Intel C2000 Atom Microserver

Power Efficient Processing for the Data Center

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Intel Corporation - Server Architecture

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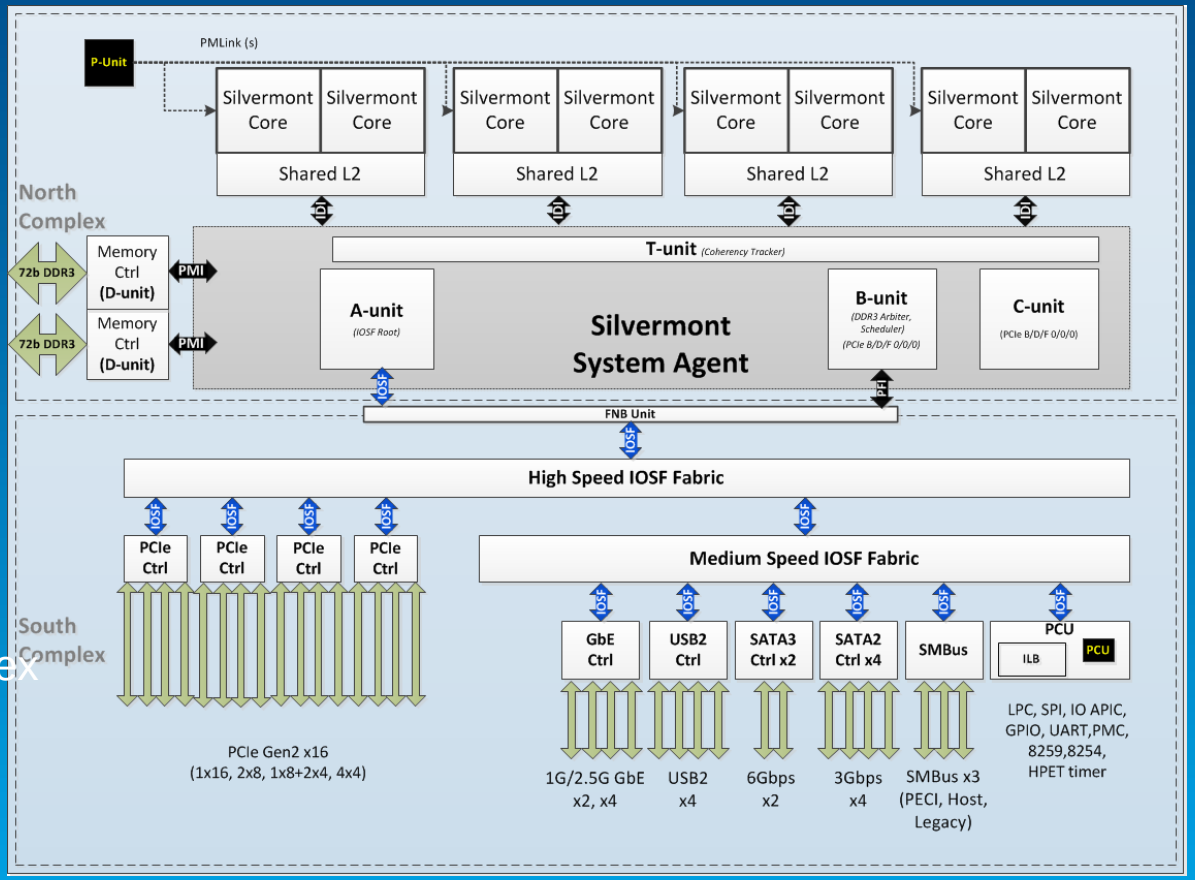
- Requires a system with a 64-bit enabled processor, chipset, BIOS and software. Performance will vary depending on the specific hardware and software you use. Consult your PC manufacturer for more information. For more information, visit http://www.intel.com/info/em64t

Introducing Avoton

- Intel's second generation 64-bit server SOC
  - Manufactured in Intel's low power SOC 22nm process
  - Combining Intel's server expertise with our client/mobile SOC building blocks and processes
- Based on the next-generation Intel Atom known as Silvermont
- Focused on enabling high density with high performance
  - 2, 4, and 8C SKUs at 5-20 Watts targeting scale out workloads
  - An Industry leading performance and performance per watt efficiency at high densities
- Targets the growing micro server and storage segments to provide IA solutions in the data center from top to bottom

Avoton Diagram

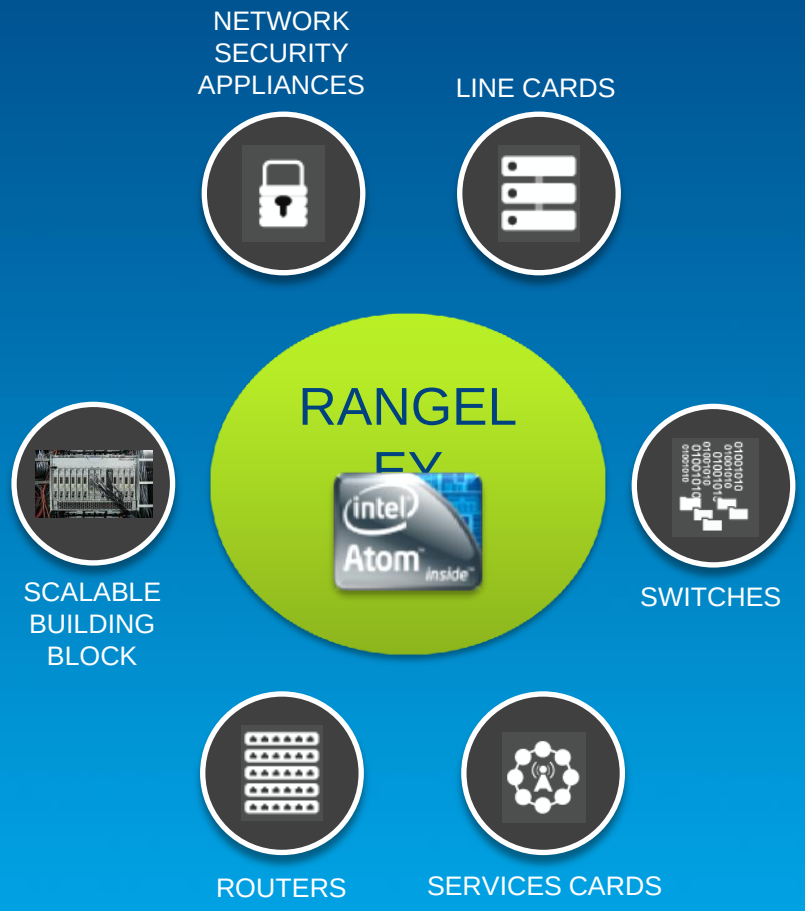
- 2-8 Silvermont Cores
  - Shared 1MB L2 / module
  - Up to 2.4GHz + Turbo
  - OOO architecture
- Silvermont System Agent
  - Up to 25.6GB/s BW
  - Crossbar Architecture
  - Goodbye FSB, hello IDI
- Fully Integrated South Complex
  - **I**ntel **O**n-chip **S**ystem **F**abric
  - Enterprise PCIe and GbE
- x86 Software Compatibility



