Atom™ -x5/x7 series processor, codenamed Cherry Trail

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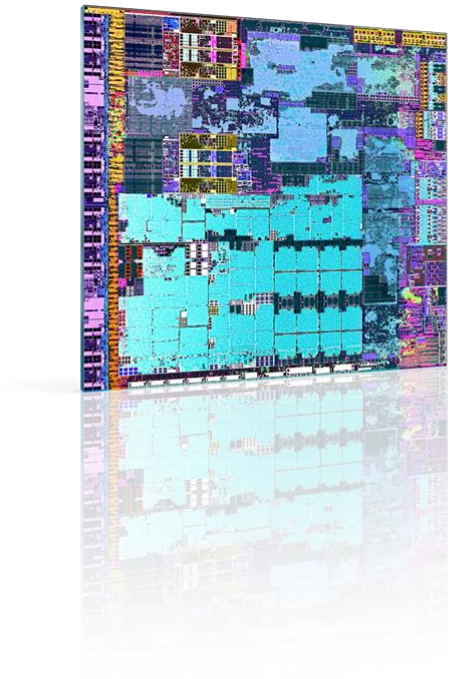
Cherry Trail Chief Architect, Senior Principal Engineer, Intel Corporation

Outline

- Cherry Trail SoC architecture product family
- Process generations for mobile product line
- Functional diagram
- Architecture & building blocks:
  - Memory and fabric, Atom™ CPU: Airmont vs Silvermont, GEN8LP Graphics & Media, Display, Integrated Sensor Hub
  - Power & power management: Rails and islands, Dynamics voltage and frequency scaling
- Performance
  - CPU, Graphics, and Media
- Cherry Trail SKUs and Feature set

Cherry Trail SoC Architecture & Product Family



“Cherry Trail” product family

Intel Atom x5-Z8500/x7-Z8700, 17x17 T4 FCBGA, 628 IOs

Intel® Atom™ x5-Z8300, 17x17 T3 FCBGA, 378 IOs

“Braswell” product family

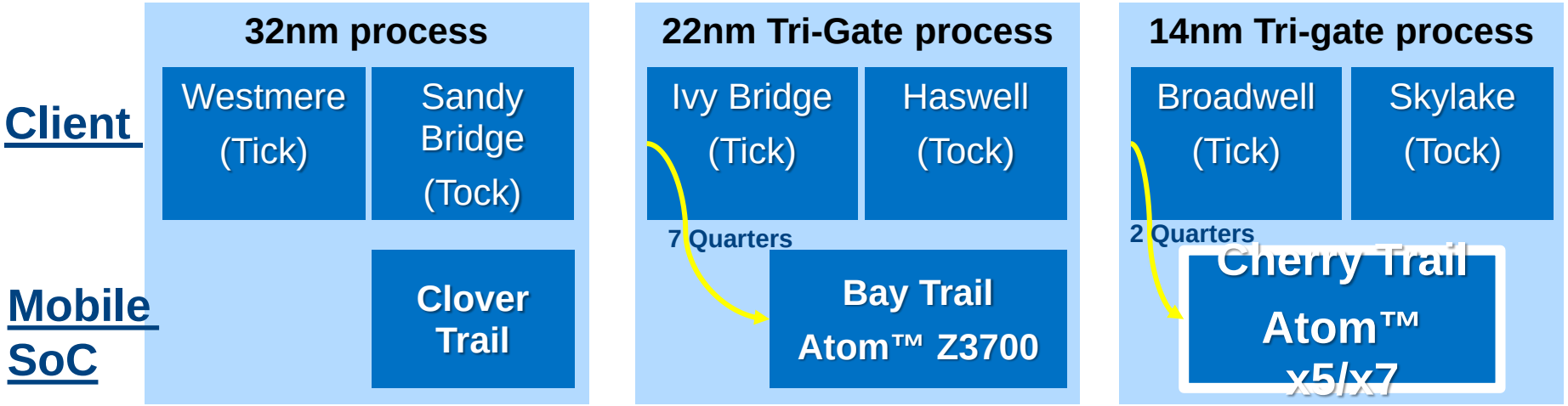
Intel Pentium™ N37xx, 25x27 T3 FCBGA, 641 IOs

Intel Celeron™ N30xx/3100, 25x27 T3 FCBGA, 641 IOs

- The first on Intel 14nm SoC process

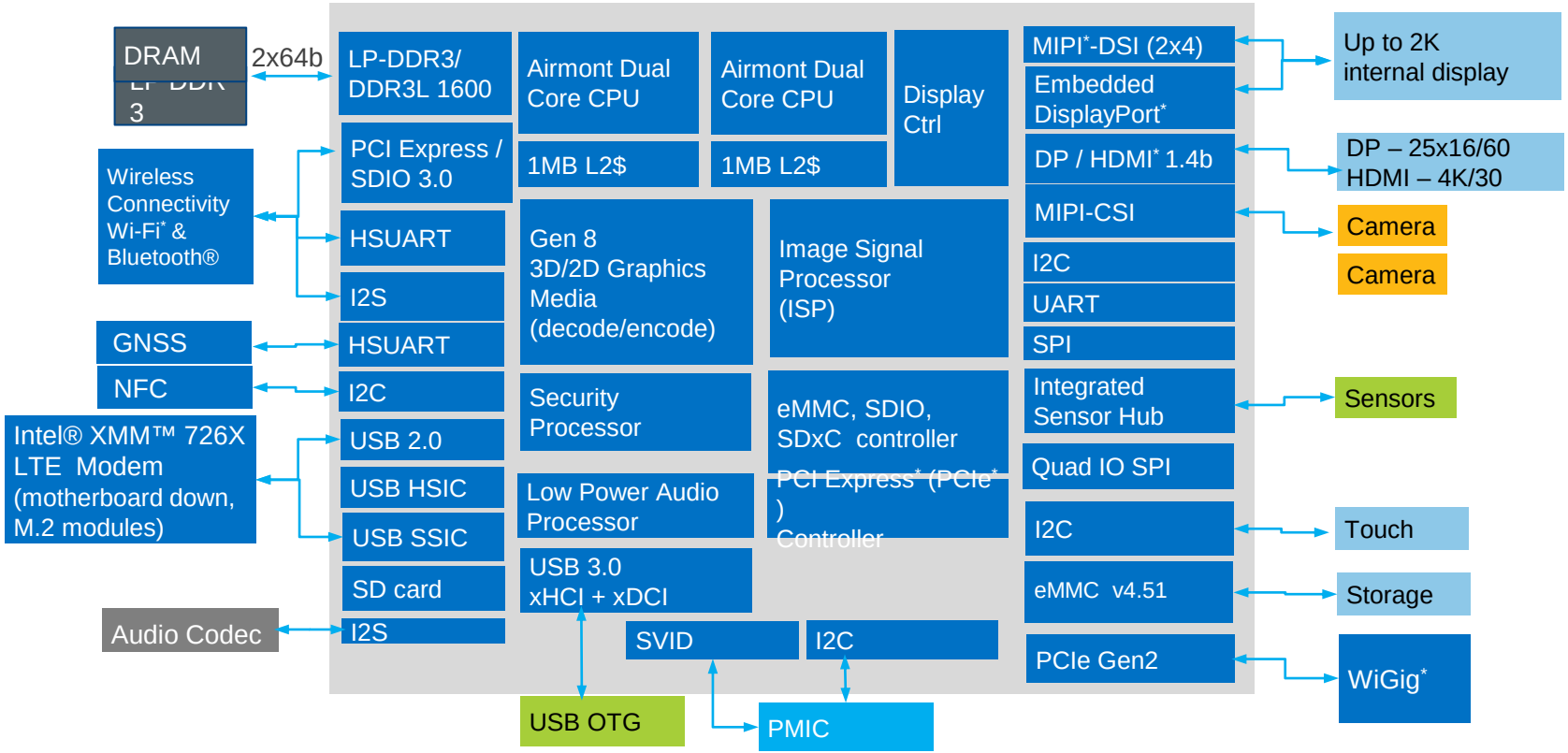
- 25% smaller than its predecessor Bay Trail
- 30% more transistors than its predecessor Bay Trail
- >2X more graphics performance than its predecessor Bay Trail

