

# NVIDIA Tegra



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# Agenda



- **What is NVIDIA Tegra?**
- **The Challenge**
- **3D Features**
- **Interesting Features**
- **3D Performance**
- **Demos**



# What is NVIDIA Tegra?



**Entertainment**  
(Perf/W)



**Mobile  
Computing  
Devices**

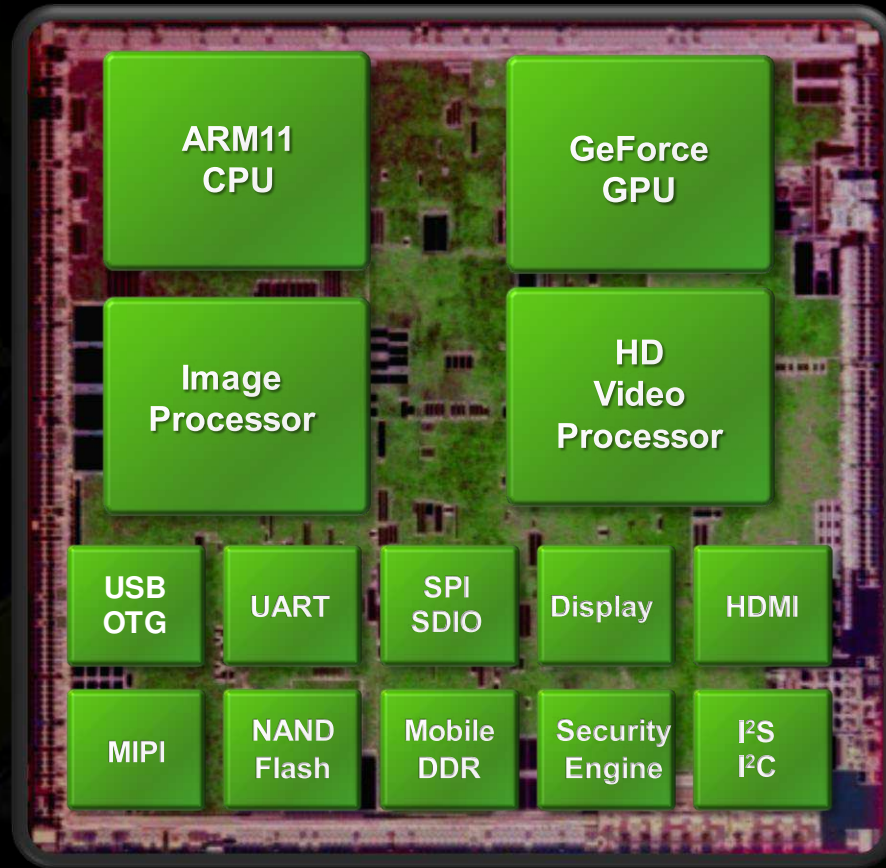


**Productivity**  
(Perf/W)





# Complete Computer on a Chip



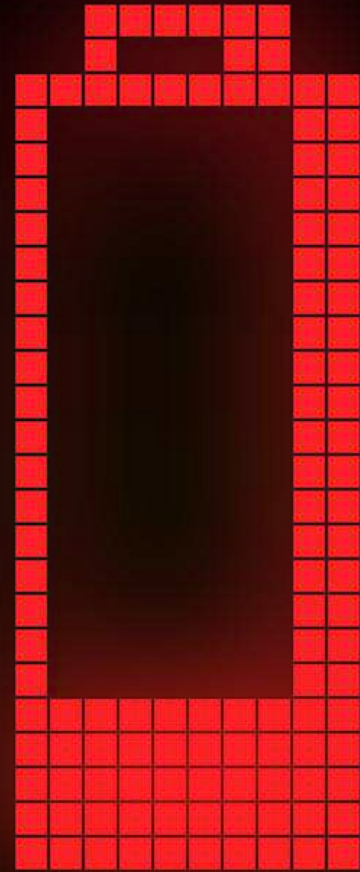
# Tegra Family



	<b>APX 2500</b>	<b>600</b>	<b>650</b>
<b>Max. LCD Resolution</b>	854x480	1280x1024	1680x1050
<b>Video decode</b>	720p 30 fps	720p 30 fps	1080p 24 fps
<b>Video encode</b>	720p	720p	720p
<b>CPU speed</b>	600 MHz	700 MHz	800 MHz
