# Understanding cloud computing

Cloud Computing Lecture 1

*Public, Private, Hybrid and Multicloud*

# Understanding cloud computing

- Sharing resources through hardwired connections is quickly being replaced with a delivery method across networks that provides
  - infrastructure,
  - services,
  - platforms, and
  - applications on demand.

# What is cloud computing?

- Cloud computing is the act of running workloads within clouds—which are IT environments that abstract, pool, and share scalable resources across a network.
- Neither cloud computing nor clouds are technologies unto themselves.
  - Cloud computing is an act—the function of running a workload in a cloud.
  - Clouds are environments—places where applications run.
  - Technologies are things—software and hardware used to build and use clouds.

# Public clouds, private clouds, hybrid clouds, and multiclouds

- The differences between public clouds, private clouds, hybrid clouds, and multiclouds were once easily defined by location and ownership.
- But it's just not that simple anymore.
- So, while we've tried our best to define the main cloud types, we do so with an eye to the future—knowing the explanations of yesterday may not indicate how clouds will be used tomorrow.

# Public clouds

- A cloud environment created from resources not owned by the end user that can be redistributed to other tenants.

- A public cloud is a pool of virtual resources—developed from hardware owned and managed by a third-party company—that is automatically provisioned and allocated among multiple clients through a self-service interface. It's a straightforward way to scale out workloads that experience unexpected demand fluctuations.

- Today's public clouds aren't usually deployed as a standalone infrastructure solution, but rather as part of a heterogeneous mix of environments that leads to higher security and performance; lower cost; and a wider availability of infrastructure, services, and applications.

# What makes a cloud public?

- RESOURCE ALLOCATION
  - Tenants outside the provider's firewall share cloud services and virtual resources that come from the provider's set of infrastructure, platforms, and software.
- USE AGREEMENTS
  - Resources are distributed on an as-needed basis, but pay-as-you-go models aren't necessary components. Some customers—like the handful of research institutions using the Massachusetts Open Cloud—use public clouds at no cost.
- MANAGEMENT
  - At a minimum, the provider maintains the hardware underneath the cloud, supports the network, and manages the virtualization software.

# What makes a cloud public?

- For example. Lotte Data Communication Company (LDCC) built a private cloud using Red Hat® OpenStack® Platform to integrate their internal systems.
- But it worked so well that LDCC began offering the exact same cloud infrastructure to customers.
- The same bundle of technologies underpin both clouds, but LDCC's customers are using a public cloud because the use, resource, and management agreements fall in line with what makes clouds public.


# Who provides public clouds?

- Anybody can provide a public cloud, and there are thousands of providers all over the world.
- But the handful above are among the largest—and most popular—ones today.

# How do public clouds work?

- Public clouds are set up the same way as private clouds.
- Both use a handful of technologies to virtualize resources into shared pools, add a layer of administrative control over everything, and create automated self-service functions. Together, those technologies create a cloud:
  - private if it's sourced from systems dedicated to and managed by the people using them,
  - public if you provide it as a shared resource to multiple users.
  - And hybrid cloud is a combination of 2 or more interconnected cloud environments—public or private.

# How do public clouds work?

- All that technology not only has to integrate for the cloud to just work, it also has to integrate with any customer's existing IT—which is what makes public clouds work well.
- That connectivity relies on perhaps the most overlooked technology of all: the operating system.
- The virtualization, management, and automation software that creates clouds all sit on top of the operating system.
- And the consistency, reliability, and flexibility of the operating system directly determines how strong the connections are between the physical resources, virtual data pools, management software, automation scripts, and customers.

# How do public clouds work?

- When that operating system is open sourced and designed for enterprises then the infrastructure holding up a public cloud is not only reliable enough to serve as a proper foundation, but flexible enough to scale.
- It's why 9 of the top 10 public clouds run on Linux, and why Red Hat Enterprise Linux is the most deployed commercial Linux subscription in public clouds.

# How do I use public clouds?

- A public cloud is perhaps the simplest of all cloud deployments:
  - A client needing more resources, platforms, or services simply pays a public cloud provider by the hour or byte to have access to what's needed when it's needed.
  - Infrastructure, raw processing power, storage, or cloud-based applications are virtualized from hardware owned by the vendor, pooled into data lakes, orchestrated by management and automation software, and transmitted across the internet—or through a dedicated network connection—to the client.

