



Internet of Things Group Silicon Roadmap Strategy and Direction December 7, 2016

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Agenda

- IOTG Silicon Roadmap
 - Purley Platform
 - Denverton Platform
 - Kaby Lake Platform
 - Apollo Lake
- Q&A

IOTG Silicon Roadmap



IOTG - Products Roadmap

Addressing the COMPLEX set of IOT requirements
 >3500 customers >20 market segments

2016 -3Q

2016-4Q

2017-1Q

2017-2Q

2017-2H

Server/Workstation

Up-to 200W & above system power

- Intel® Xeon® Processors
- Intel® Atom™ Processors

Intel® Xeon® E5 Product Family (Broadwell EP)

Purley – Skylake SP

Intel® Xeon® E3 Product Family (Skylake)

Intel® Xeon® E3 Product Family (Kaby Lake)

Intel® Xeon® D Product Family (Broadwell DE)

Intel® Atom™ Processors C2000 Family (Rangeley)

Intel® Atom™ Processors C3000 Family (Denverton)

Desktop/Mobile

30-150W system power

- Intel® Core™ Processors
- Intel® Pentium® Processors

6th Generation Intel® Core™ Processors (DT)

7th Generation Intel® Core™ Processors (Kaby Lake DT)

6th Generation Intel® Core™ Processors (MBL-H)

7th Generation Intel® Core™ Processors (Kaby Lake MBL-H)

6th Generation Intel® Core™ Processors (MBL-U)

7th Generation Intel® Core™ Processors (Kaby Lake MBL-UDT)

SoFIA 3GR

Intel® Atom™ SoC (Braswell)

Intel® Pentium®, Celeron® and Atom™ Processor Family (Apollo Lake)

Intel® Quark™ X1000 Processor Series

Sunrise Valley*

Intel® Quark™ SE Microcontroller (Atlas Peak 1.0)

Atlas Peak 2.0

Low power & SFF

Up to 30W system power

- Intel® Core™ Processors
- Intel® Celeron® Processors
- Intel® Atom™ Processors
- Intel® Quark™ Processors

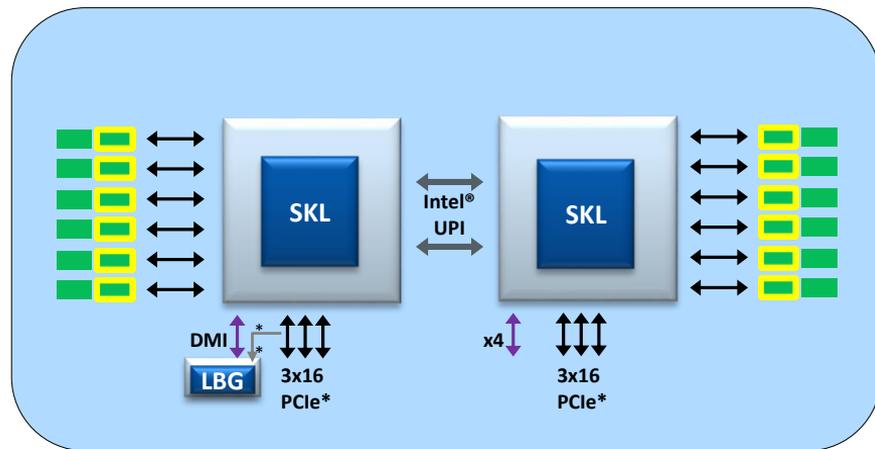
* Coming in 2018



Purley Platform Introduction

Purley Platform Highlights

- **Increased Performance**
 - Rebalance Cache Hierarchy
 - Intel® AVX-512
 - 6 memory channels and increased memory speeds
- **Abundant I/Os to meet any system needs**
 - 48 PCIe* Gen3 lanes off SKL CPU and additional PCIe* Gen3 lanes on LBG
 - Integrated Intel® Ethernet Connection X722 up to 4x10GbE
- **Security and Virtualization**
 - Intel® Boot Guard (Anchor Cove)
 - Intel® Platform Trust Technology
 - Memory Bandwidth Monitoring (Intel® Resource Director)
- **Optional Accelerators and compute engines**
 - SKX with integrated FPGA
 - Innovation Engine (IE) on LBG
- **Extended Ingredients¹**
 - **Storage:** New SATA SSDs: Downieville & Youngsville, New PCIe* SSDs: Coldstream (3D Xpoint) & Cliffdale (3DNAND)
 - **Networking:** Lewisburg as 4x10GbE with PHY, Fortville, Sageville, Sageville, Springville, Powerville



Typical 2S Configuration

- DDR4 DIMMs
- DDR4/Apache Pass
- * PCIe* uplink connection for Intel® Ethernet
- * Example DIMM population shown; please look up Apache Pass customer collateral for specific rules on DDR4/Apache Pass DIMM populations

