

Digital TV (DTV) Market Trends and DRAM Requirements

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Agenda

- Key Features and Technology Trends
- DTV System and SoC Architecture
- DRAM Memory Usage in DTVs
- DRAM Market Model for DTVs

Key Features Trends

- Resolution and screen size increasing
- Expectations of PC-like experience (graphics, Internet, browsing)
- More human interface
- CPUs need more multi-tasking

2010

- LCD, PDP TV, and CRT TV
- Max FHD resolution
- Major screen size less than 50"



2015

- Consolidation to LCD TV
- 60Hz/120Hz TV
- Smart TV + web browsing
- 3D TV, 2D→3D TV, 3D graphic
- USB host
- Complex FRC; video processing requires powerful CPU



2018

- Quantum Dot TV and OLED TV
- 24% of 4K TV
- Up to 240Hz TV
- PC-like Internet/web browsing experience
- More human interface
- Bigger screen sizes 70"-100"
- Multi tasking CPU for complicated decoding/processing power



Source: Micron and Industry Analysts

<http://www.cnet.com/news/tvs-at-ces-2015-go-beyond-4k/>; <http://4k.com/top-5-trends-4k-technology-next-four-years/>

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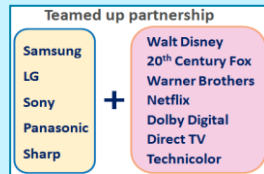
DTV Market Trends in 2015

Responding Positive 4K TV Market

- Forecasting 60Mu 4K TVs in 2017
- Various positioning, high-end to mainstream 4K TVs
- Continuous effort to reduce 4K TV price

Formed "UHD Alliance" in 2015

- Built Ecosystem, Key TV Makers Filmmakers & Content Providers : Samsung, LG, Sony, Panasonic, Sharp Walt Disney, WB, 20th C Fox, Netflix
- Collaborating to accelerate UHD Adoption



More 4K Content Providers

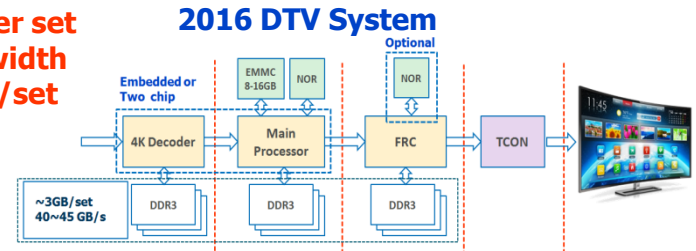
Provider	Date	Supported UHDTV
Netflix	4/14	SS, LG, Panasonic, Sony, Vizio
Amazon	10/14	Samsung, LG, Sony 4K, Vizio
M-Go	11/14	Samsung 4K UHD
Sony Video	7/14	Sony
Comcast	12/14	Free to XFINITY (VOD)
Direct TV	11/14	SS UHD, DirectTV Genie HD DVR (VOD)
YouTube	2014	Computer with 4K (VOD)

UHD is more than 4K (PQ is important)

- HDR (High Dynamic Range)
- Quantum Dot Technology

Need more memories (Gb/Set & Bandwidth/set) as UDH TV gets better video and graphics

~3GB density per set
~45GB/s bandwidth
8/16GB e.MMC/set



Source: Micron and Industry Analysts
<http://www.digitaltrends.com/computing/what-hardware-do-you-need-to-run-stuff-at-4k-resolution-on-your-pc/>

Many Operating System from 2015 DTV

- Major TV makers have their own TV Operating System
- TV becomes smarter and smarter: requires optimized operating system to support faster TV processor
- Korea : Samsung-Tizen, LG-WebOS2
- Japan : Sony- Android TV, Panasonic-Firefox
- China : Alibaba - Yun OS, Tencent - TOS+, Xiaomi: MIUI, Baidu - own Baidu's OS

Increasing Mix of Memories Drives DRAM TAM High

	2014		2018	
	Gb/Set	% Mkt	Gb/Set	% Mkt
Low	1.4	56%	1.5	30%
Mid	6.8	39%	16	46%
High	20	5%	32	24%
Gb/Set	4.5		15.6	

24% TV set drives 50% of DTV DRAM TAM in 2018

UHD Alliance

- Challenges for 4K UHD today...

- Optimized content
- Content coding/decoding
- Delivery methods
- Bandwidth concerns

- UHD Alliance Announced During CES 2015

- Goal of UHD Alliance

- Set premium quality standards for UHD 4K content, delivery, and establish a "healthy UHD ecosystem"
- Make sure the content looks really good, figure out how it's delivered, including next-generation features such as HDR, Wide Color Gamut, High Frame Rate, and immersive 3D audio
- Determine best way to enable production, distribution and consumption of content and playback capability of devices

- TV brands, Hollywood film studios, content distributors and technology companies come together

- Movie studios hope the alliance can help make video look better, will benefit true UHD experience by identifying products and content

Formed by global Leading Companies

Samsung
LG
Sony
Panasonic
Sharp

+

Walt Disney
20th Century Fox
Warner Brothers
Netflix
Dolby Digital
Direct TV
Technicolor

- TV makers want to sell more UHD TV
- Studios, looking for more outlets for digital content

