Virtualization and Cloud: Orchestration, Automation, and Security Gaps

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Introduction

- Private cloud implementations incorporate a lot of “moving parts”
- With growth and maturity of a cloud infrastructure, most incorporate orchestration and automation functions
- These are rarely secured
  - Few vendor-integrated options
  - Little operational attention to risk and security
- Let’s delve into potential risks and what we can do about them.
Architecture and Definitions
Orchestration

- The orchestration “layer” allows for planned automation and provisioning tasks within a cloud environment.
- Typically managed by a distinct software platform.
  - Can be open-source or commercial.
- Often relies heavily on APIs.
- Often focused on configuration, changes and change management, and provisioning.
- Can also play a role in monitoring, security, and other functions.
Private Cloud Architecture

Reference: http://inthepassing.files.wordpress.com/2010/01/cloud-ref-arch.jpg
Private Cloud Architecture: Single Point of Failure?

Reference: http://inthepassing.files.wordpress.com/2010/01/cloud-ref-arch.jpg
Another Orchestration Model Example

Source: Cisco.com
What about automation?

- Orchestration relies heavily on automation tools and “rules”
- Automation tools can easily manage a number of common cloud “activities”
- If **misused**, however, automation could easily lead to chaos
  - Malicious commands
  - Service disruption
  - File/system/app modification
Automation Frameworks and Tools

- LOTS of tools emerging and available, both open and commercial
  - IBM Rational
  - Cisco Intelligent Automation for Cloud (CIAC)
  - Dell Cloud Manager
  - Puppet (Puppet Labs)
  - OpsCode Chef
  - CFEngine
- OASIS also defined Topology and Orchestration Specification for Cloud Applications (TOSCA)
  - XML-based language defined for service/template provisioning
More on Puppet and Chef

Puppet Labs’ Puppet
- Centrally-defined resources are provisioned to systems and monitored
- Configuration management for OS, network, middleware, and application tiers is possible
- Integrates natively with AWS, VMware, OpenStack, etc.

Opscode Chef
- 3-tier architecture:
  - Nodes
  - Chef Server
  - Workstations
- Leverages Ruby “recipes” that are loaded to configuration “cookbooks”
Common Orchestration Tasks

- Configuration Management
- Storage
- VM/Compute
- Network
- Provisioning
  - VMs and application instances
- IT Automation and DevOps
- Security & Compliance assessment, monitoring, and reporting
An Example Use Case

1. Orchestration Engineer defines a resource and commits to the repository

Source: http://docs.opscode.com/chef_overview.html
An Example Use Case

2. Automation Tools write the new resource definition to the main server, where it’s added to a defined workflow and policy.

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An Example Use Case

1. Orchestration Engineer defines a resource and commits to the repository

2. Automation Tools write the new resource definition to the main server, where it’s added to a defined workflow and policy

3. Nodes pull the new resource config, making configuration and local policy changes as needed

Source: http://docs.opscode.com/chef_overview.html
Another Example Use Case

1. Developer navigates to internal self-service portal and requests a new virtual machine resource
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1. Developer navigates to internal self-service portal and requests a new virtual machine resource.

2. Request is sent to orchestration platform. Resource definition is verified, as is requester role and permissions.

3a. A new VM is created.

3b. FW rules are opened.

3c. Storage is provisioned.
A final example use case…
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- The Orchestration platform becomes self aware…
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- The Orchestration platform becomes self aware…
Orchestration Tools

- **Commercial:**
  - CSC ServiceMesh Agility
  - Flexiant
  - IBM SmartCloud
  - HP Operations Orchestration
  - VMware vCenter Orchestrator
  - Oracle Nimbula

- **Open-Source:**
  - Abiquo
  - CloudStack
  - Eucalyptus
  - OpenStack
  - Puppet / Chef
Orchestration and Automation Risks

