

# **WHY “NOT- COMPRESSING” SIMPLY DOESN’T MAKE SENS ?**

# IMAGES AND VIDEOS ARE LIKE SPONGES

It seems to be a solid. But what happens when you squeeze it?

It gets smaller! Why?

If you look closely at the sponge, you will see that it has lots of holes in it.

The sponge is made up of a mixture of solid and gas. When you squeeze it, the solid part changes its shape, but stays the same size. The gas in the holes gets smaller, so the entire sponge takes up less space.



# IMAGES AND VIDEOS ARE LIKE SPONGES

There is a lot of data that are not bringing any information to our human eyes, and we can remove it.

It does not make sense to transport, store uncompressed images/videos.

It is adding data that have an undeniable cost and that are not bringing any additional valuable information to the viewers.



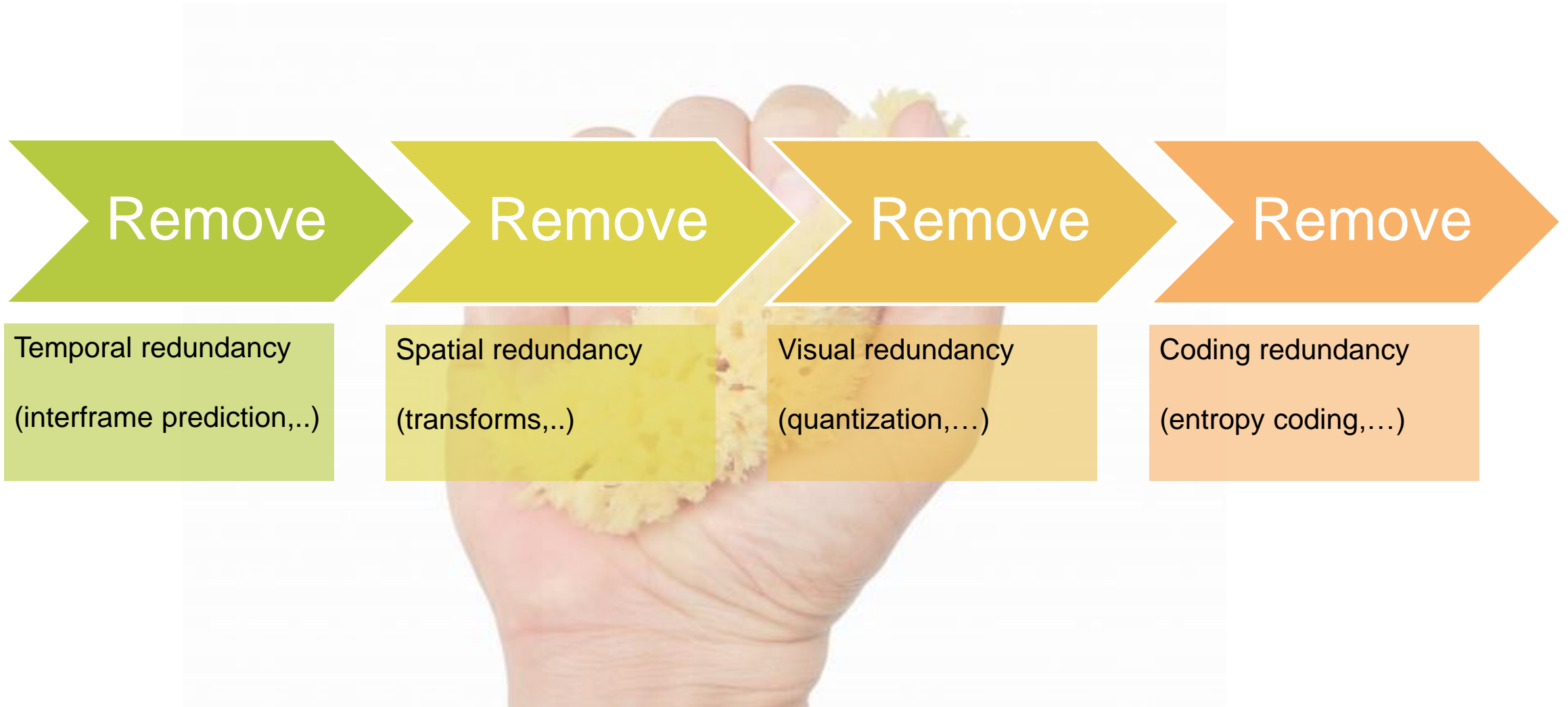
# A 4K TV SHOW WITHOUT ANY CODEC



3840x2160 60 fps 422 10bit uncompressed

