Multimedia communications
ECP 610

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- **<u>Take home messages from the course:</u>**
  - Google, Facebook, Microsoft and other content providers would like to take over the whole stack!

MWC 2015: Google Announces Wireless Carrier Plans By Becoming A 'Mobile Virtual Network Operator'

By **Kevin L. Clark**, Tech Times | March 2, 12:47 PM

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The tech boom has quickly become a monster as companies continue to outdo one another with impressive innovations. From unveiling its own version of Project Titan (solar-powered drones) to rethinking how office spaces work, Google has just announced it wants to be your future wireless carrier.

After fielding rumors for 365 days, Google confirmed on Monday that it would be offering talk and data plans to customers around the globe. The announcement took place at Mobile World Congress. Google announced it is working on a wireless service in

wireless
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About WIA

The Wireless Innovation Alliance (WIA) is a broad-based group of innovators, providers, consumer groups, think tanks and education organizations that believe that more efficient use and expanded access to the nation's spectrum resources are fundamental to the future of U.S. economic policy and global competitiveness, and that we face potential spectrum scarcities in both licensed and unlicensed bands that must be addressed in order for innovation and investment to move forward.

WIA members are committed to working with policymakers to ensure the most efficient, effective and flexible use of spectrum - including "innovation bands" like the newly-authorized Super WiFi to fuel growing demand and new technologies. A balanced, flexible, market-driven policy framework, incorporating licensed and unlicensed allocations alike, offers the best path to accommodate legitimate interests in promoting spectrum efficiency and innovation.

Our Principles

- Seek solutions that address spectrum scarcity in both licensed and unlicensed bands
- Drive efficient spectrum use by supporting the deployment of smart radio technology
- Support more efficient and shared use of underutilized spectrum
- Protect and promote unlicensed spectrum, including Super WiFi, frequencies nationwide

Spectrum Policy

Spectrum Policy

Spectrum, and specifically, the most efficient and expansive use of this most valuable natural resource, is fundamental to the future of U.S. economic growth, and global competitiveness. United States spectrum policy must also be efficient and flexible as well, so that we can encourage and accommodate new and innovative ways to meet the growing demand for wireless services and applications, and the growing inability - in both licensed and unlicensed bands - to meet that demand.

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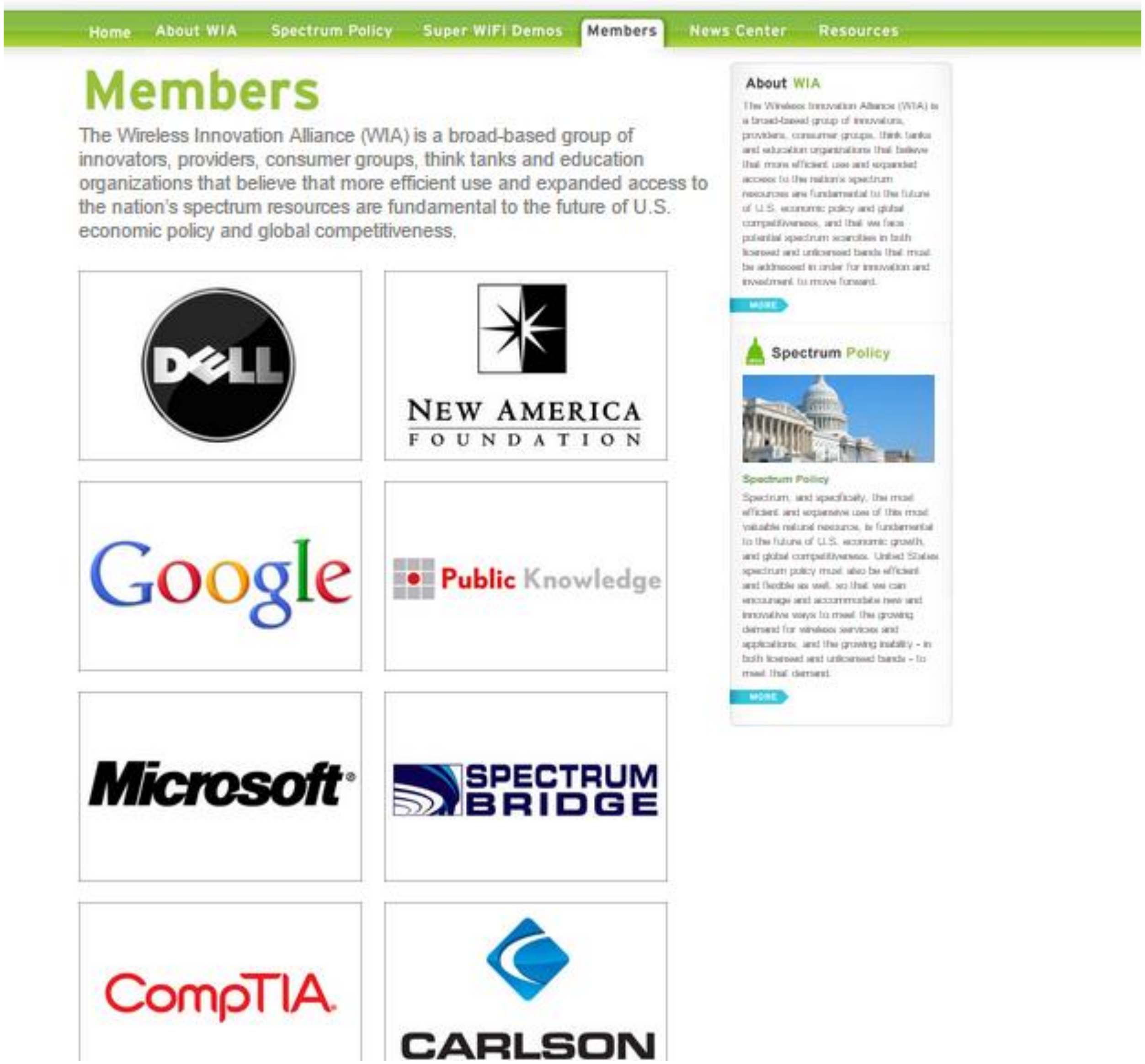
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FCC approves latecomer Microsoft as white-space database provider

August 3, 2011 | By Lynnette Luna

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The FCC's Office of Engineering and Technology (OET) has named Microsoft as an administrator of the TV white spaces database, despite the company filing late and others opposing its designation.

Microsoft is now required to develop and operate a TV bands database in its geographic area that will locate the unused slivers of broadcast spectrum. Microsoft is now the 10th company the FCC has designated as a white space database provider.

Microsoft requested to become a database provider 15 months after the OET's stated deadline. Nine companies were given the okay to provide databases back on Jan. 26--Comsearch, Frequency Finder, Google (NASDAQ:GOOG), KB Enterprises, LS Telecom, Key Bridge Global, Neustar, Spectrum Bridge, Telcordia and WSdb.

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TECH / INNOVATION

Facebook Wi-Fi Drone the Size of 747 Could Fly in 2015

The Facebook drones are on their way, and we're not talking about bored friends who send out Candy Crush Saga invites. The company shared a few more details about its plan to use drones to provide free Wi-Fi to the two-thirds of the world's population that lack Internet access. First, don't call them "drones," Yael Maguire, engineering director of Facebook's Connectivity Lab, said Monday at the Social Good Summit in New York City. Instead he refers to them as "planes," seeing as they will be "roughly the size" of airplanes "like a 747," although much, much lighter.