Intel Process Technology and SoCs Development



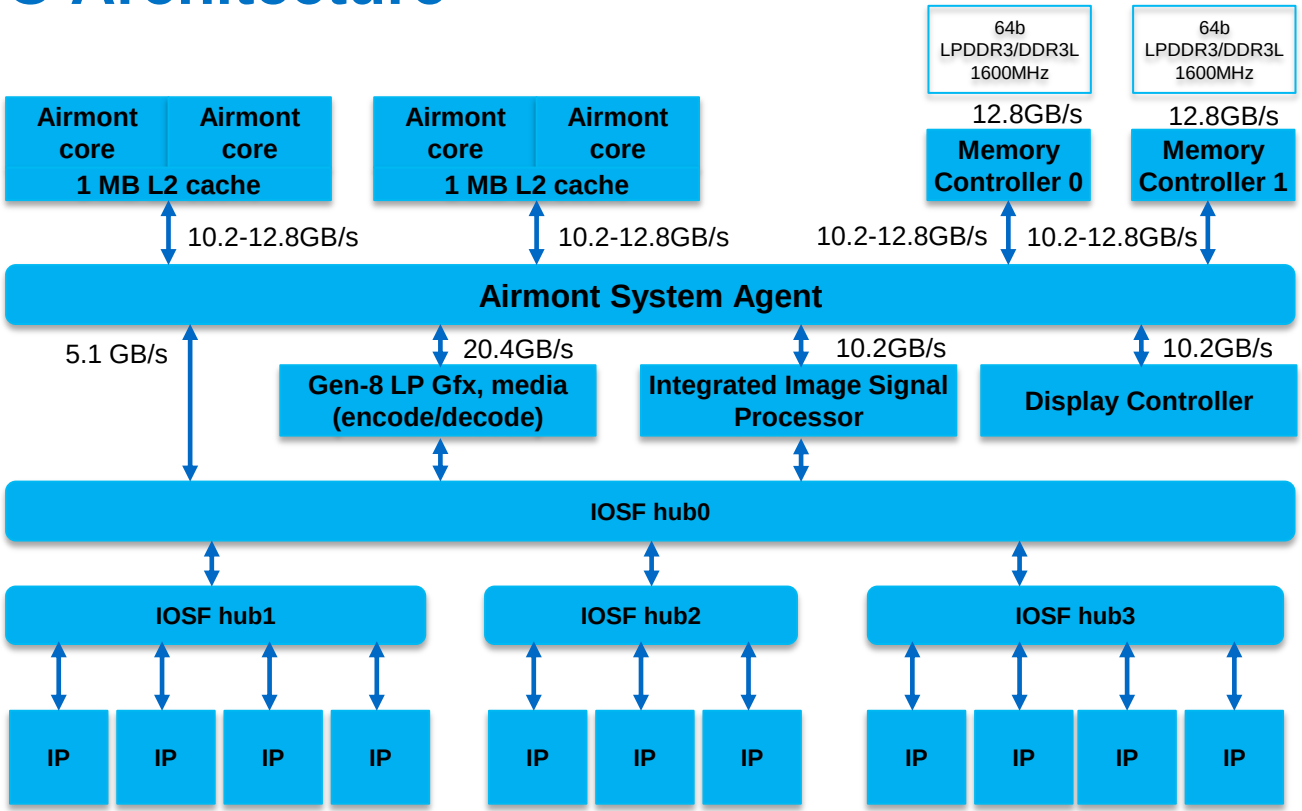
- Continues to deliver to Moore's Law - accelerated Cherry Trail by >1year on the leading 14nm processor node to meet market demands
- The new Intel Atom x5/x7 SoC architecture provides generational improvements: compute performance and battery life, scalability features, versatile form factors

Intel® Atom™ x5 and x7 SoC Platform Block Diagram



Memory and SoC Architecture

- Single/Dual x32/x64 ch LPDDR3/DDR3L 1600MHz
- Asynchronous link between System Agent to Memory Controller
- Multiple flexible System Agent arbitration to ensure isochronous traffic and allow maximizing DDR self-refresh time for power management
- Two dual-core AMT module with 1MBL2 each
- GEN8LP direct System Agent connection, max possible memory bandwidth
- Direct imaging and display controller connection to System Agent



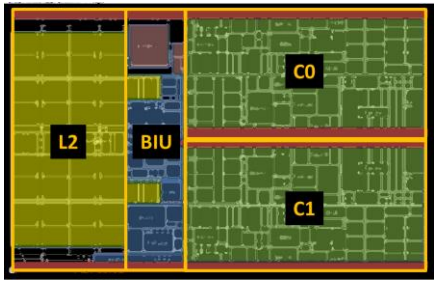
Memory Scalability

Specifications	Intel® Atom™ x5-8500/x7-8700	Intel Atom x5-8300
	17x17 T4	17x17 T3
Memory Type	LPDDR3 DDR3L[1]	DDR3L LPDDR3[1]
Connector	Memory Down	Memory Down
SM Voltage	1.2v/1.35v	1.35v/1.2v
Speed (MT/s)	1066[2]/1600	1066[2]/1600
Channels/width	2x32[1], 2x64	1x32, 1x64
Capacity (GB)	1, 2, 3[3], 4, 8, 16[3]	1, 1.5[3], 2,4, 8[3]
Max Bandwidth (GB/s)	12.8, 25.6	6.4, 12.8

Notes: 1: support via white paper. 2: Dynamically configured low frequency gear if DDR power saving feature is enabled by the platform configuration. 3: memory parts not Intel Platform Memory Organization's official suggested DRAM part list, may not be validated on Intel reference validation platform boards.