- 60 MINUTES STORAGE: **4478.85 GB**
- STREAMING: **9.953 Gbit per sec**

# IMAGES AND VIDEOS ARE LIKE SPONGES



# WHAT IS A CODEC?

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Short for **C**oder & **DE**Coder

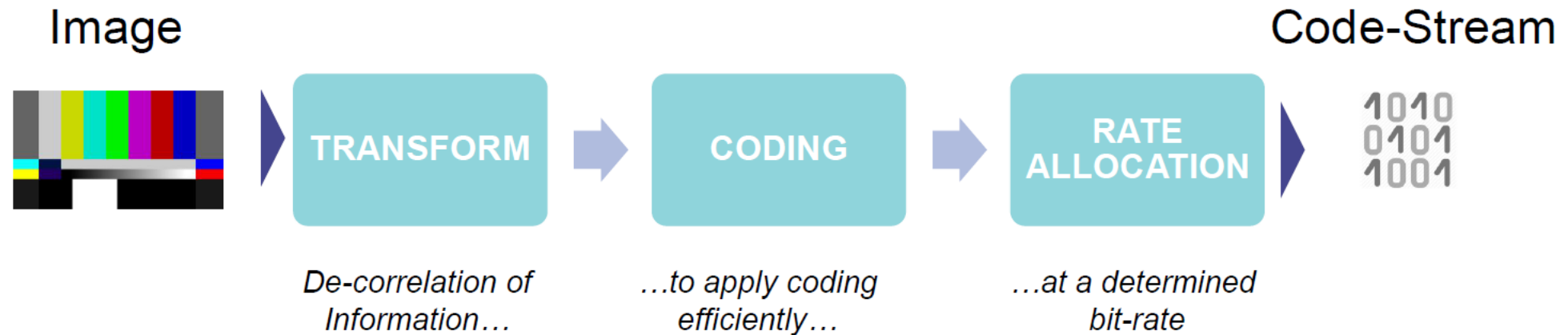


“A codec is a device or computer program for encoding or decoding a digital data stream or signal.”

*Note :*

- *It does not (necessarily) define quality*
- *It does not define transport / container format method.*

# WHAT IS A CODEC?



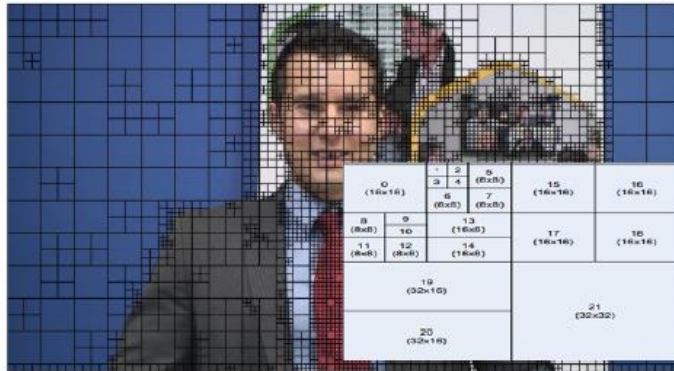
**Quality, Latency, Complexity, Bandwidth** depend on how the actual algorithms are processing the content.

- Many existing standards using different technics.
- New innovations are coming every year.

# 1. DECORRELATION OF INFORMATION

- Redundancy in space : Frame Partitioning , DCT, Wavelet Transforms, ...
- Redundancy in time : Frame differences, Motion vectors, ...