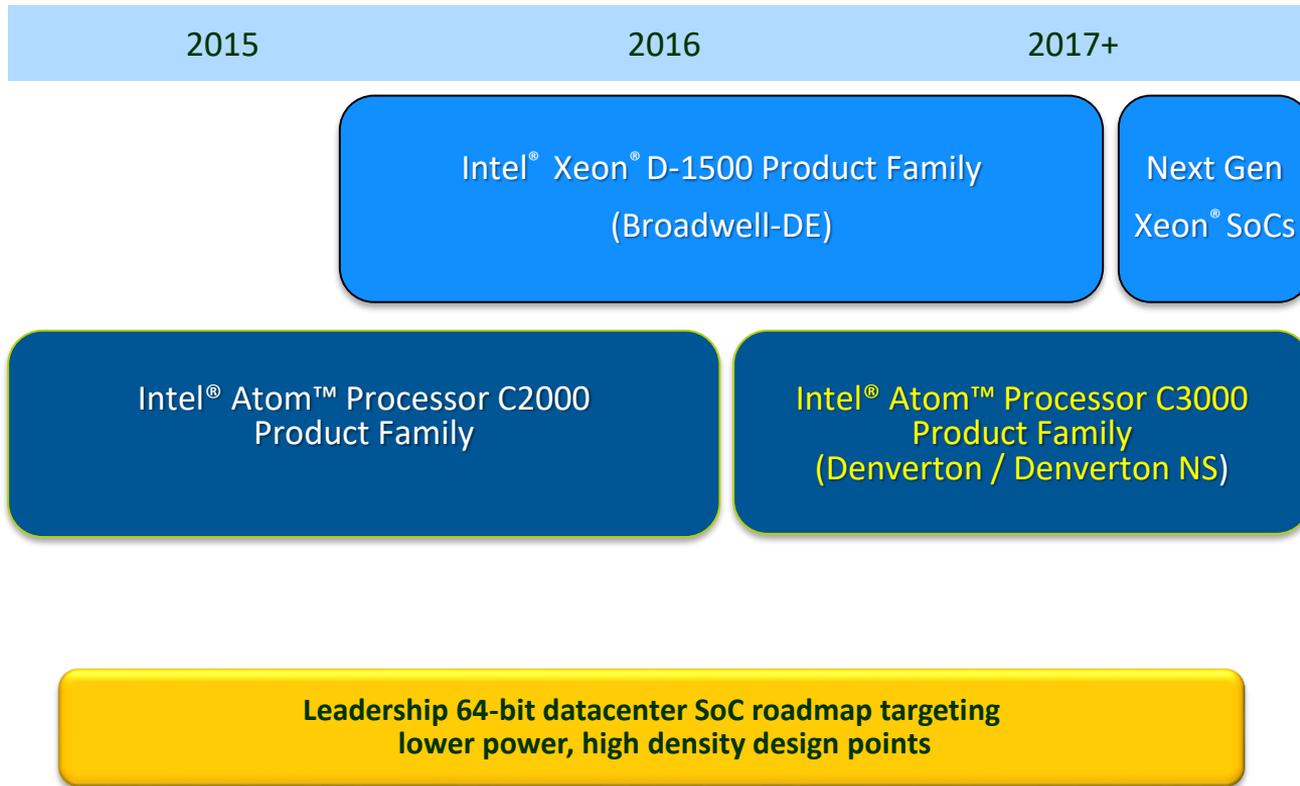
¹ These products are supported by respective division within Intel. Storage – NSG and Networking – ND

Purley Value Propositions

Internet of Things (IOTG)	
Performance	Performance improvements vs. previous generation with Intel® AVX-512 for signal processing workloads (such as radar or sensor interpretation)
	Arria10 FPGA available as configurable hardware for accelerating application/workload performance.
IOs/ Connectivity	Richer set of available IOs including more PCIe lanes, eSPI and many more
	Integrated Intel Ethernet Connection X722 up to 4x10GbE with iWARP RDMA reduces bulk data latency for critical high bandwidth IoT applications
Security	Increased platform security with the inclusion of Intel® Boot Guard (“Anchor Cove”) for hardware based boot integrity protection
RAS / Manageability	Improved error containment ensuring system survival for mission critical IoT use cases
	Integrated “Innovation Engine” for OEM system management enables abstraction of silicon capabilities for consistent management across IoT products.
Extended Long life and Reliability	Meets rigorous high ambient and component use conditions for IoT embedded applications

Intel® Atom™ Processor C3000 Product Family (Denverton)

Intel® Dense Compute SoC Roadmap



Intel® Atom™ Processor C3000 Value Proposition

3rd gen Dense Compute Intel® Atom™ SoC targeting entry Industrial, Mil/Aero, Energy, Robotics and IoT workloads that require very low power, high density and high I/O integration.

New levels of Integration

- Up to 20 flexible HSIO lanes (up to 16 SATA3, 16 PCIE3 and 4 USB3)
- Up to 4x 10GbE Intel Ethernet
- Integrated Intel® Quick Assist Technology* - Crypto and Compression accelerator

Performance/Watt Leadership

- Up to 2.5x gen to gen performance improvement
- Address extreme low power (<10W TDP) requirements and high density form factors
- Enable fan-less designs

