

INTRODUCTION TO MEDIA INFORMATICS: VIDEOS

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CONTENTS

- Video Compression
- H.264
- Video Formats & Containers
- Video Retrieval
- Video Summaries



VIDEO

- Video typically names the combination of
 - One or more audio streams and
 - One or more video streams

Video

h.264 compressed video stream

AAC encoded German audio stream/s

AAC encoded English audio stream/s

VIDEO

We focus on the visual part:

- A video is a sequence of pictures
- Shown at a certain rate
 - More than 12 images / second needed
 - e.g. 25 (PAL) 30 (NTSC), 24 (24p)
- For equal length time slots
 - cp. jitter



VIDEO COMPRESSION

- Basically there are two types of compression:
 - Intra frame compression: A single image is compressed (like a JPEG image).
 - Inter frame compression: Compression is based on surrounding frames.



VIDEO COMPRESSION

DIFFERENCE BETWEEN TEMPORAL NEIGHBORS



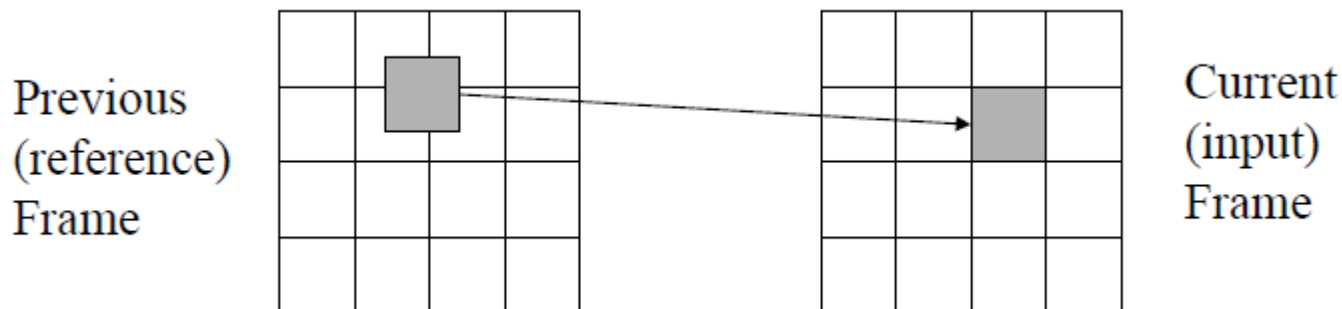
IDEA: COMPENSATE MOTION

- Difference originates from motion
 - Foreground vs. background motion
- Encoder tries to estimate motion
 - E.g. rooster moves from left to right, 2 pixels
- Decoder “moves” last decoded picture
- Difference is encoded



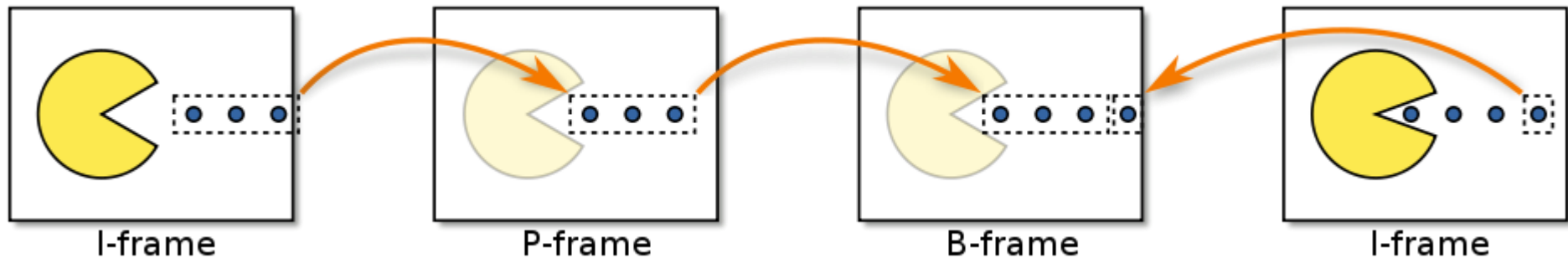
IDEA: COMPENSATE MOTION

- Image is split in blocks (e.g. 8x8 pixels)
- “Motion vectors” are computed
 - Where does the block move from the last picture?
- Difference is stored
 - Between predicted block and
 - Moved block in the previous picture



