The First International Conference on Advances in Signal, Image and Video Processing
SIGNAL 2016 | June 26 - 30, 2016 | Lisbon, Portugal

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Interactive discussion on **Image and Sound Signals**

Coordinator: Prof. Rafael F. S. Caldeirinha

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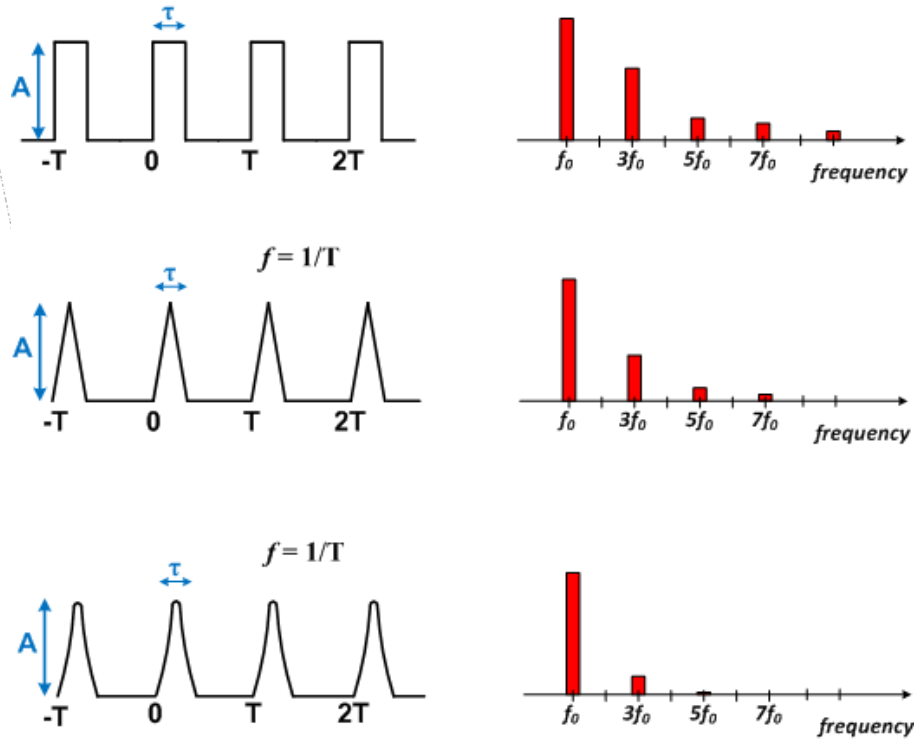
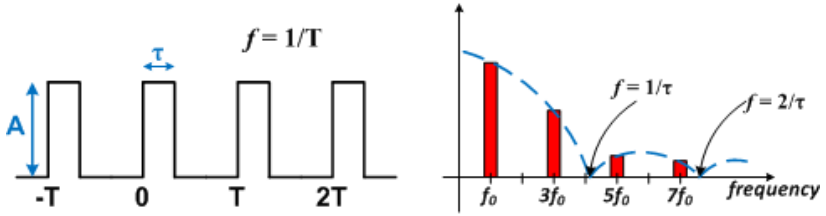
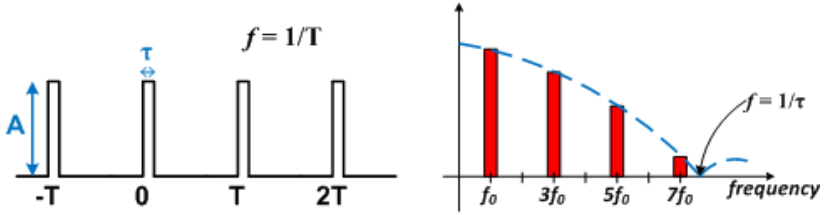
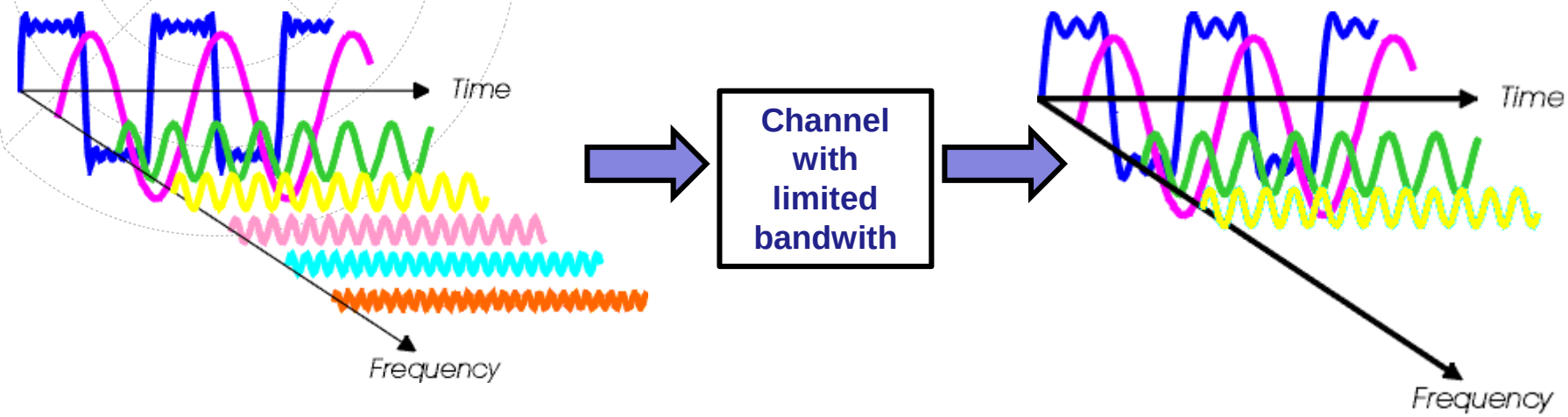
Signal representation







