Accelerate with IBM Storage: Introducing the FlashSystem A9000 and FlashSystem A9000R

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Hank Sautter
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Agenda

- Overview of the IBM Storage portfolio and introduction to the IBM FlashSystem A9000 and FlashSystem A9000R
- Hardware overview
- Data reduction
- Features: Quality of Service, multi-tenancy, encryption, small volumes
- Hyper-Scale Manager
- Cloud integration
IBM Strategic Storage Investments

Flash – $1 Billion Investment in R&D
April 2013

Cloud – $1.2 Billion Investment to expand Global Cloud Footprint
January 2014

Integrated Infrastructure – IBM and Cisco
Announce VersaStack
December 2014

Software Defined Storage - $1 Billion Investment to develop Next-generation technology in SDS
February 2015

Cloud and SDS – IBM acquisition of Cleversafe
November 2015

High Growth Markets

- All Flash Arrays
  - 18% 2016-19 CAGR

- Hybrid Arrays
  - 6% 2016-19 CAGR

- Integrated Infrastructure
  - 8% 2016-19 CAGR

- SW Defined Storage
  - 12% 2016-19 CAGR

- SW Defined Infrastructure
  - 20% 2016-19 CAGR

Sources: MDI, GMV 1H14, 2H14, and 1H15, IDC trackers
IBM Market Leadership

#1 in Software Defined Storage
#1 Object storage
#1 in All Flash Arrays *
#1 in Branded Tape Systems
#1 Mainframe Storage
#2 in Worldwide Storage

* In both units and capacity shipped
# Broader Storage and Software Defined Infrastructure Portfolio in the Market

## Storage Systems

<table>
<thead>
<tr>
<th>Tier 0 Acceleration</th>
<th>Enterprise Storage Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>FlashSystem</td>
<td>XIV</td>
</tr>
<tr>
<td>DS8000</td>
<td>FlashSystem A9000 / A9000R</td>
</tr>
<tr>
<td>Storwize V7000</td>
<td>Storwize V5000</td>
</tr>
<tr>
<td>Tape and Virtual Tape Systems</td>
<td></td>
</tr>
<tr>
<td>Virtualization Engine TS7700</td>
<td>ProtecTIER Deduplication</td>
</tr>
<tr>
<td>Tape Library and Automation</td>
<td>Tape drives for Enterprise and LTO6</td>
</tr>
</tbody>
</table>

## Software Defined Storage

- **IBM Spectrum Storage family**
  - IBM Spectrum Storage Suite
  - IBM Spectrum Virtualize
  - IBM Spectrum Protect
  - IBM Spectrum Control
  - IBM Spectrum Accelerate
  - IBM Spectrum Scale
  - IBM Spectrum Archive

## Spectrum Computing

- **IBM Spectrum Computing**
  - Spectrum Symphony
  - Spectrum LSF
  - Spectrum Conductor
  - Spectrum Cluster
  - Foundation
  - Spectrum MPI

## IBM Cloud Object Storage System

## Integrated Infrastructure Solutions

- VersaStack
- IBM Elastic Storage Server
- PurePower
Only IBM can integrate best-in-class resources to solve customers’ most critical hybrid cloud challenges

**Built with**

**IBM Spectrum Accelerate**

**DATA SERVICES**

Integrated data services, based on IBM Spectrum Accelerate, provide security and protection

**PERFORMANCE**

Field-proven IBM FlashCore™ technology drives consistent MicroLatency

**PARALLEL ARCHITECTURE**

Grid capabilities, originally pioneered by IBM XIV, make scaling simple and easy

**SIMPLE MANAGEMENT**

The innovative new interface has earned more than 15 patents, and is based on the award winning XIV GUI and extensive customer feedback

**FLASH-OPTIMIZATION**

IBM Research optimized reduction features, like deduplication and compression, for the speed of flash
IBM FlashSystem in the IBM Systems Enterprise Storage Portfolio

