IEEE 1900.7 White Space Radio
A broadcaster's view: use cases/requirements

Date: **2011-09-29; Berlin**

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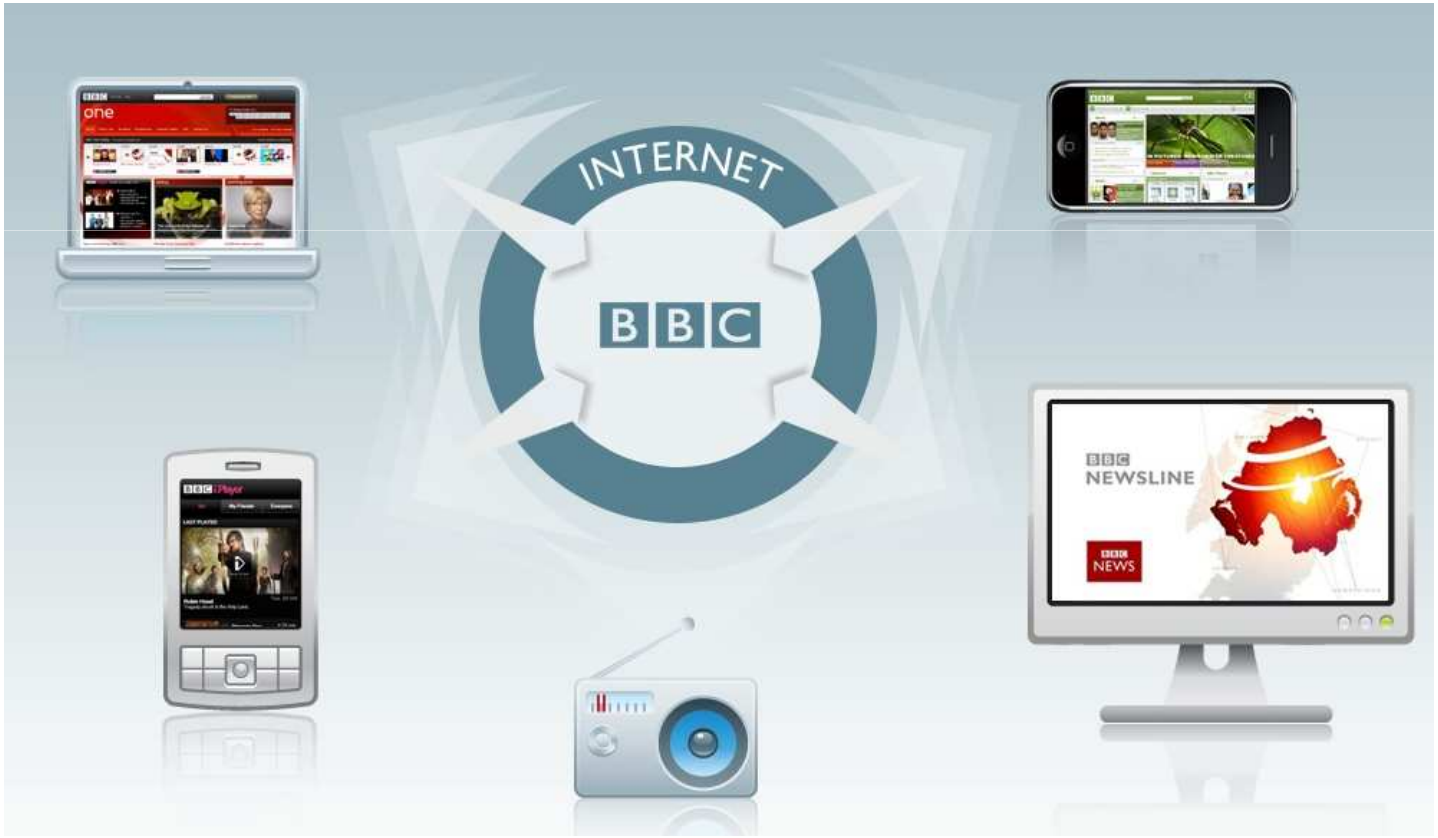
Why is White Space Important?