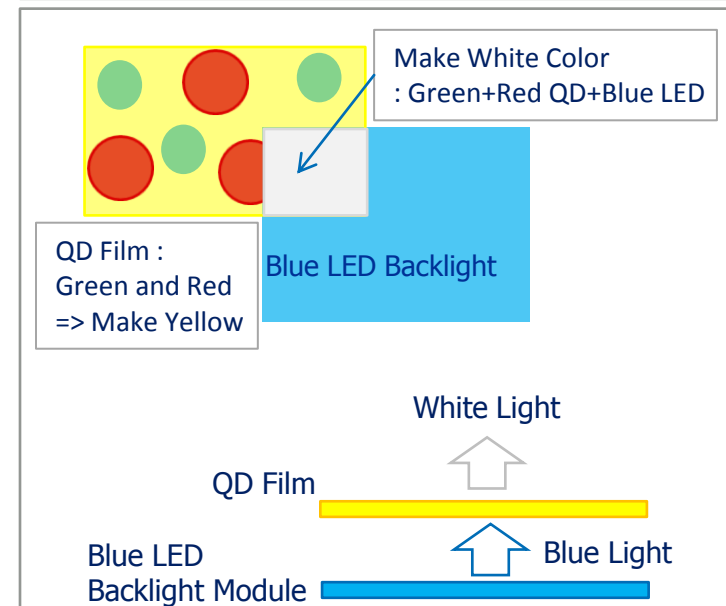
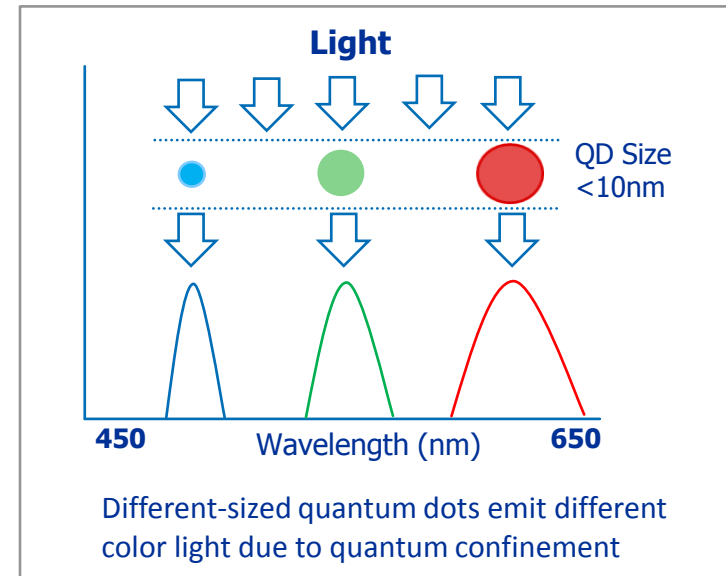
Source: Micron and Industry Analysts

<http://www.uhdalliance.org/wp-content/uploads/UHD-Alliance-Announcement-Press-Release.pdf>

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Quantum Dot Technology

- Tiny particles, Nano-crystal semiconductors
- Glow when light is shined on them
- Electronic characteristics are closely related to size and shape; size determines color
 - Larger dots emit longer wavelengths (red)
 - Smaller dots emit shorter wavelengths (green)
- Two sizes of dots in these TVs
 - Glow red and green, billions of them in a quantum-dot TV
 - Saturating a sheet of film with a bunch of quantum dots
 - When blue LED shines on the quantum dot-saturated sheet of film, the dots start glowing red and green
 - => All three combine to create the ideal white light
- Better Color performance
 - Increased color gamut on LCD screens
 - Improved color accuracy - purer whites, more precise colors
 - Higher peak brightness
 - Higher color saturation



Source: Micron and Industry Analysts

<http://www.wired.com/2015/01/primer-quantum-dot/>; https://en.wikipedia.org/wiki/Quantum_dot;
https://en.wikipedia.org/wiki/Quantum_dot_display; <http://www.nanosysinc.com/what-we-do/quantum-dots/>

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HDR (High Dynamic Range) Trends

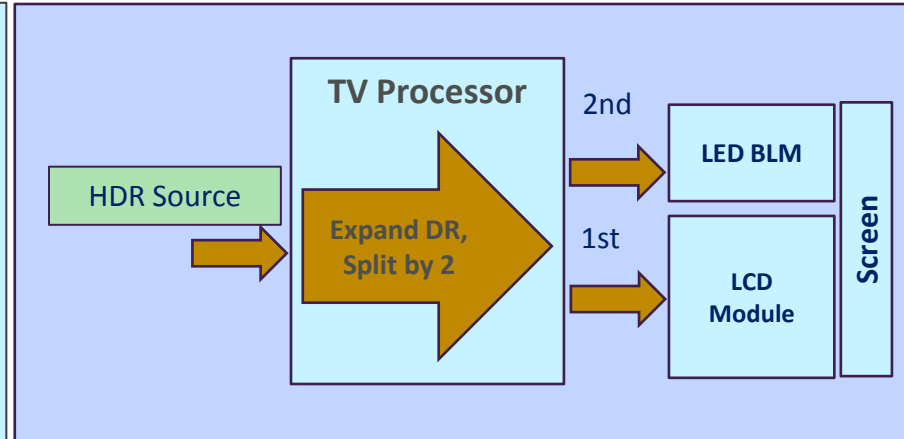
Netflix announced collaboration with LG, Sony at 2015 CES

- Anticipating most of original content in HDR by end of 2015
- Working with UHD Alliance : HDR into the 'Ultra HD' standard,
- Working with film producers to make video in 4K HDR
- HDR content : Working on 60 original series in 2015, including *Marco Polo*, a drama series

HDR Contents Bandwidth

HDR contents requires about 20-30 % more bandwidth than the equivalent resolution