- Control of and interaction with automation platforms can be very risky
  - Poor development, scripting, resource design and instantiation
  - System availability issues or resource hijack/compromise
  - Malicious insiders or lack of “least privilege”
  - Vendor lock-in (architecture, language, etc.)
  - Poor authentication/credential management
  - Weak or non-existent integration with security products
- Configuration management and access control are critical
Key Risk 1: Modification of Critical Files

- All orchestration platforms have critical configuration files and/or files that include sensitive data

- Examples:
  - Puppet: /etc/puppetlabs/installer/database_info.install
  - Chef: knife.rb or JSON Data Bag files
  - Flexiant: /etc/extility/local.cfg

- Modifying these files could grant illicit access, change provisioning parameters, modify database or other users, etc.
Examples of critical platform files

Puppet:
/etc/puppetlabs/installer/database_info.install

Flexiant:
/etc/extility/local.cfg
Critical platform files…on the Internet

- Google query: chef data_bags filetype:json password -metadata
Key Risk 2: Modification to Work Flows

- Orchestration platforms all function with defined “runbooks”
  - These include resource definitions, configuration options, scheduling and policy preferences, credentials/roles, and more
- Most work flow steps involve:
  - Integration with a cloud management platform (OpenStack, vSphere)
  - API calls to network devices, applications, or middleware
  - Pre-authenticated remote command execution
- Changing any of these could dramatically impact nodes or resources
Example of workflow modification:

- A workflow is defined that:
  - Provisions a new application VM
  - Opens numerous Check Point firewall rules to facilitate traffic to/from the new VM
  - Performs periodic health/security checks of the VM and app configuration
- An attacker is able to modify the workflow definition:
  - Adds malicious files to the VM configuration
  - Opens a new firewall port for data exfiltration and C2
  - …for ALL NEW INSTANCES.
Key Risk 3: Changes to Roles and Privileges

- Access to orchestration platforms needs to be carefully controlled.
- In addition, defined roles and privileges should be designed and implemented with extreme caution.
  - Too many privileges could easily allow insider attacks to proliferate.
- Example: Puppet Console system has a simple Web username/password field combination, and is exposed to the entire management network.
  - Brute force password guessing…and no lockout.
- Example 2: A business unit IT operator role is set up improperly to allow unfettered API access to network nodes and all hypervisor instances.
  - The user accidentally crashes hypervisors with API calls…or worse.
Key Risk 4: Availability Sabotage

- Availability of cloud nodes, middleware, applications, and even network devices could be severely impacted if:
  - API access is changed or corrupted
  - Credentials are compromised/changed/deleted
  - Shutdown commands are issued
  - Network access paths are changed/degraded
- The orchestration platform itself is a single point of failure
  - Many implementations I have seen have ZERO redundancy
Threat Models
Attacking Orchestration

- In a cloud environment, the orchestration layer is a potential weak point with much to gain for attackers
- An attacker or malicious insider that gains control over orchestration could:
  - Modify the SAN allocation for VMs
  - Modify VM templates
  - Modify user/group roles
  - Impact availability of orchestration++
- These are just starting points!
Threat Model 1: SAN Allocation

- Most cloud implementations rely heavily on large-scale storage infrastructure
- Orchestration workflows incorporate automated disk provisioning for workloads
- Modification of the storage workflow parameters for disk allocation could easily lead to a SAN becoming full or over allocated
- Deliberate or accidental configuration changes could easily lead to this threat becoming realized
- Impact: Availability and/or loss/corruption of data
Threat Model 2: VM Template Modification

- A very common use case for orchestration is deployment of new VM workloads from templates
- Templates may exist on the SAN and hypervisor platforms
  - Orchestration resource templates will modify as needed
- Modification could:
  - Add malicious programs into a template
  - Open new ports / start new services
  - Disable security features or programs
Threat Model 3: Role Modification

- Modifying orchestration roles could easily lead to:
  - Undetected backdoor/privileged access by “low privilege” users
  - Accidental configuration changes/mishaps
  - Escalation of privilege scenarios
  - “Shadow IT” or other changes
- Role definition and privileged user monitoring is critical
- Many orchestration platforms don’t natively integrate with Identity Management systems
CERT’s Cloud Insider Guide

- CERT breaks down the insiders and risks in a 2012 paper
- Lists roles and likely attack vectors
- Where’s the Orchestration Admin?