intel Look Inside.™

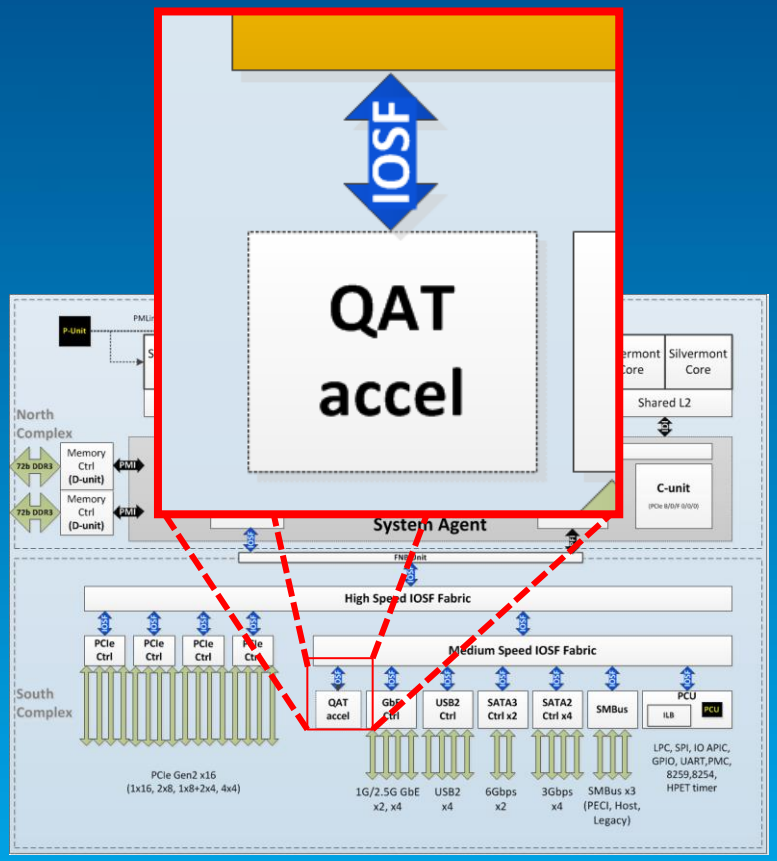
Introducing Rangeley

- Rangeley is the Comms Infrastructure derivative of Avoton
- Extends the Avoton baseline with:
  - Comms reliability profile
  - Longer product lifecycle
  - Enhanced Thermal Profiles
  - QuickAssist Technology to accelerate communications workloads



Rangeley: Accelerating Communications Workloads

- Rangeley enables acceleration through software & hardware innovations
- Intel® Data Plane Development Kit (DPDK) provides:
  - Open Source Data Plane libraries optimized for Rangeley HW
  - Low-overhead run-time environment
- Intel® QuickAssist Technology (QAT)
  - Intel API to QAT accel HW and Intel optimized SW
  - Enabled for direct access or via open source frameworks
  - Integrated hardware acceleration including
    - Ciphers: AES, DES/3DES, Kasumi, RC4, Snow3G
    - Authentication: MD5, SHA1, SHA2, AES-XCBC
    - Public Key: Diffie-Hellman, RSA, DSA, ECC



Silvermont Micro-Architecture

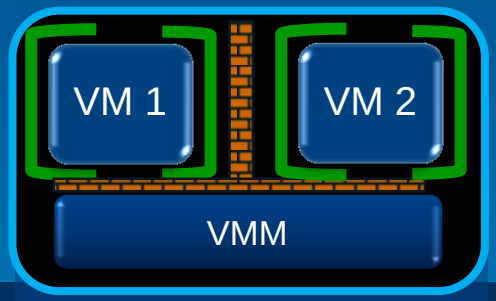
BENEFITS	FEATURES
High Performance Without Sacrificing Power Efficiency	Out-of-Order Execution Pipeline Macro operation execution pipeline Improved instruction latencies and throughput Smart pipeline resource management
Power and Performance Improvements	Efficient Branch Processing Accurate branch predictors Fast recovery pipeline
Fast and Efficient Access to Memory	Low Latency, high bandwidth caches Out of order memory transactions Multiple advanced hardware prefetchers Balanced core and memory subsystems IDI replaces lower performing Front-Side Bus

Up to 2X the Single Threaded Performance or 5X Lower Power [1]

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products.. For more information go to http://www.intel.com/performance.

1Lower power statement based on the geometric mean of a variety of power and performance measurements across various benchmarks. Benchmarks included in this geomean are measurements workloads including on SPECint* rate_base2000 & SPECfp* rate_base2000; EEMBC* workloads including CoreMark*; SunSpider* and page load tests on Internet Explorer*, FireFox*, & Chrome*; Dhrystone*; Android* workloads including CaffineMark*, AnTutu*, Linpack* and Quadrant* as well as measured estimates; on Silvermont preproduction systems compared to Atom processor Z2580. Individual results will vary. SPEC* CPU2000* is a retired benchmark. * Other names and brands may be claimed as the property of others. 2X configuration: SPECint*_rate_base2006: Atom S1260(8GB,HDD), Atom C2750(16GB, HDD).