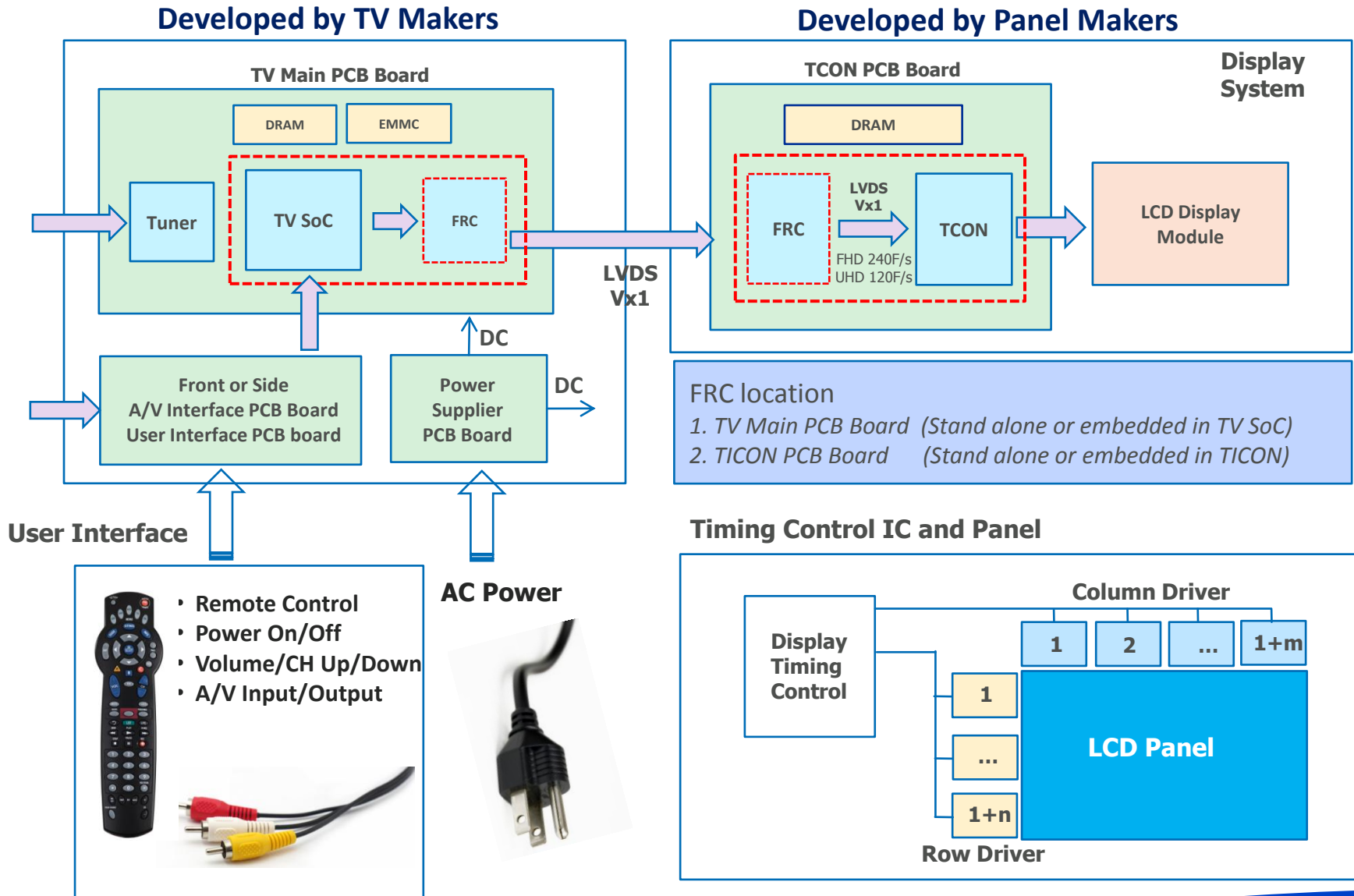
- 4K normally in 15 Mbps; 4K HDR will require 18 Mbps
- 2K in 5-6 Mbps; 2K HDR will require 8 Mbps



HDR source, two data in stream

- HDR algorithm, in TV SoC, expand its dynamic range
- Split into two streams composing an HDR image:
 - The 1st : RGB image to LCD
 - The 2nd : Luminance image to LEDs. luminance gray levels on the individual LED

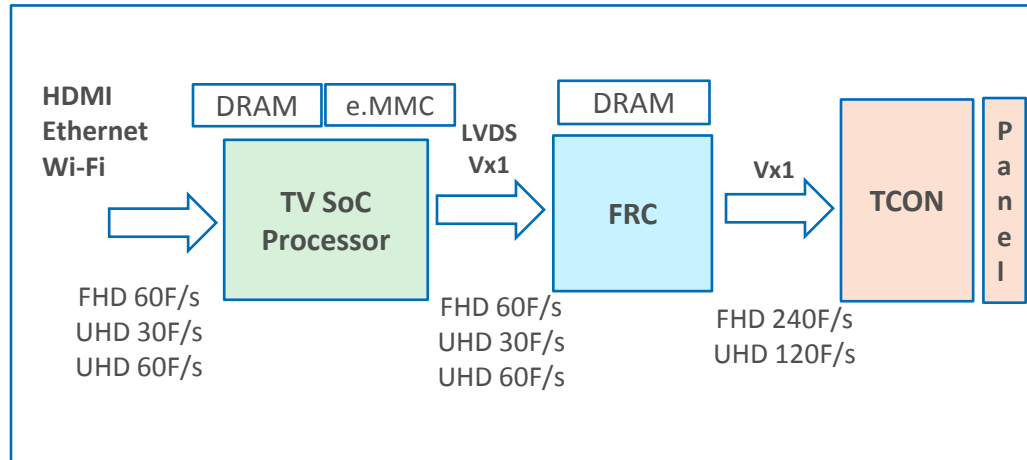
DTV System Structure



Frame Rate Converter (FRC)

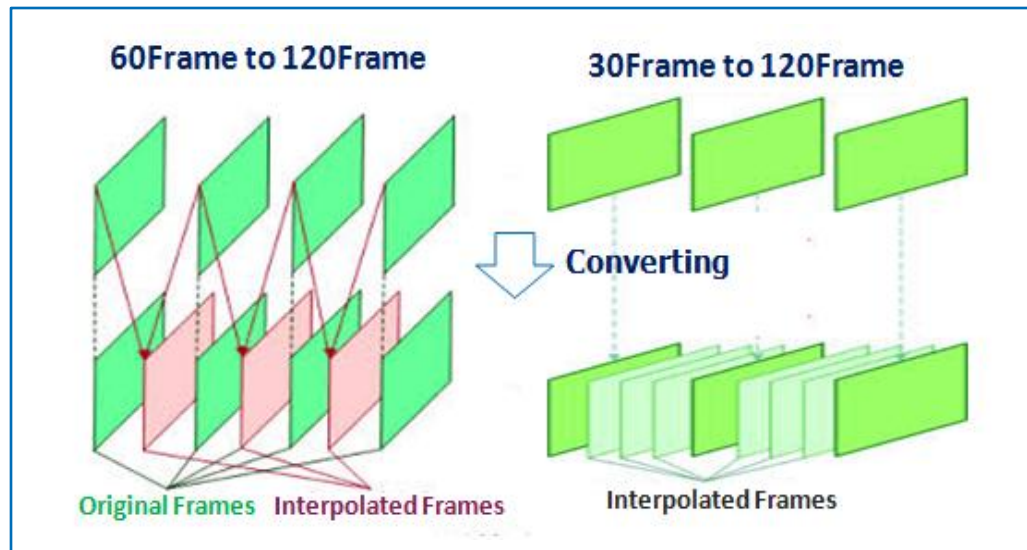
FRC (Frame Rate Converter)

