Rainy Days & Boot Storms
Always Get Me Down
Evaluating Cloud Implementations: What You Need to Know

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Agenda

- Introduction
- Cloud Computing Trends
- Case Study
  - Sunny Day - Normal Operations
  - Rainy Day - When Everything goes Wrong
  - VM Boot Behavior
- Conclusions
Growing popularity of virtualization and cloud solutions

Future workloads impossible to predict
  - Smart, mobile devices are radically changing the apps and services IT orgs support

Increased sophistication and performance of data center technology

Bottom line: Testing helps ensure successful roll-outs and operations
The Problem We Need to Solve

“Modern data centers are becoming so complex we understand them less and less.”
– quote from several large data center operations teams

Legacy Data Center

- **Predictable** application workloads
- **Dedicated** infrastructures (1 app – 1 Infrastructure)
- **Physical**: client server, n-tier web

Modern Data Center

- **Dynamic** application workloads (cloud and others)
- **Shared** infrastructures (n apps – 1 infrastructure)
- **Virtualized** everything - elastic, dynamic
- **Intelligent**, extreme performance components
Cloud Migration

- Insight (via testing) is needed to determine infrastructure behavior.

Cloud Environment

- How effective are my load balancers in allocating traffic?
- How many concurrent VMs will meet user expectations?
- What is the optimal number of VMs to boot simultaneously?
- What is the relative scalability of the storage and compute layer for my app?
- What are the impacts of Sunny Day vs. Rainy Day usage patterns?
- What do failures look like? How do I fix them?
- How will storage respond to a boot storm?
Robust understanding of infrastructure behavior (performance, capacity, scalability, and failure modes) in order to:

- Plan / Design / Integrate / Configure / Optimize / Troubleshoot

Understanding infrastructure behavior is most critical for:

- Product technologies having complex behavior
- Data center solutions that are custom or semi-custom
- Determining the root cause of problems

No longer able to use incremental deployment strategies when migrating to private clouds
Testing Needs to Change As Well

- Testing the SYSTEM at scale is rare
- Homegrown and shareware tools don’t offer the realism needed to test everything
- Testing is costly in both money and time
- Perception is the need to “Stop my work to test”
- 1 app at a time

One platform – one paradigm is needed
- Light weight, semi-automated
- Integrated in the design, configuration and troubleshooting processes

Limited infrastructure insight

All about infrastructure insight
Cloud Computing

- The use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet)
- May be based on private (Enterprise) or public (Service Provider) implementation
- May be any combination of hardware and software services
  - Physical, virtual or combination
Elastic Computing
(Cloud Computing and Virtualization)

- Cloud implementations provide elastic compute resources
- Applications delivered as Virtual Machine (VM) implementations within a computer
- Services added or removed on demand
  - Compute
  - Security
  - Efficiency
  - Network
The Big Picture

- The cloud is a system
  - Applications, platform(s), physical infrastructure
    - Access/Security, Applications and Storage all interact
  - Any application may be virtualized
- Storage protocol performance is critical
  - But is only one component
  - All components must be designed and tested to ensure max system performance
- Testing components in isolation is not enough
  - Entire system should be tested under load
What is a Sunny Day?

- Sunny day identifies “normal” operation
  - Operation that falls within design limits
- Design must include ability to handle:
  - Occasional traffic spikes
  - Maintain services up to expected peak demand
  - Handle VM adds/moves and minor outages
- Each component affects how the system operates
  - Vendor data sheets are a start, but verification is needed
  - Testers should verify vendor claims through testing
- Modeling/testing helps validate design
Even Sunny Days Can Get You Down

- Sunny Day operations include errors and delays
  - Design should anticipate transient problems
  - SLAs should not be affected
- Examples:
  - Ethernet and TCP issues
  - Authentication
  - Latency variation
  - Caching new files/objects and metadata
- Problems often have nothing to do with storage
  - But affect storage performance and must be considered
Win7/SMB: 30 Sec to Cache 1K File?

Min: 100μs at 00:00:22.580
Max: 29459694μs at 00:01:29.083

Response Time

Uncached  -----------  Cached -----

Latest Poll
Average: 658,527
NFSv3: 80 Seconds to Cache Data?

Response Time

Min: 133µs at 00:00:00.500
Max: 423156µs at 00:00:09.508

Latest Poll
Average: 11,302
Assessment of latency against number of connections and file size
SMB Win7 90 Second Data Response at 2500 Connections

Scenarios

TCP Connection Time

Latest Poll
Attempts: 5,083
Succeeds: 0
Fails: 0
Aborts: 1,083

Pending/Running
Scenarios: 4,000
Actions: 4,000
Connections: 4,000

Duration
Min: 6104214μs at 00:01:55.759
Max: 1454358994μs at 00:02:26.333

Time-to-1st-Byte
Min: 108μs at 00:00:00.500
Max: 76646μs at 00:02:03.761

Closing Time
Min: 0μs at 00:00:00.000
Max: 0μs at 00:00:00.000

Latest Poll (μs)
Avg Duration: 102,232,392
Time-to-1st-Byte: 10,688
Closing Time: 0
What is a Rainy Day?

