TI Developer Conference
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Minds in Motion

Using the DSP in the Dual-Core DaVinci as a Graphics Render Engine

Soft graphic accelerator

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TES™ Electronic Solutions

Content

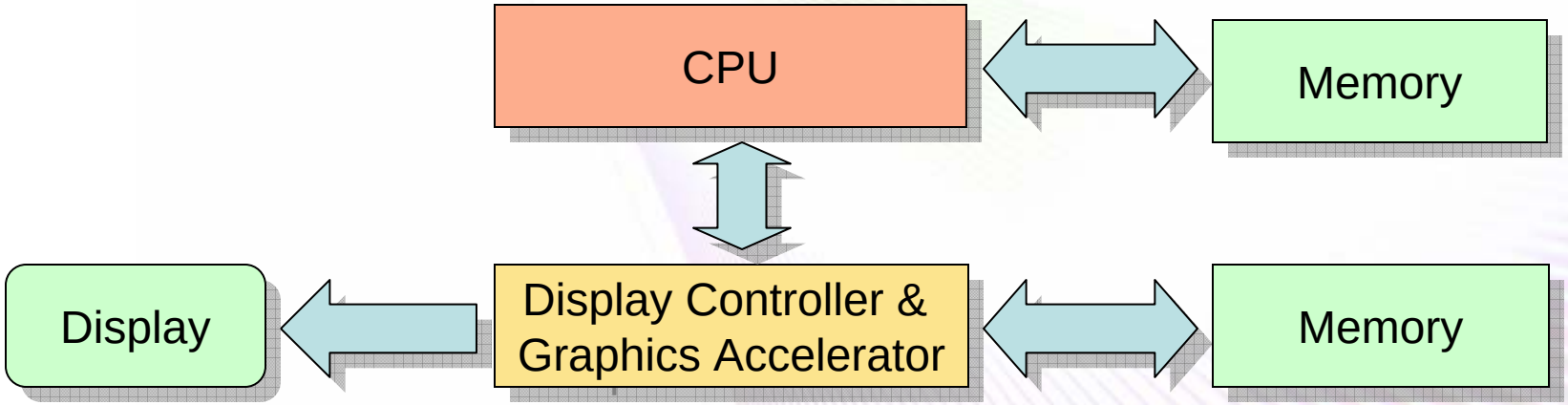
- Brief introduction into graphics
  - HW/SW System architecture
  - Graphic primitives, color formats, etc.
  - Antialiasing, blending, etc.
  - Render pipeline, rasterization, pixel pipeline
- Dynamic code generation
- Rasterization: Triangle
  - Classic / Explicit approach
  - Implicit approach
- Performance numbers
- Use Case: PMP Gui