<b>Memory speed</b>	166 MHz	166 MHz	200 MHz
<b>IDE support</b>	No	Yes	Yes

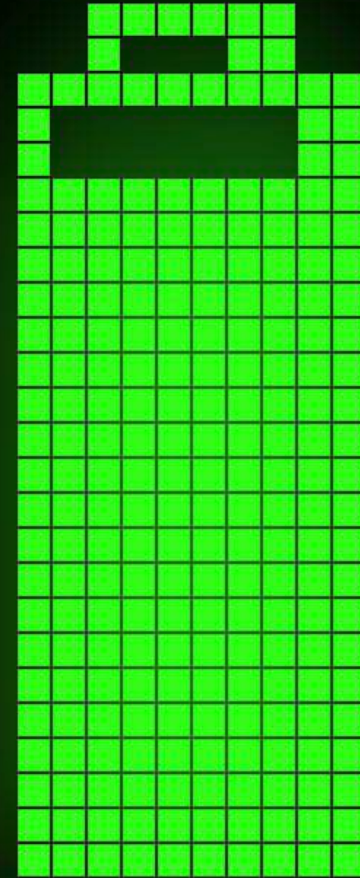
# The Challenge: Power

- A good cell-phone battery holds 1100 mAh
- Lithium-Ion batteries are 3.7 volts
- $1100 \text{ mAh} * 3.7\text{V} \sim 4 \text{ Wh}$
- Improves only 5% per year

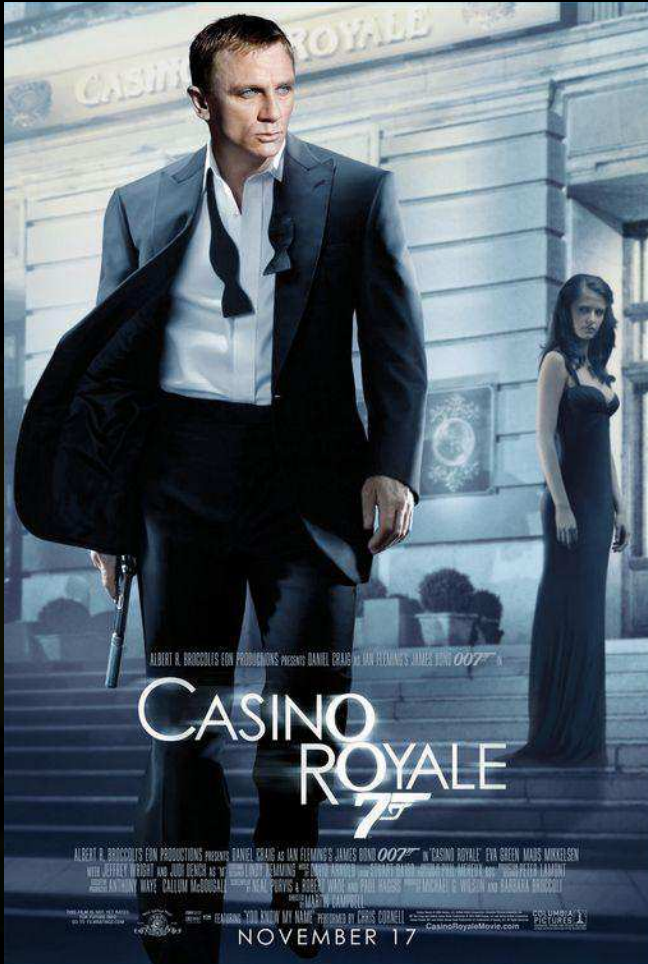


# The Challenge: MP3 playback

- Just how little is 4 Wh?
- Assume your **system** burns only 250mW
  - Audio processor, CPU, memory controller
  - IOs, RAM, flash storage, DAC...
- Further assume 85% PMU efficiency
- $4000 \text{ mWh} * 85\% / 250 \text{ mW} = 13.6 \text{ hours}$
- **Tegra can provide over 100 hours of MP3**