- 30/60 FPS → 120 FPS, → 240 FPS
- Motion estimation/compensation
- Super resolution
- Picture quality improvement: contrast, color, sharpness, gamma



FRC is driving more DRAM bandwidth increase because

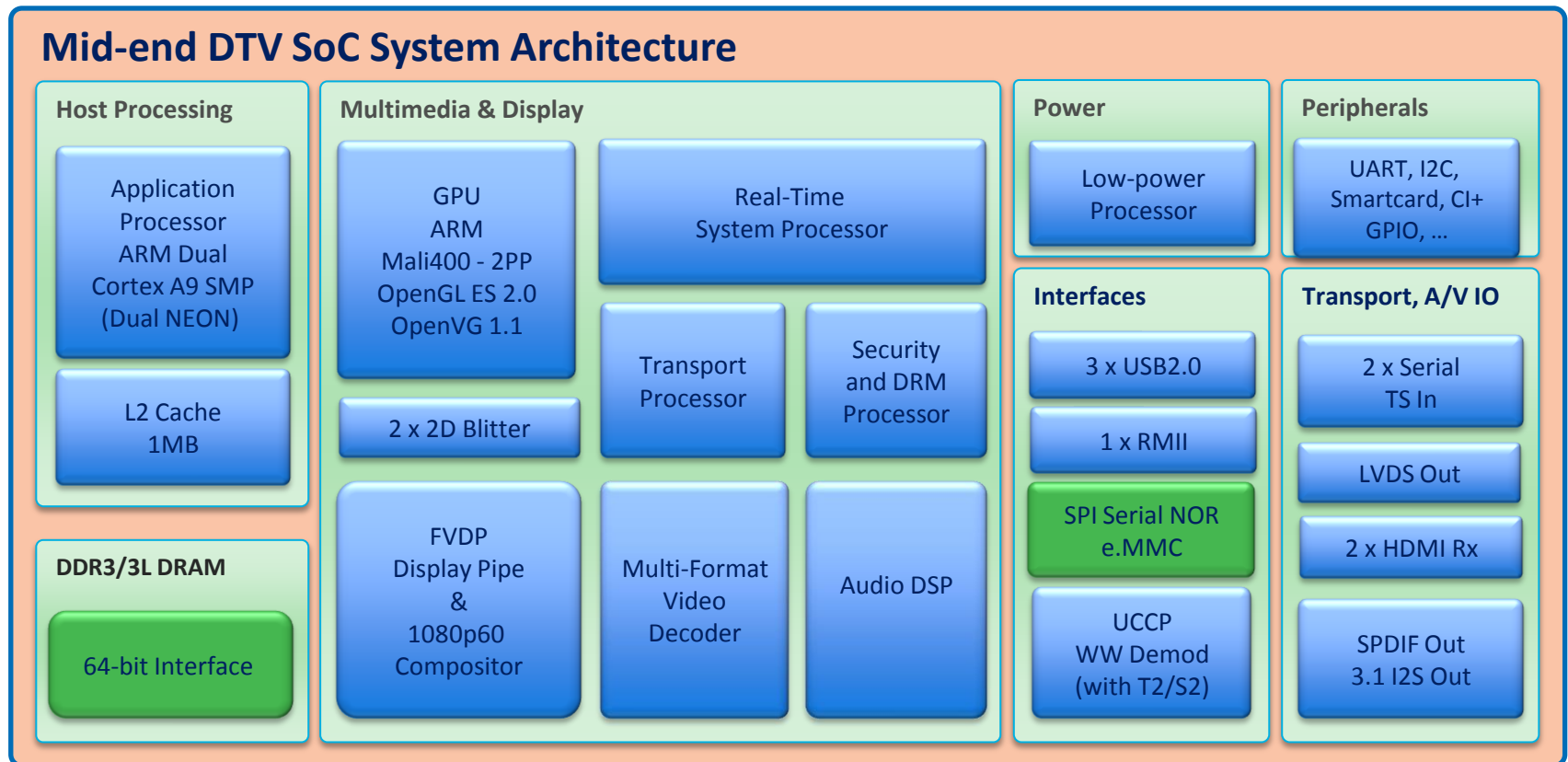
- Panel is moving to 120 FPS, 240FPS
 - Video processor needs to make more fake frame
- Image quality needs compensating
 - Processor need more processing power, more memory bandwidth



Source: Micron and Industry Analysts
http://compression.ru/video/frame_rate_conversion/index_en_frcn.html