Lead into graphics

- Examples

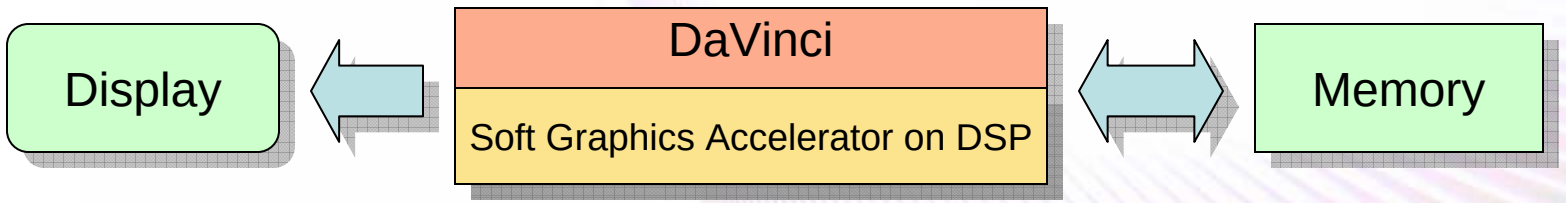
Lead into graphics

- Classic HW System Architecture
  - 4 Chip Solution



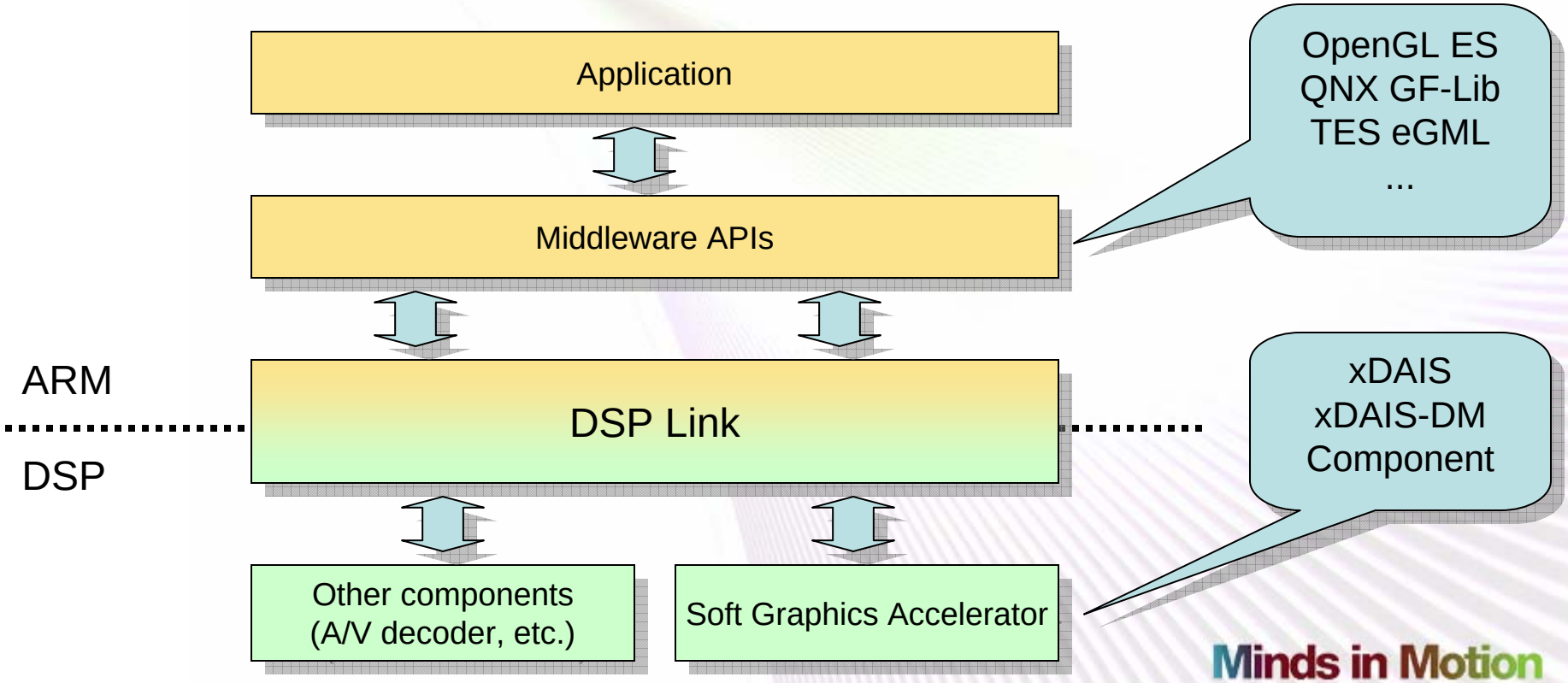
Lead into graphics

- DaVinci HW System Architecture
  - 2 Chip Solution
  - Easily adaptable to new requirements