# The Challenge: Video playback



- Imagine if your system could play HD video
- While burning only 2000 mW
  - Video processor, CPU, memory controller
  - IOs, RAM, display, HDMI output...
- $4000 \text{ mWh} * 85\% / 2000 \text{ mW} = 102 \text{ minutes}$
- **Tegra can provide 10 hours of HD video**
  - Whole chip burns well below 200 mW



# The Challenge: Doing nothing



- What your phone does before it rings
- Determines how often you must recharge it
- **Tegra can provide weeks of nothing**
  - Chip burns 10s of  $\mu$ Watts in deep sleep

# The Challenge: Gaming

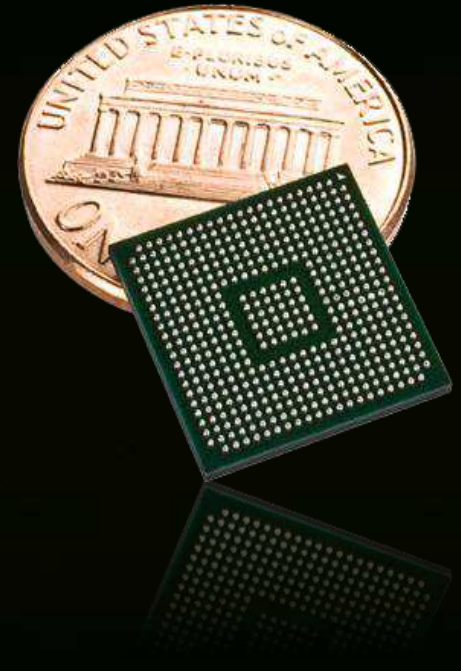


- Tegra can provide over 5 hours of 3D gaming
- Core power is only about 200 mW
- Backlight is a hog

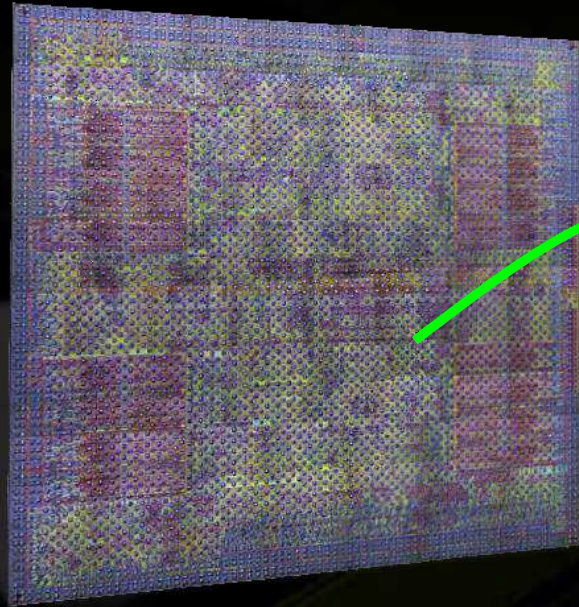
# The Challenge: Size



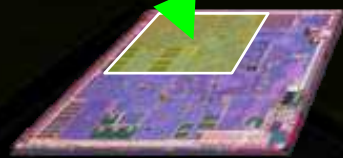
- APX package is 12 x 12 mm
- Size of a fingernail
- And almost impossibly thin
  
- Imagine the size of the circuit board in your cell phone
- No one asks for a bigger chip