# How do I use public clouds?

- Think about it like this. Cloud computing is the result of a meticulously developed infrastructure, kind of like today's electric, water, and gas utilities are the result of years of infrastructural development.
- Cloud computing is made available through network connections in the same way that utilities have been made available through networks of underground pipes.

# How do I use public clouds?

- Homeowners and tenants
  - don't necessarily own the water the comes from their pipes;
  - don't oversee operations at the plant generating the electricity that powers their appliances; and
  - don't determine how the gas that heats their home is acquired.
- These homeowners and tenants simply make an agreement, use the resources, and pay for what's used within a certain amount of time.

# How do I use public clouds?

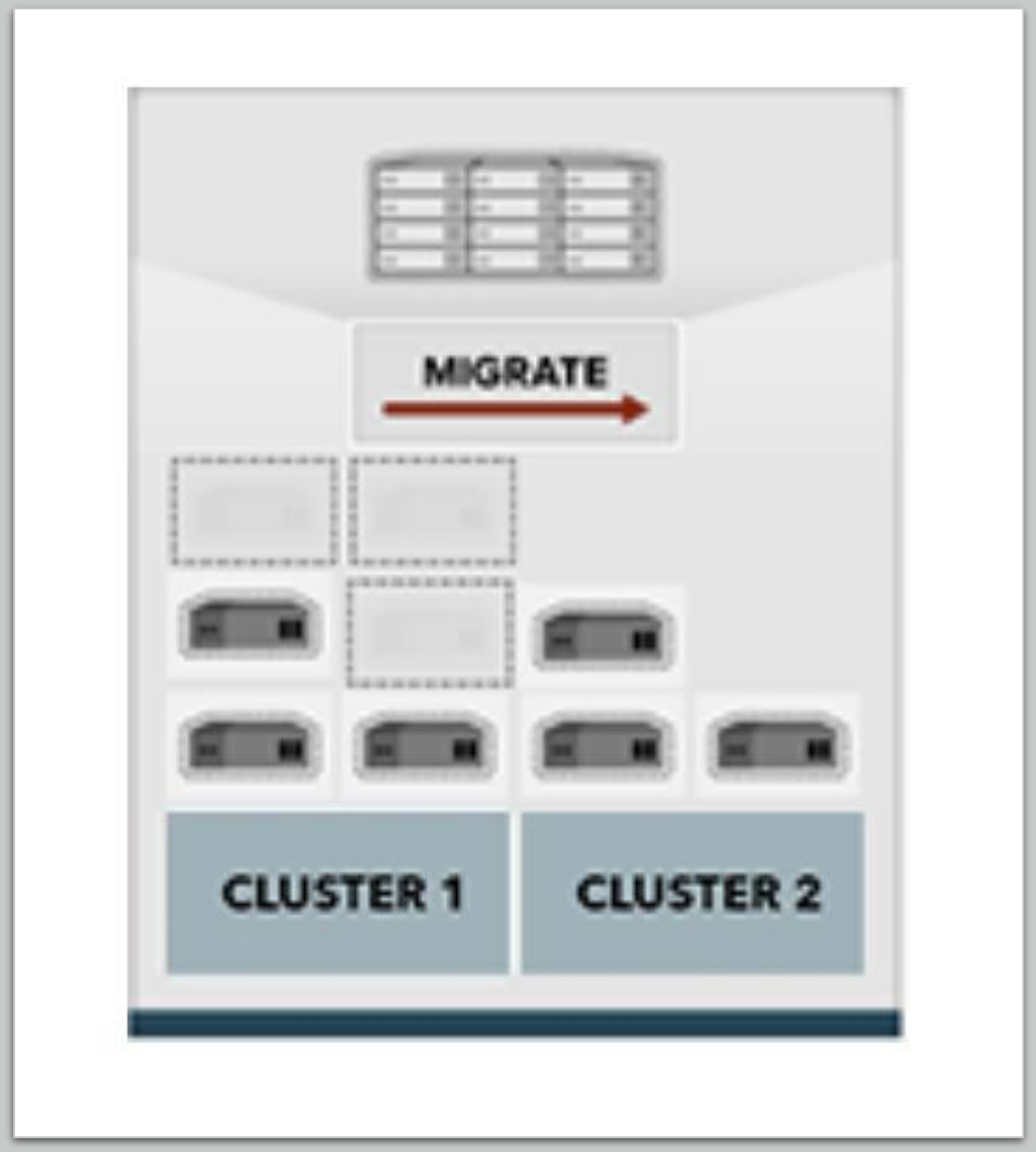
- Public cloud computing is very similar. The clients
  - don't own the gigabytes of storage their data they use;
  - don't manage operations at the server farm where the hardware lives; and
  - don't determine how their cloud-based platforms, applications, or services are secured or maintained.
- Public cloud users simply make an agreement, use the resources, and pay for what's used.

