



Intel[®] 845G Chipset Graphics Memory Controller Hub (GMCH)

Whitepaper

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Revision History

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XXXX	1.0	Initial Release.	May 2002



1 *Document Purpose*

This document details the Intel® 845G GMCH key benefits and operation. It is intended for a technical audience interested in learning about the Intel® 845G chipset architecture.

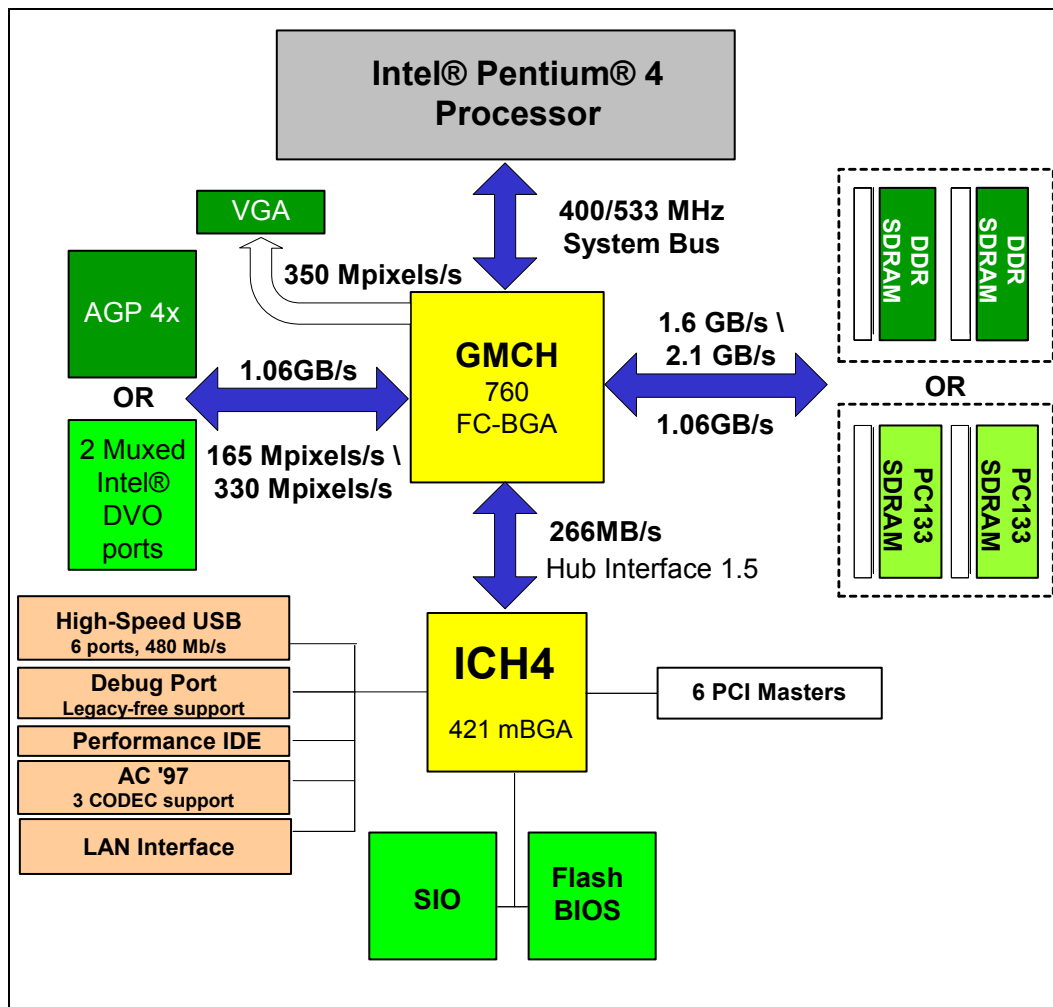
Please refer to the Intel® 82801DB (a.k.a. ICH4) Technical Whitepaper Revision. 1.0 for complete detail on the I/O Hub Controller.

2 Introduction

The Intel® 845G Graphics Memory Controller Hub (the 845G GMCH) is Intel's first memory controller hub with integrated graphics for the Intel® Pentium® 4 processor. The 845G GMCH, with its new architecture graphics engine, delivers not only high 2D/3D graphics performance, but also provides efficient, high bandwidth communication channels connecting the processor, the memory, the I/O subsystem, and other components together to deliver a stable mainstream desktop platform solution.