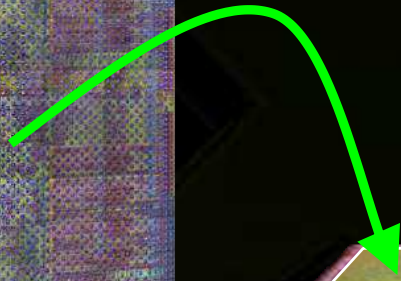
# Ultra Low Power GeForce



GeForce



Tegra



- Power was a major challenge
- Major rearchitecture required in some areas
- But both low power and high performance require maximum efficiency

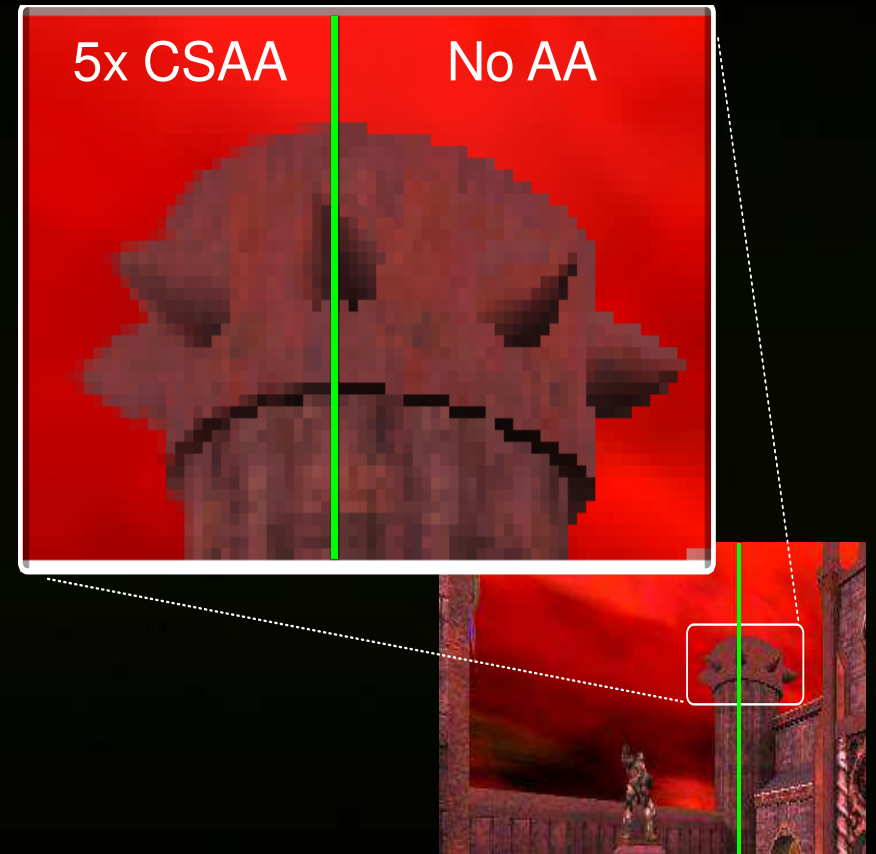
**So cost functions are quite similar to GeForce**



# Ultra Low Power GeForce



- **Fully programmable vertex and pixel shaders**
  - High level GLSL programming language
- **Floating point top to bottom**
- **OpenGL ES 2.0**
  - OpenGL 2.0 without the fixed function
- **Similar to DirectX 9**
- **Very high quality anisotropic filtering**
- **Stencil, Multiple Render Targets**
- **HDR rendering, HDR textures**
- ...