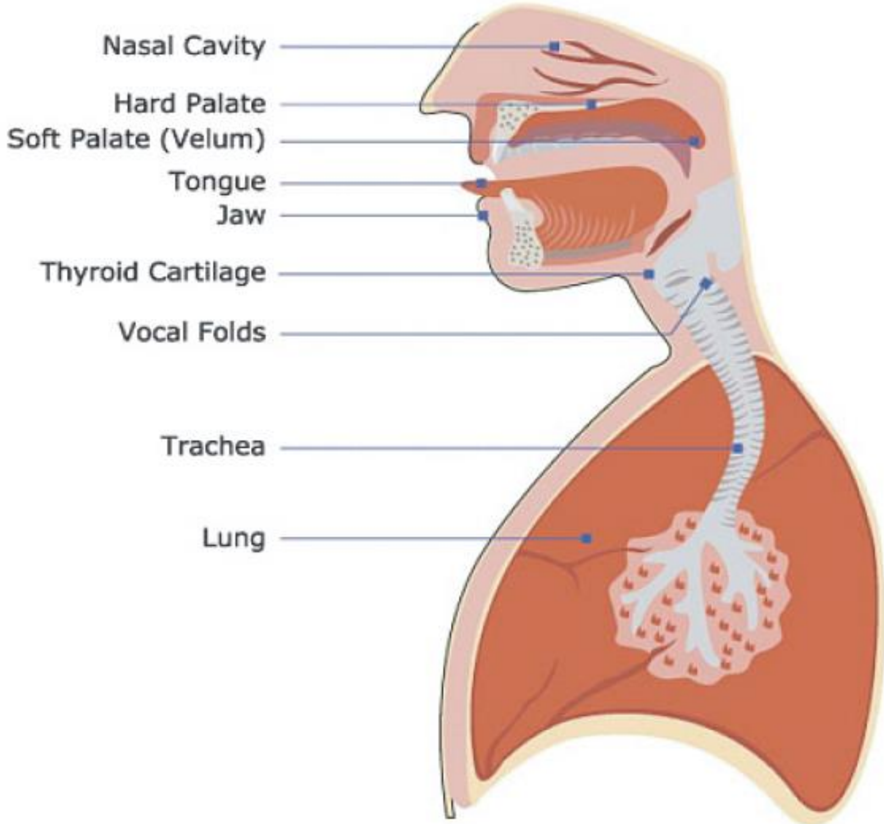
They also will have to be powered by the sun to continuously provide Wi-Fi

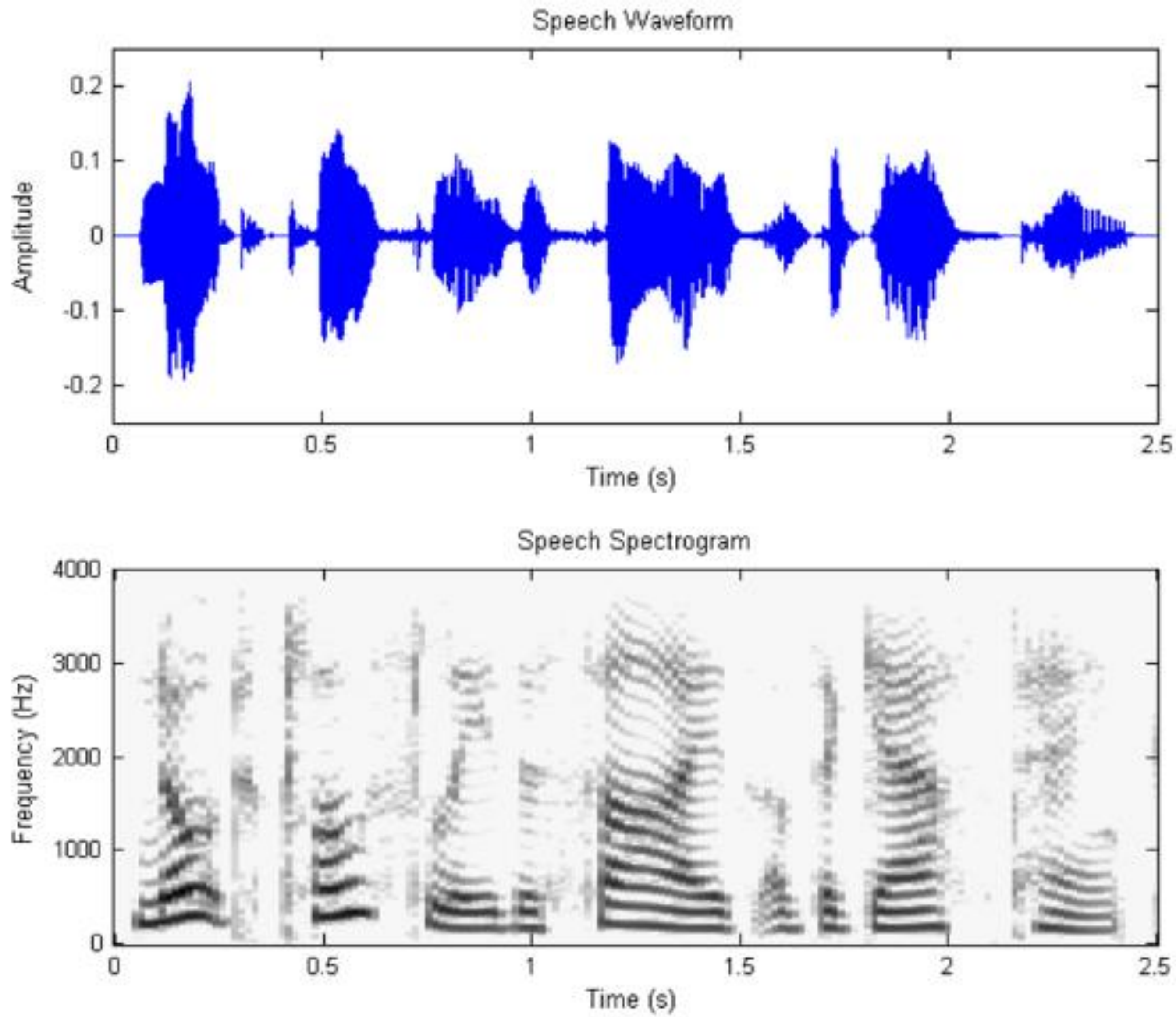
Table 10. Global Consumer Internet Traffic, 2013–2018

Consumer Internet Traffic, 2013–2018							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**CAGR 2013–2018**
By Network (PB per Month)							
Fixed	27,882	33,782	40,640	48,861	58,703	70,070	20%
Mobile	1,189	2,102	3,563	5,774	8,968	13,228	62%
By Subsegment (PB per Month)							
Internet video	17,455	22,600	29,210	37,783	48,900	62,972	29%
Web, email, and data	5,505	6,706	8,150	9,913	11,827	13,430	20%
File sharing	6,085	6,548	6,803	6,875	6,856	6,784	2%
Online gaming	26	30	41	64	88	113	34%

- Multimedia communications involves:
  - Media coding (Speech, Audio, Images, Video coding)
  - Media transmission
- Media coding (compression)
  - Production models (For speech, music, image, video)
  - Perception models
    - Auditory system
      - Masking
      - Ear sensitivity to different frequency ranges
    - Visual system
      - Brightness vs color
      - Low frequency vs High frequency
  - Quality of Service and Perception
      - QoS for voice
      - QoS for video