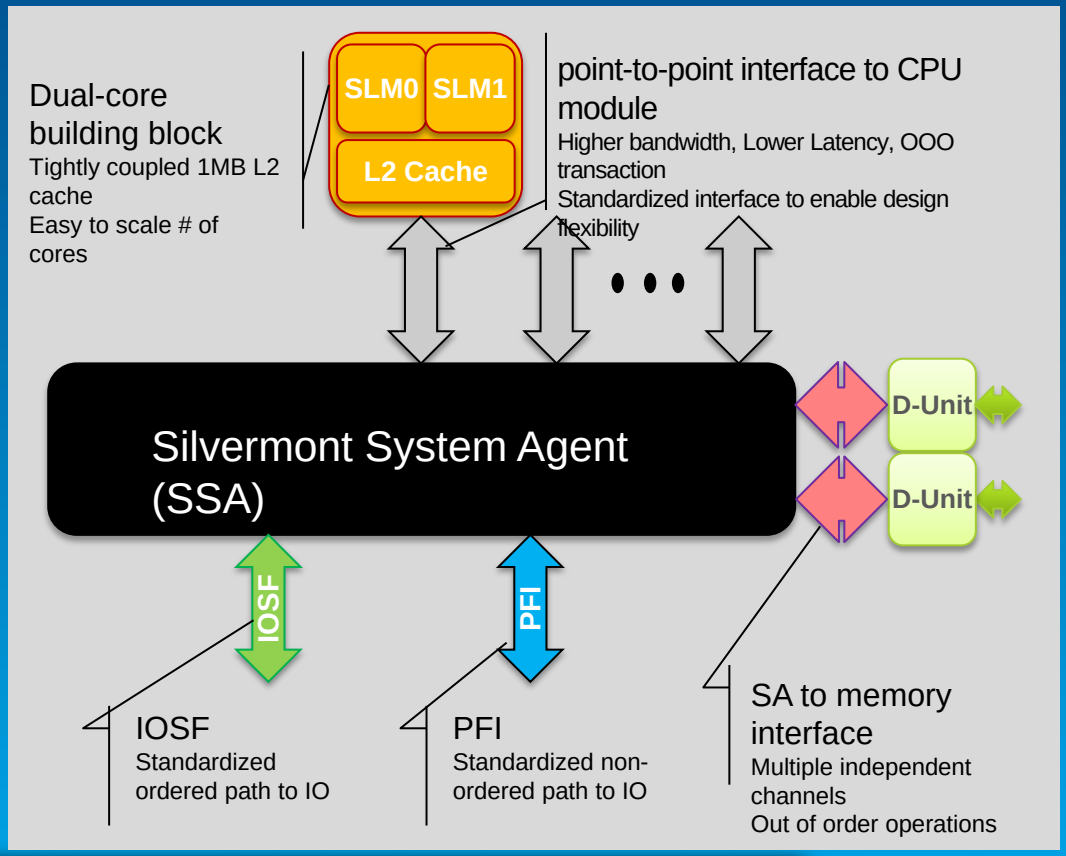
The Evolving Atom Architecture:
New Instructions and Technologies

	Performance	Virtualization	Security
			
New Instructions	Intel® Core™2 64b ISA + Core™ Westmere SSE4.1, SSE4.2, POPCNT, PREFETCHW	VMFUNC enables guest code to invoke VM Function	Intel® Core™ Westmere AES-NI, PCLMULQDQ Intel® Secure Key (RDRAND)
New Technologies	Real Time Instruction Tracing TSC Deadline Timer	Intel® VT-x2: Extended Page Tables Virtual Processor IDs Unrestricted Guest	Intel® OS Guard

Fully Compatible with the Breadth of IA Software Installed Base

Silvermont System Agent (SSA):
Enabling Multicore Atom SOCs

- Focused on modular design and scalability
- Datapath to System Memory
- SSA manages cache coherency
- NHM-style crossbar architecture
- IO Root and path to IO for Cores
- Path for interrupts to Cores



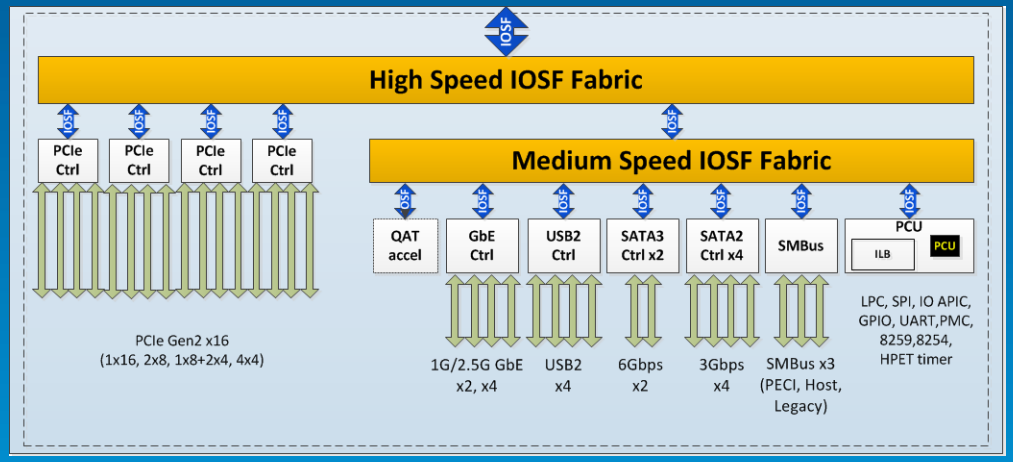
Balanced Core and Memory Subsystem for Bandwidth and Power