Channel in digital transmission



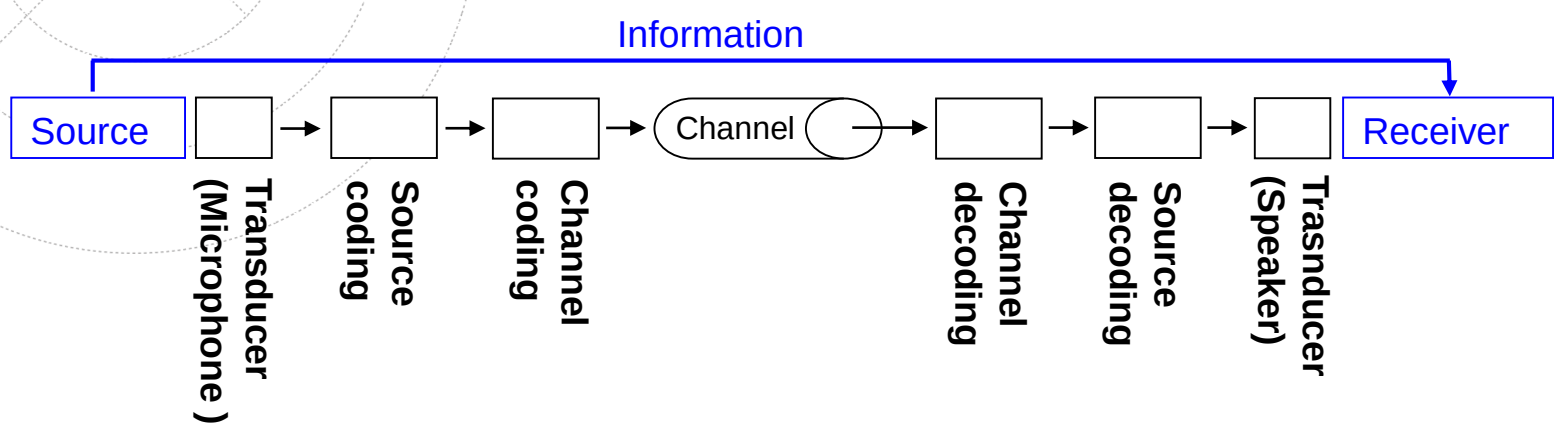
$R_b = R_S . lb(M)$

$T_m = 1/R_S$

$t_m \uparrow \Rightarrow T_m \uparrow \Rightarrow B \downarrow$ (rising edge)