The block diagram below illustrates how the 845G GMCH connects the processor and various components to make up a complete 845G-based desktop platform.

Figure 1. Intel® 845G Chipset Block Diagram





The introduction of the Intel® 845G GMCH brings cost-effective, flexible and stable solutions to Pentium® 4 processor based systems. The 845G GMCH supports a wide range of Intel® Pentium® 4 processors, and provides system cost savings with its new integrated high performance graphics engine. With the support of a 400MHz or 533MHz processor system bus, DDR200/266 or PC133 memory, and integrated graphics or AGP cards, the 845G GMCH provides high system flexibility and scalability. In addition, the 845G-based platforms use a single, innovative Intel software stack, adding stability to the whole platform.

3 *Processor Interface*

The Intel® 845G GMCH supports the host bus frequencies of both 400 MHz and 533 MHz using a scaleable V_{tt} between 1.15V - 1.75V, which support a wide range of Intel® Pentium® 4 processors. By providing a bandwidth of up to 4.2GB/s with 533MHz-enabled processors, the 845G GMCH delivers higher throughput when accessing memory and I/O devices to improve system performance. 32-bit host addressing is supported and up to 4 GB of the processor's memory address space is decoded. Matching the cache line size of the processor, the 845G GMCH implements its own cache line size of 64 bytes. This allows an entire 64-byte cache line to be transferred in 2 bus clocks and enables faster data transfer for today's system performance demand. 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 significantly decreases the power consumption of the 845G GMCH. In addition, the 845G GMCH host bus implements AGTL+ on die termination to help reducing the system BOM cost.

4 Memory Interface

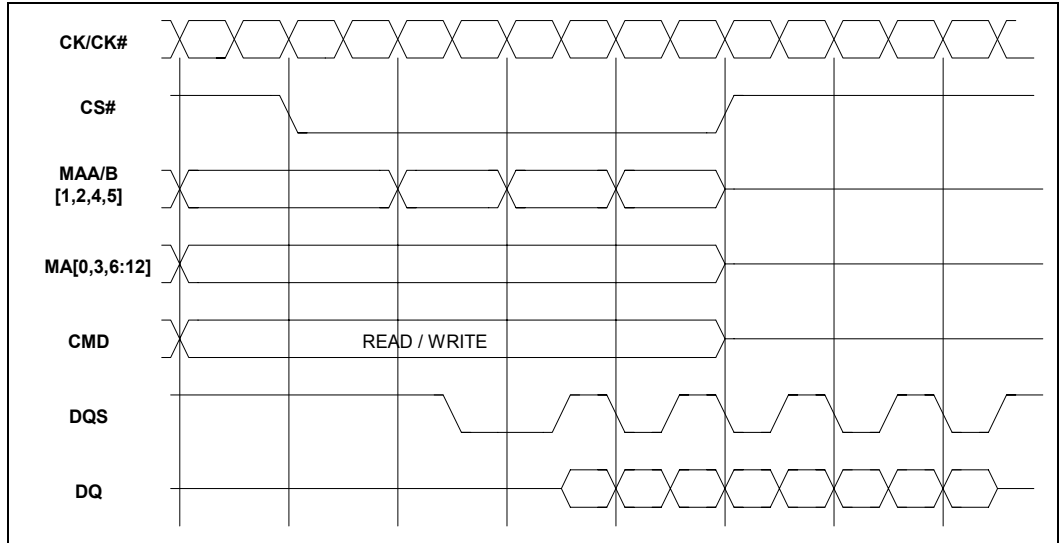
The 845G GMCH memory interface is designed to be flexible and can be configured through a set of registers to support one channel of either DDR (Double Data Rate) 266 or 200, or PC133 SDRAM memory. DDR memory capability supports two data operations being completed within one clock cycle, resulting in faster data transfer and higher memory bandwidth. This results in 2x the throughput of regular SDRAM. The memory interface can support up to 2 double-sided DIMMS for a maximum of 2GB of total system memory. The interface supports 64-Mb, 128-Mb, 256-Mb, and 512-Mb SDRAM technologies for current and future demands.