# Public clouds in hybrid environments

- Enterprises are adopting less public- or private-only cloud distributions and more hybrid environment solutions that include bare-metal, virtualization, private, and public cloud infrastructure.
- This allows each environment's advantage to minimize the disadvantages of another.

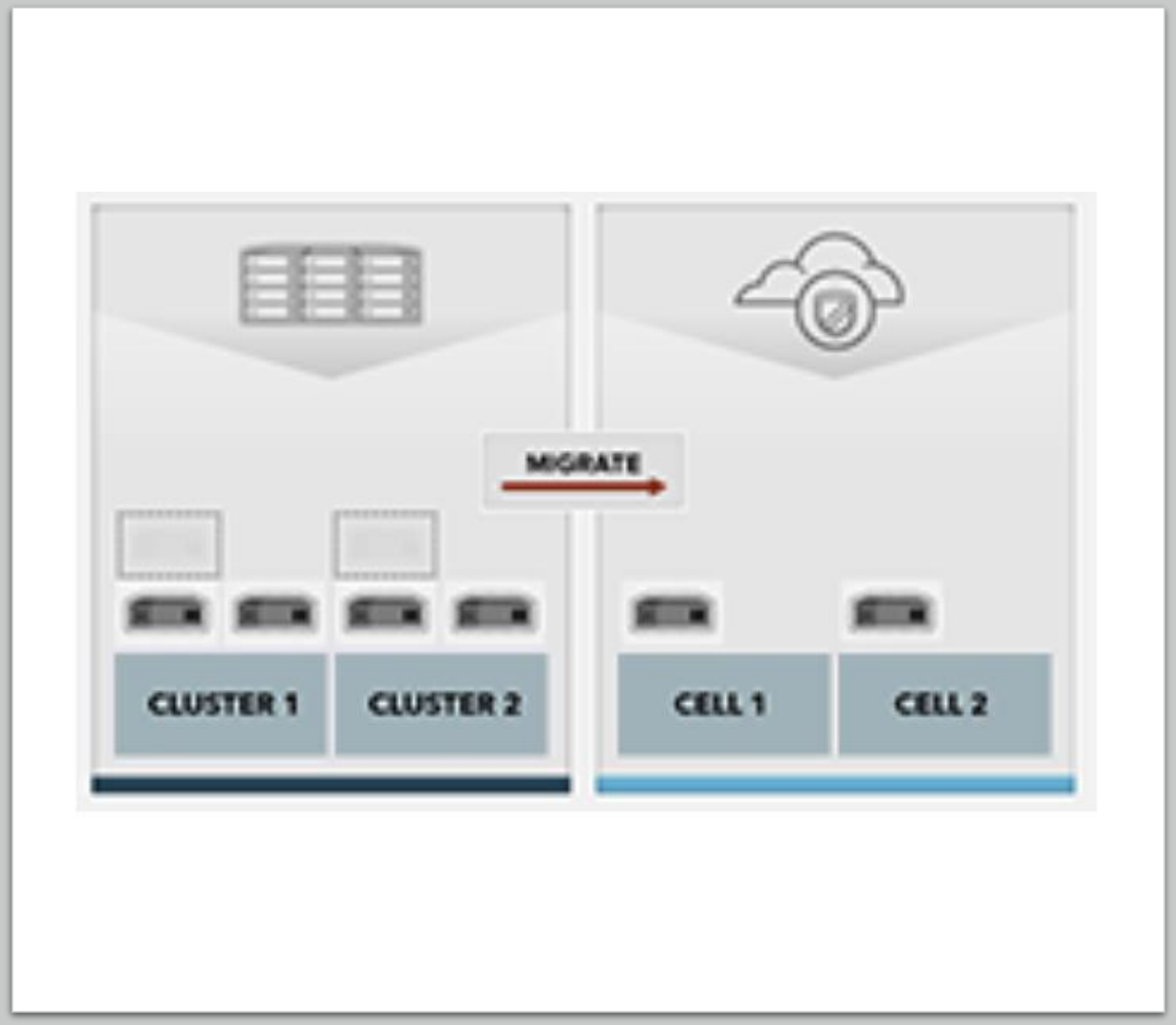
# Public clouds in hybrid environments

- For example: Imagine an enterprise running all workloads on 1 virtual cluster.
- That cluster would be running at full capacity, leading to poor response times and an inundation of calls or tickets to operations teams from upset application owners.