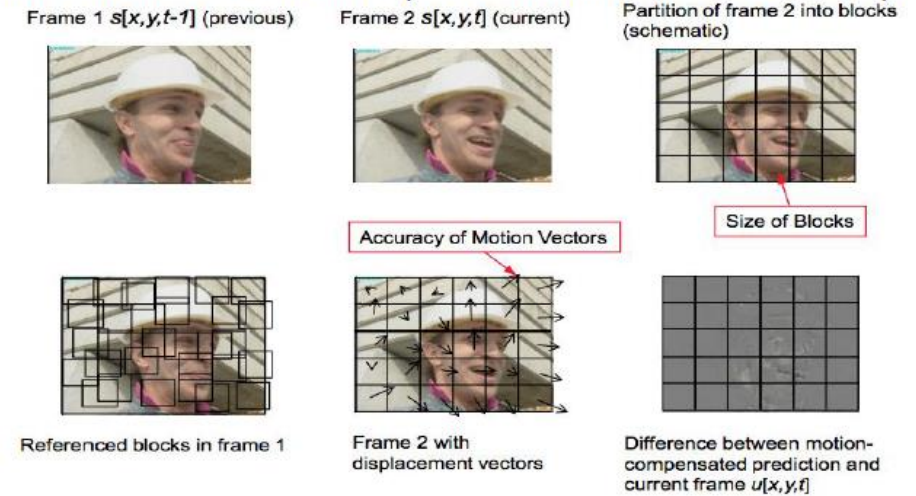
FRAME PARTITIONNING (HEVC)



DISCRETE WAVELET TRANSFORM (JXS, J2K, VC2)



MOTION VECTORS (INTERFRAME CODECS)





## 2. TO APPLY 'ENTROPY' CODING EFFICIENTLY

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Lossless compression technique

Various entropy coding technics are used :

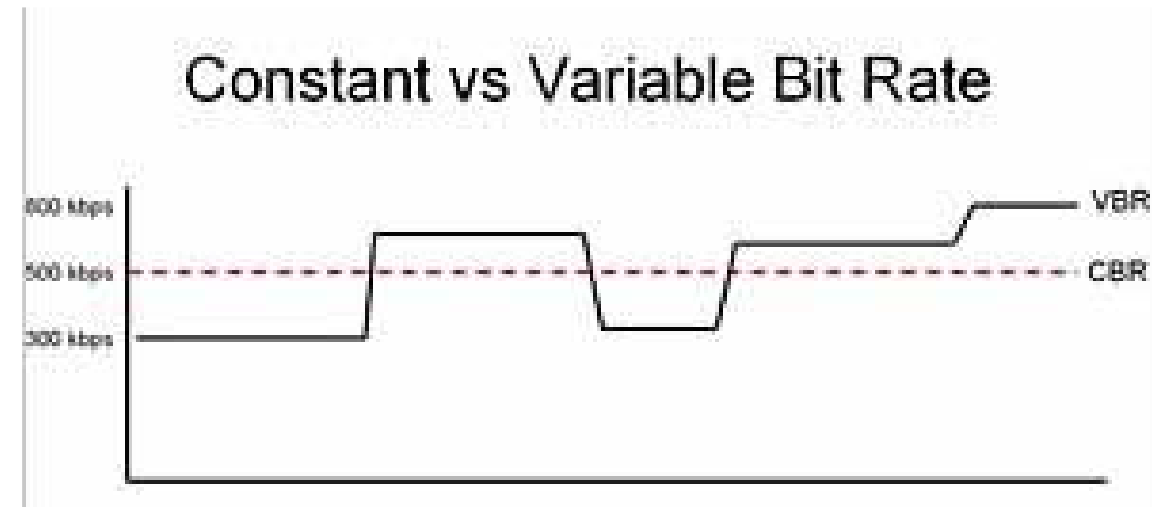
- Arithmetic coding, Huffman coding Golomb, Exp-Golomb, Run-length coding, VLC, CABAC,...

### 3. AT A DETERMINED BIT-RATE

Quantization & visual on the flow, post compression rate-distortion.

