The emergence of cloud computing combined with the convergence of information technology (IT), telecommunications, media, and entertainment have created a new enterprise market opportunity for service providers. By leveraging their networks and trusted relationships with enterprises, service providers can define a new cloud paradigm. They can transform their network infrastructures into agile, elastic virtual networked cloud platforms that provide a distributed, scalable, communication, content management, and computing infrastructure. HP and Alcatel-Lucent have created an open carrier-class cloud solution that automates and manages network, storage, compute and application resources while optimizing latency through intelligent distribution of applications and content to provide superior quality of experience (QoE) for users anytime, anywhere, and on any device.
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12 Summary
Executive Overview

With the advent of cloud computing, enterprises are looking to service providers to supplement or even replace large portions of their infrastructure. IDC estimates that the market for public cloud services will grow from $16.5 billion in 2009 to over $55 billion in 2014.

At the same time, the market is undergoing profound changes in behavior driven by the convergence of information technology (IT), telecommunications, media, and entertainment. This is creating a new application and content value chain that is connecting content owners, developers and advertisers with consumers and business customers. In this environment, service providers have an opportunity to leverage the cloud to deliver new services and value to their customers and improve their own infrastructure and business.

While these market changes present a great challenge, they also offer an opportunity for service providers to define the cloud paradigm and create a distributed, scalable, communication, content management, and computing infrastructure. Service providers can achieve this by leveraging their networks and trusted relationships with end users, and by transforming their network infrastructures into agile, elastic virtual networked cloud platforms (Figure 1).

**Figure 1. Transforming the service provider network into an elastic cloud platform**

HP and Alcatel-Lucent have the unique ability to “virtualize” data center resources through an end-to-end cloud services delivery model that links data centers and the IT services they host with their services delivery network. This enables service providers to reduce overall operational costs, improve business continuity and agility, and lower power consumption and management costs, all while driving additional demand for their networks through the creation of virtualized information and communication technology (ICT) services. In addition to creating new products based on dynamic IT services, this new ICT agility enables service providers to leverage cloud computing models in their own business environments. A virtualized environment will enable them to streamline their own operations, generate new savings and create new efficiency in their daily operations.
This paper presents the HP and Alcatel-Lucent end-to-end distributed cloud solution. It explains how service providers can best differentiate themselves through their network infrastructure to become the services/content delivery platform of choice, the challenges they face to achieve that goal, and how the alliance addresses those challenges.

**Introduction**

HP and Alcatel-Lucent are working with service providers to address the unique challenges they face delivering a highly scalable, secure cloud infrastructure. The unique HP/Alcatel-Lucent solution enables new services to be created and delivered via a distributed virtualized compute environment embedded within a service provider's network. It allows them to build on their advantage of end user proximity to communications infrastructure by distributing rich IT resources within easy reach of customers. Distribution of IT resources and control of network performance enables service providers to strongly differentiate themselves from “over-the-top” cloud providers who cannot offer guaranteed service levels for network access. This federation of IT assets embedded within a network allows service providers to evolve from communications infrastructure providers to rich communications, media, and processing customer experience providers.

The transition from network provider to customer experience provider, based on a distributed and virtualized cloud, involves several steps that use existing communications infrastructure to build a holistic solution:

1. The network infrastructure is augmented with general purpose compute, memory and storage resources. These resources are automated through a global management framework, which includes network, servers and storage assets.

2. A management layer is deployed, which combines control of network, storage, compute and applications. This management layer optimizes the distribution of resources and quality of experience (QoE), while managing latency and bandwidth.

3. Rich media processing resources are incorporated to enable new interactive multimedia applications, such as telepresence, networked video games, and desktop virtualization (VDI).

4. Content Delivery Network (CDN) capabilities are added to enable service providers to further expand the scope of delivered services, including optimized delivery of both static and dynamic data.

5. IT and network infrastructure are exposed as an open programming and development platform to end users, third parties and application providers.

These transition steps allow service providers to move from a closed system to an open system that enables access to network, compute, memory, and storage resources through Web Application Programming Interfaces (APIs). Web APIs consist of network and management Software Development Kits (SDKs) that are part of the Alcatel-Lucent approach to application enablement and those exposed within the HP software stack.