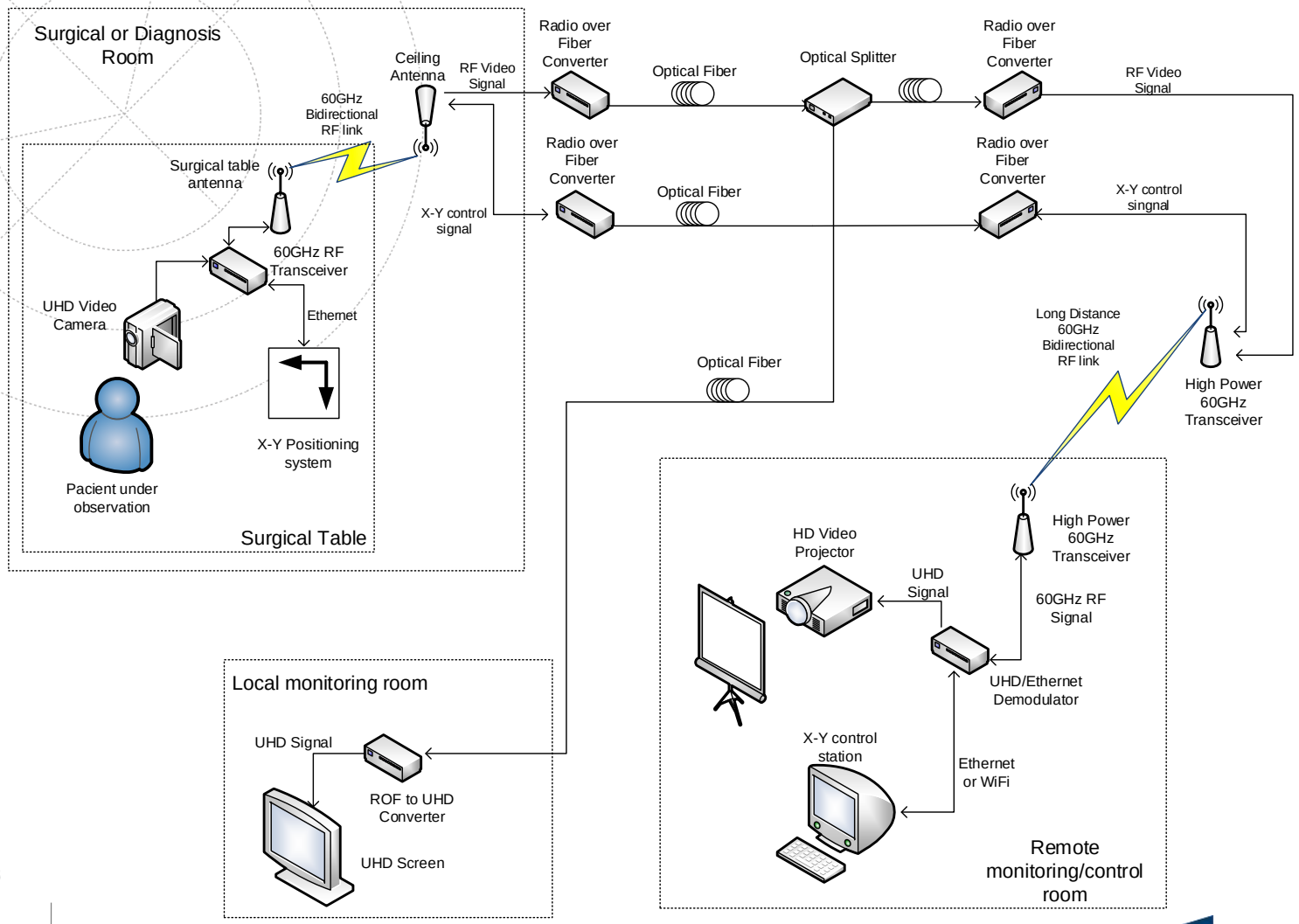
- $t_m . B \approx 0{,}35 .. 0{,}45$

A generic comunication system

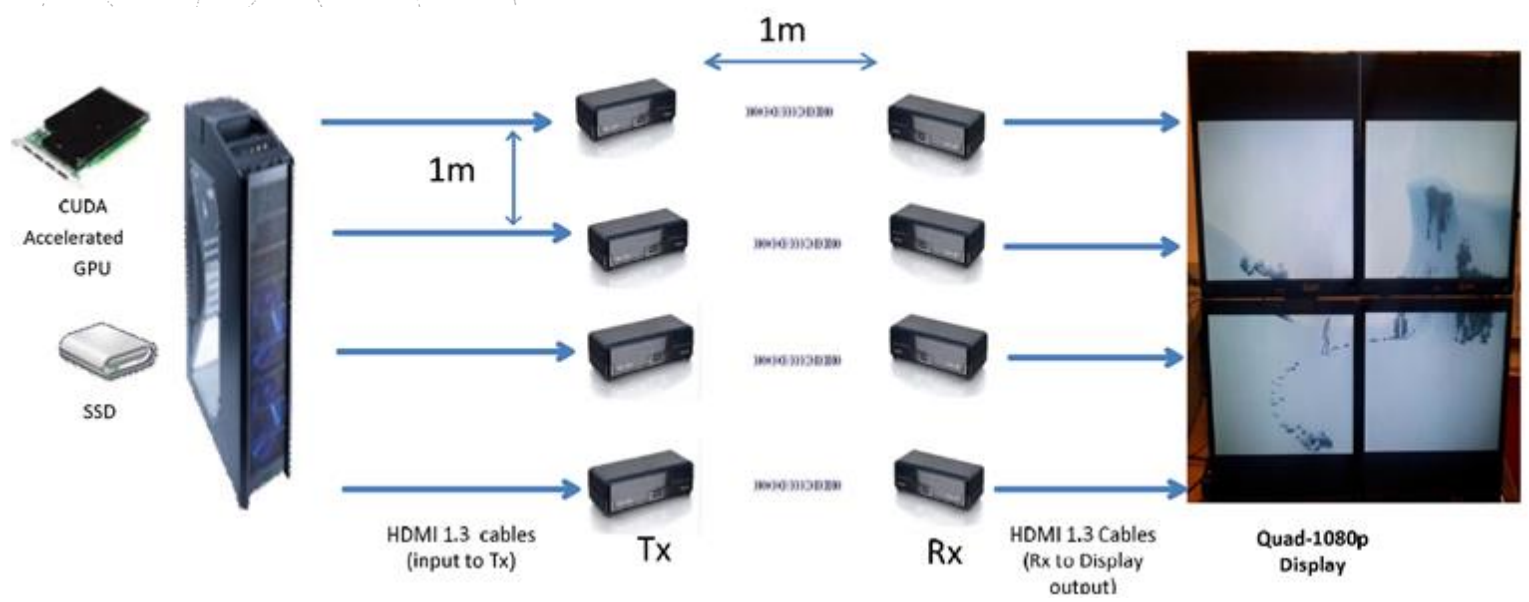


A challenging communication scenario

Real-Time Super High Resolution Image-Intensive Tele- Diagnosis



(Quasi) Real-Time Super High Resolution Image-Intensive Tele- Diagnosis

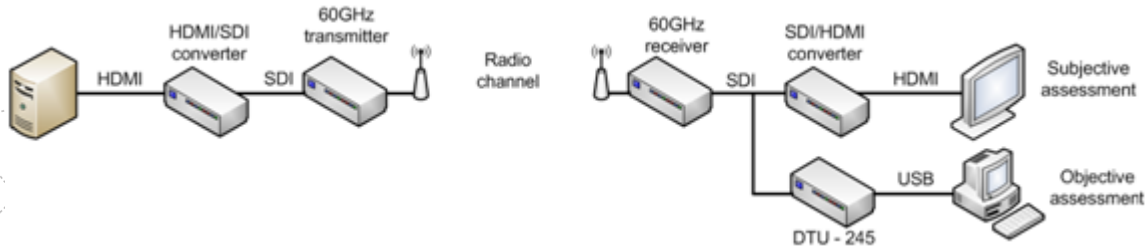


[Source: *A. Ejeye and S. Walker*, 2012]

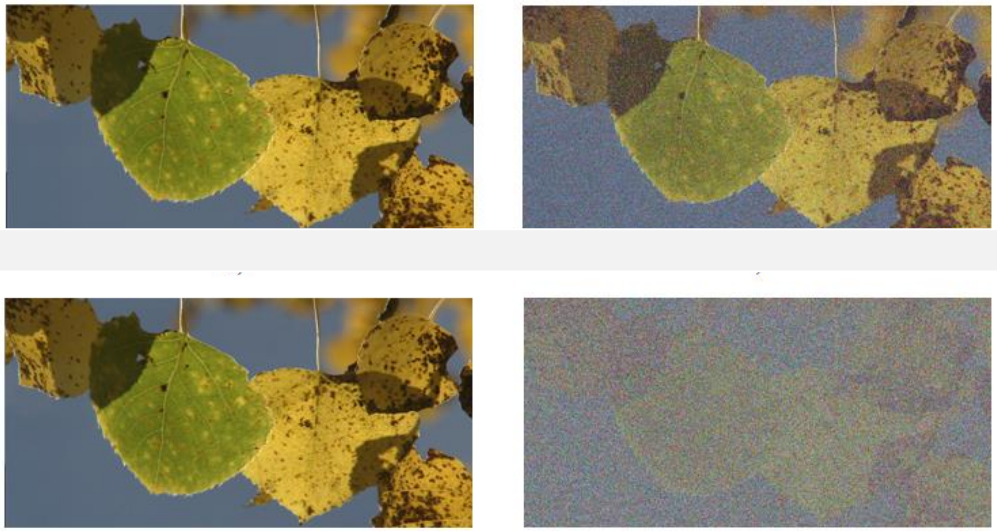
Channel 1: 57.24 59.40 GHz;
Channel 2: 59.40 61.56 GHz;
Channel 3: 61.56 63.72 GHz;
Channel 4: 63.72 65.88 GHz.