Choice between CBR, VBR

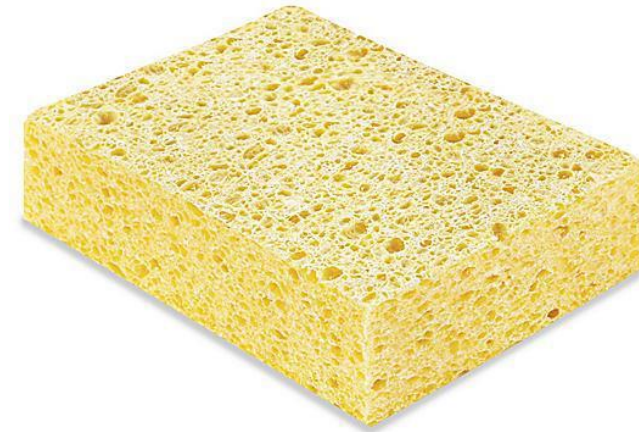
- **CBR** stands for constant bitrate.
  - The bitrate or the number of bits per second is kept the same during the encoding process.
  - Preferred for Real-time / Live transmission
- **VBR** stands for variable bitrate.
  - Adjusts the data rate down and to the upper limit you set, based on the data required by the compressor.
  - Preferred for Media File transmission



# HOW MUCH DO YOU COMPRESS?

## LOSSLESS COMPRESSION

- **For the human eyes** : called **visually lossless** :  
No differences between the source image and the decompressed image can be detected by close human inspection.
- **For machine** : the information can still be detected, extracted, analyzed.
- **Mathematically lossless** : can be proven by comparing a hash of source file and the retrieved compressed file



No degradation of the information compared to the original

# HOW MUCH DO YOU COMPRESS?

## LOSSY COMPRESSION

- Some information is discarded, but intelligent choices are made to minimize the perceived impact of the loss.
- Trade-offs between bandwidth, resolution, frame rate, color accuracy and other factors determine how lossy.



Some information is missing

# HOW DO YOU MEASURE THE QUALITY

## Subjective video quality

- What viewing distance
- Side/Side comparison
- Flickering test

## Objective video quality

- PSNR
- SSIM,
- VMAF
- ...

**It is often recommended to mix both subjective and objective video quality measurements**

Method for near-lossless quality assessment on both natural & synthetic images  
**(ISO/IEC 29170-2 ) used for JPEG XS**



**“ FLICKER TEST ”**

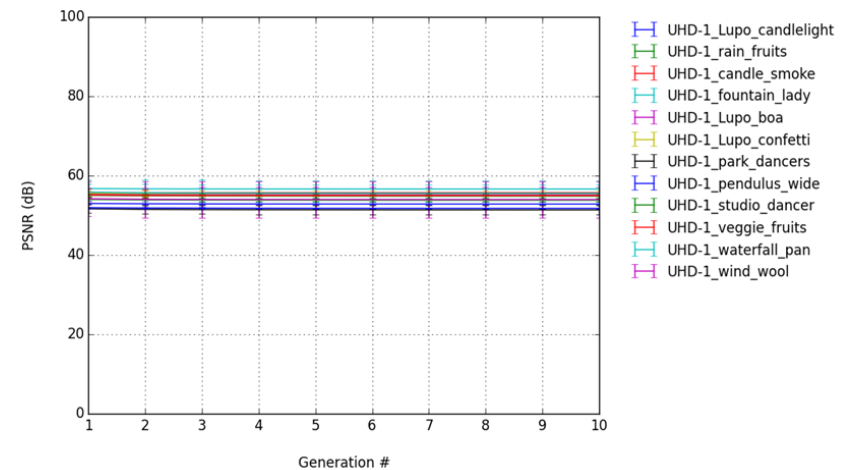
Test on 360 scores (= persons) in total  
(from 4 universities/research centers)

# HOW DO YOU MEASURE THE QUALITY

- **Visual Impairments:** Some codec generates blocking artifacts; others generates blur at (too) low bitrate. What do you prefer?