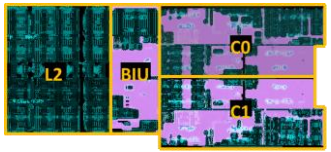
Airmont CPU Architecture and Design Improvements

- Two Dual-Core module with 1MB L2, Max Turbo frequency up to 2.4GHz
- Evolution based on Silvermont
- Optimized for 14nm
- Key IPC improvements
  - Doubled branch predictor array sizes
  - Out-of-order functions
    - Larger Reorder Window
    - Deeper Reservation Stations
    - Deeper Store Buffer
    - More load misses in flight
  - Doubled data TLB size
  - Targeted FP execution improvements
- Support for IDI (process bus) parity



22nm Silvermont

64% smaller in die size



14nm Airmont

Silvermont/Airmont Architecture: New Instructions

	Feature	Description	Benefits
Security	AES-NI[3]	Instructions to perform AES encryption and decryption	• Supports 128, 192, 256 bit keys and all modes of operation • Mitigates all known software side channel attacks
	PCLMULQDQ instruction	New instruction to improve AES-GCM (Galois Counter Mode) performance	• High Performance Message Authentication
	Intel® Secure Key[4] (RDRAND instruction)	Provides high quality random numbers to all software	• Harden attack surface
	VM Functions (VMFUNC)	Allow VMX non-root to load new EPT pointers	• Hardware assists for security technologies
Performance	SSE4.1	47 new instructions	• Primitives for compiler auto-vectorization • Media acceleration • Streaming loads to speed up accesses to device memory
	SSE4.2, POPCNT	7 new instructions	• Accelerated String and Text Processing of Large Data Sets

[3] Intel® AES-NI requires a computer system with an AES-NI enabled processor, as well as non-Intel software to execute the instructions in the correct sequence. AES-NI is available on select Intel® processors. For availability, consult your reseller or system manufacturer. For more information, see Intel® Advanced Encryption Standard Instructions (AES-NI)

[4] No system can provide absolute security. Requires an Intel® Secure Key-enabled platform, available on select Intel processors, and software optimized to support Intel Secure Key. Consult your system manufacturer for more information.

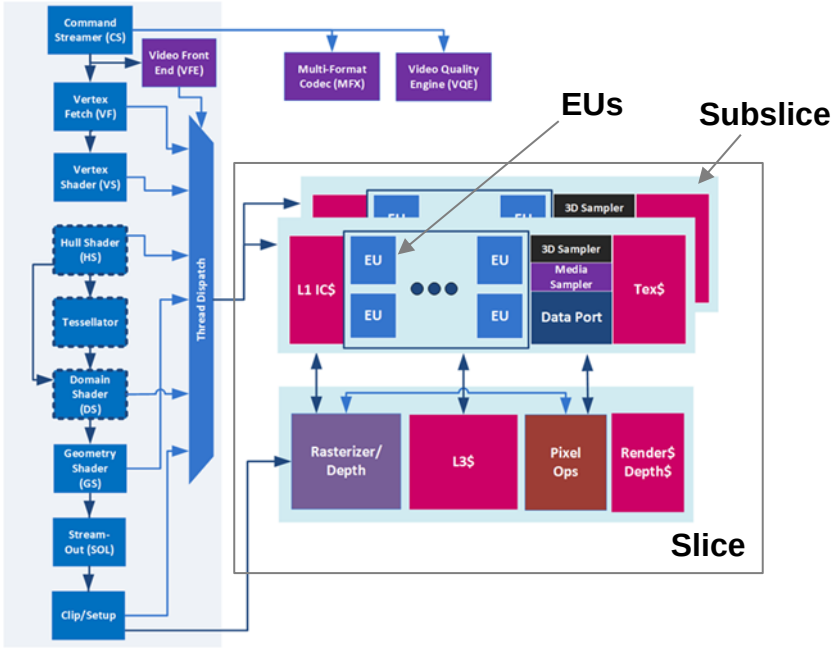
Silvermont/Airmont Architecture: New Technologies

Feature	Description	Benefits
Intel® VT-x2	Extended Page Tables Virtual Processor ID support Unrestricted Guest	• Performance improvement by Guest OS being able to modify its own page tables reducing VM exits. Memory savings by eliminating need for shadow page tables. • TLB entry retention across VM and VMM transition • Faster Boot in Guest OS
Real Time Instruction Tracing	Real time trace of executing code	• Enhanced Real-Time Hardware Debug
Intel® OS Guard (SMEP)	Helps prevent attacks on OS from using application code	• Increased Security4
TSC Deadline Timer	Allows more precise timer interrupts	• Simplifies timer interrupt programming • Avoids drift/inaccuracy
LBR Filtering	Last Branch Record Filtering	• Enhanced Debug

[4] No system can provide absolute security. Requires an Intel® Secure Key-enabled platform, available on select Intel processors, and software optimized to support Intel Secure Key. Consult your system manufacturer for more information.

GEN8LP Graphics and Media

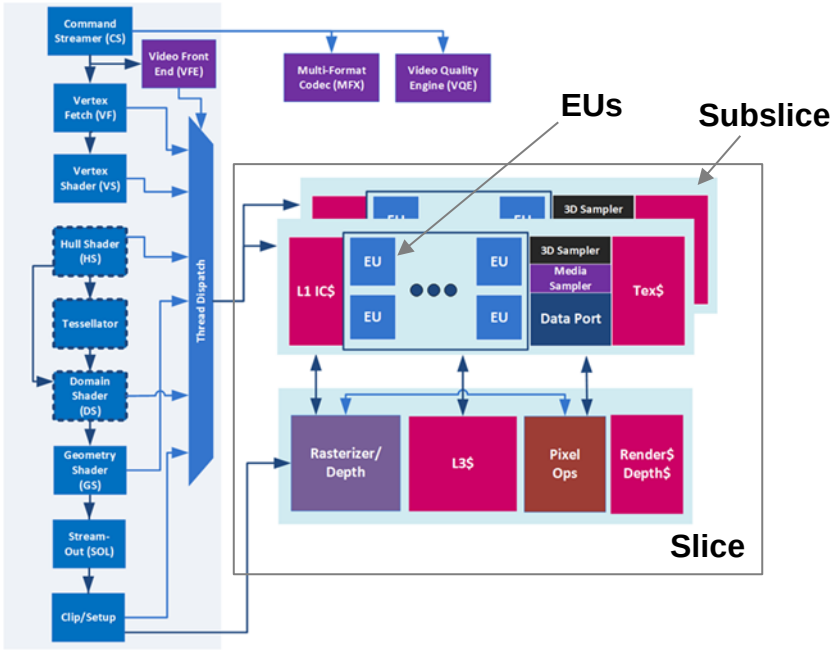
- Leading features
  - **Support DirectX11, OpenGL ES3.0, OpenCL1.2, OpenGL4.3, RS Compute**
  - Supports higher precision computes and OpenCL 1.2, natively supports latest texture compression formats like ETC and ASTC-LDR
- Performance & Power
  - **>2x performance per watt improvement**
  - **4x compute and pixel throughput, 2x texture throughput**
  - Power wells for 3D and Media, sub-slice and EU power gating
  - Native 16 bit computes with 2x performance at ISO power
  - Power optimized for UI high ppi workloads



