How to Tame Your Clouds with Automation

September 21, 2023

UF | Information Technology
UNIVERSITY of FLORIDA

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- Introductions
- Why automation
- What tools and how they're used
- Demo

Disclaimer

Despite our attempts to keep this high level, there are parts in this presentation where we do get technical.

Who are we?

- University of Florida IT (UFIT)
  - Infrastructure and Communication Technology Team (ICT)
    - Hyperconverged Infrastructure Team (HCI)
      - Cloud Enablement Team (CE)

Members

- Directors
  - Saira Hasnain – Associate VP and Deputy CIO
  - Barry Kinter – Associate Director for Hyperconverged Infrastructure Team
- Cloud Enablement Team
  - Eli Ben-Shoshan – Pre-Eminent Systems Administrator
  - Nicholas Cecere – Systems Administrator 5
  - Keith Sanders - Systems Administrator 5
  - Paul Smith - Systems Administrator 5
  - Eli Meister - Systems Administrator 5
  - Derek Gales - Systems Administrator 5

What does UFIT do?

- University of Florida has a distributed IT model
- Each college/department has some local IT
- UFIT is the overall central IT department responsible for IT direction of the University as a whole and Enterprise IT Services
- Plays a key part in advancing student success via the use of technology
- We operate like a public utility, providing shared Information Technology services throughout the University community
- Our Products are common: Infrastructure, Operations, Systems and Support

What does ICT do?

- Infrastructure
  - All of Campus networking
    - From the building to Internet connectivity
  - Private Cloud deployed on VMWare
  - Public Cloud access
  - Storage Services for Campus
  - Two Data centers in Gainesville

What does ICT do?

- Operations
  - Acts as Network Operations Center (NOC)
  - Operation Staff 24/7 responding to service alerts and customer calls

What does ICT do?

- Systems
  - Authentication and Identity Management
    - Active Directory for campus
    - SAML2 via Shibboleth
  - Infrastructure components for campus ERP system
  - Manage cloud services
    - Office 365
    - Google Workspaces
    - Dropbox
    - Zoom

What does ICT do?

- Support
  - 3rd tier in support for all services provided
  - Help Desk is the 1st Tier
  - 2nd tier is usually handled by local IT

What does ICT do?

- Offer these Services to both Enterprise customers and to hosting customers across campus

Private Cloud Infrastructure

- Two Data Centers in 5 miles apart
- ~100 ESXi hosts
- >3500 VMs
- Synchronously replicated storage via NetApp Metrocluster
- Resilient architecture designed with 2 availability zones
- Each zone has separate
  - Compute
  - Storage
  - Networking

Private Cloud Offerings

- Infrastructure as a Service
  - VMs available for self-service by hosting customers around campus
  - Enterprise customers can self-service in the same way or use automations we will talk about today
- Platform as a Service
  - Databases
  - File Shares
  - Web Hosting

Automation

- At our scale, Automation is a must for:
  - Consistency of deployments
  - Pace of requests is only increasing
  - Management and Campus priority inversion

Terrable Stack

Terraform + Ansible =
Terrable
but Awesome!

Terraform

- Infrastructure as Code (IaC) tool
  - Lots of providers that so that we can manage most any infrastructure
- Uses desired state to deploy infrastructure
  - You tell it the final state (with some hints) and it will try and get there
  - No need to tell it each step in the process
  - Will create a dependency graph which it compares to the current, desired, and last known state and will generate the steps to get to your desired state
- Modular (more on this later)
  - Let's you create reusable versioned modules with clean interfaces so that you can accomplish the same task the same way over and over

Terraform

- Really good at managing and deploying base components for a system
- Examples:
  - Deploy a VM
  - Manage day 2 operations like add a disk to an existing VM or change networking
  - Manage DNS entries
  - Manage DHCP reservations

Terraform

- Needs to store current state someplace
- Not so good at managing attributes within an OS deployment like:
  - Password maps
  - Software installs
  - Networking configuration
- We have another tool for that.....