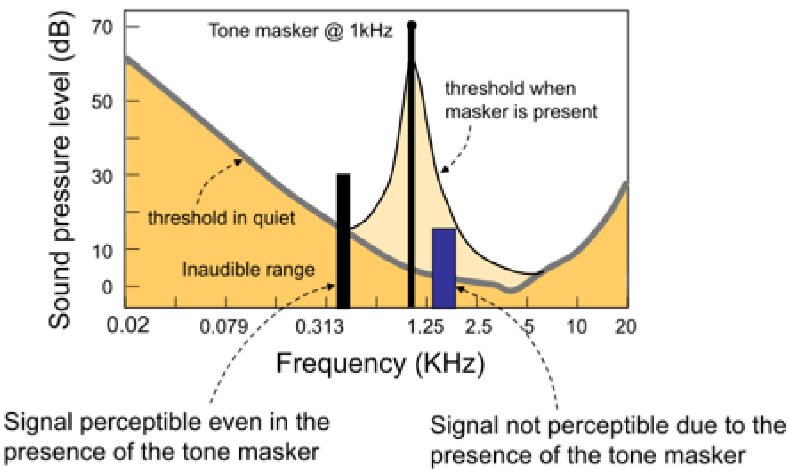
* Speech production system



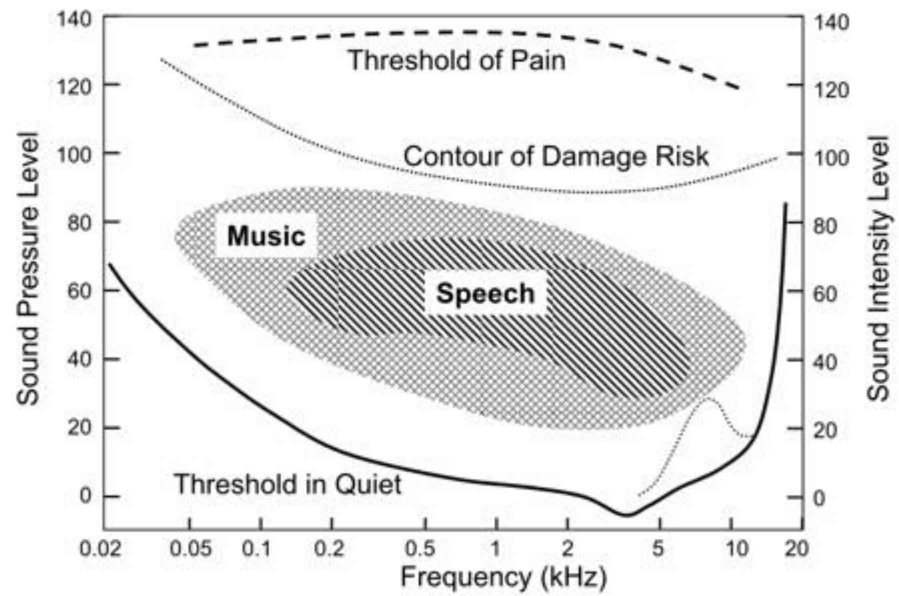

Speech Waveform
Amplitude
0.2
0.1
0
-0.1
-0.2
0
0.5
1
1.5
2
2.5
Time (s)
Speech Spectrogram
Frequency (Hz)
4000
3000
2000
1000
0
0
0.5
1
1.5
2
2.5
Time (s)

Perception system

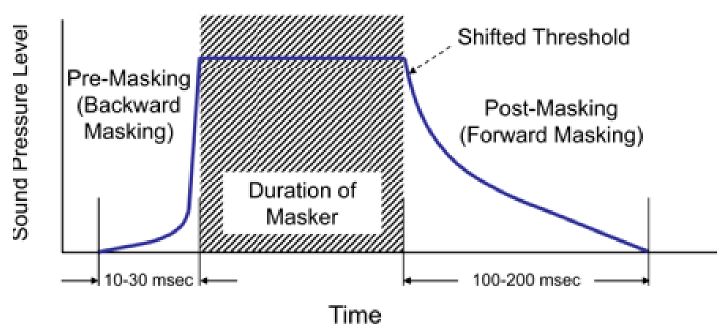
Auditory Masking



Range of Human Hearing

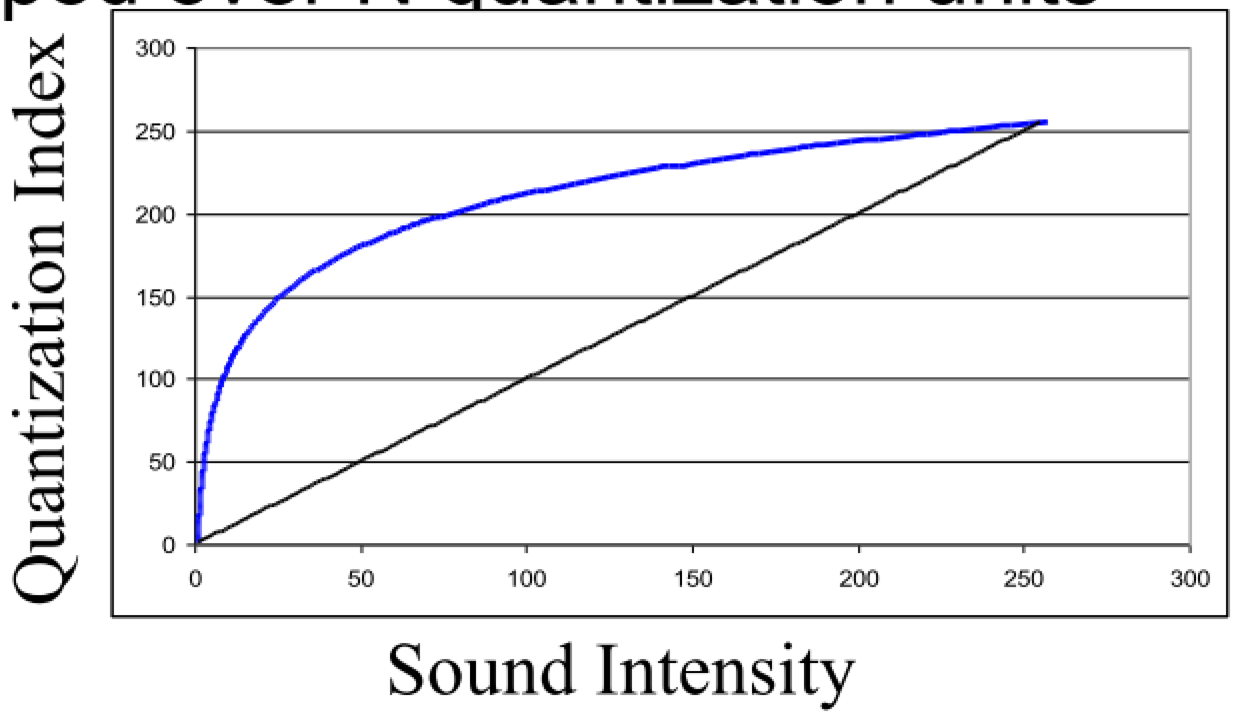


Temporal Masking



Perceptual Quantization (u-Law)

- Want intensity values logarithmically mapped over N quantization units

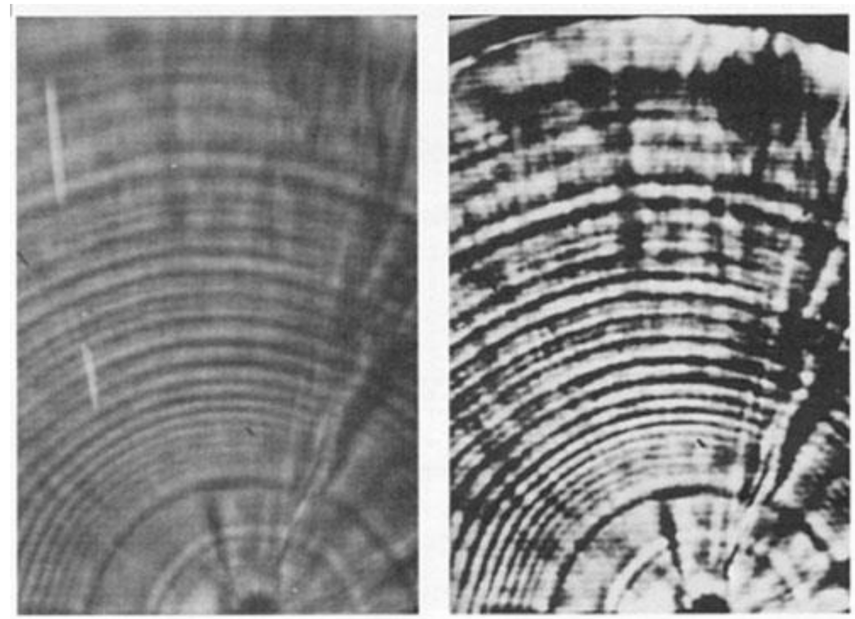


Digital Image Representation (3 Bit Quantization)

111	111	011	011	011	011	111	111
111	011	111	111	111	111	011	111
000	111	001	111	111	001	111	000
010	111	111	111	111	111	111	010
000	111	100	111	111	100	111	000
000	111	111	100	100	111	111	000
111	000	111	111	111	111	000	111
111	111	000	000	000	000	111	111

Image Representations

- Black and white image
  - single color plane with 1 bits
- Gray scale image
  - single color plane with 8 bits
- Color image
  - three color planes each with 8 bits
  - RGB, CMY, YIQ, etc.
- Indexed color image
  - single plane that indexes a color table
- Compressed images
  - TIFF, JPEG, BMP, etc.