INTER FRAME COMPRESSION

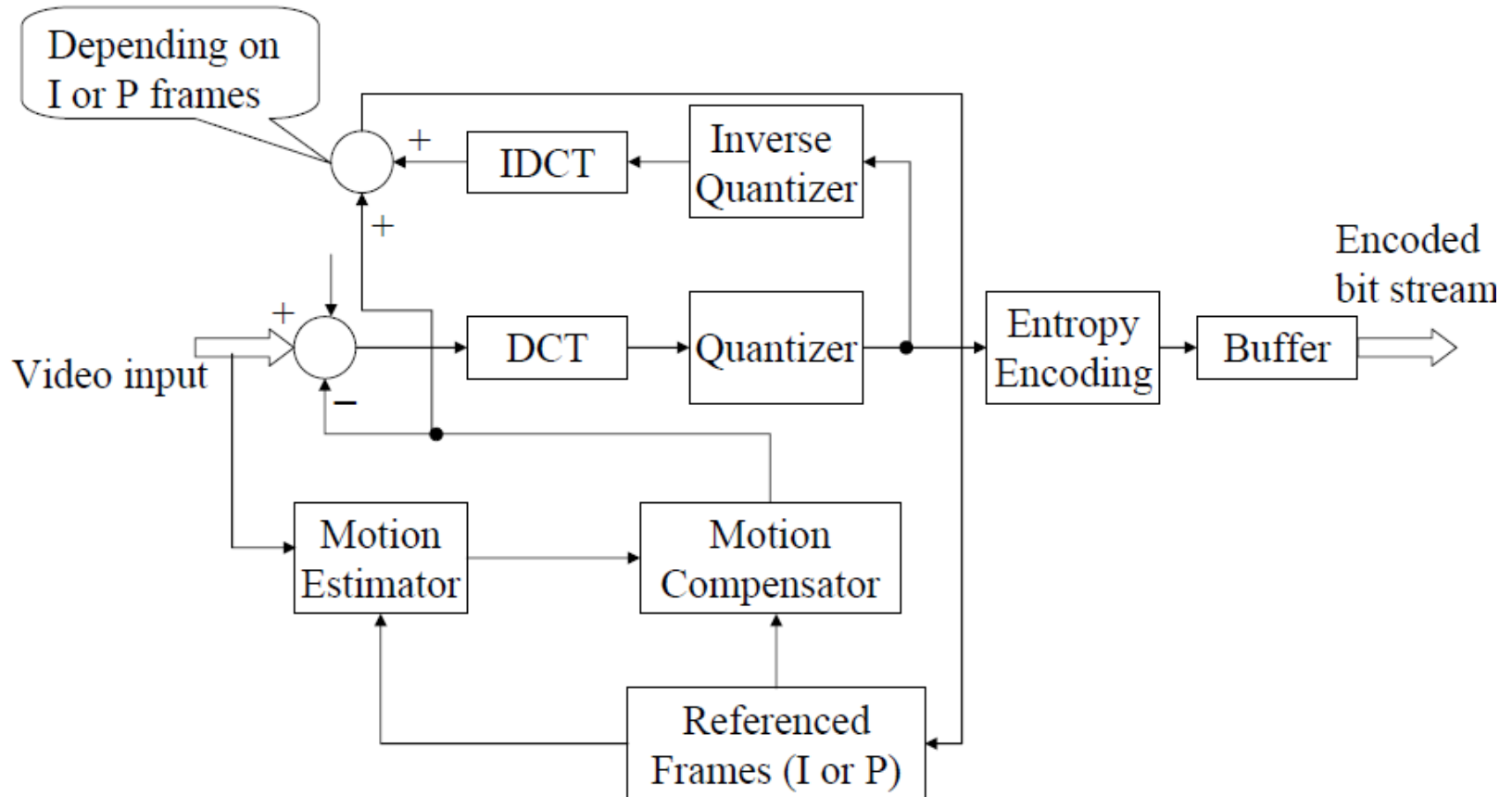
- I-Frame: Intra coded picture
- P-Frame: Predicted picture
- B-Frame: Bi-directional predicted picture



