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DevOps-Continuous Integration

Infrastructure as code

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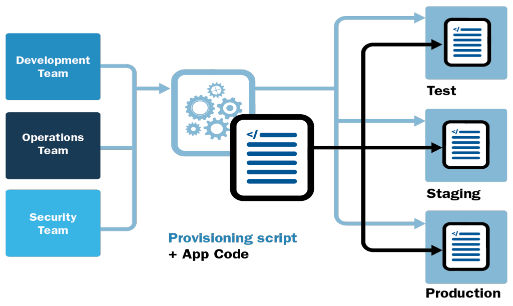
Infrastructure as Code (IaC)

A program that creates infrastructure



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Outline

- **Basic concepts**
- Environments
- Vendor lock-in

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What is IaC?

- Infrastructure as Code (IaC) is the management of infrastructure (networks, virtual machines, load balancers, and connection topology) using code segments in various languages. E.g.
  - Command line scripting
  - Provisioning specifications, e.g. Vagrant, Cloud Formation, Chef, Puppet, Ansible
  - Specification files for various tools, e.g Dockerfile

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Uniformity

- Uniformity in a variety of contexts is important
- Teams should have uniform development environments
- Various stages of the release pipeline should have environments that are as uniform as possible.
- IaC is a means for keeping environments consistent and uniform.

"Snowflakes"

- Without IaC, teams must maintain the settings of individual deployment environments.
- Over time, each environment becomes a *snowflake*, that is, a unique configuration that cannot be reproduced automatically.

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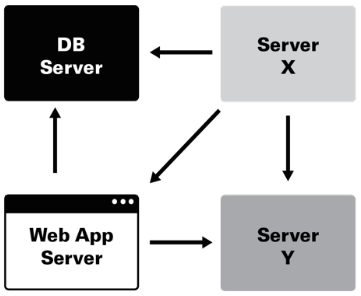
Why do we see snowflakes?

- Suppose a system requires multiple servers networked together



Each server is to be provisioned uniquely, providing a specific service

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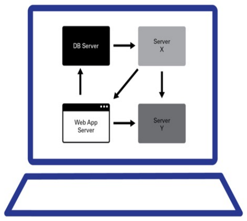
Snowflake scenario - 1

- At the time of development, developers write code assuming this specific infrastructure configuration
- During development, the environment is created by creating and provisioning virtual machines or simply running the component services on a developer's computer



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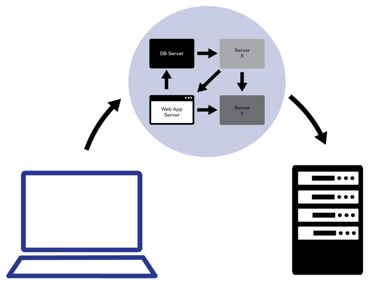
Snowflake scenario - 2

- At deployment, the deployment environment (Test / QA / Production) is manually provisioned to match the expected infrastructure configuration



This often means manual installation of packages, configurations, and networking components…

…and room for human error

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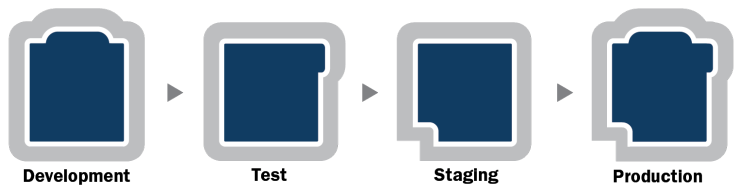
Divergence



- Environments are independent, volatile, and easily manipulated.
- Without care, they will diverge and create snowflakes.
- Hence, IaC