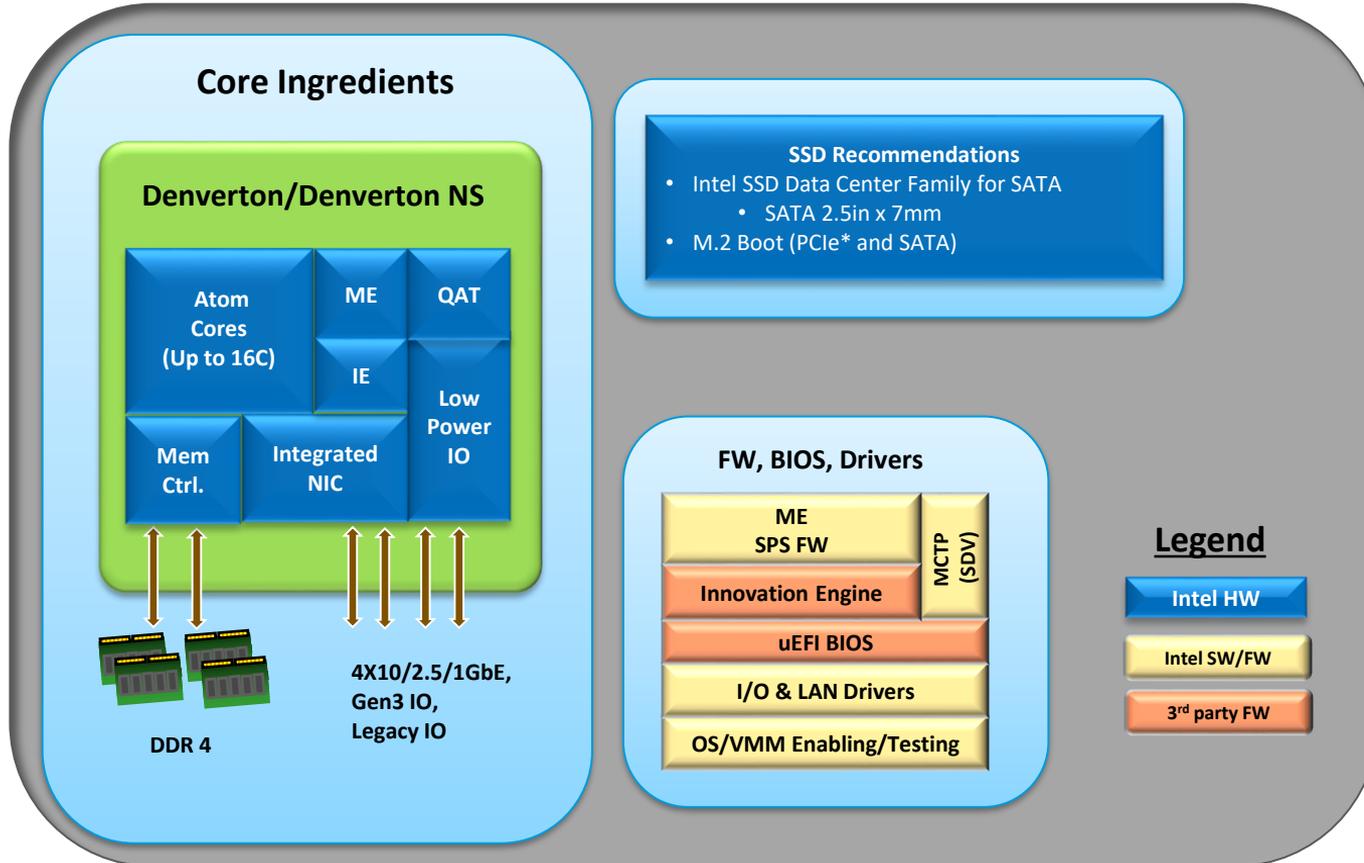
HW & SW Scalability

- x86 SW compatibility enable seamless reuse of standard SW environment
- ECC & Server class RAS
- Wide range of SKUs (2-16C) enable scaling one design across multiple target use cases

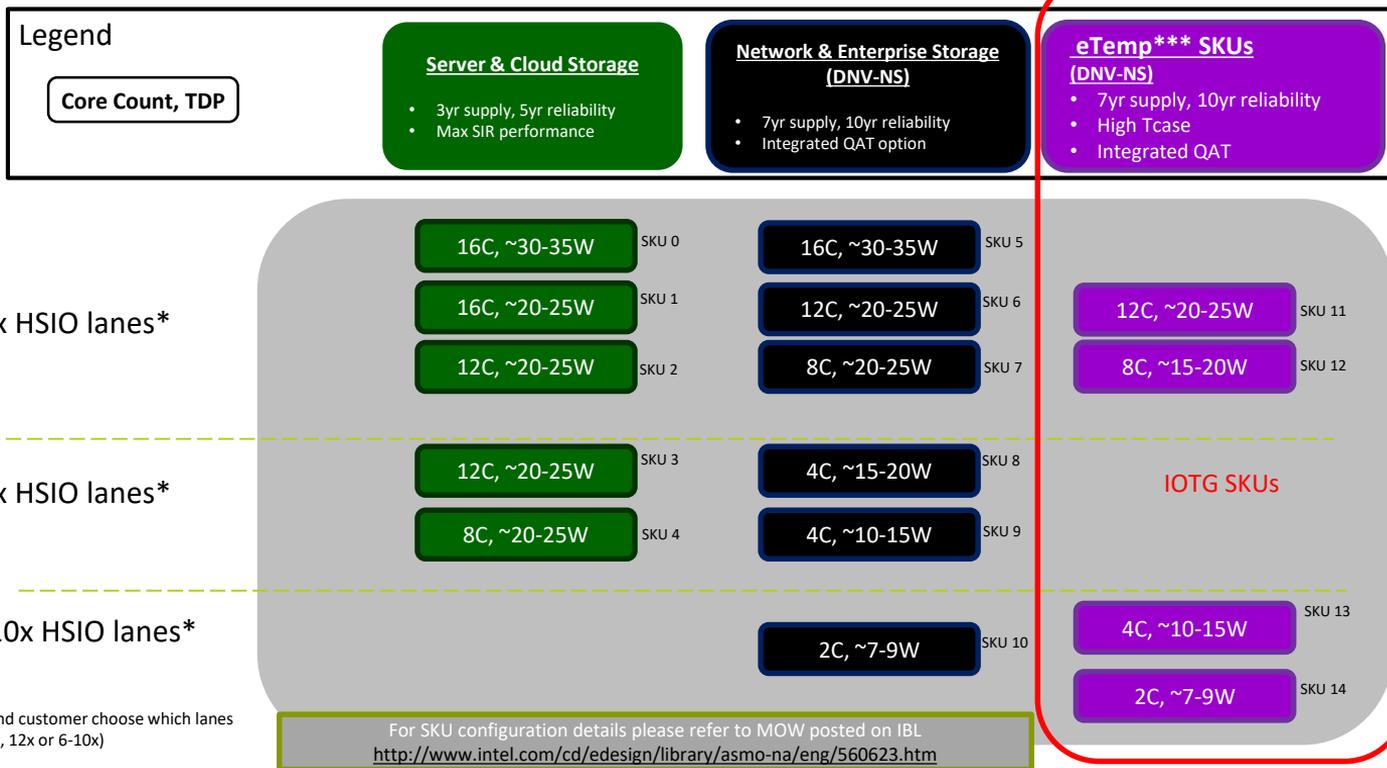
Denverton-NS (Network Series): Next-gen multi-core Atom SoC for IoT workloads
With Long Life, Extended Temperature requirements