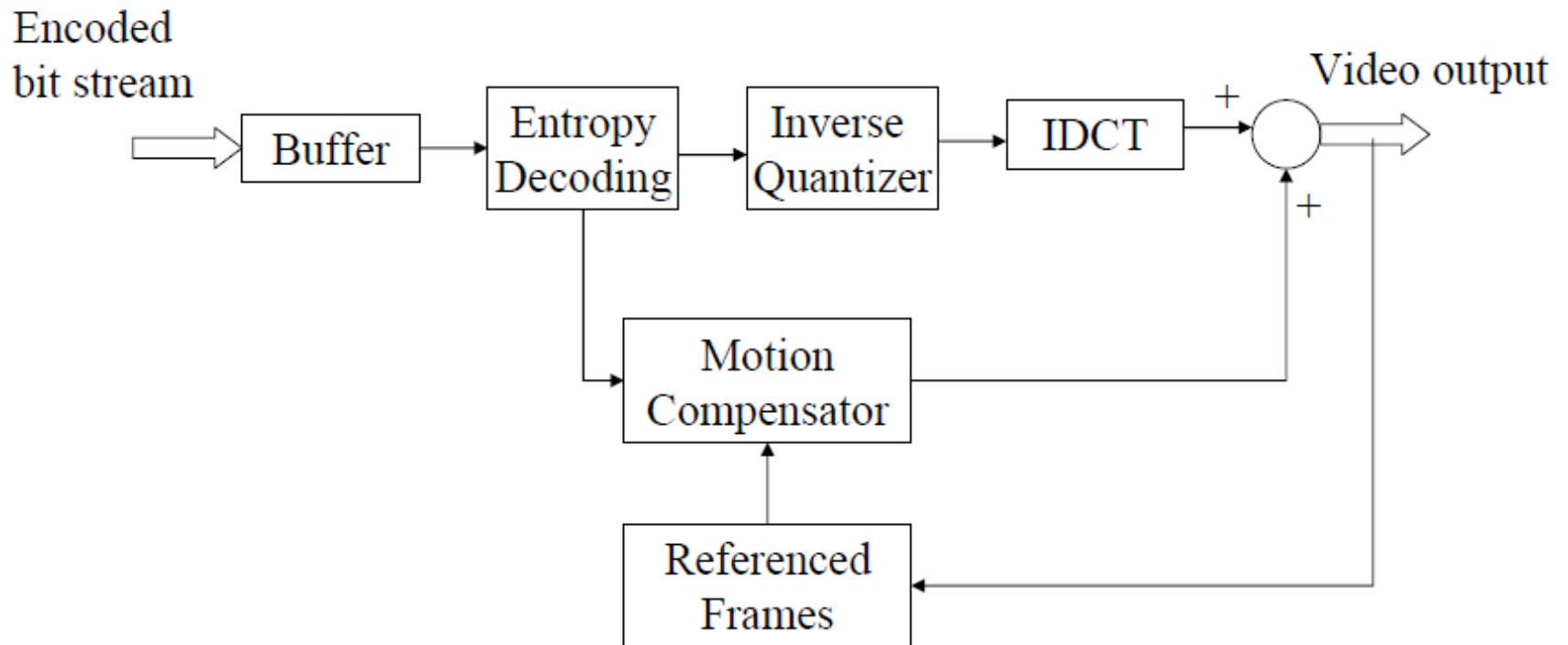
INTER FRAME COMPRESSION

- Frames are encoded in GOPs (group of pictures)
- GOPs differ in size based on the
 - Compression standard and
 - Video content
- Examples
 - GOP size 5: I-P-P-P-P
 - GOP size 17: I-B-B-B-P-B-B-B-P-B-B-B-P-B-B-B-I