- Broadband Internet connectivity is essential for people to access BBC's new services

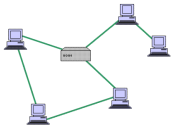


Possible Use Cases

- Broadband Wireless Access
  - Rural Area Networks (IEEE 802.22)
  - “ADSL-like” wireless broadband networks operated by an ISP

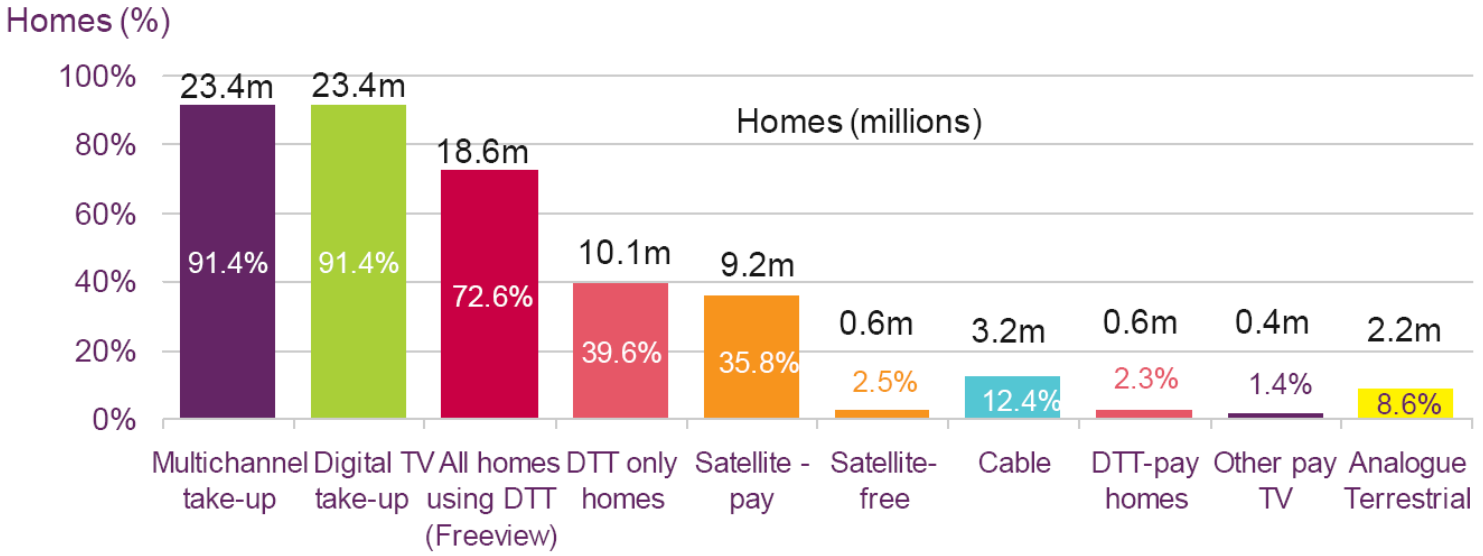
- In Home Networks / Business Campus Networks
  - Improved WiFi (better range)
  - Femtocells
  - Multimedia streaming and VOD
    - High bit rates required
  - Internet sharing (e.g. BT FON model)

- Helping to meet national broadband connectivity objectives



Why protect terrestrial TV?

- Why not just use Cable, Satellite or IPTV?
  - 10.1 million homes (40%) use DTT as main Digital TV service (Ofcom Dec 2009)
  - 8.5 million (32.6%) homes use DTT for 2nd and 3rd Digital TV services
  - 2.2 million analogue homes, likely to use DTT after DSO

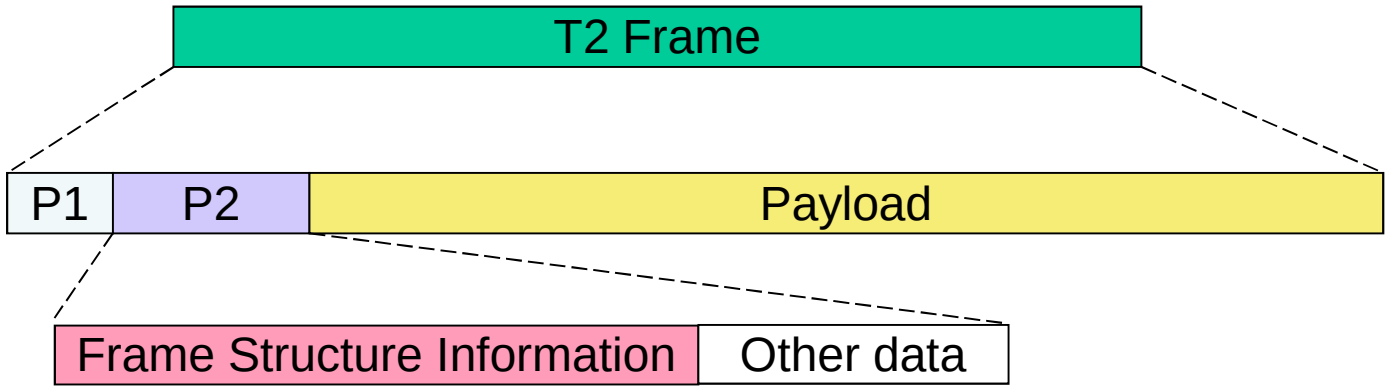


PHY: DVB-T2 (i)

