white paper

Containers and OpenStack

Creating a Platform for Distributed Applications

A FactPoint Group white paper sponsored by Red Hat Inc.

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Executive Summary

Containers, the current darling of software developers, earn their love by allowing faster delivery of application functionality and simplifying the process of deploying and managing applications. Although the first is a developer priority, IT operations likes the streamlined deployment and management of applications. Indeed, enterprises are adopting containers to encourage collaboration between developers and IT operations, a movement called DevOps.

But containers aren't a standalone technology; they require a stack of complementary technologies to create, deploy and maintain containerized applications. This white paper explores the use of open source OpenStack in the container stack (see below for a graphic of the stack). OpenStack is already used as the underpinnings for many public and private clouds, and it's well-suited for serving as a software-defined foundation for a container platform.

Almost 90% of enterprise IT managers intend to boost spending on cloud technology[1], despite pressures to cut IT spending and secure networks against hackers. Fortunately, OpenStack is already running in many corporate environments and Infrastructure as a Service (IaaS) public clouds to manage compute, networking and storage hardware as well as virtual machines (VMs). Organizations wishing to deploy containers can use their existing OpenStack deployment as a base for a full software stack for managing the lifecycle of containers.

OpenStack is deployed by large firms such as Walmart, PayPal, Union Bank, AT&T and many other telecoms, which use OpenStack to scale their cloud environments up and down, and also by smaller scientific research groups and web hosters. Because containers are so new, the use cases are prolific but the proof points are limited: Cloud hosting services Rackspace (an originator of OpenStack), Pantheon and Lithium are using OpenStack to manage container deployments, as is start-up Midokura, a virtual networking firm. The container stack on OpenStack saves money, adds flexibility and allows service providers to quickly meet the needs of their users by provisioning applications and their infrastructures to scale up and down, depending on demand.

Organizations wishing to deploy containers can use their existing OpenStack deployment as a base in a full software stack for managing containers.

Even with OpenStack, containers require additional technologies to deploy and manage their lifecycle. This white paper describes a seven-layer stack of services that can be used to run an enterprise deployment of containers on OpenStack. Not all the technologies are mature, and they include both proprietary and open source components, but the pieces to a full container solution are falling into place.

[1] 2016 Enterprise Cloud Computing Survey, Clutch, press release Feb. 11, 2016.

What are containers and OpenStack?

Linux containers were introduced in 2008, and their roots go back to 2000-01, when an early implementation of containers was added to the FreeBSD Unix operating system. The Linux Containers project (LXC) was created by engineers from IBM around 2008.[2] LXC is a "system container" for handling infrastructure; the more common containers are "application containers."

Like many open source technologies, containers have a governance structure. The Open Container Initiative, operating under the auspices of the Linux Foundation, creates open industry standards for container formats and runtime, but not yet for images. The OCI was launched in June 2015.[3]

Later in the year, also under the Linux Foundation umbrella, a new Cloud Native Computing Foundation (CNCF) was formed to improve developer experience for creating cloud-native applications that are container-packaged, dynamically scheduled and microservices-oriented. CNCF focuses on creating open source technologies, reference architectures and common formats to pave the way for faster code reuse, improved machine efficiency, reduced costs, and increased agility and maintainability of applications.

Containers represent a more lightweight approach to utilizing computing infrastructure than virtual machines (VMs), which have become ubiquitous over the last decade. VMs require an operating system bundled inside the VM package, while containers do not need a full operating system inside, instead tapping the operating system of the host machine.

A key benefit of open-source containers is the ability to enable the creation of software applications in a distributed fashion, so that containers located in different places can interact as "composites" or "microservices" applications. Microservices-based applications are far more flexible than old-style monolithic applications because individual components can be quickly iterated with less risk of breaking the application.