MPEG VIDEO ENCODING SCHEME



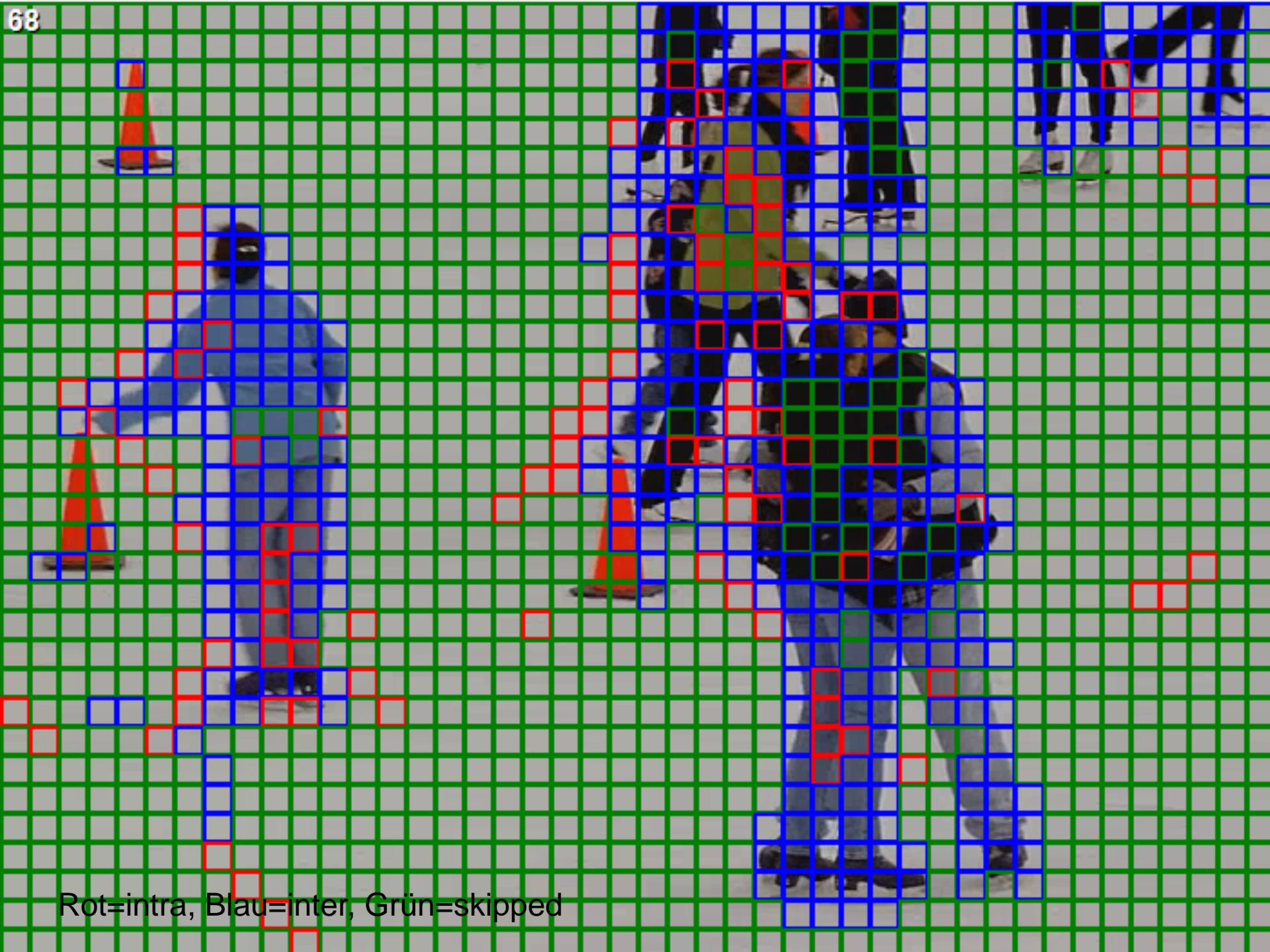
MPEG VIDEO DECODING SCHEME



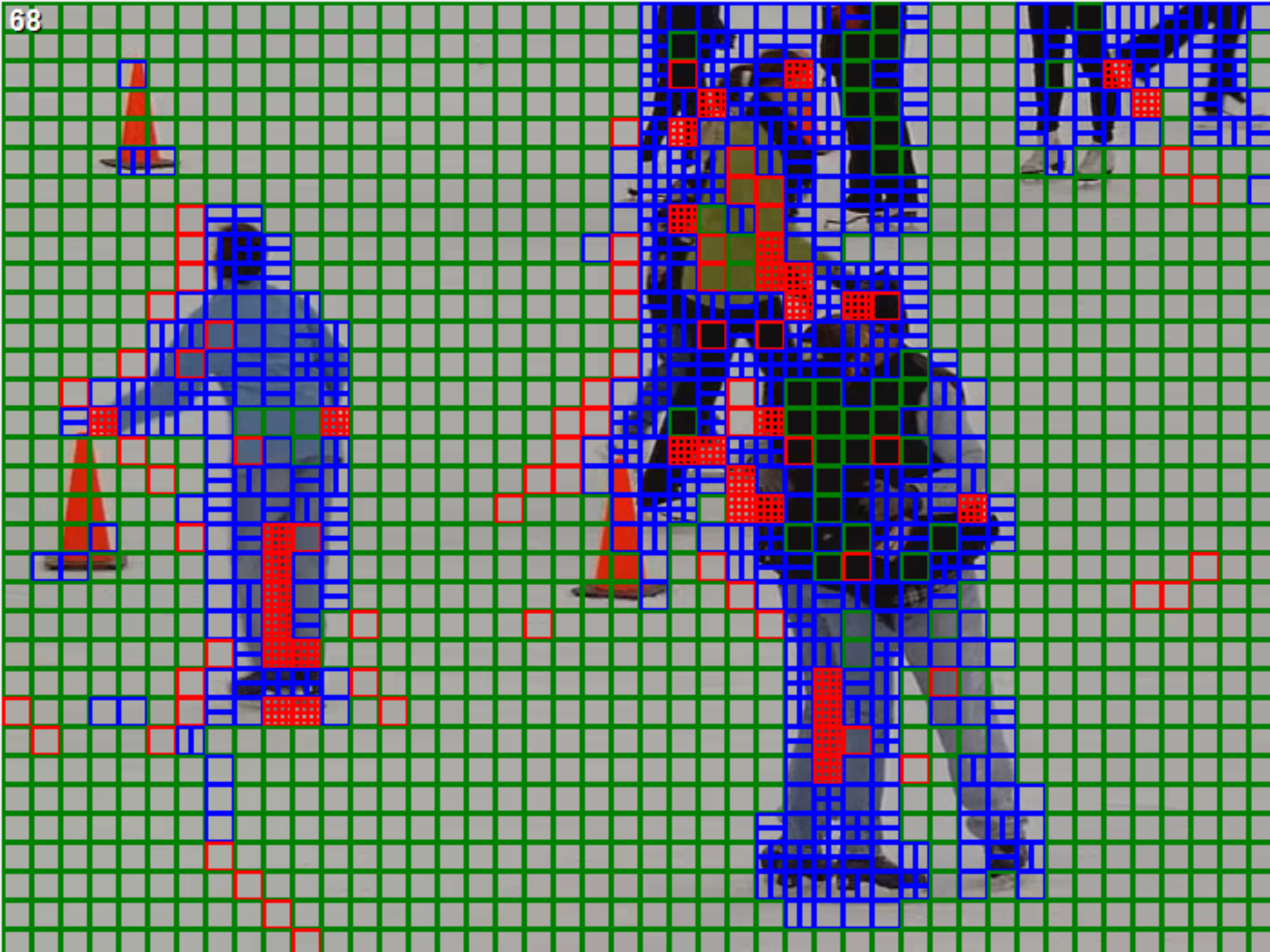
H.264 INTERNALS: EXAMPLE

- H.264 slices and macroblocks for prediction
- Skip, I- and P-macroblocks
- Motion vectors





Rot=intra, Blau=inter, Grün=skipped





VIDEO CODING: ADDITIONAL THOUGHTS

- Why does encoding take so long?
- What is multi-pass encoding?
- How can “fast forward” and “reverse” work?
- How do I jump to a certain time point in a video?

VIDEO FORMATS & CONTAINERS: AVI

- AVI := Audio Video Interleave
- Widespread format for storing audio visual data
- Defined by Microsoft, popular on Windows systems
- Based on the Resource Interchange File Format (RIFF)
 - File is organized in chunks and lists
 - Sequential and hierarchical composition of chunks and lists

VIDEO FORMATS & CONTAINERS: ASF

- ASF := Advanced Systems Format
 - Meant as replacement for AVI
- Design goal:
 - Efficient playback from servers (e.g. HTTP server)
 - Local storage
 - May be used for editing purposes (no explicit focus)
- Lessons learned
 - Support of incremental generation of content (live content)
 - 64 Bits size fields (to tackle 4 GB limitations)
- File extensions
 - .wmv (video data) and .asf (otherwise)

VIDEO FORMATS & CONTAINERS: MP4 / MOV

- Powerful and complex format
 - File organization based on boxes
 - Supports file sizes > 4 GB
 - Explicit timing information
 - Focus on MPEG-based audio and video formats
- Streaming support
 - Video streaming supported (e.g., used by iPhone)
 - File format concepts do not allow incremental generation and consumption
- MP4 is not the successor of MP3 ;)

VIDEO FORMATS & CONTAINERS: MATROSKA

- Open & patent free container format
 - For streaming and storage