- This situation could be solved by rolling out another virtual cluster and automating workload balance between the 2.
- This is the start of a hybrid environment.



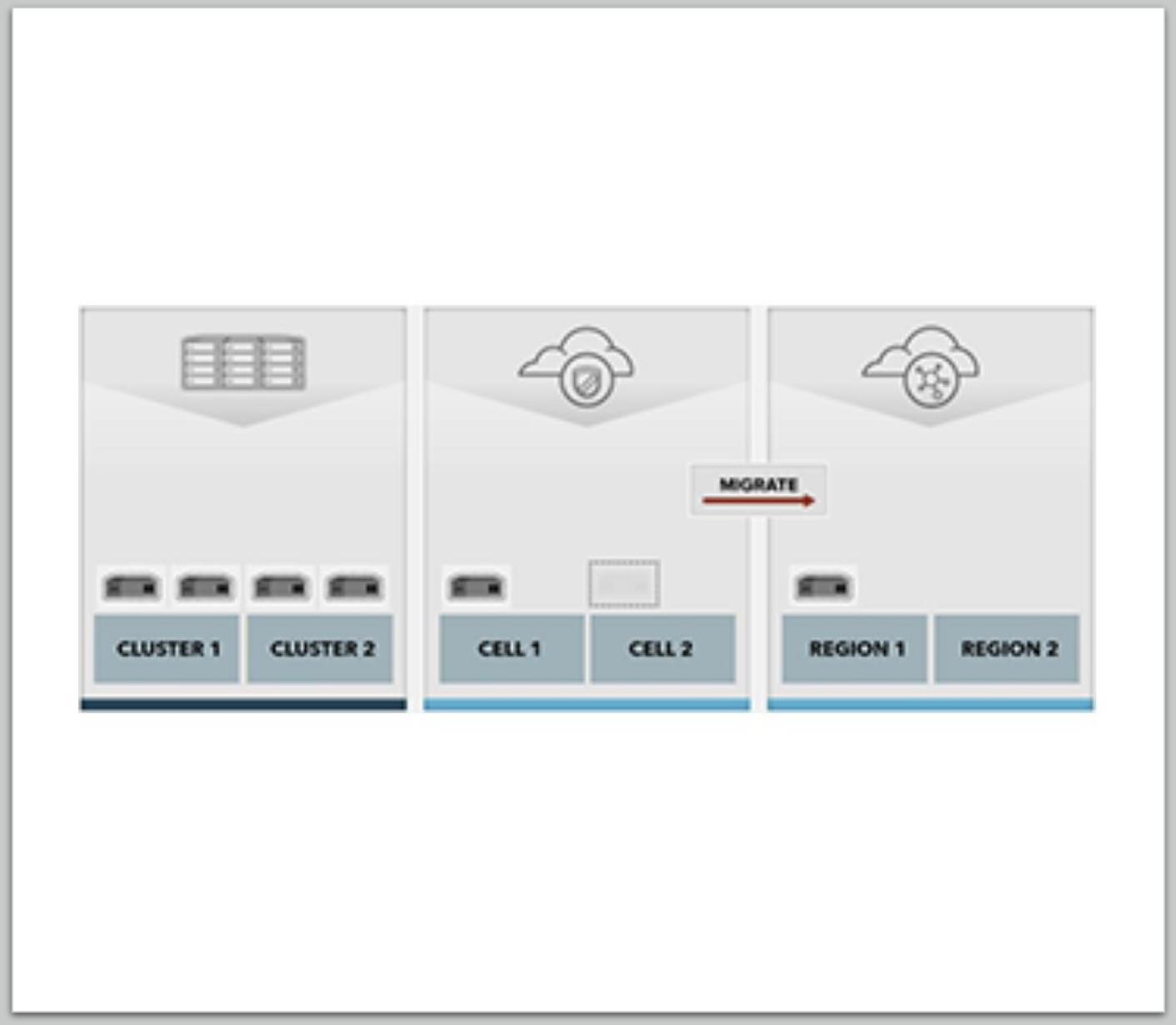
# Public clouds in hybrid environments

- The enterprise could expand its infrastructure portfolio to include a private Infrastructure-as-a-Service (IaaS) cloud (like Red Hat® OpenStack® Platform).
- Workloads that don't need to run on virtual infrastructure could be migrated to the IaaS private cloud—saving money and increasing workload uptime.