Lead into graphics

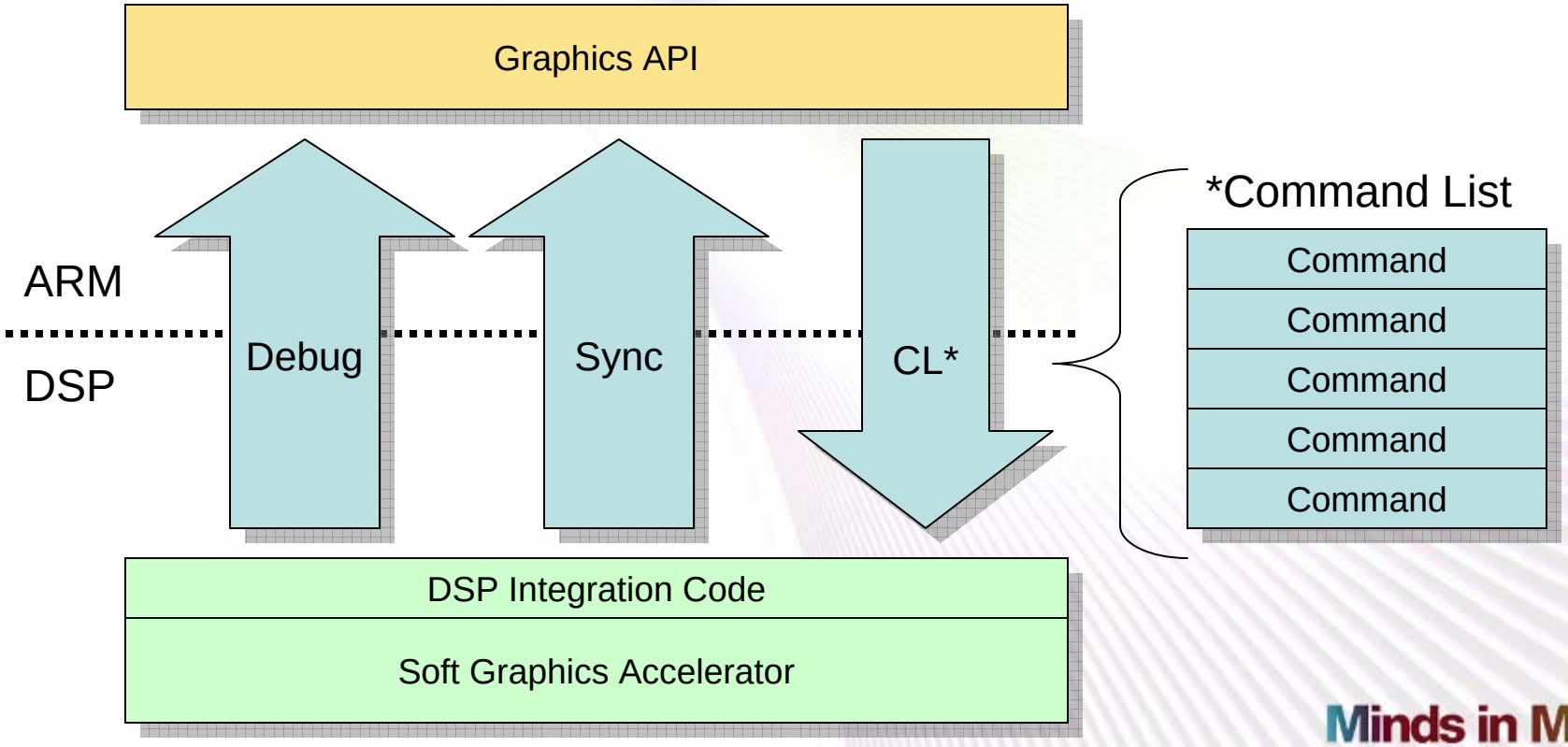
- DaVinci SW System Architecture



Minds in Motion

Lead into graphics

- Connection to Soft Graphics Accelerator



Lead into graphics

- Graphic primitives
  - Blit* operations
  - Lines
  - Triangles

*Block image transfer

Lead into graphics

- Color Formats
  - 32 Bit: ARGB8888, RGB888
  - 24 Bit: RGB888
  - 16 Bit: RGB565, ARGB1555, ARGB4444
  - 8 Bit: CLUT*