Terraform Code Example

- Show some terraform code

Ansible

- Ansible is also an IaC tool
- Does not used desired state but instead uses a procedural approach via playbooks
  - You give it the steps to run and it will take them for you
- Uses an inventory file to know what hosts to connect to with specified credentials

Ansible

- Fantastic cross OS support
  - Windows
  - Linux
- Excellent for:
  - Managing Users
  - Deploying and configuring software
  - Creating filesystems and mount points
  - Managing Docker containers
- Modular (more about this later)
  - Create reusable components called roles

Ansible

- Could be used to deploy core infrastructure components like VMs but we think the desired state in Terraform is a better fit
  - Terraform detects, notifies, and can remediate drift
  - Ansible can't really detect drift
  - Admin needs to account for drift when writing playbooks

Ansible Playbook Example

- Show a simple Ansible playbook

Use cases

- We use Terraform to:
  - Deploy a VM from a template
  - Set its cloud-init so that it has initial networking
  - Register the VMs in DNS via Infoblox
  - Create the Ansible inventory file
- We use Ansible to:
  - Apply updates
  - Install software
  - Setup extra filesystems and mount points
  - Configure software

Bonus - Vagrant

- Where do the VM templates come from?
- Hashicorp Vagrant
- Vagrant is a tool used to create a virtualized environments
- Can create:
  - VMware VMs
  - VMware templates
  - AWS AMI
  - Azure VM Image
- You can call Ansible playbooks during a Vagrant run

Secrets

- What are they?
  - Password
  - TLS Private Keys
  - API access tokens
- We all have them and need a secure way to get them onto systems
- We might need to restrict which teams can see which password
- We all "should" be rotating our secrets on a regular basis, right?
  - Required by many security standards (FedRAMP Moderate, PCI)
- We need to have an inventory of which systems have which secrets in case "something" happens

Vault

- Hashicorp Vault is a secrets management engine
- Can store static secrets:
  - Username/Password
  - Private Keys
- Can interact with authentication systems to generate and vend dynamic secrets
  - Active Directory
  - AWS IAM
  - Azure AD
- Built-in policy engine so that you can limit how secrets are shared

Vault

- Highly Available
  - Uses raft protocol to replicate secrets amongst multiple nodes
- Encrypts secrets at rest
  - Well tested and hardened system of encryption for secrets at rest
- Can authenticate with lots of authentication backends
  - LDAP
  - AWS IAM
  - Kerberos
  - Azure AD
  - JWT
- UF has Vault authenticate using LDAP to the Duo LDAP proxy which gives us 2-factor for secrets
- Also gives us LDAP groups to identity which users are in which teams

Vault

- Vault has an agent that can be deployed on a VM
- Agent will check in with Vault on a regular basis to see if a secret has changed
- Agent has a templating system (based on Go template) that can replace/rewrite a file if a secret has changed
- Agent can call a script before and/or after a secret change
- UF uses the vault agent to update TLS private keys automatically
- But how do you authenticate a system to Vault?