With this open system, services can then be extended across network provider boundaries while preventing fragmentation. This is made possible by federating Web APIs via agreements with other network providers or other cloud providers.
Our Unique Proposition

No other vendors have the combined global reach and technology and services portfolio breadth of HP and Alcatel-Lucent. Together, we create a data center deployment and network transformation offering that empowers service providers to deliver new and differentiated cloud services:

- HP and Alcatel-Lucent have committed to synchronize product roadmaps to allow for optimized end-to-end service offerings. One example of this approach is the combined data center fabric and network virtualization strategy that links the data center Local Area Network (LAN) to the services delivery network. This allows for massively scalable end-to-end service delivery from within the data center, all the way to the service provider edge.
- We offer a comprehensive solution with a modular approach that allows service providers to phase implementation and accommodate legacy or other third party systems.
- We provide the industry's richest API set for both network and IT assets. The combined assets of the IT and service network infrastructure are exposed as an open programming/development platform that presents new service capabilities to end users and application providers. This allows for the migration from a closed to an open system that enables access to network, computing, memory, and storage resources through Web APIs, creating the “new cloud” that optimizes performance and service placement. These APIs can then be federated through agreements with other network providers in order to extend the reach of services and prevent fragmentation.
- We are committed to industry standards across both IT and network stacks. This reduces vendor lock-in, eases integration and migration and ensures that service providers are not tied to technologies that are at risk of becoming obsolete.
- We offer the industry’s fastest micro/remote data center deployment using HP Performance Optimized Data Centers (PODs), pre-integrated with HP and Alcatel-Lucent servers, storage and networking components. This enables a unique plug-and-play approach to rapid service delivery.
- We provide application transformation and consulting services that enable applications to be migrated to the cloud. This expertise bolsters the service provider’s application modernization offerings and offers the capability to “burst” excess capacity into HP data centers as an outsourced service offering.
- We have complete network transformation consulting to enable development of a service provider’s infrastructure into an agile and elastic platform optimized to deliver distributed computing services.
- We offer flexible multi-vendor financing that moves from up-front equipment capital outlays to prudent growth-based ongoing operational expenditures.
- We deliver network-based cloud assurance to provide hard service level agreements (SLAs) and guarantee service performance.

The HP and Alcatel-Lucent offering for data center and network transformation ensures that a service provider’s network serves as a competitive advantage, enabling new selling opportunities. By partnering with HP and Alcatel-Lucent, service providers gain the IT expertise, data center technology, carrier-grade scalability and network agility needed to enable delivery of new, high-value cloud-based services.
1. Enabling a cloud services infrastructure

Service providers have identified a number of challenges associated with enabling value in cloud:

- **Linking network and IT resources:**
  - Dynamic scalability
  - Virtualization
  - Optimization
  - IT and the network as a utility
- **End-to-end IT and network services:**
  - Infrastructure support
  - Centralized cloud
  - Distributed cloud
  - Software support
  - Robust multi-tenancy support
- **Managing multiple supply layers:**
  - Multiple hypervisors
  - Management of multi-vendor environments
  - Augmenting service provider resources with external resource pools
- **Asset Discovery for Migration Strategy**

1.1. Linking network and IT resources

The management of network and IT assets as a single pool of flexible, agile computing resources allows service providers to deliver unique, differentiated services. These offerings are enabled by four key attributes:

- **Dynamic scalability** allows service providers to adapt dynamically to end user usage patterns by adding, changing or removing server, storage or network assets while being “asset location-aware” across the cloud. These assets can be requested via a developer API or web portal with minimal time to execution and are made available as standard building blocks of IT assets.

- **End-to-end virtualization** enables server and storage virtualization, as well as network virtualization via a single security framework.

- **Dynamic network optimization and service placement** allows service providers to dynamically configure the network to meet customer application and compute needs. Dynamic compute service placement allows service providers to create differentiated service offers while minimizing operational costs.

- **End-to-end IT and network as a utility capabilities** enable virtualized server, storage and network assets to be rapidly offered to end users as a utility. This utility can then be requested for flexible time periods with minimal or no up-front investment. By combining server and storage assets with application visibility across the network, end users only pay for consumed bandwidth, rather than fixed data pipes.