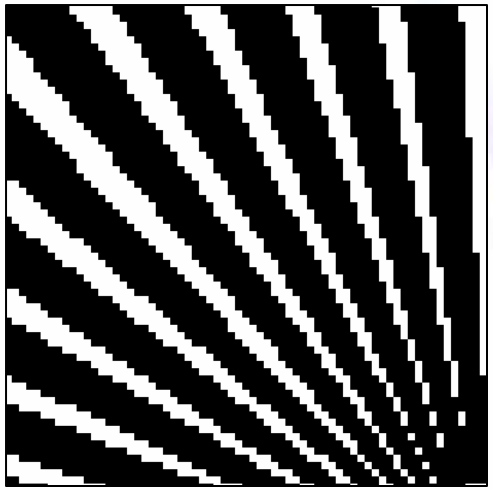
*Color Look Up Table

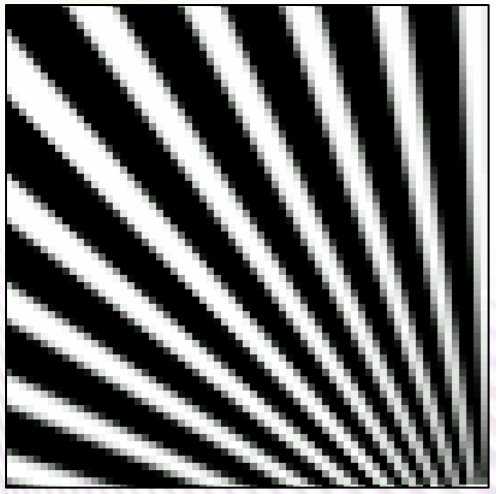
Lead into graphics

- Display Resolutions
  - QVGA: 320x240, WQVGA: 400x240
    - Mobil devices
    - In-Car-Nav-Radios
  - VGA: 640x480, WVGA: 800x480
    - NG PDAs, PNDs
    - In-Car-Multimedia-Systems