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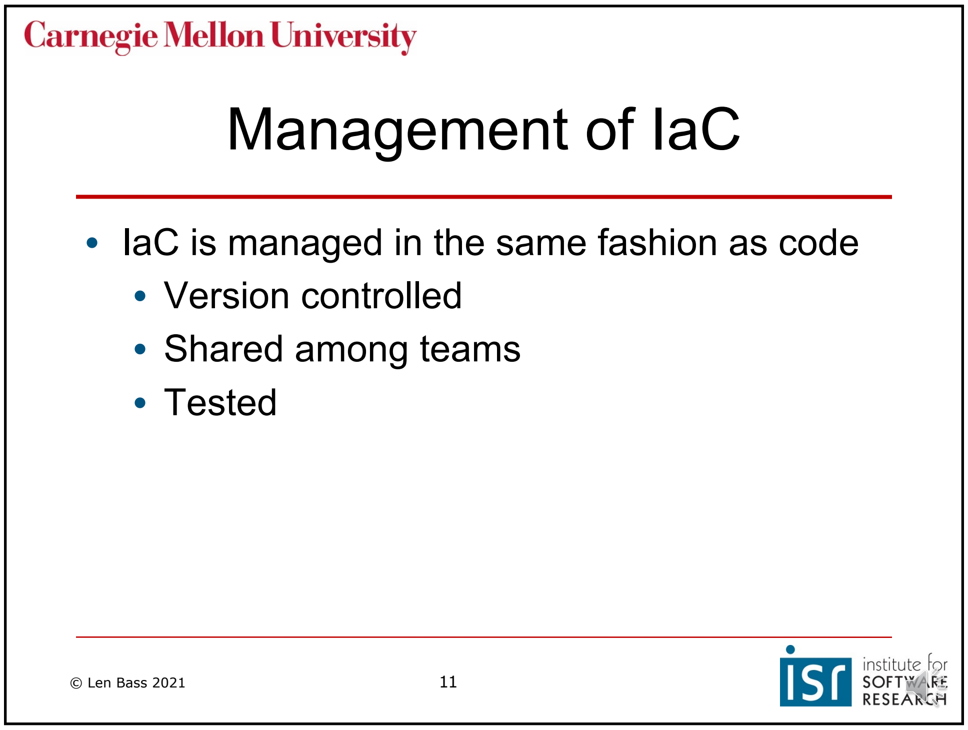

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Management of IaC

- IaC is managed in the same fashion as code
  - Version controlled
  - Shared among teams
  - Tested

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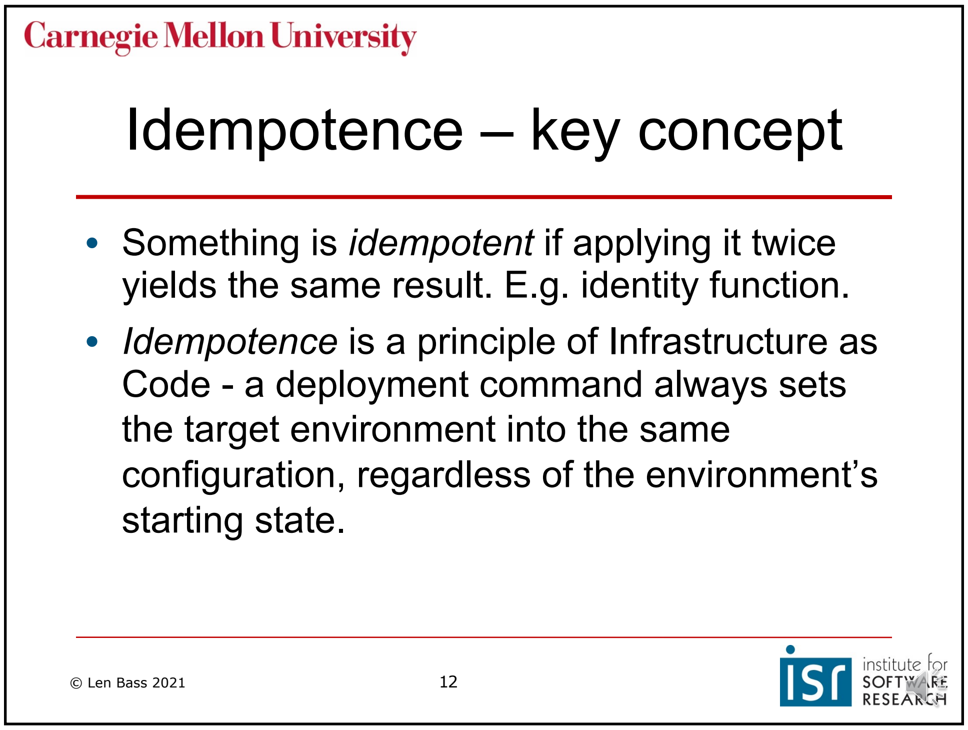

