>BUSINESS MADE **SIMPLE**

802.16e WiMAX in 3.65 GHz Band

Aug. 22, 2006
FCC_Open Range_Nortel Meeting in Washington, DC

NORTEL

Agenda

- >Problem Statement
- >802.16e OFDM / MIMO Functionality
- >802.16e RF Agility / Tool-Kit (CBP like features)
  - Spectrum sharing
  - Interference mitigation
- >802.16h Highlights
- >Summary

Problem Statement

> FCC wants a CBP (Contention Based Protocol) solution for the 3.65GHz band.

> Currently the band is unlicensed, a CBP will allow multiple use without interference. No current deployments in US.

> Open Range needs WiMAX product that has 'some mechanism' to detect other transmissions in the band, and back-off (e.g. limit transmissions, use other frequencies, etc. (PUSC)).

Plan of Record for Rls1.0 of Nortel's WiMAXe product provides initial CBP functionality until 802.16h arrives – NO DELAY REQUIRED

FCC

Appendix A: “Final Rules”

Part 90: “Private Land Mobile Radio Services”

Section 90.7 “Definitions”

Contention-based protocol. A protocol that allows multiple users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate. Such a protocol may consist of procedures for initiating new transmissions, procedures for determining the state of the channel (available or unavailable), and procedures for managing retransmissions in the event of a busy channel.

Nortel Response

Air-interface Protocol: WiMAX OFDMA MIMO with PUSC

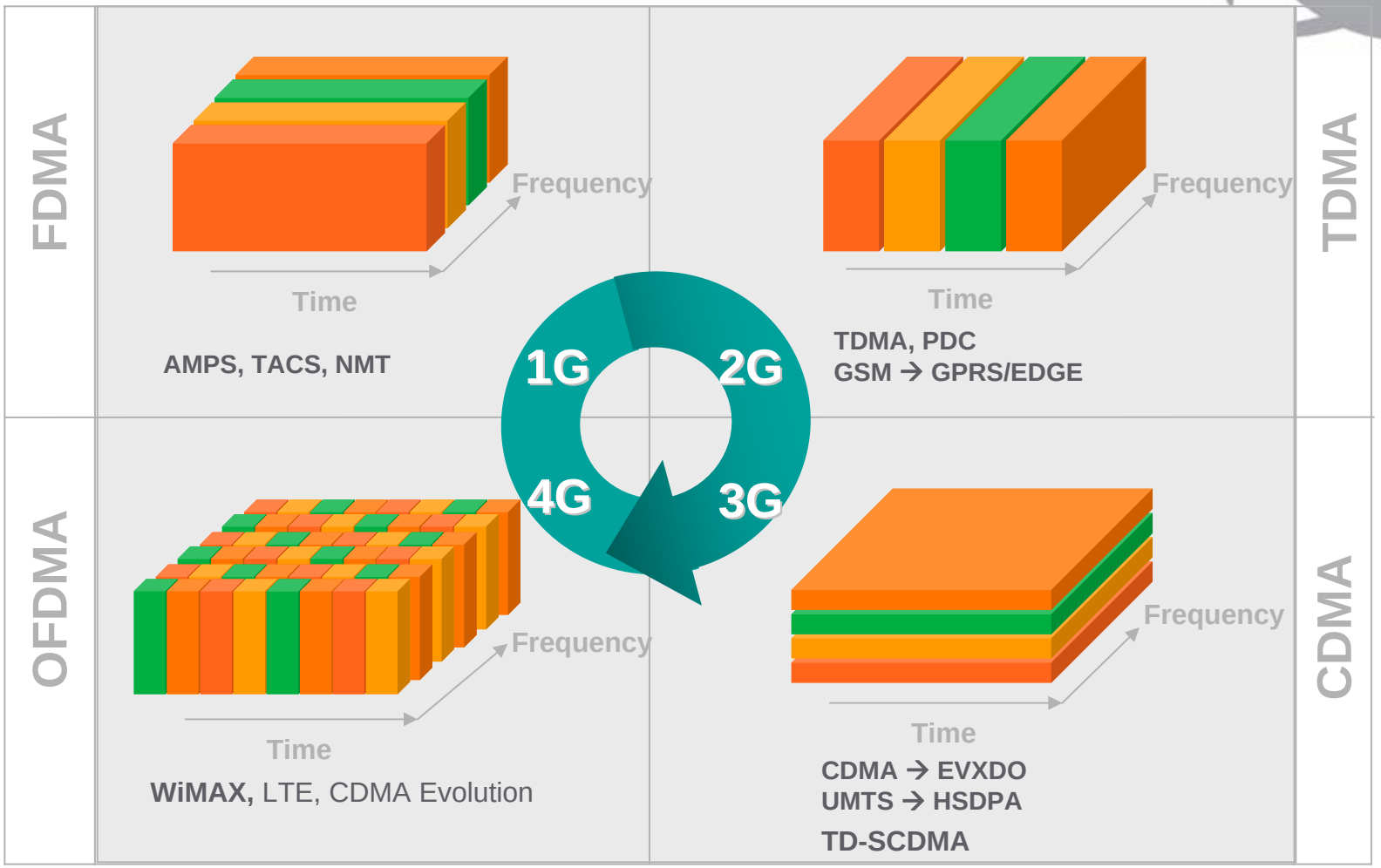
> procedures for initiating new transmissions – RRM (admission control)/RLC (channel conditions)/Scheduler (zone allocation)

