

# CPU/GPU Power Management

3/11/2010

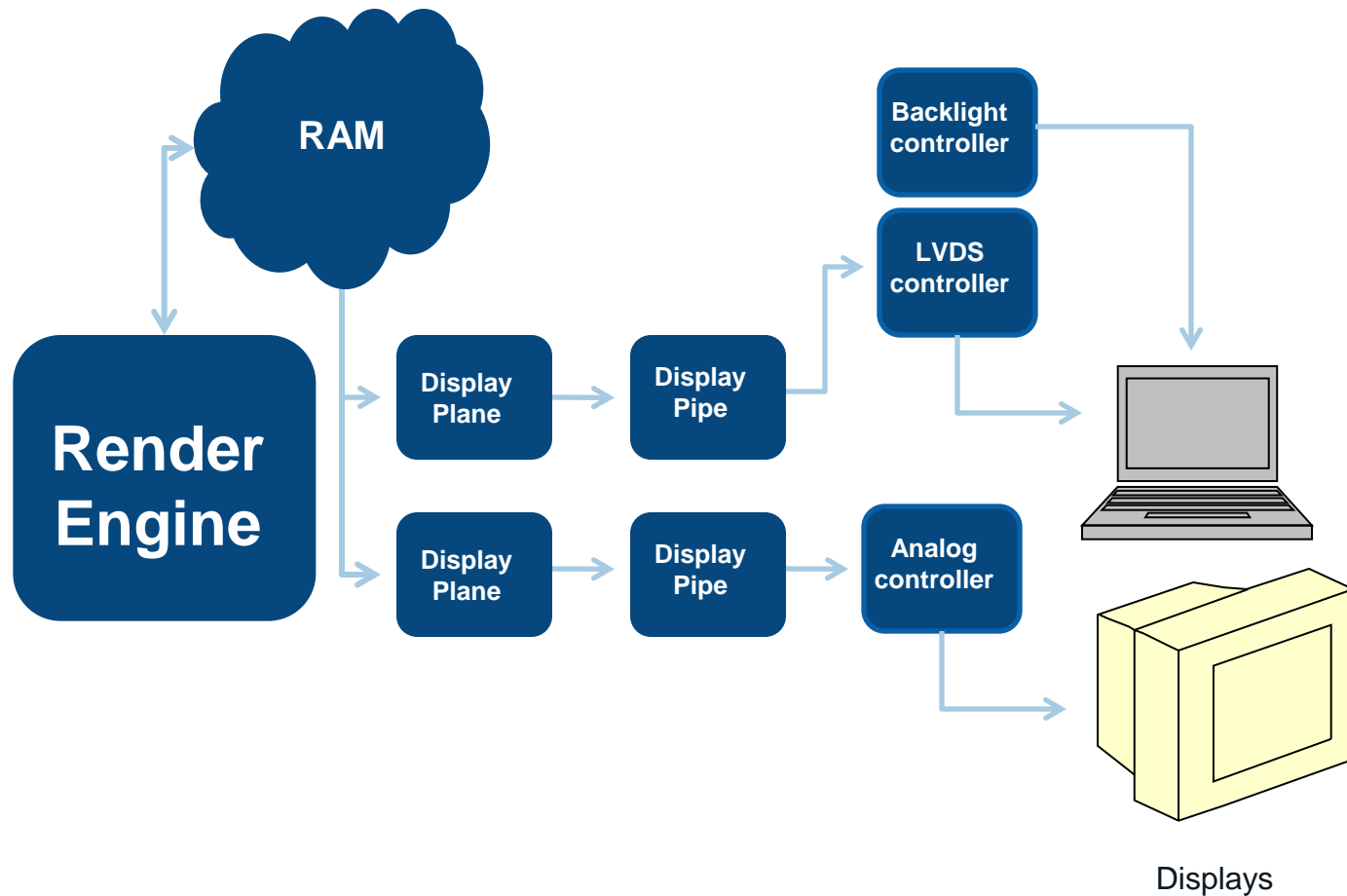
Jesse Barnes



# Agenda

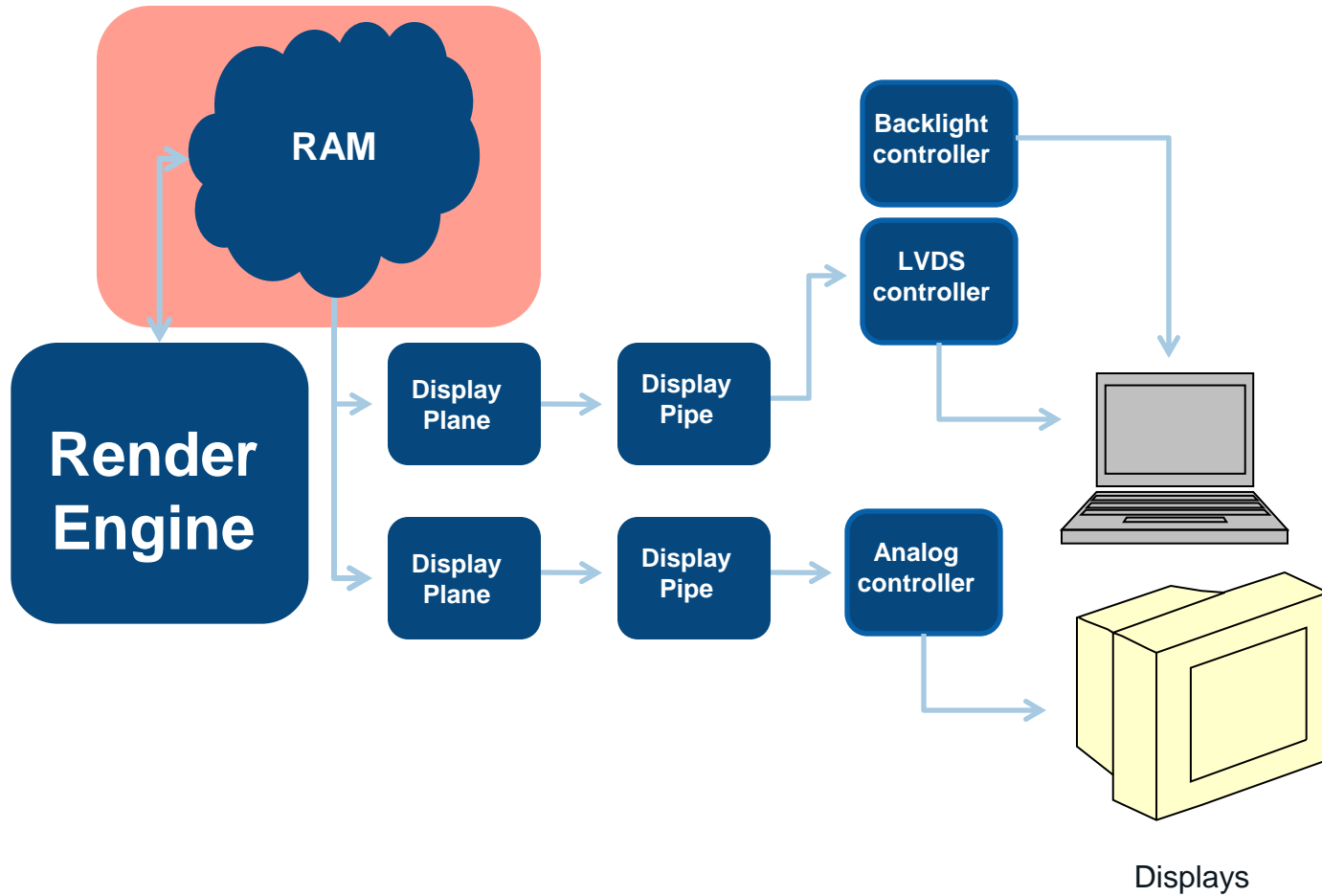
- Overview of architecture from power perspective
- RAM related power topics
  - Display planes
  - Display pipes
- Physical displays
- Power data
- Intelligent Power Sharing & Graphics Turbo
  - Overview
  - Current data