# Public clouds in hybrid environments

- To reduce poor response times to cloud users thousands of miles away, the enterprise could place some workloads on public clouds in nearby regions.
- This would allow the enterprise to control costs and maintain high availability.



# Why Red Hat?

- Because the majority of enterprises can't afford to dedicate 100% of their business to a single environment—be it public or private cloud.
- But even in a hybrid environment, your developers can't be distracted by application programming interface (API) and incompatibile integration frameworks when migrating workloads.
- Developers need to have confidence that their applications will run the same way everywhere, which is a key outcome of an open hybrid cloud strategy.

# Why Red Hat?

- When your hybrid cloud strategy includes a public cloud, we're ready to help with an ecosystem of hundreds of Red Hat® Certified Cloud and Service Providers.
- We've even designed our container platform, Red Hat OpenShift Online, so you can build, deploy, and scale cloud-native applications in a public cloud.
- It's this consistency that binds successful hybrid environments, allowing you to implement the cloud strategy that works for you, on your time, that meets your requirements.

# Private clouds

- Loosely defined as a cloud environment solely dedicated to the end user, usually within the user's firewall and sometimes on premise.

# What is private cloud?

- Private clouds are cloud environments solely dedicated to the end user, usually within the user's firewall. Although private clouds traditionally ran on-premise, organizations are now building private clouds on rented, vendor-owned data centers located off-premise.

- All clouds become private clouds when the underlying IT infrastructure is dedicated to a single customer with completely isolated access.

# How do private clouds work?

- Private clouds rely on a handful of various technologies, but understanding how virtualization works is the key to understanding how private clouds work.
- A private cloud uses virtualization technology to combine resources sourced from physical hardware into shared pools.
- This way, the cloud doesn't have to create environments by virtualizing resources one at a time from a bunch of different physical systems. A scripted IT process can just grab all those resources from a single source—like a data supermarket.

# How do private clouds work?

- Adding a layer of management software gives administrative control over the infrastructure, platforms, applications, and data that will be used in the cloud by helping cloud admins track and optimize use, oversee integration points, and retain or recover data.
- When the final automation layer is added to replace or reduce human interaction with repeatable instructions and processes, the self-service component of the cloud is complete and that bundle of technologies is now a private cloud.

# Building a private cloud

- Cloud infrastructure refers to the components needed for cloud computing. The basic elements of cloud infrastructure are the same whether you have a private cloud, public cloud, or a combination.

- All clouds require operating systems—like Linux®—but the infrastructure can include a variety of bare-metal, virtualization, or container software that abstract, pool, and share scalable resources across a network.

- You can build a private cloud on your own using resources dedicated solely to you, or use prepackaged cloud infrastructure like OpenStack®.

# Red Hat OpenStack Platform

- A leading open source cloud infrastructure project—stabilized for your enterprise
- Red Hat® OpenStack® Platform is a cloud computing platform that virtualizes resources from industry-standard hardware, organizes those resources into clouds, and manages them so users can access what they need—when they need it.

# Managed private clouds

- With private clouds, you're completely responsible for all costs at all times.
- You staff, manage, and maintain all underlying infrastructure.
- But private clouds can also be delivered by cloud providers as part of a managed private cloud approach.

# Managed private clouds

- Managed private clouds let customers create and use a private cloud that's deployed, configured, and managed by a third-party vendor.
- It's a cloud delivery option that helps enterprises with understaffed or underskilled IT teams provide better private cloud services and infrastructure to users without the day-to-day complexities of managing a private cloud themselves.

# Managed private clouds

- The bare-metal IT infrastructure used by cloud providers can also be abstracted and sold as Infrastructure-as-a-Service (IaaS), or it can be developed into a platform sold as a Platform-as-a-Service (PaaS).