This same model will work where the service provider wishes to outsource data center and network assets to a third party and white label the service to partners or end users.
1.2. End-to-end IT and network services

1.2.1. Infrastructure support

HP and Alcatel-Lucent have jointly created a modular solution architecture designed to address the unique needs of the largest service providers. The solution leverages a building block approach, which allows the offer to scale from small to very large data center requirements. The architecture combines network and computing infrastructures to seamlessly interwork with a service provider’s packet and optical service delivery network. It is designed to scale to support tens of thousands of compute and application services, and form an advanced platform for the delivery of cloud services.

The modular data center architecture is based on a compute/network cell building block. Each cell contains varying levels of compute, storage and network components. Regional deployments in smaller, distributed data centers may consist of a single cell deployed in a HP Performance Optimized Data Center (POD) and linked to the services network via Alcatel-Lucent service routers. For very large environments, a data center may consist of many cells. A cell includes servers, storage, LAN switches, Storage Area Network (SAN) switches, routers and optical systems. All of the elements within a cell and in a multi-cell data center are managed by the HP/Alcatel-Lucent cloud management software stack.

1.2.1.1. Centralized cloud

The large central data center architecture is intended to provide the optimized delivery of cloud services at strategic central locations. It is designed to support tens of thousands of services across 1000s of physical servers.

Each cell is divided into four core functional building blocks: compute and storage, access, fabric, and data center interconnect (Figure 2). The first three building blocks — compute and storage, access and fabric — consist of HP systems that focus on intra-data center operations. The fourth building block consists of Alcatel-Lucent service routers and delivers inter-data center communication. These service routers not only provide an inter-data center fabric, but also the means to seamlessly cross-connect customer virtual private networks (VPNs) to data center services.

Figure 2. Data center cell functional building blocks

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<table>
<thead>
<tr>
<th>Compute and storage</th>
<th>Access</th>
<th>Fabric</th>
<th>Data center interconnect</th>
</tr>
</thead>
<tbody>
<tr>
<td>EoR - HP A12508</td>
<td>ToR - HP A5820</td>
<td>HP A12508/A12518</td>
<td>Alcatel-Lucent 7750 SR</td>
</tr>
<tr>
<td>SAN - FC Director</td>
<td></td>
<td></td>
<td>Alcatel-Lucent 1830 PSS</td>
</tr>
</tbody>
</table>
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- Ethernet
- Fiber channel
- FC over Ethernet
To meet the scaling requirements of computing virtualization in a service provider environment, the HP/Alcatel-Lucent networking solution leverages proven technologies, such as Provider Backbone Bridging, Virtual Private LAN Services, Virtual Private Routed Network, and Multi-Protocol Label Switching (MPLS) to enable the hosting of tens of thousands of services across a service provider’s infrastructure. By leveraging these industry standard protocols, the architecture enables service providers to fully realize the benefits of compute virtualization with end-to-end computing mobility. Additionally, the solution allows service providers to offer elastic data center services where network connections can be seamlessly extended from the enterprise to a service provider’s data centers. This enables virtual machine (VM) mobility between a customer’s environment and a service provider’s distributed data centers.

Application assurance is provided through in-line application inspection technology embedded in the Alcatel-Lucent service routers. This enables better reporting and policy control across the Wide Area Network (WAN). With this functionality the service router can be used in combination with HP Insight Dynamics and Alcatel-Lucent RAM platform to provide an end-to-end view of per application performance and reporting.

1.2.1.2. Distributed cloud
The joint architecture scales down to support smaller distributed data center infrastructures at remote central offices. To reduce network latency for application delivery, these data centers are located as close to the customer as possible.

The modular data center leverages HP PODs. Alcatel Lucent 7750 Service Routers link PODs to the service provider’s network, potentially over Alcatel-Lucent 1830 Photonic Service Switch (PSS) optical switches. The HP converged service control architecture seamlessly provides end-to-end orchestration of service activation from the server rack within the data center switch fabric and across the WAN. This links micro, as well as large, virtual data center IT assets into a single pool of computing and network resources.