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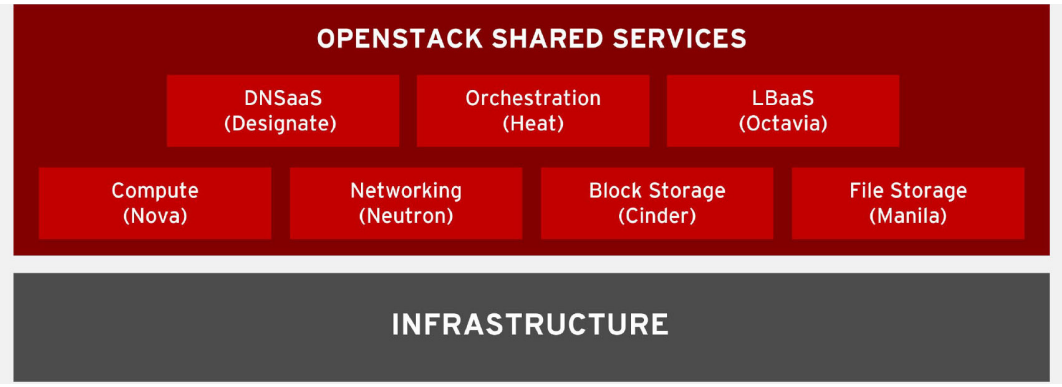
Although containers are simple in concept and relatively easy for developers to create, they are not a standalone technology. Another open source technology called OpenStack — designed initially to power public, private and hybrid clouds — is well-suited for provisioning and managing the underlying infrastructure at scale upon which containers and a container application platform are deployed.

OpenStack traces its roots to early 2010, when cloud hosting service Rackspace sought to rewrite its infrastructure software and merged its effort with a contractor for NASA called Anso Labs, which had published beta code for a "cloud computing fabric controller." They decided to open source their technologies, and OpenStack was born. Today OpenStack is overseen and promoted by the OpenStack Foundation.[4]



Source: Red Hat Inc.

[2] The History of Containers, Red Hat blog by Tim Hildred, Aug. 28, 2015.

[3] Open Container Initiative, undated web page, visited 3-7-16

[4] OpenStack Foundation, undated web page, visited 3-7-16

Cloud infrastructure vendors have positioned OpenStack as an open source alternative to Amazon Web Services, the biggest cloud hosting provider, for those wanting to maintain a private cloud but with public cloud scalability and agility. OpenStack is popular for Linux-based Infrastructure as a Service (IaaS) offerings.

As the above diagram illustrates, OpenStack is a modular architecture with many optional components, reflecting the diverse components of enterprise computing infrastructures. The most commonly used elements manage hardware compute, storage and networking hardware, but the variety makes OpenStack difficult to implement and manage without skilled engineers who are experienced with OpenStack.

A number of other tools help OpenStack and containers work closely together. Kolla, an element of OpenStack, provides recipes for building OpenStack services into containers, making them easier to deploy and manage. Open source Magnum is a system for allowing OpenStack tenants to easily deploy container orchestration engines, including Kubernetes, to run their workloads on. Magnum provisions supporting OpenStack resources including VMs to support the cluster.

Deploying containers requires a host of supporting technologies that must be mustered for companies to realize container benefits. OpenStack is a multi-function Swiss army knife that can manage not just containers but also VMs and hardware for providing compute, networking and storage resources. Containers can be managed and orchestrated by many different infrastructures, including OpenStack. In the enterprise, software developers champion containers while IT operations views OpenStack as a solution for addressing other challenges too.

IT trends: What problems is enterprise IT trying to solve?

Growing demands on enterprise IT managers are forcing them to seek new ways to operate, as business units seek to use IT for strategic advantage in competitive markets.

In response, many organizations are utilizing private clouds (within their enterprises) and public clouds (maintained by service providers) or a combination of the two, called hybrid clouds. A December 2015 survey from Clutch, a Washington, D.C.-based research firm, found spending on cloud would be strong in 2016.[5]

Furthermore, the explosion of new technology and use cases puts greater strain on IT budget at a time when IT leaders say they are most concerned, first, about cost cutting and then about security.

