Wireless Medium Access Control and CDMA, 3G, WiMax and 4G Networks

Lesson 16

4G Networks─ HS-OFDM, LTE Advanced and WiMax 16m

4G

- 3G and 3G+ provide data rates below 100 MHz.

- 4G File transfer at 100 Mbps+

- High resolution 1024 $\times$ 1920 pixel hi-vision picture transfer at 24 Mb/s

- High resolution video transfer

4G

- Ultra fast file transfers
- Streaming ultra high resolution pictures
- Streaming high definition TV
- Streaming videos
- Need 100 Mbps at the mobile systems

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4G Requirements

- Bandwidths of at least 40 MHz
- High spectral efficiency should be greater than 1.0 bps per Hz per sector
- Ability to operate up to 40 MHz channels
- Soft handoff across the heterogeneous networks
- Seamless connectivity
- Global roaming across multiple networks

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4G SYSTEM DESIGN

- Any one of the following:
- IMT-Advanced (International Mobile Telecommunications Advanced) ITU-R or LTE Advanced or WiMax 402.16m.

Modulation and Multiplexing techniques for 4G Networks

- Multi-carrier transmission OFDMA

- Frequency domain equalization in place of spread spectrum which is used in 3G.

- Multi-input Multi-output (MIMO) Antennae channel dependent scheduling with channel coding and dynamic channel allocation

- Automatic repeat request

Multi-carrier transmission OFDMA

- OFDM a spread-spectrum based multi-carrier or discrete multi-tone modulation

- Multi-carrier transmission OFDM uses multiplexing in code-space

- Multiple carriers use mutually orthogonal codes

- Each channel carrier has distinct amplitude (power level) and may have a time guard

- Bandwidth remains equal to that in the single-carrier case.

Frequency domain equalization

- Direct sequence CDMA gives high performance comparable to OFDM (multi-carrier-CDMA) if proper frequency domain equalization is performed at the receiver end

- Single-carrier FDMA (SC-FDMA)

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SC-CDMA Frequency Equilisation
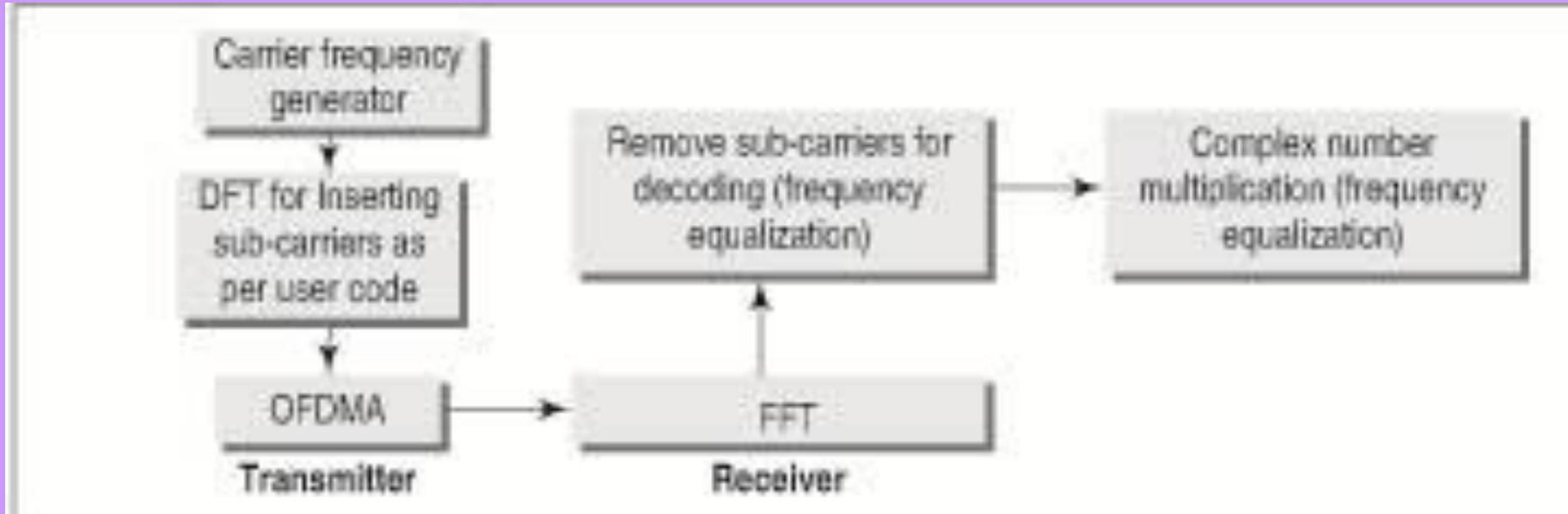
Fourier Coefficients of Single Carrier