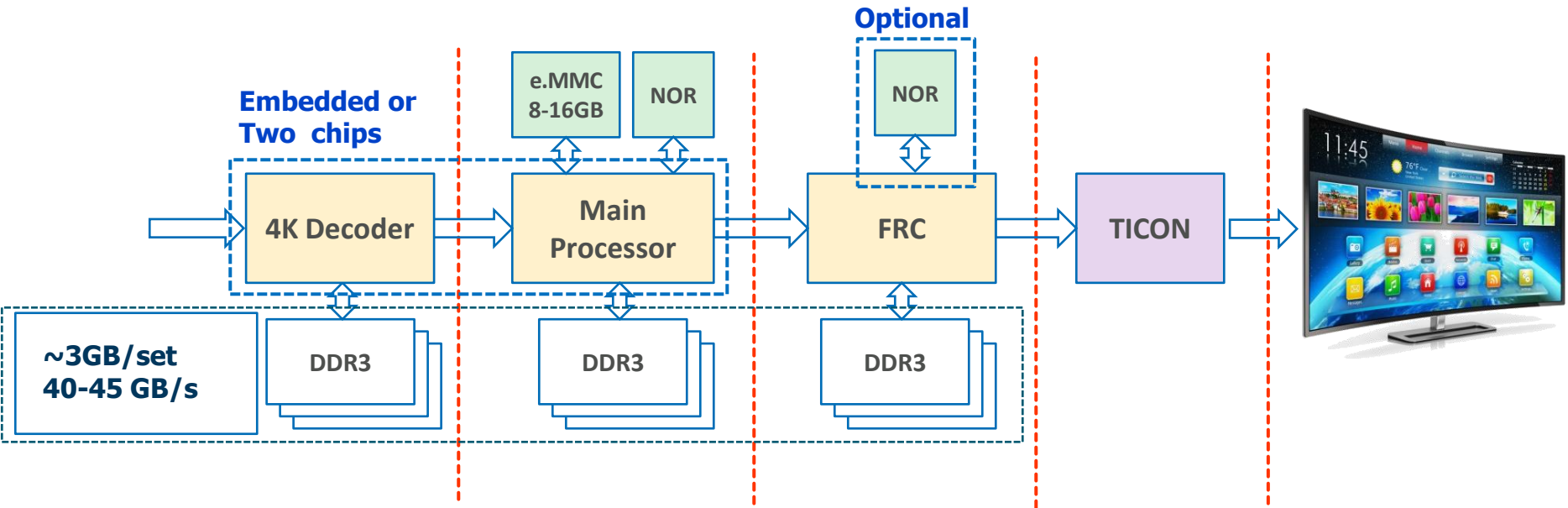
DTV SoC (System On Chip) Architecture

- Composed of mainly:
Decoder, video processor, CPU, GPU, memory controller,
Interface (transmitter, receiver)



Source: Micron and Industry Analysts
www.arm.com; androidforums.com; www.eetimes.com

4K UHD TV System and DRAM



2016 High-end 4K TV Platform

4K Decoder	Main TV Processor	FRC	TICON	Panel
<ul style="list-style-type: none"> • 3x 1Gb DDR3 (x16) 1866/2133MT/s ~3Gb, 12.8GB/s 	<ul style="list-style-type: none"> • 4x 4Gb DDR3 (x16) 1866/2133MT/s ~16Gb, 17GB/s • xMb SNOR (faster, reliable boot-up) 	<ul style="list-style-type: none"> • 4x 1Gb DDR3 (x16) 1866/2133MT/s ~4Gb, 17GB/s • 64Mb~128Mb SNOR (faster, reliable boot-up) 	<ul style="list-style-type: none"> • TICON for high-end TV, has embedded DRAM (for frame buffer) 	<ul style="list-style-type: none"> • LCD with LED • OLED • Quantum Dot • 120 FPS

Source: Micron and Industry Analysts

<http://www.digitaltrends.com/home-theater/everything-you-need-to-know-about-4k-ultra-hd/>

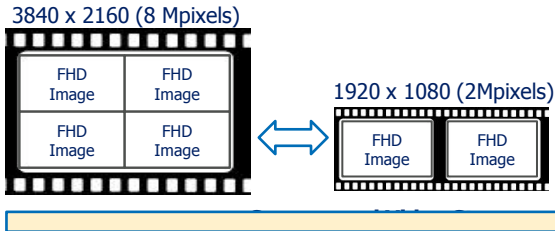
https://en.wikipedia.org/wiki/Ultra-high-definition_television

<http://vr-zone.com/articles/haswell-just-in-time-for-4k-uhd-tv/33956.html>

DRAM Usage in Video Processing

Video Streaming Source Flow (Through Internet)

- Compressed source: To DRAM (streaming buffer) through transport
- 4K Source: Need 2 times bigger streaming buffer size than FHD source because 4 times video data than FHD, but only 50% compressing efficiency
- 4K Source: Need broader Internet speed (bandwidth); for instance, Netflix recommends 25 Mbps (5 Mbps for HD)



Video Decoding and Processing Flow

- Uncompress and decode : Video data from Video decoder to DRAM (uncompressed video frame buffer)
- 4K Source needs 4 times bigger video frame buffer size than FHD source
- 4K Video Decoding needs 2 times bigger memory bandwidth than HD
- Video processing (including FRC) between DRAM and video processor : Uncompressed video data
 - De-Interlacing, motion compensation
 - Frame rate conversion, up-scaling, down-scaling
 - 3D video processing, 2D → 3D conversion
 - Picture and picture (double screen)
 - Internet, web browsing, multi-format media decoding (3D & enhanced graphic engine for web browsing/gaming)

120 FPS Panel or 240 FPS Panel



DRAM USAGE MODEL EXAMPLE

Configuration	HD Buffers	SD Buffers
Dual HD/SD CMP, MAD, bsync, PIP(Default)	3	15
Dual HD/SD CMP, MAD, bsync	3	12
Dual HD/SD CMP, MAD	2	10
Dual HD/SD CMP, bsync	3	6
Dual HD/SD CMP	2	4
Single HD CMP, MAD	2	
Single HD CMP	2	
Single SD CMP	0	

Codecs	Decoder Memory Ne
AVC/MPEG/VC1 SD/HD (default)	30
MPEG SD	6
MPEG SD/HD	23
MPEG/VC1 SD/HD	30
AVC/MPEG/VC1 SD	12

Transport Feature	Memory Needed (
RS	0.80
XC	0.85
Message FIFO	0.13
PVR- Record FIFO	10.50
PVR- Playback FIFO	4.00

