



EENGM4221: Broadband Wireless Communications

Lecture 22: WiMax PHYs

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The NLOS PHYs (1)



- 802.16-2004 has four entirely different PHYs
 - Single Carrier (SC)
 - Single Carrier ‘a’ (SCa)
 - OFDM
 - OFDMA
- SC is the PHY from the original 802.16 standard. Assuming the use of professionally installed, directional antennas with LOS channels it has very little fading (shadowing or multipath) to contend with and so is a simple solution to an easy problem
- The other PHYs are all for the NLOS case and take on a much bigger challenge

The NLOS PHYs (2)



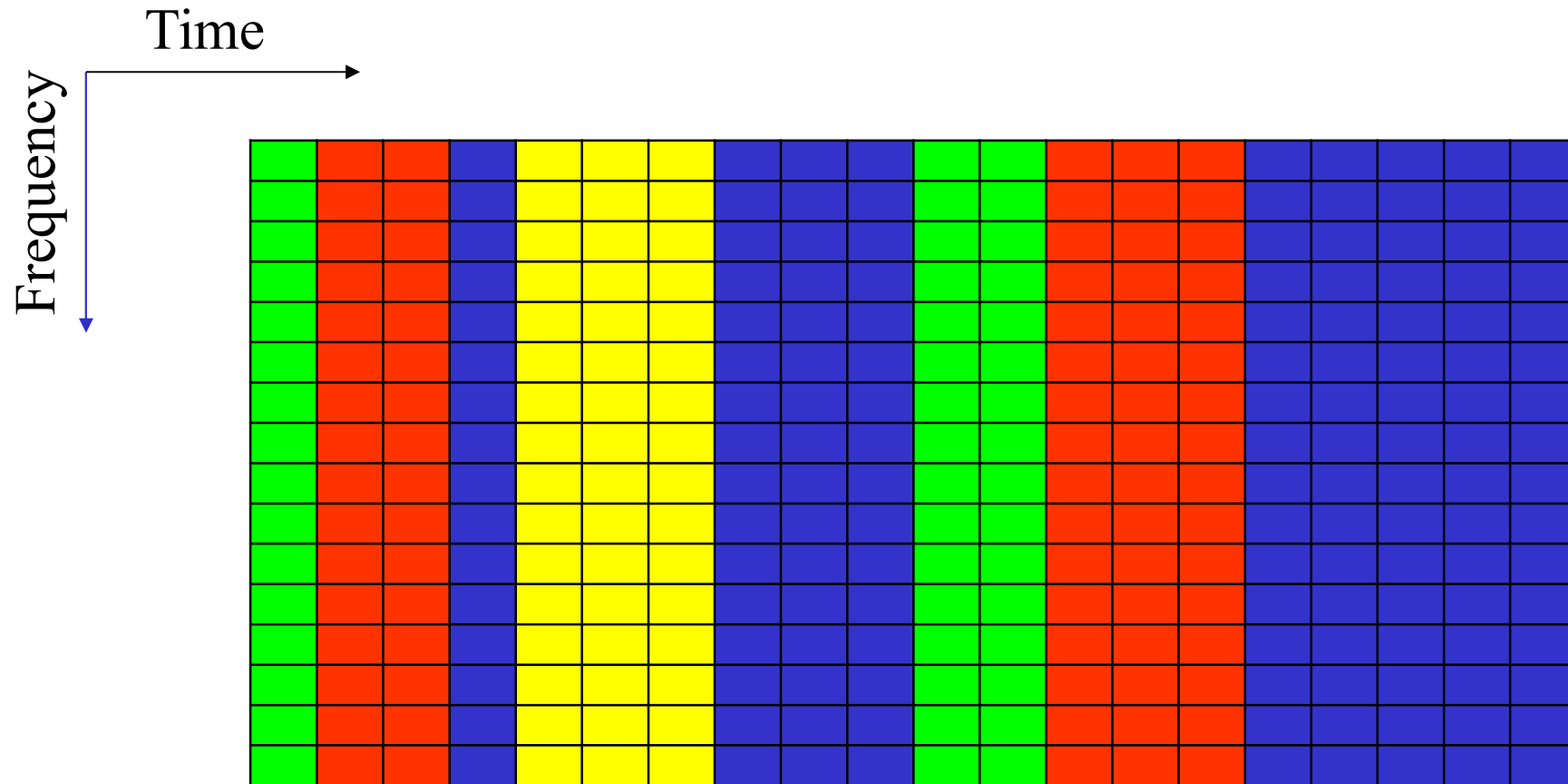
- SCa (taking the ‘a’ from 802.16a) is another Single Carrier Solution but has specific features added to enable the effective use of complex frequency domain equalisers (to combat wideband fading)
- OFDM is a multi-carrier PHY. OFDM is particularly efficient and effective at combating wideband fading
 - The OFDM PHY is specified by WiMax for fixed networks
 - The OFDM PHY is the only PHY compatible with the Mesh MAC