1.2.2. Software support
The HP/Alcatel-Lucent cloud offering is based on a management framework, which leverages existing major functional elements from both Alcatel-Lucent and HP. It uses components of HP’s CloudSystem for service providers and Alcatel-Lucent cloud enablement and application enablement API solutions. The software components are architected with a modular approach. Only the actual functionality required by service providers is included in the solution. In addition, in areas where service providers have existing systems that provide similar functionality, the alliance can provide the necessary services to evaluate the suitability of existing systems and, if possible, integrate with existing functionality.

From the service provider’s perspective, the architecture focuses on the functionality that is specific to cloud services, layered on top of a governance, business, management and security plane, which provides the global functions that transcend cloud services. Figure 3 illustrates this, with the cloud functionality decomposed into its three constituent software layers of supply, deliver and demand plus the infrastructure layer. These layers are defined to address the complete service lifecycle, from design, through deployment to provisioning, usage and assurance.
The demand layer exposes the services (or products) to the end user, maintaining the relationship between the customer-facing services and the service provider and end users. It:

- Maintains a catalogue describing the services that are available to end users
- Authenticates end users to determine their capabilities to create or modify services
- Exposes access to the services to users through APIs or an optional portal
- Allows the bundling of multiple services, both internal (provided by the deliver layer) and external (provided by third party suppliers)
- Supports both direct to customer and reseller models
- Provides service billing information and (for external services) settlement information
- Monitors customer QoE and compliance with SLAs
- Maintains mapping of customers to services

The demand layer consists of the HP Aggregation Platform, the HP Universal SLA Manager, Alcatel-Lucent Application Assurance and the Alcatel-Lucent Application Enablement APIs. The software in the demand layer can provide basic access to end users/customers/administrators or plug into higher-level Operations Support Systems (OSS), Business Support Systems (BSS), and Customer Relationship Management (CRM) systems.

The deliver layer brings together the end-to-end customer-facing services, and:

- Orchestrates the combination of multiple service elements (from one or more supply layers) into a single service
- Selects the appropriate supply layer, based on policy, demand layer request and supply layer availability
- Calculates service usage by end user
- Maintains information mapping service-to-service elements (supply layer resource pools)
• Determines optimal compute resource positioning/location based on:
  ¬ Real-time WAN/service network and data center resource availability
  ¬ Latency and bandwidth characteristics as applied to application performance and customer experience
  ¬ Business operational cost metric (maximizing provider margins)

The deliver layer provides the end-to-end view through an extension of the HP Cloud Services Automation solution, and integrates it with the Alcatel-Lucent Cloud Enablement Network Services Orchestration platform to create a link between the data center and the VPN/WAN environment. This layer brings together HP software and data center expertise with Alcatel-Lucent expertise in managing service provider networks.

The supply layer is responsible for a specific resource pool, and:
• Isolates the deliver layer from the resources by providing customer-facing service abstractions, potentially combining multiple heterogeneous resources into a single abstraction
• Provides the necessary governance and orchestration to ensure that the resources deliver the desired customer-facing service
• Optimizes the utilization of the resources within the pool
• Monitors utilization of the resources, generating usage data records for events that may be potentially billable
• Assures the health of the resources

Multiple instances of the supply layer are possible. This allows the implementations used to manage the data center to be based on HP software, while the implementations used to manage the WAN/services network and content delivery network (CDN) are based on Alcatel-Lucent software.

Securing the infrastructure and services, including providing for multi-tenancy, is not an isolated function. It works seamlessly with the underlying global security aspects. This provides a comprehensive view of security that is not a tactical afterthought, but rather integrated into all aspects of both building and operating the system.

Similarly, to provide proper governance of the infrastructure and systems, governance has to be intrinsically related to global governance policies and systems. Like security, this cannot be relegated to isolated functional components, but needs to underlay everything.

This first phase solution architecture will evolve rapidly to enable service providers to field new services and solutions, thereby enabling a fast evolution to a transformed, virtualized compute and network service environment. Alcatel-Lucent is focused on enabling providers to exploit the power of their network while HP is focused on maximizing the efficiency and the capabilities of the compute environment. Together we emphasize the management of application level SLAs throughout the entire service: VM to WAN to customer. These efforts provide a service provider with the best of both worlds: a distributed agile IT environment that is fully integrated into the network. The result is a fully optimized cloud services delivery environment.

