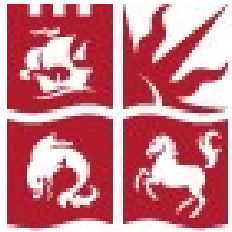
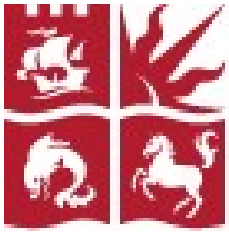


EENGM4221: Broadband Wireless Communications

Lecture 11: 802.11 Overview and Task Groups

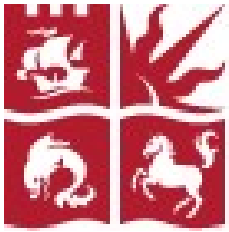
Dr Simon Armour

802.11 WLAN (1)



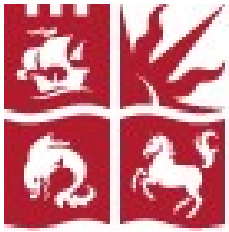
- The original 802.11 standard consisted of a single MAC layers specification with three different optional PHY specifications:
  - 2.4GHz RF Direct Sequence Spread Spectrum
  - 2.4GHz RF Frequency Hopping Spread Spectrum
  - Infrared
- All three PHY options were capable of two data rates: 1Mbit/s and 2Mbit/s
- The Infrared PHY was almost universally ignored and even the two RF PHYs achieved little commercial success
- Subsequently 802.11 actioned Task Groups a and b to ‘make it go faster’
- Commercial Success Followed

Relevant 802.11 TGs (1)



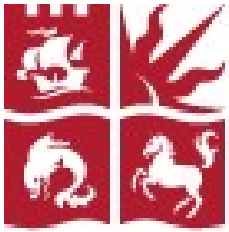
- TGa had the task of designing a high speed PHY for bands ~5GHz and the result was a Link Adaptive 54Mbit/s OFDM PHY
- TGb had the task of designing a high speed PHY for the 2.4GHz band and the result was an 11Mbit/s CCK-DS-SS PHY
- Task Groups and Extensions to the basic standards proliferated in the wake of the commercial success ensuing (primarily from the introduction of 802.11b).
  - Task Groups go as far as az (in 2017).

Relevant 802.11 TGs (2)



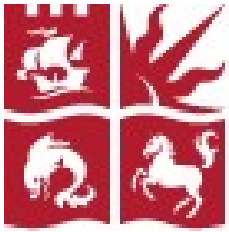
- More recent standards of particular interest:
  - TGg had the task of ‘making it go even faster in the 2.4GHz band’ and neatly solved the problem by duplicating the TGa spec and then bolting on a few extras to ensure backward compatibility between 11b and 11g
  - TGn had the task of ‘making it go even faster still’ and agreed a specification for data rates greater than 500Mbits/s
  - TGac had the task of being even faster than 11n
    - Note the ‘go faster’ mentality and continued backward compatibility
  - TGad shifted the emphasis from microwave frequencies to mmWave; this inherently removed the opportunity/constraints of backward compatibility
  - TGax put an emphasis on dense networks
  - TGaz considers ‘even faster’ versions of ad

.11 and .11b PHYs



- All three of the ‘original’ .11 PHY specifications operate with a symbol rate of 11MBaud and use either BPSK or QPSK in combination with Spread Spectrum (with a processing gain of 11) to achieve 1 or 2Mbits/s.
- .11b extends the Direct Sequence SS PHY by optional combination with ‘Complementary Code Keying’ to achieve 5.5 and 11Mbits/s
  - CCK is really slight of hand to reduce the spreading rate to either 2 or 4
  - The total range of PHY ‘modes’ in .11b is thus 1, 2, 5.5, 11Mbits/s

.11a and .11g

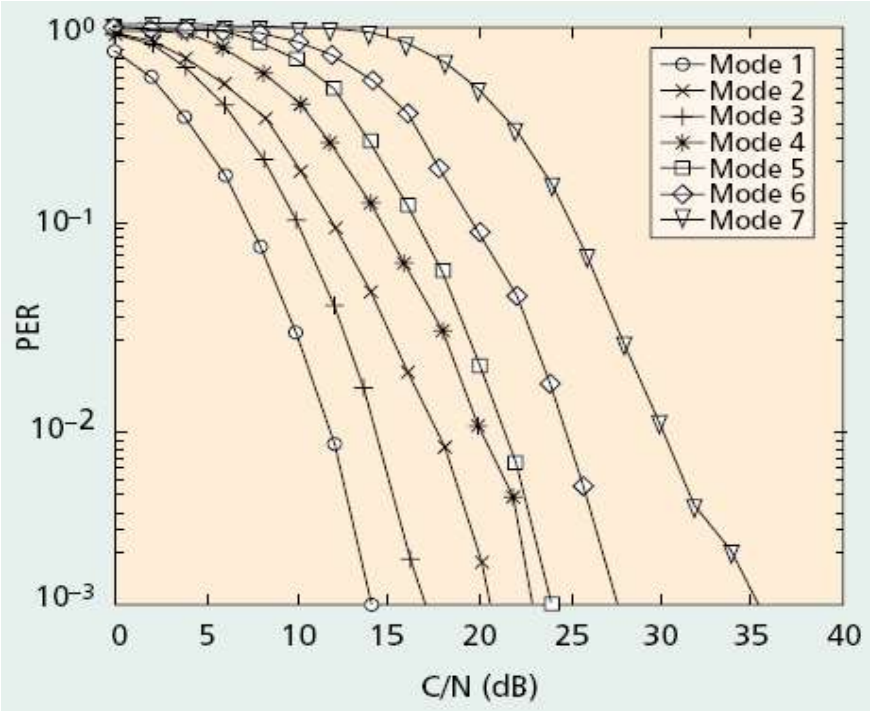


- .11a and .11g use the same modulation
  - Specified for different operating bands
- Use a symbol rate of 20MBaud and Orthogonal Frequency Division Multiplexing (OFDM) in combination with various modulation and FEC (convolutional) coding rates
- Specifically designed to enable Link Adaptation
- PHY FEC combines with MAC ARQ to achieve 'basic' HARQ