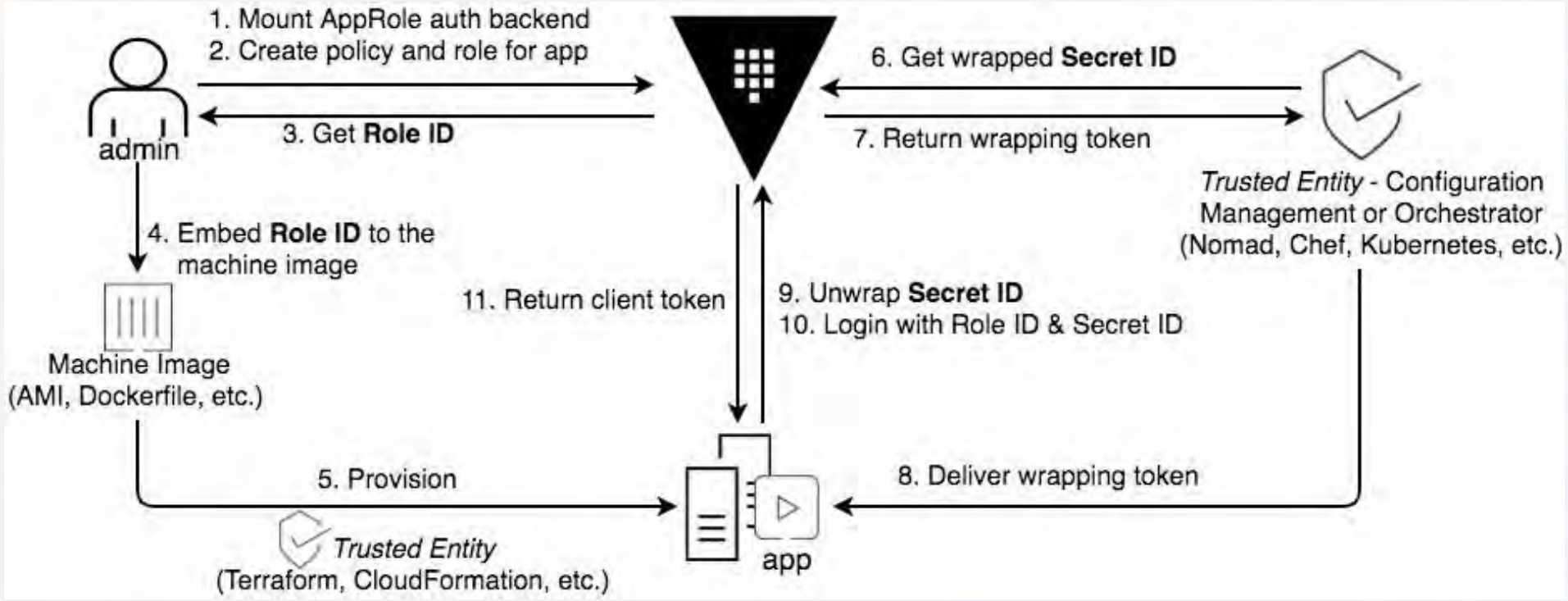
Vault

- Vault has a concept of a Role
- A role connects:
  - Backend Authentication System
  - Policies
- This is how you map a set of authenticated entities to policies which is where you limit access to certain secrets

Vault

- Vault has a powerful abstraction called an AppRole
- Instead of using only a token (like an access key or username/password) to identify an authenticating entity, it uses a Role ID and a Secret ID
- The Role ID is the Role that the entity would like to assume
  - It is not sensitive
- The Secret ID is a secret token used to authenticate to Vault
  - Once it authenticates it uses a session token from there on out to keep access
- The combination of the two gives an entity access to a set of secrets based on the policy assigned to the role
- Vault Agent uses an AppRole to authenticate with Vault
- Ansible interacts with Vault during VM deployment to request the Secret ID on behalf of the VM and places the Secret ID in a file on the VM

Vault


1. Mount AppRole auth backend
2. Create policy and role for app
admin
3. Get **Role ID**
6. Get wrapped **Secret ID**
7. Return wrapping token
Trusted Entity - Configuration Management or Orchestrator (Nomad, Chef, Kubernetes, etc.)
4. Embed **Role ID** to the machine image
Machine Image (AMI, Dockerfile, etc.)
11. Return client token
9. Unwrap **Secret ID**
10. Login with Role ID & Secret ID
5. Provision
Trusted Entity (Terraform, CloudFormation, etc.)
app
8. Deliver wrapping token

Quick Summary

- Terraform is used to deploy the infrastructure components
- Ansible is used to configure any operating systems
- Vault is used to manage secrets
- Terraform and Ansible interact with Vault to gain access to secrets
- So what orchestrates this seemingly complicated dance

GitLab is the glue that ties all these components together!

GitLab

- GitLab is a lot more than just a fancy web interface for managing git repos
  - Issue Tracking
  - Merge Request with approvals
  - Deployment pipelines triggered based on various events
  - Terraform
    - Registry for modules
    - State repository
  - Container registry

GitLab

- Deployment Pipelines are what facilitate Continuous Integration / Continuous Deployment (CI/CD)
- Pipelines specify a set of stages
- Each stage has a set of steps that will be executed in order
- Dependencies can be setup between stages so that some can run in parallel and others run in series

GitLab

- Pipelines are modular in such that you can import stages from another pipeline
- GitLab allows for the creation of centrally managed stages that can be imported for use by other pipelines
- This reuse of centrally managed stages is what allows for standards to be defined and used by all

GitLab

- All these pipelines run on runners which could be:
  - Docker based
  - Kubernetes based
  - Host with an agent
- We have different runners deployed for different groups
  - Usually this is because the end point that is being manipulated via CI is in a restricted network

GitLab

- Most of our pipelines need to have access to some secrets
  - vSphere username/password to create VM
  - AWS IAM access key id and secret
- Gitlab has a JWT token that it uses to authenticate to Vault
- When Gitlab authenticates to Vault it adds claims to the token which specify which project or groups it is acting on behalf of
- Vault maps the claims to the appropriate Role
- The Role then enforces a set of policies
- The policies specify which secrets can be accessed

Notes

- This might seem complicated and overly complex but we can assure you it is not once you get used to all the components.
- Don't expect to accomplish this overnight. It takes a while to get to this level of maturity. I took us about a year to get here and to be honest there are still some teams that have not really gotten onboard.

Demo