# Why use private clouds?

- Private clouds are the ideal solution for IT leaders who want to make enterprise resources available on-demand, but can't (or don't want to) move to the public cloud.
- This can be due to security policies, budgets, compliance requirements, or regulations, like those that define the healthcare and financial service industries.

# Why use private clouds?

- Companies in these industries use encryption protocols and firewalls to secure their IT systems, but private clouds add an extra level of security—compared to public clouds—because access is limited.

# Why use private clouds?

- Whether or not you invest in private cloud infrastructure also depends on the workloads that need to be supported.
- Traditional, stateful workloads are well supported by enterprise virtualization products.
- But stateless, loosely coupled workloads—typically found in development, research, and telecommunications (particularly network functions virtualization)—are better supported by private clouds.

# Private cloud benefits

- Private clouds reduce instances of underused capacity.
- They allow the enterprise to automatically configure and reconfigure resources in any way it wants, since those resources aren't restricted by their physical installations.

# Private cloud benefits

- Private clouds provide additional benefits, such as:
  - Increased infrastructural capacity to handle large compute and storage demands
  - On-demand services using self-service user interfaces and policy-based management
  - Efficient resource allocation based on user needs
  - Increased visibility into resources across the infrastructure

# Private cloud storage

- Big data and the Internet of Things (IoT) have made private cloud storage very important to businesses, particularly in an era where it can difficult to appraise the value of a byte until long after it was created.
- Private clouds use something called software-defined storage (SDS) to archive and sort data. One of the more common SDS solutions for private clouds—particularly those deployed using OpenStack®—is Ceph. Ceph is the open source project behind Red Hat Ceph Storage, and it works well with clouds because it unifies object, block, and file storage into a single resource pool.

# Why Red Hat

- Because each private cloud is unique, and building unique private clouds by yourself can get exponentially expensive.
- That's why we developed a bunch of cloud solutions that let you build a unique private cloud from wherever you are right now.
- Already have a virtual infrastructure? Red Hat OpenStack Platform runs off the virtual resources you've already deployed.

# Hybrid clouds

- Multiple cloud environments with some degree of workload portability, orchestration, and management among them.

# Hybrid clouds

- Hybrid cloud is an IT architecture that incorporates some degree of workload portability, orchestration, and management across 2 or more environments.
- Depending on whom you ask, those environments may need to include:
  - At least 1 private cloud and at least 1 public cloud
  - 2 or more private clouds
  - 2 or more public clouds
  - A bare-metal or virtual environment connected to at least 1 cloud—public or private

# Hybrid clouds

- These varying requirements are an evolution from the earlier age of cloud computing, where the differences between public clouds and private clouds were easily defined by location and ownership.
- But today's cloud types are far more complex, because location and ownership are abstract considerations. For example:
  - Public clouds traditionally ran off-premises, but public cloud providers are now running cloud services on their clients' on-premise data centers.
  - Private clouds traditionally ran on-premises, but organizations are now building private clouds on rented, vendor-owned data centers located off-premises.

# Hybrid clouds

- This is why it can be more helpful to define hybrid cloud computing by what it does.
- All hybrid clouds should:
  - Connect multiple computers through a network.
  - Consolidate IT resources.
  - Scale out and quickly provision new resources.
  - Be able to move workloads between environments.
  - Incorporate a single, unified management tool.
  - Orchestrate processes with the help of automation.

# How do hybrid clouds work?

- The way public clouds and private clouds work as part of a hybrid cloud are no different than how standalone public clouds or private clouds work:
  - A local area network (LAN), wide area network (WAN), virtual private network (VPN), and/or application programming interfaces (APIs) connect multiple computers together.
  - Virtualization, containers, or software-defined storage abstract resources, which can be pooled into data lakes.
  - Management software allocates those resources into environments where applications can run, which are then provisioned on-demand with help from an authentication service.

# How do hybrid clouds work?

- Separate clouds become hybrid when those environments are connected as seamlessly as possible.
- That interconnectivity is the only way hybrid clouds work—and it's why hybrid clouds are the foundation of edge computing.
- That interconnectivity is how workloads are moved, management is unified, and processes are orchestrated. How well-developed those connections are has a direct impact on how well your hybrid cloud works.

# How do I build a hybrid cloud?

- Every cloud is unique.
- Private clouds are one-of-a-kind and there are thousands of public cloud providers. There's no one-size-fits-all cloud architecture.
- The way you organize your cloud resources and build a hybrid cloud will be as unique as your fingerprint. But there are a few basic principles that correspond to 2 general ways of building a hybrid cloud environment: The traditional way and the modern way.