Lead into graphics

- Antialiasing
  - Post Filtering (Supersampling)
  - Pre Filtering



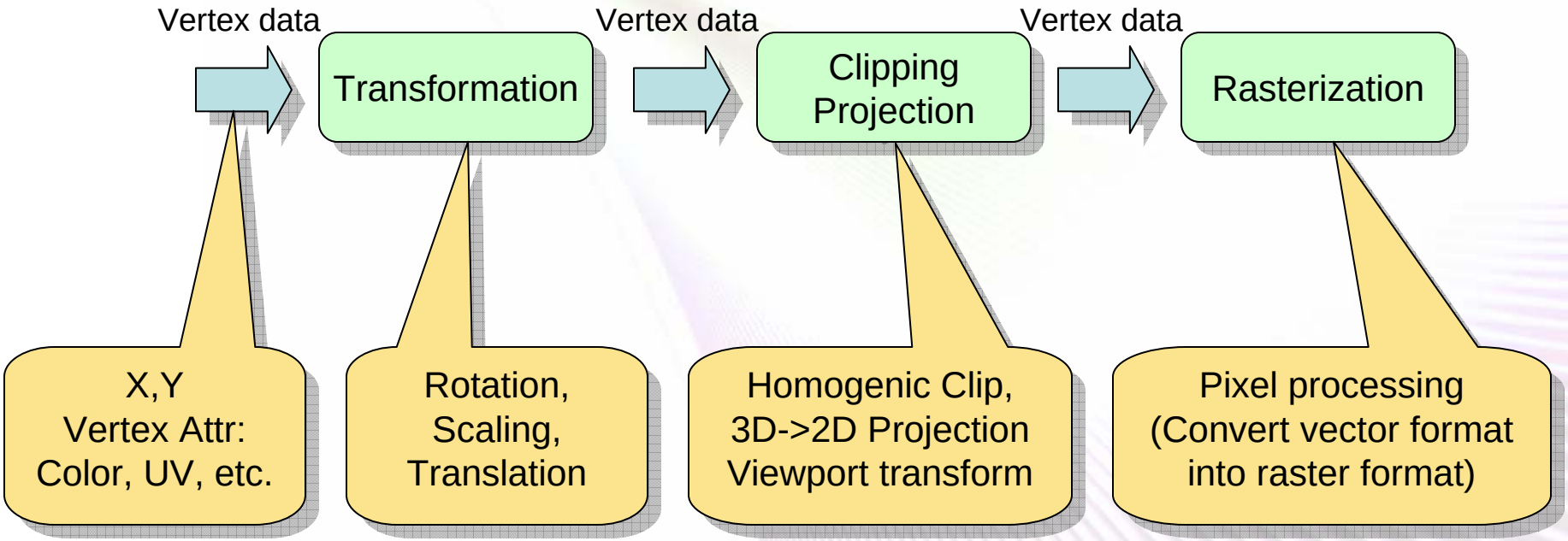


Lead into graphics

- Blendmodes
  - Blending combines the source color (Cs) with destination (framebuffer) color (Cd).
  - Examples:
    - Copy: C = Cs
    - Add: C = Cs + Cd
    - Multiply: C = Cs*Cd
    - Blend: C = Cs*As + Cd*(1-As)

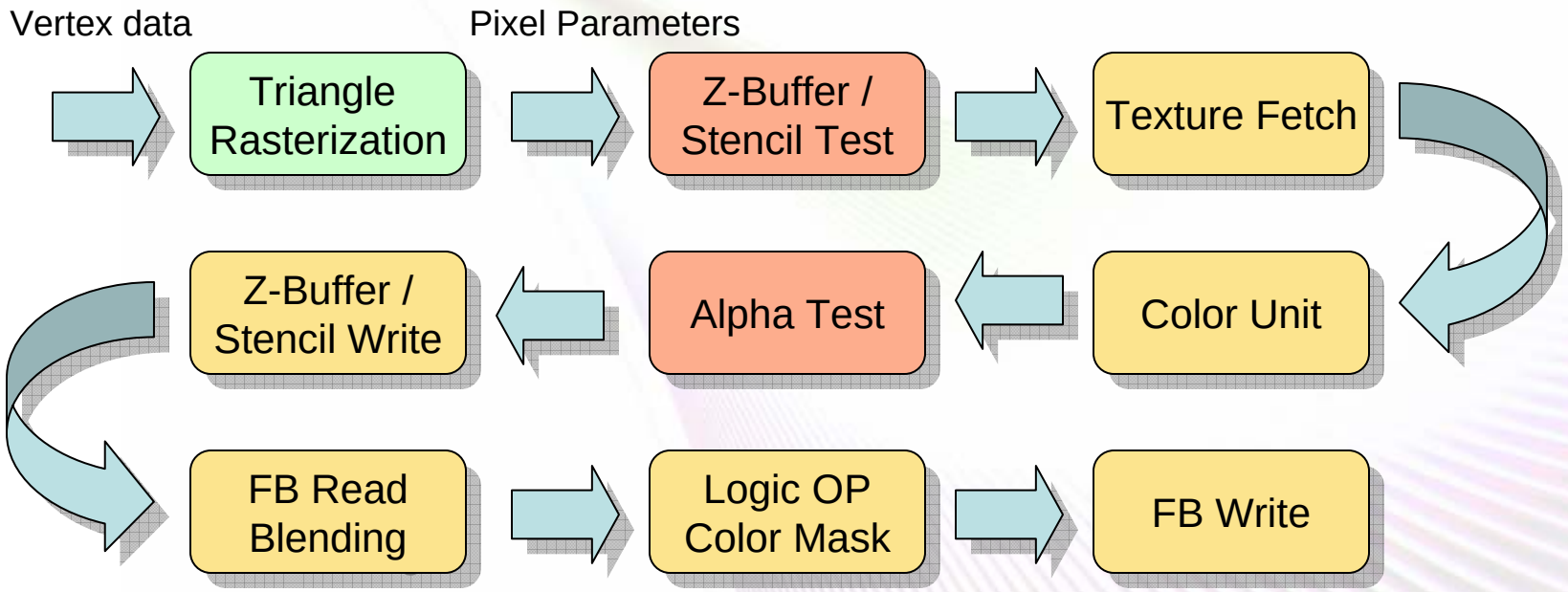
Lead into graphics

- Rendering-Pipeline



Lead into graphics

- Rasterization / Pixel Pipeline



Dynamic Code Generation

- Motivation
  - Pixel processing is the *Hot Spot*
  - Every cycle counts
  - Special code for each pixel process combination would give optimal performance