The NLOS PHYs (3)

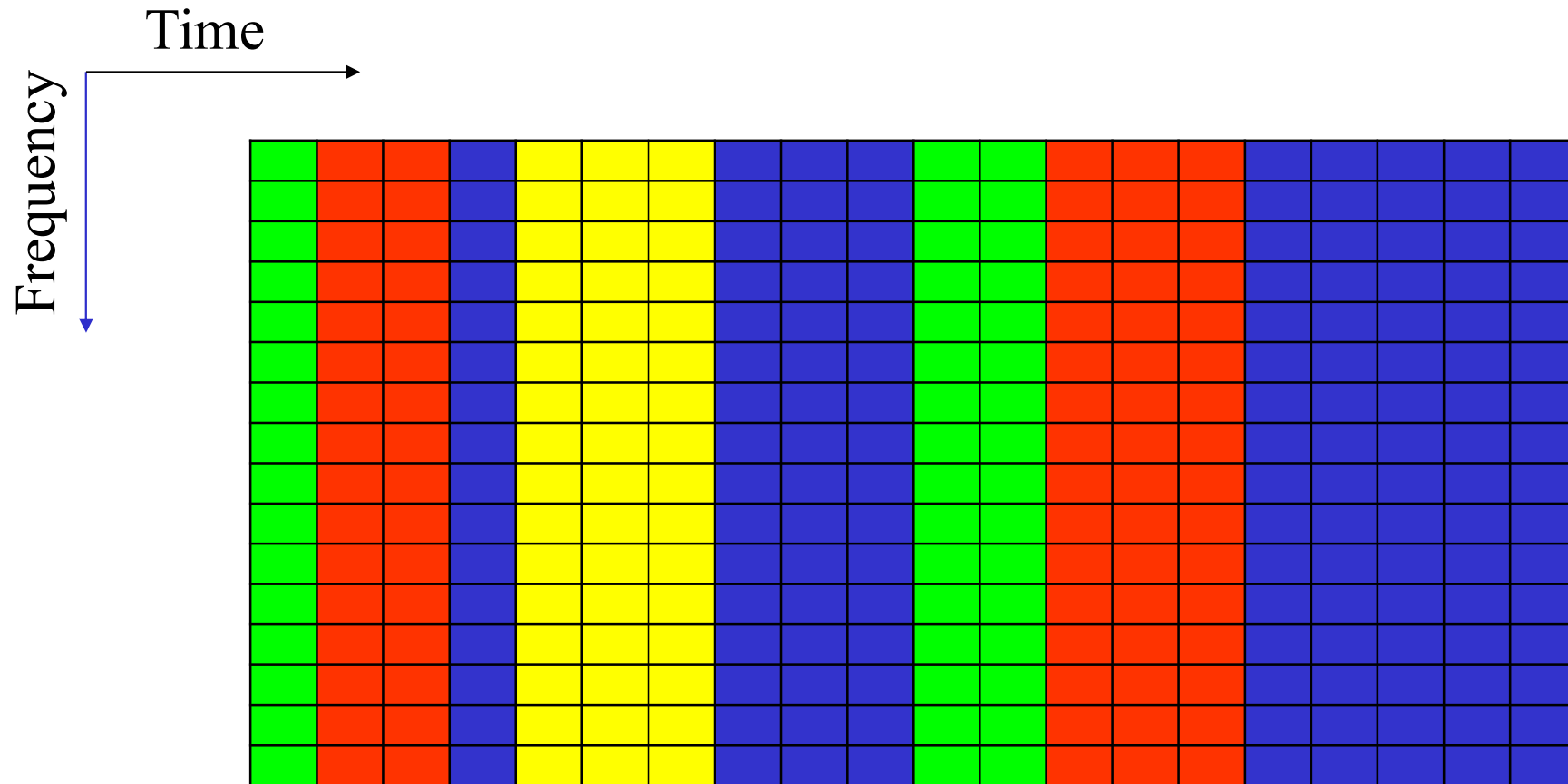


- OFDMA is a combination of OFDM with FDMA
 - All other PHYs assume TDMA or TDM
 - OFDMA is specified by WiMax for mobile networks and by WiBro
- OFDMA has the advantage that each SS may simultaneously transmit using a (distributed) fraction of the total bandwidth for the Uplink
 - This achieves an SNR gain:
$$Gain = \frac{Total_number_of_Subcarriers}{Number_of_Subcarriers_Allocated_to_SS}$$
 - This can be a substantial gain