# A Real, Modern GPU



# Interesting design decisions



- **Early-Z and fragment caching**
  - These are big computation and bandwidth savers
- **Ultra Efficient 5x Coverage Sampling Anti-Aliasing Scheme**
  - Mobile version of CSAA technology from GeForce
- **Not a tiling architecture**
  - Tiling works reasonably well for DX7-style content
  - For DX9-style content the increased vertex and state traffic was a net loss
- **Not a unified architecture**
  - Unified hardware is a win for DX10 and compute
  - For DX9-style graphics, however, non-unified is more efficient

# Ultra Low Power GeForce Performance

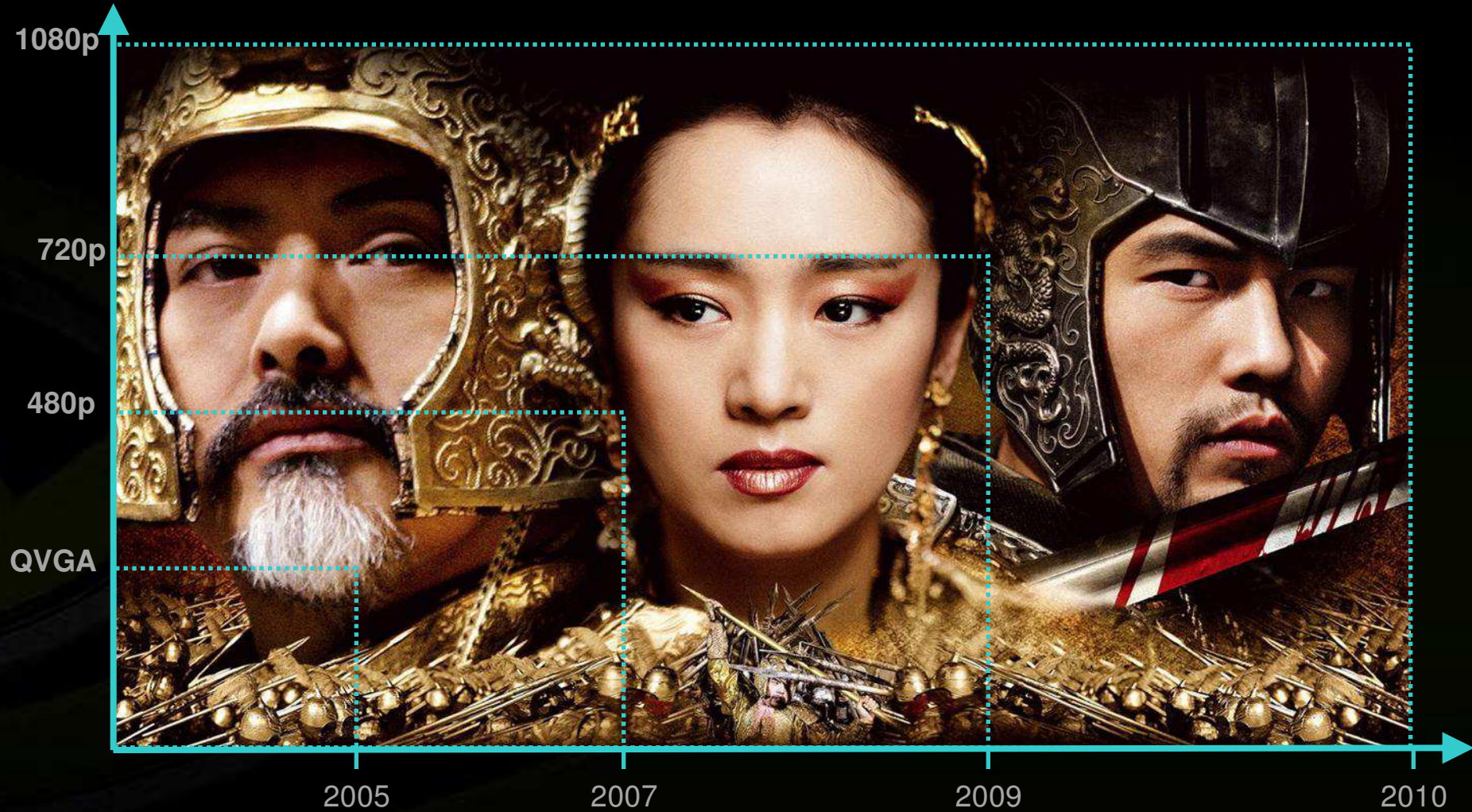


- **Tegra APX can achieve:**
  - Over 40M triangles/sec
  - Up to 600M pixels/sec
  - Texture 240M pixels/sec
- **Run Quake 3 Arena**
  - 45+ fps WVGA (800 x 480)
  - 8x Aniso Texture Filtering
  - 5x Coverage Sampling AA





# High Definition Audio Video Processor



# High Definition Audio Video Processor



## Video/Image Codec

- **High Definition Decode**
  - 1080P/720P decode
  - Peak bit-rate of 14-20 Mbps
  - H.264, VC1 and MPEG-4
- **High Definition Encode**
  - Up to 720P resolution
  - H.264 and MPEG-4
  - Peak bit-rate of 10 Mbps
  - Flexible Macroblock mode selection
- **Baseline JPEG**
  - Decode and Encode
  - Maximum resolution of 256 MP
  - 4:2:0, 4:2:2, 4:4:4, 4:2:2R support

## Audio

- **Formats supported**
  - AAC-LC, AAC+, eAAC+
  - AMR-WB, AMR-NB
  - WMA7, 8, 9
  - WMA10 Pro LBR
  - MP3
  - PCM
  - SBC
  - Real Audio 8, 9, 10
  - MIDI Ringtone