Avoton Memory Technology

- Avoton supports 1or 2 channels of DDR3/DDR3L
  - Speeds up to 1600 MT/s
  - 25.6 GB/s of peak bandwidth
  - Capacity of up to ***64GB*** (using 2DPC UDIMM/S0-DIMMs per channel)
- Enterprise class features include:
  - Robust DRAM failure protection including:
    - ECC (SEC-DED)
    - Patrol and Data Scrub Capabilities
  - Internal data path parity protection (to IO or Core)
  - Low power modes (CKE, self-refresh, thermal management)
  - Data Scrambler for signal integrity and basic data protection

Intel On-chip System Fabric (IOSF):
A scalable IO Fabric with IA compatibility

- Intel's converged infrastructure for SOCs
  - Enabling greater reuse across client and now server designs
  - Highly scalable for performance, power and connectivity
- Unique benefits of IOSF
  - Fully supports PCIe headers and ordering rules
  - Supports existing software and OSes without modification



IOSF merges the best features of PCIe and other SOC fabrics

Integrated Enterprise Ethernet

- Based on Intel's Powerville (i350) design
  - widely deployed Ethernet solution
  - Supported by existing software installs
  - Integration drives lower power & higher density vs. LOM solution
- Extended to provided greater backplane bandwidth with 2.5GbE
- Enables in-band management via SMBus or NC-SI to BMC or MMC to reduce TCO
- PCIe AER implementation provide server RAS capabilities

Components / Features	Powerville	Avoton Integrated Powerville
Host Interface	PCIe Gen2(5.0GT/s)	Internal SoC Fabric
# of ports	4 (no PCIe bridge) and 2	4
Package	17x17mm and 25x25mm	Integrated into Avoton
Peak Throughput	1000BaseX: 1 Gbps per port (max of 4Gbps)	1000BaseX: 1 Gbps per port (max of 4Gbps) 2500BaseX: 2.5 Gbps per port (max of 10Gbps)
VMDq	8 per port	
IO Virtualization (SR-IOV / VMDc)	1 PF, 8 VFs per Port	N
Jumbo Frames	9KB	
#queues/port	8 queues/port	
MSI-X, LLI	Yes	
Manageability	SMBus, NC-SI, WOL	SMBus, NC-SI, WOL
IEEE 1588	Yes (per packet)	
Environmental	RoHS, HF	
L2 MAC address Filters	32	
MAC / VLAN Anti-spoofing	Y	
Auto-ARP	Y	
Integrated Cu PHY	Y	N (external)

Integrated High-Speed IOs

- 16 lanes of PCIe enabling flexible connectivity
  - Gen2 bandwidth providing up to 80Gbps (~64Gbps effective) total bandwidth
  - 4 enterprise class PCIe Root Ports
  - Supporting full bifurcation: 1x16, 2x8, 1x8, 2x4, 4x4
    - Degraded mode down to x1 lanes per RP
  - 256B Max Payload Size with Efficient TLP packing
- 6 total lanes of SATA
  - 2 ports support of SATA 3 achieving 6 Gbps bandwidth
    - Capitalizing on increased SSD capabilities
  - 4 ports support of SATA 2 achieving 3 Gbps bandwidth
    - Providing broader connectivity for rotational storage

PCH Integration

Interface	Capabilities
USB2	• 4 ports USB 2.0, 1.1 • EHCI controller with RMH
Intel (x86) Software Compatibility	• Provides full compatibility with existing software • RTC, 8254, 8259, IO APIC, LPC, HPET, UART, SPI
Power Management Controller	• PMC to control handshakes with platform • Drive full node power flows • 8051-based controller with secure patch capabilities
SMBus controllers	Support for 3 SMBus interfaces (beyond GbE): • Legacy uses (SPD presence detect, platform sensors) • PECI over SMBus • HOST master

Traditional IA feature set provides software compatibility and usability

Silvermont: A Big Step Forward

Saltwell vs. Silvermont

Silvermont provides a tremendous performance lift over the previous generation (Saltwell)

Combined with Avoton's increased integration, improved system agent and improved memory system, Avoton achieves significant gains over Centerton

Based on the geometric mean of a variety of power and performance measurements across various benchmarks. Benchmarks included in this geomean are measurements on browsing benchmarks and workloads including SunSpider* and page load tests on Internet Explorer*, FireFox*, & Chrome*; Dhrystone*; EEMBC* workloads including CoreMark*; Android* workloads including CaffineMark*, AnTutu*, Linpack* and Quadrant* as well as measured estimates on SPECint* rate_base2000 & SPECfp* rate_base2000; on Silvermont preproduction systems compared to Atom processor Z2580. Individual results will vary. SPEC* CPU2000* is a retired benchmark. * Other names and brands may be claimed as the property of others.