Full paper available at www.cert.org/archive/pdf/CERT_cloud_insiders.pdf
Threat Model 4: Availability Impact

- Any modification to the orchestration platform itself, or various settings, could have major availability impact:
  - Locking out admin accounts
  - Changing resource definitions
  - Modifying workflow steps or parameters
  - Changing/closing local ports for communication
  - Starting/stopping orchestration services
- The orchestration platform could be a single point of failure, too.
Orchestration Attack Tree

Attacker or malicious insider takes control of orchestration tools

- Attacker modifies workload provisioning to fill SAN with large disks
  - Denial of Service conditions occur within the storage environment
- Attacker inserts backdoors into VM templates
  - Attacker can now control VMs and/or intercept sensitive data
- Attacker modifies roles for cloud tenants and orchestration administrators
  - Cloud business unit tenants may have too much access provisioned
- Attacker removes all access to orchestration and/or destroys data
  - Orchestration tools are inaccessible or corrupted, leading to downtime
Remediation Options and Tools
Key Areas Of Focus

- Orchestration Platforms
  - Often multi-tiered
  - Focus on code/data repos, master servers, and client configs
- Databases
  - Usernames and passwords, config files containing sensitive data
- Automation platforms
  - Separate repos or “workstations” (Chef) used for configuration and resource management
Key Areas Of Focus

- Operations teams
  - Social engineering attacks targeting orchestration and automation teams - more focus on security awareness
- API calls and logging
  - Local access and calls of APIs
  - Remote API logging at nodes and infrastructure
- “Failsafes” – affected platforms and systems
  - “Deny All” stance and “triggers”/”tipping point” fallbacks
What To Do Now
A Checklist for Security Teams

- **Review security options available within orchestration platforms**
  - Most offer role-based access
  - Privilege creation and assignment is often limited, though
  - Key- and cert-based authentication
  - Look for integration with Privileged User Management and IAM tools
  - Assess depth and breadth of API integration
  - Look for logging and event generation
A Checklist for Security Teams (cont.)

- Review security options available within orchestration platforms
- Evaluate whether file integrity monitoring tools can run on the orchestration management platforms
  - Many attacks are focused on modification of critical files or configuration parameters
  - FIM is likely “unsupported”, especially with “appliance” form factors
A Checklist for Security Teams (cont.)

- Review security options available within orchestration platforms
- Evaluate whether file integrity monitoring tools can run on the orchestration management platforms
- Consider dual-factor authentication to the orchestration servers, if possible
  - May help to mitigate attack vectors coming from compromised Ops workstations
  - Can also require access from a “jump box” for control and audit
A Checklist for Security Teams (cont.)

- Review security options available within orchestration platforms
- Evaluate whether file integrity monitoring tools can run on the orchestration management platforms
- Consider dual-factor authentication to the orchestration servers, if possible
- Integrate orchestration logs and events into your monitoring/SIEM strategy
  - Develop behavioral profiles for admin-level tasks and operations
A Checklist for Security Teams (cont.)

- Review security options available within orchestration platforms
- Evaluate whether file integrity monitoring tools can run on the orchestration management platforms
- Consider dual-factor authentication to the orchestration servers, if possible
- Integrate orchestration logs and events into your monitoring/SIEM strategy
- Heighten security awareness for Orchestration teams!
Conclusion

- Orchestration and automation platforms have the potential to streamline cloud operations
  - Properly implemented, can improve effectiveness & efficiency
- Many orchestration platforms are lacking in security, however
- Many security teams also aren’t aware of the risks these systems pose!
  - Perform a security/risk assessment of orchestration platforms and governance/usage of them
- If well-managed, these systems can **improve** security, too!
Questions?