Key Functions Consuming DRAM

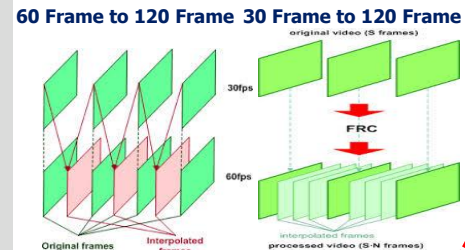
- Firmware (video and audio)
- Transport
- Compressed data buffers
- Compressed video decoding
- Video processing (capturing, scaling, image processing, playback)
- Graphics
- Dual -> Quad -> Octal Core CPU

e.MMC

OS, Web 2.0 Applications, Video IPs

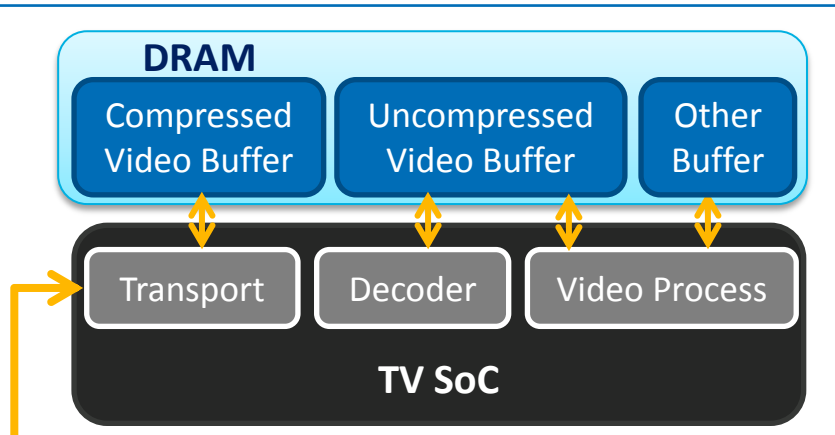
High Frame Rate and FRC

- Panel is moving to 120 FPS, 240FPS; video processor needs to make more virtual Frame
- To compensate image quality, DSP needs more processing power, more memory bandwidth



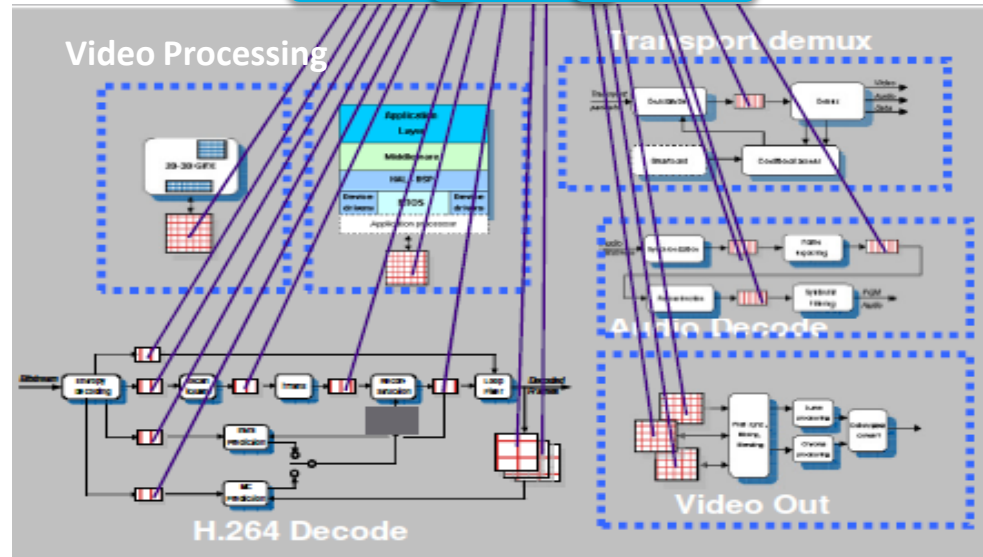
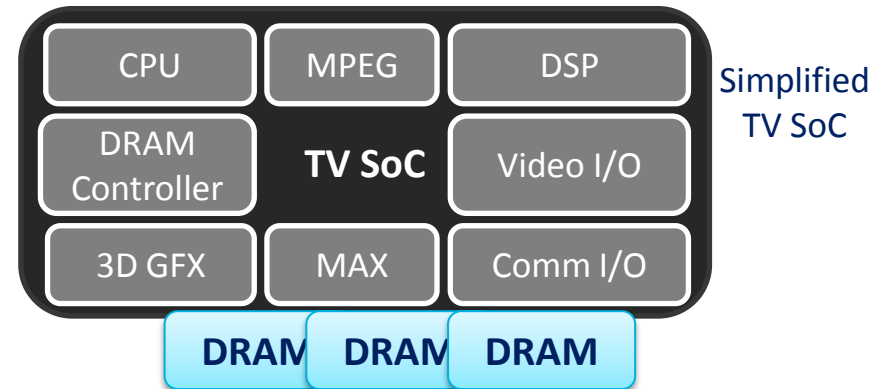
DRAM/DTV SoC Interface Structure

- DRAM is engaged in every function inside TV SoC



Compressed Video Stream

- Buffering compressed video stream before decoding by decoder
=> 4K TV will require 2 times bigger buffering size than 2k (FHD) TV
- Requires uncompressed video buffer for multiple video processing support
=> 4K TV will require 4 times bigger buffering size than 2K (FHD) TV



Source: Micron and Industry Analysts

https://en.wikipedia.org/wiki/Video_processing; www.socionext.com; <http://www.slideserve.com/tymon/digital-tv-soc>
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Major Density and DRAM Bandwidth Consumers

- Compressed Video Decoding - largest memory consumer in system
- Firmware (Video and Audio) – application software
- Transport Block
 - Receives incoming compressed data streams and de-multiplexes the video and audio
- Compressed Data Buffers
 - Simultaneous decodes are supported by the system
- Video Decoding (H.264, H.265, multimedia format)
- Video Processing
 - Capturing, scaling, image processing, playback
- Graphics
 - Height, bit depth(x-bit per pixel), resolution, the number of display layers => directly impact the memory requirements