4 gray levels 2gray levels

Image Representation Example

24 bit RGB Representation (uncompressed)

128	135	166	138	190	132
129	255	105	189	167	190
229	213	134	111	138	187

128	138
129	189
229	111

135	190
255	167
213	138

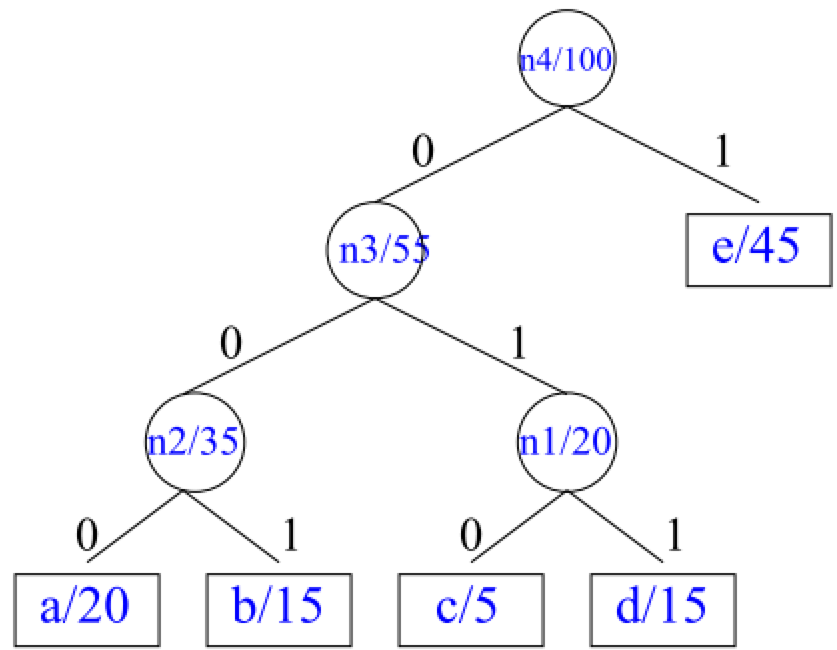
166	132
105	190
134	187

Color Planes

Techniques used in coding:

- Loss-Less compression : Huffman coding
  - Variable length, prefix, uniquely decodable code
  - Main objective: optimally assign different number of bits to symbols having different frequencies

$$A_3 = \{n3/55, e/45\}$$

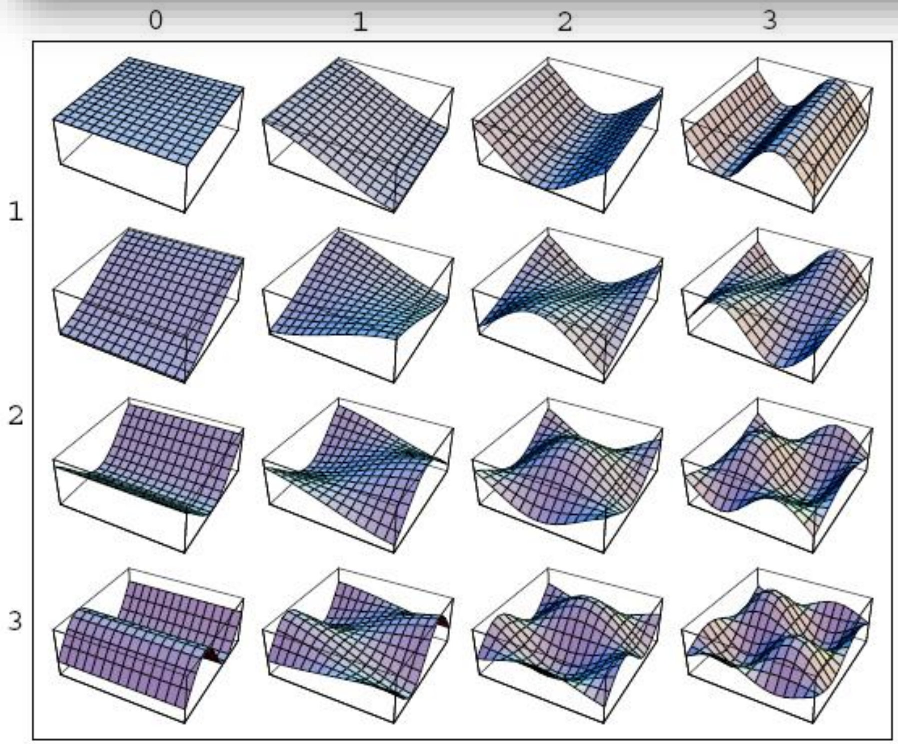


$$a = 000, b = 001, c = 010, d = 011, e = 1$$

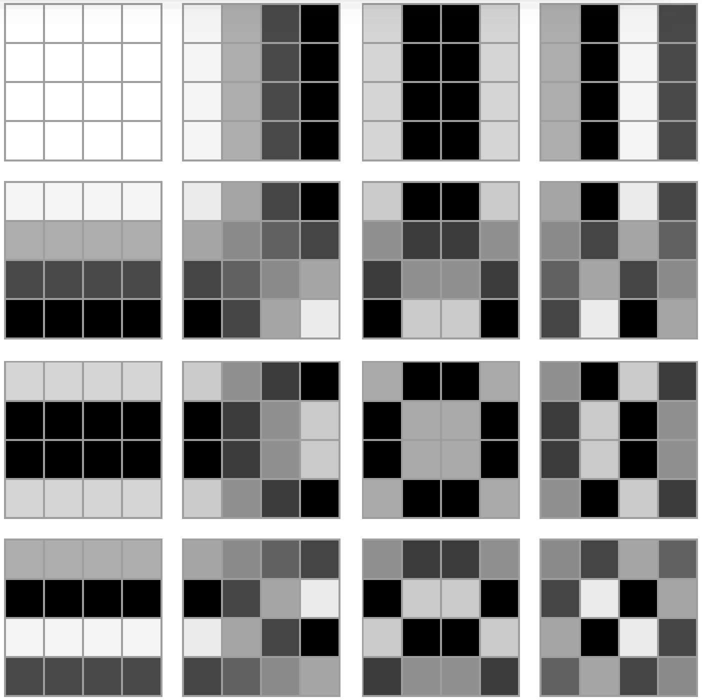
Discrete Cosine Transform

$$f(x) = \sum_{u=0}^{N-1} \alpha(u) C(u) \cos\left(\frac{(2x+1)u\pi}{2N}\right)$$

$$f(x,y) = \sum_{u=0}^{N-1} \sum_{v}^{N-1} \alpha(u)\alpha(v) C(u,v) \cos\left(\frac{(2x+1)u\pi}{2N}\right) \cos\left(\frac{(2y+1)v\pi}{2N}\right)$$



