
Self-Study


Exercise

Block lecture

Multimedia Coding

- Methods and Applications -

Part 5:
Bearer Systems for Digital TV

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Multimedia Coding

Part 5: Bearer Systems for Digital TV

Digital Broadcast Systems Worldwide

- **TV**
  - DVB (Digital Video Broadcast) – standard, mainly Europe
  - ATSC (Advanced Television Standards Committee) – standard, mainly U.S.
  - ISDB-T (Intergrated Services Digital Broadcast – terrestrial) – standard, mainly Japan
- **Radio**
  - DAB (Digital Audio Broadcast) – standard, used worldwide
  - drm (Digital Radio Mondiale; digital LW/MW/SW) – standard
  - Sirius/XM Radio (Commercial Digital Satellite Radio Systems) – commercial systems in U.S.
  - ADR (Astra Digital Radio) – commercial system in Europe
- **Mobile TV**
  - new market, battle of systems, see later
- **IPTV**
  - TV systems using IP, see later

Digital Dividend

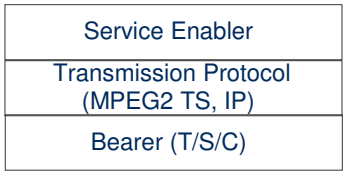
- **Digital TV uses the spectrum resources much more efficient**
  - increase of the number of programs by a factor of 4, using same spectrum
- **Analogue TV switch-off in EMEA in 2015**
- **What to do with the resources becoming free?**
  - save transmission costs?
  - more TV programs?
  - higher quality (HD)?
  - new services (mobile TV)?

Multimedia Coding

Part 5: Bearer Systems for Digital TV

Digital TV Bearer Standards for fixed TV

- **DVB: International Standard for Digital Video Broadcasting**
- **Reception: usually via Set Top Box (STB) or DVB card / USB module for PC**
- **Flavours of DVB**
  - DVB-S (Satellite)
  - DVB-S2 (HDTV via Satellite)
  - DVB-C (Cable)
  - DVB-T (Terrestrial)
  - DVB-T2 and DVB-C2 under development



- **DVB-S and DVB-C widely deployed (Free TV, Pay TV)**
- **Regarding DVB-T, the process of switchover from analogue to digital is running full speed**
  - Regional Radio Conference 2006 has defined the frequency plan for the digital terrestrial TV age
  - Analogue TV switch-off in EMEA will be 2015

DVB-T bearer
Modulation overview

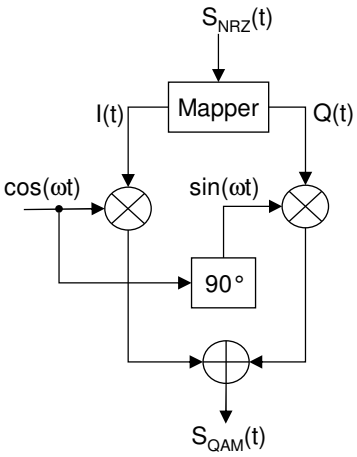
- **Modulation method: Coded Orthogonal Frequency Division Multiplexing (COFDM)**
  - FDM: use of many small-bandwidth modulated sub-carriers (8k or 2k) in parallel
  - O: orthogonal: no crosstalk because of specific sub-carrier spacing
  - C: coded → redundant use of the sub-carriers, allowing to ignore distorted carriers
    - Code rate (CR): measure of redundancy. Used rate / total rate
    - Example: CR=2/3 means 3 bits are transmitted per 2 bits of payload
- **Properties**
  - Symbol time and **Guard Interval** → robust against multi-path (multi-path may even strengthen the signal!)
  - Single-frequency networks allow efficient usage of spectrum
  - Greater robustness than analogue TV
    - → lower transmitter power possible → less interferences
    - → portable indoor reception with small antennas
  - Program proliferation (4 digital programs can be transmitted per analogue program equivalent) due to efficient (MPEG2) video coding