* Denverton-NS skus

Harrisonville Platform Overview



Denverton/Denverton-NS Preliminary SKU Line-up

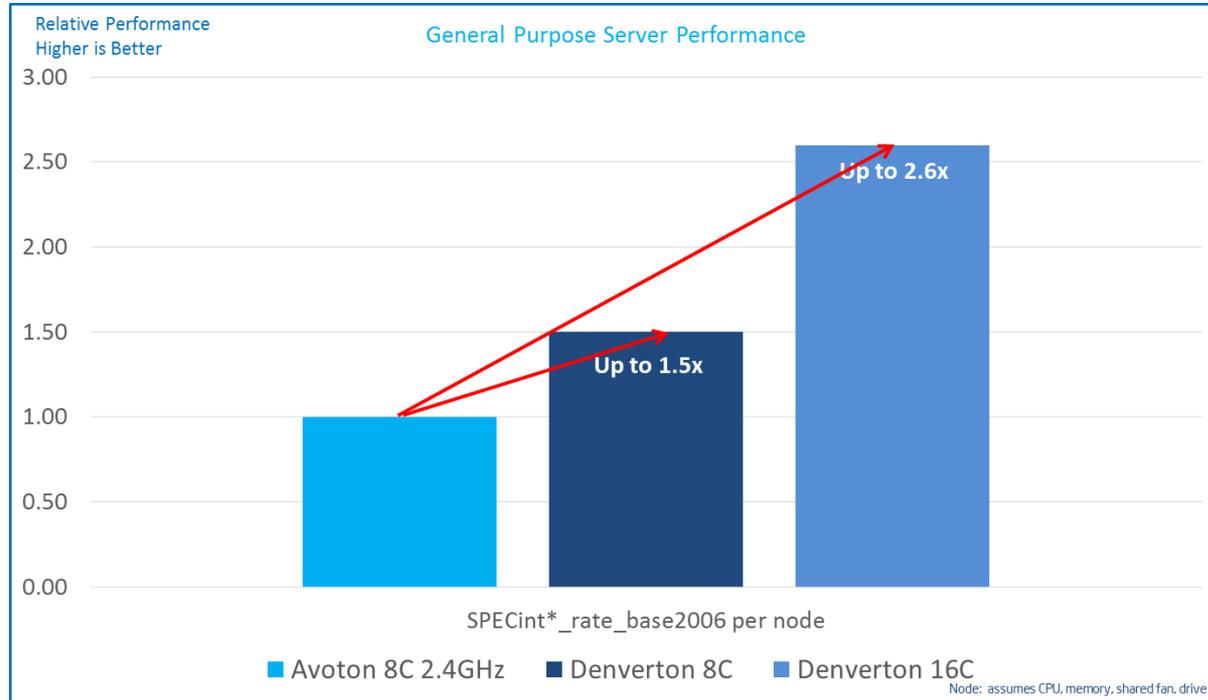


All SKUs and features are PRELIMINARY and can change without notice

***Definition of eTemp upper temperature range values has been updated – please refer to TMSDG

Estimated Denverton Performance

General Purpose Server Performance: SPECint*_rate_base2006



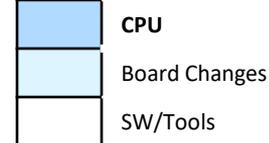
Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may 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. Results have been simulated and are provided for informational purposes only.

Results were derived using simulations run on an architecture simulator or model. Any difference in system hardware or software design or configuration may affect actual performance. All products, computer systems, dates and figures specified are preliminary based on current expectations, and are subject to change without notice. *Other names and brands may be claimed as the property of others.

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7th Generation Intel® Core™ Processors Family (Kaby Lake)

Kaby Lake** Feature Improvements



Feature	Kaby Lake** Improvements	Backward compatible with Skylake** (SKL) board + Kaby Lake** (KBL) CPU	Changes Required	IOTG Supported and Long-life supply
Intel® Software Guard Extensions (Retail, MAG)	Intel® Authenticate Technology with Hardened Security	Yes	SW updates and board components (Finger print scanner) may needed	Yes Refer to Slide 35
No Wires	Windstorm Peak**, Oak Peak** WiGig1.x,, Wireless Charging (CCG Pilot engagement only)	No (WiDi, WiGig SW will be backward comp)	New components, SW/FW update and re validation required for new components.	No
Imaging 2D,3D camera	SR 300, R200, IR Sensor for Windows* hello.	Yes		No
Audio voice and speech (Retail)	Intel® Smart Sound Technology (Intel® SST) for KBL enables new experiences, high quality and long battery life (Intel SST FDK, DSP Offload to HDMI/DP)	Yes	Debug , tuning and additional components may be required to reap full benefit.	Yes Refer to Slide 32
Touch and Sensing	Integrated Sensor Hub w/new ISH FW and Windows 10 Context SDK	Yes	Debug , tuning may be required to reap full benefit.	No Sensor Solution for Precise Touch

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

IOTG 7th Generation Intel® Core™ and Xeon® E3-1200/1500 Series SKUs

	Kaby Lake** - S		Kaby Lake** - H		Kaby Lake** - U	
	Mainstream WS/DT (LGA)	Low Power WS/DT (LGA)	Mainstream MBL WS/Halo (BGA)	Low Power MBL WS/Halo (BGA)	U Series Mobile (BGA)	Quad Core
	4C/8T 8M GT2 80 w, Intel® vPro™, ECC		4C/8T 8M GT2 45 w/35w/cTDP, Intel® vPro™, ECC	4C/8T 8M GT2 25 w, Intel® vPro™, ECC		Dual Core
	4C/8T GT2 8M 65 w, Intel® vPro™	4C/8T GT2 8 M 35 w, Intel® vPro™	4C/8T 8M GT2 45w/35w/cTDP Intel® vPro™		2C/4T 4M GT2 15w , Intel®vPro™	
	4C/4T GT2 6M 65 w, Intel® vPro™	4C/4T GT2 6 M 35 w, Intel® vPro™	4C/4T 6M GT2 45 w/35w cTDP Intel® vPro™	4C/4T 6 M GT2 25w, Intel® vPro™	2C/4T 3M GT2 15 w , Intel® vPro™	
	2C/4T GT2 3M 65 w, (ECC Optional)	2C/4T GT2 3M 35 w, (ECC Optional)	2C/4T 3M GT2 35w, (ECC Optional)	2C/4T 3M GT2 25w, (ECC Optional)	2C/4T 3M GT2 15 w	
						
					2C/2T 2 M GT1 15 w (Base PCH)	

18 SKUs Total:
Four U Series IOTG RM
Seven Halo IOTG RM
Seven DT IOTG RM

ECC requires Workstation PCH (C236/CM236) + Eligible CPU (Xeon®, Core™ i3, Pentium®, Celeron)
Intel® vPro™ requires Q series PCH (Q170/QM170) + Eligible CPU (Core™ i7, Core™ i5)
C/CM236 and Q/QM170 PCH both support PEG Bi-furcation abilities.

Kaby Lake**: OS POR

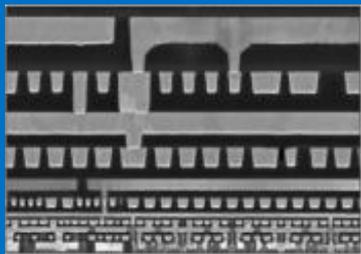
OS Vendor	Operating Systems	Platform	Distribution	Support
Microsoft*	Windows* 10 IOT Enterprise (64b)	KBL- U/S/H	Microsoft*	Intel/Microsoft*
Linux*	Fedora* 24 or later (Mid 2016) (64b)	KBL - U/S/H	Open source	
	Ubuntu*, SuSe*, Redhat* Enterprise (64b)	KBL - U/S/H	Canonical Ltd*, Attachmate Grp, Red Hat* and Open source	
	Yocto* v2.2 (kernel 4.x) Tool-based Embedded Linux Distribution† (64b)	KBL- U/S/H	Yocto* project community	
	Chromium* (Chrome*)	KBL- U	Open source community (Google*)	
RTOS	Wind River* VxWorks (VX 7 or later)	KBL- U/S/H	Wind River* systems	

- POR is same as SKL w/later versions, may add Windows* Server “Next” 2016 (on XEON® E3/E5) If demand seen from segments?
- Chromium is open source and available, Chrome* requires an SLA with Google*
- † Commercial Linux* support provided by Wind River

Apollo Lake Product Family



Power, performance and new features



- Fast processor and graphics performance
- 14nm technology using 2nd generation 3-D tri-gate transistors
- Low-power standby with improved memory performance

- Extreme coordination of sensing & actuation
- Improved[†] camera, printer and IVI image processing ability over Bay Trail
- Fast performance enhanced Integrated Sensor Hub (ISH4.0)
- Fast Audio Digital Signal Processor performance with Low Power Always Listening
- Enhanced reliability with Dual Channel ECC on DDR3L memory



† Bay Trail & Braswell provided a (1) 64-way vector processor versus Apollo Lake's (4) 32-way vector processors.

