Intel® 865G Chipset Graphics and Memory Controller Hub (GMCH) with Intel® Extreme Graphics 2

White Paper

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Revision History

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1 Introduction

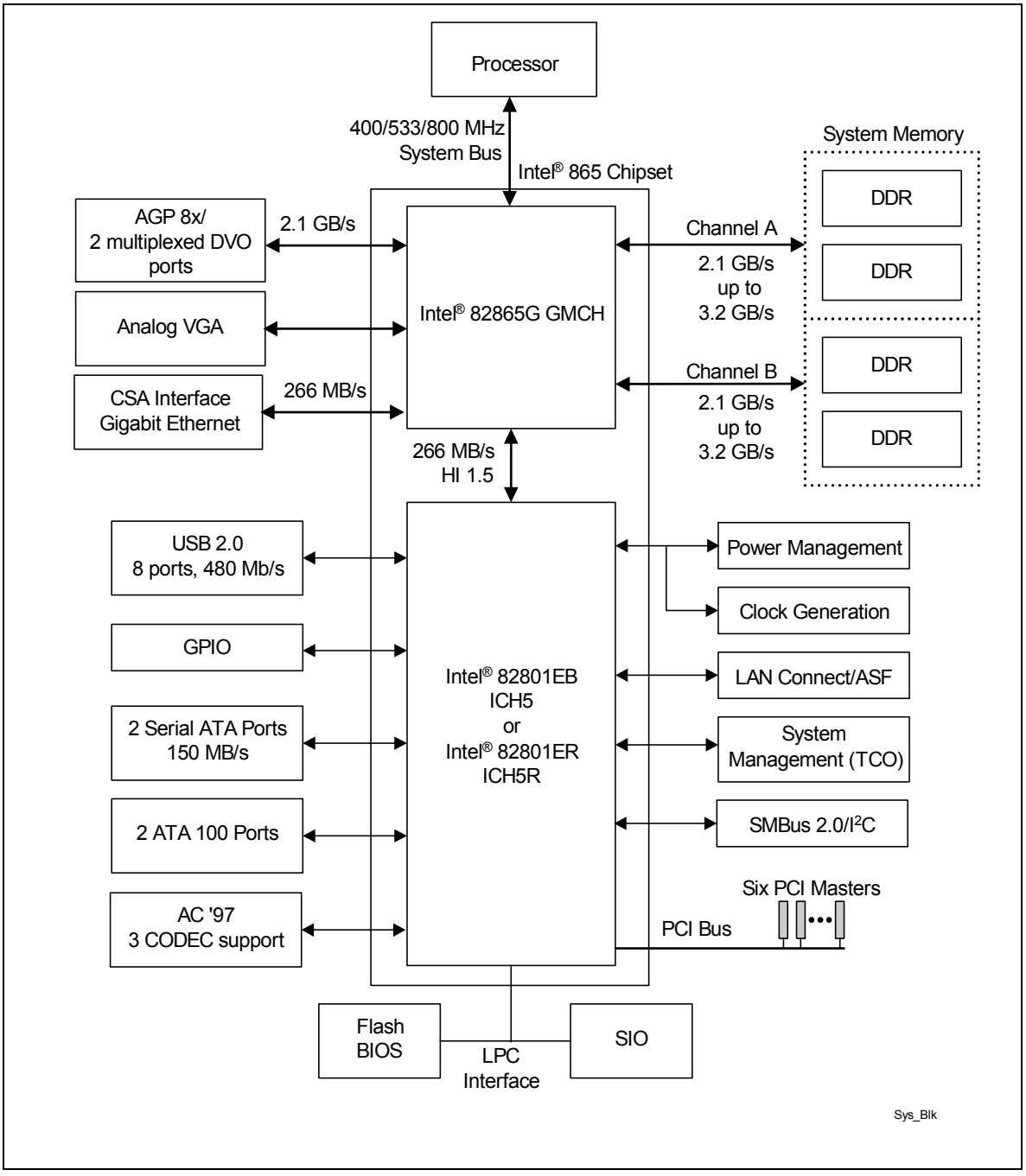
This document details the Intel® 865G chipset GMCH key benefits and operation. It is intended for a technical audience interested in learning about the 865G chipset architecture.