# High Definition Audio Video Processor



## Broadcast TV

- ISDB-T, DVB-H, DVB-T, T-DMB

## Optimized mobile viewing experience

- High-resolution display
- High-quality video playback
- Over 9 hours of continuous live TV



# Tegra CPU



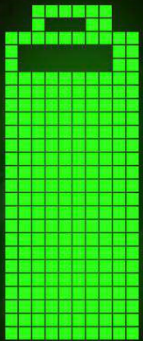
- **ARM11 Core, optimized for high performance**
  - 32K I and 32K D L1 caches
  - 256K L2 cache exclusive with L1
  - Low latency path to DRAM
  - Up to 800 MHz operation
- **Importantly also optimized for low power**
  - Caches reduce power hungry DRAM accesses
  - A dedicated PLL means the CPU runs just fast enough
  - Extensive clock gating
  - The media processing is done by hardware units, which is much more power efficient than doing it in software



# Tegra Memory Controller



- **Challenge is to share 1.6 GB/s of 200 MHz LP-DDR efficiently**
  - Optimize DRAM page usage
  - Maximize bandwidth for the multi-media clients
  - Minimize CPU latency for maximum performance
  - High priority for real time display and camera
  - Extensive modeling to balance these
- **While still minimizing power**
  - DRAM clock stopping and standby modes
  - Minimize expensive pre-charge/activates
  - Dynamic frequency and voltage scaling



# Image Signal Processor (ISP)

- Image processing for 12 Megapixel camera burst mode
- Also needed during video encode, 720p at 30 fps
- Roughly **1.6 GOPS** of image processing required
  - Lens shading
  - De-noising
  - De-mosaicing
  - Color correction
  - Sharpening
  - Contrast enhancement
  - Special effects