# GPU Power Consumption



**GPU power consumption has multiple components**

# RAM

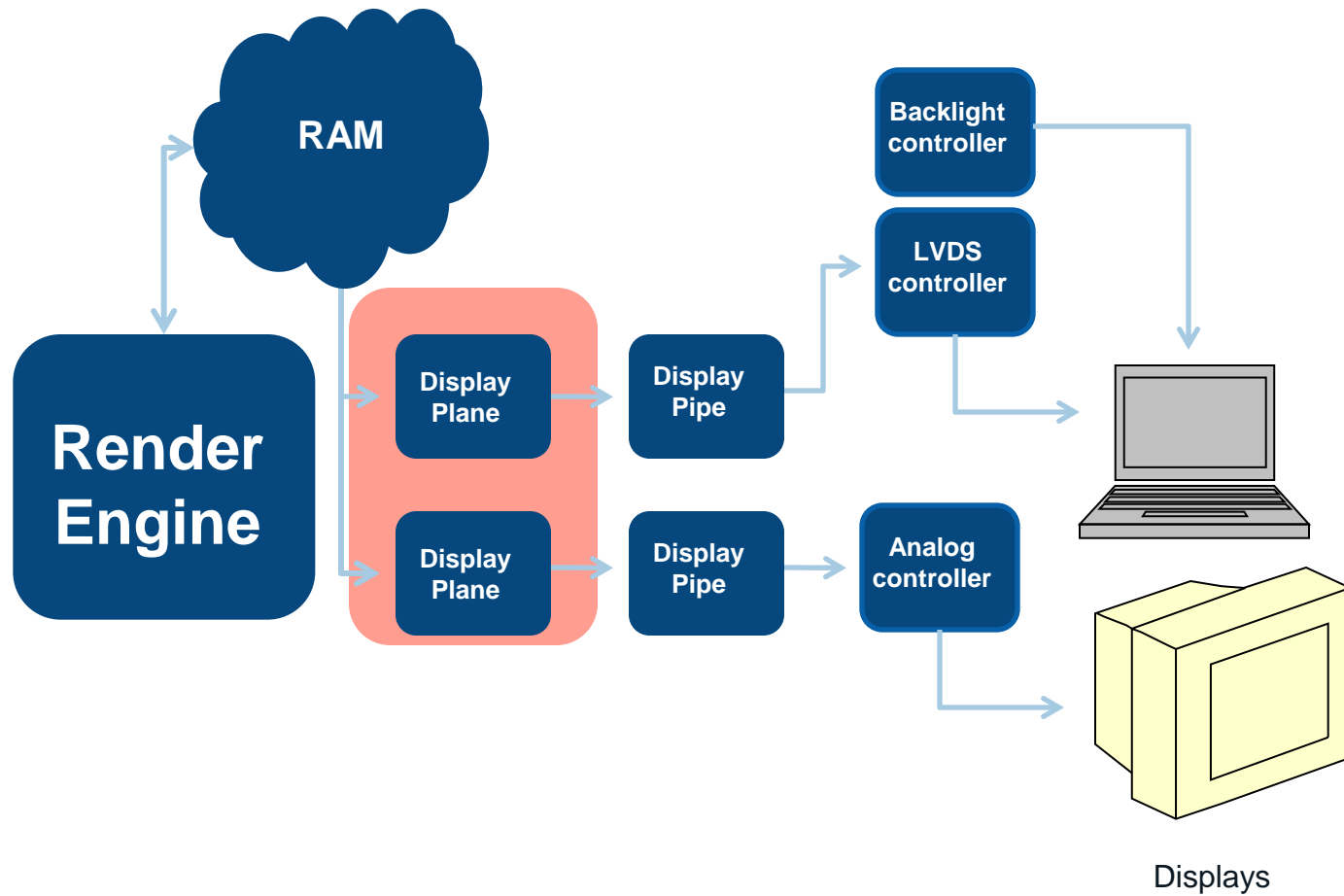


# Managing RAM power consumption

- RAM
  - GPU is part of GMCH (the 'G' in GMCH)
  - Can put RAM into self-refresh when idle
  - Means GPU should be minimizing access to RAM
    - Buffer accesses inside GMCH to avoid frequent fetching
    - Track accesses and bus activity and enable self-refresh when possible
    - Reduce total readout through buffer compression
    - Optimize memory accesses with tiling to avoid reading the same pages repeatedly

