Executive Summary

Cloud computing offers new efficiencies and higher agility for deploying and scaling IT services, yet many companies are reluctant to host critical workloads in public clouds. OpenStack* software offers a solution to this challenge—a secure and open private cloud platform that is designed to integrate with existing data center infrastructure and applications and also with the widest range of public cloud offerings. More than 1,200 companies, including Best Buy*, Comcast*, PayPal*, Walmart*, and Wells Fargo*, are using OpenStack* software to help them move toward cloud-like IT models that enable efficient resource pooling, elastic scalability, and self-service provisioning for end users.

The OpenStack cloud platform is based entirely on open source software and is backed by a vibrant global ecosystem of users and vendors. Initiated in 2010, this flexible cloud platform has matured rapidly and is now ready for production cloud deployments in many environments. Intel has worked closely with the OpenStack software development community to help ensure that compute, storage, and networking workloads can take advantage of advanced Intel platform technologies in OpenStack clouds.

This white paper explores the maturity and value of the OpenStack cloud platform and highlights a number of enterprise users that are achieving high value today. It also discusses the key contributions Intel has made to OpenStack software and how those contributions can help users achieve enterprise-class levels of security, compliance, availability, manageability, and performance.

“For anyone out there who’s thinking of standing up a mature private cloud capable of supporting enterprise applications, rest assured: Today, OpenStack is mature and up to the task.”

– Matt Haines, VP of cloud engineering and operations, Time Warner Cable

Moving to the Cloud on Your Own Terms

“After several years in this field, today we truly believe that OpenStack is the Linux of cloud computing.”

— Mariano Cunietti, CTO, Enter/Cloudup

We are in the midst of an explosion in data volumes and computing requirements. As people become more mobile and markets more global, there are increasing numbers of connected people with an increasing number of devices and apps per person—all adding to data center traffic and workloads.

Yet these people-generated demands are just the beginning. Analysts estimate there will be as many as 50 billion intelligent machines and sensors connected to the Internet by 2020, and that this Internet of Things (IoT) will increase global data center traffic by nearly 300 percent.3

Because of this rapid growth, cloud computing is not just an option going forward, but an imperative. Traditional infrastructure solutions are simply too expensive and inflexible to support such rapidly growing and changing requirements.

Cloud computing enables self-service portals that let end-users and software development teams access computing resources on demand and with very little effort, so businesses can develop and deploy new applications at a faster pace. It also enables multitenant resource sharing and increased automation throughout the data center, both of which can substantially reduce the cost of scaling and adapting IT services.

There is a great deal of focus on using public clouds to provide these capabilities, and public clouds will undoubtedly play a critical role for most businesses. Yet business and IT decision makers in many organizations are reluctant to move critical workloads into public clouds, largely due to perceptions about security, compliance (including data residency), and service-level guarantees.

Because of these perceptions, there is a move toward hybrid cloud strategies that allow organizations to run critical workloads on an in-house private cloud and use one or more public clouds for less sensitive workloads and burst capacity. Based on a Gartner survey, nearly 50 percent of enterprises expect to have hybrid clouds in production by 2017.4

A number of options exist for building a private, on-premise cloud that can link to public cloud resources. Multiple proprietary cloud solutions are available and many enterprises have used them to move forward in their journey. OpenStack software offers another option for transforming existing data centers: a modular cloud platform based entirely on open-source software and backed by a broad ecosystem of contributors and vendors. It offers a clear path forward for organizations that prefer the flexibility, choice, and economic models of an open-source solution.

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OpenStack Cloud Software Paves the Way

By the holidays last year, Walmart.com’s entire U.S. production traffic was on OpenStack compute.\(^5\)

— Amandeep Juneja, senior director of cloud operations and engineering for @WalmartLabs

OpenStack software provides a scalable, open cloud computing platform for private, public, and hybrid clouds. It includes a collection of interoperable, open-source software modules that can be used to orchestrate large pools of compute, storage, and networking resources (Figure 1). All of these resources can be managed through a web-based dashboard, command line tools, and RESTful APIs, so organizations have a great deal of flexibility in how they deploy, operate, and manage their cloud.

OpenStack software provides a solution for delivering infrastructure as a service (IaaS) to end users through a web portal. It also provides an open, standards-based foundation for layering on additional cloud management tools. These tools can be used to implement higher levels of automation and to integrate analytics-driven management applications for optimizing service levels, utilization, cost, and business alignment.

OpenStack software is designed to integrate with a wide range of existing hardware and software infrastructure, including element management and monitoring tools. It also provides a flexible foundation for integrating and managing resources across diverse private and public clouds. As noted by Forrester, “Although many vendors still leverage their own unique cloud platform at the core of their solution, support for OpenStack as a supplemental cloud platform is quickly becoming a standard.”\(^6\) This wide support among vendors will help provide flexibility and choice for enterprises, cloud service providers, and telecom companies as they work to make the most efficient use of available resources.

The OpenStack\(^\text{®}\) Cloud Platform in Action - Walmart

Continuous integration of cutting-edge technology has keyed Walmart’s rise to retail success. Now the USD 480B retail giant has implemented OpenStack cloud software to provide:

- **The scalability** to meet explosive demand,
- **The flexibility** to adapt to ever-changing application needs,
- **The “big data smarts”** to predict what customers want and to provide them with recommendations.

For more information on how and why Walmart is using OpenStack software as a technology foundation for rapid and efficient growth, read the @WalmartLabs blog, at http://tinyurl.com/ne8n4ug

![Figure 1. OpenStack* software and Intel® architecture offer comprehensive support for private cloud implementations, enabling agile and efficient orchestration of existing compute, network, and storage resources.](image-url)
The OpenStack Foundation continues to grow. Membership increased 50 percent in 2014 and now includes over 18,500 individuals in 148 countries, with 463 supporting companies, and more than 1,300 active contributors. OpenStack software has been adopted by more than 1,200 businesses and a growing number of public and hosted private cloud services. Current users include some of today’s most successful and fastest growing organizations, such as Best Buy*, Bloomberg*, CERN*, Comcast*, eBay*, HP*, PayPal*, Rackspace*, Walmart*, Walt Disney Co.* , and Wells Fargo*.

These and many other contributors have invested significant engineering resources toward implementing and extending OpenStack clouds. They have demonstrated the value at scale in complex IT environments and helped to address many of the challenges that have been holding back more mainstream adoption. Based on these advances, 2015 seems poised to be the year in which OpenStack technology moves rapidly toward widespread production deployments.

Recent releases of OpenStack software have included many enhancements to simplify deployment and support enterprise requirements. Based on a report by Forrester, the Juno release includes:

• More than 3,200 bug fixes to provide higher stability and increased capability
• 97 new drivers and plug-ins for enhanced legacy integration
• Improvements in core storage, compute, and networking elements
• Support for identity federation, including integration with multiple back-end solutions
• Better support for clustered data architectures, such as Apache Hadoop*

“The maturity in the core platform is there now. The upgrade capabilities are sufficient to ease the pains of the past releases, and the mature features in Juno are compelling enough to warrant the move.”

- Forrester, November 7, 2014

The open-source community continues to harden and extend OpenStack software to deliver advanced support across all enterprise workloads, from front-end applications and services to back-end, mission-critical business solutions. In the meantime, a good path forward for many prospective users is to begin deploying an OpenStack cloud for targeted workloads today, so their organizational experience and expertise can grow and mature along with the platform, enabling a progressive transition toward an open, fully cloud-optimized data center.

Intel Contributions Break Down Deployment Barriers

Intel is a platinum member of the OpenStack Foundation and uses OpenStack software as the basis for its own private cloud. Intel developers have contributed to all major modules in the latest release and play a key role in the Win the Enterprise (WTE) Workgroup. The WTE Workgroup was started in May 2014 and focuses on the issues most important to large-scale, production deployments.

Intel developers work with the community to expose Intel® hardware technologies to OpenStack software modules and to extend OpenStack technology to improve security and compliance, high availability, manageability, performance, and the end-user experience. These efforts provide direct value to all OpenStack software users and to the vendor ecosystem. They also help to ensure that users get the best possible results when using OpenStack software with Intel architecture.

The following sections provide an overview of Intel’s key contributions to OpenStack cloud solutions.

Stronger Security, Trust, and Compliance

Security and compliance are among the most critical roadblocks to cloud adoption and have been a major focus of Intel’s OpenStack software contributions. Together, OpenStack software and Intel architecture allow administrators to establish trusted resource pools and create policies that constrain selected workloads from running on other, untrusted infrastructure. These capabilities are based on a number of technologies developed by Intel (Figure 2).
By enabling broad collaboration, the open-source developmental model has become one of the most powerful sources of innovation in the world today. Intel is strongly committed to this collaborative approach and is a top upstream contributor to more than 50 projects, including Linux*, Android*, Chromium*, HTML5, and many others.

Intel also works with downstream users, vendors, and standards-bodies to help ensure strong ecosystem support to fuel adoption and further growth. This approach offers benefits for everyone involved, and provides Intel with a path for ensuring that its products and technologies deliver high value in today’s increasingly open source world.

For more information, visit https://01.org/
Reliable High Performance

Intel processors, chipsets, solid-state storage drives, network adapters, and other components include technologies that can dramatically improve performance for certain workloads. The challenge in a cloud environment is to match workloads and VMs to best-fit server platforms that have the combination of resources needed to maximize performance and utilization. This requires a higher level of visibility and control than is currently available in many cloud platforms, whether public or private.

Intel works with the OpenStack software development community to expose platform technologies and integrated telemetry to the software to enable intelligent scheduling and enhanced monitoring. This work includes enhancements to both the Nova scheduler and the Glance metadata catalog, so that:

- **Cloud administrators** can expose advanced platform attributes to management applications and end users
- **Enterprise IT organizations and end users** can deploy workloads on best-fit platforms
- **Cloud service providers and telecommunication companies** can deliver premium services based on advanced platform capabilities (see the Deliver Premium Cloud Services sidebar.)

Intel technologies that are exposed for intelligent infrastructure orchestration include:

- **Intel® AES-NI** for encryption/decryption acceleration.
- **Intel® Advanced Vector Extensions (Intel® AVX)** for accelerating floating point performance and Intel AVX 2.0 which also accelerates integer performance and other compute-intensive workloads.
- **Intel® QuickAssist Technology**, which offloads cryptographic and data compression algorithms to dedicated hardware accelerators that are available in certain Intel chipsets, PCIe* cards, and system on a chip (SoC) solutions.
- **Intel® Quick Sync Video technology**, which accelerates transcoding of certain video codecs.
- **Intel® Xeon Phi™ coprocessors**, which provide up to 61 processor cores and 244 threads to enable dramatic performance gains for highly parallel applications and workloads. Intel Xeon Phi coprocessors are currently available as add-in PCIe cards. The next-generation (code-named Knights Landing) will also be able to function as standalone server processors.

Intel and the OpenStack software development community are working together to expose additional platform capabilities across compute, storage, and networking infrastructure and to provide standard APIs that simplify integration and orchestration in OpenStack clouds. Near-term enhancements include support for cache and memory monitoring. Since these two platform resources are shared among all the VMs running on a physical server, contention can be a serious performance limitation. The ability to monitor cache and memory utilization per VM will help to solve “noisy neighbor” scenarios, enabling higher platform utilization with better performance and reduced risk.

Deliver Premium Cloud Services

By exposing advanced Intel® platform capabilities to the Nova scheduler, OpenStack® software provides optimized support for demanding workloads, such as:

- Network and security applications with heavy cryptographic or data compression requirements
- Business and technical applications with complex floating-point or integer computations or massively parallel resource requirements
- Media servers that require high-speed transcoding

For more information, read the Intel white paper, “OpenStack® Enhanced Platform Awareness.” [http://tinyurl.com/oq8r7ce](http://tinyurl.com/oq8r7ce)

Higher Availability

Cloud computing using OpenStack software provides support for improving service levels across all workloads and for taking advantage of the high availability capabilities built into cloud-aware applications. There are two key aspects to high availability in a cloud environment: high availability for applications running in the cloud and high availability for the cloud platform, itself. Intel is adding to the robustness of OpenStack software in both categories.

For applications, Intel is working with the OpenStack software development community to integrate advanced capabilities for supporting enterprise-class service-level agreements (SLAs) (this is discussed in more detail in a later section). Intel contributions to OpenStack software also provide support for detailed CPU usage monitoring, so overloaded platforms can be detected and action taken before performance or availability is compromised.
To improve availability for the OpenStack cloud platform itself, Intel worked with the community to provide support for rolling upgrades by adding an object layer for access to the services database. With rolling upgrades and automatic failback, adopters can update their OpenStack software more easily and with less risk.

Intel and the community are working together to deliver additional capabilities for maintaining high availability in OpenStack clouds, including:

- **Ongoing improvements** in rolling upgrades, to further simplify cloud evolution.
- **Automatic VM restarts on failure**, without relying on the underlying hypervisor. This will enable simpler and more consistent support for high availability across heterogeneous environments.
- **VM live migration after host evacuations**, so servers can be easily prepared for maintenance without bringing down applications.
- **Ongoing work** to harden basic OpenStack cloud services and to extend platform and application health monitoring.

### Greater Efficiency and Lower Costs

Intelligent scheduling through enhanced platform awareness is a powerful tool for optimizing infrastructure efficiency. Running workloads on best-fit platforms with telemetry-driven monitoring enables higher performance with better infrastructure utilization.

Intel has also made software contributions to enable policy-based control of Swift object storage. The Intel contributions enable different data types to be stored with appropriate levels of performance, latency, redundancy, and governance. Capabilities for error correction and consistency have been enhanced, a new performance tiering feature improves solid state drive (SSD) utilization, and geotagging will allow users to specify data storage locations. These capabilities can help to improve the efficiency of object storage to meet the demands of a range of applications, which will be increasingly important as data volumes continue to rise and big data analytics becomes a mainstream usage model. For more information, see the Intel solution brief, “OpenStack Swift 2.0: Storage Policies Open Up Broader Horizons.” [http://www.intel.com/content/www/us/en/storage/openstack-swift-v2-solution-brief.html](http://www.intel.com/content/www/us/en/storage/openstack-swift-v2-solution-brief.html)

Ongoing Intel work with the OpenStack software development community is focused on:

- **Additional improvements to object storage efficiency** through the integration of erasure coding in Swift object storage. Erasure code provides high data durability while reducing storage requirements by as much as 50 percent in comparison with current best practices, which require triple data redundancy in many distributed storage environments.\(^9\) The Intel contributions are designed to significantly improve erasure coding performance.

- **Enhancements in power and thermal monitoring and control** using Intel® Node Manager in combination with the Intelligent Platform Management Interface (IPMI).

- **Simpler and more efficient administration and use** by enabling applications to be simultaneously provisioned with compute, network, and storage resources.

- **Simpler and more secure operational support** by providing read-only access for administrators.

- **More flexible and agile networks** by providing support for virtual local area networks (VLANs) using Open vSwitch*, which runs on Intel processor-based servers to support next-generation network applications (see the Bring Your Network into Your Cloud section).

\(^9\) Erasure coding (EC) algorithms can be configured to provide equal or better data durability than triple RAID data redundancy while using up to 50% less storage. Calculation based on internal Intel measurements on usable capacity of 320 drives totaling 960 TB of raw capacity with no single point of failure, compared to a 3-way RAID setup: EC uses a configurable scheme so numbers vary but a common one is for every 14 drives you get to store 10 drives worth of data so 14n/10n = 1.4x vs. 3x for typical tri-replication. Features and benefits may require an enabled system and third party hardware, software, or services. Performance varies depending upon your specific configuration. Consult your system provider. For more information go to [http://www.intel.com/performance](http://www.intel.com/performance).
on these advantages, by providing the monitoring, remediation, and management capabilities needed for enterprise-class orchestration of critical resources based on both workloads and service level agreements (SLAs).

Intel plans to provide enhancements across multiple OpenStack software modules to enable increasingly intelligent scheduling of virtual machines based on both SLAs and workload requirements. Improvements in the monitoring of hardware, virtual machines, and resource consumption will help detect and resolve issues that might otherwise compromise an SLA. A key component of these enhancements is a capacity planning engine, which is based on normalized compute units that take into account the increasing performance of each new Intel processor generation (most clouds today base scheduling on overly simplistic vCPU counts). This will enable organizations to improve utilization, plan more accurately, and take better advantage of all available compute capacity.

Bring Your Network into Your Cloud

Transformative new approaches to networking are emerging.

- **Software-defined networking (SDN)** separates the network control plane from the data plane, so network and security resources can be centrally controlled using standards-based, vendor-independent solutions.

- **Network functions virtualization (NFV)** replaces purpose-built networking appliances with software applications that can run in VMs on standards-based servers.

Together these technologies will help bring the agility and cost efficiencies of cloud computing to the data center network.

The OpenStack Cloud Platform in Action—Workday

Workday is a fast-growing software as a service (SaaS) provider that delivers human resources (HR) and financial applications for enterprises, governments, and education institutions. The company adopted OpenStack software to extend an existing but limited cloud to support an increasing range of internal and customer workloads—with the ultimate goal of using OpenStack technology to run its entire data center.

For details about Workday’s journey and for recommendations about evaluating and implementing OpenStack software, listen to Carmine Rimi, the company’s director of cloud engineering. [http://tinyurl.com/lnb23l5](http://tinyurl.com/lnb23l5)
Together, these technologies enable high performance for virtualized networking applications running on cost-effective, Intel Xeon processor-based servers.

Although compatible with other network orchestration solutions, the Intel ONP Server RA was specifically designed with OpenStack clouds in mind. In combination with OpenStack Neutron, it enables flexible orchestration of NFV resources to address rapidly changing network requirements in an OpenStack cloud. For more information, see the Intel white paper, “Developing High-Performance, Flexible SDN & NFV Solutions with Intel Open Network Platform Server Reference Architecture.” [Website Link]

The Road Ahead

“OpenStack is now poised to become the dominant private cloud architecture.”

- Forrester, November 7, 2014

In less than 5 years, OpenStack software has grown to become what many consider the leading private cloud platform in the world today. It has been deployed by more than 1,200 companies and is supported by an active community of more than 18,000 members.

Throughout this time, the OpenStack software development community has maintained an aggressive 6-month release cycle, delivering major gains in capability with each new release. As stated by Saran Mandai, senior director of infrastructure engineering for PayPal, “We take advantage of an aggressive roadmap of what the community is contributing, while we put our code back in for others to consider and leverage if they want to.” This is the power of the open-source development model that has driven innovation and quality into the Linux operating system and that is now driving comparable progress in OpenStack cloud software.

As cloud computing advances to become the dominant paradigm for agile and efficient IT service delivery, OpenStack software offers a unique value proposition: a flexible, open, and affordable cloud platform that is supported by a broad and vibrant ecosystem. It can help enterprises, cloud service providers, and telecommunications vendors move forward more quickly and cost effectively to achieve next-generation cloud efficiencies, without limiting their future options.


12 Source: OpenStack cloud software user success story. [Website Link]
Additional Resources

From the OpenStack Foundation website

Learn the Basics

- OpenStack software. https://www.openstack.org/software/
- Users and success stories. https://www.openstack.org/user-stories/

Dig Deeper

- Understand the software roadmap. https://www.openstack.org/software/roadmap/
- Find vendors and resources. https://www.openstack.org/marketplace/
- Read the “OpenStack SuperUser” magazine. http://superuser.openstack.org/articles

Take the Plunge

- Get started. https://www.openstack.org/software/start/
- Engage with the OpenStack cloud community. https://www.openstack.org/community/

Appendix: Intel Contributions to OpenStack software


<table>
<thead>
<tr>
<th>ADDITION OR ENHANCEMENT</th>
<th>DESCRIPTION</th>
<th>REQUIRED HARDWARE CAPABILITY OR SOFTWARE LIBRARY</th>
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<tbody>
<tr>
<td>Available Now - In the Kilo OpenStack Software Release</td>
<td>Support for trusted compute pools (TCP) through trusted boot and third-party verification (using TCP with OpenAttestation)</td>
<td>Intel® Trusted Execution Technology (Intel® TXT)</td>
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<td></td>
<td>More granular role-based access controls through support for multiple domains</td>
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<tr>
<td>Security, Trust, and Compliance</td>
<td>Enhanced platform awareness for matching workloads with advanced Intel® platform technologies</td>
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<td></td>
<td>A catalog of tags and an indexing service for VMs/applications to publish their infrastructure requirements</td>
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<td></td>
<td>Metadata tagging for virtual machine (VM) images so applications can publish their infrastructure resource requirements</td>
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<tr>
<td>Reliable High Performance</td>
<td>Nova filter extensions to parse metadata imports</td>
<td>Applies to multiple Intel® technologies*13</td>
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<td>PCle-based NUMA-aware scheduling through I/O device and CPU core affinity</td>
<td>Intel® QuickAssist Technology</td>
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<td></td>
<td>Support for workload pinning to physical CPU cores and NUMA-specific memory locations</td>
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<tr>
<td>Higher Availability</td>
<td>Improved monitoring through accurate CPU usage data</td>
<td>Included in the main code base</td>
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<td></td>
<td>Versioned object support for rolling OpenStack upgrades (individual module support to be implemented in a later release)</td>
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<td></td>
<td>Improved PCI® testing with Intel’s third-party continuous integration (CI) system for PCI (new upstream code can be tested and verified for PCI compatibility)</td>
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<tr>
<td>Next-Generation Networking (SDN/NFV)</td>
<td>Enhancements to OpenStack Neutron provide feature parity with Nova network and prepare for software-defined networking (SDN)</td>
<td></td>
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<td></td>
<td>High-performance I/O virtualization in multitenant environments through support for single root I/O virtualization (SR-IOV)</td>
<td>Intel® Virtualization Technology, SR-IOV</td>
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<td></td>
<td>NUMA-aware scheduling so latency-sensitive workloads can be pinned to processor cores</td>
<td>Data Plane Development Kit (DPDK)</td>
</tr>
<tr>
<td><strong>Greater Efficiency and Lower Costs</strong></td>
<td><strong>Policy-based object storage in Swift</strong> to enable targeted levels of performance, latency, redundancy, security, and governance based on applications and data types</td>
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<tr>
<td><strong>Framework for Power/Thermal-Aware Scheduling (PTAS)</strong> to support expected future Intel contributions to OpenStack</td>
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<tr>
<td><strong>Full support for erasure coding in Swift</strong> supports high data resiliency without requiring triple data replication</td>
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<tr>
<td><strong>Full support for PTAS and a framework for continually testing module enhancements prior to release.</strong></td>
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<tr>
<td>Intel® Xeon® processor E5 v3 family and later</td>
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| **Targeted for Release in 2015 or Later** | **Data residency management** through platform and workload geotagging |
| **Virtual firewall-as-a-service (FWaaS)** support via a new driver and port security extensions |
| **Bare metal trust** allows non virtualized servers to be included in trusted compute pools |
| **Simpler and more secure management** with support for read-only access roles across all OpenStack modules and tenants |
| Intel TXT |

| **Security, Trust, and Compliance** | **Nova filter extensions** to parse metadata imports |
| **New wizard** provides better visibility of available flavors and images when launching new instances |
| **Network quality of service (QoS)** through the ability to define traffic classes |
| **Cache QoS monitoring** to identify and resolve virtual performance issues due to cache contention |
| **Memory bandwidth monitoring** to identify and resolve VM performance issues due to memory contention |

| **Reliable High Performance** | **Enhanced rolling upgrades for OpenStack** (versioned objects can be implemented in Oslo and prototyped in Heat) |
| **Automatic Evacuation** (VMs can be restarted due to guest OS or hardware component failure (without relying on the hypervisor)) |
| **Higher availability for basic OpenStack services upon node failure** (multiple test cases written and bugs fixed) |
| **Improved live migration** (multiple fixes and support for preserving network resources during migration) |
| **Policy-based high availability for SR-IOV ports** without requiring application changes |
| **Enhanced physical platform monitoring** via a push agent for collectD and 90+ plug-ins |
| **Improved disaster recovery** through the replication of block storage between cloud regions |
| **Auto-healing framework** (resource monitoring and dynamic, template-based control of applications and infrastructure stacks) |

| **Higher Availability** | **Multiple enhancements** to support DPDK and vSwitch*-enabled applications |
| **Virtual network function scaling** (running instances can vary the number of virtual functions associated with them) |
| **Simpler, more agile NFV service provisioning** through service chaining for DPDK-based vSwitches |
| **Enhanced network performance** through awareness of NIC stateless offload capabilities (checksum management, protocol segmentation, LRO/LSO/TSO, and so on) |
| DPKD |
| DPKD |
| Intel® Ethernet Technology |

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*13 Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI), Intel® Advanced Vector Extensions (Intel® AVX) for accelerating vector and floating point computations and Intel AVX 2.0 for accelerating integer and other computations, Intel® QuickAssist Technology for offloading cryptographic and data compression algorithms to dedicated hardware accelerators, Intel® Quick Sync Video technology for accelerating transcoding of certain video codecs, and Intel® Xeon Phi™ coprocessors for offloading highly-parallel application code.
### Enhanced network QoS through policy-based bandwidth control for defined traffic classes
DPDK, Intel Ethernet Technology

### Simplified security/network management with a security group driver for open vSwitch Database (OVSDB)/OpenFlow*-compatible DPDK-based vSwitches (in collaboration with Rackspace)
DPDK

### Simplified lifecycle management of NFV applications via an Advanced Network Service Agent

### Scalable SDN networking via the ability to automatically launch SR-IOV ports without pre-creating them in Neutron
SR-IOV

### Simplified network topologies (and reduced costs) through VxLAN support in Open vSwitch with DPDK (dependent on VxLAN support in DPDK in Q1'15)
DPDK

<table>
<thead>
<tr>
<th>Next-Generation Networking (SDN/NFV) (cont.)</th>
<th>Greater Efficiency and Lower Costs</th>
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</thead>
<tbody>
<tr>
<td>Simultaneous compute/storage/network scheduling across the Nova, Cinder, and Neutron modules</td>
<td>Simpler, more flexible scheduling with the ability to import Open Virtualization Format (OVF) image metadata</td>
</tr>
<tr>
<td>Support for bare metal client provisioning</td>
<td>Utilization-based scheduling in Gantt to avoid resource over-loading</td>
</tr>
<tr>
<td>Simpler, more flexible scheduling with the ability to import Open Virtualization Format (OVF) image metadata</td>
<td>Cache and memory QoS, NM</td>
</tr>
<tr>
<td>Nova filter extensions to parse metadata imports</td>
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</tr>
<tr>
<td>Capacity monitoring for users and administrators across compute, storage, and networking resources</td>
<td>Applies to multiple Intel technologies</td>
</tr>
<tr>
<td>Support for Intel® Rack Scale Architecture to enable next-generation infrastructure efficiencies</td>
<td>Intel Rack Scale Architecture</td>
</tr>
<tr>
<td>Cold VM migration to enable the transfer of powered-off VMs among hosts or data centers</td>
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</tbody>
</table>

Intel technologies, features and benefits depend on system configuration and may require enabled hardware, software or service activation. Performance varies depending on system configuration. No computer system can be absolutely secure. Check with your system manufacturer or retailer or learn more at intel.com.

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