Dynamic Code Generation

- Combinations for solid fill Triangles
  - Framebuffer formats
    - RGB565, RGB888 (x2)
  - Blendmodes
    - Color Blendmodes (x4)
    - Alpha Blendmodes (x3)
  - Antialiasing
    - On/Off per Edge (x4)

Combinations
96

Dynamic Code Generation

- Combinations for solid fill triangles
  - Alpha Test (x9)
  - Stencil Test (x324)
  - Z-Buffer Test (x10)

Combinations

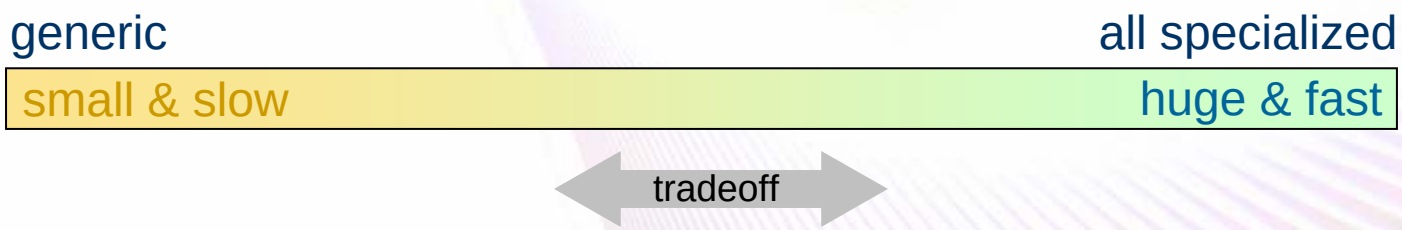
2799360

Dynamic Code Generation

- How to handle this many combinations?
  - Generic Code
    - Using a lot of *if* and *switch* statements does the job
    - It‘s easy to write and perfect to maintain
    - But makes pixel processing terribly slow
  - Specialized Code
    - Can get best performance in theory
    - Needs clever coding for automatic generation at compile time
    - But makes the memory footprint / compile time explode

Dynamic Code Generation

- Hybrid approach
  - Use C++ templates for codepath generation
  - Only small blocks are specialized
  - Function pointers used to call specialized code blocks

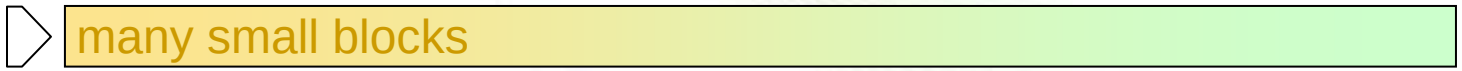


Dynamic Code Generation

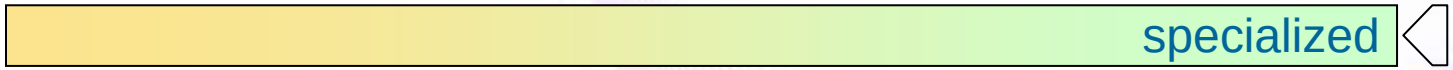
- Hybrid approach - disadvantages
  - New features push combinations much further
  - Find optimal balancing is difficult
  - DSP does not like code with a lot of jumps
  - Huge code size of library

