Architecting Cloud Infrastructure for the Future

Jason Waxman
VP and General Manager
Cloud Platforms Group
Data Center and Connected Systems Group
July 22, 2013
Experiences Today and Tomorrow

**Voice & Gestures**
- Personal assistant
- Natural Interaction

**Video/Media**
- Content Delivery
- Video Search

**Predictive Analytics**
- Improve healthcare
- Reduce car/aircraft parts failure

---

20X growth in speech driven mobile network traffic

>22X increase in smartphones with gesture recognition features

16X increase in mobile video traffic

4X increase in servers for media / graphics

43% CAGR for infrastructure supporting Big Data & Analytics

---

1. ABI Research Aug 2012
3. Intel internal analysis and forecast, 2013
An Inflection Point in Speech

Revolutionary shift from task-centric to user-centric

Speech Recognition
- Command & Control
- Dictation
- Search
- Natural Language

6 billion mobile handsets

70+ languages

65+ countries

Intelligent Systems
- Understand
- Inform
- Be Aware
- Ubiquitous

© 2002-2013 Nuance Communications, Inc. All rights reserved. Page 4
## Delivering an Optimal UX Globally

Only the cloud can deliver the compute power required

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Speed</th>
<th>New Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>Users</td>
<td>Data</td>
</tr>
<tr>
<td>Languages</td>
<td>Transactions</td>
<td>Platforms</td>
</tr>
</tbody>
</table>
Intel & Nuance Collaboration

The Nuance Cloud, powered by Intel

Nuance Data Centers
Powered by Intel Xeon Processors

Balanced Computing
Device and cloud data centers leveraged for optimal performance

Joint Optimizations on Intel-based Platforms

Hardware + Software Accelerators
Scale Natural Language Processing

© 2002-2013 Nuance Communications, Inc. All rights reserved. Page 6
Delivering Great User Experiences

What's Needed?
Architecting Cloud Infrastructure for the Future
Addressing Requirements

Workload optimized technologies

Composable Resources

Software defined infrastructure
Architecting Cloud Infrastructure for the Future
Addressing Requirements

- Workload optimized technologies
- Composable Resources
- Software defined infrastructure
Workload Optimized Technologies
Diversity of Requirements

Servers
- CPU & Memory Intensive
  - Enterprise Applications
  - Graphics Rendering
  - High Performance Computing
  - E-Commerce
  - Dedicated Hosting
- I/O Intensive

Storage
- Frequent Access
  - Hot
  - Cost of storage
- Infrequent Access
  - Warm
  - Cold
  - $$$$$

Network
- CPU Intensive
  - Enterprise Security & Routing
  - Wire Base Station
  - Media + Processing
- I/O Intensive
  - Branch Office Router
  - Wireless Core
  - SMB Security Appliance
  - E-Commerce Dedicated Hosting
CUSTOMIZED SILICON

ACCELERATORS

EXTREME LOW POWER

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

Up to 8 cores with integrated I/O

Higher Performance

Up to 7x faster

Datacenter Class Features

64-bit, ECC memory, Intel® Virtualization Tech

2.5X increase in system designs for microservers, network and storage

Workload Optimized

8x (64GB) Memory capacity

Intel® QuickAssist Technology

Higher Efficiency

Up to 4x higher performance per watt

IA Software Compatibility

Intel® Atom™ Processor C2000 Product Family

2nd Generation 64 bit Workload Optimized SoCs

“Avoton” & “Rangeley”
Architecting Cloud Infrastructure for the Future
Addressing Requirements

Workload optimized technologies

Composable Resources

Software defined infrastructure
Composable Resources
Evolution of Rack Scale Infrastructure

Today
Physical Aggregation
Shared Power
Shared Cooling
Rack Management

Next
Fabric Integration
Rack Fabric
Optical Interconnects
Modular refresh

Future
Fully Modular Resources
Pooled compute
Pooled storage
Pooled memory
Shared boot

Enable flexible & efficient datacenters
205,000+ CUSTOMERS
100,000+ SERVERS
26,000+ VM
≅70 PB STORED

GLOBAL FOOTPRINT
CUSTOMERS IN 120+ COUNTRIES

10 WORLDWIDE DATA CENTERS
We’re on the “Open Journey”
The Rackspace OpenRack Server
Using Intel technologies for servers and networking
Rackspace Innovating Faster with Intel® Xeon® family

- Take advantage of greater VM density
- Improved revenue per WATT
- Great partnership
- Accelerated time to market
- A strong product roadmap
- OCP deployment will include Intel 10G implementation
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 estimated based on internal Intel analysis and are provided for informational purposes only. Any difference in system hardware or software design or configuration may affect actual performance.