- Symbols of a user channel are assigned distinct set of non-overlapping Fourier-coefficients

- Each user transmitter does distinct insertion of silent Fourier coefficients

- Silent means missing a_n and b_n at certain specific values

- Receiver removes the silent Fourier coefficients after the fast Fourier transform (FFT)

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Frequency Equalisation

- Frequency equalisation performed at the receiver

- First fast Fourier transform (FFT) performed

- Then each Fourier coefficients multiplied by a complex number

- Frequency selective fading and phase distortion does not affect the received frequency signal after equalisation

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Equalization and FFT

- The computations of frequency domain equalization and FFT require less number of computations than when compared to correlation by time shifts at the rake receiver unit of DSSS receiver.

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Multi-input Multi-output (MIMO) Antennae

- Channel dependent scheduling with channel coding and dynamic channel allocation
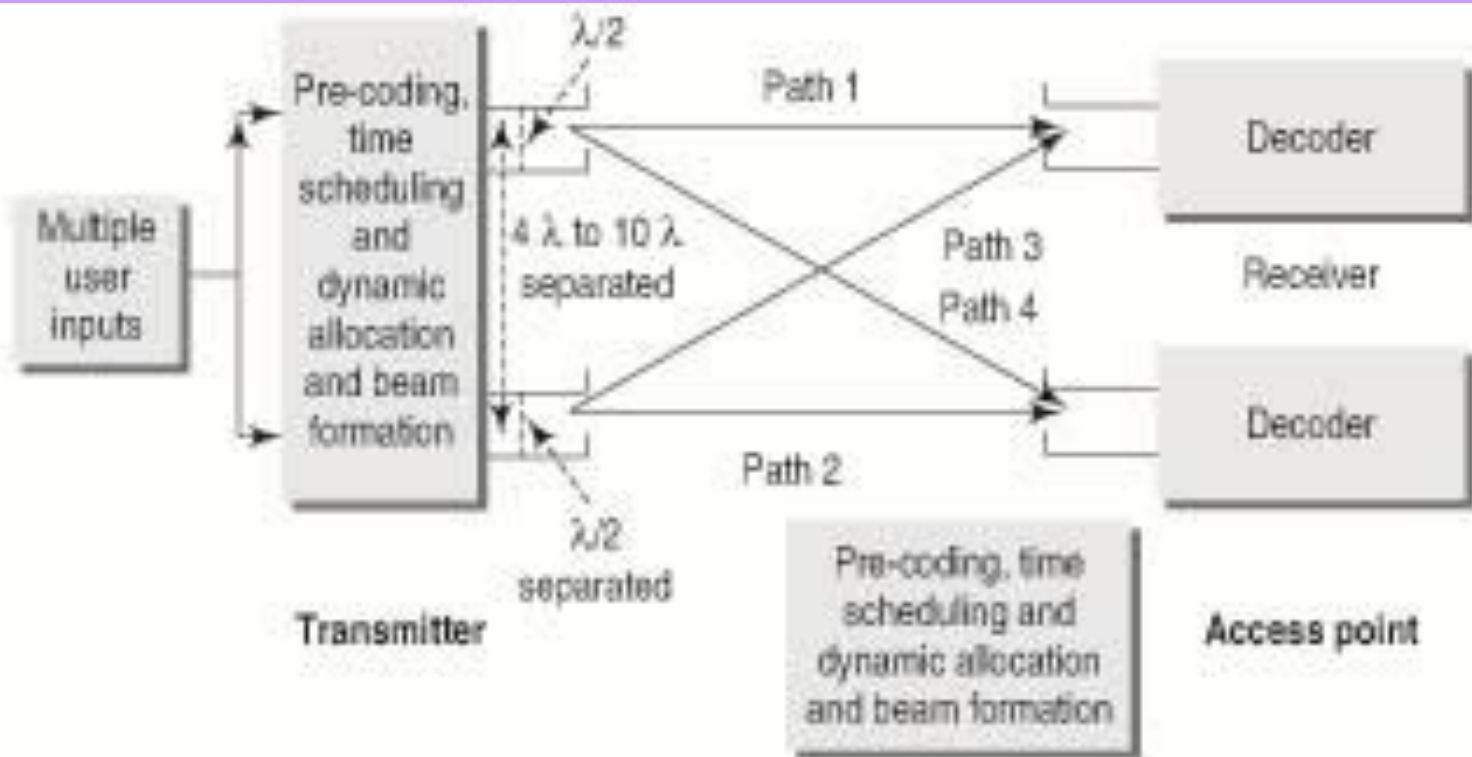
Advanced 2×2 MIMO