- Second generation Digital Terrestrial TV broadcasting standard
- 'Classical' Guard Interval OFDM (as DVB-T)
  - FFT sizes: 1K, 2K, 4K, 8K, 16K, 32K
  - Guard Intervals: 1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
  - Constellations: QPSK, 16-QAM, 64-QAM, 256-QAM
  - Bandwidths: 1.7, 5, 6, 7, 8, 10 MHz
- Error coding uses LDPC + BCH; 16200 & 64800 bit FEC blocks
  - Rates (1/3, 2/5), 1/2, 3/5, 2/3, 3/4, 4/5, 5/6
- Rotated Constellations
  - Offer improved performance in highly-selective channels
- Flexible Time Interleaving (multi-frame and multiple TI block)
- MISO (Alamouti-based transmit diversity)

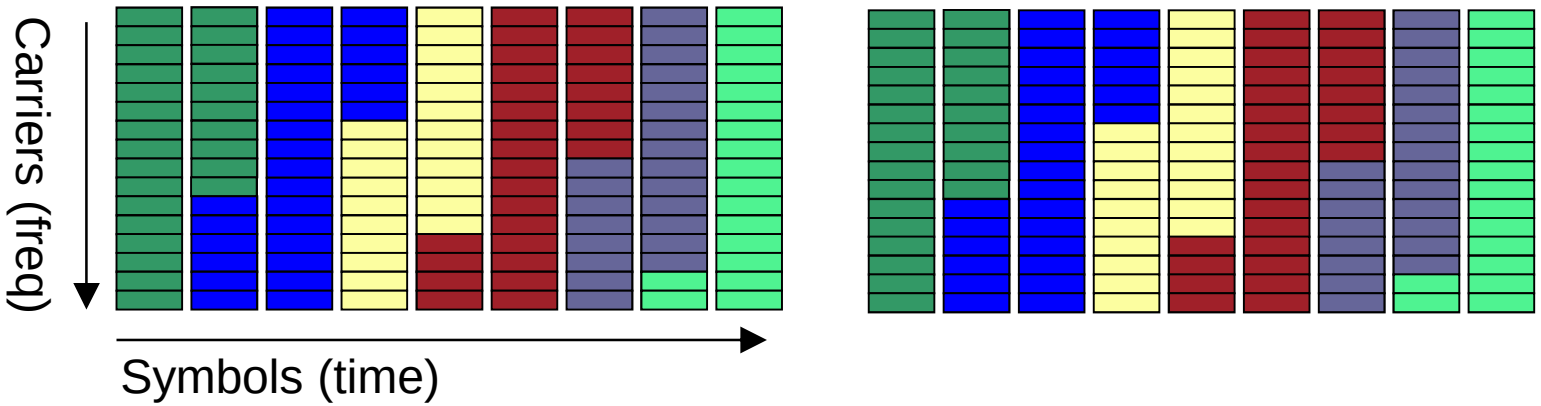
PHY: DVB-T2 (ii)

- Frame structure
  - P1 symbol
    - Coarse synchronisation and initial configuration
  - P2
    - Layer 1 signalling information – configuration of payload symbols
  - Payload
    - Data symbols carrying content