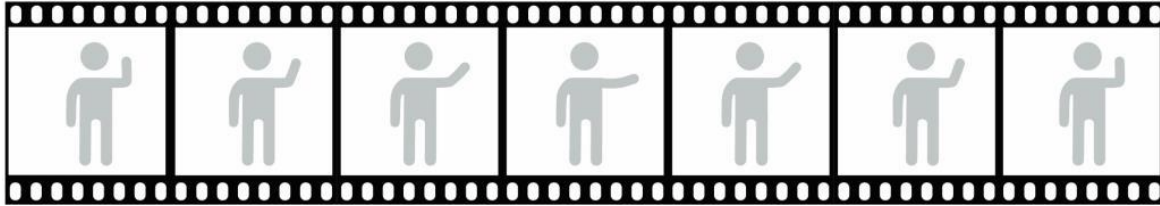
- **Multigeneration robustness.** Some codecs resists to multiple encoding/decoding which is important if you go over multiple editing steps during the production workflow.



- **Intra-frame versus Interframe codecs :** In intra-frame coding , each frame remains accessible independently. Errors in inter-frame coding can affect multiple frames. ©2020 The Society of Motion Picture and Television Engineers, Inc (SMPTE)

# INTRA-FRAME VS INTER-FRAME CODECS

## Intra-Frame

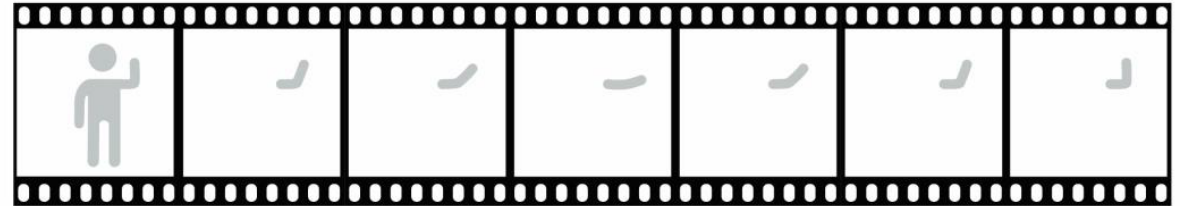


### “Intra” means “within”

Each frame of video is individually compressed as if it were an individual picture.

Some codecs go also to “sub-intra-frame” level, meaning that they are not keeping a full picture, just few lines to perform the compression.

## Inter-frame



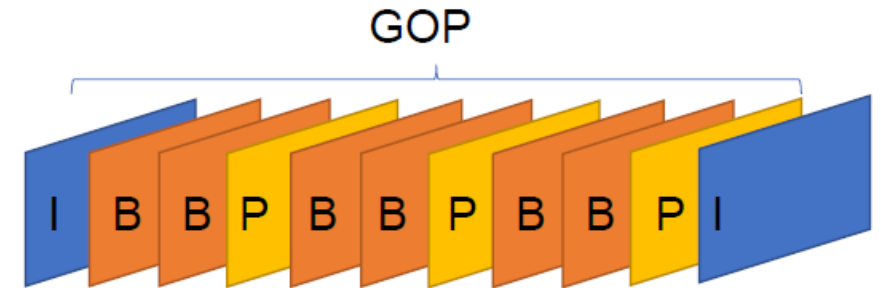
### “Inter” means “between”

Use multiple frames as references for each other allowing portions of the frames that do not change to just be repeated, or just changing the differences, rather than resending the information.

# INTER-FRAME CODECS

Use 3 types of frames into a Group of Pictures (GOP)