**RAM takes a lot of power when active**

# Display planes

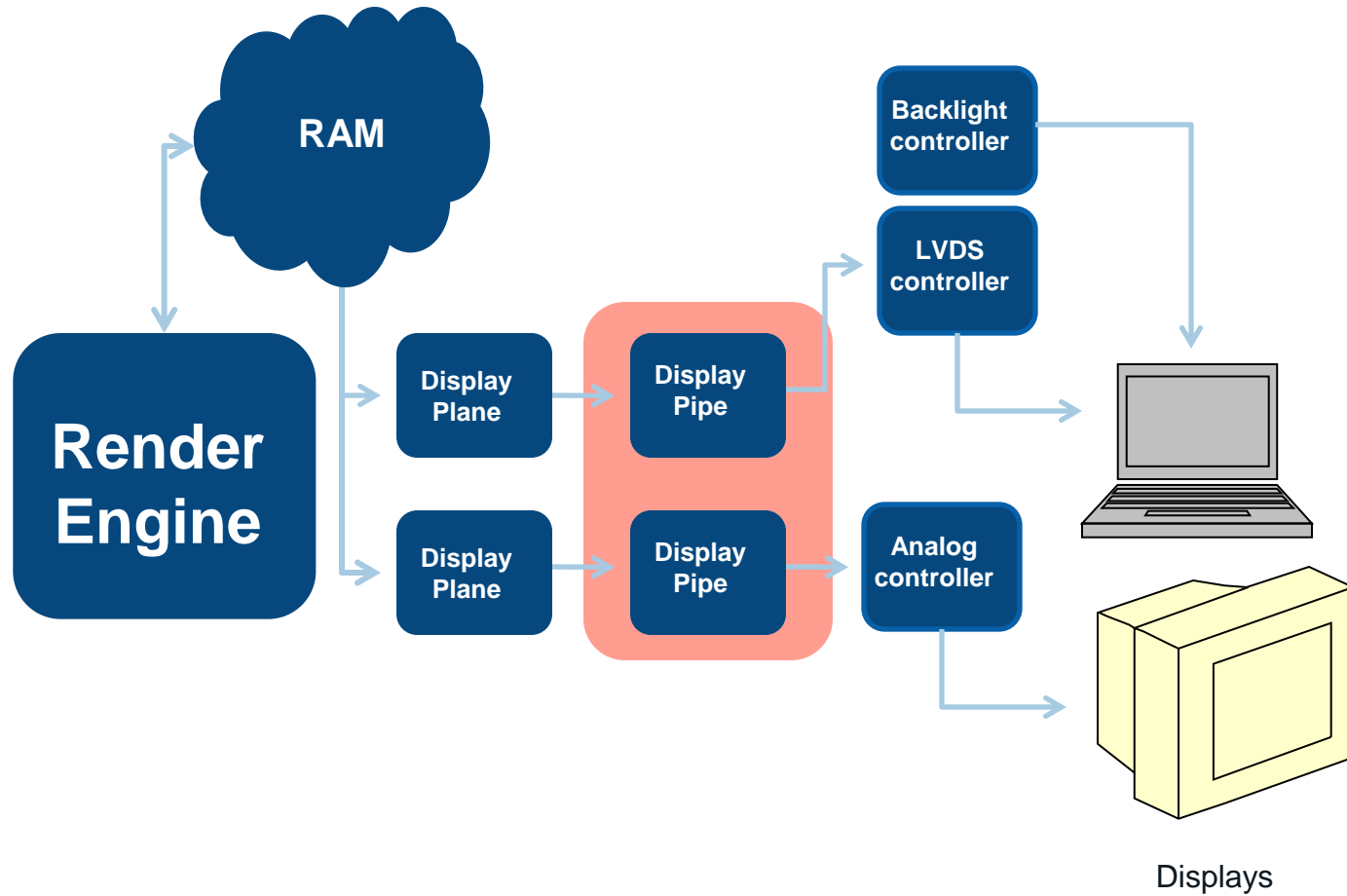


# Display planes

- Planes are just pixel pools fed to display pipes
- Internal display FIFO is periodically refreshed to feed to pipes
- Large FIFO and optimized fetch frequency saves power by reducing RAM access
- Framebuffer compression improves FIFO utilization

