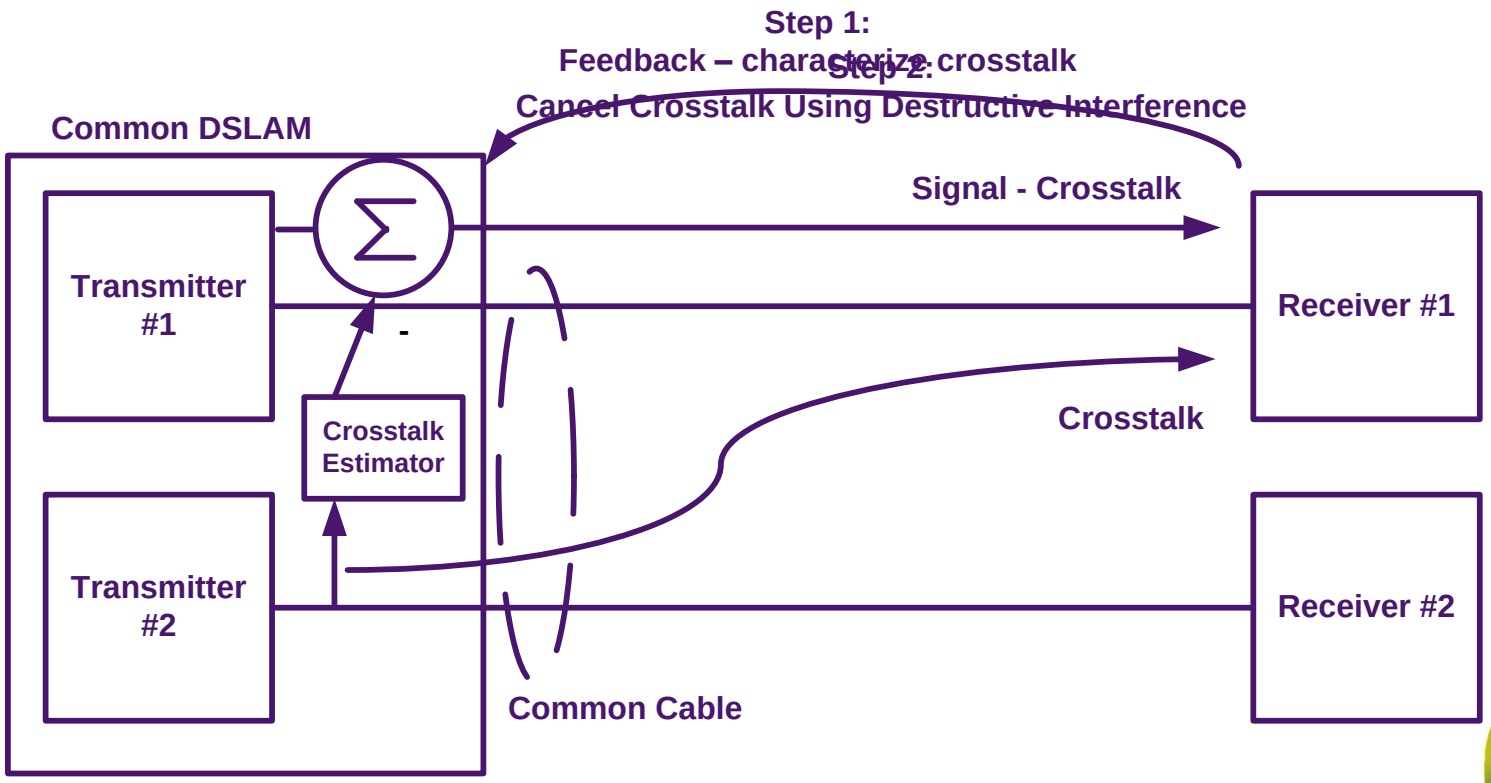
The Crosstalk Problem





$$C = BW * \log_2 (1 + S/N)$$

Potential solution - Vectoring



Vectoring

- (aka Dynamic Spectrum Management L3)
- ITU Activity G.vector – late 2009?
- Challenges:
  - New hardware
  - Not a panacea – crosstalk only, does not deal with external noise sources
  - Speed gains in real world unknown
  - Requires common DSLAM
  - Significant other administration
- No current view on carrier commitment

Wired Access - FTTH

Why Not Just Run Fibre To Each Home?