1.2.3. Robust multi-tenancy support
The need for end-to-end solutions that incorporate secure, scalable and manageable multi-tenancy is critical to service providers. These solutions must extend from the VM within a blade server to the end customer across a services network. Enterprise and content provider access to distributed IT resources within a data center must be, at a minimum, logically separated to comply with legislative and corporate risk initiatives, such as BASEL 2, European Privacy Laws, US HIPPA, Sarbanes-Oxley (SOX).
Just as virtualization improves on the productivity of a computing resource, network virtualization provides the same benefits by virtualizing wide area resources. Virtual Local Area Networks (VLANs) on their own are often not enough because large enterprises route their backbones, which drives demand for complex Access Control Lists (ACLs) and firewalls. Creating a virtualized network as a service maximizes IT security and economies of scale, while helping to ensure risk management.

As a result, multi-tenancy support needs to go well beyond what happens inside a single data center. For example, robust Infrastructure as a Service (IaaS) multi-tenancy dictates that each customer security zone should be provisioned on at least one separate VLAN, with typical deployments requiring three or more VLANs per VM. The 4094 usable VLAN availability limit can severely restrict the number of customers supported unless a scalable solution is implemented.

Technologies such as Provider Backbone Bridging (PBB) within the data center switching fabric enabled on HP switches, combined with Virtual Private LAN Services (VPLS) and PBB de-encapsulation at the customer edge implemented on Alcatel-Lucent Multi-Service Routers (MSRs), enables a robust, massively scalable combined network solution that allows delivery of end-to-end, separated client connections.

For industry leading storage multi-tenancy support, HP provides thousands of secure virtual private arrays known as Virtual Domains. By providing secure administrative segregation of users, hosts, and application data, HP Virtual Domains allow service providers to deliver virtual private array services and self-service storage that is both secure and capable of high quality-of-service.

As shown in Figure 4, multi-tenancy is a fundamental part of the governance, Business, management and security plane that underpins the joint solution. A common set of security and multi-tenancy polices drive the processes and tools throughout the infrastructure.

Figure 4. Multi-tenancy as part of global security
For the particular example described above, trying to solve the scalable multi-tenant problem in a piecemeal, non-automated fashion will result in service degradation and potential security breaches through misconfiguration. Thus the alliance mechanisms and policies are implemented in the deliver layer, which enables the end-to-end view spanning multiple VLAN pools using the networking infrastructure.

1.3. Managing multiple supply layers
The supply layer is responsible for managing a pool of resources and exposing basic customer-facing services. The resource pools exposed by the supply layer are not just data centers and related services. The alliance has extended the supply layers above and beyond general purpose computing platforms and can include caching resources and dedicated media processing hardware with arrays of Digital Signal Processors (DSPs) or Graphics Processing Units (GPUs), such as the Alcatel-Lucent 9980 Network Media Processing Platform. In addition, the customer-facing network services that tie into the end-to-end service, such as a customer VPN, are abstracted through the supply layer.

The deliver layer brings together one or more basic customer-facing service elements, exposing the composite service that is provided to the customer. The delivery layer may select between multiple instances of a supply layer providing a particular service element, but it is unaware of the details of how that service element is provided.

This decoupling of the services delivered to the customer from the resource pools delivering the service provides unique flexibility.

The existing deliver layer implementation provides for basic policy selection of different supply layers. This can be extended using optional components that provide for more intelligent use of resources. For example, sophisticated selection policies can combine parameters such as customer to data center latency, network and data center loading with power and cooling optimization.

HP and Alcatel-Lucent are enhancing the sophistication of the policies that can be used to select appropriate resource pools. The vision is to allow the intelligent, automatic selection of resources based on the combination of network- and IT-specific factors that affect end-to-end QoS and cost of delivery.