# Traditional hybrid cloud architecture

- Hybrid clouds used to be the result of literally connecting a private cloud environment to a public cloud environment using massive, complex iterations of middleware.
- You could build that private cloud on your own, or you could use prepackaged cloud infrastructure like OpenStack®.
- You would also need a public cloud, like one of the few listed: Alibaba Cloud, AWS, Google Cloud, IBM and Microsoft Azure

# Traditional hybrid cloud architecture

- Finally, you would need to link the public cloud to the private cloud.
- Moving huge amounts of resources among these environments require powerful middleware, or a preconfigured VPN that many cloud service providers give customers as part of their subscription packages:
  - Google Cloud offers Dedicated Interconnect.
  - Amazon Web Services (AWS) offers Direct Connect.
  - Microsoft Azure offers ExpressRoute.
  - OpenStack provides the OpenStack Public Cloud Passport.

# Modern hybrid cloud architecture

- Today's hybrid clouds are architected differently.
- Instead of connecting the environments themselves, modern IT teams build hybrid clouds by focusing on the portability of the apps that run in the environments.

# Modern hybrid cloud architecture

- Think about it like this: Instead of building a local 2-lane road (fixed middleware instances) to connect 2 interstate highways (a public cloud and a private cloud), you could instead focus on creating an all-purpose vehicle that can drive, fly, and float.
- Either strategy still gets you from one place to another, but there's a lot less permitting, construction, permanency, and ecological impact if you focus on a universally capable vehicle.

# Modern hybrid cloud architecture

- Modern IT teams build hybrid clouds by focusing on the car—the app.
- They develop and deploy apps as collections of small, independent, and loosely coupled services.
- By running the same operating system in every IT environment and managing everything through a unified platform, the app's universality is extended to the environments below it.
- In more practical terms, a hybrid cloud can be the result of:
  - Running Linux® everywhere
  - Building and deploying cloud-native apps
  - Managing everything using an orchestration engine like Kubernetes or Red Hat OpenShift®

# Modern hybrid cloud architecture

- Using the same operating system abstracts all the hardware requirements, while the orchestration platform abstracts all the app requirements.
- This creates an interconnected, consistent computing environment where apps can be moved from one environment to another without maintaining a complex map of APIs that breaks every time apps are updated or you change cloud providers.

# Modern hybrid cloud architecture

- This interconnectivity allows development and operations teams to work together in a DevOps model:
  - A process by which teams work collaboratively across integrated environments using a microservice architecture supported by containers.

# Are hybrid clouds secure?

- A properly designed, integrated, and managed hybrid cloud can be as secure as traditional on-premise IT infrastructure.
- While there are some unique hybrid cloud security challenges (like data migration, increased complexity, and a larger attack surface), the presence of multiple environments can be one of the strongest defenses against security risks.
- All those interconnected environments let enterprises choose where to place sensitive data based on requirements, and it lets security teams standardize redundant cloud storage that can augment disaster recovery efforts.

# Why Red Hat

- Because it's hard to get the benefits of a unified environment when proprietary code stands in the way.
- That's why we promote an open hybrid cloud strategy as a way enterprises can achieve their digital transformation objectives.

# Why Red Hat

- An open hybrid cloud strategy brings the interoperability, workload portability, and flexibility of open source software to enterprise environments.
- Everything above and below the operating system is abstracted—every environment, every app—thereby providing consistent interaction with any app in nearly any environment without retooling the app, retraining people, splitting management, or sacrificing security.
- And because it's all open source, your data will move with you—no matter where tomorrow takes you.

# Multiclouds

- An IT system that includes more than 1 cloud—public or private—that may or may not be networked together.

# What is multicloud?

- Multicloud is a cloud approach made up of more than 1 cloud service, from more than 1 cloud vendor—public or private.

- For example, your enterprise invests in expanding a cloud infrastructure. You've moved from bare-metal servers to virtualization-based workloads, and now you're evaluating public cloud options—not for everything, but to support a specific customer-facing application with highly variable use rates.