Please refer to the *Intel® 82801EB/ER I/O Controller Hub 5 (Intel® ICH5) / (Intel® ICH5R) White Paper*, http://developer.intel.com/design/chipsets/applnots/252729.htm for complete details on the I/O hub controller.

The 865G Graphics and Memory Controller Hub (865G GMCH) is Intel's first dual-channel memory controller hub with integrated Intel® Extreme Graphics 2 for the Intel® Pentium® 4 processor. The 865G GMCH, with its enhanced architecture graphics engine, delivers not only high 2D/3D graphics performance, but also provides an efficient high-bandwidth communication channel connecting the processor, system memory, CSA (Communications Streaming Architecture), I/O subsystem, and other components together to deliver a stable mainstream desktop platform solution. The 865G GMCH also provides an Accelerated Graphics Port interface for discrete AGP8X adapters, or conversion of the digital video output streams from the integrated graphics engine to NTSC signaling or digital flat panel modes.

Figure 1 illustrates how the 865G GMCH connects the processor and various components to make up a complete 865G-based desktop platform.

Figure 1. Intel® 865G Chipset Block Diagram



The introduction of the 865G GMCH brings high performance, flexibility and stability to Pentium 4 processor-based systems. The 865G GMCH supports a wide range of Pentium 4 processors, and provides system cost savings with its new integrated high-performance graphics engine. With the support of 400 MHz, 533 MHz and 800 MHz processor system bus, single- or dual-channel DDR266/333 or DDR400 system memory, integrated graphics core or discrete AGP4X/8X cards true Gigabit Ethernet through CSA, the 865G GMCH provides high system flexibility and scalability. In addition, the 865G-based platforms use a single, innovative Intel® software stack, adding stability to the whole platform.

1.1 Processor Interface

The 865G GMCH supports the host bus frequencies of 400 MHz, 533 MHz and 800 MHz using a scaleable VTT between 1.15 V – 1.55 V, which support a wide range of Pentium 4 processors. By providing a bandwidth of up to 6.4 GB/s with 800 MHz-enabled processors, the 865G GMCH delivers higher throughput when accessing memory and I/O devices to improve system performance. The 32-bit host addressing is supported, and up to 4 GB of the processor's memory address space is decoded. The 865G GMCH implements its own cache line size of 64 bytes to match the cache line size of the processor. This allows an entire 64-byte cache line to be transferred in 2 bus clocks, enabling faster data transfers for today's demanding applications. It also supports Dynamic Bus Inversion (DBI), which limits the number of data signals that are driven low on the bus on each data phase. This performance significantly decreases the power consumption of the 865G GMCH. In addition, the 865G GMCH host bus implements AGTL+ on die termination to help reduce the system BOM cost.

1.2 Memory Interface

The 865G GMCH memory interface is designed to be flexible and can be configured through a set of registers to support either single- or dual-channels of DDR (Double Data Rate)–266DDR, 333DDR or 400DDR SDRAM memory. This allows up to 6.4 MB/s of memory bandwidth available, providing a balanced platform. DDR memory capability supports two data operations being completed within one clock cycle, resulting in faster data transfer and higher memory bandwidth. This translates into twice the throughput of regular SDRAM. The 865G GMCH memory interface can support up to four double-sided DIMMS for a maximum of 4 GB of system memory. The memory technologies supported are 128-Mb, 256-Mb, and 512-Mb SDRAM technologies.