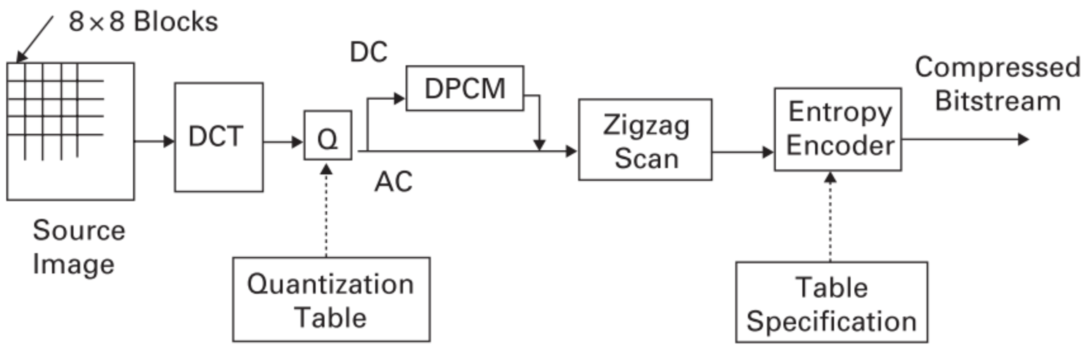
Basis functions



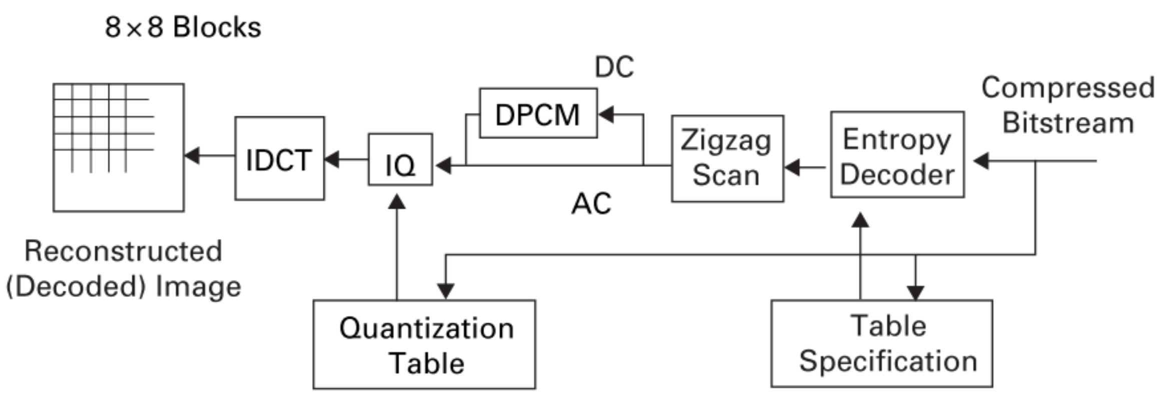
Basis patterns (imaged functions)

- The DCT provides energy compaction
  - Low frequency coefficients have larger magnitude (typically)
  - High frequency coefficients have smaller magnitude (typically)
  - Most information is compacted into the lower frequency coefficients (those coefficients at the 'upper-left')

JPEG:



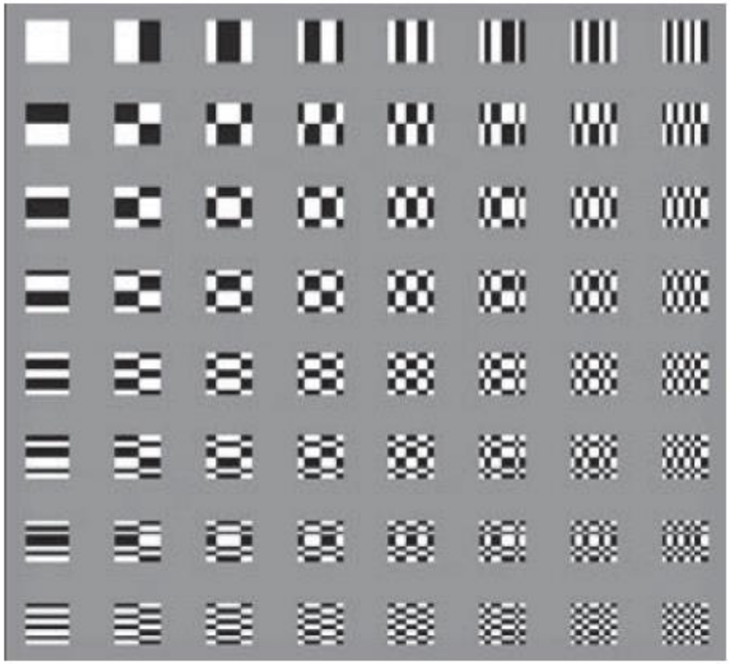
8×8 Blocks
Source Image
DCT
Q
DC
DPCM
AC
Quantization Table
Zigzag Scan
Entropy Encoder
Table Specification
Compressed Bitstream



8×8 Blocks
Reconstructed (Decoded) Image
IDCT
IQ
DPCM
DC
AC
Zigzag Scan
Entropy Decoder
Compressed Bitstream
Quantization Table
Table Specification

<u>Techniques used for JPEG:</u>

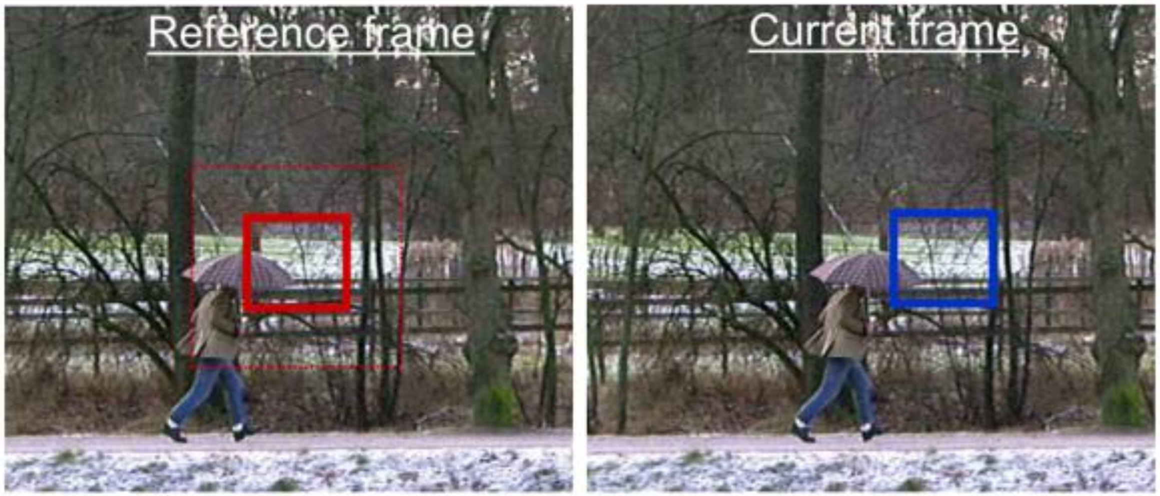
- YCbCr instead of RGB
- Chroma Subsampling
- Block based DCT
- Quantization tables
  - Different for Luma and Chroma
  - Quality vs compression (Quality factor)
- Zigzag scanning
- Run Length coding
- Entropy coding for DC-diff
- Entropy coding for Run-Category



Run/ Category	Base Code	Length	Run/ Category	Base Code	Length
0/0	**1010 (=EOB)**	**4**			
0/1	00	3	8/1	11111010	9
0/2	01	4	8/2	111111111000000	17
0/3	100	6	8/3	1111111110110111	19
0/4	1011	8	8/4	1111111110111000	20
0/5	11010	10	8/5	1111111110111001	21
0/6	111000	12	8/6	1111111110111010	22
0/7	1111000	14	8/7	1111111110111011	23
0/8	1111110110	18	8/8	1111111110111100	24
0/9	1111111110000010	25	8/9	1111111110111101	25
0/A	1111111110000011	26	8/A	1111111110111110	26

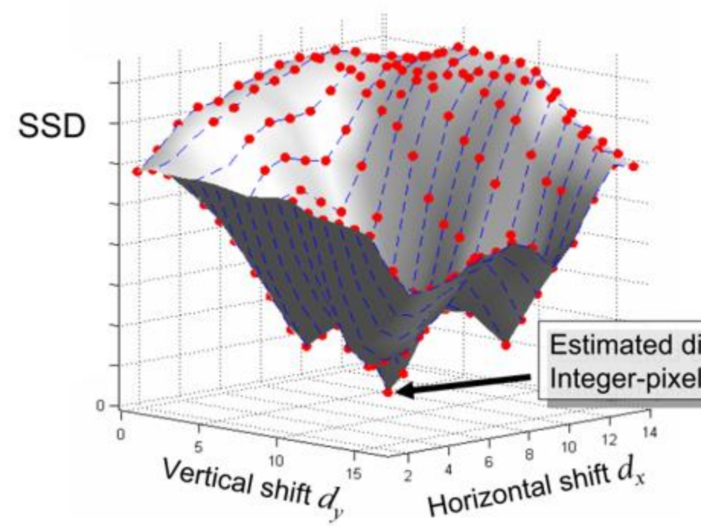
Techniques used for video compression:

- Motion Estimation



Block is compared with a shifted array of pixels in the reference frame to determine the best match

Block of pixels is considered



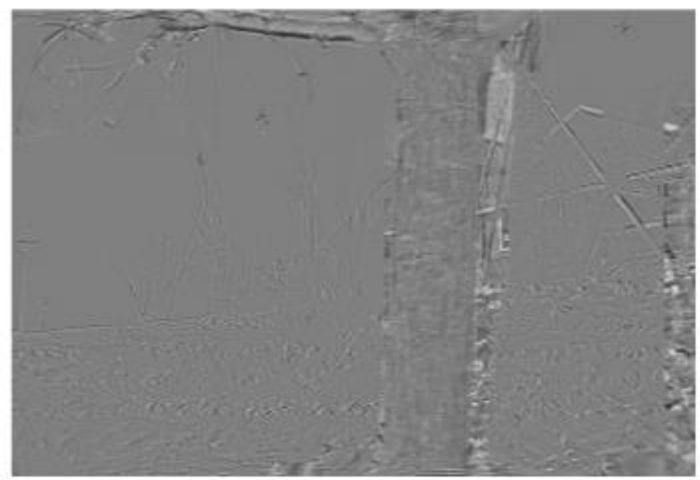
- The most challenging task in video compr.

Motion-compensated prediction: example

Previous frame

Current frame

Current frame with displacement vectors



Motion-compensated Prediction error

Rate distortion

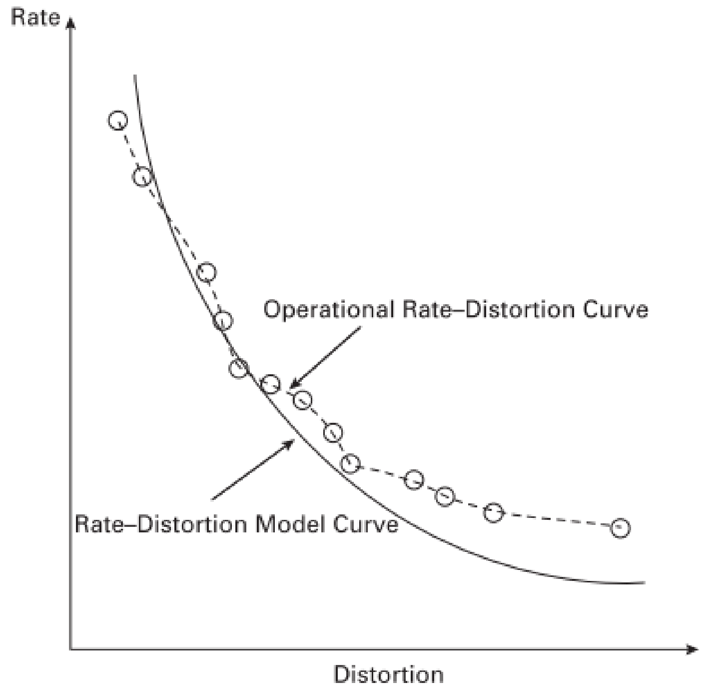


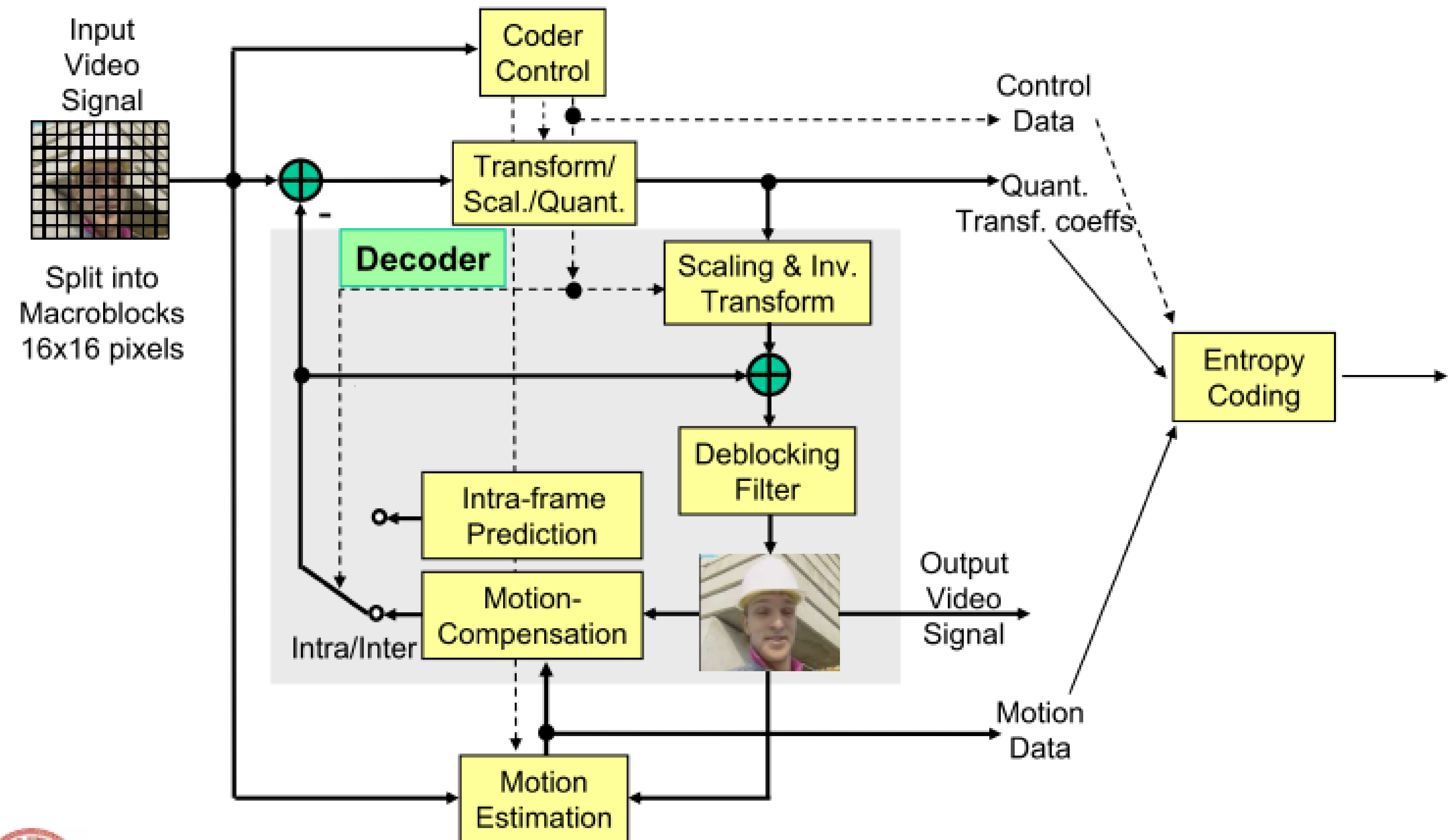
Figure 5.13 According to rate–distortion (R–D) theory, the distortion D is a decreasing function of the bitrate R [21].

- Peak signal to noise ratio

Motion estimation and compensation:

- Fast techniques
- Half pixel, quarter pixel
- Block size (16x16, 8x8, …etc)
- Fixed or variable block sizes
- Initial motion vector estimation
- Delta encoding for motion vectors
- Prediction from one frame (previous)
- Prediction from two frames (previous and next)
- Prediction from Multiple frames (as in H.264)
- I frames, P frames, B frames (Why?)