> procedures for determining the state of the channel – RLC (Physical CINR, MIMO mode) /RRM (feedback CQICH)

> procedures for managing retransmissions in the event of a busy channel – RLC (MCS selection, # of repetitions, HARQ), Scheduler (allocate different SCs), RRM (Moving on a different carrier – Sector/BTS - handoff)

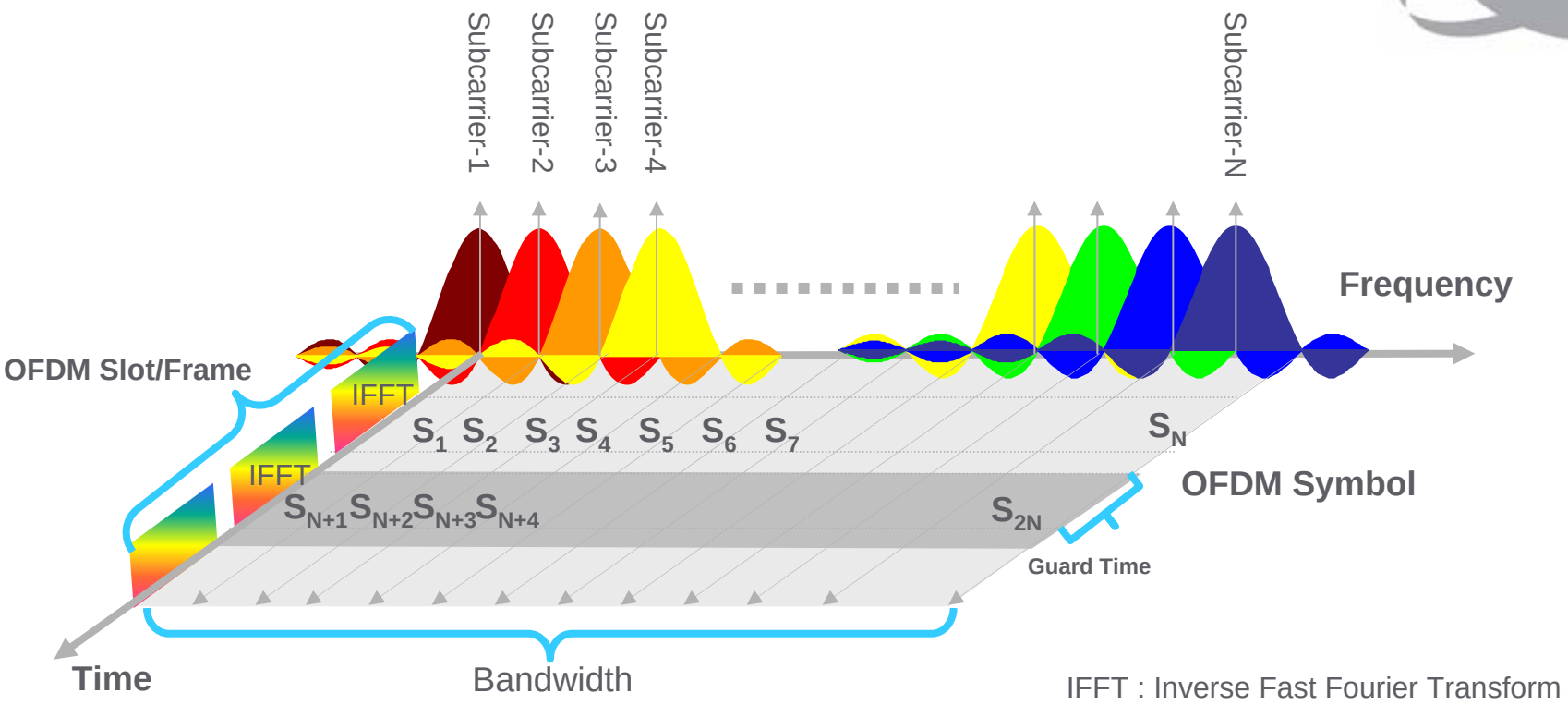
Nortel WiMAX 802.16e Solution satisfies the FCC rule when operating in the unlicensed frequency band 3.65-3.7GHz