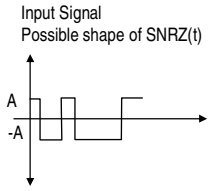
DVB-T bearer
Modulation (1)

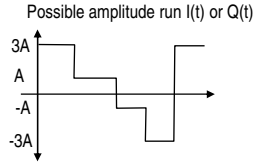
- **What is modulation?**
  - "impressing" a digital signal onto an analogue carrier signal
  - considered here exclusively: QAM (Quadrature Amplitude Modulation): QPSK aka 4QAM, 16QAM, 64QAM
- **Basic idea**
  - use a cosine wave of a defined frequency f (I axis, cos(x)) and the according sine wave (Q axis, sin(x)) as carrier
  - separate the digital input signals S(t) into two amplitude runs I(t) and Q(t), each having N states (→ 2^NQAM), by extending the symbol time accordingly
  - modulate these amplitude runs onto the sine resp. cosine carrier

DVB-T bearer Modulation (2)

Block diagram of a 16QAM modulator



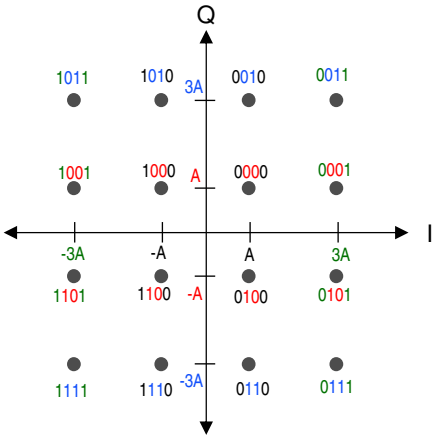




DVB-T bearer Modulation (3)

Constellation diagram 16QAM

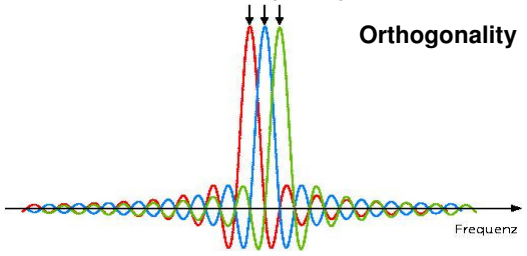
- shows the possible amplitudes of the signals I and Q plus the 16 assigned 4bit symbols
- reading the signal, the decoder computes the probability for each point in the constellation diagram to be "hit"
- if there is no unique "winner" (i.e. the distance between the actual point and each of the 16 constellation points is too big), then the symbol is marked as erroneous

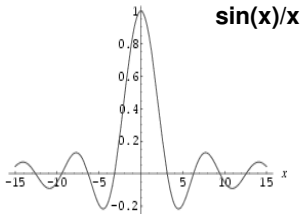


DVB-T bearer
OFDM: Orthogonality of the sub-carriers

FDM Frequency Division Multiplexing

- modulation described before is applied separately to many low-bandwidth sub-carriers (2K: 1705 or 8K: 6816)
- as each symbol is represented by a rectangular pulse, overlapping spectra are created which have strong side bands → sinc function, sin(x)/x
- goal: erasure of these side bands to improve frequency economy → orthogonality, OFDM
- this goal is met by choosing the distance of the sub-carriers in frequency domain and the symbol time such that the dominant frequency of one sub-carrier coincides with the zero-crossing of the sinc function of the neighboring sub-carrier