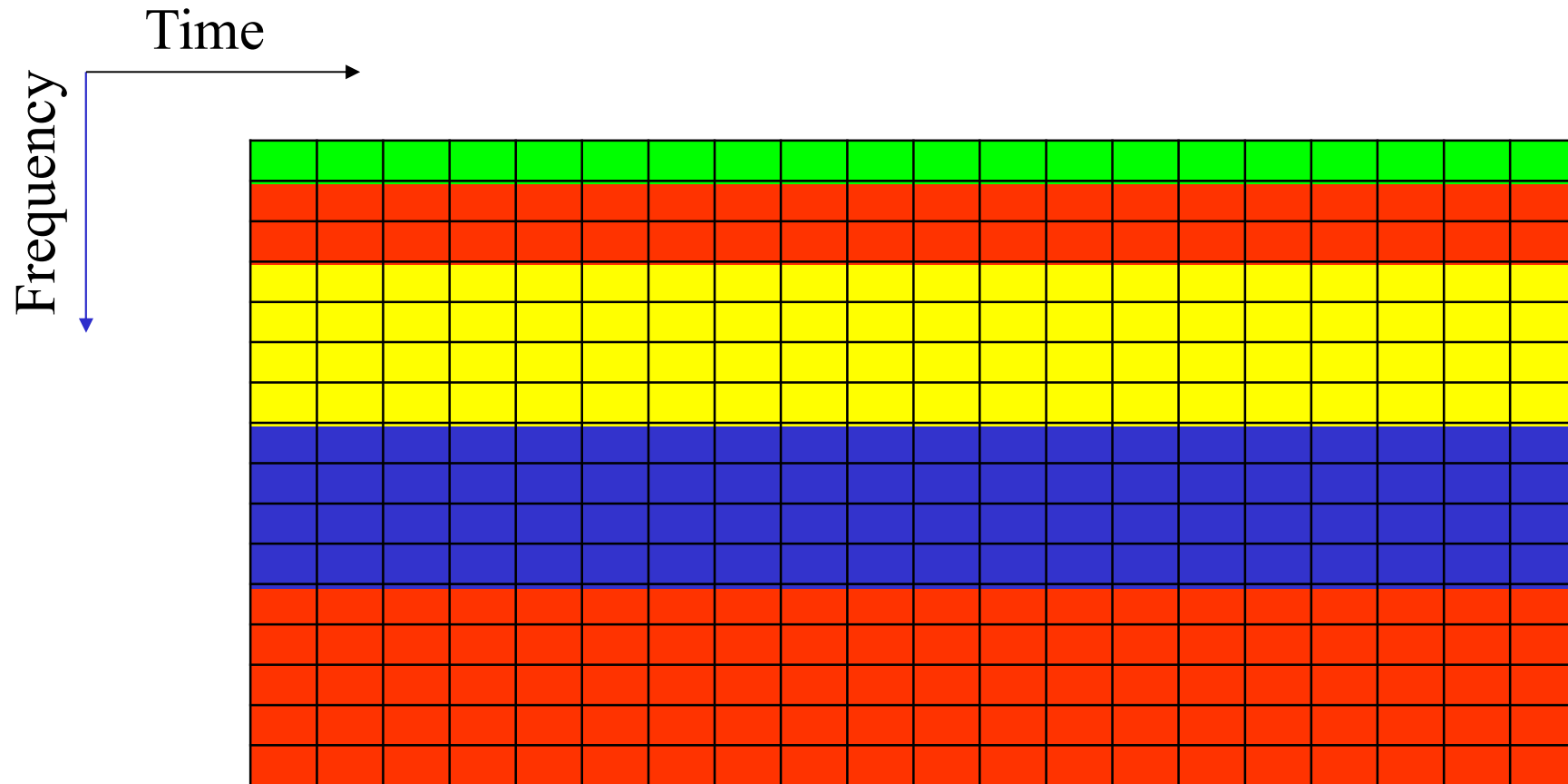
2D Resources and Scheduling – OFDM/TDMA