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 complete information visit <http://www.intel.com/performance>.

Apollo Lake Value Vectors



Time Coordinated Computing

- Improved Determinism from Fabric & Memory Quality of Service
- Extreme coordination of sensing & actuation
- Unified Timekeeping between CPU & PCIe* Device via PTM Hardware



Full-HD Media Performance

- Fast HD video acceleration over previous generation
- Up to 15 simultaneous 1080p30 decode streams^Δ



Immersive 3D Graphics

- Fast graphics and media performance @ ISO power over previous generation
- Enhanced API support



Enhanced Security Executions

- Integral Intel® Security Engine
- Fast cryptographic execution with Intel® AES New Instructions (Intel® AES-NI)^Δ
- Secure/measured booting features



Improved I/O Capability

- Fewer external hubs needed
- MIPI* CSI v2.0 for Image Processor
- Enhanced Integrated Sensor Hub (ISH4.0)



Reliable and Efficient Computing

- Enhanced reliability with ECC
- Optimized architecture for better QoS delivery
- Full-featured “I” SKUs @ T_j=110°C extreme 7-year lifetime for Industrial

^ΔSKU-dependent

*High Density Interconnection PCBs not required to support Apollo Lake



Derivative flexibility

14nm leading-edge low-power SoC

Embedded software environment

0.594 minimum ball pitch for non-HDI[†] designs

Industrial environment (T_j: -40°C to 110°C)

Extend Embedded Legacy Value

(ECC, Extended T_j, Secure Boot, Intel® AES-NI)

Apollo Lake-I SKUs: SKUs Covering the Full Performance Spectrum

IOTG Apollo Lake SKU Details	ADOPT		MODIFY		
	Mobile Intel® Celeron® Processor 2C 2.3 GHz N3350	Desktop Intel® Pentium® Processor 4C 2.5 GHz N4200	Intel® Atom™ Processor x5 2C 1.8 GHz Entry E3930	Intel® Atom™ Processor x5 4C 1.8 GHz Intermediate E3940	Intel® Atom™ Processor x7 4C 2.0 GHz High E3950
					
Launch	Q3'16	Q3'16	Q3'16	Q3'16	Q3'16
Number of CPU Cores	2	4	2	4	4
Number of GPU EUs	12	18	12	12	18
CPU HFM (TDP) GHz	1.1	1.1	1.3	1.6	1.6
CPU TFM GHz	2.3	2.4	1.8	1.8	2.0
CPU DMIPS	24242	50592	18972	37944	42160
Graphics GFLOPS	125	216	106	115	187
Industrial GPU HFM (TDP) – MHz	Not Applicable		400	400	400
GPU HFM (TDP) – MHz	200	200	400	400	500
GPU Single Core TFM High F _o – MHz	650	750	550	600	650
Target FPS @ 70°C	161	165	76	120	138
T _i (max)	105°C	105°C	110°C	110°C	110°C
T _j (min)	N/A	N/A	-40°C	-40°C	-40°C
LPDDR4 # of Channels / MT/s	1x32; 2x32; 4x32 @ 2400	1x32; 2x32; 4x32 @ 2400	1x32; 2x32; 4x32 @ 2133	1x32; 2x32; 4x32 @ 2133	1x32; 2x32; 4x32 @ 2400
DDR3L # of Channels / MT/s	1x64 or 2x64 @1600 (no-ECC)	1x64 or 2x64 @1866 (no-ECC)	1x64 or 2x64 @ 1600 (1866 for non-ECC)	1x64 or 2x64 @ 1600 (1866 for non-ECC)	1x64 or 2x64 @ 1600 (1866 for non-ECC)
DDR3L ECC Option	No	No	Yes	Yes	Yes
Package Size	31x24 mm Type 3	31x24 mm Type 3	31x24 mm Type 3	31x24 mm Type 3	31x24 mm Type 3
Socket / Ball Pitch	FCBGA1296 / 0.594	FCBGA1296 / 0.594	FCBGA1296 / 0.594	FCBGA1296 / 0.594	FCBGA1296 / 0.594

All SKUs shown above are supported over a 7 year lifecycle

IOTG Apollo Lake Software Support

Category	Operating System (Targeted for Support)	Implementation	Distribution and Support
Microsoft*	Windows* 10 Enterprise (64-bit), IoT Core (32/64-bit)	Intel	Intel, Microsoft
Linux*	Wind River* 8.0 Linux distribution (64-bit)	Wind River	Wind River
	Yocto Project* BSP tool-based embedded Linux distribution (64-bit)	Intel	Yocto Project and ISV Partners ¹
Android*	Android* 6.0 (64-bit) Marshmallow	Intel	ISV Partners ¹
RTOS	Wind River VxWorks* 7.0	Wind River	Wind River

Sources for BIOS Delivery

- American Megatrends Inc.*
- Insyde Software*
- Phoenix Technologies*
- Nanjing Byosoft*

Sources for Boot Loader Support Based on Intel® Firmware Support Package (Intel® FSP)

- Wind River*
- American Megatrends Inc.*
- Insyde Software*
- Waris*
- Ircona*
- Eltan*
- Nanjing Byosoft*