1. Improvement based on standard rack with 40 DP servers, 48 port ToR switch, 1GE downlink/server and 4 x10GE uplinks, Cables: 40 downlink and 4 uplink vs. rack with 42 DP servers, SiPh patch panel, 25Gb/s downlink, 100Gb/s uplink, Cables: 14 optical downlink, and 1 optical uplink. Actual improvement will vary depending on configuration and actual implementation.

2. Improvement as compared to 20 Dell PowerEdge R720, N+1 redundant power, 705W PSU x2, peak power provisioned 30,000 Watts vs. same server, shared DC power using 1 power shelf of 7x 700W modules and 4200W (N+1) : power provisioned 4900 Watts


Composable Resources
Intel Rack Scale Architecture Innovation

Open Network Platform
Storage-PCIe-SSD & Caching
Photonics & Switch Fabric
Silicon: Intel® Atom™ & Xeon

CPU / Mem Modules

Up to 1.5X
Density servers/rack Improvement

Up to 6X²
Power provisioning Reduction

Up to 2.5X³
Network uplink Improvement

Up to 25X⁴
Network downlink Improvement

Up to 3X⁵
Cable Reduction
Architecting Cloud Infrastructure for the Future
Addressing Requirements

- Workload optimized technologies
- Composable Resources
- Software defined infrastructure
Software Defined Infrastructure
The Need for Better Workload Orchestration

TODAY’S CHALLENGES
- Pressure to meet SLAs
- Overprovisioning of resources
- Inefficient workload placement

FUTURE:
INTELLIGENT ORCHESTRATION

ORCHESTRATION SOFTWARE

- Citrix
- Microsoft
- VMware

IO
Compute
Memory
Storage

thermals
power
performance
utilization
security
Software Defined Infrastructure
Intel: Accelerating Software Defined Networks

Building blocks for Open Networking
Programmable platform
Enable SDN with Open APIs
## Architecting Cloud Infrastructure for the Future

**Opportunities in Cloud Systems by 2016**

<table>
<thead>
<tr>
<th>Service</th>
<th>CAGR</th>
<th>‘16 Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Cloud Servers</td>
<td>25%</td>
<td>$15B\textsuperscript{1}</td>
</tr>
<tr>
<td>Distributed Storage</td>
<td>50%</td>
<td>$21B\textsuperscript{2}</td>
</tr>
<tr>
<td>SW-Defined Networking</td>
<td>175%</td>
<td>$5.5B\textsuperscript{3}</td>
</tr>
</tbody>
</table>

---

1. Intel forecast, 2013
2. IDC Storage Solutions, 2013, doc #241515, May 2013
3. SDN Market Sizing Plexxi, Lightspeed Venture Partners, SDN Central April 2013; Markets & Markets - 2013
Delivering Great User Experiences

Intel® CPUs & Chipsets
SOCs & Accelerators

Intel 10GbE
Silicon Photonics

Flexible building blocks

Intel NVM & SSD

Software Defined Networking

Rack Scale Architecture

Server
Intel® CPUs & Chipsets
SOCs & Accelerators

Network
Intel 10GbE
Intel Switch Silicon
Intel Silicon Photonics

Storage
Flexible building blocks
Intel NVM & SSD

Cache Acceleration Software

WIND RIVER

McAfee
An Intel Company

Data Center Manager
Today's presentations contain forward-looking statements. All statements made that are not historical facts are subject to a number of risks and uncertainties, and actual results may differ materially. Please refer to our most recent Earnings Release and our most recent Form 10-Q or 10-K filing for more information on the risk factors that could cause actual results to differ.

If we use any non-GAAP financial measures during the presentations, you will find on our website, intc.com, the required reconciliation to the most directly comparable GAAP financial measure.

INFORMATION IN THIS DOCUMENT IS PROVIDED IN CONNECTION WITH INTEL PRODUCTS. NO LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT. EXCEPT AS PROVIDED IN INTEL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, INTEL ASSUMES NO LIABILITY WHATSOEVER AND INTEL DISCLAIRES ANY EXPRESS OR IMPLIED WARRANTY, RELATING TO SALE AND/OR USE OF INTEL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