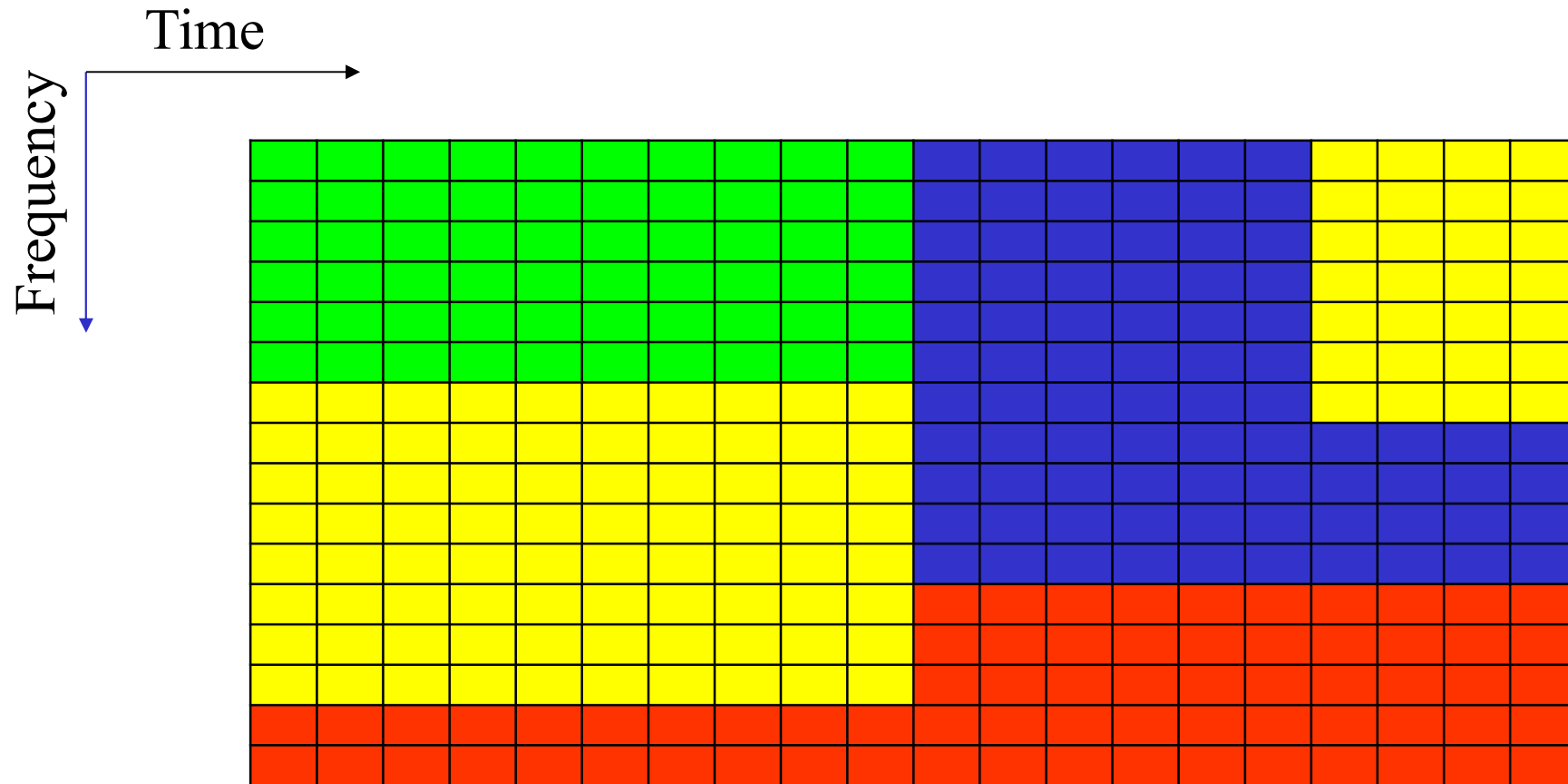
2D Resources and Scheduling – OFDMA/TDMA – low gain