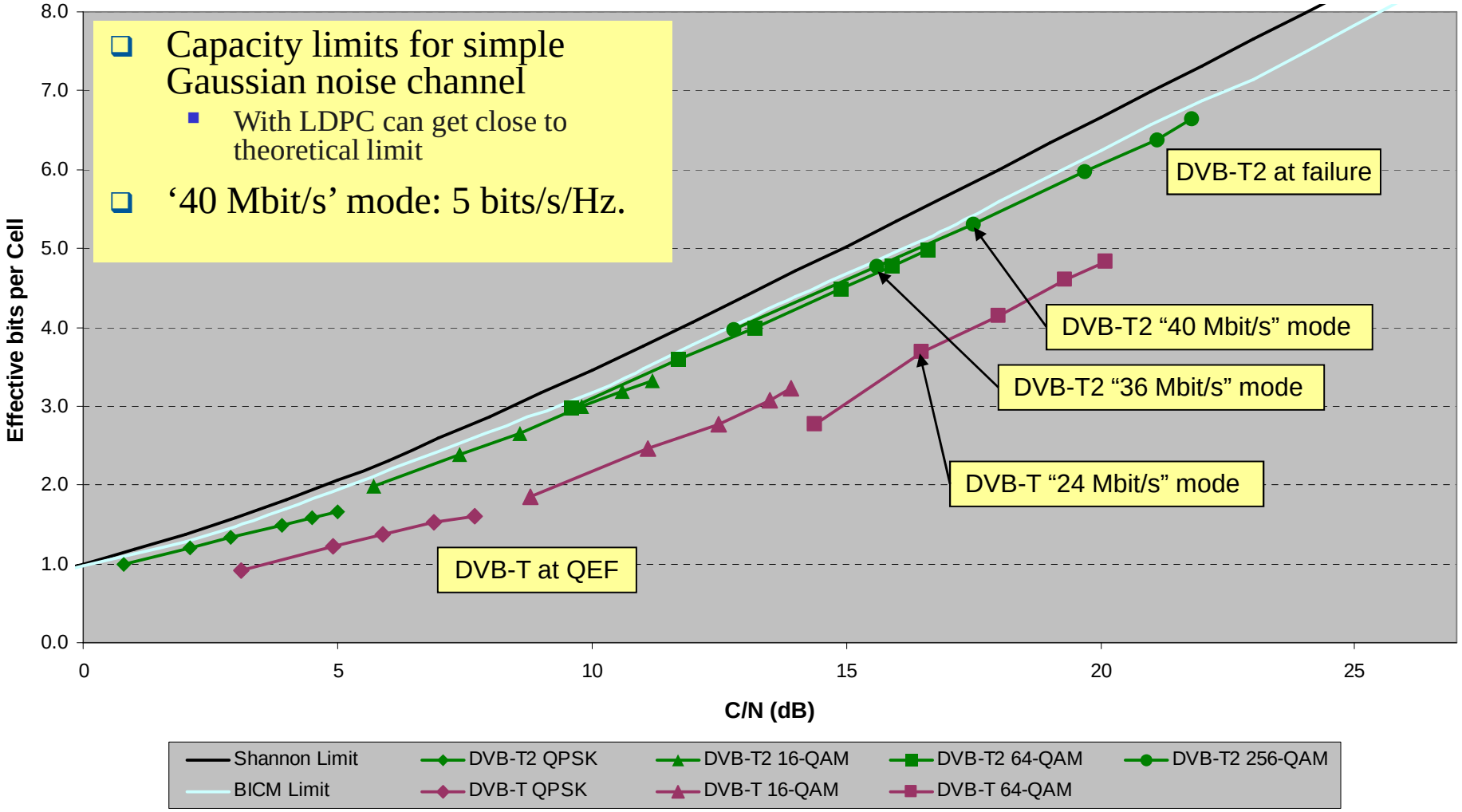
PHY: DVB-T2 (iii)

- Highly flexible frame structure: Physical Layer Pipes (PLPs)
  - Service specific robustness
  - Time-slicing at physical layer



PHY: DVB-T2 Performance

- Capacity limits for simple Gaussian noise channel
  - With LDPC can get close to theoretical limit
- '40 Mbit/s' mode: 5 bits/s/Hz.