- The Good Part

$$C = BW * \log_2 (1 + S/N)$$

- The Challenge

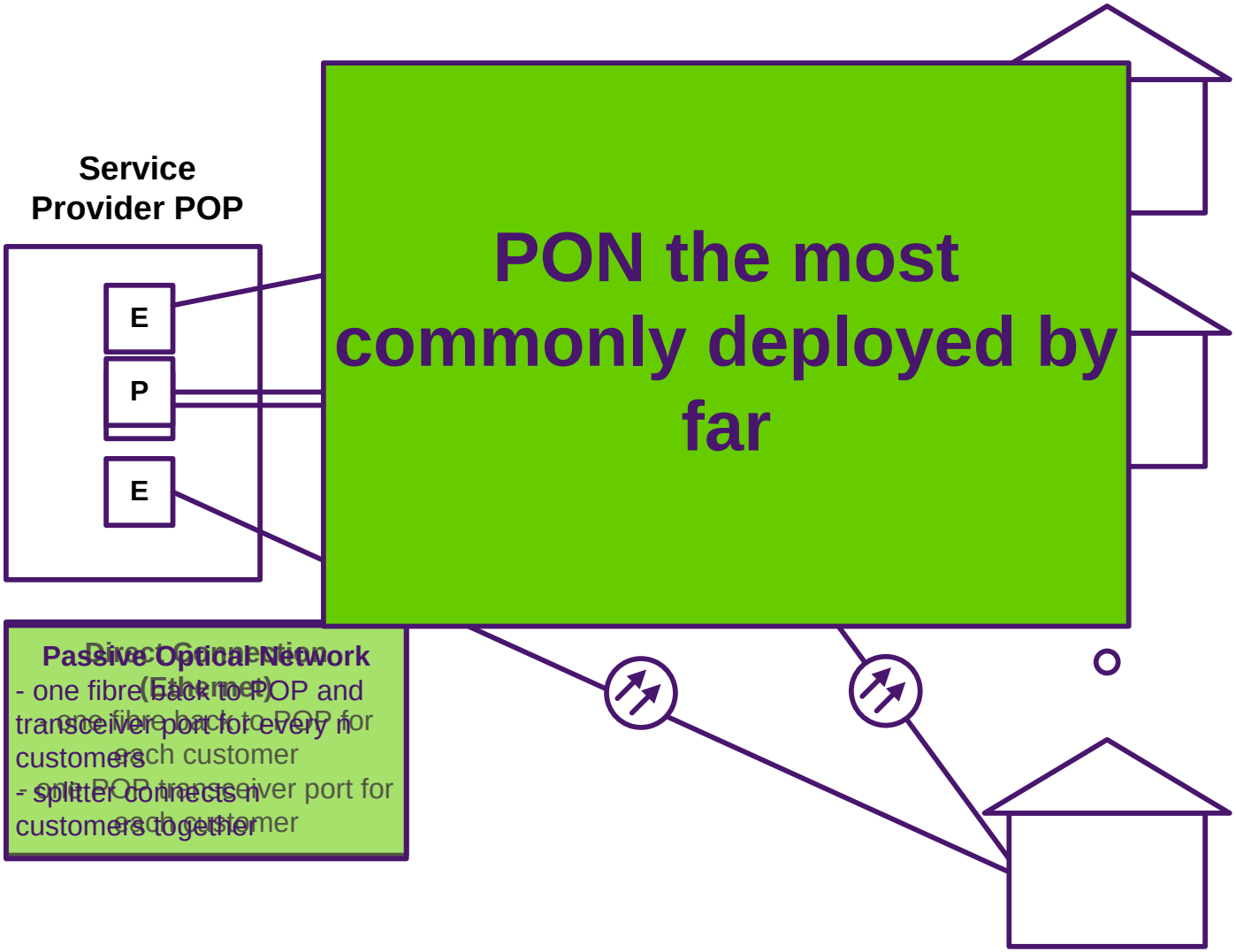
From Telephony Magazine Online, October 2007

"To keep within its capex budget, Verizon is working on the assumption it can reduce by 2010 the cost per home passed and cost per connection to US$700 and US$650 respectively (at the end of 2006, cost per home passed was US$850 and cost per connection US$880)."