- Matroska is derived from matryoshka (**Матрёшка**) == „nesting doll“
- File extensions: .mkv .mka .mks



VIDEO CONTAINERS & FORMATS: MPEG

- MPEG-1
 - Meant for Video CDs
- MPEG-2
 - Meant for high resolution materials
 - Used for DVDs & DVB, main cash-cow of MPEG
- MPEG-4 SP & ASP
 - First try on a better format
- AVC / H.264
 - Adapted from H.264 / ITU, used for e.g. Blue-Rays, etc.
- HEVC (High Efficiency Video Coding)
 - Supports 8K Ultra HD

VIDEO CONTAINERS & FORMATS: WEBM

- Royalty free online video format
 - Matroska container
 - VP8 & VP9 video codec
 - Opus audio stream
- Native support in
 - Chrome, Firefox, Opera

VIDEO CONTAINERS & FORMATS: XVID & DIVX

- Both are basically MPEG SP/ASP implementations
- DivX is proprietary
 - DivX ;) was hacked from a MS codec
 - Developer got hired by DivX, Inc.
 - Later DivX “learned” AVC, HEVC and uses MKV
- XVid is open source software
 - Typically packed into an AVI container

OTHER VIDEO FORMATS ...

- OGG (Vorbis & Theora)
 - Open source, patent free
 - Used in CC, Wikimedia, many game engines
- Bink (RAD Game Tools)
 - Proprietary, used in games, library & effects
- FLV - Flash Video
 - Adobe container for Sorenson, VP6 & AVC
- MXF
 - Professional container for B2B
- Real Media
 - Streaming server & player along with format

DEMO: FFMPEG CMD-LINE

- Show ffmpeg -i
- Show ffmpeg -i -> webm
- Show ffmpeg -i ED_HD.avi -s 640x360 -b 1024k ed.webm

MULTIMEDIA NETWORKING

- Applications
 - Streaming stored data
 - Streaming live data
 - Real time interactive video
- Characteristics
 - Delay sensitive
 - Loss tolerant

INTERNET MULTIMEDIA: DOWNLOAD & PLAY

- Data stored in file
- File transferred via HTTP
 - Received at the client
 - Passed on to the player
- That's not streaming
 - Long start-up delays, etc.