Delivered on Intel leading14nm low-leakage process

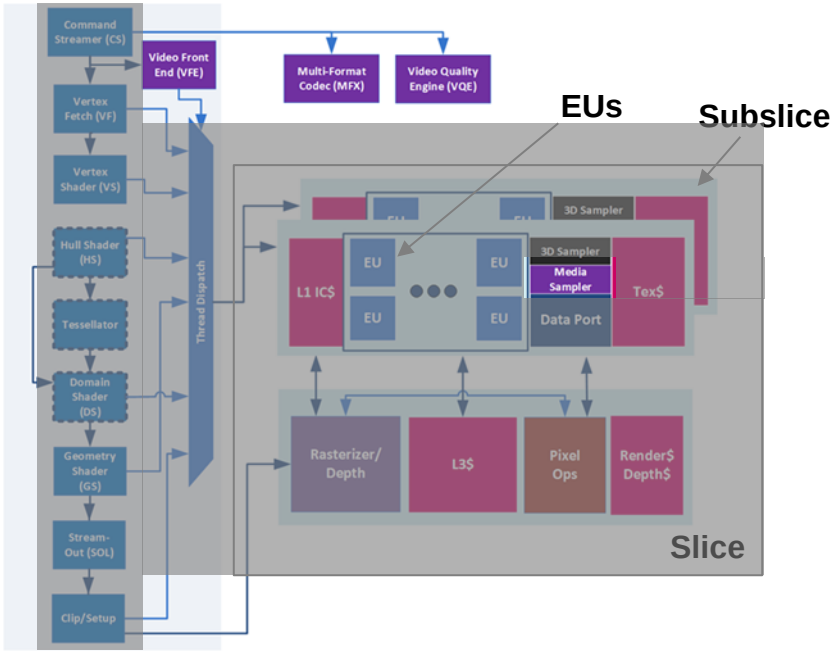
Architecture - GEN8LP Graphics

- EU (Execution Unit)
  - 7 HW threads per EU, 128 “GRF” registers per thread, 32 bytes per “GRF” register
  - Arch register, SMT Instruction Dispatcher
  - 2 floating point units, Branch and messaging unit
- Sub-slice
  - 8 EUs, thread dispatcher, instruction cache, texture/image sampler unit
  - 64 bytes/cycle read bandwidth
- Slice
  - 2 Sub-slices x 8 = 16 EUs.
  - 2x8x7=112 hardware threads
  - L3 data cache, 384KB/slice, 64 byte cachelines,
  - Shared local memory 64KB/Subslice

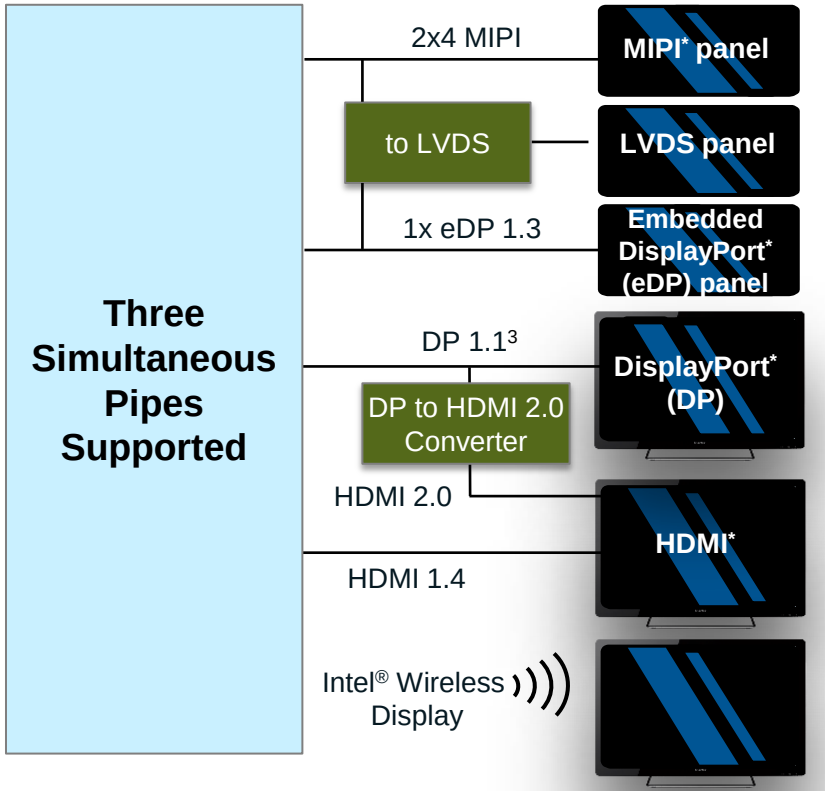


Architecture - GEN8LP Media

- Major media asserts
  - Multi-format codec engine:
    - video decode (HEVC, H.264, VP8, MPEG2, JPEG etc.)
    - video encode (H.264, VP8, MVC, JPEG, etc.)
  - Video quality engine: Video and imaging enhancement
  - Media sampler: video motion estimation, image enhancement filter, advanced video scalar
- A multi-generation transition for media processing
  - Dedicated media fixed function unit
  - Race-to-halt
  - Fine granularity power management



Display



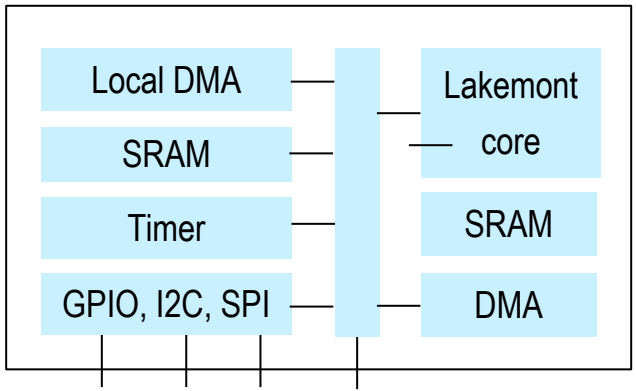
Intel® Atom™ x5-8300	Intel Atom x5-8500	Intel Atom x7-8700
2 Displays	3 Displays[3]	3 Displays[3]
1900x1200@60Hz (1x4)	2560x1600@60Hz	2560x1600@60Hz
1900x1200@60Hz	1900x1200@60Hz	1900x1200@60Hz
1900x1200@60Hz	2560x1600@60Hz	2560x1600@60Hz 3840x2160@60Hz[1]
2560x1600@60Hz	2560x1600@60Hz	2560x1600@60Hz
1920x1080@60Hz 3820x2160@30Hz	1920x1080@60Hz 3840x2160@30Hz	1920x1080@60Hz 3840x2160@30Hz 3840x2160@60Hz[2, 1]
1080p@60Hz 2560x1440@30Hz 2560x1600@30Hz	**1080p@60Hz** 2560x1440@30Hz 2560x1600@30Hz	**1080p@60Hz** 2560x1440@30Hz 2560x1600@30Hz

Notes: 1. requires slightly power increase, not yet official SKU. 2. this requires a DP-to-HDMI convert chip, which converts DP1.1 with HDCP1.4 to HDMI2.0 up to 4k2k @60Hz with HDCP2.2. not yet official SKU. 3. multiple displays configuration may have performance implications depending on resolutions, check platform design guide for details.