Dynamic Code Generation

- Dyn. Codegen approach
  - Using many very small code blocks



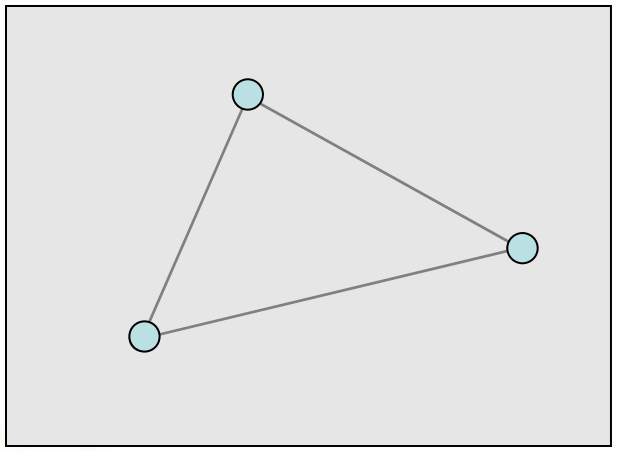
  - Build a specialized code at runtime

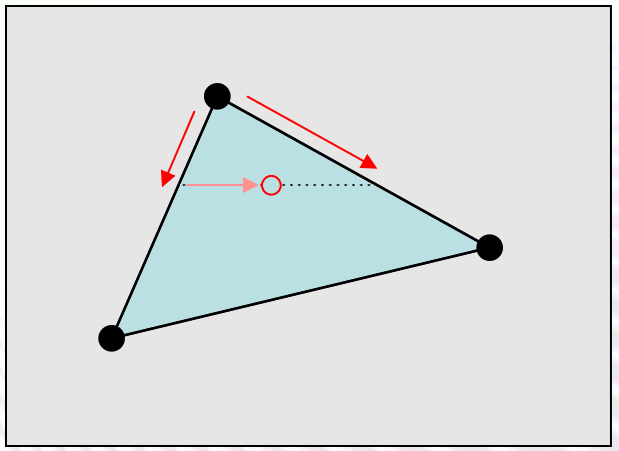


=> Result: Small code size and high speed

Rasterization

- Classic Approach
  - Geometry specified by vertices
  - Rasterization by interpolation
  - Suitable for GPP



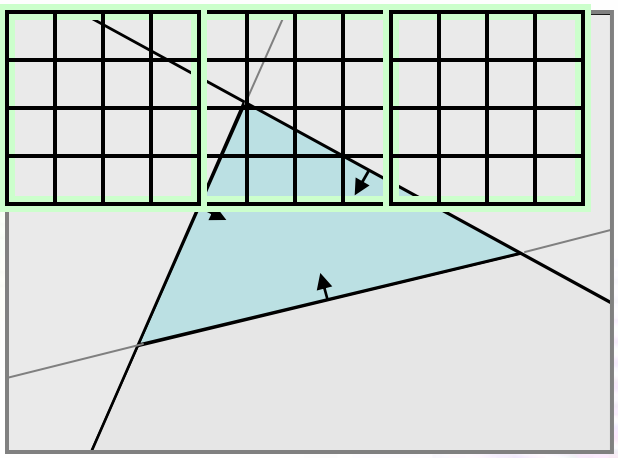


Rasterization

- Classic Approach – Disadvantages
  - Interpolation generates point samples
    - Difficult to antialias
  - Clipping explicit required
    - Causes artifacts at the border (jumping edges)

Rasterization

- Implicit approach
  - Splitting the plane into two halfs by an edge
  - Forming a region
  - Pixel inside if positive side of all edges
  - Allows blockwise rendering



Rasterization

- Implicit Approach – Advantages
  - Process any number of pixels in parallel
  - Clipping and tiling trivial because of implicit rendering
  - Pre Filtered Antialiasing becomes easy

Rasterization

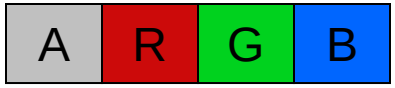
- Why suited for DSP?
  - Evaluate distance to each edge for every pixel
  - Only one addition/edge if done incrementally
  - DSP calculates 2 pixels of a triangle in one cycle
  - Setup is using only dot products, no division