Figure 4.26   Advanced multiuser 2 × 2 MIMO

LTE Advanced

Property	Description
LTE Advanced	LTE Release 10; 100 Mbps 100 Mz spectrum bandwidth
Downlink	Release 9 LTE Advanced; nearly 500 Mbps downlink Release 10 LTE Advanced; greater than 1 Gbps downlink
Network	Heterogeneous: LTE cells, Pico-cells and Femto-cells
Peak data rate uplink	500 Mbps
Peak data rate downlink	1 Gbps
MIMO	4×2 MIMO LTE 4×2 MIMO LTE
Spectral efficiency	Uplink 15 bps per Hz Downlink 20 bps per Hz

LTE Advanced

Property	Description
Uplink power control	Fractional path loss compensation
Latency	10 ms user plane; 50 ms control plane
Applications	Streaming multimedia, Video, HDTV, Broadband Internet

WiMax 802.16m

Property	Description
Frequency	450–470 MHz, 698–960 MHz, 1.710–2.025GHz, 2.110–2.200 GHz, 2.300–2.400 GHz, 2.500–2.690 GHz; 3.400–3.600 GHz
Multiplexing	FDD (4 frames) and TDD (uplink and downlink 2 sub-frames per frame) Modulation QPSK, 16-QAM, 64-QAM
WiMax Advanced	1. WiMax Release 1.5; 4 × 2 MIMO 2. WiMax Release 1.5; 2 × 2 MIMO 3. WiMax Release 2.0; 802.16m Mobile Broadband, FDD + TDD 300 + Mbps
802.16m	1. 1 Gbps fixed speed 2. Similar to 802.16e with the exception of soft classification of the common part of MAC sublayer
OFDM Channel bandwidth	5 MHz, 7 MHz; 8.75 MHz, 10 MHz, 20 MHz Subcarriers: 18 × 6 sub-carriers Type 1 sub-frame; 18 × 7 Type 2 sub-frames; 18 × 6 Type 3 sub-frames;
MIMO	1. Single user MIMO 2. Multi user MIMO 3. Beam former 4. Pre-coder 5. User Scheduler Resource Mapper 6. Feedback Hybrid ARQ

WiMax 802.16m

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Encoder	Channel Encoder, Interleaver, Rate-matcher, Modulator
Superframe	20 ms (4 × 5 ms frames)
RRCM layer	Radio Resource and Management
MAC Layer	Multi-radio coexistence (802.11, 802.15.1, 802.16); sleep mode management, scheduling and resource multiplexing; Data forwarding, Control signalling, Interference Management, Ranging and Link Adaptation
Uplink power control	Both closed loop and open loop
Applications	Mobile Wireless Internet Access, Streaming multimedia, Video, HDTV, Data, Broadband Internet