DVB-T bearer
Symbol time and modes

• Symbol time and sub-carrier frequency

- time *T* during which a symbol is transmitted
- is determined by the spacing of the sub-carriers in frequency domain (zero-crossings of sinc(x) at 1/T)
- correlation between T and f_i: (f_c center frequency of channel, N number of sub-carriers, f_i frequency of actual sub-carrier):

$$f_i = f_c + \frac{i}{T} \quad i = \frac{-N}{2} \ldots \frac{N}{2}$$

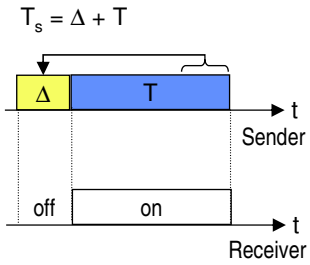
• Properties of the modes

- 8k mode: T=896µs, 1/T=1116 Hz
  - long symbol time → big SFNs possible
  - narrowly spaced sub-carriers → sensitive to Doppler shift → limited mobility
- 2k mode: T=224µs, 1/T=4464 Hz
  - short symbol time → small SFNs of single transmitters
  - widely spread sub-carriers → robust against Doppler shift → good mobility

DVB-T bearer
Guard interval

Guard Interval

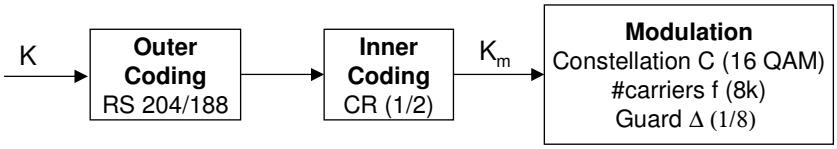
- goal: low inter symbol interference (disruption of one symbol by echoes of the preceding symbol that arrive late)
- solution: Guard Interval Δ.
  - time interval that is added at the beginning of a symbol time T, during which the same signal is transmitted as during the symbol time (cyclic symbol extension)
- the receiver is switched inactive during guard interval
- this mechanism allows to compensate effects of multi path propagation
  - as long as the delayed signal echo arrives during symbol time it even contributes to the wanted signal
  - inter symbol interference is minimized
- the Guard Interval is a design parameter which can be 1/4, 1/8, 1/16 or 1/32 of the symbol time T and which is added to T



DVB-T bearer
Redundant coding

- **Inner Coding: Data are transmitted redundantly on multiple sub-carriers in order to compensate transmission errors**
  - punctured convolution code with different code rates: 1/2, 2/3, 3/4, 5/6, 7/8
  - code rate CR is a measure for the added redundancy: CR = used bits / total bits
- **Outer Coding: Additional error protection of the MPEG2 TS packets**
  - Reed-Solomon-Code RS(204,188)
  - 16 Bytes redundancy, correction of up to 8 errors possble

DVB-T bearer
Channel capacity – an example calculation



C=16QAM
→ 16 symbols, 2^4=16, i.e. symbol capacity per sub-carrier S=4 bit

#carriers=8k
→ symbol time T=896 us
→ usable #carriers n_{eff}=6048 (some carriers are needed for pilots and system signaling)

Channel capacity of modulation:
$K_m = n_{eff} * S / (T * (1+\Delta)) = 6048 * 4$ bit / (896 us *1,125) = 24 Mbit/s

Channel capacity with error protection (Coding)
$K = 188/204 * CR * K_m = 188/204 * 1/2 * K_m$ = 11,059 MBit/s