At 50% penetration, that's over $2K investment / customer up front *just for the access*

Now add in core network, services, ongoing maintenance, customer care…

FTTH Approaches



PON vs. Direct Fibre

- PON less expensive
  - Sharing of resources
  - Less to install, maintain
- But isn't sharing Evil?
- Not if you're sharing something big enough!
  - (and can ensure appropriate sharing)
- Think turkey!

How Big Is That Bird?

- Current generation PON capacity large
  - EPON (Asia) 1 Gbps up/down
  - GPON (N/A and Europe) 2.4 Gbps down, 1.2 Gbps up
- Furthermore, this is just a small part of what the fibre is capable of

NG-PON Industry Standards

- Several new PON standards under development
- Near-term TDM Standards
  - IEEE 802.3AV (10G EPON), expected end of 2009
    - 10G down/1G up and 10/10 ONTs likely
    - Will coexist with 1G EPON through OLT replacement
    - 10/10 systems frequency compatible with GPON
  - ITU-T G.987 (XG-PON,10G GPON) expected 2010
    - Will coexist with GPON
    - 10/2.5 (XG-PON1), 10/10 (XG-PON2) versions
    - ONTs will share components with 10G EPON

NG-PON Industry Standards (continued)

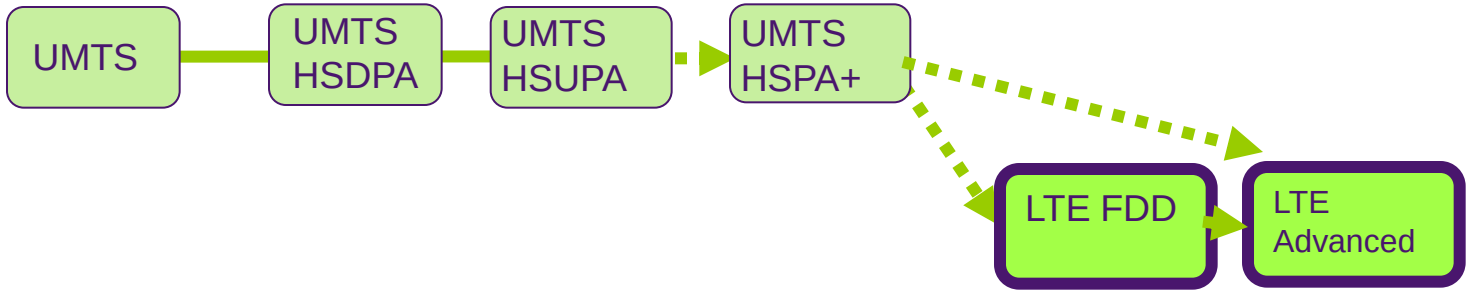
- Non-standard WDM
  - Various early non-standard out there
  - Still very complex and expensive
- Far-term Standards
  - FSAN NGPON2 (candidates are WDM, hybrid, synchronous: OFDM, CDM)
    - Target is 40G down, may not be required to be backwards compatible
    - Project has been stalled, is starting up as XG-PON moves to ITU
  - Pure WDM is possible, but not certain end-state for PON:
    - OFDM is the default end-state for most comm. technologies
    - Transport technology crystal ball suggests photonic integrated circuits, potential for multiple λs to an ONT: λ-bonded GPON