IBM FlashCore™ Technology Optimized

FlashSystem A9000
All flash array for cloud service providers
- Best performance with full time data reduction
- Targeting VDI and VMware

FlashSystem A9000R
All flash array for large deployments
- Best performance with full time data reduction
- Targeting mixed workloads

FlashSystem V9000
All flash array for virtualizing the hybrid Data Center
- Best performance with storage services & selectable data reduction
- Targeting database/analytics workloads

Storwize V7000
Mid-Range

Storwize V5000
Entry / Mid-Range

SVC
High End Server
- Mainframe
- Power
- Extreme reliability and replication
- Available in All Flash & Hybrid configurations

XIV Gen3
High End Capacity Optimized

FlashSystem 900
All flash array for application acceleration
- Extreme performance
- Targeting database acceleration & Spectrum Storage booster

DS8880
High End

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IBM Spectrum Accelerate EcoSystem

Intelligent, feature rich and field proven storage services

- **Data services**
  - Snapshot
  - Sync/Async, 3 site replication
  - Thin-Provisioning
  - Hyper-Scale Manager, Mobility and Consistency
  - Encryption
  - Multi-tenancy
  - QoS per host, domain, pool and volume
  - Data Migration

- **Integrations**
  - VMWare
  - Microsoft (Hyper-V)
  - OpenStack

- **New for A9000/A9000R**
  - Data Reduction: Pattern Removal, Deduplication and Compression
  - Cross platform management GUI

*Note: Not all features available in each deployment model*
IBM FlashSystem A9000 / A9000R - Compute Building Block

- **A9000/A9000R Compute building block**
  - A9000 utilizes 3 Grid Controllers
  - A9000R utilizes 4 – 12 Grid Controllers

- **Grid Controllers responsible for**
  - Cache coherency
  - Data reduction
  - iSCSI + FC ports or all iSCSI
  - Back-end InfiniBand connections for full mesh architecture between Grid Controllers and Flash enclosures
Custom designed Flash Media with field proven Architecture

- **IBM FlashSystem products share a consistent core Flash Architecture**
  - IBM MicroLatency™ Flash Modules delivering industry leading performance
  - IBM FlashCore™ Technology with IBM Enhanced MLC Flash
    - Non-blocking Crossbar Switch
    - Hardware Only Data Path
    - Concurrent Code Lode and Concurrent Maintenance
  - High Availability Flash Enclosure with dual canister design
  - Integrated Data Integrity Checking
  - Multi-Dimensional RAID
FlashSystem A9000 and FlashSystem A9000R

**FlashSystem A9000**
- 8U, complete offering
- Ideal building blocks for...
  - Cloud storage
    - IBM SoftLayer
    - OpenStack Cinder
- 60TB-150TB-300TB effective capacity
- Up to 500K+ IOPS @ 250μs minimum latency

**FlashSystem A9000R**
- Integrated 42U rack offering
- Pre-integrated
- “White gloves” experience
- Scale-out grid architecture
- Ideal for larger enterprise environments
- 300TB – 1.8PB effective capacity
- Up to 2.0M IOPS @ 250μs minimum latency
Grid-scale ensures reliability and consistency

- Data is spread across all of the grid controllers and flash enclosures
- Data is protected on the flash enclosure
- No manual intervention
- No tuning
- No pre-planning
- Linear scalability
New management interface simplifies management

Web based application

Powerful Navigation

Holistic View

Instant Analysis
Hardware
FlashSystem A9000 & FlashSystem A9000R

- FlashSystem A9000R
- Integrated 42U rack offering
  - Pre-integrated
  - “White gloves” experience
- Scale-out grid architecture
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- FlashSystem A9000
- 8U, complete offering
- Ideal building blocks for…
  - Cloud storage
    - IBM SoftLayer
    - OpenStack Cinder
- 60TB-150TB-300TB effective capacity
IBM FlashSystem A9000