A "Mission Critical Application" is any application in which failure of the Intel Product could result, directly or indirectly, in personal injury or death. SHOULD YOU PURCHASE OR USE INTEL'S PRODUCTS FOR ANY SUCH MISSION CRITICAL APPLICATION, YOU SHALL INDEMNIFY AND HOLD INTEL AND ITS SUBSIDIARIES, SUBCONTRACTORS AND AFFILIATES, AND THE DIRECTORS, OFFICERS, AND EMPLOYEES OF EACH, HARMLESS AGAINST ALL CLAIMS COSTS, DAMAGES, AND EXPENSES AND REASONABLE ATTORNEYS' FEES ARISING OUT OF, DIRECTLY OR INDIRECTLY, ANY CLAIM OF PRODUCT LIABILITY, PERSONAL INJURY, OR DEATH ARISING IN ANY WAY OUT OF SUCH MISSION CRITICAL APPLICATION, WHETHER OR NOT INTEL OR ITS SUBCONTRACTOR WAS NEGLIGENT IN THE DESIGN, MANUFACTURE, OR WARNING OF THE INTEL PRODUCT OR ANY OF ITS PARTS.

Intel may make changes to specifications and product descriptions at any time, without notice. Designers must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined". Intel reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The information here is subject to change without notice. Do not finalize a design with this information.

The products described in this document may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request. Contact your local Intel sales office or your distributor to obtain the latest specifications and before placing your product order.

Copies of documents which have an order number and are referenced in this document, or other Intel literature, may be obtained by calling 1-800-548-4725, or go to: http://www.intel.com/design/literature.htm

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.

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel.

Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

Intel product plans in this presentation do not constitute Intel plan of record product roadmaps. Please contact your Intel representative to obtain Intel's current plan of record product roadmaps.
Legal Disclaimers

All products, computer systems, dates, and figures specified are preliminary based on current expectations, and are subject to change without notice. Intel processor numbers are not a measure of performance. Processor numbers differentiate features within each processor family, not across different processor families. Go to: http://www.intel.com/products/processor_number

Intel, processors, chipsets, and desktop boards may contain design defects or errors known as errata, which may cause the product to deviate from published specifications. Current characterized errata are available on request.

Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM). Functionality, performance or other benefits will vary depending on hardware and software configurations. Software applications may not be compatible with all operating systems. Consult your PC manufacturer. For more information, visit http://www.intel.com/go/virtualization

Intel, Intel Xeon, Intel Atom, Intel Xeon Phi, Intel Itanium, the Intel Itanium logo, the Intel Xeon Phi logo, the Intel Xeon logo and the Intel logo are trademarks or registered trademarks of Intel Corporation or its subsidiaries in the United States and other countries.

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

Copyright © 2013, Intel Corporation. All rights reserved.
Risk Factors

The above statements and any others in this document that refer to plans and expectations for the third quarter, the year and the future are forward-looking statements that involve a number of risks and uncertainties. Words such as “anticipates,” “expects,” “intends,” “plans,” “believes,” “seeks,” “estimates,” “may,” “will,” “should” and their variations identify forward-looking statements. Statements that refer to or are based on projections, uncertain events or assumptions also identify forward-looking statements. Many factors could affect Intel's actual results, and variances from Intel's current expectations regarding such factors could cause actual results to differ materially from those expressed in these forward-looking statements. Intel presently considers the following to be the important factors that could cause actual results to differ materially from the company's expectations. Demand could be different from Intel's expectations due to factors including changes in business and economic conditions; customer acceptance of Intel's and competitors' products; supply constraints and other disruptions affecting customers; changes in customer order patterns including order cancellations; and changes in the level of inventory at customers. Uncertainty in global economic and financial conditions poses a risk that consumers and businesses may defer purchases in response to negative financial events, which could negatively affect product demand and other related matters. Intel operates in intensely competitive industries that are characterized by a high percentage of costs that are fixed or difficult to reduce in the short term and product demand that is highly variable and difficult to forecast. Revenue and the gross margin percentage are affected by the timing of Intel product introductions and the demand for and market acceptance of Intel's products; actions taken by Intel's competitors, including product offerings and introductions, marketing programs and pricing pressures and Intel's response to such actions; and Intel's ability to respond quickly to technological developments and to incorporate new features into its products. The gross margin percentage could vary significantly from expectations based on capacity utilization; variations in inventory valuation, including variations related to the timing of qualifying products for sale; changes in revenue levels; segment product mix; the timing and execution of the manufacturing ramp and associated costs; start-up costs; excess or obsolete inventory; changes in unit costs; defects or disruptions in the supply of materials or resources; product manufacturing quality/yields; and impairments of long-lived assets, including manufacturing, assembly/test and intangible assets. The tax rate expectation is based on current tax law and current expected income. The tax rate may be affected by the jurisdictions in which profits are determined to be earned and taxed; changes in the estimates of credits, benefits and deductions; the resolution of issues arising from tax audits with various tax authorities, including payment of interest and penalties; and the ability to realize deferred tax assets. Gains or losses from equity securities and interest and other could vary from expectations depending on gains or losses on the sale, exchange, change in the fair value or impairments of debt and equity investments; interest rates; cash balances; and changes in fair value of derivative instruments. Intel’s results could be affected by adverse economic, social, political and physical/infrastructure conditions in countries where Intel, its customers or its suppliers operate, including military conflict and other security risks, natural disasters, infrastructure disruptions, health concerns and fluctuations in currency exchange rates. Expenses, particularly certain marketing and compensation expenses, as well as restructuring and asset impairment charges, vary depending on the level of demand for Intel's products and the level of revenue and profits. Intel’s results could be affected by the timing of closing of acquisitions and divestitures. Intel's results could be affected by adverse effects associated with product defects and errata (deviations from published specifications), and by litigation or regulatory matters involving intellectual property, stockholder, consumer, antitrust, disclosure and other issues, such as the litigation and regulatory matters described in Intel's SEC reports. An unfavorable ruling could include monetary damages or an injunction prohibiting Intel from manufacturing or selling one or more products, precluding particular business practices, impacting Intel's ability to design its products, or requiring other remedies such as compulsory licensing of intellectual property. A detailed discussion of these and other factors that could affect Intel's results is included in Intel's SEC filings, including the company's most recent reports on Form 10-Q, Form 10-K and earnings release.
Intel® Atom™: Performance Configuration Details