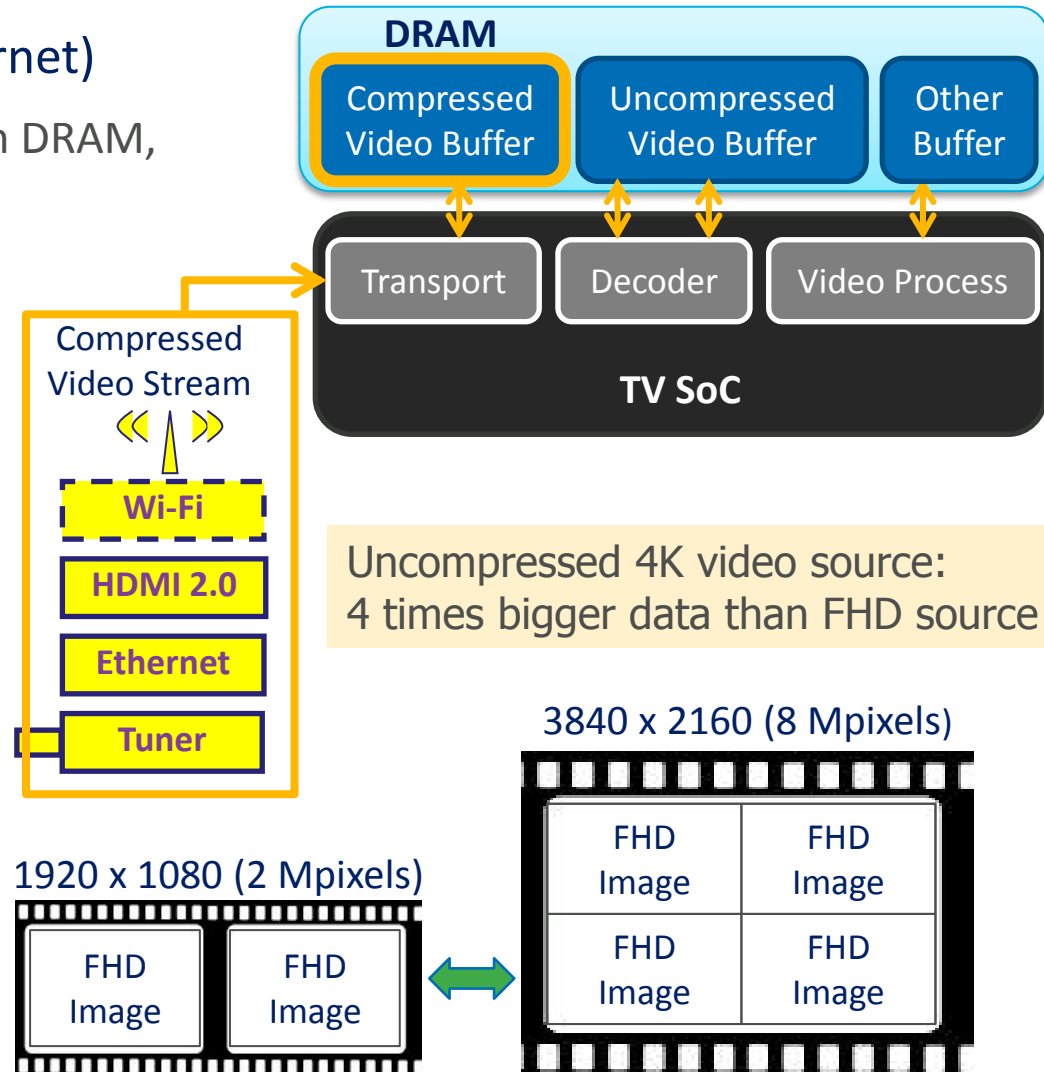
Source: Micron and Industry Analysts

https://en.wikipedia.org/wiki/Video_processing; www.socionext.com; <http://www.slideserve.com/tymon/digital-tv-soc>; www.renesas.com

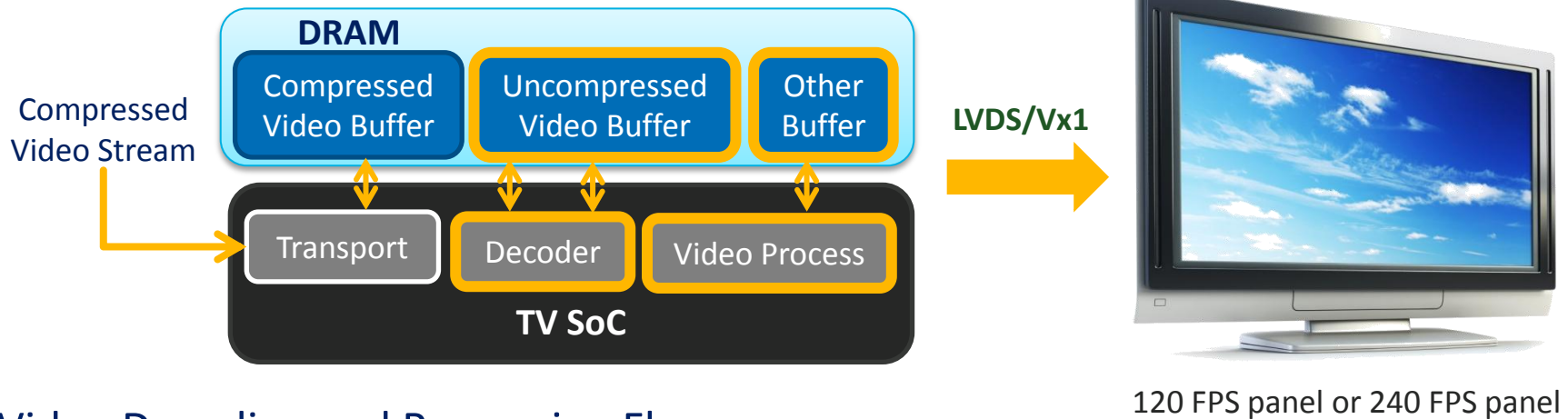
DRAM Usage in Compressed Video Processing

- Video Streaming Flow (through Internet)

- Compressed source: flow to buffer in DRAM, through transport block in TV SoC
- 4K source needs 2 times bigger buffer size than FHD source
 - Why 2 times bigger ?
Because of 4 times larger video data than FHD, 50% compression efficiency,
- 4K source needs broader Internet speed (bandwidth)
 - Netflix recommends 25 Mbps (vs. 5 Mbps for HD)