1.3.1. Multiple hypervisors
No one hypervisor is the ideal solution providing the best cost/benefit for all situations. The alliance's solution is built without a dependence on any particular hypervisor. In fact, it can support multiple hypervisors simultaneously — even if any particular supply layer involved is able to manage only one hypervisor at a time. This flexibility is provided through the abstraction between the supply layer and the deliver layer.

For example, a customer service may require the provisioning of some virtual machines. The deliver layer may need to select from among several potential suppliers of the VM. These could be a supply layer focused on providing VMs using VMware hypervisor, a supply layer focused on providing VMs using the Kernel-based Virtual Machine (KVM) hypervisor, and even an external supplier that could temporarily augment the service provider's capacity.

Where the Supply layer is implemented by the HP BladeSystem Matrix, multiple hypervisors can be supported directly. HP BladeSystem Matrix hypervisor support currently includes VMware Hyper-V and HP Integrity Virtual machines.
1.3.2. Management of multi-vendor environments
The abstraction of the Supply layer also allows for support of multi-vendor environments. The orchestration engine within the demand layer uses one of two approaches to communicate with the supply layer.

Where the Supply layer is managed by software that provides high-level abstractions, such as that contained within HP BladeSystem Matrix or Alcatel-Lucent Service Aware Manager (SAM), the operations orchestration function will communicate directly with the manager of the resource pool. In those situations where the resource pool does not have a manager that exposes a high-level interface, such as physical servers or third party network infrastructure, operations orchestration function will use HP Server Automation and HP Network Automation to provide the required interface.

Both server automation and network automation already have integrations to a large number of platforms and devices. If the required support is not available, this is easily added and can be provided to service providers as a service.

1.3.3. Augmenting service provider resources with external resource pools
The abstraction between the deliver and supply layers provides an additional benefit that may be of interest to service providers. The deliver layer can use external supply layers to augment internal resources. Service providers can contract with HP, Alcatel-Lucent or another vendor to augment internal resources when demands exceed currently available capacity.

1.4. Asset discovery for migration strategy
To achieve operational efficiency it is critical to maintain accurate topology information across both IT and network assets. An actionable configuration management repository based on Configuration Management Database (CMDB) maintains this information. This resides within the deliver layer. It is populated both by discovery mechanisms and direct updates during the provisioning/service activation process.

Resource discovery is managed at the supply layer. The alliance has a number of topology and service discovery tools that gather both IT and network-based resource information. For example, HP’s Network Node Manager i-series (NNMi) uses a variety of network protocols (read-only queries) to gather information about each discovered device. Well over 3,000 pre-configured device profiles are provided, one for each known sysObjectID. The Alcatel-Lucent Service Aware Manager (SAM) is used to discover the applicable subset of client-facing service profiles. For existing resources or services that are maintained in separate systems, HP has tools that can be configured to provide an integration layer to the actionable configuration management repository.

Converged services automation ensures that the repository remains consistent with any changes that are made in the supply layer. By having active maintenance of the repository, discovery intervals can be drastically reduced.

With assurance that the repository is consistent with the actual status of IT and network assets, the verified data can be used to enhance operational processes. For example, SLA management requires a dynamic view of real-time configurations, such as the movement of a VM across a blade system.
Summary

In today’s rapidly changing technology and business landscape, transformation is key. HP and Alcatel-Lucent have helped thousands of companies improve their IT infrastructure and operations to enable their business strategy. Together we create true end-to-end solutions for all service providers. We provide complete data center-specific solutions from the server cabinet, within the data center via resilient, highly scalable switching fabric, and between data centers via optical photonic switching combined with existing high performance, MPLS-enabled switching and routing via the services network.

In addition, our offering allows service providers to markedly differentiate themselves in the market by exposing combined network, server and storage APIs to customers or third party developers.

The alliance offers a comprehensive portfolio and in-depth expertise acquired through extensive partnerships with numerous service providers. This offering, unique in the industry, is now available to service providers who are interested in forming a close partnership with the alliance to capitalize on the alliance’s vision for cloud services delivery embedded within the network.

We invite you to take the time to meet with us to assess your current approach to transformation for cloud service delivery. Look to us to understand your challenges and apply a fresh approach and a new perspective on how to move to a profitable revenue-generating infrastructure for cloud services.