Multimedia Coding
Part 5: Bearer Systems for Digital TV

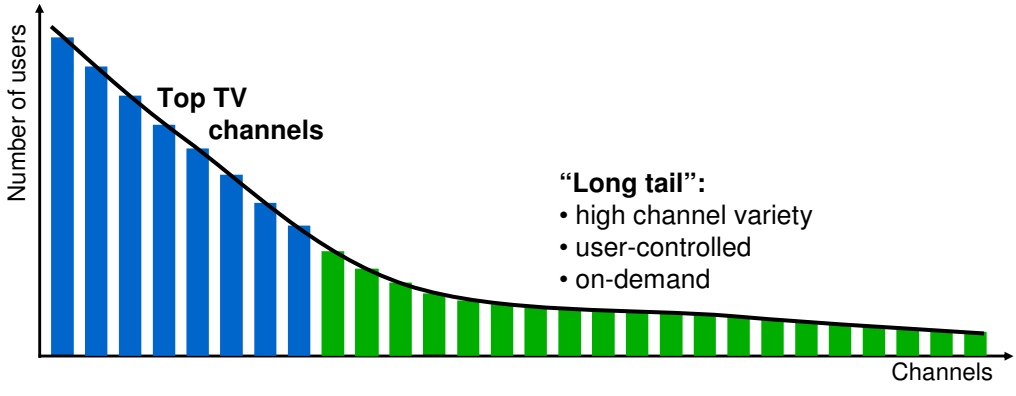
Mobile TV
Unicast, Multicast, Broadcast

Highest individualization via Mobile Network:	Economic Mulitcast/Broadcast via Mobile Network:	Economic Broadcast via separate Broadcast Network:
Continuous TV experience with **personalized** channels and interactivity	Tailored for **multi user group**, Delivery to selected regions possible	Delivery of content to **many subscribers** at the same time. Interactivity via Mobile Network
Point to Point	Point to Multipoint (MBMS)	Broadcast (DVB-H)

Mobile Network is essential to offer interactivity, personalization & charging

Source: Siemens Networks

Mobile TV
The most efficient channel mix



Top TV channels account for 80% of the usage ⇨ Broadcast

Content with great diversity and lower popularity ⇨ Unicast

Source: Nokia Siemens Networks

Mobile TV Bearer Layer
Technology Landscape

Several different broadcast bearer technologies (one-to-many) have been developed for mobile receivers

- **DVB-H:** Digital Video Broadcast – Handheld (evolution of DVB-T supporting mobile terminals)
- **DVB-SH:** Digital Video Broadcast – Satellite Service for Handheld (new satellite-based system with terrestrial repeaters)
- **MBMS:** Multimedia Broadcast Multicast Services (Broadcast bearer in UMTS)
- **BCMCS:** BroadCast MultiCast System (Broadcast bearer in CDMA2000)
- **DMB:** Digital Multimedia Broadcast (Korean extension of the DAB digital radio standards for mobile multimedia, now standardized with WorldDMB, leverages existing DAB infrastructure)
  - T-DMB: terrestrial variant
  - S-DMB: satellite-based variant with terrestrial repeaters
- **ATSC-M/H:** New activity in U.S. to define a mobile-capable mode for the American DTT system
- **DMB-TH and S-TIMI:** Chinese systems for terrestrial and mobile TV
- **MediaFLO:** Development of Qualcomm for mobile TV; started as proprietary system but is now specified by the Qualcomm-dominated FLO forum

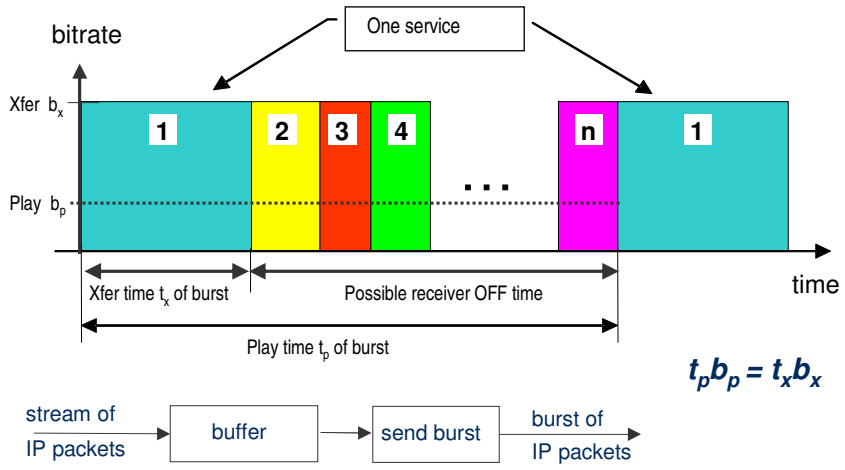
Mobile TV Bearer Layer
Details of selected bearer technologies