Software developers champion containers while IT operations views OpenStack as a solution for addressing other challenges too.

Easy, on-demand scalability — ideally in a self-service mode for developers—is in high demand.[6] In implementing their cloud strategies, IT leaders sometimes find that developers, seeking to address business demands to build applications faster, may go around corporate IT and directly to an unapproved cloud provider to write, test or deploy their application. This trend, sometimes referred to as shadow or stealth IT, has given rise to the DevOps movement, a trend closely tied to containers in which developers become more responsible for testing and deploying their code. DevOps seeks better communications and cooperation among IT operations, application developers and IT management to driver faster delivery of applications to their customers.[7]

Finally, although containers have caught developers' imaginations, container technology itself is not enough for the lifecycle of applications, so enterprises are looking to tools to deploy and manage containerized applications.

[5] 2016 Enterprise Cloud Computing Survey, Clutch, press release Feb. 11, 2016.

[6] *Ibid*.

[7] Wikipedia, retrieved March 7, 2016

OpenStack deployments illustrate benefits

OpenStack is well-established for cloud infrastructure and its deployments reveal multiple value propositions, including cost savings, scalability, speed and agility. Service providers, enterprises and research institutions that use OpenStack are showing gains.

OpenStack is being used in massive deployments at Walmart and PayPal. Walmart Labs handled 100% of its U.S. production e-commerce operations on OpenStack infrastructure during the 2014 holiday shopping season. As of February 2015, Walmart ran 100,000-plus compute cores on OpenStack.[8]

In 2015, online payment platform PayPal transitioned its entire front-end cloud to OpenStack, driven by the need for greater ability and agility to innovate. "It is important we have highly available infrastructure that is consistently manageable at scale," said Sri Shivananda, PayPal's VP, global platform and infrastructure.[9]

Similarly, Union Bank, headquartered in New York with retail branches on the West Coast and commercial offices throughout the U.S., used OpenStack to upgrade its IT infrastructure to deliver new applications faster. The 45-day implementation reduced application deployment time from 8-12 weeks to just a few hours, automated application deployments so engineers could to focus on strategic activities, and expanded IT's ability to scale its IT environment to meet business demand.[10]

Other OpenStack users have achieved other benefits:

- **Deliver services faster:** At Penn State, OpenStack transforms a traditional IT infrastructure to adapt to changing needs of researchers with flexibility and greater choice to meet demands.[11] These new development and operations practices allow scientists to innovate faster.
- **Optimize traditional IT environments:** In a research environment at Oak Ridge National Labs, administrators have centralized workloads for more efficient use of resources.[12]
- **Improve operational efficiency:** Brazil's DualTec Cloud Builders[13] boosted operational efficiency by 35% with OpenStack on its cloud hosting operation, enabling expansion of cloud services as Brazil's first OpenStack-based public cloud.
- **Accelerate service delivery:** Korean Broadcasting Station (KBS)[14] installed a private OpenStack cloud to cut production time in half and deliver programs to global viewers faster, using a public-cloud-like infrastructure that is scalable and programmable. KBS also cut total cost of ownership (TCO) by more than 40% and boosted expected ROI by more than 50%.

Driving container adoption

In May 2016, Forrester Consulting published a study on behalf of Red Hat on why enterprises are adopting containers for application delivery. It surveyed 151 IT architecture, software and operations professionals. Answers reflect major or moderate factors in adoption:

- **Deliver application functionality faster: 86%**
- **Simplify deployment, management of apps: 85%**
- **Improve efficiency over VMs: 83%**
- **Faster iteration: 78%**
- **Improve collaboration of devs & ops (DevOps): 78%**
- **Portability across platforms: 77%**

Source: a commissioned study conducted by Forrester Consulting on behalf of Red Hat, May 2016

[8] Why we chose OpenStack for Walmart Global eCommerce, blog post, Walmart Labs, Feb. 18, 2015

[9] PayPal's Front-End Cloud Powered by OpenStack, blog post, PayPal, March 24, 2015

[10] MUFG Union Bank serves customers faster with private cloud from Red Hat, case study, Red Hat, July 2015.