Rasterization

- Why suited for DSP?
  - Pixels are examined blockwise
  - An entire 8x8 pixel block can be tested to be inside/outside the triangle with just 3 cmp's
  - DSP can fill 'fully inside' 8x8 blocks very fast issuing two 64 bit stores/cycle

Rasterization

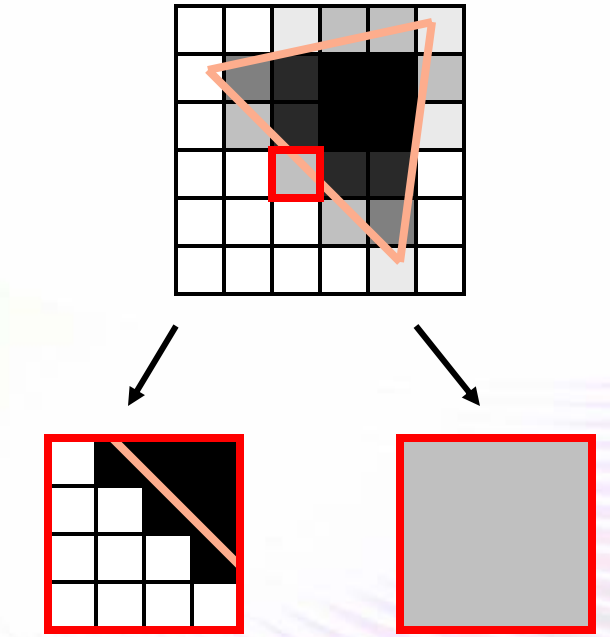
- Why suited for DSP?
  - Blending has to be performed on 4 color channels in parallel



  - DSP can operate on packed 8bit quantities directly

Rasterization

- Direct edge antialiasing
  - Requires pixel coverage (PC) value (Range: 0-1)
  - Blend source and test color with pixel coverage C=Cs*PC+Cd(1-PC)
  - PC calculation
    - Multi-sampling (number of hits/number of samples)
    - Distance field (distance to edge)



Performance numbers

- System description
  - DSP: c64p
  - DSP Clock: 567 [MHz]
  - Memory Clock: 187 [MHz]
  - Memory Type: DDR

Performance numbers

- Fill (RGB565)
  - 640x200 -> 1.22 ms -> 98.1 mpix/s
- Small Line (RGB565)
  - Len: 6, Width: 1, AA=Off -> 412000 lines/s
  - Len: 6, Width: 1, AA=On -> 333000 lines/s
- Small Triangle (RGB565)
  - (10,10)(13,10)(10,13) -> 210000 triangles/s

Performance numbers

- Blit Copy (RGB565->RGB565)
  - 800x480 -> 5.1 ms -> 74.5 mpix/s
- Blit Const Alpha (RGB565->RGB565)
  - 800x480 -> 8.8 ms -> 43.6 mpix/s
- Blit Pixel Alpha (RGB565+A8,RGB565)
  - 800x480 -> 9.3 ms -> 41.2 mpix/s
- Blit Color (A8,RGB565)
  - 800x480 -> 6.6 ms -> 58.1 mpix/s

Use Case: PMP Gui

- Requirements:
  - RGB565, 480x240
  - 100ms refresh (10 FPS)
  - Blitoperations:
    - 480x240 Background (Blit Copy)
    - 4x64x64 Animated Icons (Blit Pixel Alpha)
    - 64x32x32 Text / 1 Color Icons (Blit Color)

Use Case: PMP Gui

- Performance Requirements:
  - Blit copy
    - 1.53 mpix/s -> 1.8 mpix/s -> 22.5 ms
  - Blit Pixel Alpha
    - 0.164 mpix/s -> 0.2 mpix/s -> 5 ms
  - Blit Color
    - 0.656 mpix/s -> 0.8 mpix/s -> 15 ms

=> 42.5 ms ~ 5% DSP Load ~ 30 MHz

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More information:

- **Meeting room #3184**
- **www.tesbv.com**

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