- 8U modular offering
- Composed of 3 grid controllers & 1 flash enclosure
- Scales via IBM Hyper-Scale Manager

<table>
<thead>
<tr>
<th>Effective Capacity(^1)</th>
<th>Flash Enclosure-60</th>
<th>Flash Enclosure-150</th>
<th>Flash Enclosure-300</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60 TB</td>
<td>150 TB</td>
<td>300 TB</td>
</tr>
<tr>
<td>IBM modules</td>
<td>12 x 1.2 TB</td>
<td>12 x 2.9 TB</td>
<td>12 x 5.7 TB</td>
</tr>
</tbody>
</table>

\(^1\)Assuming up to a 5.26 to 1 data reduction ratio
## IBM FlashSystem A9000R

### EFFECTIVE CAPACITY\(^1\)

<table>
<thead>
<tr>
<th>Number of grid elements</th>
<th>1.8 PB configuration</th>
<th>900 TB configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>600 TB</td>
<td>300 TB</td>
</tr>
<tr>
<td>3</td>
<td>900 TB</td>
<td>450 TB</td>
</tr>
<tr>
<td>4</td>
<td>1,200 TB</td>
<td>600 TB</td>
</tr>
<tr>
<td>5</td>
<td>1,500 TB</td>
<td>750 TB</td>
</tr>
<tr>
<td>6</td>
<td>1,800 TB</td>
<td>900 TB</td>
</tr>
</tbody>
</table>

\(^1\) Based on a up to a 5.26 to 1 data reduction ratio

*IBM MicroLatency™ modules per flash enclosure*  

<table>
<thead>
<tr>
<th>Flash Enclosure</th>
<th>12 x 5.7 TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Controllers</td>
<td>12 x 2.9 TB</td>
</tr>
<tr>
<td>IB Switches PDUs</td>
<td></td>
</tr>
<tr>
<td>Maintenance Module</td>
<td></td>
</tr>
<tr>
<td>Grid Element</td>
<td></td>
</tr>
</tbody>
</table>
IBM FlashSystem A9000R - Performance & Capacity

- 600 TB
- 900 TB
- 1,200 TB
- 1,500 TB
- 1,800 TB

Assuming up to a 5.26 to 1 data reduction ratio;

Add grid elements for more capacity and performance.
IBM FlashSystem A9000 & A9000R Hardware Building Blocks

- **Grid Controller** - x3650M5 server
- Dual Socket Haswell 10Core processors
- Up to 8 SFF direct attached drives
- Internal BBU solution

- **Flash Module**
- 12 Flash cards 1.2, 2.9, 5.7TB
- High Availability / Fully Redundant
- Battery protection

- **Infiniband Switch**
- 36 Ports - FDR 56Gbps
- Internal BBU solution

- **Custom design 20KW PDU**
- Cascaded control connectors
IBM FlashSystem A9000 & A9000R - Grid Controller

Server Configuration

Grid Controllers In FlashSystem A9000:
• Dual Socket 8 Core CPU @ 2.3Ghz
• 192GB RAM – DDR4.
• 2 SAS HDDs – boot & log RAID1.
• 2 SAS SSDs – Vault devices.
• 2 IB Cards – Dual Port 56Gbit FDR, 16 lanes
• 2 Coleto Creek compression accelerators.
• 2 or 3 Dual ported Host Adapters
  • 2 x FC cards and 1 x 10 GigE. or 2 x 10 GigE.

Grid Controllers In FlashSystem A9000R:
• Dual Socket 10 Core CPU @ 2.3Ghz
• 384GB RAM – DDR4.
• 2 SAS HDDs – boot & log RAID1.
• 2 SAS SSDs – Vault devices.
• 1 IB Card – Dual Port 56Gbit FDR, 16 lanes
• 2 Coleto Creek compression accelerators.
• 2 or 3 Dual ported Host Adapters
  • 2 x FC cards and 1 x 10 GigE. or 2 x 10 GigE.
IBM FlashSystem A9000 & A9000R - Flash Module

**Flash card options**

- 1.2TB
- 2.9TB.
- 5.7TB.