2D Resources and Scheduling – OFDMA/TDMA – high gain



2D Resources and Scheduling – OFDMA/TDMA – traffic dependent



The NLOS PHYs (4)



- OFDMA can also mitigate interference between cells.
 - Interference between SSs on the edges of adjacent cells can be severe if they transmit on the same frequency and at the same time
 - It is not easy to co-ordinate schedules between BSs to prevent certain nodes transmitting at the same time
 - Using OFDMA, the frequency allocation can be randomised as an alternative way of reducing interference
- Alternatively, OFDMA can be exploited for Dynamic Resource (Sub-Carrier) Allocation

PHY Parameters (1)



- 802.16 includes MANY options in its PHY layers
 - Bandwidth is variable, hence symbol rate is variable
 - Modulation is variable with BPSK, QPSK, 16-QAM and 64-QAM available for Link Adaptation
 - A variety of FEC options including: Block Codes, Convolutional Codes, Trellis Codes, Turbo Codes, LDPC codes...
 - The use of Convolutional Codes in combination with BPSK, QPSK, 16-QAM and 64-QAM is mandatory and results in a set of modes almost identical to those in 802.11a and 802.11g
 - Other combinations are optional

PHY Parameters (2)



- ARQ is employed
 - No FEC is also allowed (i.e. ARQ only)
 - Otherwise HARQ can be seen to be used
 - Enhanced HARQ using Incremental Redundancy is also allowed
- MIMO techniques including Space Time Block Coding and Adaptive Antenna Arrays are also included
 - These include features similar to those that 802.11n introduces
- Thus the 802.16 PHY can be expected to be at least as good as those of 802.11a, 802.11g and 802.11n and possibly better, depending upon the optional extras
- However, it is debatable whether 802.16 will achieve higher capacity/spectral efficiency due to the variable bandwidth and potentially higher operating range (lower SNR at the cell boundary)

Review of Lecture 22



- We discussed the four different PHY options in 802.16 up to version ‘e’
- We highlighted the uplink gain achieved by OFDMA
 - We discussed how scheduling would interact with this gain
 - We discussed implications for inter-cell interference and DRA
- We reviewed the modulation and coding options – essentially: everything good at the time (at least optionally)