- **DVB-H (Digital Video Broadcast – Handheld)**
  - extension of DVB-T for mobile terminals
  - optimized for low power consumption, error robustness and mobility
  - big “cells” (SFN – Single Frequency Networks); diameter some 10 up to 200 km
  - capacity: 5-11 MBit/s
  - IP based
- **3GPP MBMS (Multimedia Broadcast Multicast Service)**
  - broadcast bearer in UMTS
  - local in each UMTS cell
  - capacity: up to 5x64 kBit/s
  - IP based
- **DMB (Digital Multimedia Broadcast)**
  - Korean system for streaming of audio/video and MPEG4 BIFS over DAB
  - able to uses existing DAB infrastructure
  - capacity: 1.5 MBit/s
  - originally MPEG2 TS based (Specification for IP layer exists since 2007 – DAB-IPDC)

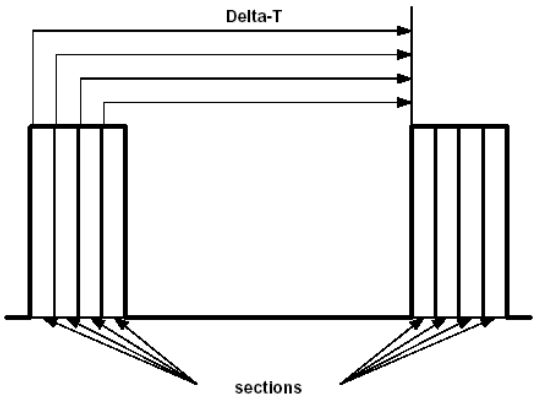
Mobile TV Bearer Layer
DVB-H: Technical Overview

- **DVB-H is an all-IP based Extension of DVB-T, optimized for Mobility**
  - IP as abstraction layer for Multimedia services (Audio und Video via RTP!)
    → Convergence between Mobile data and Broadcast („IP Datacast“)
  - IP packets are encapsulated into the DVB transport layer, called MPEG-2 Transport Stream
- **Support for Mobility at High Speeds and Error resilience**
  - New modulation mode “4k Mode” which is better suited for moving receivers
  - Forward Error Correction of the IP packets
    - for each 191 bytes of IP data, 64 bytes Reed-Solomon error correction code are added
- **Support for Receiver Power Saving**
  - Receiver circuits in the terminal are high-speed components which consume a lot of energy
  - Time slice mode: the IP data packets of each service are bundled and transmitted at a high bitrate in a short time interval as a so-called “burst”
  - between these transmissions, the receiver circuits can be off (or in a sleep mode)

Mobile TV Bearer Layer
DVB-H: How Timeslicing works (1)



Mobile TV Bearer Layer
DVB-H: How Timeslicing works (2)



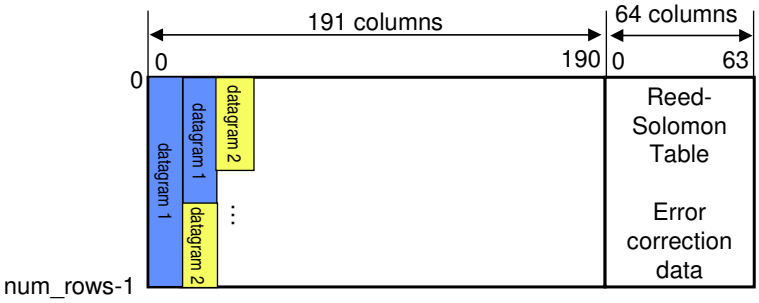
Signalisation

The time until the start of the next burst is signalled in the header information of the current burst

Source: ETSI EN 301192 v1.4.1

Mobile TV Bearer Layer
DVB-H: MPE-FEC (1)

- **Goal: better forward error correction to enhance mobility**
- **Idea:**
  - add error correction information to the MPE datagrams
  - backwards-compatible with MPE