- A9000 will support all 3 module sizes
- A9000R will support 2.9 & 5.7TB modules.

**InfiniBand QDR 40Gb - 4 ports per canister.**
Connections via IB interface using SCSI RDMA protocol (SRP).
  
  4 IB ports per enclosure, 2 per canister, 1 per IB HCA.
IBM FlashSystem A9000

- Grid Controllers In FlashSystem A9000:
  - Three-way active Grid Control enclosures w/ 16 CPU cores each (48 total)
  - Each Grid Controller contains 192GB DRAM cache (768GB total)

- FC+ISCSI, or ISCSI only host ports
- InfiniBand for backend connections to Flash Enclosure as well as providing the connections between the grid controllers

<table>
<thead>
<tr>
<th>Host Port Configurations</th>
<th>16Gb FC Dual +10 GigE Dual</th>
<th>Two 10 GigE Dual Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grid Controller 1</strong></td>
<td>4 + 2 Ports</td>
<td>4 Ports</td>
</tr>
<tr>
<td><strong>Grid Controller 2</strong></td>
<td>4 + 2 Ports</td>
<td>4 Ports</td>
</tr>
<tr>
<td><strong>Grid Controller 3</strong></td>
<td>4 + 2 Ports</td>
<td>4 Ports</td>
</tr>
<tr>
<td><strong>Total Ports</strong></td>
<td>12 - 16Gb FC + 6 - 10Gb iSCSI</td>
<td>12 - 10Gb iSCSI</td>
</tr>
</tbody>
</table>

Host port connections must be identically configured in each of the grid controllers.
IBM FlashSystem A9000R - Architectural Grid Elements

Entry Configuration Includes:

- Mellanox 36 port InfiniBand Switch – FDR 56Gbps
- Management Module
- Custom design 20KW PDU
- Four 2U Grid Controllers (20 CPU cores each)
  - 4 x 16Gb FC + 2 x 10Gb iSCSI
    - Upgradable to 48 16Gb FC + 24 10Gb iSCSI
  - or... 4 x 10Gb iSCSI
    - Upgradable to 48 10Gb iSCSI
  - 384GB DRAM cache (maximum of 4.6TB DRAM cache)
- Two 2U Flash Enclosures
  - 2.9TB or 5.7TB Flash Modules
  - 300TB effective capacity (up to 1.8PB effective capacity)

Expansion (Grid Element):

Two 2U Grid Controllers + one 2U Flash Enclosure
IBM FlashSystem A9000 – Maximum Power

- **Power source**
  Each grid element requires two 10 A, 200–240 VAC power sources. Each grid element must be connected to two independent power sources, for a total of eight power sources per storage system.

- **Power Consumption**

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Maximum power consumption in VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>25°C (77°F)</td>
<td>2000</td>
</tr>
<tr>
<td>40°C (104°F)</td>
<td>3210</td>
</tr>
</tbody>
</table>
IBM FlashSystem A9000R - Maximum Power

- **Power sources**

  Several AC power source configurations are available:
  - Four 60 A, 200-240 V AC, North American, EMEA, and Japan single-phase receptacles, each connected to a different power source.
  - Two 60 A, 200-240 V AC, US and Japan delta three-phase receptacles, each connected to a different power source.
  - Two 32 A, 200-240 V AC, EMEA WYE three-phase receptacles, each connected to a different power source.