Wireless Access

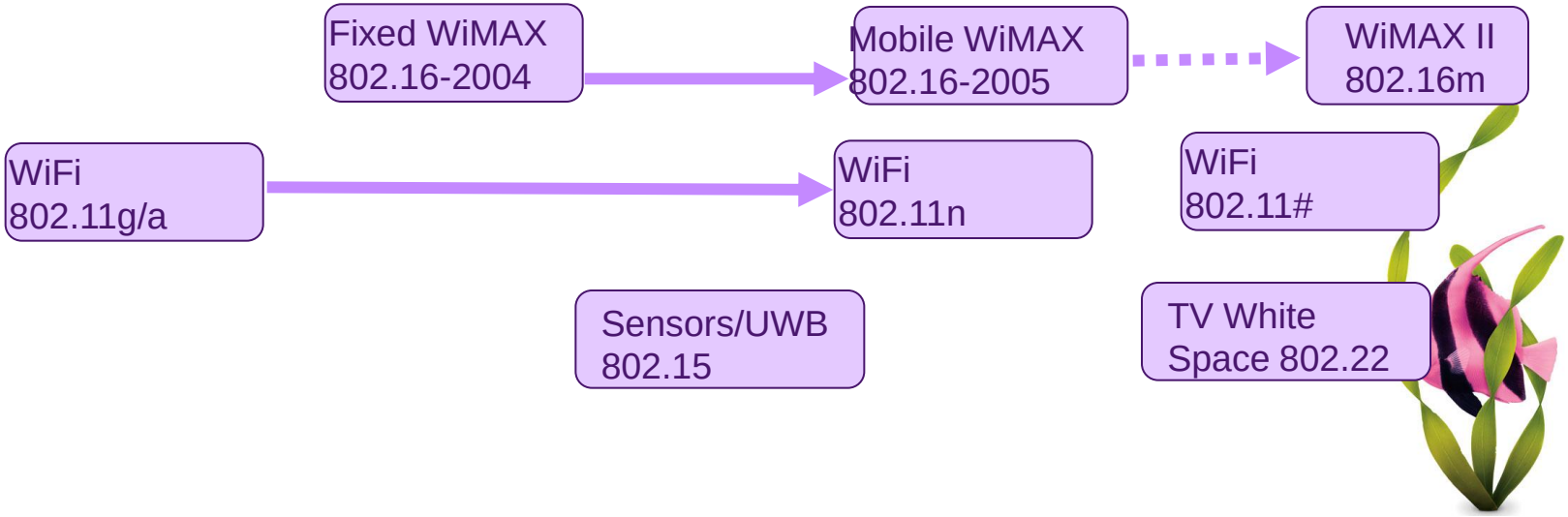
Two (Three) Paths

2007 2009 …… 2015

3GPP Ecosystem:



IEEE Ecosystem:



HSPA

- Evolution of WCDMA UMTS
- Optimized for:
  - Co-existence with existing WCDMA (voice and original 3G data)
    - Ability to hard allocate some of the resources (CDMA “spreading codes”) to data
    - Uses same 5 MHz channels
  - Higher data speeds *where S/N allows it*
    - Still no free lunch
    - **$C = BW * \log_2 (1 + S/N)$** *even with cool technology*
  - Lower latency (delay)
  - Ability to more dynamically allocate resources