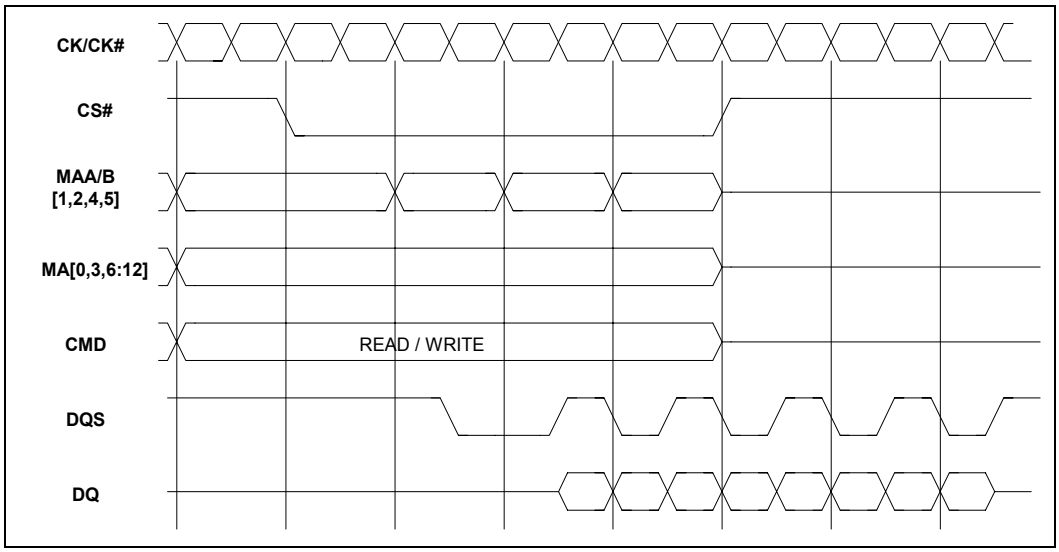
The 865G GMCH is equipped with many advanced system memory interface features to create a balanced performance environment for the platform. Twelve pairs of DDR system memory clocks are integrated into the GMCH. This eliminates the need for external memory clocks to the DIMMs, and allows better control of system timings for higher system robustness. The memory controller supports the memory thermal management capability that increases the system reliability by decreasing thermal stress on the system memory and the 865G GMCH. Suspend-to-RAM support allows for environmentally friendly and energy efficient systems by enabling lower power states when the system is idle.

With two 64-bit wide data channels, the memory controller supports up to 16 open pages (four per row, four rows) simultaneously in dual-channel mode and up to 32 open pages in single-channel mode, reducing the access time to system memory. The GMCH also supports Data Masking by providing eight additional data masking signals from the GMCH to memory. Byte writes of less than a QWord are allowed to increase memory bandwidth.

New to the 865G GMCH is support of dynamic mode. When used with matched SDRAM memory in either single- or dual-channel mode, the processor bus to memory Bus address mapping undergoes a significant change compared to when in a linear operating mode (normal operating mode). In linear operating mode, the ROW selection (ROW indicates the side of a DIMM) via chip select signals is performed based on the size of the ROW. In dynamic mode, the ROW selection signals are optimized based on DIMM type and organization, resulting in increased performance.

When the integrated graphics is implemented, the GMCH automatically supports selective command-per-clock through a set of independent address lines to the memory. These address lines enable CS# assertion in consecutive clocks as illustrated in the figure below. This eliminates a dead clock between consecutive QWord accesses, and allows the integrated graphics engine to access the system memory faster improving graphics performance.

Figure 2. Example of Selective Command-Per-Clock (CS# Asserted in Consecutive Clocks)



1.3 Hub Interface

The 865G GMCH utilizes the Hub Interface v1.5 protocol to connect to the I/O subsystem (Intel® 82801EB I/O controller hub, ICH5). The hub interface uses a 0.8 V ground-referenced swing and 1.5 V power source. This is different from the previous hub interface generation (hub interface 1.1) that requires a 1.8 V CMOS signaling. The voltage requirement change reduces the power consumption and simplifies the voltage regulator designs in the system. With a bandwidth of 266 MB/s and a point-to-point 8-bit data bus, the 865G GMCH hub interface provides high throughput to improve I/O performance.

1.4 CSA Port

The Communication Streaming Architecture (CSA) port is connected to the 865G GMCH and provides a dedicated interface for a Gigabit Ethernet device. The CSA Interface runs at 266 MB/s and is used as a dedicated connection between the two components. All the functions and protocols reside in the CSA device and in the GMCH. Gigabit Ethernet is the primary communication device connected to CSA. The device connects to the GMCH via the CSA interface to provide high bandwidth for data and control/status transfers.

1.5 Graphics

With end-users demanding a more realistic digital experience, Intel continues to evolve integrated graphics solutions designed to support today's complex graphics environment. Intel® Extreme Graphics 2 expands Intel's graphics core and delivers intense, realistic 3D graphics with sharp images, fast rendering, smooth motion, and incredible detail.