PHY: Spectral Efficiency Comparison

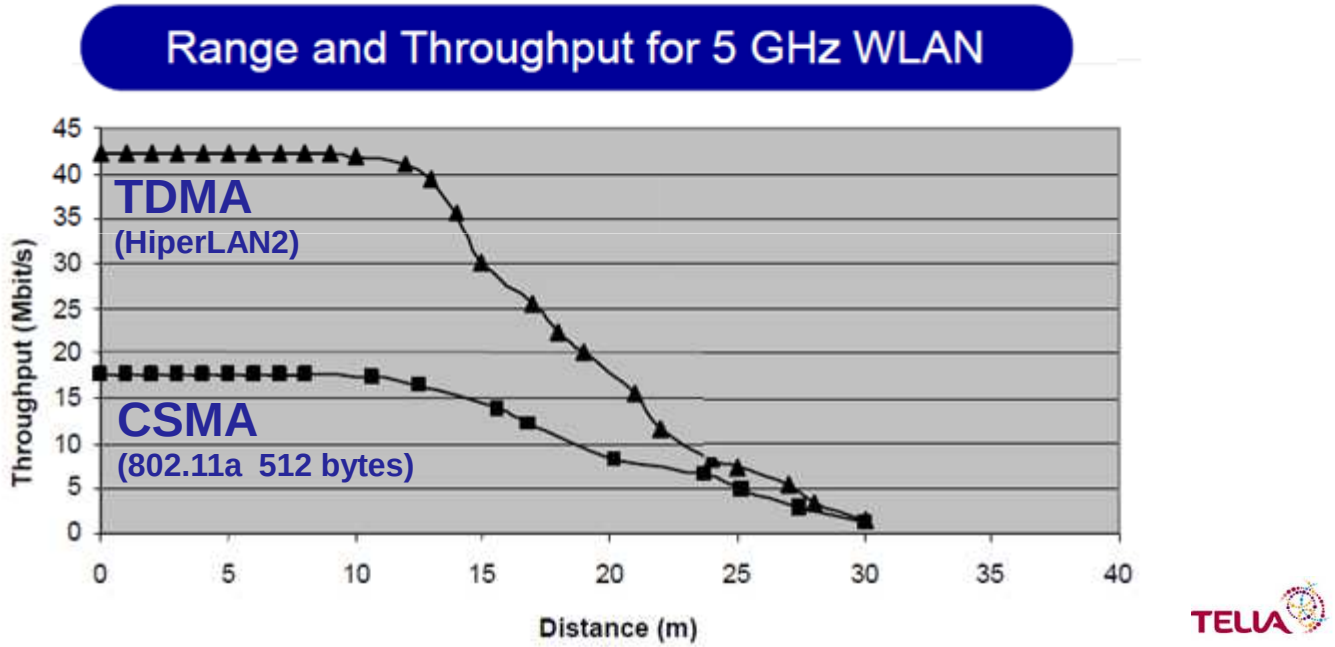
System (#UE Cat)	Modulation	Number of Codes (CDMA)	FEC Code Rate	Data Rate [Mb/s]	Spectrum Efficiency [bit/s/Hz]
3G HSDPA #6	16-QAM / SISO	5	0.76	3.6	0.72
3G HSDPA #8	16-QAM / SISO	10	0.76	7.2	1.44
3G HSDPA #10	16-QAM / SISO	15	0.97	14.0	2.80
4G LTE (20MHz)	64-QAM / SISO	-	1.00	100.0	5.00
4G LTE (20MHz)	64-QAM / MIMO	-	1.00	172.8	8.64
4G LTE (20MHz)	64-QAM / MIMO 4x4	-	1.00	326.4	16.32
3G HSDPA #14	64-QAM / SISO	15	0.98	21.1	4.22
802.11g	64-QAM SISO	-	0.75	54	2.7
DVB-T	64-QAM SISO	-	0.67	24.1	3.01
DVB-T2	256-QAM SISO	-	0.67	40	5.00
DVB-NGH	256-QAM MIMO	-	0.67	80	10.00

PHY: Geo-location vs Sensing

- Sensing
  - Concern over accuracy of sensing within devices
  - Time taken for sensing to take place
    - Difficulties of sensing at ground level
  - Complexity of modelling required by device
    - How can a device simply model what effect it might have kms away?
      - Antenna patterns
      - Topography
      - Knowledge of services consumed locally
    - Sensing of future standards?
- Geo-location database
  - Issues around database accuracy and security
    - Certification

MAC: CSMA vs TDMA

- Motivation is to avoid loss of throughput cf. PHY layer capacity
  - Deliver PHY layer performance to application layers



  - CSMA vs TDMA graph indicates potential gain of scheduled MAC layer
    - 802.11a (2.7 bit/s/Hz reduced to 0.9 bit/s/Hz)
  - Backwards compatibility not a strong requirement in new WS spectrum

Conclusions

- White Space important to BBC
  - But must protect existing terrestrial TV services used by millions of people
- Use cases
  - Broadband wireless access: Rural area networks
  - In-home networks: Distribution of content
- Requirements
  - Efficient PHY layer
    - Highest possible bit rates needed e.g. DVB-T2: 5 bit/s/Hz
    - Concern about viability of device sensing
  - Efficient MAC layer
    - Concerned about efficiency of CSMA with heavy traffic
      - Time division system would solve this
    - Whitespace is new spectrum
      - Backwards compatibility with existing CSMA (as @ 2.4 GHz) not a strong requirement