# ISP Example: Color artifact reduction

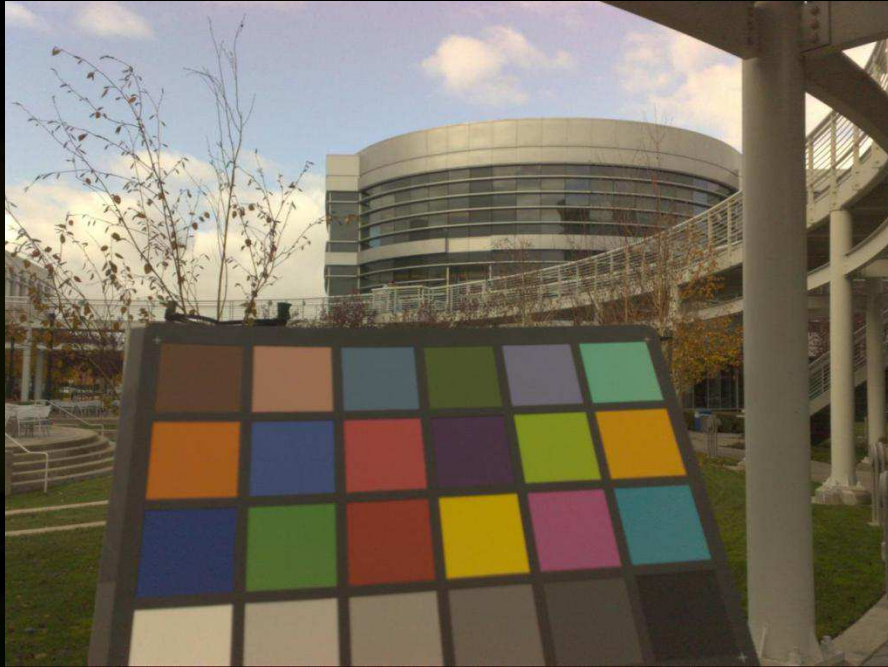
- Reduces noise and false chroma ringing in shadows and high frequency regions



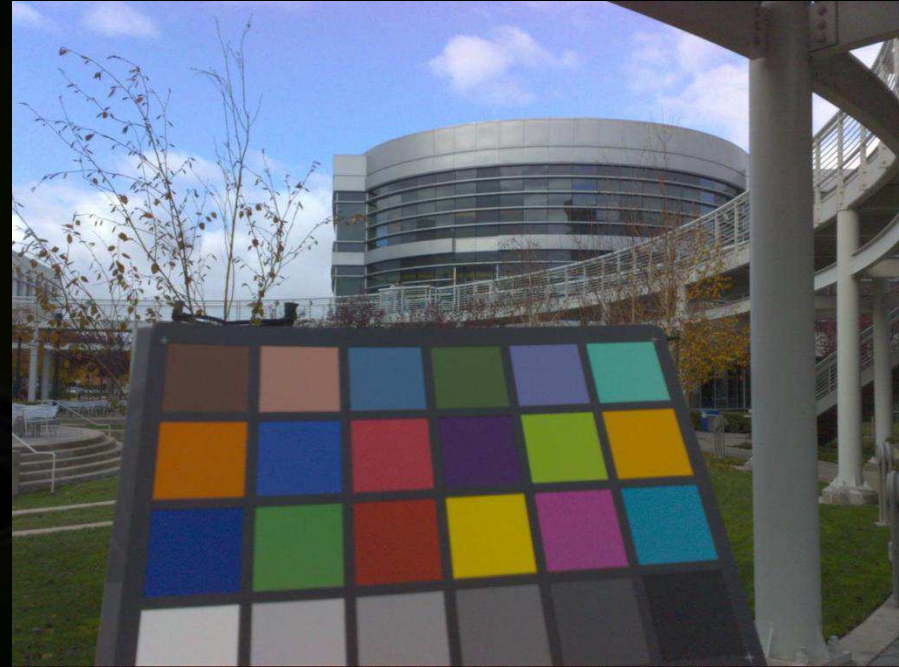
# ISP Example: Auto White Balance (AWB)