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Idempotence – key concept

- Something is *idempotent* if applying it twice yields the same result. E.g. identity function.
- *Idempotence* is a principle of Infrastructure as Code - a deployment command always sets the target environment into the same configuration, regardless of the environment’s starting state.

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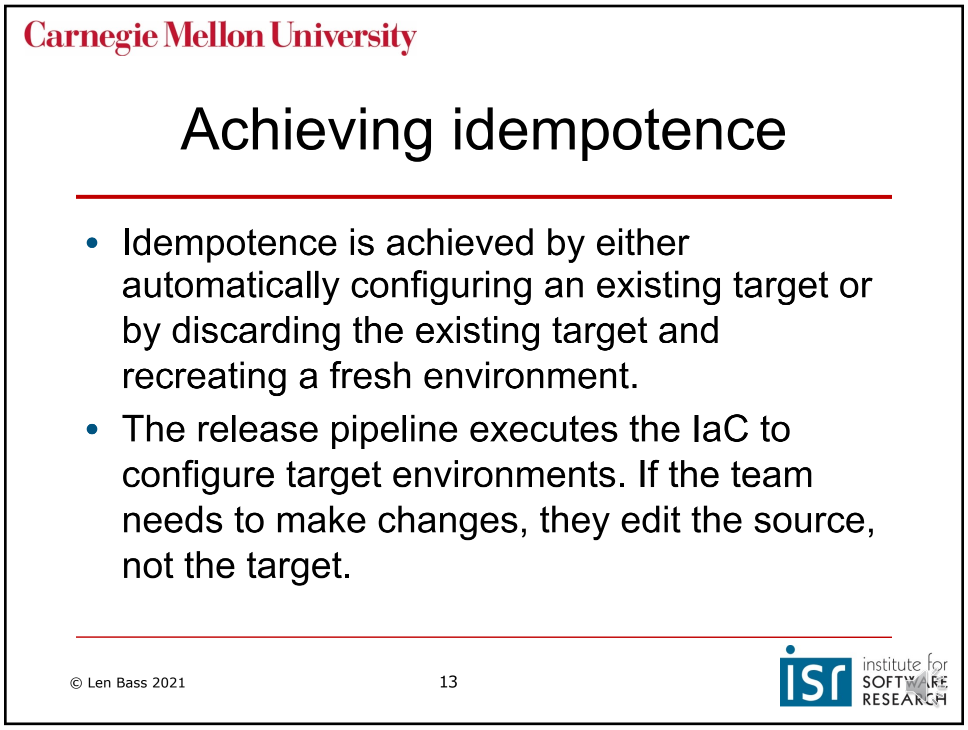

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Achieving idempotence

- Idempotence is achieved by either automatically configuring an existing target or by discarding the existing target and recreating a fresh environment.
- The release pipeline executes the IaC to configure target environments. If the team needs to make changes, they edit the source, not the target.