Radio Access Evolution



→ User #1 → User #2 → User #3 → User #4

OFDM Overview



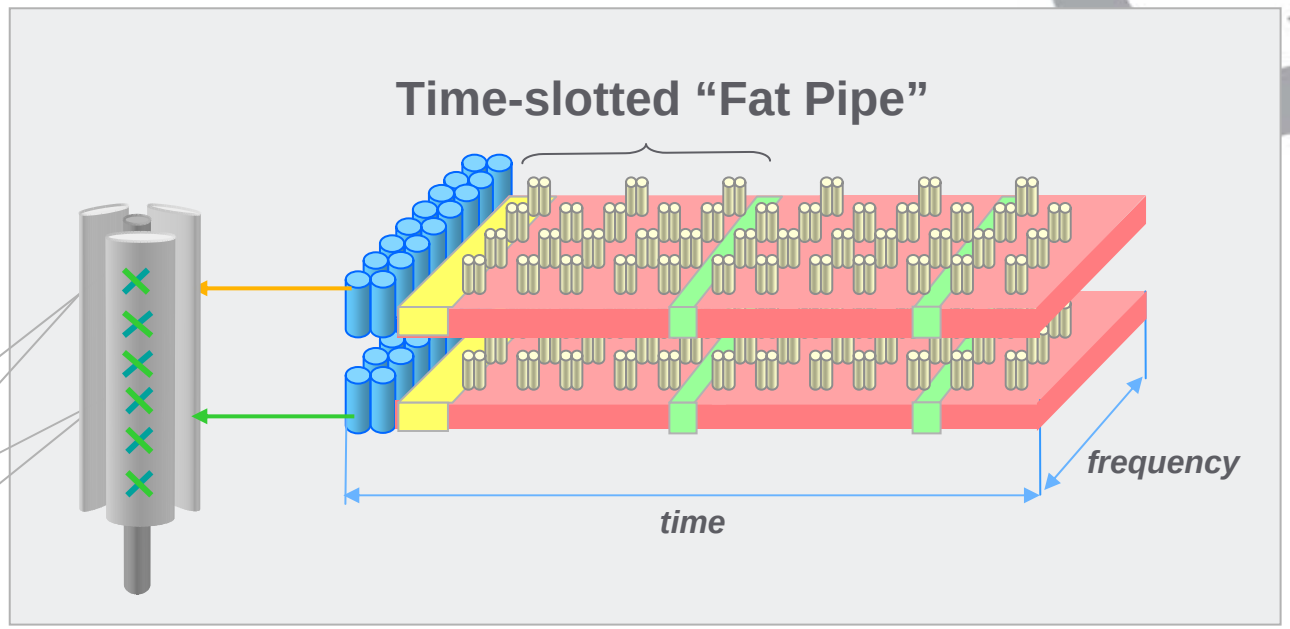
IFFT : Inverse Fast Fourier Transform

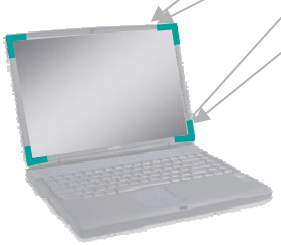
Advantage OFDM

- **High spectral efficiency in real-world time dispersive channels**
- **Robust – less multi-path interference**
- **Easy to integrate MIMO technology**
- **Simple receiver to cope with real-world time dispersive channels → lower cost**

OFDM and MIMO

Dual-polar base station antenna supporting 2-branch MIMO





2 or more antennas

OFDM is more naturally Integrated to MIMO

> High capacity, high spectral efficiency
> Better coverage and QoS
> Spatial dimension to exploit multi-user diversity
> Multi-path fading as advantage
> Increase maximum achievable diversity

OFDM / MIMO Best Capacity and Coverage at Lowest Cost

802.16e RF Agility / Tool Box

- > FUSC / PUSC Subchannelization
- > Radio Link Control (RLC)
- > Radio Resource Management (RRM)
- > Scheduler
- > Fractional Frequency Reuse (FFR)
- > Timing / Synchronization

802.16e Flexible, Intelligent, Agile

FUSC / PUSC Subchannelization

> FUSC
- Uses all subcarriers per sector

> PUSC 1/3
- Can be configured to only use 1/3 of subcarriers per sector (effectively N=3)

> PUSC
- Can use all subcarriers per sector
- Can dynamically, frame to frame and even within frame, allocate more or less subcarriers to increase capacity or reduce interference
- Requires mobiles to measure CINR, BTS scheduler then groups users in low CINR and high CINR, high CINR are served with all subcarriers to maximize capacity / throughput, low CINR users are served with a subgroup of subcarriers (e.g. one subgroup per sector) to reduce interference.