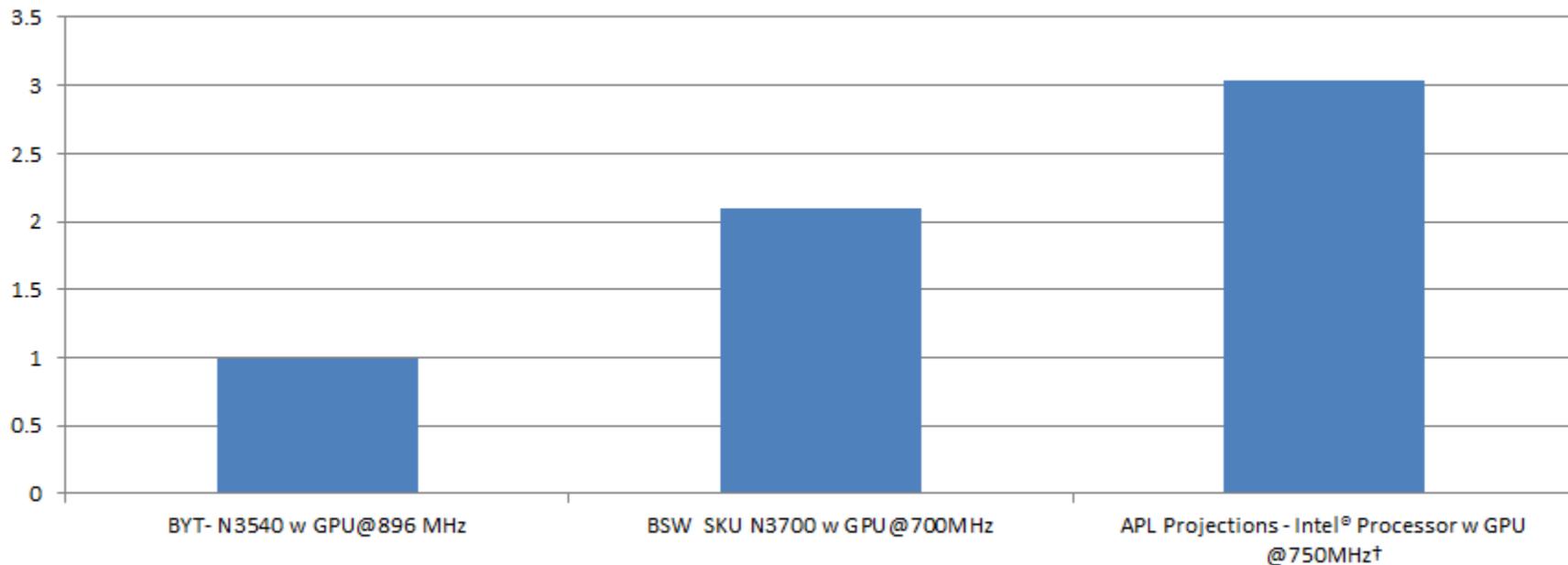
Derivative Operating Systems

- Windows* 10 IoT Enterprise is supported but not validated

*Other names and brands may be claimed as the property of others.
¹ See the "Linux* and Android* GTM" page for ISV Partner information

Apollo Lake 3D Graphics Performance Estimates[†]

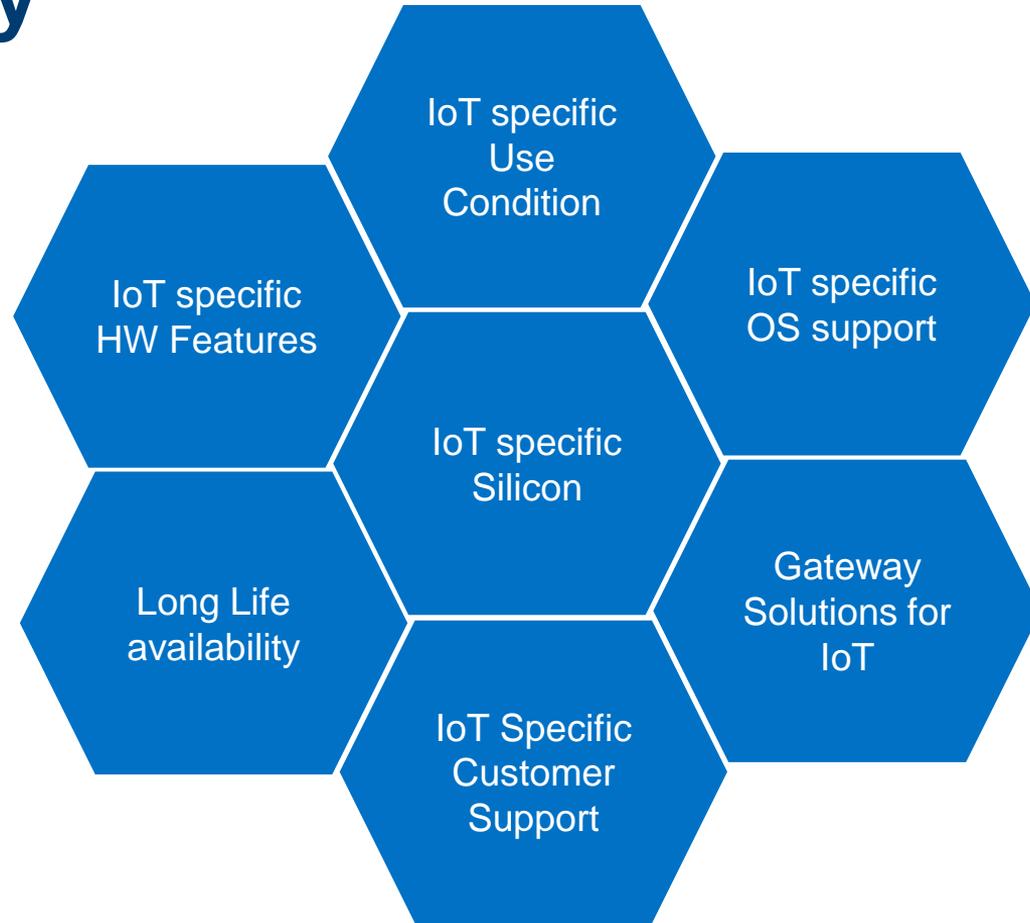
GLBenchmark 2.5.1 Egypt Off-screen Normalized to BYT-N3540



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Please refer to "Performance References" page 39 for detailed notes shown on this page