Architecture – Integrated Sensor Hub

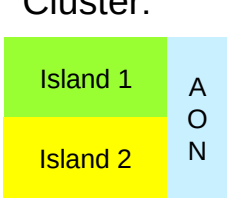
“Always On, Always Sensing” and it provides the following functions to support this goal:

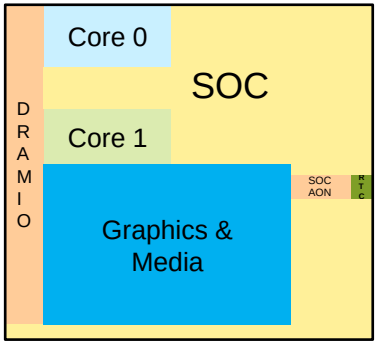
- Acquisition / sampling of sensor data
- The ability to combine data from individual sensors to create a more complex Virtual sensor that can be directly used by the firmware/OS.
- Low power operation through clock gating and power gating of parts of the ISH together with the ability to turn sensors off.
- The ability to operate independently when the host platform is shut off



Power Management – Rails and Islands

- Power Rails
  - total 9 rails from PMIC
  - Power states
    - S0: all rails on
    - S0i3/S3: CPU & GPU rails off, SOC & IO rails on
    - S4/S5/RTC: only RTC rail on
- Power Islands
  - Implemented at physical partition cluster level
  - Up to 2 islands and 1 AON island per cluster
  - 40+ clusters





PMIC to SoC Rails	Voltage Range at Pin	Power state ON/OFF			
		S0	S0ix/S3	S4/S5	RTC
CPU Core0 VID	0.75-1.2	ON	OFF	OFF	OFF
CPU Core1 VID	0.75-1.2	ON	OFF	OFF	OFF
GFX VID	0.75-1.2	ON	OFF	OFF	OFF
SOC VID	0.75-1.2	ON	ON	OFF	OFF
RAM Rail	1.15	ON	OFF	OFF	OFF
1.05v logic & IOs	1.05	ON	ON	OFF	OFF
1.24V IOs	1.24	ON	ON	OFF	OFF
1.8V IO	1.8	ON	ON	OFF	OFF
1.8-3.3 variable SDIO	1.8 or 3.3	ON/OFF	ON/OFF	OFF	OFF
3.3V IO	3.3	ON	ON	OFF	OFF
3.3V RTC	3.3	ON	ON	ON	ON

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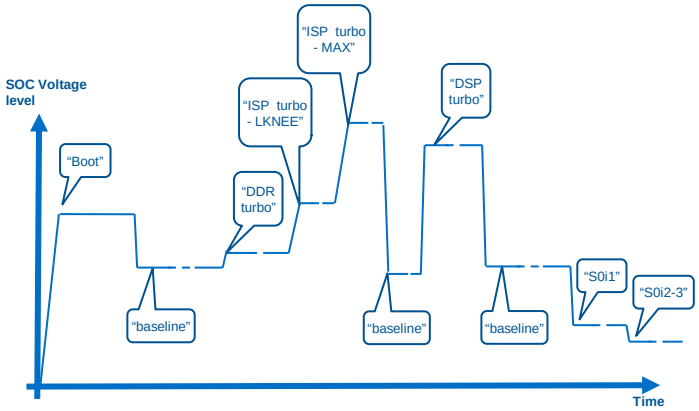
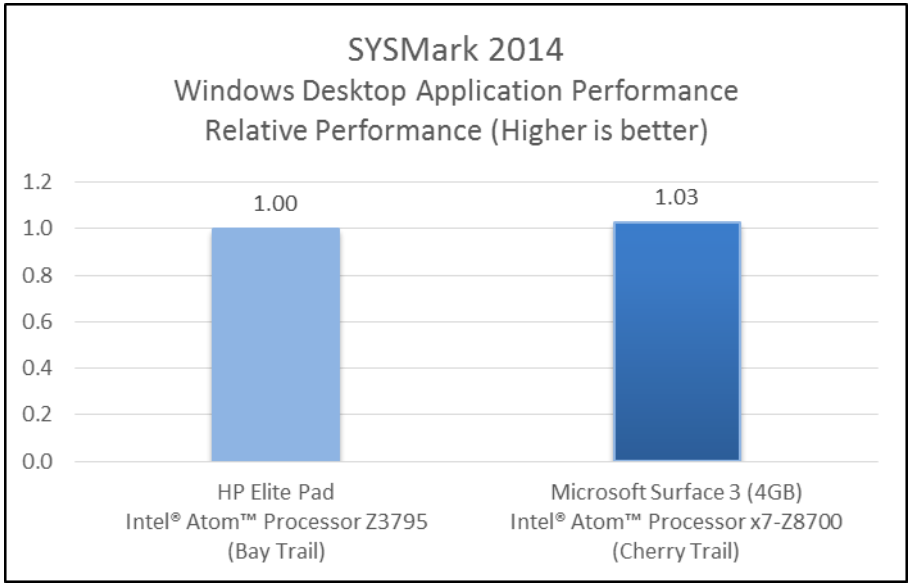
Power Management - DVFS: Dynamic Voltage and Frequency Scaling