8k UHD (7680 x 4320p), <91 Mbps (H.264) or <50 Mbps (HEVC)
4k UHD (3840 x 216p), <35 Mbps (HEVC)

A challenging communication scenario
Real-Time Super High Resolution Image-Intensive Tele- Diagnosis



- Uncompressed vídeo/image, zero latency (degradation in low SNR regimes):



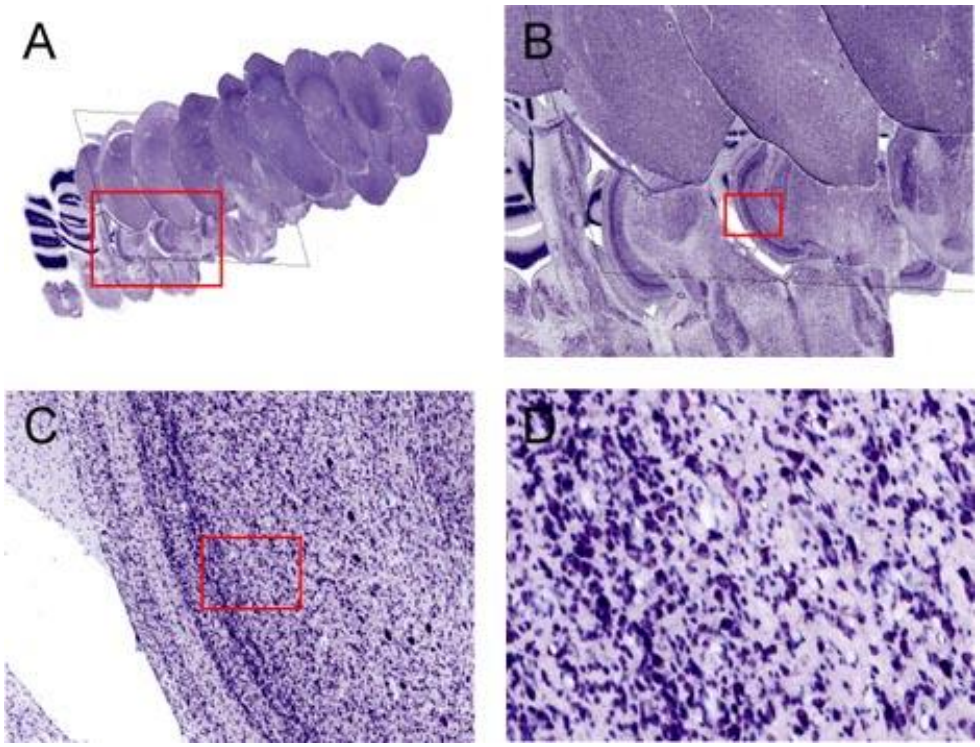
A challenging communication scenario

Real-Time Super High Resolution Image-Intensive Tele- Diagnosis

A single **Whole Slide Image** (WSI):

- 20mm x 15mm region of a glass slide samples at 0.25 microns/pixel
- 24 bits/pixel (8bpp/colour channel)

can easily occupy in excess of 15GB in size.