INTERNET MULTIMEDIA: PROGRESSIVE DOWNLOAD

- Video URL is handled by browser, plugin or video player
- Server is contacted via TCP/HTTP
- Streaming-like experience using HTTP-GET
- Player starts as soon as there is enough downloaded
- Stops or pauses if there is not enough data

INTERNET MULTIMEDIA: STREAMING

- Non-HTTP protocol between server and media player
- Can use e.g. UDP (see later)
 - Each frame is packaged in a UDP datagram
 - If one datagram is lost, then the frame is lost
 - Client takes care of package order
 - Pause, forward, rewind are supported

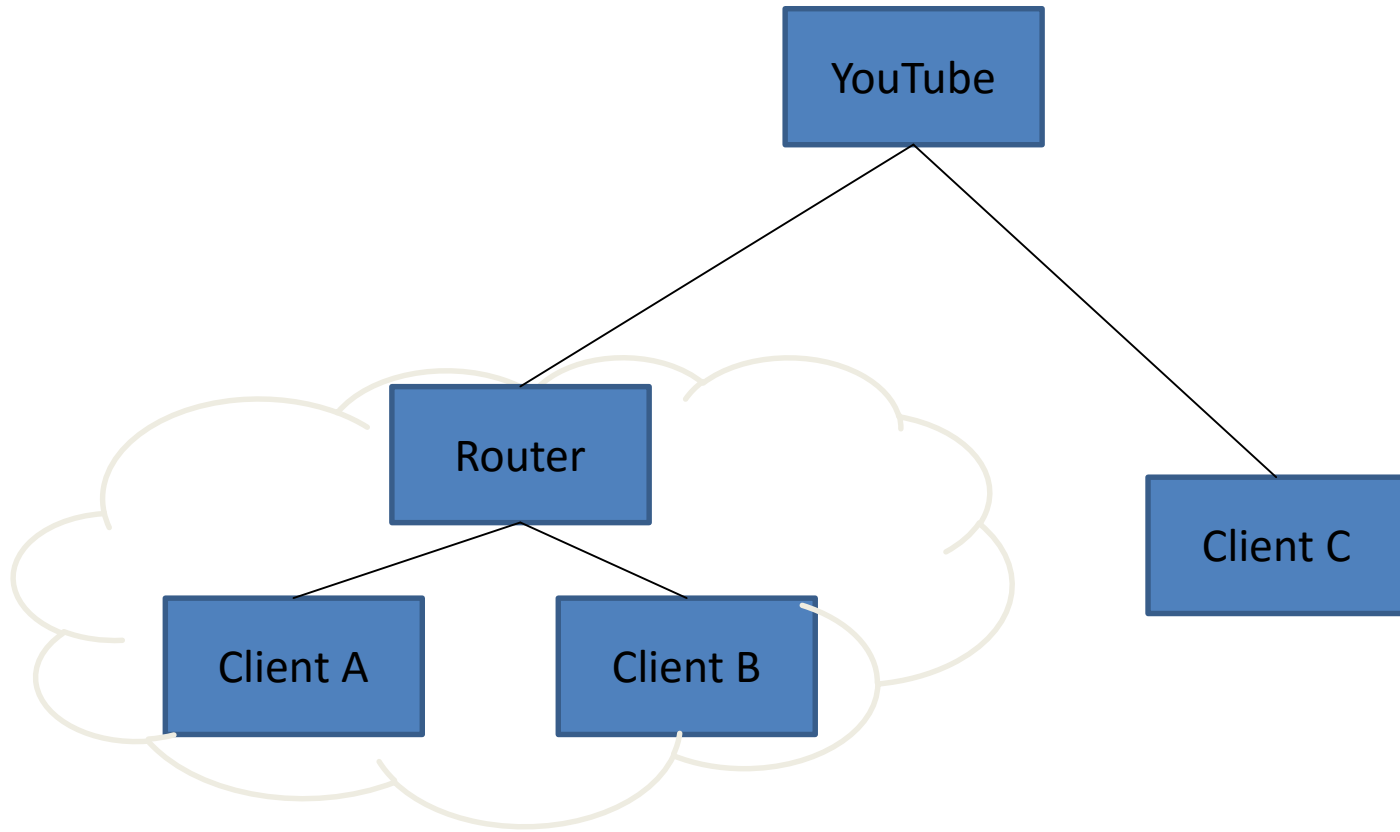
INTERNET MULTIMEDIA: CURRENT APPROACHES

- HTTP pseudo-streaming
 - Like progressive download
 - But seeking is supported (jump to time point)
- HTTP dynamic/live streaming
 - Server provides many small files
 - In different resolutions / bitrates
 - Client glues files together for full video