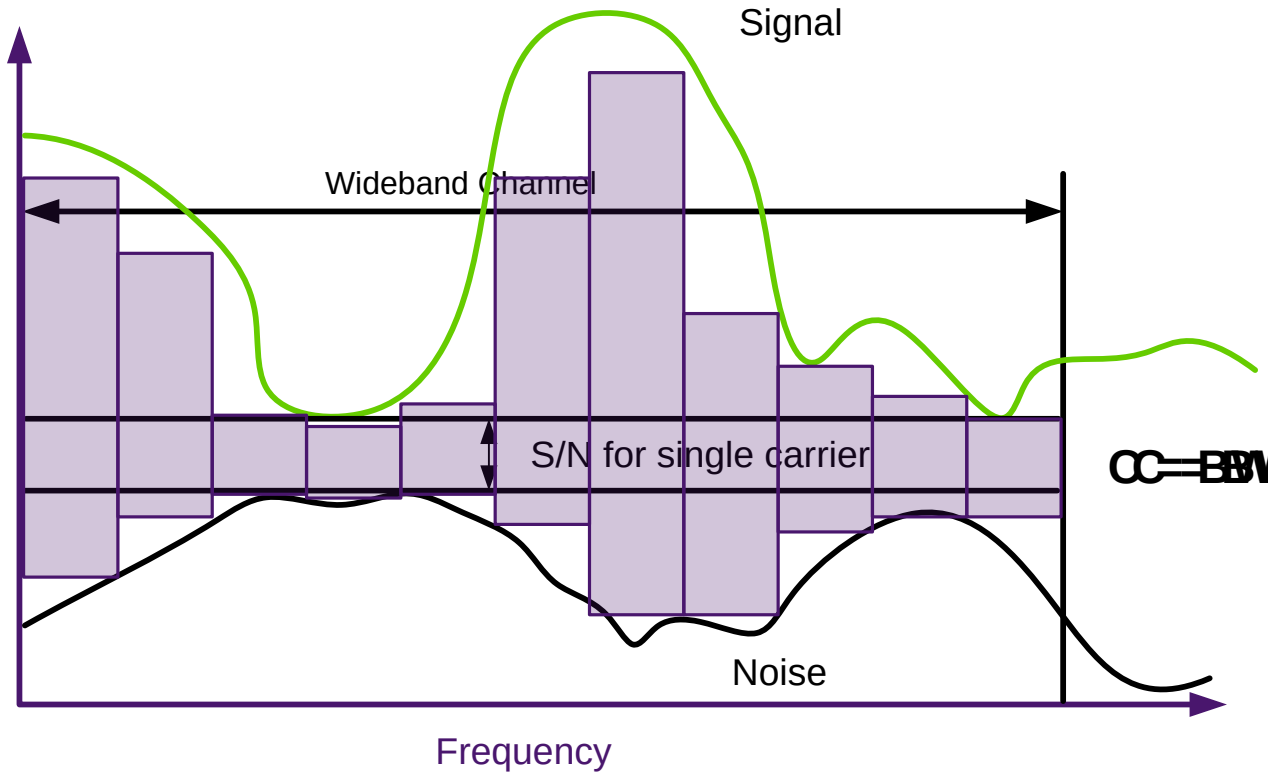
Enhancements

- High Speed Downlink Channel (HSDPA) and High Speed Uplink Channel (HSUPA)
- Optional deeper modulation (16 QAM, later 64 QAM instead of original QPSK -> 4 or 6 bits / Hz instead of 2 *to take advantage of situations with better S/N*)
- Optional less aggressive coding *to take advantage of situations with better S/N* (base WCDMA uses Turbo 1/3)
- Improved retransmit mechanism for error correction (Hybrid ARQ with soft combining)
- Shortened allocation time (Transmission Time Interval) of 2 ms (rather than 10/20/40/80 ms options of WCDMA)
  - allows lower latency and greater granularity of bandwidth allocation