**Again, need to keep RAM idle**

# Display pipes

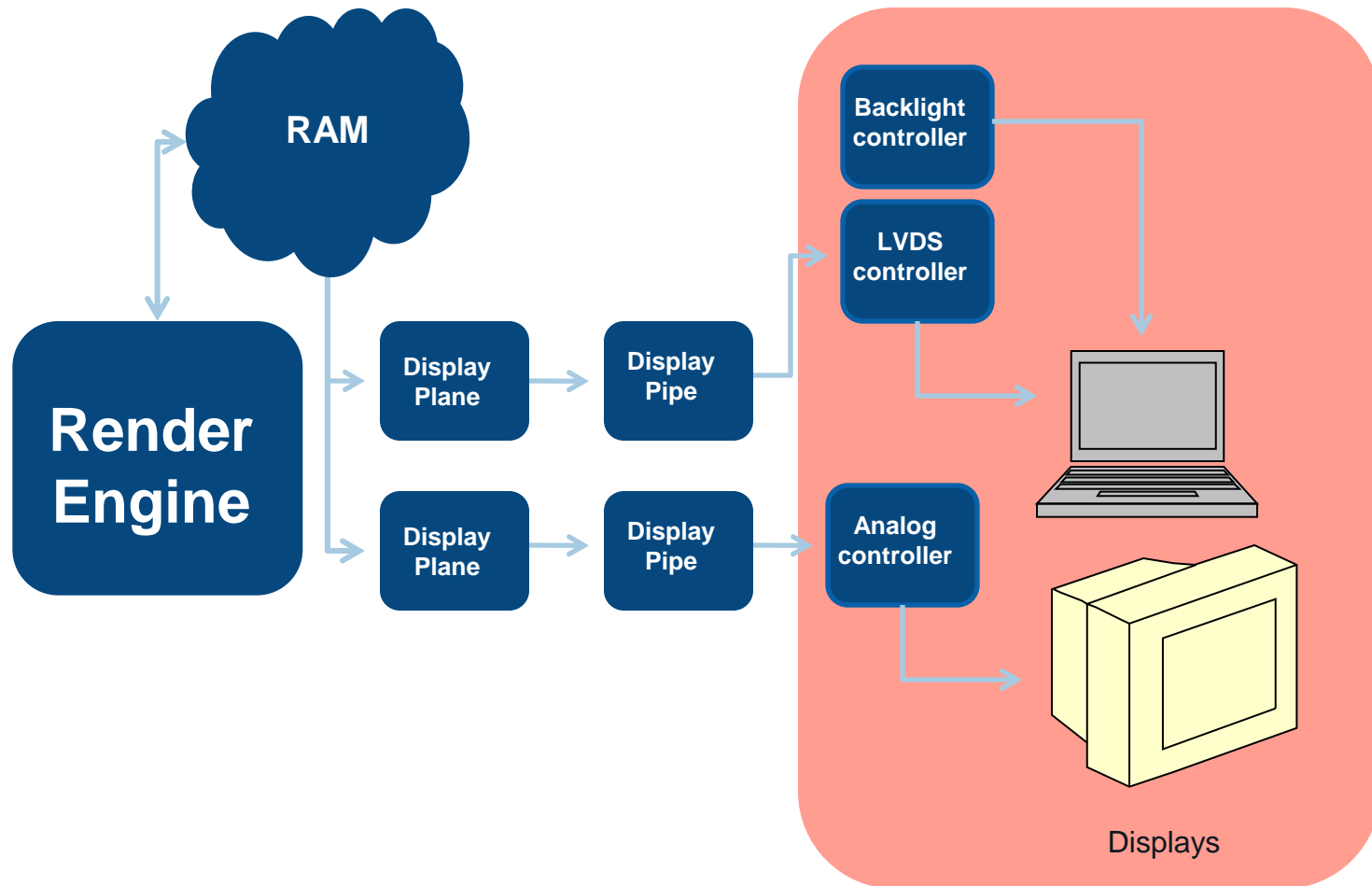


# Display pipes

- Pipes fetch pixels from display plane FIFOs based on pixel clock determined by output mode and depth
- Low clock frequency drains FIFOs slower
- Need to choose low refresh rates and depths when possible
- Some displays support dual frequency, can seamlessly switch to lower refresh when display is idle