[11] Penn State enhances research computing with Red Hat Cloud Infrastructure, case study, June 2015.

[12] How Open Source Cloud Technology Can Eliminate IT Silos & Centralize Workloads, Red Hat white paper, Feb. 25, 2015

[13] Dualtec Cloud Builders Selects Red Hat to Deploy Brazil's First OpenStack-based Cloud, Red Hat press release, Oct. 26, 2015.

[14] KBS Improves Productivity of Broadcast Systems with Red Hat, Red Hat case study, Nov. 5, 2015

Use cases for containers with OpenStack

> "The important thing for us as a community is to think about OpenStack as an integration engine that's agnostic…and puts users in the best position for success. Just as we didn't reinvent the wheel when it comes to computing, storing and networking, we'll do the same with containers."
>
> —OpenStack Foundation COO Mark Collier[15]

Although OpenStack's value for cloud computing is established, OpenStack also delivers additional benefits for deploying and managing containers at scale. The clearest use case is running containers on "bare metal," meaning that containers run directly on top of OpenStack, eliminating the need for additional layers of software.

In addition, organizations that run containers on OpenStack can:

- **Enable portability** of containers on top of OpenStack VMs or bare-metal servers.
- **Deploy and manage containers** without creating a new container-only infrastructure, a huge savings. As an OpenStack.org white paper states, "Rather than create new vertical silos to manage containers in their data centers, IT organizations find value in OpenStack providing a cross-platform API to manage virtual machines, containers and bare metal."[16]
- **Efficiently provision a container stack.** Magnum, OpenStack's container service, supports three Container Orchestration Engines (COE) (Kubernetes, Mesos or Docker Swarm) to automatically provision compute instances for containers.
- **Boost scalability** of containerized applications.
- **Facilitate high availability** by moving containers quickly from failed hardware to healthy infrastructure.
- **Reduce costs in multiple scenarios** by:
  - Enabling admins to create and destroy containers without cost.
  - Boosting hardware utilization by adding containers on the underutilized hardware.
  - Scaling clusters quickly up and down by running additional containers—or stopping them.
  - Increasing density on servers by running more containers on a single machine, compared to VMs.
  - Using older or lower-performing hardware.
  - Utilize fewer servers, or smaller cloud instances, to achieve objectives.

Because containers are so new, some use cases remain more theoretical than in real-world operations. However, beyond enterprises, both service providers and start-up software companies have leveraged containers on OpenStack.

OpenStack originator Rackspace provisions LXC system containers at scale in production for Rackspace Private Cloud and other products. Rackspace Private Cloud runs all infrastructure components of an OpenStack-powered cloud, using containers as disposable bare metal, discarded when no longer needed. For newer offerings such as Carina and Magnum, Rackspace uses Docker containers.

Likewise, website management platform Pantheon, serving 100,000-plus WordPress and Drupal sites, is powered by more than 1 million containers on VMs and bare metal, provisioned with the same OpenStack-based tools.

Similarly, Lithium, which runs social networks as a service, is moving from its VM-based application running on an OpenStack private cloud to a container-based model. For Lithium, containers enable development, testing and deployment on a single standardized platform.