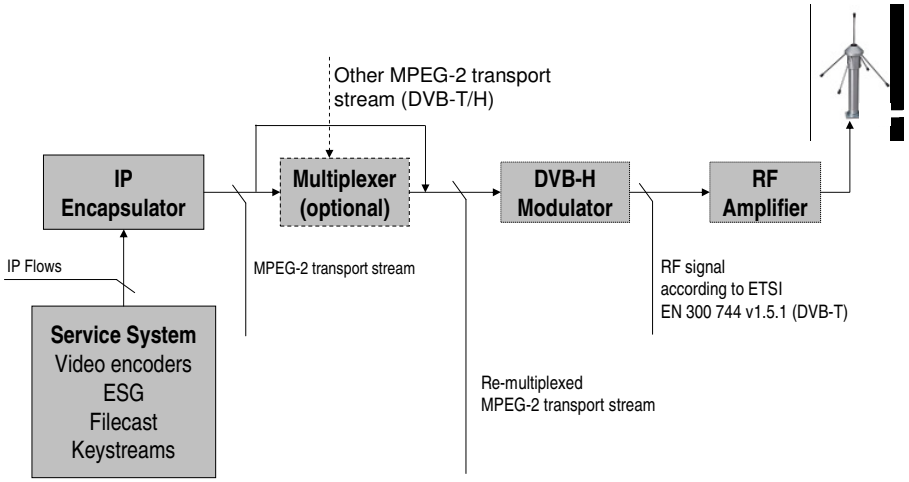


Application Data Table
(IP datagrams according to MPE Spec)

Mobile TV Bearer Layer
DVB-H: MPE-FEC (2)

- **Approach**
  - for each row, a Reed-Solomon code RS(255,191) is computed
  - Application Data Table and RS Table are transmitted column-by-column in MPE sections
  - if the checksum of an MPE section is correct at the receiver, these data are marked as „Reliable“ and are written to the Application Data Table or RS Table in the receiver
  - by the column layout, erroneous sections are spread over multiple rows and can be error corrected row-by-row
  - after receiving all data, the tables have “holes” (erasures) which have been caused by erroneous sections → max. 64 erasures per row can be corrected by the RS decoder
- **Degrees of freedom**
  - Padding of the Application Data Table: Stronger protection
    - Fill columns are defined in the Application Data Table, which are considered when computing the RS code. These data are not transmitted but added again by the receiver, meaning they are error-free in every case!
  - Puncturing of the RS Table: Lower overhead, weaker protection
    - As it is irrelevant for a RS codes which byte positions are erroneous, one can simply omit some columns in the RS table from transmission to decrease the overhead

Mobile TV Bearer Layer
DVB-H: Schematic transmitter setup

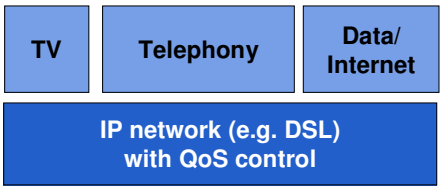


Multimedia Coding

Part 5: Bearer Systems for Digital TV

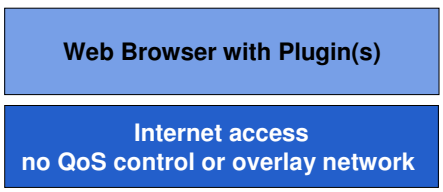
IPTV vs. Internet TV

Triple Play / IPTV



- Network operator in control
- QoS management ensures sufficient transmission capacity
- Business opportunity for Network provider to offer more than just bit-pipe
- Usually received by Set Top Box
- Usually, vertically integrated system