- PUSC can also use power boosting to low CINR users

MIMO PUSC Powerful Mechanism for Mitigating Interference From Other Service Providers, Technologies etc

Radio Link Control (RLC)

RLC on BTS implements advanced capabilities to allow transitioning from one burst profile to another while maintaining QoS guarantees

- Monitors UL and DL radio channel conditions via a set of channel quality indicators (averages and standard deviation of DL RSSI, DL CINR and round trip delay). Parameters reported from terminal to BTS via various feedback mechanisms
- Implementing channel behavior predictive model
- Link adaptation optimization (with respect to modulation scheme, channel coding, repetition, and sub channel power to be used)
- Control the dynamic mapping of mobiles to different subchannel permutation zones

RLC Mechanism that Decides System Configuration Based on Real-Time Physical Channel Conditions

Radio Resource Management (RRM)

RRM is responsible for the measurement, exchange, and control of radio resource-related indicators and the allocation management of various control channels of the wireless link

- Per user channel quality indicator (RSSI, CINR) for UL and DL (via terminal) measurements
- Reporting to NW nodes (i.e. ASN Gateway) on radio resource available (for inter-BTS load balancing)
- Radio Admission Control for new/modified service flows to be admitted by the system
- Triggers “Overload Avoidance Detection” mechanism on the BTS based on the utilization levels on wireless link

RRM Responsible for the Integrity of the Wireless Link

Scheduler

Key to efficient utilization of radio resources and guaranteeing QoS for individual service flows by defining contents of the 802.16e MAC frame