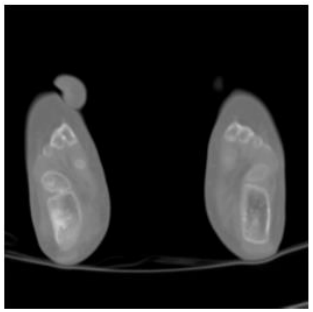


[Source: https://digitalpathologyassociation.org]

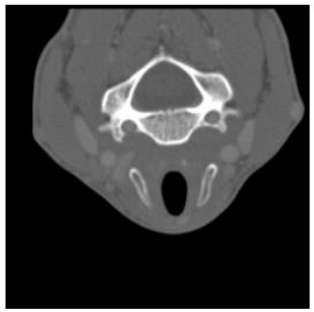
Medical images processing

Middle slice of each of the used medical images:

Datasets	Type	Slices	Resolution	Depth (bpp)
Aperts	CT	97	256x256	8
Carotid		74	256x256	8
Skull		203	256x256	8
Wrist		183	256x256	8
Liver T1	MRI	58	256x256	8
Liver T2E1		58	256x256	8
Ped Chest		77	256x256	8
Sag Head		58	256x256	8



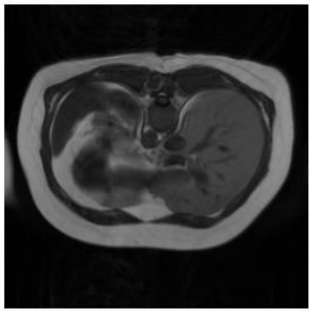
(a) CT_Aperts



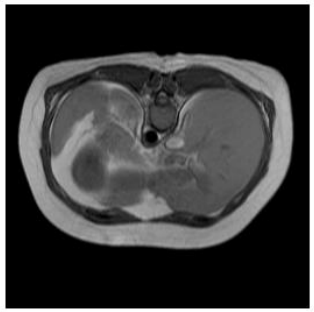
(b) CT_carotid

(c) CT_skull

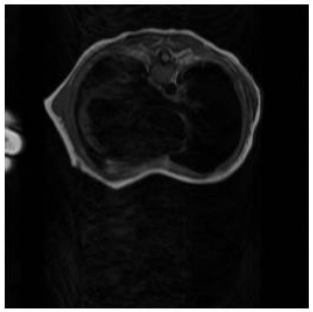
(c) CT_wrist



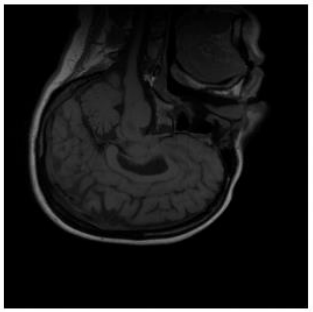
(a) MR_liver_t1



(b) MR_liver_t2e1



(c) MR_ped_chest



(c) MR_sag_head

[Source: Caldeirinha et al, Project report "Ultra High Definition Image Communication for Medical Imaging", 2015]

Medical images processing

Coding performance evaluation for lossless encoders applied to medical images (results in bpp):

Sequence	H.264	HEVC Intra	HEVC RA	HEVC RExt	MMP	MMP 3D	JPEG 2000	JPEG-LS	CALIC	MRP	JP3D
Aperts	1.193	1.289	0.825	0.728	1.178	0.938	1.261	1.058	0.998	0.775	0.941
carotid	2.062	2.198	1.586	1.424	1.977		2.019	1.778	1.684	1.374	1.547
skull	3.183	3.083	1.905	1.766	2.959		2.991	2.761	2.628	2.329	2.088
wrist	1.911	2.195	1.155	1.002	1.717		1.757	1.627	1.550	1.173	1.238
liver_t1	3.489	3.742	2.391	2.052	3.393		3.256	3.160	3.022	2.582	1.745
liver_t2e1	2.806	2.811	1.725	1.509	2.460		2.572	2.418	2.269	1.722	2.356
ped_chest	3.080	3.352	1.700	1.536	3.074		3.021	2.937	2.789	2.337	2.071
sag_head	2.635	2.732	1.873	1.748	2.808		2.905	2.582	2.519	2.279	2.160
Average	2.545	2.675	1.645	1.471	2.446		2.473	2.290	2.183	1.821	1.768

[Source: Caldeirinha et al, Project report "Ultra High Definition Image Communication for Medical Imaging", 2015]

Medical images processing

Results of the encoding of the pixel-wise dierence residue (results in bpp).