# What is multicloud?

- After some research, you find the public cloud provider that has the right blend of service-level agreements (SLAs), security protocols, and uptime to host your custom application.
- You're happy with your choice.
- But eventually, customers start asking for features that are only available through a different vendor's proprietary app. Integrating these features into your custom app requires that you not only purchase the vendor's app, but also host the app in that vendor's proprietary public cloud—a solution that allows both apps to scale with demand.

- You now have a multicloud.

# What's the difference between multicloud and hybrid cloud?

- Multicloud refers to the presence of more than 1 cloud deployment of the same type (public or private), sourced from different vendors.
- Hybrid cloud refers to the presence of multiple deployment types (public or private) with some form of integration or orchestration between them.

# What's the difference between multicloud and hybrid cloud?

- A multicloud approach could involve 2 public cloud environments or 2 private cloud environments.
- A hybrid cloud approach could involve a public cloud environment and a private cloud environment with infrastructure (facilitated by application programming interfaces, middleware, or containers) facilitating workload portability.

# What's the difference between multicloud and hybrid cloud?

- These cloud approaches are mutually exclusive:
  - You can't have both, simultaneously because the clouds will either be interconnected (hybrid cloud), or not (multicloud).
- Having multiple cloud deployments, both public and private, is becoming more common across enterprises as they seek to improve security and performance through an expanded portfolio of environments.

# Why multiple clouds?

- Shadow IT
  - Shadow IT is becoming a reality that contributes to multiclouds.
  - Hardware or software deployed independently from the central IT team may become large enough to warrant more oversight.
  - At that point, migrating the infrastructure and data to a preferred system (let's pretend we're talking about public clouds here) might be out of the question.
  - That shadow IT deployment is simply aggregated as part of the enterprise's existing clouds—thereby creating a multicloud.

# Why multiple clouds?

- Flexibility
  - You might find the perfect cloud solution for 1 aspect of your enterprise—a proprietary cloud fine-tuned for hosting a proprietary app, an affordable cloud perfect for archiving public records, a cloud that scales broadly for hosting systems with highly variable use rates—but no single cloud can do everything. (Or, rather, no single cloud can do everything well.)

# Why multiple clouds?

- Proximity
  - To reduce poor response times for cloud users thousands of miles away from a company's headquarters, some workloads could be hosted by regional cloud providers that operate closer to where the users are.
  - This solution lets the enterprise maintain high availability and adhere to data sovereignty laws—protocols that subject data to the regulations of the country in which that data is located.

# Why multiple clouds?

- Failover
  - Multicloud environments help protect enterprises from outages.
  - As a failover solution, multicloud allows enterprises to have an available, highly scalable backup for data, workflows, and systems if—or perhaps when, as Murphy's Law suggests—your primary cloud goes dark.

# Managing and automating multicloud environments

- IT is becoming more dynamic, based on virtual infrastructure both on-premise and off.
- This introduces significant complexity around self-service, governance and compliance, resource management, financial controls, and capacity planning.
- Cloud management and automation tools help maintain greater visibility and oversight across these disparate resources.

# Managing and automating multicloud environments

- Automation has been used discretely within enterprises, with different tools used by different teams for individual management domains.
- But today's automation technologies (like Red Hat® Ansible® Automation Platform) are capable of automating assets across environments.
- Adding modern automation capabilities to multicloud environments limits the environment's complexity while enhancing workload security and performance for traditional and cloud-native applications.

# Multicloud and containers

- Linux® containers give enterprises choices when it comes to public cloud vendors.
- Because containers package and isolate apps with their entire runtime environment, users can move the contained app between clouds while retaining full functionality.
- This gives enterprises the freedom to choose public cloud providers, based on universal standards (e.g. uptime, storage space, cost) instead of whether it will—or won't—support your workload due to proprietary restrictions.

# Multicloud and containers

- This portability is facilitated by microservices, an architectural approach to writing software where applications are broken down into their smallest components, independent from each other.
- Containers—which are Linux—just happen to be the ideal place to run microservice-based apps.
- Together, they can be the key to taking your apps to any cloud.

# Why Red Hat?

- Multicloud helps enterprises avoid the pitfalls of single-vendor reliance.
- Spreading workloads across multiple cloud vendors gives enterprises flexibility to use (or stop using) a cloud whenever they want.
- There's nothing evil about having multiple clouds—in fact, it's a good thing. And open source software magnifies that good.
- Our open hybrid cloud strategy, supported by our open source technologies brings a consistent foundation to any cloud deployment: public, private, hybrid, or multi.

# END