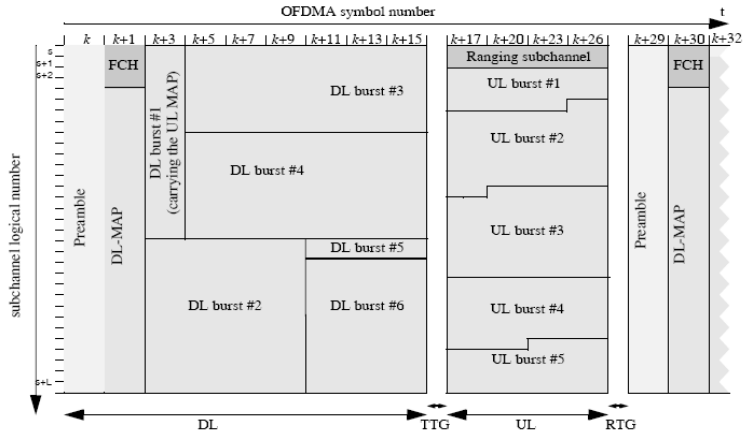
- DL and UL burst scheduling (data, signaling, ARQ, H-ARQ)
- Packet scheduling into DL frames with determination of modulation and coding
- Resource granting in the UL frame
- Per QOS queue prioritization across registered service flows
- Per frame available link resource view (BTS optimizes resource usage)
- Scheduler partitions RF resources for application classes dynamically

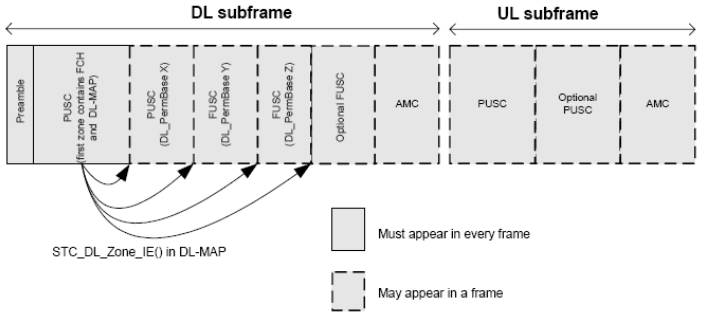
Scheduler uses QoS commitments on UL / DL and RLC info to determine when and how much of the frame is allocated

Fractional Frequency Reuse

802.16e supports multiple frequency reuse patterns. Users operate on subchannels which occupy a small fraction of the whole channel bandwidth

- Zone switching within DL sub frame is permitted, and different zones can use different subchannel allocations
- Different zones can be on different frequency re-use patterns
- Each sector can use any combination of six subchannel group





FFR Used to Mitigate Interference by Configuring Subchannel Usage - Provides More Flexibility than Traditional Frequency Planning

Timing / Synchronization

802.16e based on GPS timing

- Terminal synchronizes to BTS GPS timing
- Inter BTS synchronization
- In TDD system, ensures time alignment of transmit and receive
- If BTS hears other transmissions, can back off timing; adjust frequencies to avoid interference / share channel
- Since BTS controls mobile transmissions (schedules them), BTS can instruct mobile to not transmit (i.e. back-off) or move frequencies

GPS-based Timing Helps Avoid Collisions and Can Provide Synchronization between Carriers

IEEE 802.16h Summary

IEEE802.16 mandate to develop means for 802.16 systems to operate in shared spectrum (unlicensed bands)

- Add protocol and messages enabling 802.16 units to communicate with each other about sharing radio channel resources.
- Extend frame formats to provide extra timeslots so that units can listen for neighbors (i.e. discover who their neighbors are) and to enable exchange of sharing control messages among units
- Connecting all units to the Internet so that they can exchange messages that include location (i.e. GPS coordinates), channel usage and power levels for purposes of allocating resources
- Sharing (among 802.16 systems) is to be accomplished either by using different frequency channels or different time slots
- Sharing with other systems (i.e. 802.11) to be accomplished by coordinating use of different frequency channels

Final Standard Expected in 2008/2009

Summary

- > Nortel MIMO / OFDMA 802.16e well-suited for 3.65 GHz band
  - Coverage, Capacity, Spectral Efficiency, QoS, Cost
- > 802.16e is a robust, intelligent, flexible standard to help deal with coexistence issues
- > Nortel 802.16e solution employs adaptable and powerful mechanisms for mitigating interference from other service providers, technologies, etc.
- > Nortel's 802.16e Rel 1 product provides initial CBP functionality (detection and mitigation) until 802.16h arrives

Existing Feature Set Meets FCC CBP Intent