Sequence	H.264	HEVC Intra	HEVC RA	HEVC RExt	MMP	MMP 3D	JPEG 2000	JP3D	JPEG-LS	CALIC	MRP
Aperts	0.798	0.857	0.722	0.673	0.890	0.869	0.938	0.942	0.794	0.774	0.632
carotid	1.511	1.633	1.366	1.272	1.544		1.592	1.472	1.396	1.355	1.147
skull	2.033	2.101	1.510	1.444	2.095		2.137	1.984	1.974	1.899	1.660
wrist	1.112	1.254	0.905	0.860	1.133		1.212	1.218	1.043	1.054	0.851
liver_t1	2.189	2.387	1.986	1.852	2.229		2.255	1.693	2.070	2.020	1.765
liver_t2e1	1.789	1.971	1.329	1.228	1.721		1.818	2.283	1.685	1.604	1.310
ped_chest	1.639	1.738	1.346	1.301	1.749		1.815	1.916	1.631	1.586	1.365
sag_head	1.988	2.065	1.580	1.510	2.218		2.185	2.113	2.001	1.979	1.803
Average	1.632	1.751	1.343	1.268	1.697		1.744	1.703	1.574	1.534	1.317

[Source: Caldeirinha et al, Project report “Ultra High Definition Image Communication for Medical Imaging”, 2015]

Medical images processing

Results of the encoding of the HEVC residue (results in bpp):

Sequence	H.264	HEVC Intra	HEVC RA	MMP	JPEG 2000	JPEG-LS	CALIC	MRP
Aperts	0.778	0.836	0.819	0.890	0.926	0.814	0.807	0.700
carotid	1.472	1.581	1.562	1.544	1.576	1.430	1.410	1.259
skull	1.836	1.891	1.834	2.095	1.957	1.818	1.736	1.589
wrist	1.081	1.179	1.152	1.133	1.209	1.087	1.055	0.933
liver_t1	2.138	2.300	2.256	2.229	2.275	2.120	2.038	1.899
liver_t2e1	1.560	1.693	1.629	1.721	1.659	1.532	1.461	1.316
ped_chest	1.583	1.678	1.652	1.749	1.787	1.667	1.553	1.413
sag_head	1.803	1.863	1.811	2.218	2.015	1.843	1.804	1.661
Average	1.531	1.627	1.590	1.697	1.676	1.539	1.483	1.346

[Source: Caldeirinha et al, Project report "Ultra High Definition Image Communication for Medical Imaging", 2015]

Communications at 60 GHz - IEEE 802.15.3c

Usage Models:

- (UM1) Uncompressed video streaming
- (UM2) Uncompressed multivídeo streaming
- (UM3) Office desktop
- (UM4) Conference ad hoc
- (UM5) Kiosk file downloading

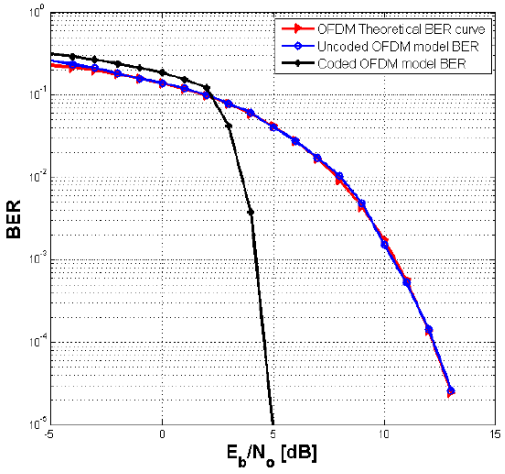
SC: Single Carrier mode
HSI: High-Speed Interface mode
AV: Audio-Visual mode

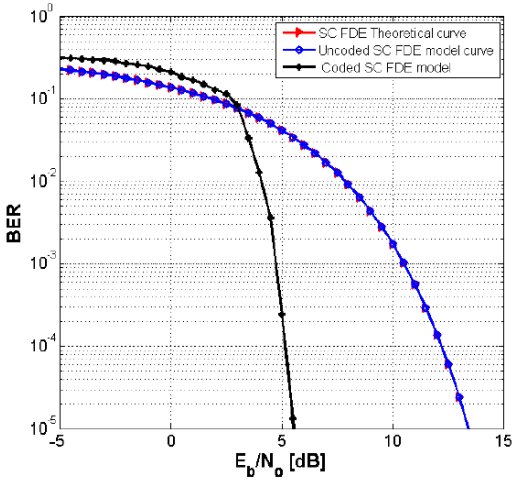
Comparison of the three modes provided by the standard:

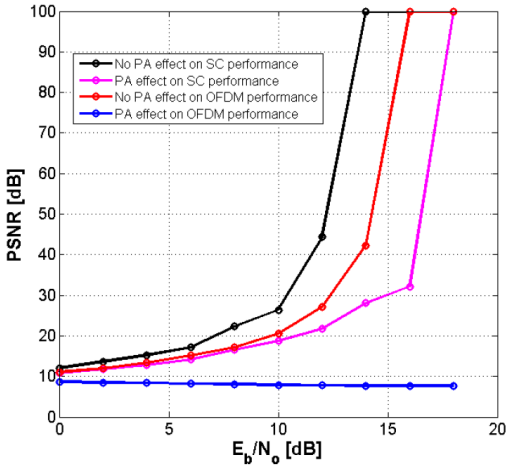
	SC PHY	AV PHY	HSI PHY
Main usage model	UM3 and UM5	UM1 and UM2	UM3 and UM4
Typical data rates	0.3 Mbps-5 Gbps	0.95-3.8 Gbps	1.54-5.78 Gbps
Transmission scheme	SC-FDE	OFDM	OFDM
Forward error control	Reed Soloman code/LDPC	Reed Soloman code	LDPC
Block size	512	512	512