- **Power Consumption**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Maximum power consumption in VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 grid controllers and 2 flash enclosures</td>
<td>5318</td>
</tr>
<tr>
<td>6 grid controllers and 3 flash enclosures</td>
<td>7840</td>
</tr>
<tr>
<td>8 grid controllers and 4 flash enclosures</td>
<td>10,362</td>
</tr>
<tr>
<td>10 grid controllers and 5 flash enclosures</td>
<td>12,884</td>
</tr>
<tr>
<td>12 grid controllers and 6 flash enclosures</td>
<td>15,406</td>
</tr>
</tbody>
</table>
Data Reduction
Flash Optimized Data Efficiency

Designed together for comprehensive & complementary data reduction

- Pattern Removal + Deduplication
- Compression
- Snapshots

Patterns:
- Supports scalable workloads
- Global, inline
- 8K block size w/4K alignment

- Hardware accelerated
- No performance-degrading background scrubs
- Inline

- Redirect-on-write
- Space-efficient
- High-performance
Data Reduction Methods

- 8KB pattern detection
- Deduplication
- Compression
Data Reduction terms

- Raw capacity – Takes into account over provisioning at the MicroLatency module level, but typically not important

- Usable capacity – How many bytes can be written to
  - A9000R with 6 grid elements, using 57TB FlashSystem 900 – 6 X 57 = 342TB

- Effective capacity – How many bytes appear to be available
  - Same A9000R, assuming 5.26:1 data reduction ratio – 1800 TB
  - Actual results shown in GUI
The Basic Dedupe Mechanism

- The user space is split into constant sized chunks
- A fingerprint/hash is calculated for each chunk written
- The fingerprints are stored in a repository
- Future writes query the repository for existing fingerprints
- If fingerprint is found a reference to the existing chunk is created
Pattern Detection

- Patterns are detected by comparing the fingerprints of a write to a static database of popular fingerprints
- Patterns are stored using a pattern ID (no hash is stored)
- When read, the data is code generated
- More efficient than dedupe in both time and space
- There are currently ~260 patterns
Compression

- Data reduction is accomplished below cache
  - Allows for very good write times
- Modified RtC code, based on XIV code
  - Variable input, fixed output
- Uses hardware assist for compression

- Data reduction node resides in all grid contr
  - Utilizes grid architecture to ensure all resources are used
Challenges Dedupe Creates

- Reporting per volume usage statistics
  - Volumes hold or share data with other volumes

- Estimate space freed by deleting a volume
  - Must know how many references are cross volume

- Reduction estimation
  - Cannot rely on sparse sampling – require full data read
  - Must run on all volumes to give system wide estimation
Data Reduction Estimation tool

- Supports Linux, AIX, Windows, ESXi
- CLI only
- Requires root access
- Has ability to run partial scan, but full scan is required for guarantees
- Has ability to run in batch mode
Features
Feature list – very similar to XIV Gen3

- LDAP Support
- Quality of Service
- Multi-tenancy
- Encryption
- Snapshots
- Small volumes
- VMware integration
- Openstack support
- Role based access
- 1 year of historical performance data
- SMI-S 1.6
- RESTful API
- Host attachment kits
- Grid architecture
- Data migration
- .....
Quality of Service

- Allows limitation of both bandwidth and IOPs
  - Domain
  - Pool
  - Host
  - Volume

- Also adds new capability
  - Shared – all objects in performance class contribute to meeting a single shared limit
  - Independent – each object in the performance class contributes to a specific limit for that object
Multi-tenancy

- **Domain** - isolated set of storage resources
- Domain admin has access to the specified domains only
- Global admin can manage domains and assign admins to domains
- Private objects are assigned to domains
- Global Objects
  - Users, Hosts, Clusters, Targets
  - Hosts created by domain admin are assigned to that domain
- Closed/Open Policy:
  - Open – default
    - A "global" storage admin will be able to see "inside" a domain
  - Closed
    - A "global" storage admin will not be able to see "inside" a domain
Encryption

- Industry standard AES-XTS 256 required by most leading compliance regulations such as HIPAA and FIPS
- Flash System A9000 and FlashSystem A9000R support data at rest encryption
  - Requires IBM SKLM
  - Other KMIP 1.1 compliant key managers may become available via RPQ
  - Does not require USB key per individual FlashSystem 900.
- Hot encryption activation and re-key
- GA supports encryption of data on FlashSystem 900s only
  - June release will support encryption of SSDs in grid controllers
Snapshots