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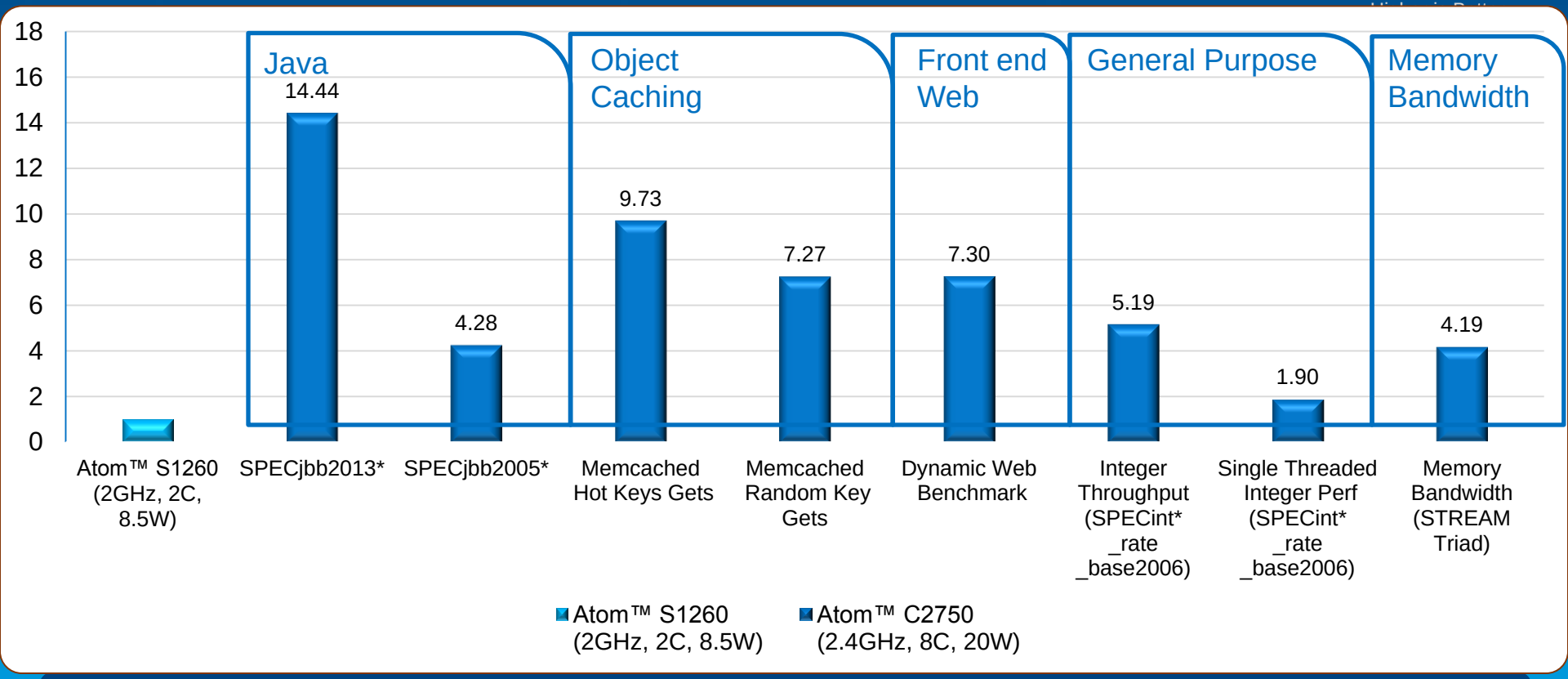
Intel® Atom™ C2000 Processor Family

- Preliminary Performance Summary - Single node

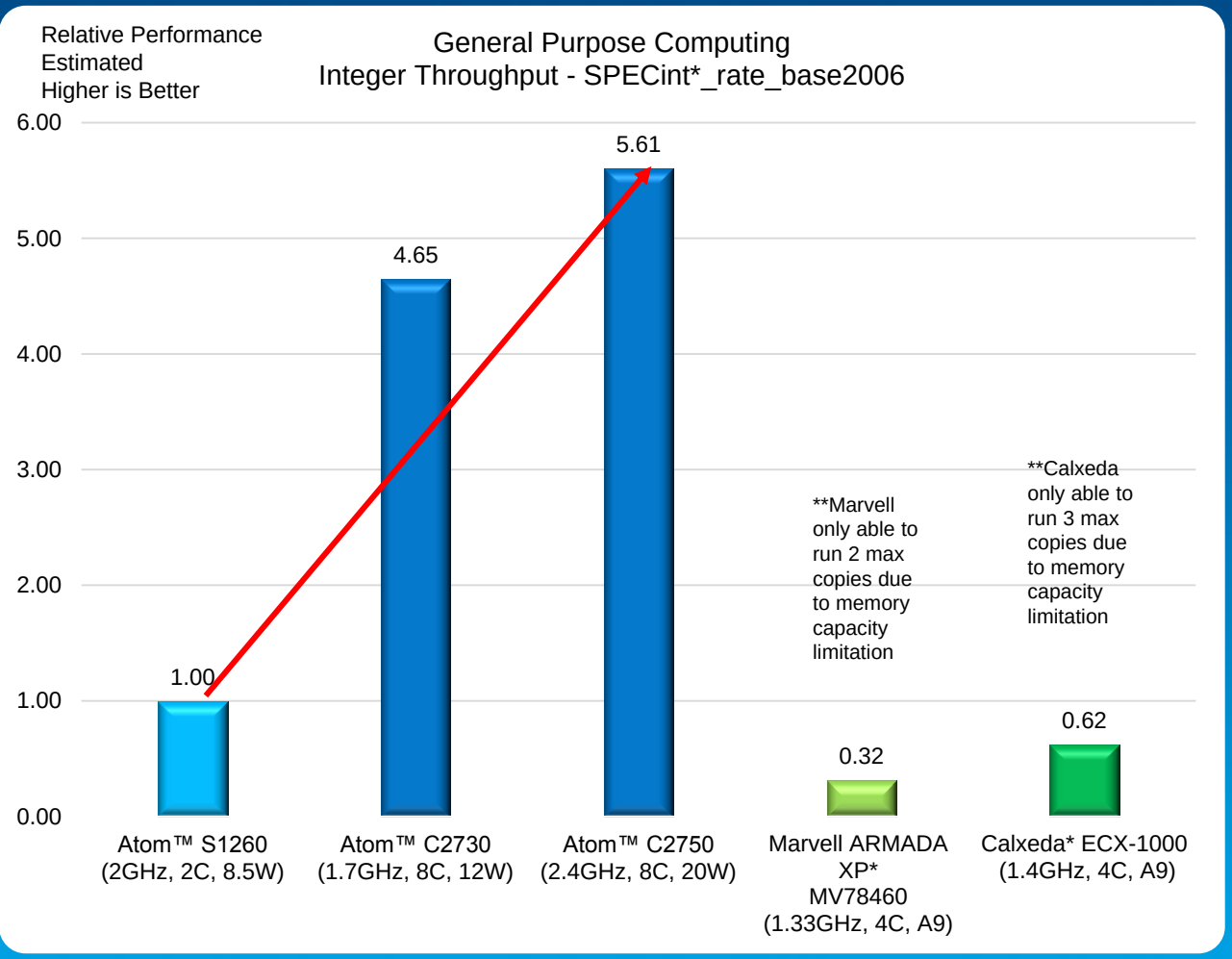


Intel® Atom™ processor C2750 delivers performance gains up to 14X

Configuration: SPECjbb2003/2013: Atom S1260(8GB,HDD),Atom C2750(16GB,HDD). Memcached v1.4.15:Atom S1260(8GB,2xHDD),Atom C2750(8GB,1xHDD). Dynamic Web Benchmark:Atom S1260(8GB,SSD,1GbE),Atom C2750(32GB,SSD,10GbE). SPECint_rate_base2006:Atom S1260(8GB,HDD),Atom C2750(16GB, HDD). STREAM:Atom S1260(8GB,HDD),Atom C2750(32GB, HDD). Intel Internal measurements as of July 2013. Results are estimated by Intel using the SPEC benchmark software cited and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.. Refer to backup for additional details.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to