This unique architecture enables balanced memory usage between graphics and the system for optimal performance. Innovative technologies add new levels of both 2D and 3D graphic quality to integrated graphics chipsets:

- Enhanced Rapid Pixel and Texel Rendering
- Dynamic Video Memory 2.0
- Zone Rendering 2
- Intelligent Memory Management

The Extreme Graphics 2 core supports the latest 2D and 3D APIs, delivering real-life environment and character effects. A 256-bit internal path enables up to four textures per pixel on a single pass for super light maps, atmospheric effects, and more realistic surface details. Flexible display capabilities enhance the personal computing experience, offering significant benefits for applications requiring 32bpp and higher display resolution.

1.5.1 Intel® Extreme Graphics 2 Architecture

1.5.1.1 Enhanced Rapid Pixel and Texel Rendering Architecture

Rapid Pixel and Texel Rendering (RPTR) architecture allows for a reduction in the required memory bandwidth for operation in a variety of ways. The 256-bit 2D Block Level Transfer (BLT) engine allows for a much higher fill rate than previous 64-bit BLT engines. Dedicated non-blocking and multi-tier cache structures for textures, colors, Z and vertex rendering allow for more efficient access to pixel/texel data, which also results in increased memory efficiency. Single-pass quad-texture support, the ability to blend four textures on a single pass through the graphics engine, decreases the system memory overhead required to perform texture blend operations. Support for DXTn and FXT1 texture decompression on-chip reduces memory bandwidth required to read texture memory and reduces the amount of memory required for texture storage by allowing for up to 8x compression of texture data. Dynamic multi-context switching allows both 2D and 3D operations to be overlapped. The graphics core and switching between 2D and 3D operations without completing all operations of the same mode minimize the overhead required for

mode switches. Enhancements for the 865G chipset include added hardware support for A8, XRGB8888 and XBGR8888 texel formats which are supported both in D3D and OpenGL APIs. Hardware support for these formats reduces the time required to support these via the software driver. Additional new feature for 865G GMCH is support for linear gamma blending modes. These new functions have been added to permit higher quality image blending by performing the blending on colors in linear gamma space. The increased accuracy of colors allows the 865G GMCH to supports RGB as well as Microsoft's VMR XP.

For the 865G chipset, a new 4x4 programmable texture filter called Bi-Cubic Filter was added. A bi-cubic texture filter can be selected instead of the bilinear filter. This can be used to provide high quality up/down scaling of rendered 2D or 3D rendered images

1.5.1.2 Dynamic Video Memory Technology 2.0

Dynamic Video Memory Technology (DVMT) allows for up to 64MB of system memory to be shared among the operating system, applications, and graphics display. DVMT mitigates the need for additional stand-alone memory dedicated for graphics by allowing memory to be allocated for graphics usage as needed and re-allocated to the system once it is no longer needed. By re-allocating memory to the system, memory is freed up for other applications when not needed by the graphics subsystem. Thus, efficient memory usage is ensured for optimal graphics and system memory performance.

Refer to the Dynamic Video Memory Technology Whitepaper Revision 1.1 for more information.

1.5.1.3 Zone Rendering 2 Technology

Zone Rendering Technology is a unique technology developed by Intel that is used for rendering (drawing) 3D graphics scenes, addressing memory bandwidth limitations by reducing the required memory bandwidth for graphics. The 3D graphics engine divides the frame buffer into rectangular zones and then sorts the triangles into memory by zone. The 3D graphics engine then completely processes the zone, writing the pixel data to memory and then proceeds to the next zone. By processing only a single zone of the frame buffer at a time, the use of on-chip memory (cache) is highly optimized and each pixel in each scene is drawn only one time. As a result, the system memory bandwidth required to render each scene is greatly reduced. This ensures the most efficient system memory usage for optimal graphics and system memory performance.

Refer to the Zone Rendering Technology Whitepaper for more information.

Zone rendering 2 increases performance by increasing the size of the zone render blocks, which allows the GMCH to use optimal zone dimensions. These larger zones allow support of larger resolution images with higher performance, resulting in faster rendering of zones.

Zone Rending 2 also adds new commands to decrease the time required to execute each cycle.