**Dynamic Web Performance:**

**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

**Atom C2xxx:** MPK SDP w/Intel® Atom™ C2xxx (8C), Turbo Disabled, 4x8GB DDR3-1600 MHz UDIMM ECC, BIOS version 18D05, 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: 11109

**Performance Per Watt:**

**Atom S1260:** FOR.INTEL.cpu2006.1.2.ic13.1.linux64.01june2013
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:int_rate_base2006=18.7. Est. Power=20W

**Atom C2xxx:** FOR.INTEL.cpu2006.1.2.ic13.1.linux64.01june2013
Intel® Mohon Peak Alpha platform with one Intel® Avoton processor (8-core), Turbo Boost Disabled, 16GB memory (2x 8GB DDR3-1600 UDIMM ECC), 250GB SATA 7200RPM HDD, Red Hat Enterprise Linux 6.4. Estimated score:int_rate_base2006=69, Est. Power=19W
## Estimated Xeon® E3-1285L v3 vs. nVidia* GTX 680 Comparison

<table>
<thead>
<tr>
<th></th>
<th>nVidia* GTX 680</th>
<th>Xeon E3-1285L v3</th>
<th>Xeon E3 Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Per Node</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Transcodes</td>
<td>8</td>
<td>10</td>
<td>up to 25% more</td>
</tr>
<tr>
<td>Power (1 CPU + 1 GPU)</td>
<td>290W</td>
<td>65W</td>
<td></td>
</tr>
<tr>
<td><strong>Per Rack</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Transcodes</td>
<td>336 (42 GPUs)</td>
<td>1,560 (156 GPUs)</td>
<td>up to 4.6x better</td>
</tr>
<tr>
<td>Power</td>
<td>14,524W</td>
<td>10,865W</td>
<td></td>
</tr>
<tr>
<td>3yr TCO per Transcode</td>
<td>$353.52</td>
<td>$127.42</td>
<td>up to 64% lower</td>
</tr>
</tbody>
</table>

Platform configurations:
- Discrete graphics: 1U server with two Intel® Xeon® processor E5-2650, 2.0 GHz, 20MB cache, 8GT/s QPI, 8x1GB DDR3-1333 memory, 1 hard drive, 1 power supply, 2 nVidia* GTX680 graphics cards; Xeon E3v3: 3U microserver with twelve Intel® Xeon® processor E3-1285Lv3, 3.1 GHz, 8MB cache, 4x1GB DDR3-1333, 1 hard drive, 1 power supply. Concurrent transcode per GPU: 8 (Discrete graphics), 10 (E3v3). GTX680 transcode performance from nVidia* whitepaper at http://international.download.nVidia*.com/webassets/en_US/pdf/GeForce-GTX-680-Whitepaper-FINAL.pdf. Intel E3 transcode performance came from Intel whitepaper: Intel Quick Sync Video Technology on Intel® Iris™/Iris Pro Graphics (5100+ Series and Intel HD Graphics (4200+ Series)—Flexible Transcode Performance and Quality Explained.

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

* Results, which are provided for informational purposes only, were estimated as of March 2013 by Intel based on a comparison of performance (number of 1080p 30fps HD concurrent transcode per GPU) and related results utilizing Intel's product data and data published by nVidia*.*