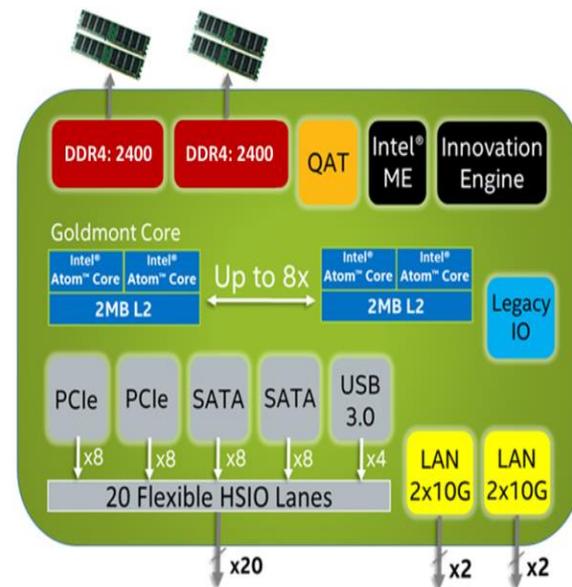
Take-away



Backup

Denverton & Denverton –NS SoC Overview

CPU	2-16 Intel® Atom™ Processor “Goldmont” Core (14nm)
→ Cache	32kB L1/Core, ≤8C L2 is 2MB/Core; ≥8C is 2MB/Core Pair
→ Addressing	39-bit PA / 48-bit VA
DDR Interface	Up to Dual channel DDR4
→ Supported Memory	DDR4 up to 1600/1866 ¹ /2133/2400, two Channels, 2DPC
→ Memory Types	ECC, RDIMM, UDIMM, SO-DIMM, Memory Down
→ Server Class RAS	Enhanced ECC SEC-DED covers address and data paths, DDR scrambler to reduce error rate, Error injection, HW based Demand and Patrol engine, PCIe End-To-End CRC, ADR
Flexible I/O	Up to 20 High-Speed Flexible Lanes configured as PCIe/SATA and USB 3.0
→ PCI-E Gen 3	Up to eight RPs and 16 lanes (Depends on flexible I/O)
→ SATA Gen 3	Up to 16 ports (Depends on flexible I/O)
→ USB Gen 3	Up to four ports (Depends on flexible I/O)
→ Additional I/O	Up to four ports USB 2.0, eMMC 5.0
Networking	Up to four Intel® Ethernet Ports (1G, 2.5G and 10G combinations) 10Mb/100Mb/1Gb supported using Full Duplex SGMII (Half Duplex SGMII is not supported).
Technologies	Intel® VT-x, Intel® VT-d, SR-IOV, VMDq PECI over SMBUS and In-Band, NC-SI, Core and Memory RAPL, Memory OLTT and CLTT
Manageability	Intel® Manageability Engine (Intel® ME), Innovation Engine (IE)
Targeted TDP/Pkg	7W-35W / FCBGA 34x28mm
Legacy I/O	SPI for boot Flash, SMBus, UART, LPC, GPIO, 8259, I/O APIC, 8254 Timer, RTC



Denverton-NS extensions

Intel® QuickAssist Technology (QAT)	Up to 20Gbs bulk Crypto
	Up to 20kops 2k RSA Decrypts
	Up to 20Gbps Compression

Note: 1. Silicon design supports but is not validated on Intel platforms; Customer is responsible for validation.

All products, platforms, dates, features, and figures specified are preliminary based on current expectations, and are subject to change without notice.

Intel[®] Quark[™] Product Family

Intel® Quark™ Products Roadmap

Product Class	2016	2017	2018
Intel® Quark™ Discrete ASSPs	Intel® Quark™ SoC X1000 Series		<div style="background-color: #92d050; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Sunrise Valley</div> <div style="background-color: #e6f2e6; padding: 5px; border: 1px solid black;">Lakemont 2x Atom @1GHz core, TSN/AVB Integration, Industrial IOs, Industrial Temp/Pkg</div>
Intel® Quark™ D IOT Edge 2	<div style="background-color: #333; color: white; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Intel® Quark™ SE Microcontroller C1000</div> <div style="background-color: #e6f2e6; padding: 5px; border: 1px solid black;">Quark-LP @ 32MHz, 80KB SRAM, 384KB Flash, USB, Pattern Matching Engine</div>	<div style="background-color: #92d050; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Atlas Peak 2.0</div> <div style="background-color: #e6f2e6; padding: 5px; border: 1px solid black;">Quark-LP @ 120MHz, 2MB Flash, 256KB SRAM, BLE 4.2</div>	
Intel® Quark™ D IOT Edge 1	<div style="background-color: #333; color: white; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Intel® Quark™ Microcontroller D1000</div> <div style="background-color: #e6f2e6; padding: 5px; border: 1px solid black; margin-bottom: 5px;">32MHz, 32KB Flash, 8KB SRAM</div> <div style="background-color: #333; color: white; padding: 5px; border: 1px solid black; margin-bottom: 5px;">Intel® Quark™ Microcontroller D2000</div> <div style="background-color: #e6f2e6; padding: 5px; border: 1px solid black;">Quark-ULP @ 32MHz, 32KB Flash, 8KB SRAM, I2C, UART, SPI</div>		

Launched

Development

Planning
Not POR

Atlas Peak 2.0

Intel® Quark™ MCU Core

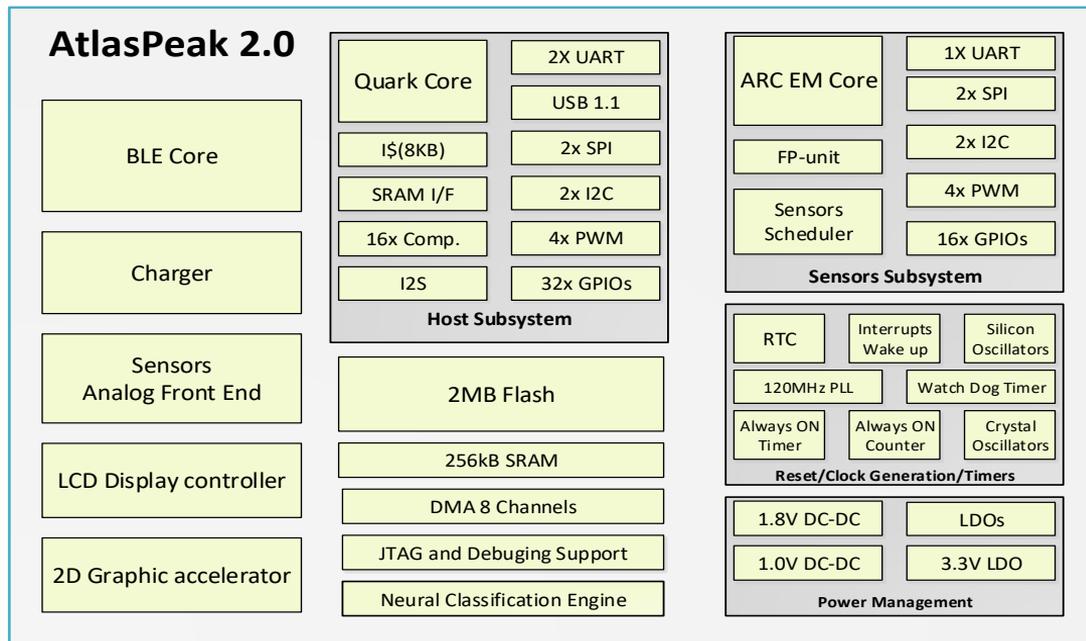
- Pentium x86 ISA compatible CPU
- **120 MHz clock**, 32-bit address bus
- 8 kB 2-way L1 instruction cache
- 1.4 DMIPs/MHz