Intel® Atom™ C2000 Processor Family
General Purpose Computing Performance

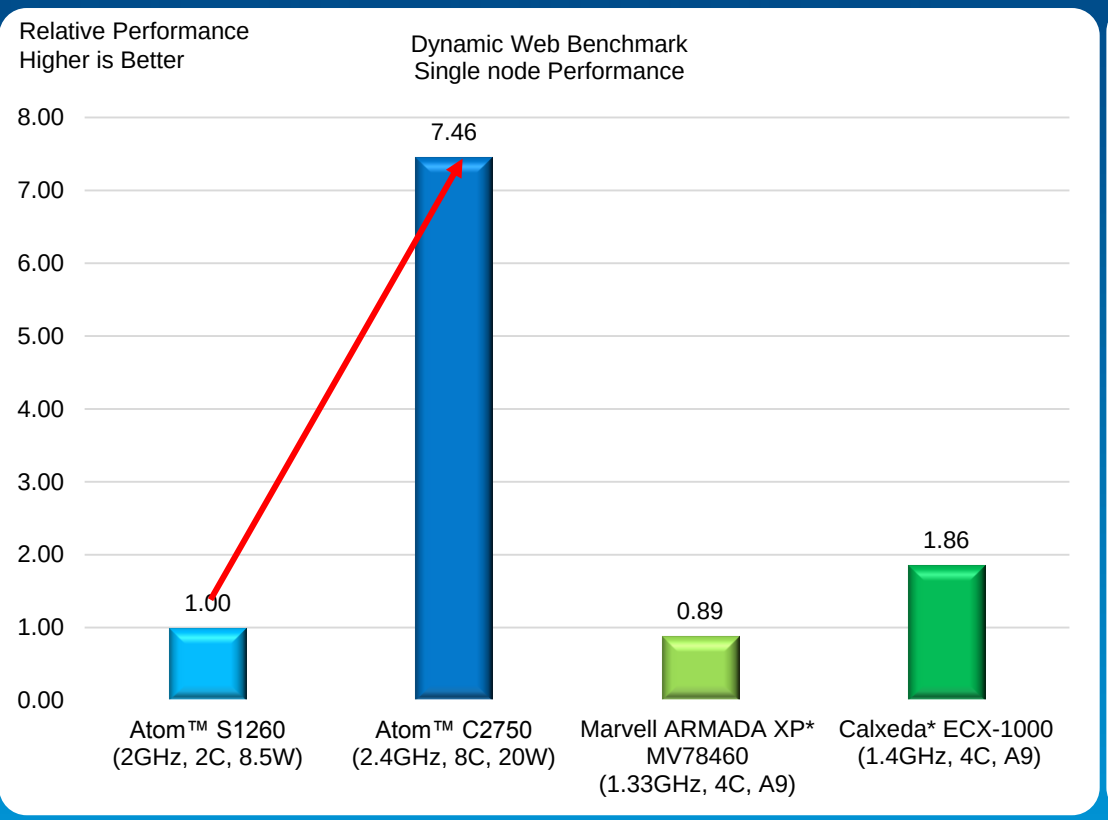


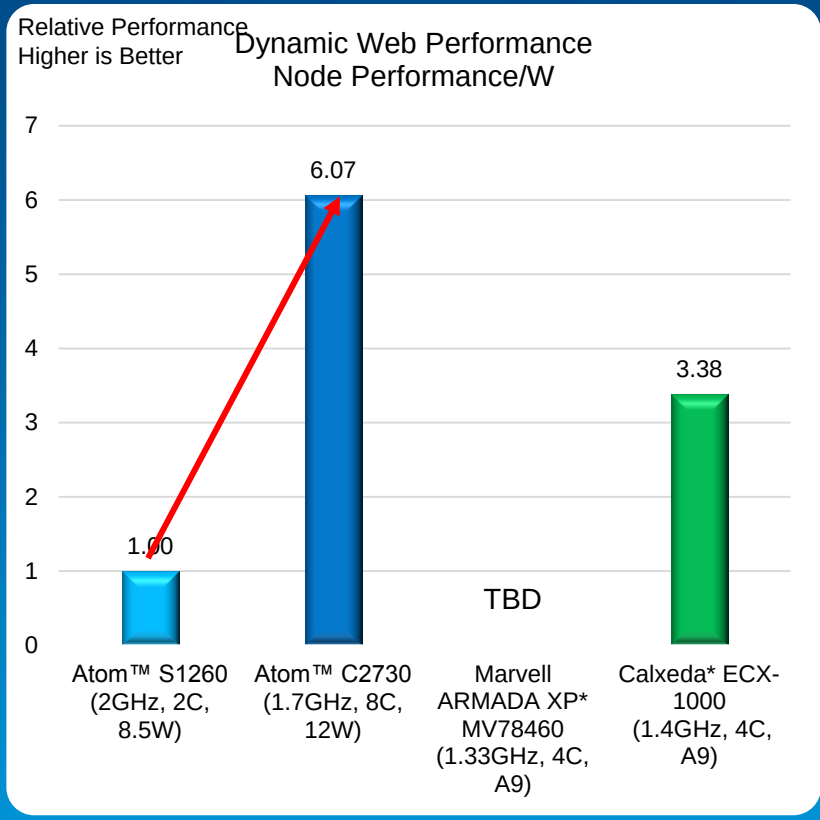
SPEC CPU2006:

- Measures integer and floating point operations performance
- Contains 12 integer and 17 floating point applications
- Compute intensive, concentrates on the CPU and memory
- Disk I/O and network not measured
- “Rate" determines the throughput, i.e. how many tasks can be completed in parallel.