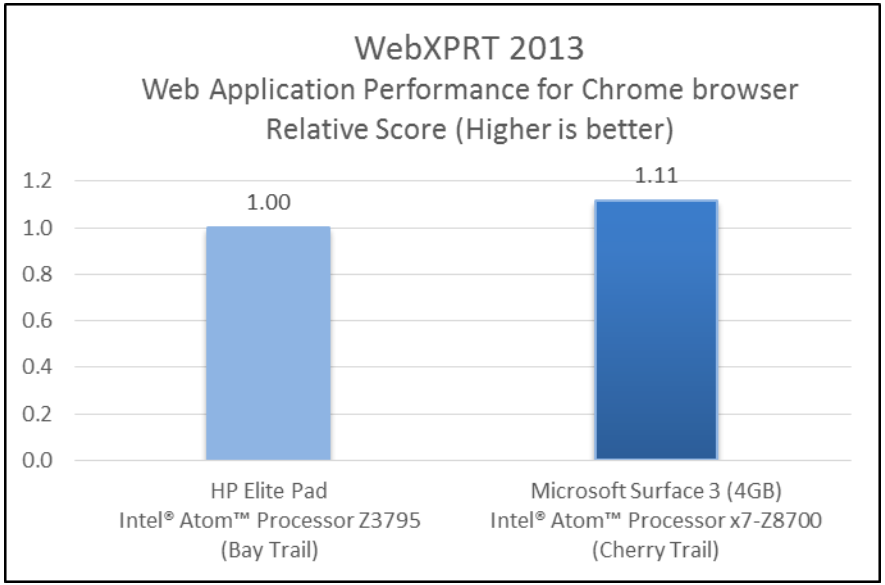
- DVFS domain:
  - CPU cores: fine level VID (voltage level ID) control
  - Graphics & Media: fine level VID (voltage level ID) control
  - Imaging processing unit
    - Imaging pipe frequency is driven by use cases
    - Pipeline frequency drives voltage level
  - Display processing unit
    - Resolution drives pipeline frequency, which in turns drives voltage level
  - DRAM DVFS
    - Dynamically switch among 1600, 1066, or 800MHz DRAM frequency, lower DDR Phy voltage level while operating at lower frequency modes, turning off ODT mode while at lower frequency modes
    - DDR PHY frequency is driven by memory bandwidth demand which is drive by use cases
    - DDR PHY frequency may switch from 1600 to 1066 or lower if down switching criteria is met, up switching is also true based if BW demand increases
    - Challenge is to achieve power saving while avoid quality of service disruption during down and up switching, i.e. to ensure no display glitch, camera image distortion, etc.



Application Performance

Source: Intel Corporation



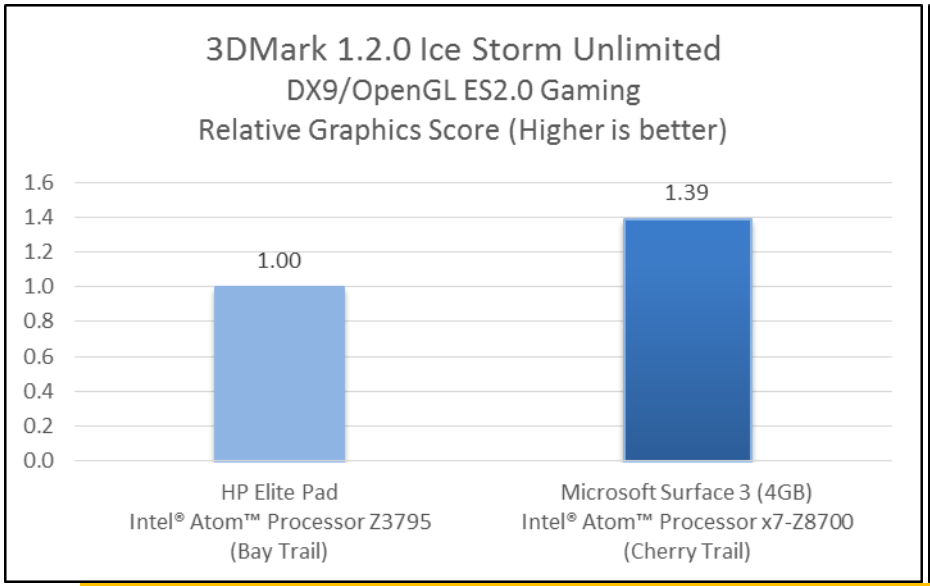


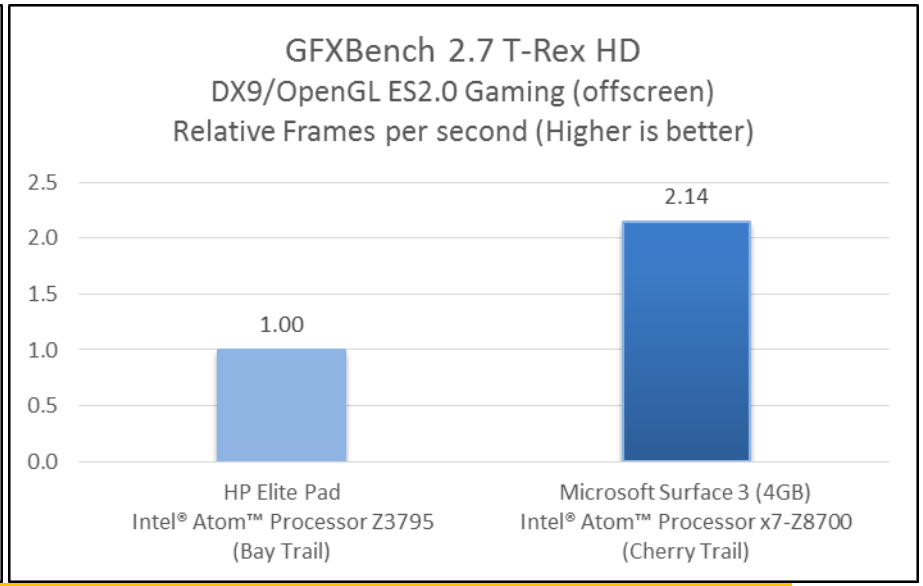
Cherry Trail offers the same great performance as Bay Trail for Windows Desktop Applications and Web Applications