- Space efficient
- Redirect on write
- Snaps are dependent on the master only, never each other
  - Recover from any snap at any time, in any order, as often as needed
- Multiple features around snaps
  - Overwrite
  - Format snap
  - Update snap
  - Duplicate snap
- Consistency groups
Small Volumes

- In XIV, allocation unit was 17GB (actually 17.18GB)
- All pools and volumes were on a 17GB boundary
- A9000/A9000R allocation unit is 103GB
- Pools are still allocated on this boundary
  - This is too large for a minimum volume size
- Minimum volume size is 1GB
  - However, if volume size is within 5% of a multiple of the 103GB, it will automatically rounded up to that allocation unit boundary
What is yet to come

- **June release**
  - A9000/R to A9000/R replication
    - Sync
    - Async
  - A9000/R to A9000/R Hyper-Scale mobility via FC
  - Statistics enhancements in GUI
  - Encryption of vault SSDs

- **4Q release (announced at Edge in Sep) (October?)**
  - QoS enhancements
  - XIV gen3 and Spectrum Accelerate support in new GUI
  - A9000R MES
  - Vvol
  - Hyper-Scale consistency
  - Port statistics and events in GUI
  - Hyper-Scale mobility with XIV Gen3
  - Async replication with XIV Gen3
Licensing
Two ways

- A9000/A9000R can be licensed in one of two ways
  - Standard license
    - License is tied to the serial number of the hardware
  - Separate software license
    - Cost benefit on hardware refresh

- Spectrum Accelerate

- Spectrum Storage Suite
Management
FlashSystem A9000 and FlashSystem A9000R Management

- **Hyper-Scale Management Hub**
  - Next generation storage management
  - HSM installed on RHEL 6.x or 7.x
  - Access via browser
  - RESTful API and documentation links
  - Spectrum Control Base

- **Command Line Interface (CLI)**
  - Downloadable via link within the Hyper-Scale Management Graphical User Interface (GUI)
  - Based on the XIV CLI
  - Run in session mode or in scripts

- **Mobile Application Dashboard**
  - Monitoring system health and events

- **Host Attachment Kit**
  - Customize host multipathing
  - Management utilities
  - Support and troubleshooting utilities
Hyper-Scale Manager

- **Hardware requirements:**
  - RHEL 6.x or 7.x
  - 64-bit OS
  - 4 GB RAM
  - 2 CPUs
  - At least 80 GB free space

- **Install bin executable via root privileges**

- **Connect with a browser to complete configuration**
  - Supported with Chrome and Firefox
  - Creates a new user: manager_server_user
  - Manage up to 144 systems
  - Holds up to 1 year of data
Hyper-Scale Manager – Dashboard View

- **Health widget**
- **System Usage**
- **Data Reduction**
- **System Statistics**
- **Link to view details**
- **Click to view hardware**
Hyper-Scale Manager – System View

- A9000 view

- A9000R
Hyper-Scale Manager - Views

1. Systems & Domains Views
   - All Systems
   - Domains
   - All Alerts
   - System Connectivity
   - Hardware View
   - System Capacity (Data Reduction)

2. Statistics Views
   - System & Interfaces Statistics
   - Volume Statistics
   - Snapshot Statistics
   - GoS Statistics
   - Host Statistics

3. Pools & Volumes Views
   - Pools
   - Volumes
   - Snapshots
   - Snapshot Tree
   - Consistency Groups
   - Snapshot Groups

4. Hosts & Clusters Views
   - Volumes by Hosts/Clusters
   - Mapped Volumes
   - Hosts
   - Clusters
   - Host Connectivity
   - Quality of Service