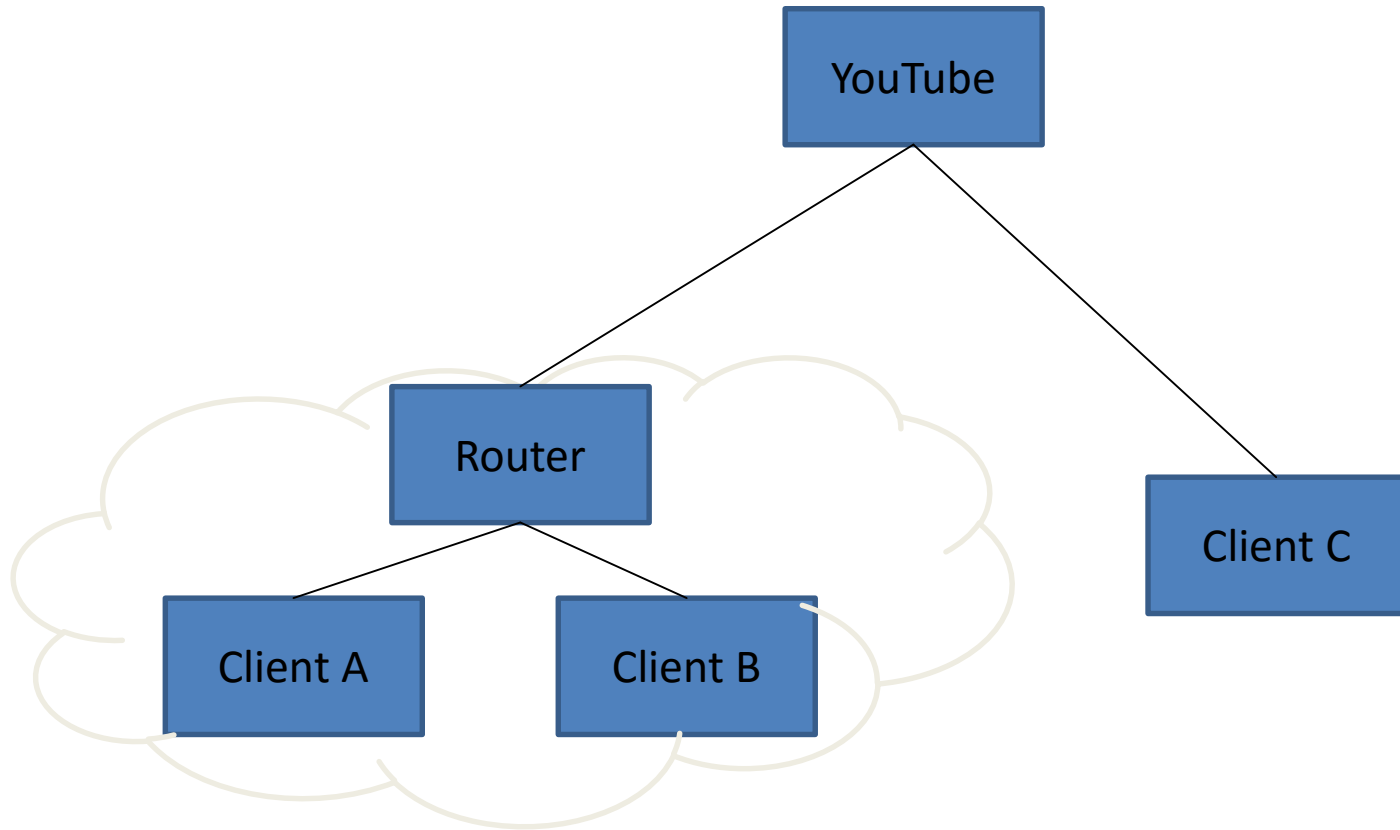
MPEG DASH

- Server has for each video
 - lots of small chunks, ie. 1 sec each
 - pre-transcoded in different sizes & bit rates
- Client gets Media Presentation Description
 - knows which chunks are available
 - requests what is appropriate
- Features:
 - stream & bitrate switching, HTTP transport, ...