**Yet another way to avoid reading RAM**

# Outputs

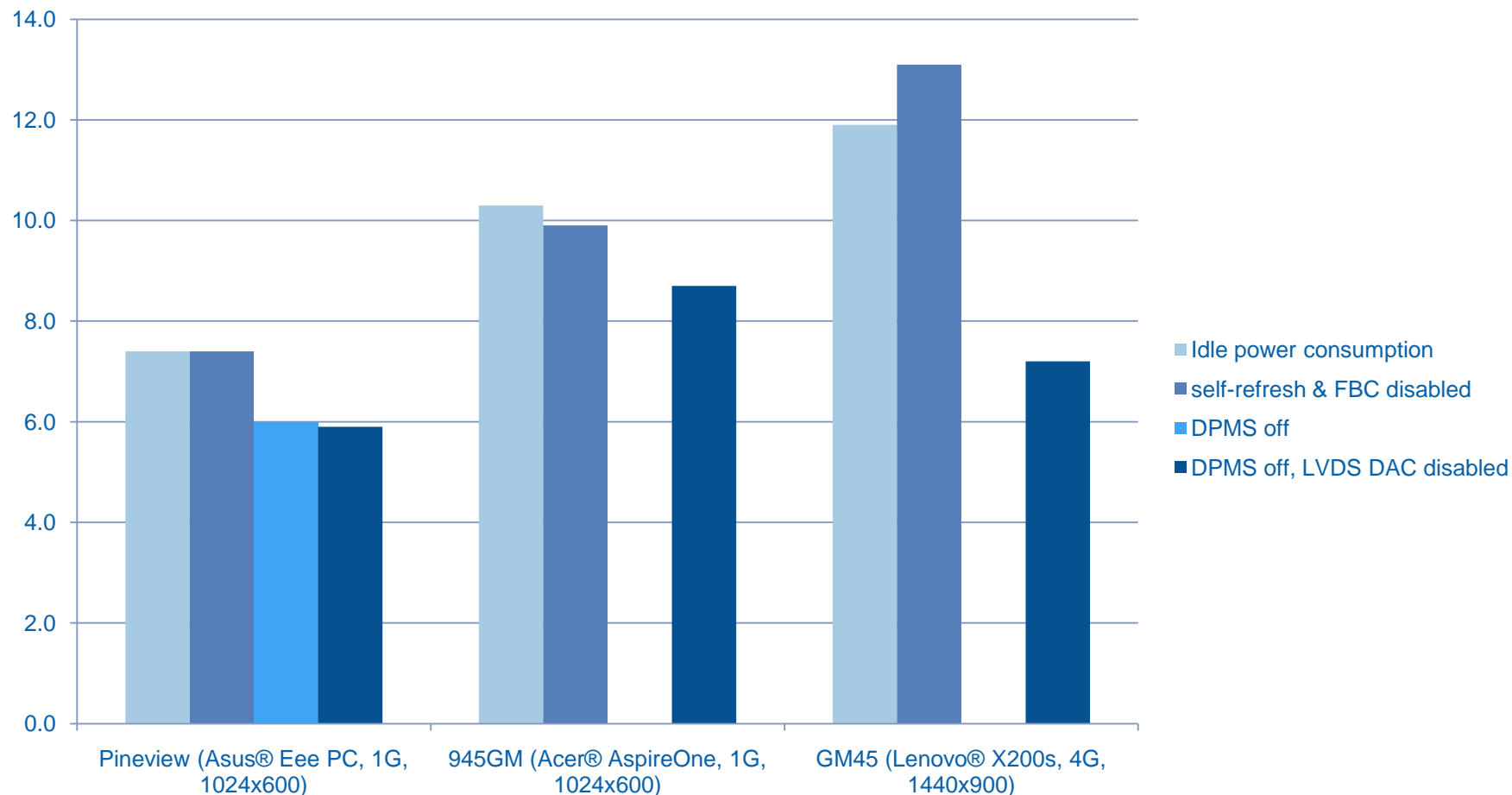


# Outputs

- Outputs themselves consume a lot of power
  - Backlight
  - LCD polarization
  - CRT voltage & current
- Mostly outside graphics driver control
  - Higher level software needs to turn off display aggressively
  - Keep backlight as low as possible, use ambient light sensors to optimize
  - Usability tradeoffs
    - Latency for turning display back on
    - Visibility of various backlight levels
    - Low refresh rate artifacts
- Some hardware features available
  - Display P-states (DPST)
    - Automatically adjusts contrast to preserve image quality while backlight is dimmed
  - Dual-frequency refresh