H.264/AVC Coder



[source: G. Sullivan, VCEG]

Scalable video coding:

Base layer, enhancement layer(s)

- SNR scalability
  - Send more DCT coefficients
  - Send more (Least significant bits)
- Spatial scalability
  - Encode a lower resolution version of the video
  - If higher resolution is required, extrapolate and add the enhancement layer
- Temporal scalability
  - Base layer: low frame rate

This is used for Transcoding

Speech coding:

- Good speech coder: low bit rate, high quality, low complexity, low delay
- Waveform coders, parametric coders, hybrid coders
- Waveform coders (G.711 (PCM with A,Mu law), G.726 ADPCM)
- Parametric coders
  - LPC-10
  - Linear Prediction Coefficients: understanding in time, understanding in frequency, Long Term prediction
  - Pitch Period
  - Gain
- Vector quantization

- Hybrid coders:
  - Regular Pulse Excitation Coders
  - Analysis by Synthesis
  - Code Excited Linear Prediction
  - Low Delay CELP
  - Vector Sum Excited Linear Prediction
  - Adaptive CELP
- Mixed Excited Linear Prediction
  - Different Speech production Model
  - Excitation Pulse
  - Different bands can be voiced or unvoiced

Video Communications:

- Streaming stored video:
- The most important and famous: Adaptive HTTP streaming
- Typically : HTTP streaming over TCP (e.g. Youtube and Netflex)
- Uses HTTP byte range header to tell what exactly to read

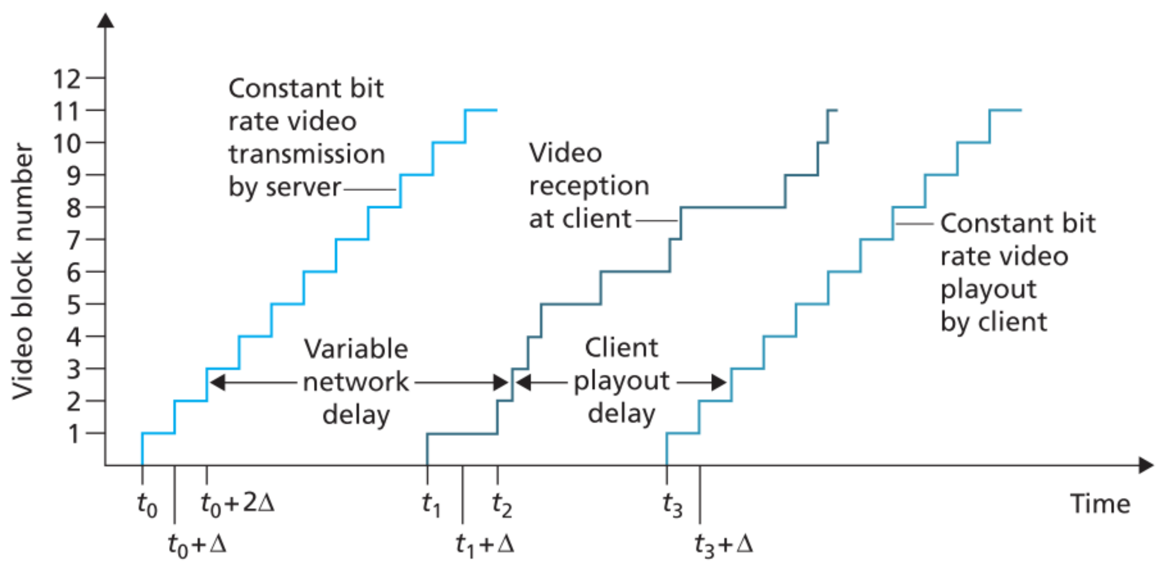
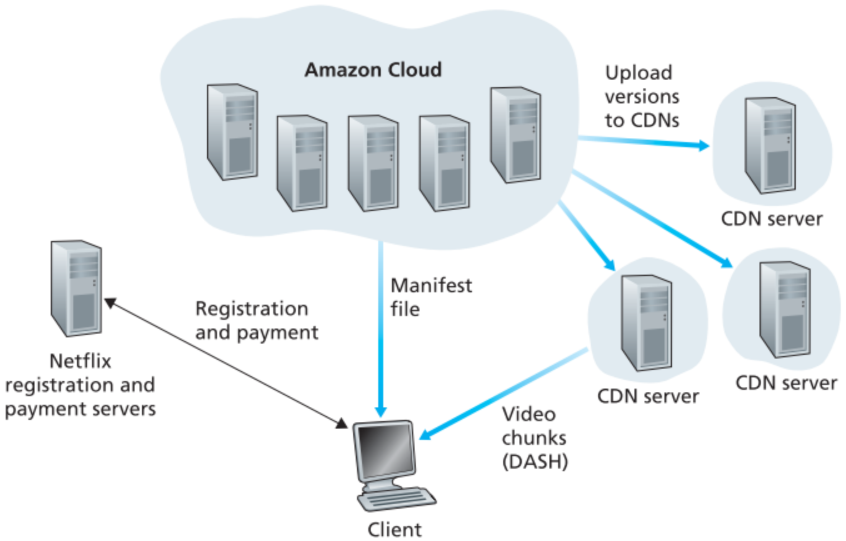


Figure 7.1 ♦ Client playout delay in video streaming

- DASH (Dynamic Adaptive Streaming over HTTP)
  - In DASH, the video is encoded into several different versions, with each version having a different bit rate and, correspondingly, a different quality level.
  - When the amount of available bandwidth is high, the client naturally selects chunks from a high-rate version; and when the available bandwidth is low, it naturally selects from a low-rate version.
  - Controlled by client
  - Each video version is stored with different URL
  - Same for audio
  - Manifest file is sent to the client
    - Where are the files, what bit rates

Content Distribution Networks (CDNs)

- Motivation?
- A CDN manages servers in multiple geographically distributed locations, stores copies of the videos (and other types of Web content, including documents, images, and audio) in its servers, and attempts to direct each user request to a CDN location that will provide the best user experience.
- Private CDNs (Youtube), or third party CDNs (Netflix uses Akamai)
- Enter Deep CDN, vs Bring home



- **<u>Real time conversational applications:</u>**

- Cannot use HTTP streaming
  - Real time constraints
- Usually RTP over UDP
  - Most importantly: sequence number and time stamp

Payload type	Sequence number	Timestamp	Synchronization source identifier	Miscellaneous fields

Figure 7.11 ♦ RTP header fields

  - For control: RTCP

Broadcast:

Table 6.1 Various digital broadcasting standards [11]; CMMB denotes China Mobile Multimedia Broadcasting

Region	Fixed reception standards	Mobile reception standards
Europe, India, Australia, Southeast Asia	DVB-T	DVB-H
North America	ATSC	DVB-H
Japan	ISDB-T	ISDB-T one-segment
Korea	ATSC	T-DMB
China	DVB-T/T-DMB/CMMB	

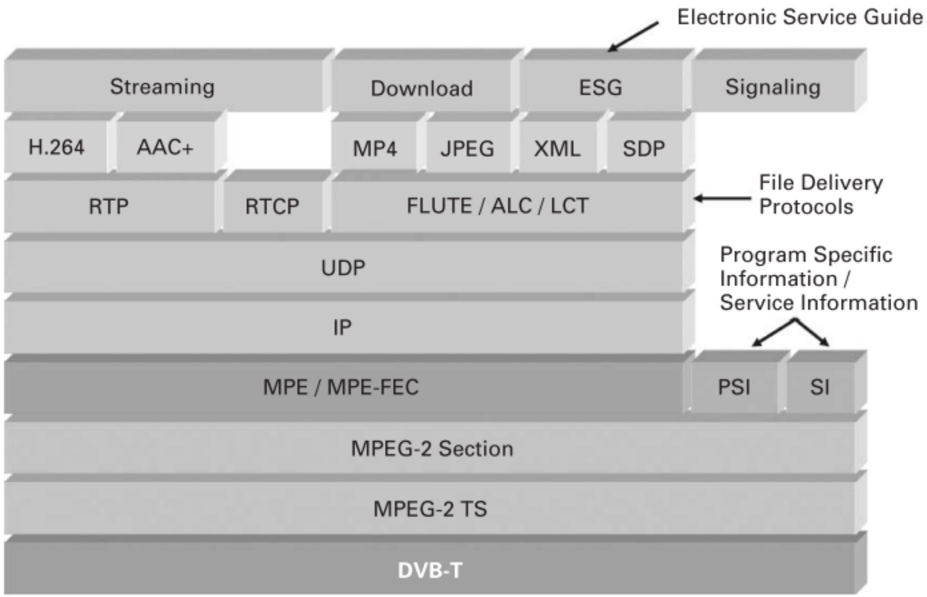


Figure 6.2 The protocol stack of DVB-H [22].