MULTIMEDIA NETWORKING: MULTICAST VS. UNICAST



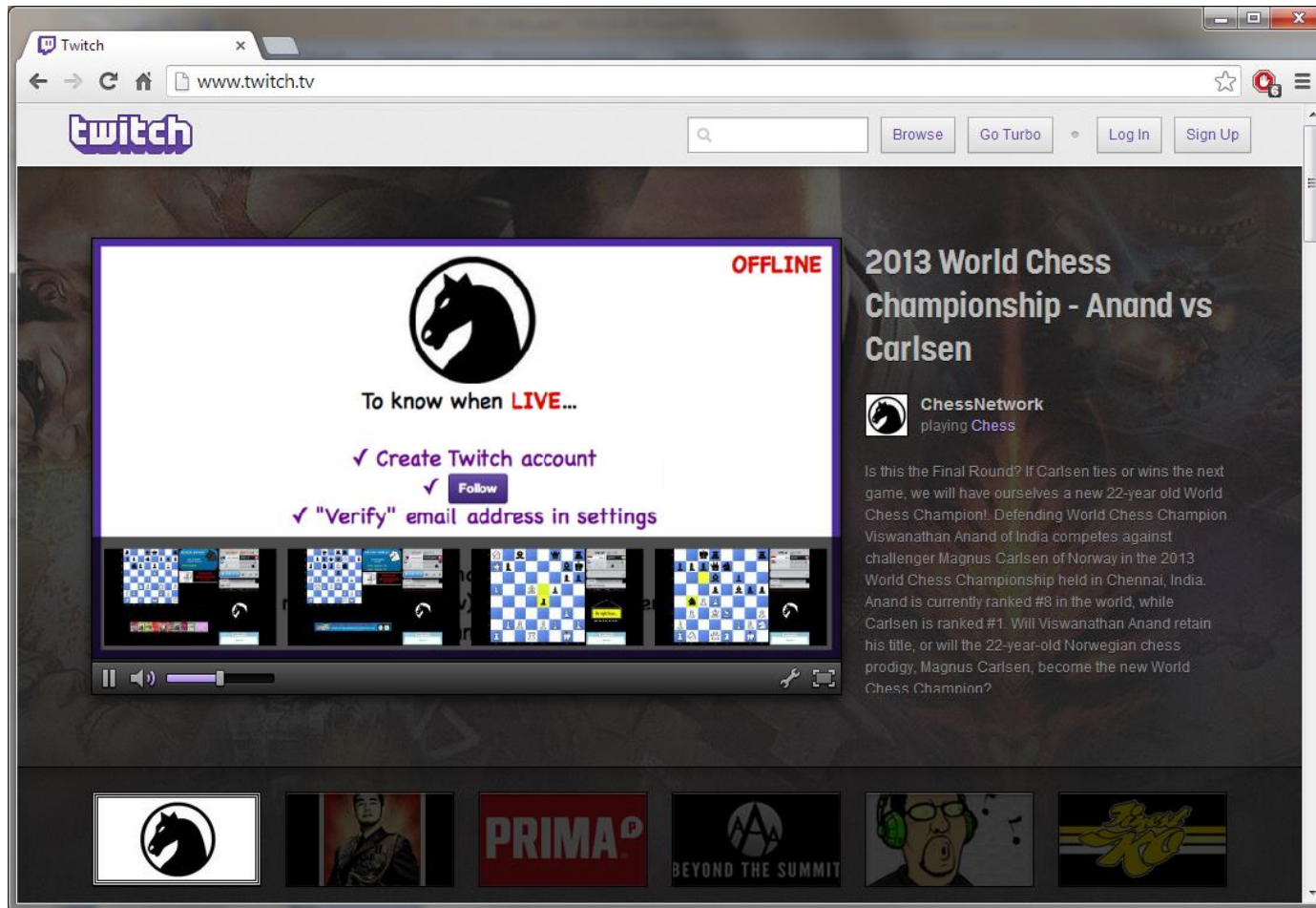
MULTIMEDIA NETWORKING: MULTICAST VS. UNICAST



WHY STREAMING?

- DRM & Security in ...
 - IP-TV & Interactive TV: Aon TV, etc.
 - Movie & video rentals: Netflix, Xbox Video Store
- Real time services like
 - VoIP, video conferencing
- Live streaming
 - Sports event, etc.
- Multicast: Delivery to many clients at once

DEMO: TWITCH.TV



DVB

- DVB := Digital Video Broadcast
- European standardization and development effort
- Suite of open standards for digital television since 1990s
 - Based on existing standards



DVB

- DVB Project (www.dvb.org)
 - Industry-led consortium of 280 companies from 35 countries(broadcaster, network operator, manufacturer)
 - Currently more than 200 million DVB receivers deployed
- European Telecommunications Standards Institute (ETSI)
 - Founded in 1988, now 740 members
 - Independent, non-profit standardization organization

DVB - TRANSMISSION

- Common source coding and multiplexing
- DVB-S (1994)
 - DVB-S2, DVB-SH
 - 107 million receivers deployed
- DVB-T (1997)
 - DVB-T2, DVB-H
 - 81 million receivers deployed
- DVB-C (1998)
 - DVB-C2
 - 42 million receivers deployed

DVB-S

- Broadcast by geostationary satellites
- Coexistence with existing analog programmes
- Very popular in Europe
 - Inexpensive equipment (< 100 €)
 - No follow-up expenses
 - Coverage of sparse-populated areas
 - Variety of different channels (free to air, FTA)
 - Astra and Hotbird satellites

DVB-S

- Geostationary Communication Satellites
 - Appear at a fixed position for an earth-based observer
 - Moves with the same speed as earth rotation
 - Orbital position of about 36000 km above equator
 - Comparison:
 - 1/10 way to the moon
 - ISS or Space Shuttle - orbit of 400 km
- Satellites can be positioned at different longitudes, e.g.
 - Astra at 19.2° East
 - Hotbird at 13° East