DRAM Usage in Uncompressed Video Processing



- Video Decoding and Processing Flow

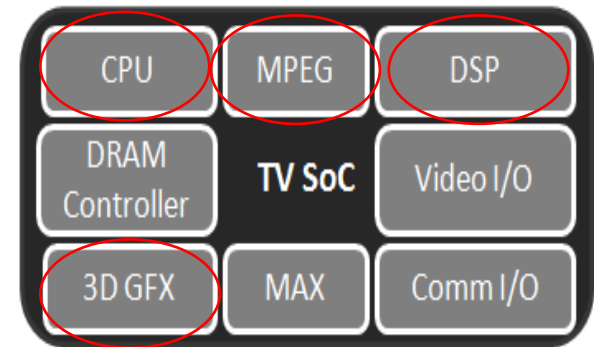
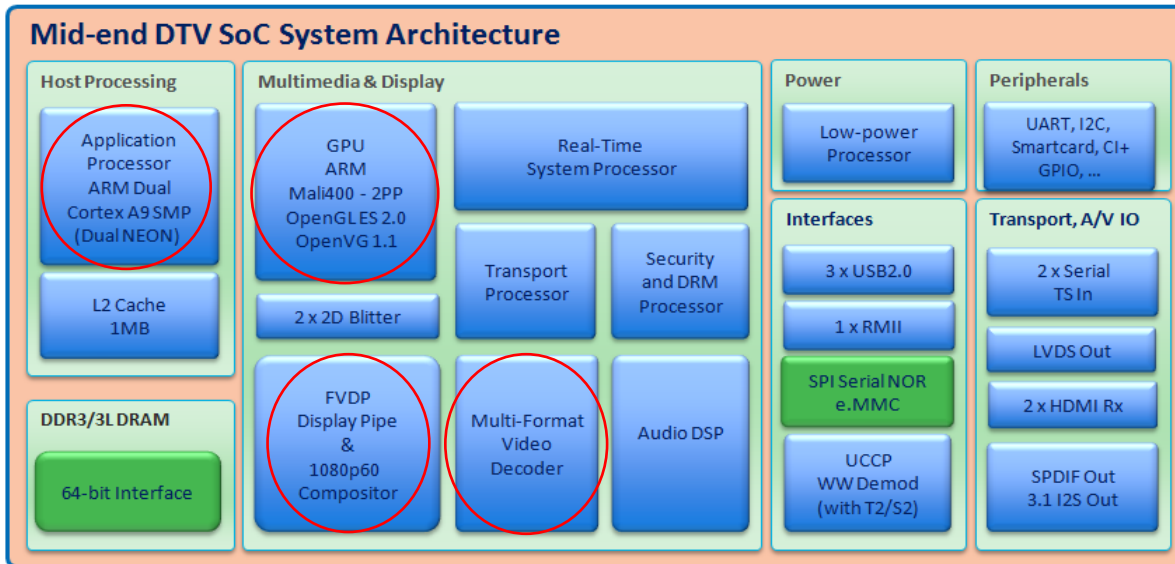
- Video decoder sends uncompressed and decoded video stream to DRAM (uncompressed video buffer)
 - 4K source needs 4 times bigger video frame buffer size than FHD source
 - 4K video decoding needs more than 2 times bigger memory bandwidth than HD decoding
- Uncompressed video processing (including FRC) between DRAM and video processor
 - De-interlacing, MEMC (Motion Estimation & Compensation)
 - FRC (Frame Rate Conversion), Up-Scaling, Down-Scaling, Picture-and-Picture (double screen)
 - 3D video processing, 2D→3D conversion
 - Internet, web browsing, multi-format media decoding
 - 3D and enhanced graphic engine for web browsing/gaming

Source: Micron and Industry Analysts

https://en.wikipedia.org/wiki/Video_processing; www.socionext.com; <http://www.slideserve.com/tymon/digital-tv-soc>; www.renesas.com

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DRAM Bandwidth Usage Model



DRAM bandwidth usage in TV

- Take 60% of total:
 - Decoding
 - Video processing
 - Graphics
 - CPU

Source: Micron and Industry Analysts

https://en.wikipedia.org/wiki/Video_processing; www.socionext.com; <http://www.slideserve.com/tymon/digital-tv-soc>; www.renesas.com

DRAM Market Model

Year	2015	2016	2017	2018	2019	2020
TV Set(M unit)	240	244	252	261	268	275
Revenue(M)	1,245	1,354	1,597	1,970	2,333	2,633

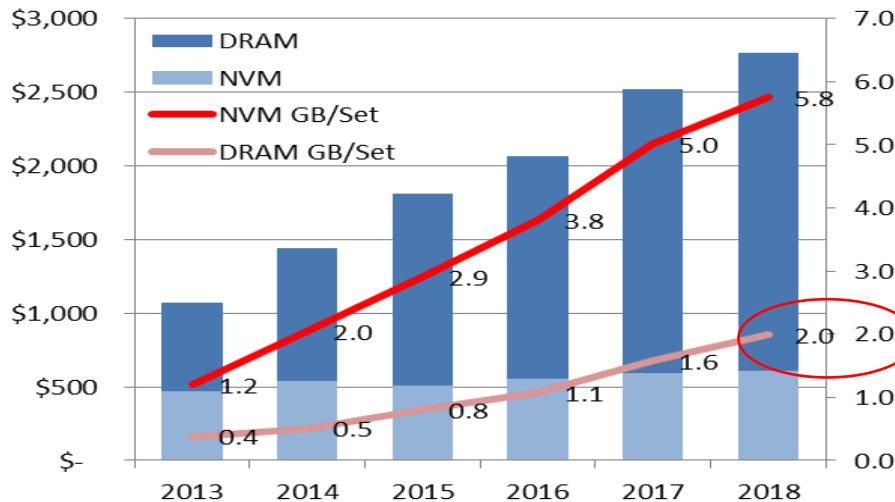
Major TV Customers in 2015

Samsung, LG, Sony take over 50% share of total DRAM TAM

Market Size (TAM)

1.25 B\$(2015) to 2.6 B\$ (2020)

=> ~100% Growth



	2014		2018	
	GB/Set	% Mkt	GB/Set	% Mkt
Low	0.2	56%	0.2	30%
Mid	0.9	39%	2	46%
High	2.5	5%	4	24%
GB/Set	0.6		2	

- 24% high-end TVs (mostly 4KTV) drives 50% of DTV DRAM TAM in 2018

2GB/set in 2018

Mixed between low-, mid-, high-end TVs

Source: Micron Market Model 2015