 See appendix for configurations details and important disclaimers

3D Gaming Performance

Source: Intel Corporation



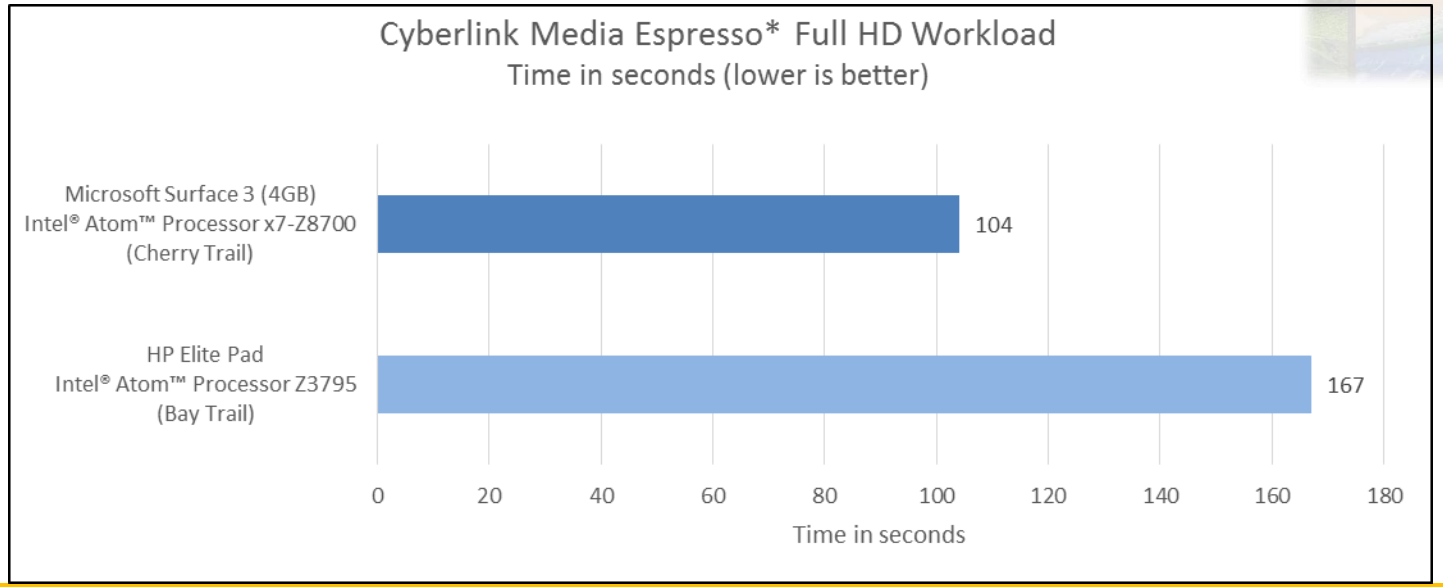


Cherry Trail offers ~2X higher 3D Gaming Performance compared to Bay Trail

 See appendix for configurations details and important disclaimers

Media Performance – Video conversion

Source: Intel Corporation

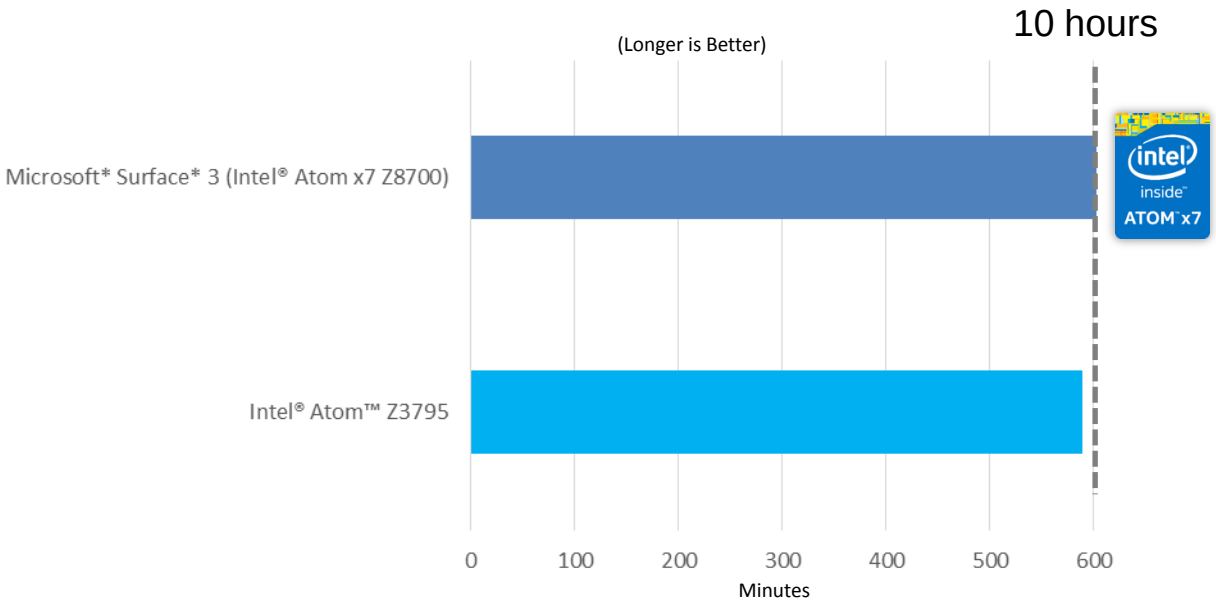


Cherry Trail is up to 60% faster on video conversion compared to previous generation Bay Trail

*Other names and brands may be claimed as the property of others

 See appendix for configurations details and important disclaimers

Scenario Power & Battery Life



27Whr

30Whr

Longer battery-life with a smaller battery

Longer battery life while playing full-HD movies and video on Microsoft* Surface 3* with the Intel® Atom™ x7-Z8700 Processor.

Source: Intel Corporation

As measured by Tears of Steel* Video Playback Battery Rundown workload

See appendix for configurations details and important disclaimers

Intel® Atom™ x5/x7 SoC SKUs & Features

Specifications	Intel® Atom™ x5-8300	Intel Atom x5-8500	Intel Atom x7-8700
Scenario Design Power	2 watts	2 watts	2 watts
Form Factor	7” to 11.6” tablet, and small screen 2 in 1s	7” to 11.6” tablet, and small screen 2 in 1s	7” to 11.6” tablet, and small screen 2 in 1s
CPU	Quad core 64-bit Atom x5 Up to 1.84 GHz[1]	Quad core 64-bit Atom x5 Up to 2.24 GHz	Quad core 64-bit Atom x7 Up to 2.4 GHz
Process	14nm	14nm	14nm
Graphics (GPU)	Gen8 12EU, up to 500MHz DirectX* 11.1, OpenGL* ES 3.1, OpenCL* 1.2, OpenGL 4.3, RS Compute	Gen8 12EU, up to 600 MHz DirectX 11.1, OpenGL ES 3.1, OpenCL 1.2, OpenGL 4.3, RS Compute	Gen8 16EU, up to 600 MHz DirectX 11.1, OpenGL ES 3.1, OpenCL 1.2, OpenGL 4.3, RS Compute
Media (Encode/Decode)	HEVC (decode), H.264, VP8	HEVC (decode), H.264, VP8	HEVC (decode), H.264, VP8
Memory	1x32, 1x64 DDR3L-RS[2] 1600, 1-2GB	2x64 LPDDR3 1600, 2-8GB	2x64 LPDDR3 1600, 2-8GB
Display Resolution	INTERNAL: 1920x1200 (MIPI*-DSI or LVDS) EXTERNAL: 1920x1080 (HDMI*)	INTERNAL: up to 25x16 (MIPI-DSI or Embedded DisplayPort* (eDP)) EXTERNAL: up to 4k2k (HDMI)	INTERNAL: up to 25x16 (MIPI-DSI or eDP) EXTERNAL: up to 4k2k (HDMI)
Modem (Discrete)	Intel® XMM™ 7260/62 LTE Cat-6 (up to 300Mbps DL) M.2 only for x5 8300	Intel XMM 7260/62 LTE Cat-6 (up to 300Mbps DL, 50Mbps UL for modem-down)	Intel XMM 7260/62 LTE Cat-6 (up to 300Mbps DL, 50Mbps UL for modem-down)
Connectivity	Intel® WLAN, Intel® WWAN (M.2 modules), Intel® NFC	Intel WLAN, Intel WWAN (Intel XMM 726x), Intel NFC	Intel WLAN, Intel WWAN (Intel XMM 726x), Intel® WiGig*, Intel NFC
Input Output	6xI2C[4], 2xHSUART, 1xSDIO, 3xI2S, SPI[5], PCI Express* (PCIe*) 2.0 x1, 1xI2C(ISH), 1xI2C (NFC)	7xI2C[4], 2xHSUART, 1xSDIO, 3xI2S, 1xLPC, 1xSPI[5], PCIe 2.0 x2, 1x I²C[4] (ISH), 1xI2C (NFC)	7xI2C[4], 2xHSUART, 1xSDIO, 3xI2S, 1xLPC,1x SPI[5] , PCIe 2.0 x2, 1x I²C[4] (ISH), I2C[4](NFC)
USB	1xUSB3 OTG, 2xHSIC, 3xUSB2	1xUSB3 OTG, 3xUSB3[6] 2xSSIC, 2xHSIC	1xUSB3 OTG, 3xUSB3[6] 2xSSIC, 2xHSIC
Storage	eMMC 4.51[7]	eMMC 4.51[7]	eMMC 4.51[7]
ISP / Camera (rear/front)	Up to 8MP Intel® RealSense™ Snapshot	Up to 13MP Intel® RealSense™ 3DCamera	Up to 13MP Intel RealSense 3DCamera