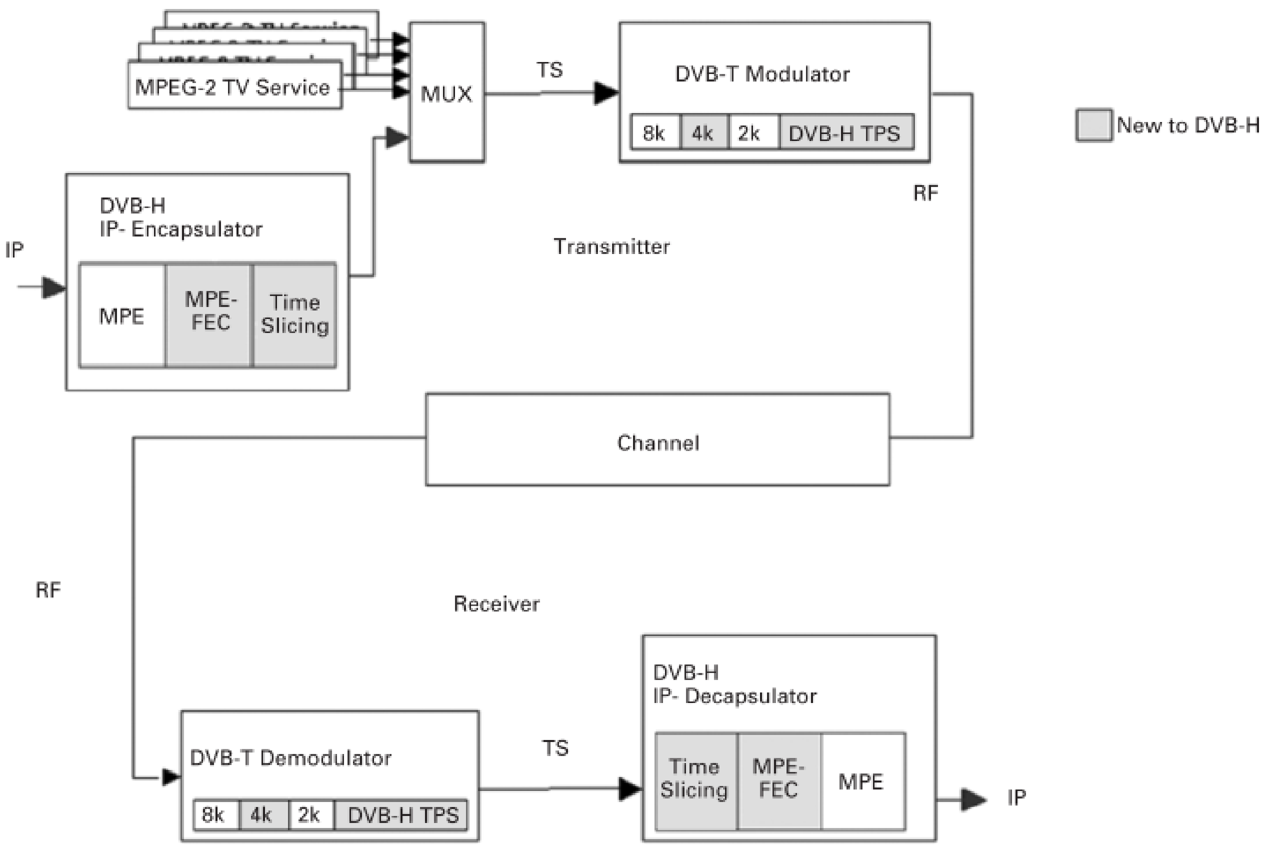


Figure 6.4 A conceptual description of the use of the DVB-H service [8] (© IEEE 2006).

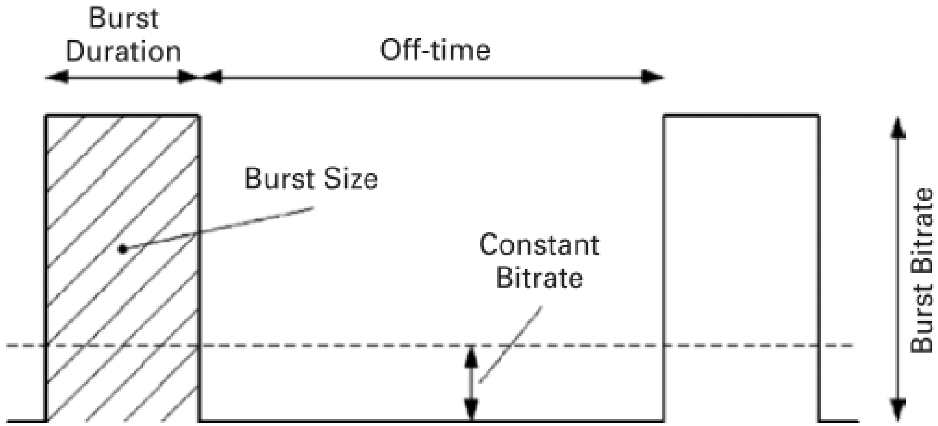


Figure 6.5 Principle of time slicing [8] (© IEEE 2006).

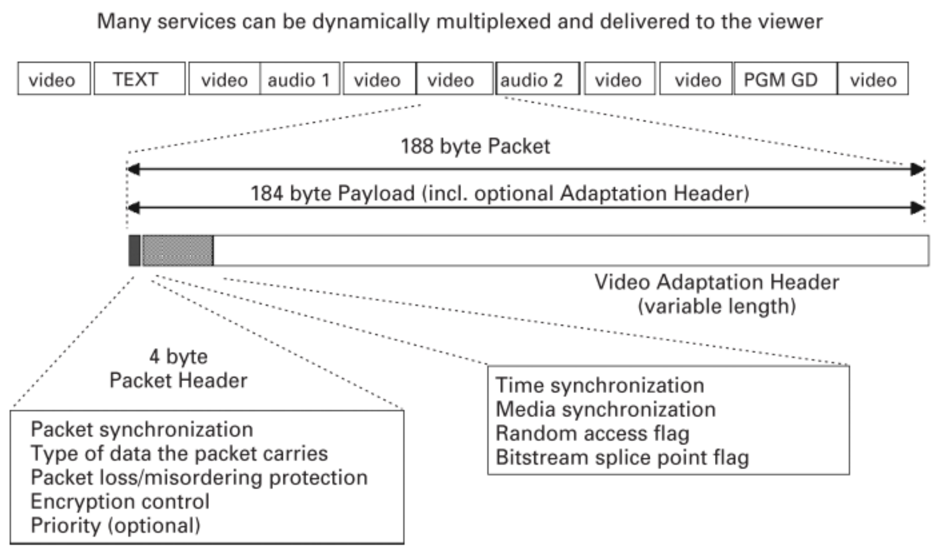


Figure 6.1 A typical representation of the MPEG-2 TS data format [20].

Exam questions ☺

- A Huffman coding problem
- A DCT problem
  - Draw basis functions (I will give you the equations)
  - Get the transform (I will give you the equations)
- Run length encoding question
- A JPEG entropy coding question
- Estimate a motion vector
- I will give you some basis functions in 2D, encode the image
- CELP like question
- Estimate the pitch of a waveform
- Choose suitable encoder
- What is the minimum buffer size for a decoder
- Some other questions: what is the role of CDN, …etc

I really loved teaching to you and enjoyed the course

Hope you enjoyed it :)

Thanks!