WiMax 802.16m Access Point
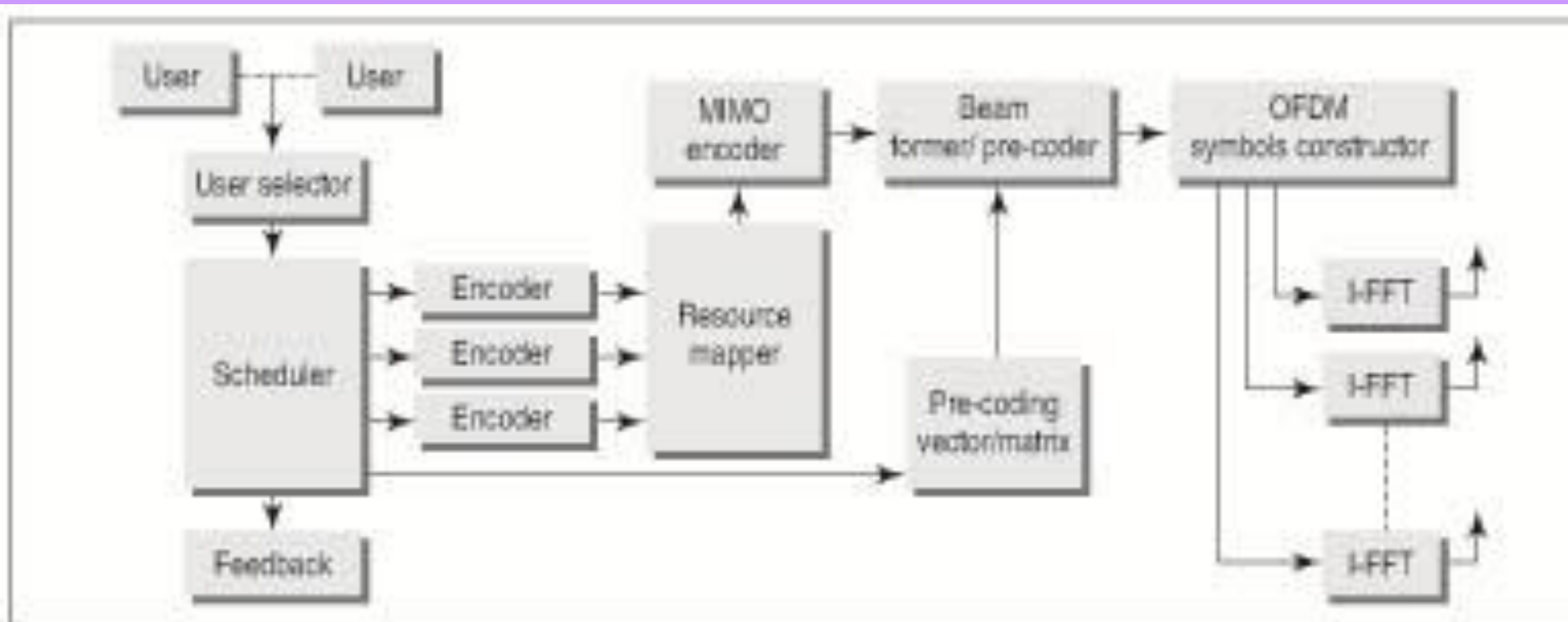
Figure 4.27 Multiple outputs from Multiple users in WiMax 802.16m Access Point

Summary

- Single-carrier FDMA (SC-FDMA)
- IMT-Advanced (International Mobile Telecommunications Advanced) ITU-R or LTE Advanced or WiMax 402.16m
- Advanced MIMO

…Summary

- Seamless connectivity
- Global roaming across multiple networks
- Bandwidths of at least 40 MHz
- High spectral efficiency should be greater than 1.0 bps per Hz per sector
- Ability to operate up to 40 MHz channels
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End of Lesson 16

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