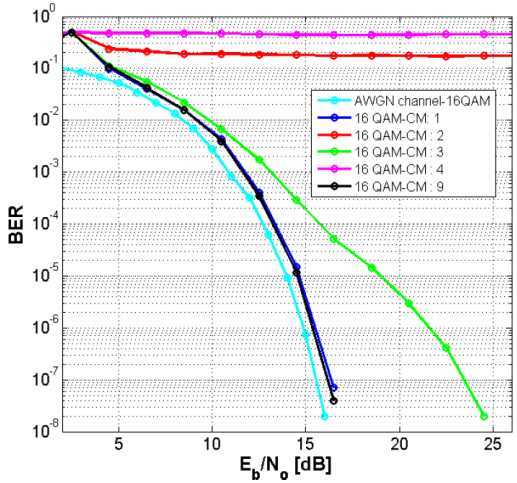
[Source: Caldeirinha et al, Project report "Ultra High Definition Image Communication for Medical Imaging", 2015]

Communications at 60 GHz - IEEE 802.15.3c







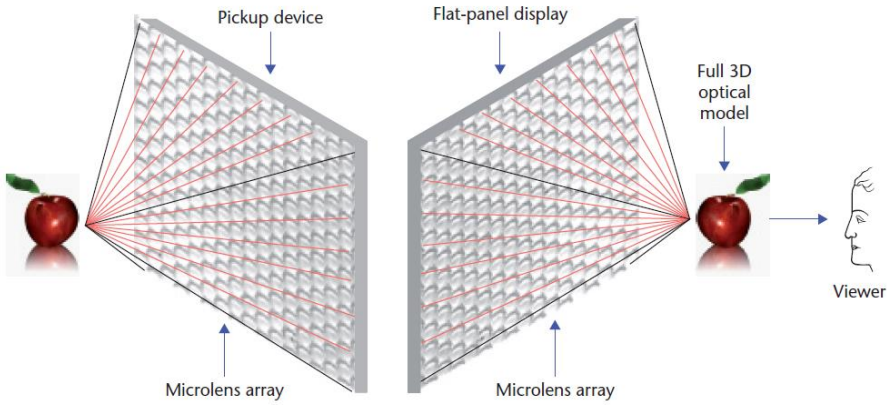


[Source: Caldeirinha et al, Project report "Ultra High Definition Image Communication for Medical Imaging", 2015]

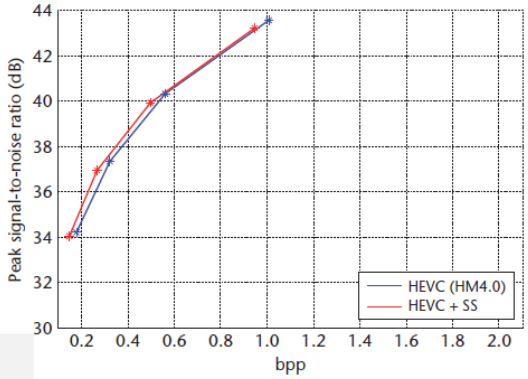
Immersive 3D Holoscopic Video Processing

3D imaging and video applications are emerging in the consumer market:

- visual inspection
- multilayer incremental vídeo,
- refocusing photography
- glasses-free 3D television