The 845G GMCH is equipped with many advanced system memory interface features to create a balanced performance environment for the platform. Six 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 which increases the system reliability by decreasing thermal stress on the system memory and the Intel® 845G GMCH. Suspend-to-RAM support allows for environmentally friendly and energy efficient systems by enabling lower power states when the system is idle.

With 64-bit wide data channel, the memory controller supports up to sixteen simultaneously open pages (four per row, four rows maximum), and reduces the access time to the system memory. The GMCH also supports Data Masking. By providing an additional 8 data masking signals from the GMCH to memory, byte-wise writes of less than a Quad-Word are allowed to increase memory bandwidth.

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

Figure 2. Example of Selective Command-Per-Clock (CS# asserted in consecutive clocks)



5 *Hub Interface*

The Intel® 845G GMCH utilizes the hub interface 1.5 protocol to connect to the I/O subsystem (Intel® 82801DB I/O Controller Hub, a.k.a. ICH4). The Hub interface uses a 0.7V ground-referenced swing and 1.5V power source. This is different from the previous hub interface generation (hub interface 1.1) which requires a 1.8V CMOS signaling. The voltage requirement change reduces the power consumption and simplifies the voltage regulator designs in the system. With a bandwidth of 266MB/s and a point-to-point 8-bit data bus, the 845G GMCH hub interface provides high throughput to improve I/O performance.

6 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 is a revolutionary graphics core that 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:

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

The Extreme Graphics 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.

6.1 Intel® Extreme Graphics Architecture

6.1.1 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 dedicated 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 4 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 switch between 2D and 3D operations without completing all operations of the same mode minimize the overhead required for mode switches.

6.1.2 Dynamic Video Memory Technology

Dynamic Video Memory Technology (DVMT) allows for up to 48MB 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](#) for more information.

6.1.3 Zone Rendering 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.

6.1.4 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.

6.2 Flexible Display Solution

The Intel® 845G 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 350MHz (up to 2048x1536 resolution) and easy graphics upgrade-ability via a 1.5V AGP connector, the 845G 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 845G GMCH implements a multiplexed AGP and DVO interface allowing the support for ADD cards with no motherboard circuitry required other than an 1.5V AGP Connector.

7 AGP Interface

The Intel® 845G 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 1.5v AGP transactions at 1x/2x/4x, as well as Fast Write transactions at 2x/4x speeds. This allows the 845G GMCH to be paired with today's highest performance standalone graphics solutions.

This interface also provides display flexibility when using the Intel® Extreme Graphics architecture. The AGP interface can be run in Intel® DVO mode - an innovative solution where the 845G GMCH can be paired with AGP Digital Display (ADD) cards to provide a variety of display solutions.

7.1 AGP Digital Display (ADD) Cards

The Intel® 845G GMCH is the first chipset to fully support ADD cards. ADD cards are designed to plug into a 1.5v AGP connector but will be utilized by the Intel® 845G 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. The cards will only be detected by Intel® GMCHs that support ADD cards, such as the 845G.

Through the use of ADD cards, Intel® 845G systems can offer an easy and low-cost solution when TMDS (DVI), 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 Intel® 845G offers system designers the following flexibility:

- Don't need to burden the motherboard with additional circuitry or costs to support a variety of display options
- Doesn't 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 refer to <http://developer.intel.com>



8 *Summary*

The Intel® 845G chipset enables ultimate flexibility with support for the new 533MHz system bus and the 400MHz system bus, with either DDR200/266 or PC133 SDRAM memory and an AGP4X port for graphics upgrade-ability. Intel® 845G chipset-based platforms also offer integrated Hi-Speed USB 2.0, and an enhanced AC'97 audio implementation for improved sound quality and new audio usage models. The Intel® 845G chipset ensures that tomorrow's applications will run best on Pentium® 4 processor platforms.

The Intel® 845G chipset is critical to continue the success of Intel's Breakaway strategy, by enabling lower cost system price points with graphics and hi-speed USB 2.0 integration. The Intel® 845G chipset delivers a complete range of support for the Intel® Pentium® 4 processor with integration of the revolutionary Intel® Extreme Graphics 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.