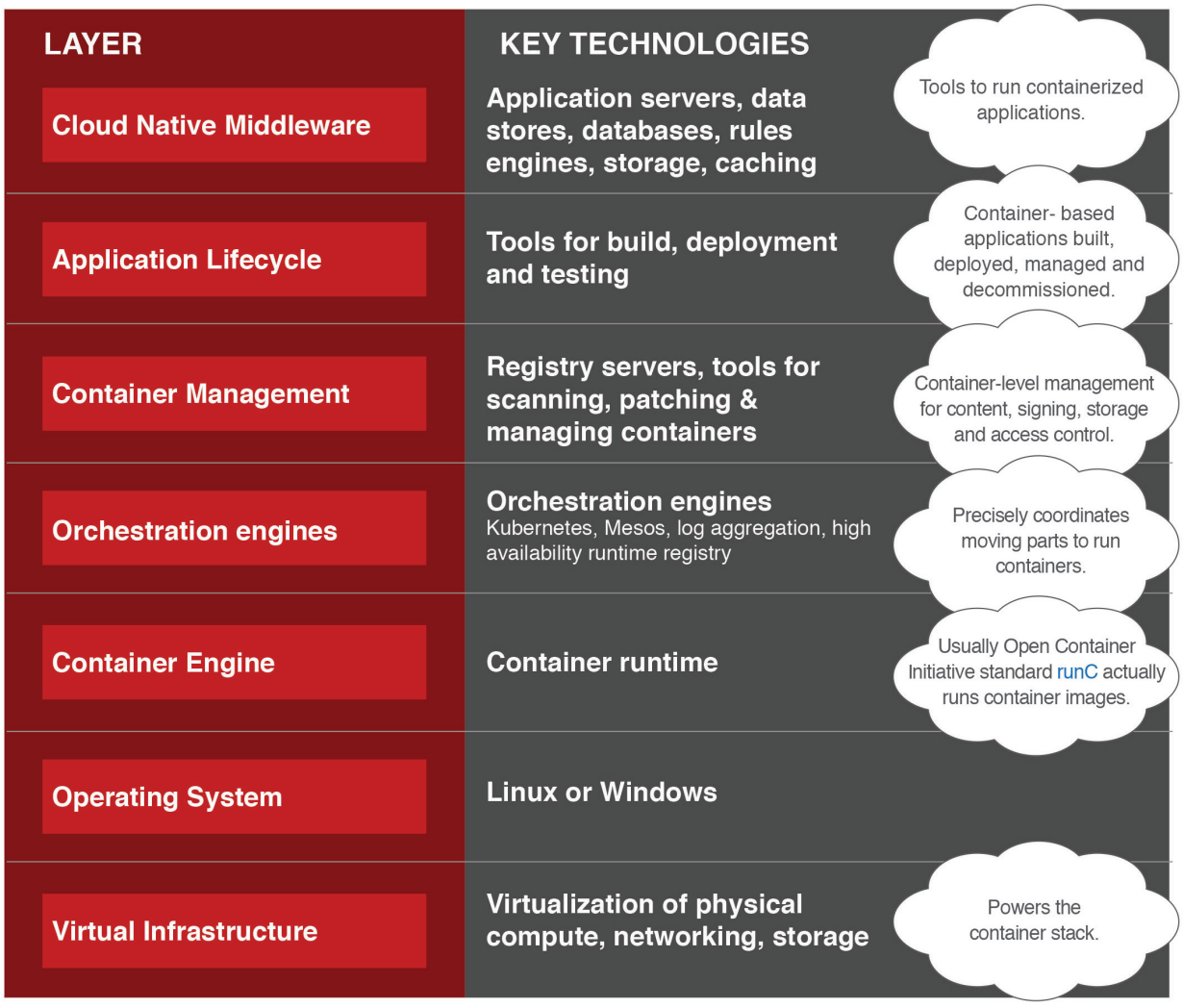
[15] Mastering containers with OpenStack: a white paper, OpenStack Superuser magazine article, Feb. 17, 2016

[16] Exploring Opportunities: Containers and OpenStack, OpenStack.org, white paper, Feb. 17, 2016

A young networking start-up called Midokura, working from an OpenStack private cloud, is challenging networking incumbents and their proprietary technologies with MidoNet, Midokura's network virtualization software solution, which is targeted for container usage.[17]

For the future, the OpenStack Foundation has prioritized improvements to utilize containers within OpenStack for new use cases: Full support for running containers on OpenStack, simplified setup to run a multi-tenant container service in production, and modular choices for OpenStack cloud operators who have not yet defined their containers strategy.