Configuration: SPECint*_rate_base2006: Atom S1260(8GB,HDD), Atom C2750/C2730(16GB, HDD), Marvell Armada (4GB,HDD), Calxeda ECX-1000 . Intel Internal measurements as of September 2013. Refer to backup for additional details. * Other names and brands may be claimed as the property of others.

Intel® Atom™ C2000 Processor Family
Front Web Performance (PHP on LAMP)





Dynamic Web Benchmark:

- Measures build and serve web page interface using the LAMP stack
- LAMP combination of free and open source software
- Principle components to build a web server:

  LAMP = **L**inux (operating system) **A**pache (HTTP server) **M**ySQL (database s/w) **P**HP, Perl, or Python

Configuration: Dynamic Web Benchmark: Atom S1260(8GB,SSD,1GbE), Atom C2750(32GB, SSD,10GbE), Marvell Armada(4GB,,HDD,1GbE), Calxeda ECX-1000 (4GB,SSD,1GbE). Intel Internal measurements as of August 2013. Refer to backup for additional details.

How did we get here?
Combination of Process Technology + Architecture

The Silvermont Core

Major performance improvements were achieved with power-efficiency as the primary goal

Process Technology Leadership w/ 1271

AVN uses the same SOC base process as phones/tablets

- Super-low leakage
- Different optimization point than used on Xeon line
- Not as high frequency, but better power efficiency
- Collaboration with the Fab to tweak/tune to optimal behavior

Leveraging Expertise from Across the Company

Leveraging the low-power techniques and HW from SOC's

Bringing together the knowledge from Xeon, Client, Tablets, and Phones

Consistency Across Product Lines

Algorithmic and Interface Consistency w/ XEON®

Enables server OEMs to leverage data-center infrastructure

Socket RAPL and Turbo – Same base algorithm/interface as SNB/IVB

Same architectural PECI interfaces for power/thermal management/optimization

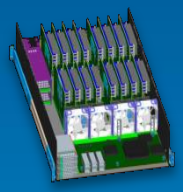
Improved memory thermal management for dense deployments

SOC Power Management for Servers

- PCIe L1, Power-off
- SATA2/3 Partial/Slumber/Power-off
- Ethernet “EEE” w/ Cu PHY, P2, Power-off
- USB Suspend, Power-off
- Gating of unused IO’s

50+ Atom C2000 System Designs

Microserver



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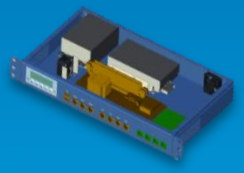
Entry Network



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Cold Storage

ASRock · CETC · DELL · HUAWEI · FOXCONN · inspur 浪潮 · NEWISYS · SANMINA · 中科曙光 Sugon · TYAN · Quanta (Optimize Your Datacenter) · wiwynn · zt Systems

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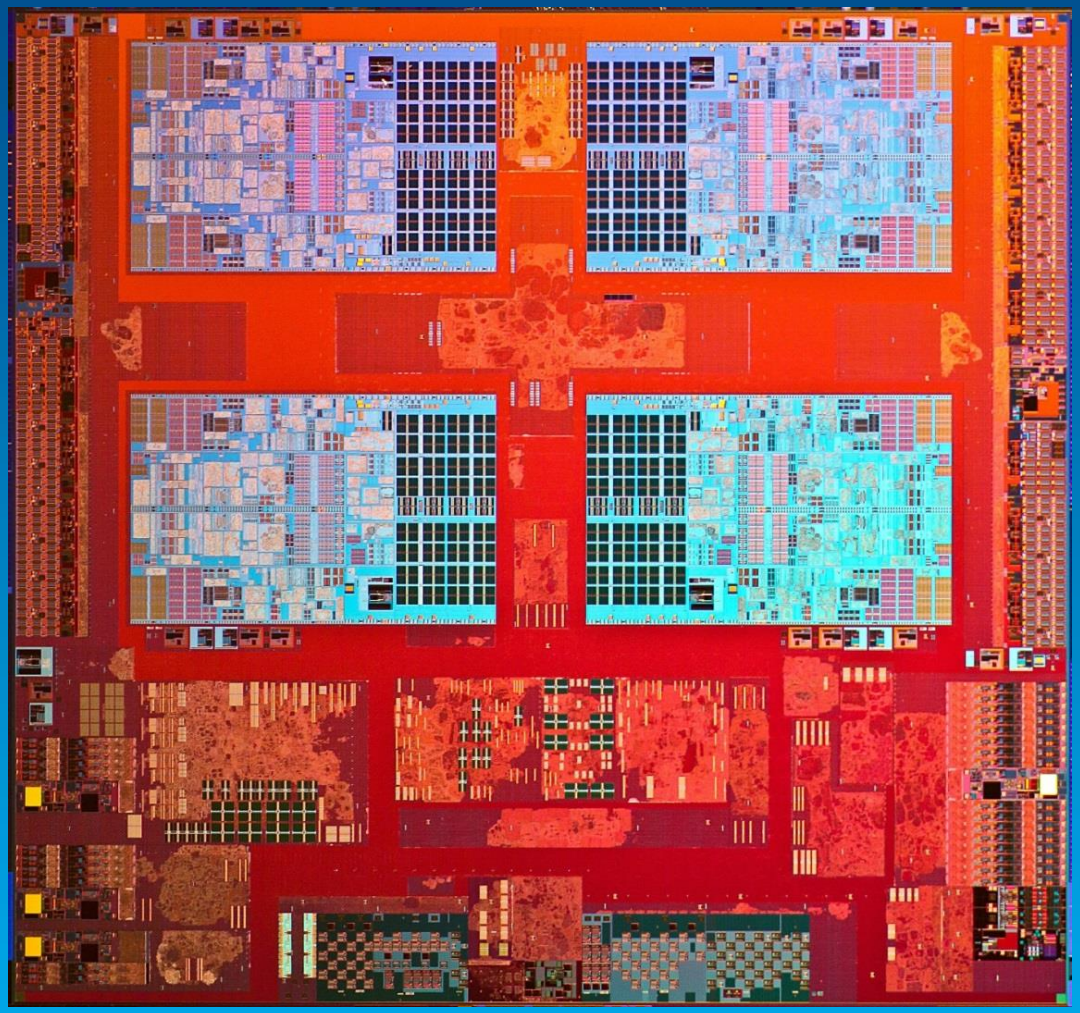
intel Look Inside.™