[1]Max. CPU Burst Frequency for 1 or 2 Cores. Max. CPU Burst Frequency for 3 or 4 cores bursting simultaneously is 1.60GHz
[2] Additionally, LPDDR3 can be supported on customer designs if needed
[3] Simultaneous display resolution capabilities may differ.
[4] General Purpose I2C
[5]SPI on Intel Atom x5-8300 and 8500 is multiplexed with other pins. SPI availability is implementation dependent
[6]USB 3.0 backward compatible to USB 2.0
[7]eMMC 5.0 storage devices can be used and are compatible with the eMMC 4.51 storage controller included in Intel Atom x5/x7

Summary

- Continuing based on Moore’s law, Intel accelerated 14nm SOC lead product by more than one year as compare to previous generation Bay Trail SoC

- Cherry Trail SoC and Braswell SoC product family offered generational improvement in graphics performance and power efficiency to customers

- Cherry Trail SoC product family begins to enable PC class gaming in tablet form factor at affordable price points

Glossary

- SoC – System On Chip
- GNSS – global navigation satellite system
- NFC – near field communication
- WiGig – Wilreless Gigabit Allicance
- HSUART – high speed UART
- HSIC – high-speed inter-chip
- SSIC – SuperSpeed inter-chip
- MIPI – Mobile Industry Processor Interface
- CSI – Camera Serial Interface
- DP – Display Port
- eDP – embedded Display Port

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(for data marked ‘(e)’): Results have been estimated or simulated using internal Intel analysis or architecture simulation or modeling, and provided to you for informational purposes. Any differences in your system hardware, software or configuration may affect your actual performance.

For more complete information about performance and benchmark results, visit http://www.intel.com/benchmarks

Workloads and Configurations

System Configuration:

HP* ElitePad* (1000G2*); SOC: Intel* Atom Z3795* (4C, up to 2.39 GHz); OS: Windows* 8; mem: 4GB; storage: 64GB; display size: 10", res: 1920x1200; Battery Size: 30 Whr; Default Browser ver: 11.09.9600.17031 ; Chrome Browser ver: 40.0.2214.94; Soft. Build: 6.3.9600 Build 9600 "17196" ; Measured on: 10/02/2014

Microsoft* Surface 3* (4GB); SOC: Intel* Atom x7-Z8700* (4C, up to 2.4 GHz); OS: Windows* 8.1; mem: 2GB; storage: 64GB; display size: 10.2", res: 1920x1280; Battery Size: 27 Whr; Default Browser ver: IE; Chrome Browser ver:40.0.2214.94; Soft. Build: 1.71.0.x64; Measured on: ??

Workloads:

WebXPRT* 2013 is a benchmark from Principled Technologies* that measures the performance of web applications using four usage scenarios: Photo Effects, Face Detect, Stock Dashboard and Offline Notes. WebXPRT tests modern browser technologies such as HTML5 Canvas 2D, HTML5 Table, HTML5 Local Storage, as well as JavaScript*. **Reported metrics**: elapsed time in seconds (lower is better) for each scenario, plus an overall score (higher is better). **Scaling efficiencies**: CPU dominant (newer browsers are GPU accelerated), sensitive to frequency. Note that WebXPRT is very sensitive to browser type and version. **OS support**: any OS that supports an HTML5 browser

SYSmark* 2014 is a benchmark from the BAPCo* consortium that measures the performance of Windows* platforms. SYSmark tests three usage scenarios: Office Productivity, Media Creation and Data/Financial Analysis. SYSmark contains real applications from Independent Software Vendors such as Microsoft* and Adobe*. **Reported metrics**: SYSmark 2014 Rating and a rating for each scenario result (higher is better for all). **Scaling efficiencies**: CPU dominant, sensitive to frequency, core count and memory. QSV enabled. **OS support**: 32-bit & 64-bit Desktop Windows 7 and 8.

3DMark* 1.2.0 is a benchmark from Futuremark* that measures DX* 9 / OpenGL* ES 2.0, DX 10 and DX 11 gaming performance. There are three main tests: “Ice Storm” for DX 9 / OpenGL ES 2.0, “Cloud Gate” for DX 10, “Sky Diver” for DX11 and “Fire Strike” for DX 11 graphics. **Reported metrics**: Graphics Score (GPU), Physics Score (CPU), Combined Score (GPU & CPU) and an overall 3DMark Score (higher is better for all Scores). **Scaling efficiencies**: Graphics tests are GPU dominant, sensitive to graphics and CPU frequency, core count and memory. **OS support**: Desktop Windows*, Android*, iOS* and Windows RT.

GFXBench* 2.7, previously known as GLBenchmark* and DXBenchmark*, is a benchmark from Kishonti Informatics* that measures OpenGL* ES 2.0 and DX* 9 gaming performance. There are three major graphics tests: GFXBench 2.7 T-Rex HD (not compatible with GLBenchmark* 2.5.1) and GFXBench 2.5 Egypt HD. **Reported metrics**: Frames per second. **Scaling efficiencies**: Graphics tests are GPU dominant, sensitive to graphics and CPU frequency, core count and memory. **OS support**: Android*, iOS* and Windows*.

Cyberlink* Media Espresso* Full HD Workload (in seconds) - Using CyberLink*Media Espresso* 7. The workload file is a 6 minute, ~1GB, 1920x1080p, 23738 kbps, MOV video file that one would have obtained from an iPhone 4S. The file is transcoded to a smaller 1920x1080, 8 Mbps, H.264, .m2ts file for reduced file size during internet transfers or for viewing on a portable device with bit rate such as an iPod.

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