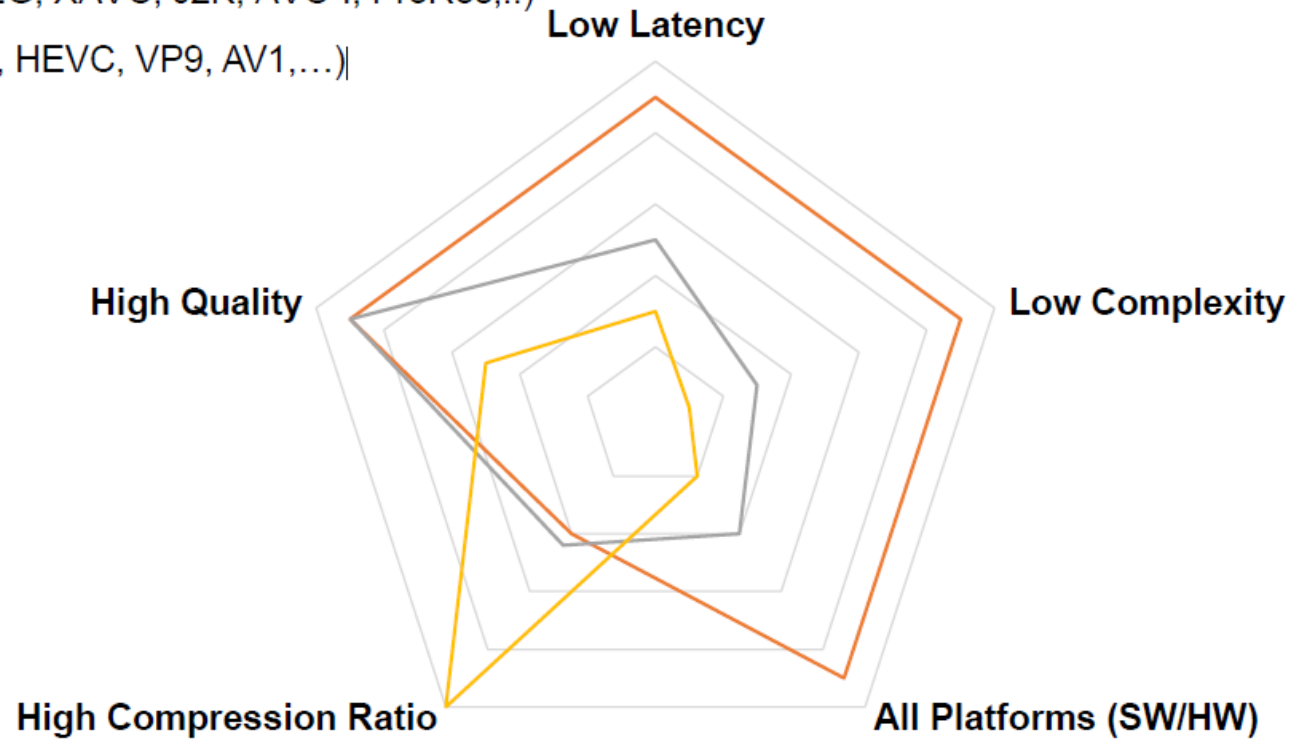
- Always starts with an I-frame (referred to as the 'key' frame).
- The codec defines how the various P and B frames are interleaved.
  - P frame (predictive) : Use data from previous frames as a reference
  - B frame (bi-predictive) : Use both previous and future frames as references. Cannot be encoded (or decoded) until the future frame is received.
- GOP size is generally user configurable settings : The longest is the GOP, the lowest is the bitrate, the highest is the latency.





# WHICH CODEC IS FOR ME?

- Sub-intra-frame Codec (ie JPEG XS )
- Intra-frame Codecs (MJPEG, XAVC, J2K, AVC-I, ProRes,...)
- Inter-frame Codecs (H264, HEVC, VP9, AV1,...)



# WHICH CODEC IS FOR ME?

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- **Is latency important in my workflow?**
  - Face to Face video conferencing, Cloud Gaming, KVM, Live production, Remote production
- **How much and what type of storage is needed? What will be the file size?**
  - SD card capacity, Long term Archives, Cost of storage,...
  - Need Fast-forward, Rewind data retrieval, Proxy access, Random frame access and editing?
- **What is the computing complexity?**
  - Does it efficiently run-in software, does it need a dedicated hardware chip? What is the economy of the solutions?
  - Preference for Symmetric/Asymmetric complexity between encoder / decoder?
- **How much bandwidth is available in my network?**
  - LAN, WAN, Over the Internet, Satellite, Fiber, CAT5E,..
- **Compatibility**
  - Proprietary, Standard, ...
  - Closed circuit? Interoperability between various vendor equipments?