Intel Inside the Data Center

- The new Atom Processor Family extends Intel's portfolio of products that service the diverse needs of the data center
  - Adds to Xeon, MIC, Storage, and Networking products
- Avoton provides power efficient performance and density across the micro server and storage segments
- Rangeley is the first Avoton derivative extending Atom into communication products

Thanks!



Configuration

Integer Throughput (SPECint*_rate_base2006)

Atom S1260: FOR.INTEL. cpu2006.1.2.ic14.0.2aug2013
Supermicro* 5017A-EF with one Intel® S1260 processor (2-core 2.0GHz), EIST Enabled, Hyper-Threading Enabled, 8GB memory (1x 8GB DDR3-1333 UDIMM ECC), 250GB SATA 7200RPM HDD, Red Hat Enterprise Linux 6.4. Estimated Score:SPECint*_rate_base2006=18.90

Atom C2750: FOR.INTEL. cpu2006.1.2.ic14.0.15aug2013
Intel® Mohon Peak Alpha platform with one Intel® Avoton processor (8-core 2.4GHz, 20W, B0-stepping), Turbo Boost Enabled, 16GB memory (4x 4GB DDR3-1600 UDIMM ECC), 250GB SATA 7200RPM HDD, Red Hat Enterprise Linux 6.4. Estimated Score: SPECint*_rate_base2006=106

Atom C2730: FOR.INTEL. cpu2006.1.2.ic14.0.15aug2013
Intel® Mohon Peak Alpha platform with one Intel® Avoton processor (8-core 1.7GHz, 12W, B0-stepping), Turbo Boost Enabled, 16GB memory (4x 4GB DDR3-1600 UDIMM ECC), 250GB SATA 7200RPM HDD, Red Hat Enterprise Linux 6.4. Estimated Score:SPECint*_rate_base2006=87.9

Marvell ARMADA XP*: CPU2006 v1.2 compiled with gcc version 4.6.3(Ubuntu/Linaro 4.6.3-1ubuntu5
Wiwynn* SV118 with one Marvell* Armada* XP MV78460 (4-core 1.333GHz, <10W), 4GB memory (1x 4GB DDR3-1600L @ 1333MHZ UDIMM ECC), 250GB SATA 7200RPM HDD, Ubuntu 12.04 for ARM. Estimated Score:SPECint*_rate_base2006=5.98

Calxeda ECX-1000: Boston* Virdis server with one Calxeda EnergyCore ECX-1000(4-core 1.4GHz), 4GB memory (1x 4GB DDR3-1333 Ubuffered ECC), 250GB SATA 7200RPM HDD, Ubuntu 13.04 for ARM.
Score:SPECint*_rate_base2006=11.8

Configuration

Dynamic Web Perfomance and Perf/W:

Atom S1260: DBC SDP w/Intel® Atom™ S1260 (2.0GHz, 2C), Hyper-Threading Enabled, 1x8GB DDR3-1333 MHz UDIMM ECC, BIOS version D134.4, Fedora* 17, Linux Kernel 3.3.4-5fc.x86_64, Apache 2.2.22, PHP 5.4.7, Boot Drive 1x 150GB SSD, Addl Drive 2x 150GB SSD, 2xGbE, Score: 1522, Estimated node power=20W, PPW=76.1

Atom C2750: MPK SDP w/Intel® Atom™ C2750 (2.4GHz, 8C, B0), Turbo Enabled, 4x8GB DDR3-1600 MHz UDIMM ECC, BIOS version 24D03, Fedora* 17, Linux Kernel 3.3.4-5fc.x86_64, Apache 2.2.22, PHP 5.4.7, Boot Drive 1x150GB SSD, Addl Drive 1x 800GB SSD, 1x10GbE, Score: 11351

Atom C2730: MPK SDP w/Intel® Atom™ C2730 (1.7GHz, 8C, B0), Turbo Disabled, 4x8GB DDR3-1600 MHz UDIMM ECC, BIOS version 22D05, Fedora* 17, Linux Kernel 3.3.4-5fc.x86_64, Apache 2.2.22, PHP 5.4.7, Boot Drive 1x150GB SSD, Addl Drive 1x 800GB SSD, 1x10GbE, Score: 8778, Estimated node power=19W, PPW=462

Calxeda* ECX 1000: Boston Viridis* w/Cortex* A9(1.4GHz, 4C), 1x4GB DDR3-1333 MHz UDIMM ECC, BIOS version ECX-1000 2.2.10, Ubuntu* 13, Linux Kernel 3.8.0-19-generic#30-Ubuntu SMP arm v7, Apache 2.2.22, PHP 5.4.9-4ubuntu2.1, Boot Drive 1x250GB HDD 7K RPM, Addl Drive 1x 450GB SSD, 2x1GbE, Score: 2831, Estimated node power=11, PPW=257.4

Marvell* Armada XP: Wiwynn* SV118 with one Marvell* Armada* XP MV78460 (4-core 1.333GHz, <10W), 4GB memory (1x 4GB DDR3-1600L @ 1333MHZ UDIMM ECC), 2TB SATA 7200RPM HDD, Addl Drive 1x2TB HDD, Fedora 18, Linux Kermel 3.20-1617-armadaxp, Apache 2.4.3 (Fedora), PHP 5.4.9, 1x1GbE, Score=1351