Although OpenStack is well-matched for running containers, it is not sufficient in itself. The diagram below describes a seven-layer stack of additional technologies needed for containers to match their potential. The functions of Container Management (shown here as Layer 5) actually exists in multiple layers. In addition, the container stack (and actual deployments) must have security features interlaced in multiple layers as well as between layers.



[17] Midokura Launches New Network Virtualization Solution to Support OpenStack Liberty Release and Soaring Popularity in Containers, press release, Midokura, Oct. 27, 2015

How to avoid obstacles to deploying OpenStack for containers

"Across the board, the biggest complaint about OpenStack is that organizations cannot find enough technicians with the expertise to successfully deploy and manage an OpenStack environment."

—Arthur Cole, *Enterprise Networking Planet*[18]

Such difficulties, exacerbated by OpenStack's release of a new version every six months, push enterprises toward more stable, proprietary alternatives to OpenStack. OpenStack is not simple to implement, often requiring the use of pricey outside talent. Enterprises can reduce the risks (and costs) of implementing OpenStack:

- Select an OpenStack distribution with easy-to-use tools to install and manage OpenStack.
- Use a supported version of OpenStack, not a free community edition with no support.
- Pick the right open source partner, considering commercial experience, commitment to open source, its ecosystem, and available single point of contact for problem resolution.
- Use OpenStack consultants on implementations but have them train in-house staff.
- Look to other open source projects that may address shortcomings in OpenStack. The OpenStack Foundation's Project Navigator online tool is designed to help users choose from roughly 20 cloud-related services or projects offered under OpenStack Foundation.
- Consider proprietary alternatives, but expect them to cost significantly more.

Conclusion

Open source containers show promise in addressing vexing issues for enterprise IT executives. As the business side of enterprises demands greater agility bringing IT-based products to markets, IT executives cry out for cost-effective ways to scale and manage their infrastructures. Containers can play a significant role in the solution, but they still require additional software to deploy, manage and scale.

OpenStack's flexibility remains unparalleled in its ability to encompass emerging technologies and to underpin the stack of software to manage and scale containers. OpenStack users are discovering that a single platform to manage virtual machines, containers and the underlying infrastructure hardware carries significant benefits. Plus many enterprises already have OpenStack in place for VMs and hardware, so they don't need to deploy a new, containers-only infrastructure in parallel.

The software infrastructure needed to deploy and manage containers — themselves barely entering puberty — remains immature. OpenStack has demonstrated its capabilities in managing VMs and hardware, and early adopters are using it for containers and the container stack too. Among the options for deploying containers, users can choose proprietary (but still immature) technologies or open source and more mature OpenStack.

What will it be? It's a reasonable and not uncommon trade-off between proprietary and open source, immature and almost proven. We hope this white paper helps with the choices.

[18] Doubt Creeps Into OpenStack Enterprise Networking Planet Nov. 13, 2015

About The FactPoint Group

The FactPoint Group is a research, consulting and content company based in Silicon Valley. Since 2001, it has conducted proprietary research projects for specific clients, including software companies and users of technology. FactPoint, with Internet Research Group, also co-publishes Focus on Containers, an online publication that provides news and commentary on the business impact of containers.

About Red Hat

The world's leading provider of open source software, Red Hat is working to advance both container technology and the supporting ecosystem to make containers enterprise-ready, much as it did with Linux. Taking a community-powered approach to its technologies, Red Hat delivers reliable and high-performing cloud, Linux, Linux container, OpenStack, middleware, storage and virtualization solutions. Red Hat also offers award-winning support, training, and consulting services. Learn more at http://www.redhat.com.