# ATTRIBUTE COMPARISON EXAMPLES

	H264	AVC-I	HEVC	J2K	JPEG XS
Inter / Intra	Inter	Intra	Inter	Intra	Intra (Sub-)
Transform	DCT	DCT	DCT	Wavelet	Wavelet
Bit depth	8 to 12	10	8 to 12	8 to 16	8 to 16
Visual Impairments at low bitrate	Blocking Error propagation	Blocking	Blocking Error propagation	Blur	Blur
Encoder / Decoder complexity	Asymmetrical	Asymmetrical	Asymmetrical	Symmetrical	Symmetrical
Bitrate	Low	High	Very Low	High	High
End to end latency	+ 500 msec	< 100 msec	+500 msec to 1sec	<100 msec	< 1 msec
Applications	HD Low bitrate distribution,	Production	4K Low bitrate distribution	Cinema, Archiving Contribution	Low latency Live production (Studio, Remote), Contribution, AVoIP

# BACK TO OUR 4K TV EPISODE WITH COMPRESSION

	Uncompressed	10% (10:1)	0.5% (200:1)
STREAMING	9.953 Gbit/sec	953 Mbit/sec	47.5 Mbit/sec
60 MINUTES STORAGE	4478.85 GB	447 GB	22 GB
		<i>Intra frame for Production/ Editing / Low Latency</i>	<i>Inter frame For Distribution</i>



3840x2160 60 fps 422 10bit

# THE CODEC WORLD

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## Joint Photographic Experts Group (JPEG)

- ISO/IEC JTC1 & ITU-T
- Primarily designed for still pictures
- JPEG, JPEG2000, JPEGXS, JPEGLS,...

## Motion Picture Experts Group (MPEG)

- ISO/IEC JTC1
- MPEG-1, MPEG2, MPEG4/H264 , HEVC, EVC, VVC...

## SMPTE

- VC1, VC2, VC3, VC5, VC6

## Others

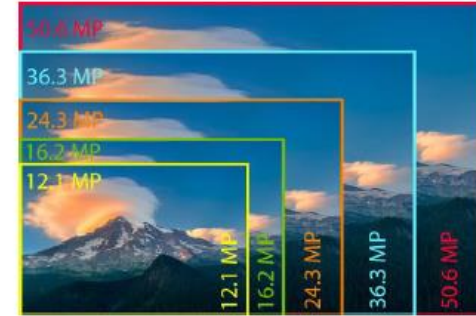
AV1 (AOMedia) , VP8, VP9 (Google), ProRes (Apple), TICO (intoPIX), LLVC, XAVC (Sony), RAW codec (CRC, NEF, REDRaw, BlackmagicRAW, TICO-RAW...) and many others...

# WHY SO MANY EVOLUTIONS?

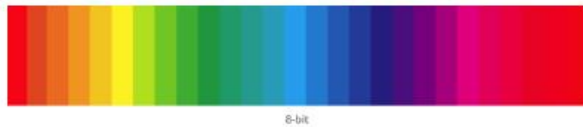
Multiple billions of pixels to manage, store and transport worldwide...



TV Resolutions



Camera Resolutions

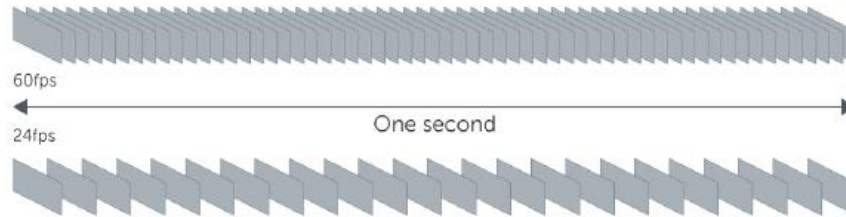


8-bit



10-bit

Higher bit depth



Higher Frame Rates

**Video traffic account for 80% of all consumer Internet traffic.**

# LATEST TRENDS

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## **Efficiency beyond HEVC and AV1**

- VVC, EVC, LCEVC...

## **Latency as close as possible to uncompressed video**

- JPEG XS Low complexity Visually Lossless coding

## **Exploring the benefits of AI for compression optimizations**

- Open many new & ongoing research initiatives in the compression world

## **Compression on display interfaces**

- HDMI 2.1 is using VESA DSC compression to support 8K on HDMI cables

## **Compression on RAW sensor data**

- Standardization of low complexity RAW bayer compression at JPEG on JPEG XS.

Thank you for your attention!

Please contact us for more info.  
[sales@intopix.com](mailto:sales@intopix.com)