1.5.1.4 Intelligent Memory Management

Intelligent Memory Management utilizes tiled memory addressing, deep display buffers, a dynamic data management scheme, and Unified Memory Architecture memory management to reduce the aggregate CPU latency and increase memory efficiency and performance. For the 865G GMCH, support for up to 6.4GB/s memory bandwidth, effectively eliminates graphics memory bottlenecks. The 865G GMCH has been optimized to take advantage of the greater memory bandwidth, the higher memory channel speed, as well as 800 MHz front side bus.

1.5.2 Flexible Display Solution

The 865G chipset offers innovative display capabilities allowing for maximum display flexibility. In addition to supporting CRTs via a VGA connector with a maximum pixel clock of 350 MHz (up to 2048x1536 resolution) and easy graphics upgrade-ability via a 1.5 V AGP connector, the 865G GMCH also allows for an easy upgrade to digital displays and TVs with AGP Digital Display (ADD) cards. The ADD cards utilize the Intel Extreme Graphics architecture to enable the support for TVs, LVDS and TMDS displays (Flat Panels, Digital CRTs, etc.). The 865G GMCH implements a multiplexed AGP and DVO interface allowing the support for ADD cards with no motherboard circuitry required other than an 1.5 V AGP Connector.

1.6 AGP Interface

The Intel® 865G GMCH AGP interface is designed to provide flexibility as well as performance. For users that demand the latest graphics cards, upgrade through supported AGP interface is simple. The interface supports 1.5 V and 0.8 V AGP transactions at 1X/4X/8X, as well as fast write transactions at 4X/8X speeds. This allows the 865G GMCH to be paired with today's highest performance standalone graphics solutions.

This interface also provides display flexibility when using the Intel Extreme Graphics 2 architecture. The AGP interface can be run in Intel® DVO mode – an innovative solution where the 865G GMCH can be paired with AGP Digital Display (ADD) cards to provide a variety of display solutions.

1.6.1 AGP Digital Display (ADD) Cards

The 865G GMCH is the first chipset to fully support ADD cards. ADD cards are designed to plug into a 1.5 V AGP connector but will be utilized by the 865G GMCH as a digital display upgrade. The cards make use of the multiplexed DVO ports from the Intel Extreme Graphics architecture to provide an easy upgrade path for display.

Through the use of ADD cards, 865G chipset systems can offer an easy and low-cost solution when Time Multiplexed Differential Signaling (TMDS), Low Voltage Differential Signaling (LVDS), or TV-Out displays are desired. The extra functionality associated with ADD cards requires no additional circuitry or design constraints on the motherboard. By using ADD cards, the 865G chipset offers system designers the following flexibility:

- No burden to the motherboard with additional circuitry or costs to support a variety of display options
- Does not require feature set tradeoffs on the motherboard or back panel in order to support a variety of display options
- Can utilize a single motherboard design to support a variety of display options. For example, by using ADD cards, a single motherboard can support: CRT only, DVI flat panel, CRT and Flat panel simultaneous, S-Video TV Out, etc.

For a listing of ADD Card vendors, please contact your local Intel representative.

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2 Summary

The 865G chipset enables ultimate flexibility with different system bus speeds, memory configurations, and graphics solutions. The 865G chipset supports the new 800 MHz system bus and 533 MHz and 400 MHz system bus, either DDR266/333 or DDR400 memory in single- or dual-channel mode, integrated graphics or discrete AGP8X cards. Intel 865G chipset-based platforms also offer integrated Hi-Speed USB 2.0, an enhanced AC ’97 audio implementation for improved sound quality and new audio usage models and high-performance network connections with up to 2 Gb/s LAN connectivity with a CSA device. The 865G chipset ensures that tomorrow’s applications will run best on Pentium 4 processor platforms.

The 865G chipset enables lower system price points with graphics and hi-speed USB 2.0 integration. The 865G chipset delivers a complete range of support for the Pentium 4 processor with integration of the enhanced Intel Extreme Graphics 2 core. This chipset is a great choice for users who want superb graphics quality for the latest digital entertainment without the complexity and cost of an add-in graphics card. It is also an ideal solution for business users who demand highly stable drivers and value the Intel® Stable Image Technology quality.