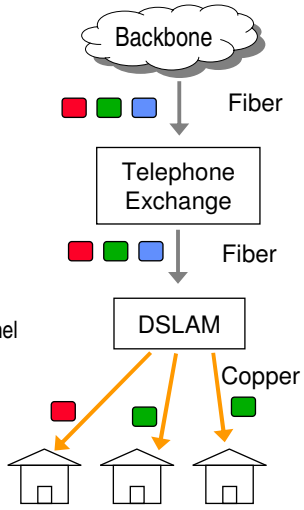
Internet TV



- Offered as Internet Service
- No control of the network (but sometimes overlay networks used)
- Based on Web 2.0 technologies and widespread proprietary media technologies e.g. Flash Video
- Usually (still?) targeted at PC

IPTV
Content delivery

- **IPTV service is delivered over DSL**
- **We distinguish**
  - IPTV: Live multicast of the same program to many households at the same time
  - VOD: Point-to-point streaming of media content on demand
- **Channel switching**
  - Using “classic” DSL technologies, the capacity of the “last mile” is limited to a few Megabits per second.
  - That is why it is not possible to simply provide all TV channels to the set top box at the same time and to switch channels there (one channel occupies ~1Mbps)!
  - Instead, the channel switching must be done in the network, in the DSLAM component (Digital Subscriber Line Access Multiplexer).
  - Signaling: using IGMP (Internet Group Management Protocol)



IPTV
Network-based storage

- **IPTV Systems with VOD capability offer the opportunity to record TV programs in the network and play them back to the user**
  - This may be allowed if it is triggered (programmed) by the user
- **Automatically recording all programs and offering them to the user to choose from poses rights problems, however**
  - the rights acquired by IPTV providers usually only allow “rebroadcast” but not this use.
  - content providers are reluctant to grant these rights because they feel they might give up control over their content

IPTV
Inviolableness of the Screen

- **Content is King.**
- **When Interactivity is combined with TV content, the principle of "Inviolableness of the screen" is often enforced by the content owners in their contracts.**
- **That means, that interaction options displayed along with the content are only allowed if they**
  - are controls to operate the service ("On Screen Display")
  - have otherwise been agreed with the content provider
- **Especially, it is not allowed to place own or partner advertisements along with content unless this use has been agreed with the content owner**

IPTV
End user networks

- **Today's IPTV services are provider-controlled end-to-end.**
- **New IPTV services will have to cope with the fact that the "last hop" is a Home Network in the consumer's premises which is not tightly controlled by the provider. Today, technologies are developed to address such needs of tomorrow's services.**
- **UPnP: Universal Plug and Play**
  - protocol suite to discover nodes in a home network and the services they offer
- **DLNA: Digital Living Network Alliance**
  - builds upon UPnP protocols
  - addresses
    - networking and connectivity of devices
    - device and service discovery and control
    - media format and transport model
    - media management, distribution, control
    - DRM / content protection

Internet TV
aka “IPTV without QoS Support”

- **Integration of streaming technologies (e.g. Flash video) with Web 2.0 technologies (AJAX) video services via the Internet**
- **Characteristics:**
  - usually only video on demand support
  - point to point
  - central server, portal
  - no QoS control → usually lower quality, big buffers needed
  - accessible with general purpose computers, but also with Set Top Boxes

- **and there is Peer2Peer TV…**
  - no central server
  - each node is consumer and provider/relay of media streams

Multimedia Coding
Part 5: Bearer Systems for Digital TV

Further information (1)

- **DVB website: www.dvb.org**
- **DVB Standards**
  - available from http://pda.etsi.org/pda/queryform.asp after entering the ETSI number of the standard
  - DVB-T: ETSI EN 300744
- **Official DVB-H Website: http://www.dvb-h.org**
- **DVB-H Interest Group: http://www.hig-info.tv**
- **Digital modulation: www.web-ee.com/primers/files/5965-7160E.pdf**
- **Ulrich Reimers. *DVB: The Family of International Standards for Digital Video Broadcasting.* Springer, Berlin, 2004.**
- **DLNA website:** http://www.dlna.org/
- **UPNP forum website:** http://www.upnp.org/