- **Make white objects look white under various illuminants**

Too yellow



Corrected





# ISP Example: Bilateral noise reduction filter

- Small sensors with high resolutions => tiny noisy pixels



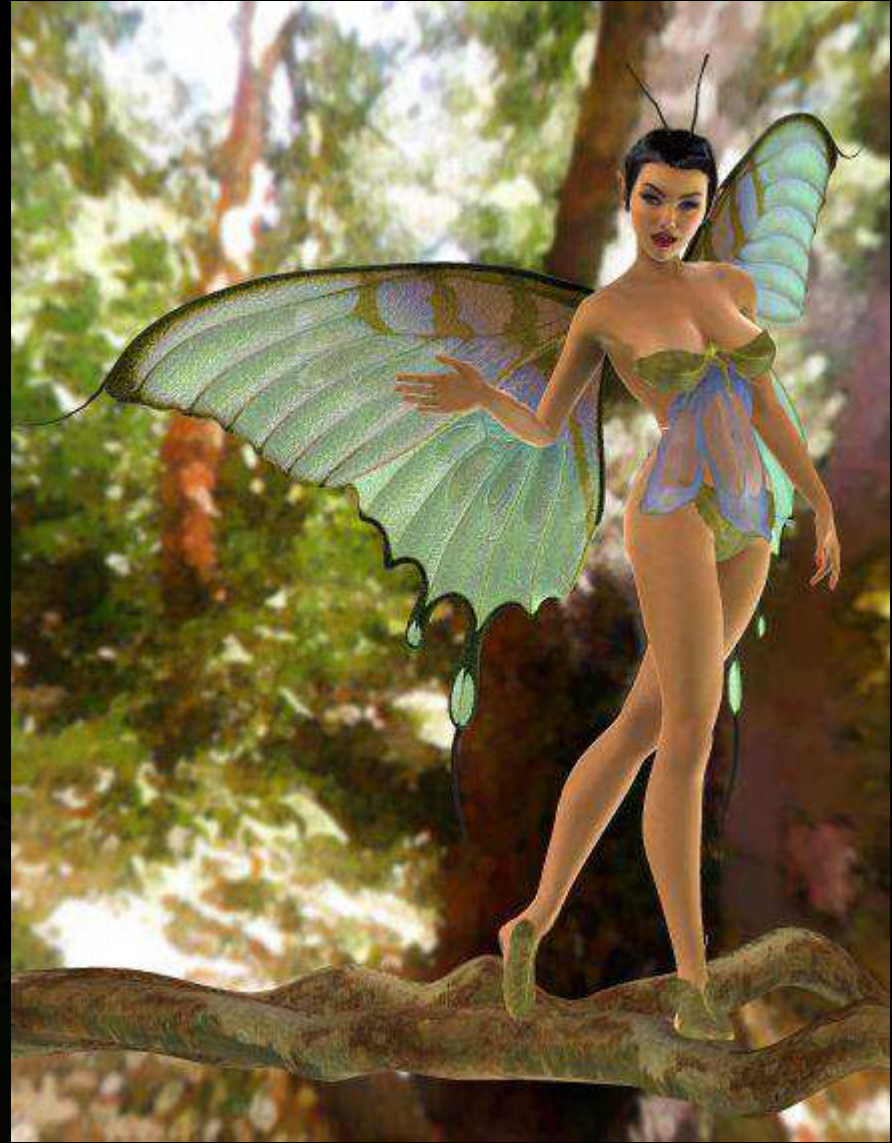
# APX 2500 Development Platform Demos



AP	NVIDIA APX 2500
Memory	256MB DDR, 8GB NAND
Display	Sharp 4" WVGA (800x480x24bit)
HSDPA	Infineon SGOLD3H
Audio	Wolfson WM8753L
WiFi	Atheros 802.11b/g
BlueTooth	Murata CSR BC5FM
GPS	SiRF
Mobile-TV	Siano DVB-H / DVB-T / T-DMB
Imaging	5MP & VGA Micron Sensors

# APX 2500 Demos...

- Also come to the lobby after the talk...





# Summary



Horsepower  
close to  
XBOX



Quality & Features  
comparable to  
PLAYSTATION 3



Tiny  
and eats power  
LIKE A BIRD