- Performance drop, or loss of service, caused by:
  - Overwhelmed compute or network resources
  - Loss of compute or network resources
    - VMs, Servers, network devices or links, etc.
    - Power transients or hard power loss
- System outage may occur even if storage is OK
  - Restart may highly impact storage
    - Restarted components may cause traffic spike while booting
    - Especially products like caches that must rebuild after a failure
Rainy Day: Hot Spots

- A Hot Spot is an overloaded part of the system
- Can be the result of failures elsewhere
  - Individual VM or server
  - Blade server or entire rack
  - Network link or device
  - Power dip or failure
- Remaining resources are often the Hot Spot
  - Devices must share the additional load during recovery
    - Shortcoming of Active – Active implementations
    - Failures may cascade
    - Dedupe and caching can be particularly vulnerable
What Causes Hot Spots?

- Inadequate data or metadata distribution
  - Too few disks available to handle required load
- Inadequate redirection
  - DNS or other load balancing shortcomings
- Inadequate network bandwidth
  - Too many VMs on one network segment
  - Device failure results in overload on remaining link(s)
- Inadequate authentication resource
  - Domain controller loss or degradation
  - Access controller loss or degradation
Sunny Day to Rainy Day:
Increased Response Time

TCP Connections

Count

Port Time (sec)

Response Time

Min: 102μs at 00:00:01.000
Max: 3222858μs at 00:02:11.198

Latest Poll
Attempts: 56,678
Opened: 56,596
Closed: 55,441
Reset: 0
Failed: 37
Open Timeout: 0
Data Timeout: 0
Rejected: 0

Average: 61,019
Sunny Day to Rainy Day: Out of Sequence Failures
Boot Storms

- Time during which multiple VMs boot
- Caused by:
  - Initial system start
  - Rainy Day issues
  - Unanticipated client load increase
- Examples:
  - After power failure
  - During times of rapidly increasing application demand:
    - Time of Day (e.g. logins at beginning of a shift)
    - Flash Crowd (High # of VM boots triggered by demand)
VM Boot Behavior

- VM requires a source for:
  - Boot Image
  - Application image(s)

- Applications are dependent on each other
  - Boot process may have to cascade through all infrastructure tiers before entire system can start

- Time is required to both load and boot a VM
  - Highly impacted by:
    - Number of concurrently booting VMs
    - VM Boot start delay
How Do You Tune the Boot?

- Find the limit of VMs per:
  - Hardware instance
  - Network segment
  - Boot source

- Block or File?
  - Block is common
  - SMB 3 and NFS 4.1 offer potential

- Use standard frame size when possible
  - Jumbo frames may cause problems – test!
    - Especially in routed network implementations
VM Booting: L2 v L3 Network

Detection of networking issue affecting the VM booting process.
Boot Time v Start Delay

VM Boot Response vs. Start Delay

Optimal boot response!
Limits Testing: VM Ramp

- 2000 VM, MTU = 1500
- 4000 VM, MTU = 8000
- 4000 VM, MTU = 1500

Acceptable booting behavior at 2x expected load with MTU = 1500

Booting behavior at expected load

... but ultimately, failure

Slightly faster ramp with larger frames...
Cloud Migration Considerations

- How will it the implementation scale?
  - Test Sunny Day and Rainy Day Scenarios

- How will it react to a boot storm?
  - Understand effects of booting
  - Understand effect on remaining infrastructure

- What is the failover behavior under load?
  - Does the system:
    - Degrade performance gracefully?
    - Further impact the failure?
Cloud Migration Considerations (continued)

- How does VM behavior and load affect the storage service performance and availability?
  - Failure of other components may look like a storage failure
  - Failure of other components may cascade to storage

- What is the relative scalability of the storage component regarding the compute component?
  - Both must be robust to maintain SLAs
Summary

- Cloud implementations require new thinking
  - Manageable, but more difficult to understand
  - Virtualization must be understood well
- Virtual implementations are complicated
  - Entire data center must be part of your thinking
- System-Level Testing is needed more than ever
  - Understand what a Sunny Day looks like
  - Understand what a Rainy Day looks like
  - Understand how to mitigate Boot Storm behavior
Q&A
Supporting Materials
Case Study – Emulating the VMs

**Testing Approach:** Emulate VM requests upon the storage services

**Key Emulation Scenarios**
- VM boot behavior
- VM-NFS image run-time traffic
- VM-SMB application traffic

**Measurements**
- Response time
- Crashes
- Error rates

**Type of Tests**
- **Capacity:** Load vs. response time
- **Stress:** Increase load to identify performance limits and failure modes
- **Endurance:** Extended duration testing to identify problems such as memory leaks or hardware defects
- **Scalability:** Vary infrastructure configurations to optimize scalability
Test scalability limits
- Throughput, connections, IOPS etc.

Test reliability / performance under extreme load
- Not reproducible by in house tools

Test availability and fail-over under load
- How many sessions transition seamlessly?
- Does load impact failover?

Meta-data operations
- How many file attributes per-second can be changed?

Does storage recover gracefully from high load?
- Verify file, metadata and content fidelity at all functional levels and at scale
- Create race conditions
  - E.g. All hosts start a function (tree connect) at once
- Create special request headers/flags that can’t be tested with operating system-based internal tools
- Change headers and flags
  - Discover untested configuration issues
- Do storage connections work well over congested WAN links?
Interoperability Tests

- How resilient is storage to large numbers of connections?
  - Remote site flapping can cause new connections to initiate
  - May momentarily double the number of storage connections

- How inter-operable is WAN acceleration with storage under high load?
  - WAN acceleration terminates TCP connections and data
  - May cause incompatibilities and increase latency

- How does a firewall affect storage under high load?
  - Firewalls also terminate connections and data and may cause incompatibilities and increase latency