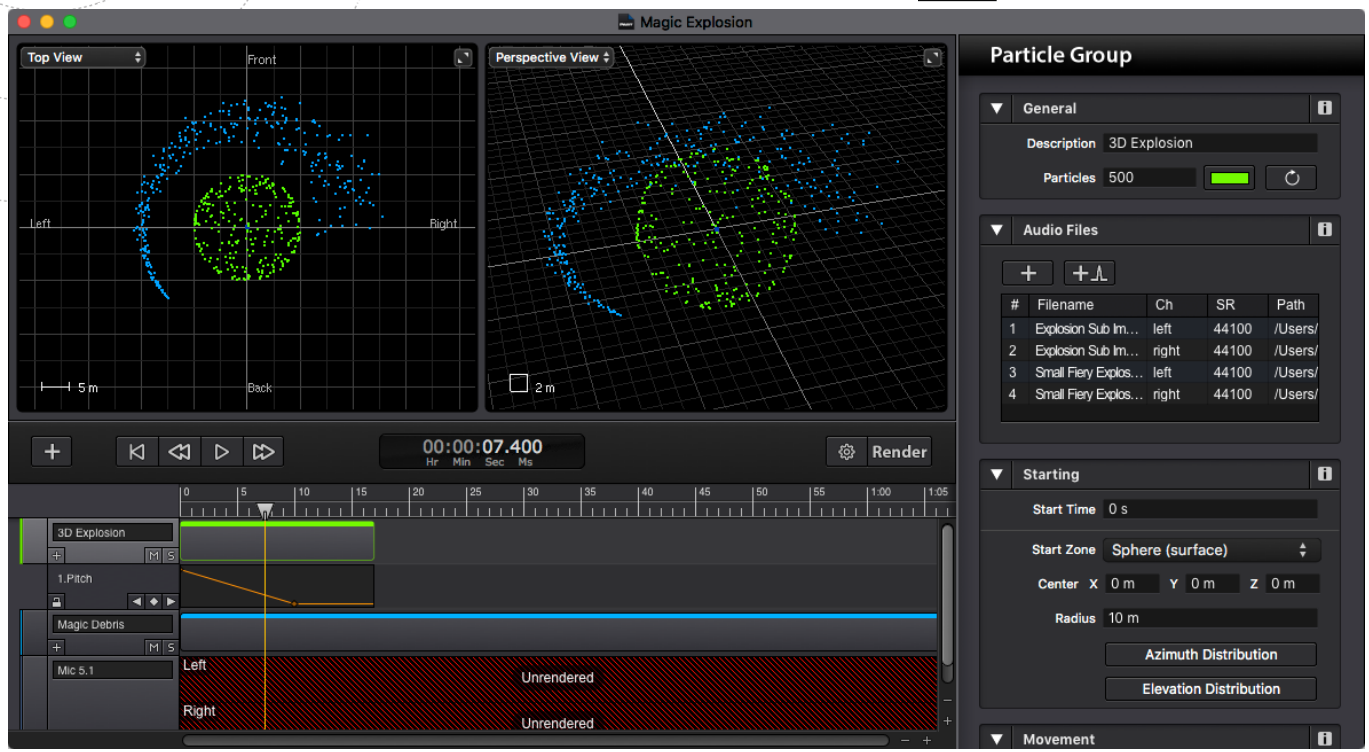
Capture Replay



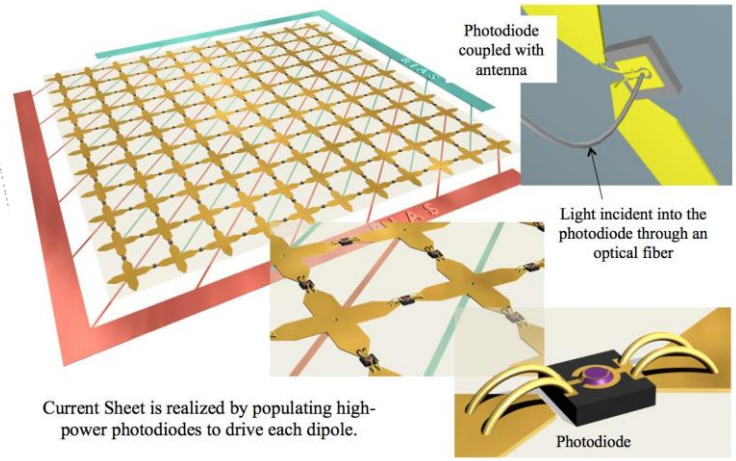
[Source: A. Aggoun et al, 2013]

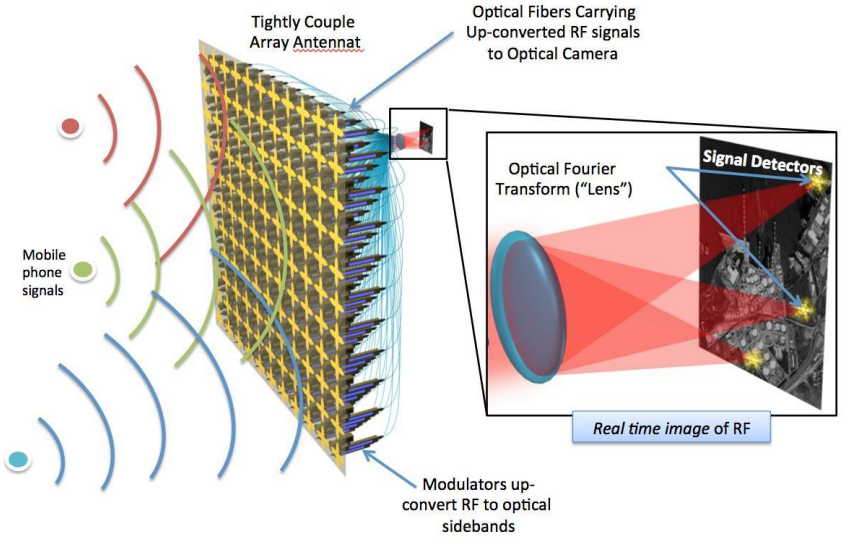
Sound particles

- Sound Particles is a CGI-like software for Sound Design, capable of using particle systems to generate thousands of sounds in a virtual 3D world.



5G Moves into the light: Holographic massive MIMO





[Source:Dennis W. Prathe, IEEE ComSoc Technology News, June 2016]

"(…) new technology that uses optical holographic methods to literally image the signals coming off the massive MIMO antenna array, avoiding a lot of the difficult issues with ADC cost and beam processing. Could this be the missing technology to bring practical MIMO to the field? (…)"