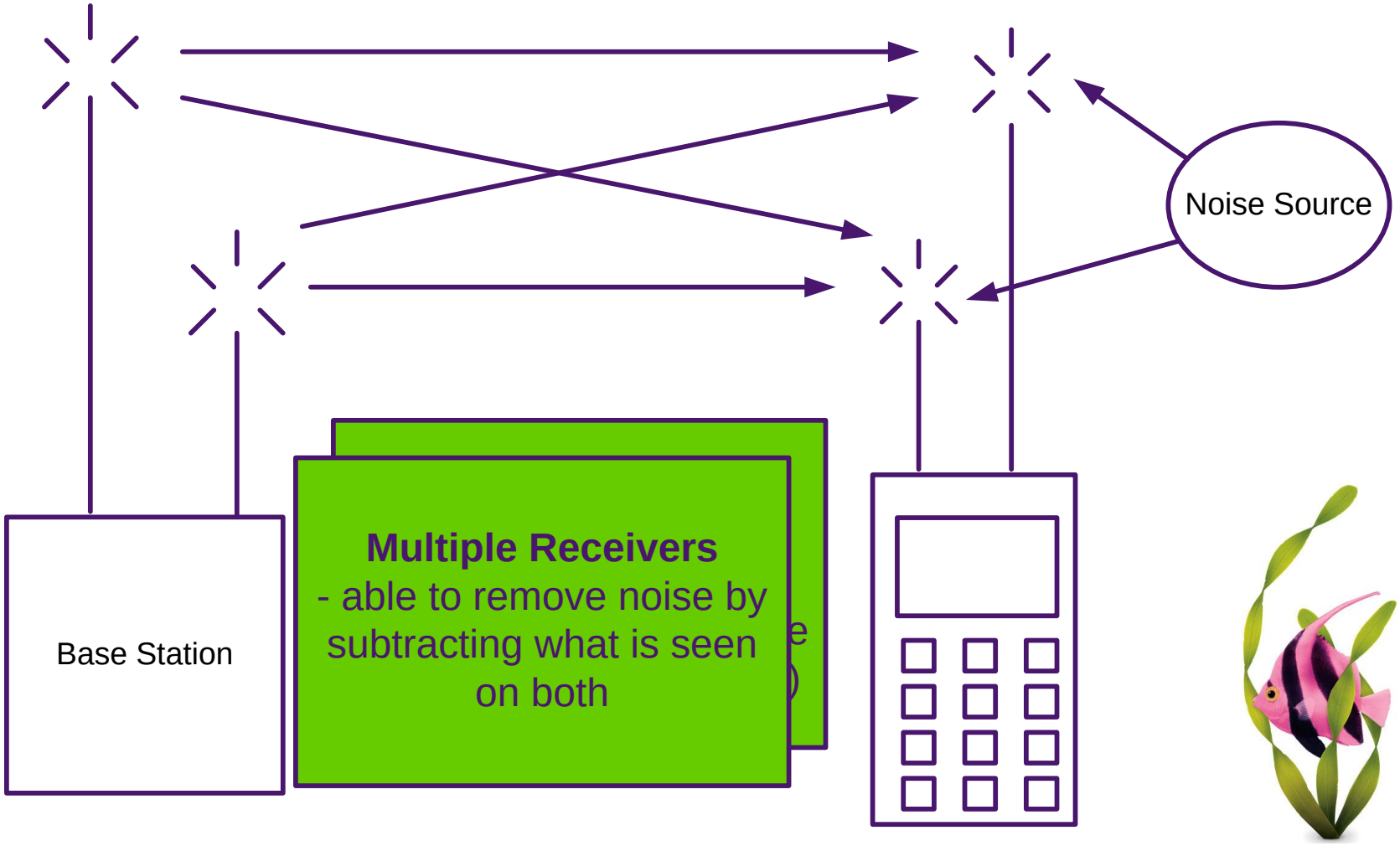
LTE

- HSPA built for compatibility
  - Incremental development of WCDMA
  - Compatible air interface
- LTE built for future capabilities
  - Thus new air interface – not directly compatible with WCDMA
  - (which is not to say that there won't be terminals that can attach to either – don't confuse the air interface with what your device will do)

OFDM


Signal
Wideband Channel
S/N for single carrier
Noise
Frequency
C = BW * log2(1 + S/N)

MIMO (LTE and HSPA+)



Wireless Speeds

Mobile Access Technology

Metric	1xEVDO Rev A	HSDPA R5	HSUPA R6	HSPA+ R7	LTE R8
Deployed Widely	Now	Now	Now	2009	2010+
Channel BW (MHz)	1.25	5	5	5	20 (1.25/5/ 10)
Peak Forward Data Burst Rate (Mbps)	3.1	14.4	14.4	21	100
Peak Reverse Data Burst Rate (Mbps)	1.8	.384	5.8	11.5	50
Latency (ms)	30	50	40	25	5

Data rates do not include MIMO gains (5-20%)

Typical user throughputs for all technologies are a function of radio implementation, cell design, environment, traffic, mobility, interference, user location, clutter/obstructions, building materials and device types.

- E.g. EVDO RevA typical throughput is quoted as 0.45-0.8 Mbps forward link, and 0.3-0.4 Mbps rev link. Peak rate is 3.1Mbps/ 1.8Mbps

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