Memory

- **2MB of on-die eFLASH**
- **256KB of on-die SRAM**
- **Support external SNOR Flash**

Host interfaces

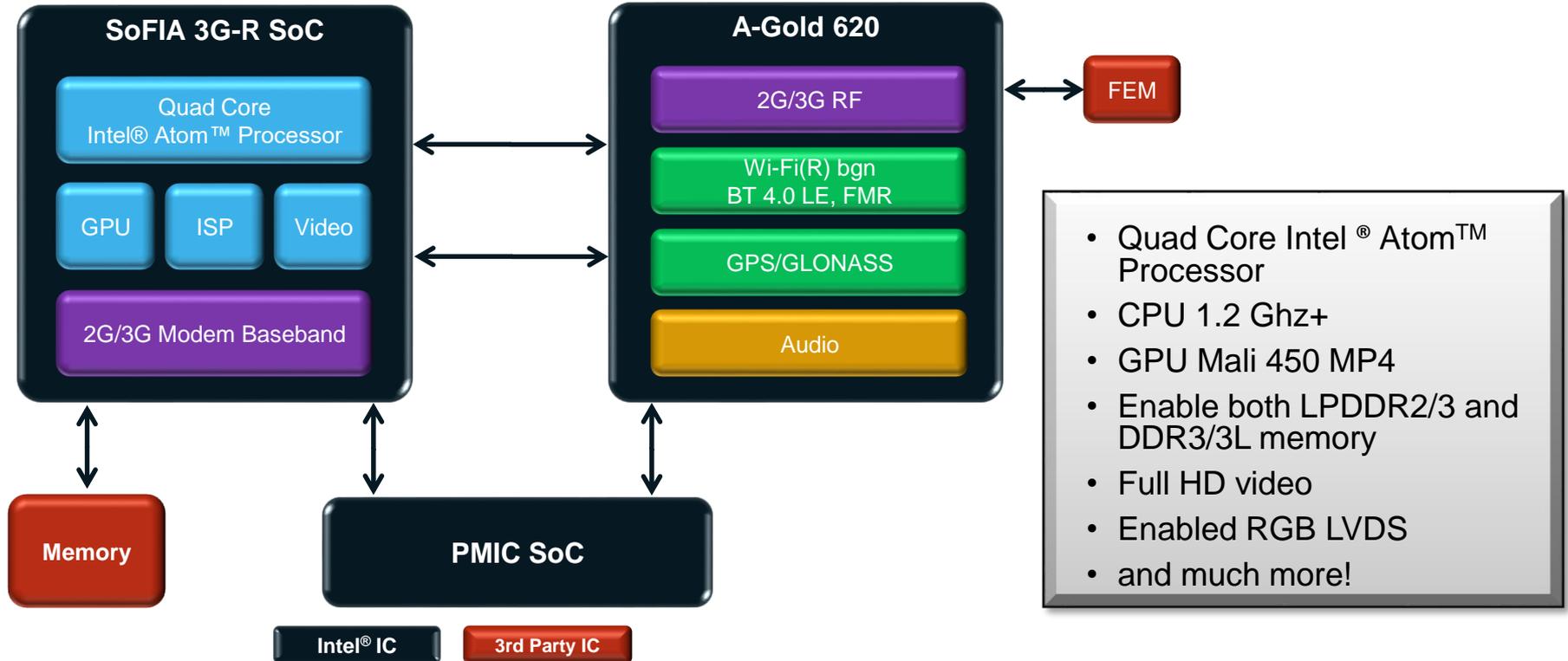
- **3 SPI masters (up to 60 MHz clock) – 2 are XIP**
- **Haptic vibrator driver (ERM up to 100mA)**
- **USB 1.1 FS device, 2 I2C M/S, SPI Slave, 2 UARTs, 4 Timers, 4 PWM, 1 I2S, 32 GPIOs**



SoFIA Product Family

SoFIA 3G-R Platform Architecture

Quad-Core Performance with a Highly Integrated 3-Chip Solution



IOTG Intel® Atom™ Processor x3 C32x5RK Solutions Summary (Sofia 3GR)

Intel Chipkit Solution

Solution	Silicon	Form Factor	Key Features	Timing	Production
<ul style="list-style-type: none"> Wilbur Bay (no radios) 	<ul style="list-style-type: none"> Intel® Atom™ Processor x3-C3205RK (0-70C) Intel® Atom™ Processor x3-C3215RK (-40-+85C) 	<ul style="list-style-type: none"> Customer Specific 	<ul style="list-style-type: none"> AP only (no radios enabled) 	EA starts May '16	Sept '16

ODM Partner Enabled Solutions

Solution	Silicon	Solution Type	Key Features	Timing	Production
<ul style="list-style-type: none"> Wailea Beach 	<ul style="list-style-type: none"> Intel® Atom™ Processor x3-C3205RK (0-70C) Intel® Atom™ Processor x3-C3215RK (-40-+85C) 	<ul style="list-style-type: none"> Certified Module 	<ul style="list-style-type: none"> AP plus Wifi/BT/GNSS enabled 	EA Starts May '16	Nov '16
<ul style="list-style-type: none"> Malibu Beach 	<ul style="list-style-type: none"> Intel® Atom™ Processor x3-C3235RK (0-70C) Intel® Atom™ Processor x3-C3245RK (-40-+85C) 	<ul style="list-style-type: none"> Certified Module 	<ul style="list-style-type: none"> AP plus 3G/Wifi/BT/GNSS enabled 	EA Starts May '16	Jan '17

IOTG Intel® Atom™ Processor x3-C32x5RK

Operating Systems

*	Today	Upcoming
 *	Marshmallow	Marshmallow
	1.7.1 Compatible Kernel 3.14	2.0 Compatible Running Kernel 3.14 (Evaluating Kernel 4.1)

Note: Intel® Atom™ Processor x3-C34xx (SoFIA LTE) supports Android*, Yocto* Linux*—versions are TBD