Mode	Modulation	Coding Rate	Rate (Mbits/s)
1	BPSK	1/2	6
2	BPSK	3/4	9
3	QPSK	1/2	12
4	QPSK	3/4	18
5	16-QAM	1/2	24
6	16-QAM	3/4	36
7	64-QAM	2/3	48
8	64-QAM	3/4	54

.11a/g Link Adaptation (1)

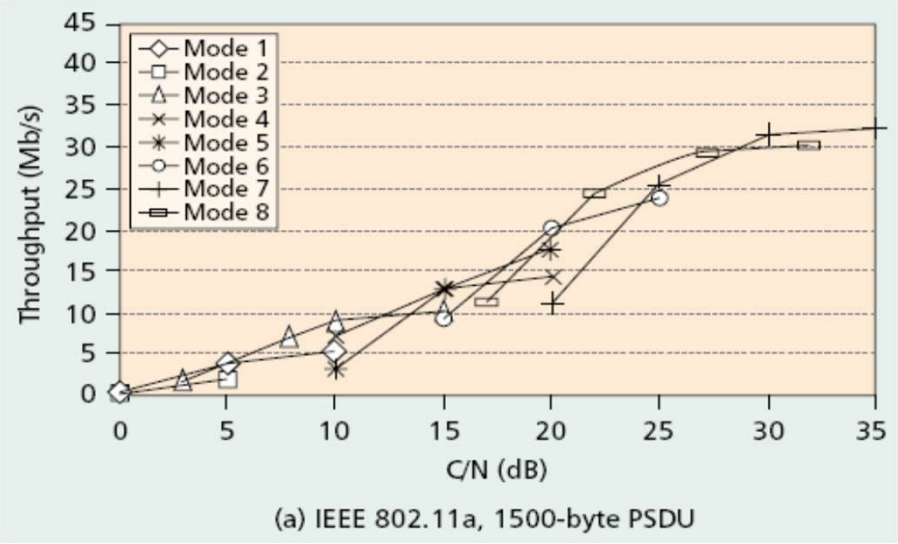
- The range of PHY modes included in 802.11 enables the PHY to adapt to link quality in order to support QoS requirements and maximise throughput
- Higher rate modes generally require more SNR to achieve an acceptable BER/PER



Source: Doufexi, Armour, et. al., IEEE Communications Magazine May 2002.

.11a/g Link Adaptation (2)

- PER has implications for throughput
- 802.11a and g can choose the mode so as to:
  - Maximise throughput
  - Maximise throughput whilst maintaining an upper limit on PER

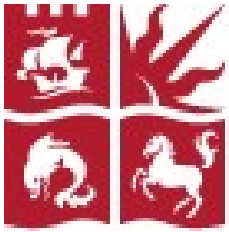


(a) IEEE 802.11a, 1500-byte PSDU

Source: Doufexi, Armour, et. al.,
IEEE Communications Magazine May 2002.

Ref:

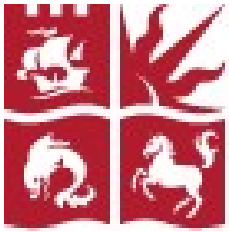
The 802.11 MAC



- The 802.11 MAC comes in two ‘flavours:’
  - Distributed – based on a Distributed Coordination Function (DCF)
  - Centralised – based on a Point Coordination Function (PCF)
- Long ago, the 802.11 (distributed) MAC was referred to as DFWMAC: Distributed Foundation Wireless Medium Access Control
  - This name has more or less been forgotten but it is accurate
- The DCF is what its name implies; distributed – all nodes in a Basic Service Set jointly accept responsibility for the MAC process – there is no central control
- This simple fact is essential to understanding why the 802.11 MAC works the way it does and, arguably, all that is ‘wrong’ with it

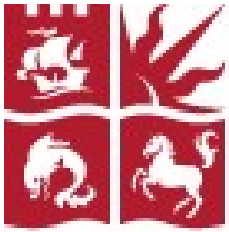
Ref:

BSS, EBSS and SSID



- Basic Service Set (BSS) is the term used in 802.11 to define a network of nodes communicating purely via 802.11 protocols
- Each BSS has a ‘Service Set Identity’ SSID
  - You may have heard of the SSID before. This is an identifier for the networks you use:
    - Your home router has its own SSID
    - If you want to use a public WiFi network (when you go to a café or coffee shop, for example) the SSID is what you need to know (along with its corresponding password)
- Extended networks formed by internetworking with other communications protocols (e.g. connecting two BSSs via wired Ethernet) are Extended BSSs (EBSS)

Review of Lecture 11



- We have introduced various versions of the 802.11 ‘WiFi’ standards
  - We have done a very brief ‘history’ lesson
- We have highlighted some key PHY versions and related these to Link Adaptation
- We’ve introduced some key terminology
- We have introduced and named two MAC protocols
  - We haven’t yet discussed how they work!

Ref: