Executive Summary

The OpenStack* cloud platform offers a uniquely flexible and open foundation for implementing private cloud networks in today's data centers. More than 1,200 organizations are using it today to deliver IT services on demand,1 while maintaining internal control over security, compliance, and service levels.

The OpenStack cloud platform can be architectured for high availability, and the inherent efficiency and resilience of the cloud can help to improve cost models and service levels for a wide range of business applications. Yet high availability is not automatic. Careful planning and execution is required, both in building an OpenStack cloud and in deploying sensitive applications within the cloud.

This white paper provides a high-level overview of the opportunities, challenges, and methods for delivering required service levels in an OpenStack cloud. It also discusses the work Intel is doing in collaboration with the OpenStack software development community to deliver increasingly simple and reliable high availability solutions, so the OpenStack cloud platform can evolve into an ideal hosting environment for the full range of enterprise applications.
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All Roads Lead to the Cloud
Traditional data center infrastructure is becoming a barrier to innovation. IT organizations are under pressure to deploy new services and applications faster and to provide better tools and resources for storing and analyzing vast and growing amounts of data. Addressing these demands with static, dedicated infrastructure is costly and cumbersome. Every new application has to be carefully provisioned with the appropriate compute resources, configured with required network ports and virtual LANs, and assigned suitable storage resources. Completing these tasks can take days or even weeks.

Business units are increasingly frustrated by these delays. Many have turned to public cloud services, such as Amazon Web Services* (AWS) and Microsoft Azure*, to launch new applications. They are willing to accept lower levels of security and compliance—and potential downtime—in order to achieve the advantages of cost and agility provided by the cloud.

Staying in Control with an OpenStack Cloud
OpenStack software offers an alternative to public clouds that allows IT organizations to maintain internal control over their systems, applications, and data. Businesses and independent service providers are using this comprehensive cloud platform to set up private cloud networks that mirror the services of the large public clouds. By establishing a cloud-like control plane for managing their compute, network, and storage infrastructure, they are able to address the demands of their business units through self-service provisioning and on-demand scaling.

The OpenStack cloud platform is based entirely on open-source software and is evolving rapidly, fueled by the collaborative contributions of hundreds of organizations and tens of thousands of individuals. Private OpenStack clouds have been deployed successfully by more than 1,200 businesses, including Fortune 500 leaders, such as eBay, PayPal, Walmart, Walt Disney Corporation, and Time Warner. With an in-house private cloud based on open standards, these businesses are now well positioned to optimize IT service delivery using a balanced mix of internal and external cloud resources.

Meeting Service Level Requirements
Cloud computing provides a radical departure from traditional, dedicated infrastructure. Workloads become portable within and between data centers, and, potentially, into public clouds. This portability creates both opportunities and challenges when it comes to delivering required service levels. Strategies for achieving high availability vary depending on whether the cloud is being used to support new or existing applications.

Many OpenStack adopters are focusing primarily on new applications. They are delivering developer build environments on-demand through self-service portals. This approach is ideal for agile application development models. The entire application life cycle—from initial development to production—is supported on the same dynamic and cost-effective infrastructure. Software developers are typically among the first to fully appreciate the advantages of an OpenStack cloud, and often drive usage rates much higher than expected.
Developers can architect new applications for high availability by taking advantage of the strengths of the cloud environment. Achieving the best results requires innovative approaches to code development, since many capabilities traditionally provided by dedicated infrastructure are now provided and managed through cloud-aware application features. For an excellent introduction to the opportunities and challenges associated with developing new applications for the cloud, see the white paper: Open Data Center Alliance Best Practices: Architecting Cloud-Aware Applications Rev. 1.0.

Moving existing applications into an OpenStack cloud presents a different set of requirements. Stateless applications, in which every request can be processed independently of every other request, are a great fit for an OpenStack cloud. This includes many web tier, middle tier, and infrastructure applications. Workloads can be scaled horizontally through load-balancing across multiple, identical instances to meet both performance and availability requirements. Since new virtual machines can be instantiated almost instantly in an OpenStack cloud, infrastructure can easily be scaled up or down to match usage rates.

Transactional applications, and other stateful workloads, require a different approach. They are more difficult to scale in a cloud environment and tend to have complex hardware and software dependencies that must be maintained to ensure transaction integrity in the event of a failure. Eliminating single points of failure in such cases is more challenging. If a stateful application can endure a small amount of downtime while a new virtual machine is brought online, an OpenStack cloud may be a good option today. If not, it may be better to maintain the application on traditional, dedicated infrastructure for the time being. As the OpenStack cloud platform continues to evolve, it will become easier to support increasingly complex and sensitive workloads.

Better Control with Intel® Architecture

Intel has been working with the OpenStack community for several years to expand and improve the enterprise-readiness of OpenStack software. Much has been accomplished. OpenStack clouds now have visibility into advanced Intel architecture platform capabilities, such as hardware-assisted data encryption and platform trust verification. These and other integrated Intel technologies can be instrumental in maintaining desired service levels for particular applications. With this support, workloads can be scheduled more intelligently, so they land on platforms that meet their specific requirements. (For details, see the Intel white paper, An Open, Trusted Platform for Your Private Cloud.)

Intel architecture also offers a wide variety of platform options with various levels of support for reliability, availability, and serviceability (RAS). By selecting platforms with appropriate RAS features, IT organizations can support a wider range of workloads in their OpenStack clouds (see the sidebar, Optimizing Availability with Intel® Architecture).
Raising the Bar for High Availability

Intel and the open-source community are working in concert to advance the OpenStack cloud platform and make it an ideal environment for hosting the full range of enterprise applications. These efforts are driven by requirements gathered through the Enterprise Workgroup at the OpenStack Foundation. Intel is currently focused on two key issues.

• Enabling higher availability for OpenStack cloud services, through improved support for automatic service failover and rolling software upgrades.

• Enabling higher availability for the workloads running in OpenStack clouds, through improved support for automatic virtual machine evacuations from a failing host and through increasingly robust support for live migration.

Each of these areas is discussed in the following sections.

Automatic failover for OpenStack cloud services

The OpenStack cloud platform is designed to support enterprise requirements for highly available cloud services. With an appropriate deployment architecture, uptime levels of 99.99 percent are feasible, which equates to less than one hour of total downtime per year.

OpenStack software consists of a collection of shared-nothing services for tasks such as workload scheduling, image management, monitoring, identity management, task automation, and more. The platform also includes an underlying database and message brokering layer that is used by the services to store and communicate persistent data.

These services, including the database and messaging layer, can be architected for high availability through active/passive or active/active clustering, using familiar monitoring and clustering tools, such as Pacemaker* for cluster management, HAPproxy* for load balancing, and Galera* for synchronous database replication. For detailed deployment information, see the OpenStack High Availability Guide.

Intel is working with the various OpenStack software projects to resolve any remaining issues that could potentially impact the availability of OpenStack cloud services. Current efforts include the following.

• Extending the Cinder block storage service to support active/active clustering with automatic failover. Cinder is used to provide virtual machines with persistent storage by creating and exporting volumes from backend storage systems. Currently, the non-distributed locking mechanism in Cinder may lead to various race conditions when running in active/active failover configurations. Intel is working closely with the Cinder community to address this issue and to ensure reliable failover of Cinder requests.

• Developing a Tooz* driver for service groups in Nova, with interfaces into ZooKeeper*, Redis*, Memcached*, and other components. This will allow Nova to detect failures and isolate compute nodes much faster. It will also re-enable ZooKeeper support, which is currently broken due to dependency issues. Intel developers are also using Tooz to enhance the Cinder volume manager. (For more information, see http://docs.openstack.org/developer/tooz/).
Rolling upgrades for OpenStack software

OpenStack cloud software is evolving very rapidly, with new releases occurring on a regular, six-month cycle. In this fast changing environment, it is critical to ensure that OpenStack clouds can be upgraded easily, and with little or no downtime.

Intel is working with the community to enable each OpenStack service to be upgraded independently of the others, regardless of their different versions and library dependencies. Some of this work has been done already and some will become available in future OpenStack releases.

Even greater agility and stability can be expected through enhanced support for Linux containers (through the Kolla project) and for bare metal provisioning (through the TripleO project). By deploying each OpenStack service in its own container, IT organizations will be able to build large-scale OpenStack environments quickly and easily. They will also be able to upgrade each service independently and with little or no impact on the production cloud environment.

For more information about current capabilities and future plans, see the Intel white paper, Rolling Upgrades for OpenStack Clouds.

Automatic evacuation of workloads from a failed host

OpenStack currently supports a manual process for evacuating and migrating virtual machines from a host server. The administrator first disables the Nova scheduler on the host compute node using the Horizon dashboard, so that no further workloads can be scheduled on that server. The administrator then moves the virtual machines using a live or cold migration process.

Intel is working to support automated evacuation based on host health monitoring in a future OpenStack release (Figure 1). Two issues must be resolved to support this process.

First, OpenStack must be able to obtain host health information directly through an API, rather than indirectly through a check on the health of the compute service. Some OpenStack developers have suggested that high availability, in general, is best left to tools outside of OpenStack (see https://review.openstack.org/#/c/137768/3/specs/kilo/approved/host-health-monitoring.rst). However, these tools would still require an API to access the host status. An API has been developed to address this issue, and will most likely be included in the Liberty release of the OpenStack cloud platform.

In combination with the new API, a cluster manager such as Pacemaker, can be used to detect host failure, fence the affected host, and communicate with the OpenStack control plane. The control plane would then begin

Figure 1. Manual and automated VM evacuation for high availability

Figure 1. OpenStack clouds support manual virtual machine evacuation today, and Intel and the community are working to enable automated evacuation in response to host failures.
virtual machine evacuation. The details for this solution are currently under discussion in the community, with Intel and Red Hat playing active roles.

**Faster and more reliable live migrations**

Intel continues to work with the community to improve the speed and reliability of live virtual machine migration in OpenStack clouds. This work includes enhancements to libvirt*, the widely used open-source virtualization management tool, and QEMU*, the open source CPU emulator that is commonly used with Linux hypervisors, such as KVM* and Xen*.

A key requirement during a live migration is that the destination host is compatible with the incoming workload. There must be sufficient compute, memory, and I/O resources, including the right number and type of PCIe* devices. The destination host must also support any required technologies, such as Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI), which provides hardware-accelerated encryption. To address these needs, Intel developers are working to ensure that any constraints that are used to select the original host are used in the same manner to select the destination host.

Enhancements are also needed to ensure that a migrated virtual machine cannot be left in an inconsistent state. For example, Intel developers have improved the handling of libvirt errors during live migration preliminary checks, so a virtual machine cannot be left in a “migrating” state. Additional work is underway to identify and address remote procedure call (RPC) exceptions that could potentially cause problems during live migrations.

Intel developers are also working on new OpenStack features that will improve the speed and reliability of live migrations, including the following (Figure 2).

- **Virtual machine fingerprinting.** Some virtual machines have almost continuous memory updates, which can prevent timely completion of a live migration. Fingerprinting can be used to identify such virtual machines, so they can be paused briefly during migration, and then restarted on the destination host.

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**Figure 2. Improving the Speed and Reliability of OpenStack Live Migration**

![Diagram](Diagram.png)

Figure 2. Intel is working to provide increasingly fast and reliable live migration in OpenStack clouds, through virtual machine fingerprinting and multi-threaded memory compression.
**Multi-threaded memory compression.**
Compression reduces the amount of data that must be transferred across the network from the source host to the destination host during a live migration. Executing compression algorithms simultaneously across multiple CPU cores accelerates this compute-intensive process and can substantially reduce overall migration times. This capability is currently targeted for availability in QEMU 2.4.

**The Road Ahead**
Intel shares a vision with the OpenStack community to deliver increasingly powerful and automated control over SLAs in OpenStack clouds. The ultimate goal is for applications to communicate their needs directly to the cloud control plane, and have those needs met automatically and in the most efficient and cost-effective way possible.

This will require:
- **Ongoing enhancements to the OpenStack cloud platform** to deliver simpler, more reliable, and more comprehensive control across all infrastructure resources and all application requirements.
- **More comprehensive cloud standards** to improve interoperability and workload portability between OpenStack clouds and other cloud platforms.
- **Mature tools and strategies** to help developers write cloud-aware applications that can take advantage of advanced and evolving cloud capabilities.

As this model evolves, it will lead to faster and more agile development, with greater cross-cloud portability and increasing levels of automation across the application lifecycle. It will also lead toward growing support for software-defined high availability, so every workload can be provided with the right service levels in the most cost-effective way, based on business and IT priorities.

**Conclusion**
OpenStack software on Intel architecture offers an open, flexible path toward hybrid cloud solutions that help IT organizations deliver higher value to business units, while maintaining control over sensitive data and applications. Achieving high availability for OpenStack cloud services and for a wide range of hosted applications is possible today through careful planning and implementation.

Intel and the OpenStack software development community are working to deliver increasingly simple, robust, and comprehensive support for high availability in OpenStack clouds. The goal is to make OpenStack clouds running on Intel architecture an ideal hosting environment for the full range of enterprise applications, with software-defined high availability that automatically optimizes service levels for every workload.

“Intel shares a vision with the OpenStack community to deliver increasingly powerful and automated control over SLAs in OpenStack clouds.”
Delivering High Availability in OpenStack® Clouds

Learn More

For more information about Intel's contributions to next-generation cloud and data center solutions, visit the following links.

OpenStack Cloud Platform: www.01.org/openstack

Software Defined Infrastructure: www.intel.com/CenterOfPossibility

Cloud Solutions: www.intel.com/cloud

1. Support for the OpenStack cloud platform continues to grow. For the latest information, visit the OpenStack Foundation website at https://www.openstack.org/.

2. For more details about OpenStack software adoption, including detailed case studies, visit the OpenStack Foundation website at https://www.openstack.org/user-stories/.


4. Cold and live migrations can be conducted through the command line interface in Juno or later releases of the OpenStack cloud platform. They can be conducted through the Horizon dashboard in Kilo or later releases. The dashboard makes the process both faster and easier.

5. For more information, visit the OpenStack Foundation web site, at https://review.openstack.org/#/c/169836/20/specs/liberty/approved/mark-host-down.rst

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1015/R5/HBD/PDF 332177-001US