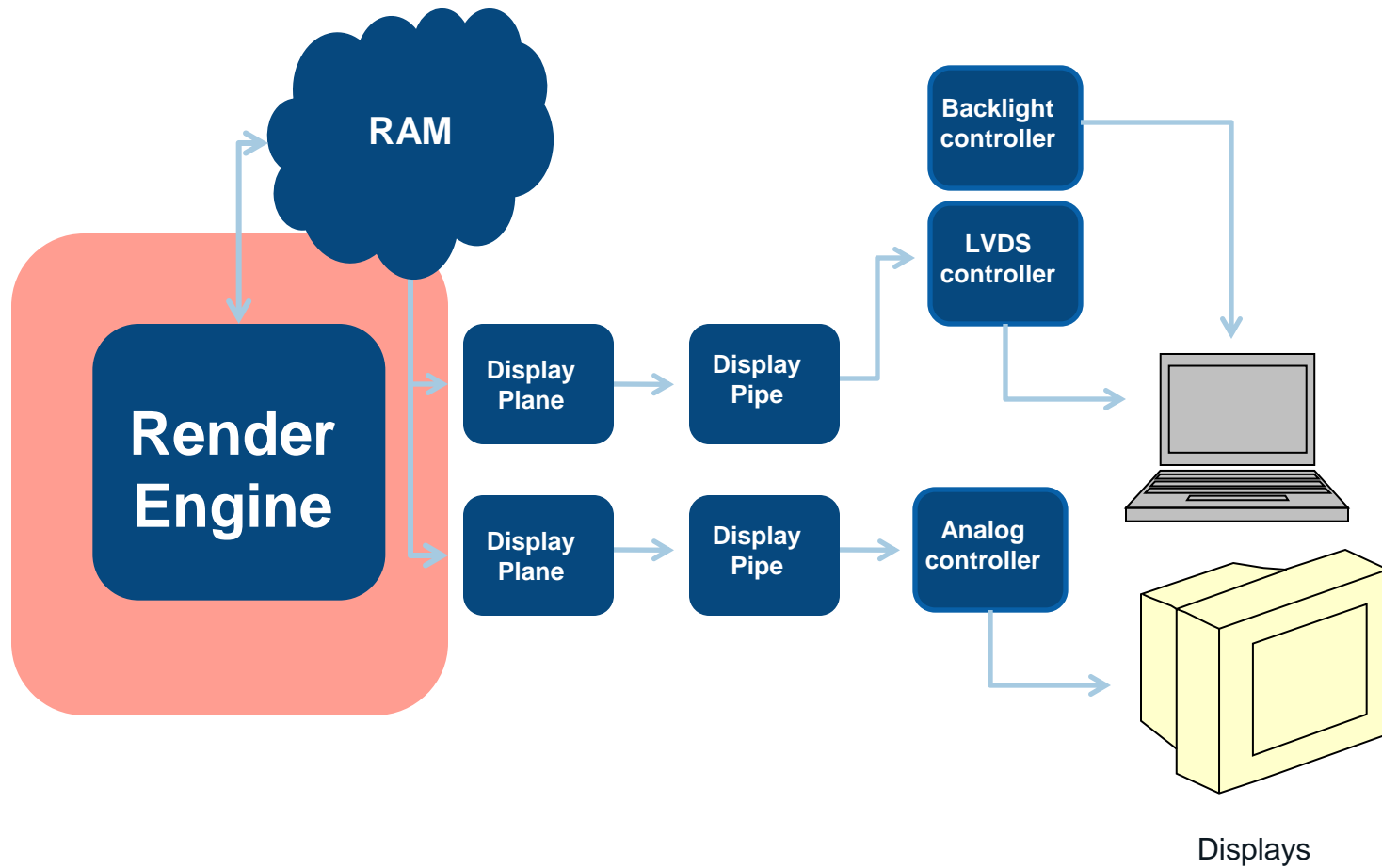
**Significant savings possible**

# Basic Data from 3 Platforms



**Keep display power down!**

# Render engine

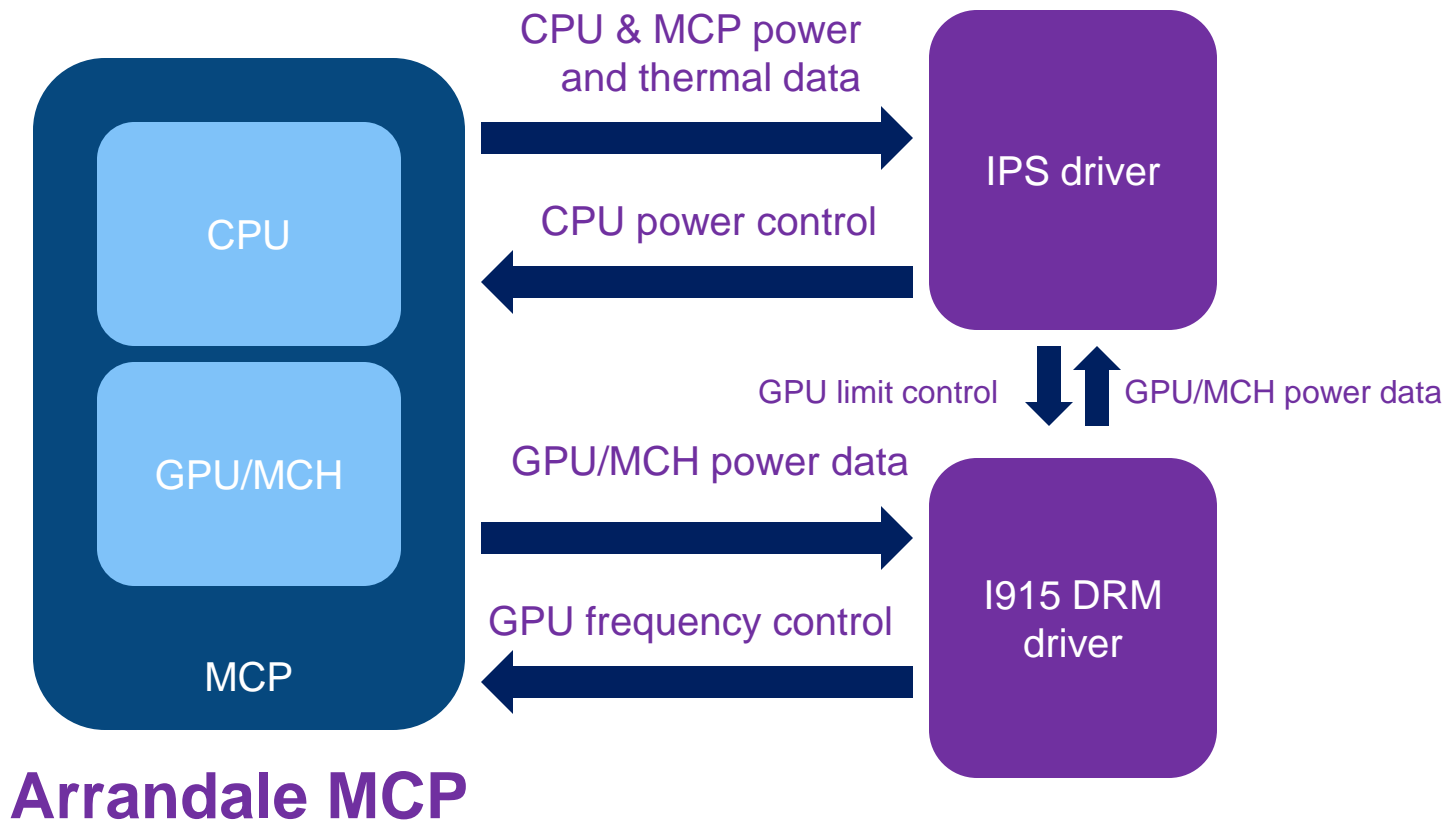


# Dynamic render clock control

- **Intelligent Power Sharing & Graphics Turbo**
  - Graphics turbo allows fine grained render clock frequency control on Ironlake
  - Intelligent power sharing can help maximize performance in a given TDP
- Can switch to low frequencies when load is low
- Can turn off render clock when idle
- Voltage automatically adjusted based on requested frequency
- Sandy Bridge does it all in hardware

**More work to do**

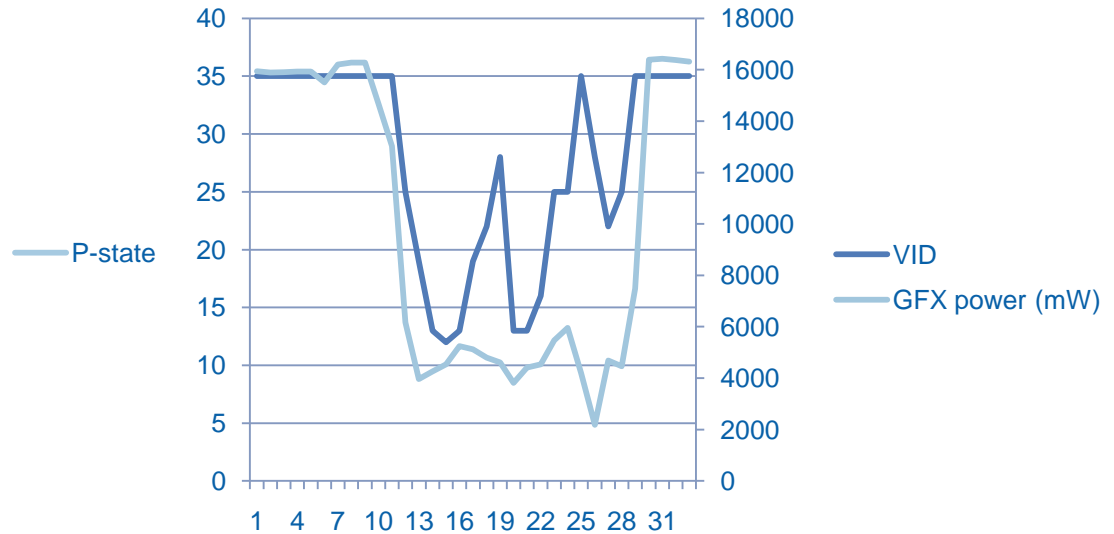
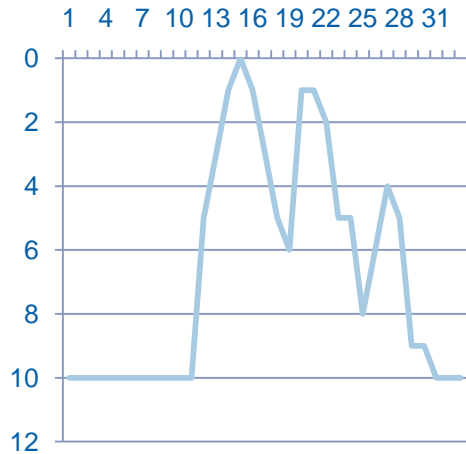
# Intelligent Power Sharing



**Goal is to maximize CPU and GPU performance in a given TDP**

# IPS & Graphics turbo

## P-state



OpenArena running 5-29s

(note power is reverse of what it should be!)

# Questions?

# Backup

# Power Analysis

- Display power saving is most significant
  - Dim backlight ASAP or just turn display off if off->on latency is low
  - Especially on platforms where self-refresh or FBC aren't available
- New platforms have better power control
  - Core i3/5/7, GM45 and 965 have working FBC and self-refresh
  - Significant power savings when CPU is in deep sleep state
  - Idle power very good, even competitive with 945

**Keep that display off!**

# IPS & Graphics turbo

- IPS core driver monitors CPU and GPU power and temperature
  - If CPU or GPU is busy and there's power and thermal headroom, allocate more power to the busy component(s)
  - Ratchet back CPU and/or GPU power consumption if near or at limits
  - Working with hardware guys to debug GPU power monitoring
- Graphics turbo
  - Program GPU to generate interrupts when certain activity thresholds are passed
  - Allows us to increase or reduce render clock frequency based on demand, to save power or increase performance (up to 15% in tests so far with IPS driver managing power)

**Graphics turbo in 2.6.34, IPS still in progress**

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