5. Remote Views
   - Mirrored Volumes
   - Migrating Volumes
   - Mirroring Connectivity
   - Migration Connectivity

6. Access Views
   - Users
   - User Groups

7. Management Server
   - Manager Configuration
   - Add Systems to Monitor
   - Access Restriction (recommended)
Hyper-Scale Manager – Tabs and Menus

- Ability to open multiple tabs
  - Letter indicates what the tab is for (S=systems, V=volumes, H=hosts, P=pools)

- Create an item with the “NEW” button

- Settings to access management server and Spectrum Control Base

- Use the “Help” button for help videos, documentation and downloading the CLI

- View alerts
Hyper-Scale Manager – Demo
Hyper-Scale Manager – Tabs and Menus

- Single pane of glass management
- Easy to use web-based application
- Easy installation and upgrades
- Quickly find anything with filtering and navigation
- Provision, monitor and troubleshoot on a single screen
- Real-time statistics
- Multi-tasking with tabs
- Capacity reporting and trend forecasting
- Scalability

- Resources:
  - IBM FlashSystem A9000 and FlashSystem A9000R: Architecture, Implementation and Usage, Redbook SG24-8345 - Draft
  - IBM FlashSystem A9000 Product Guide, REDP-5325
  - IBM FlashSystem A9000R Product Guide, REDP-5326
Cloud Integration
IBM is Open by Design

Don't build a dead-end cloud

**OpenStack**
Founding member and Platinum Sponsor
Built on OpenStack, the ubiquitous, massively scalable open source IaaS platform:
- IBM Cloud Orchestrator
- PowerVC
- BlueBox

**Cloud Foundry**
Founding member and platinum sponsor of the Cloud Foundry Foundation
Built on Cloud Foundry, the industry’s open PaaS that provides choice of clouds, frameworks and application services:
- IBM Bluemix

**Docker**
Leading the move toward open governance as Member of Docker advisory board and Contributing significant code to the project
Supporting Docker, an open platform to build, ship and run distributed applications:
- IBM Container Service for Bluemix
- Docker Hub Enterprise on SoftLayer
- WebSphere Liberty Profile Application Server

The OpenStack project mission is to produce the ubiquitous Open Source Cloud Computing platform that will meet the needs of public and private clouds regardless of size, by being simple to implement and massively scalable.

Code available under Apache 2.0 license. Design tenets – scale and elasticity, share nothing and distribute everything
VMware / IBM Storage Integration Capabilities

vCenter Management of IBM Storage
- Provisioning, mapping and monitoring IBM storage in vSphere

vStorage APIs for Array Integration (VAAI)
- Host server offload capability

vStorage APIs for Storage Awareness (VASA)
- IBM Storage Overview
- Profile driven storage direction

SRM Integration
- Replication simplification with XIV

vRealize Suite (vCloud Suite)
- Includes VMware vCenter Orchestrator (vCO), VMware vCenter Operations Manager (vCOPS), and VMware vCloud Automation Center (vCAC)

IBM Spectrum Control Base
- Central Storage Control Plane for Cloud

vSphere Virtual Volumes (VVOLs)
- XIV Storage abstraction delivers easy automated provisioning with tenant domains, policy-compliant service, snapshot and cloning offloading, and instant space reclamation
- Technology Demo available at https://www.youtube.com/watch?v=HZtf5CaJx_Y&feature=youtu.be

vStorage APIs for Data Protection (VADP)
- Tivoli Flash Copy Manager and Tivoli Storage Manager for Virtual Environments
Spectrum Control Base - IBM Storage VMware Integration

Disaster Recovery

Discovery
Provisioning
Optimization

Automation
Operations Management
Self-service

Backup
Snapshot
Management

Cloud Operation (vRealize Suite for vSphere6)

Server Virtualization

SRM
vRA / vCAC
vRO / vCO
vROPS / vCOPS
vCenter

Spectrum Control Base

VAAI support (data path integration)

Spectrum Virtualize, Storwize, V9000, XIV, Spectrum Accelerate, A9000, DS8000
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