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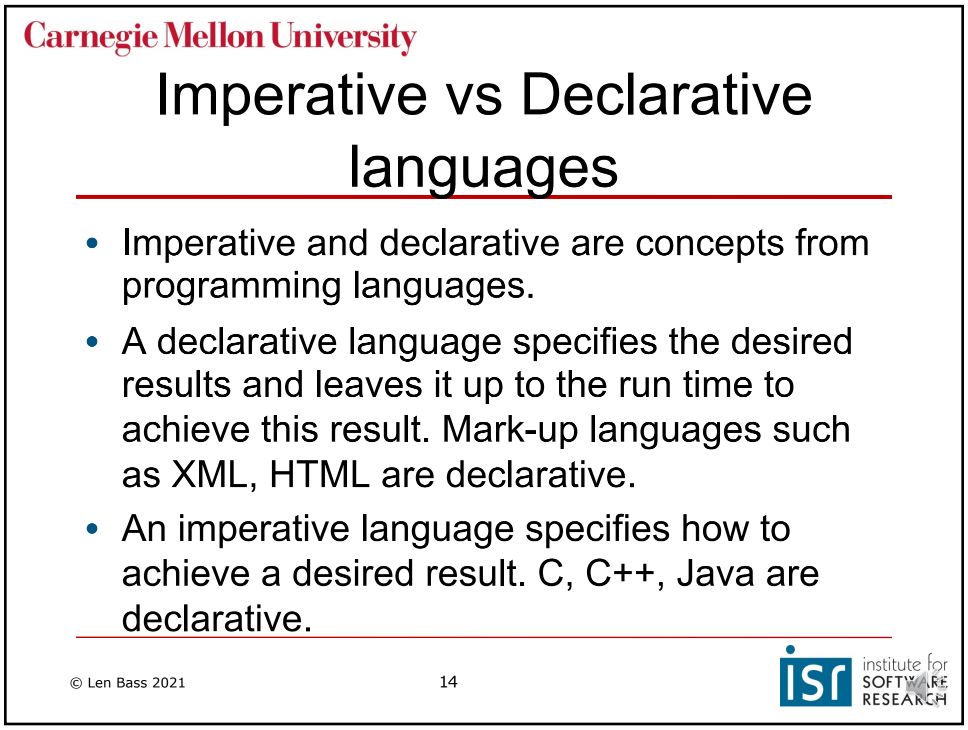

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Imperative vs Declarative languages

- Imperative and declarative are concepts from programming languages.
- A declarative language specifies the desired results and leaves it up to the run time to achieve this result. Mark-up languages such as XML, HTML are declarative.
- An imperative language specifies how to achieve a desired result. C, C++, Java are declarative.

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IaC languages

- IaC languages are typically declarative although they may have some imperative portions.
- Command line scripting is declarative but may invoke an imperative procedure.
- Declarative languages make achieving idempotence easier.

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Outline

- Basic concepts
- **Environments**
- Vendor lock-in

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Environments

- If IaC manages environments – what is an environment?
- An *environment* is a collection of provisioned resources.
- These days, typically a collection of resources in the cloud. Although it could be resources on a developer's computer.

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What kinds of environments?

- Environments exist for
  - Development
  - Integration
  - Testing
  - Staging
  - Production

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Environments have a life cycle

1. Creation
2. Provisioning
3. Use
4. Saving
5. Tear Down
   - Creation, provisioning, saving, and tear down can all be managed by IaC
   - Use is typically not managed by IaC.

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Creating an environment

- Cloud providers have specialized tools to create an environment.
  - AWS has CloudFormation
  - Azure has ARM (Azure Resource Manager)
- These tools
  - Allocate VMs of various types
  - Specify access rules

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Access rules

- An access rule specifies the relationship between an identity (class of users and systems) and resource permissions (what can a member of that class do with that resource).
- Users must authenticate (prove who they are) and be authorized (have the right to do particular operations on the resource)

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Cloud providers provide templates

- The constrction of an IaC program is simplified by the availability of templates provided by cloud providers.

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Sample Cloud Formation template (with no access control)

```
"AWSTemplateFormatVersion" : "2010-09-09",
"Description" : "A sample template", "Resources" : {
"MyEC2Instance" : { "Type" : "AWS::EC2::Instance",
"Properties" : { "ImageId" : "ami-2f726546",
"InstanceType" : "t1.micro", "KeyName" : "testkey",
"BlockDeviceMappings" : [ { "DeviceName" :
"/dev/sdm", "Ebs" : { "VolumeType" : "io1", "Iops" :
"200", "DeleteOnTermination" : "false", "VolumeSize" :
"20" } } ] } } } }
```

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Vulnerabilities

- However, inappropriate access control is a source of many production vulnerabilities.
- One study by Palo Alto Networks found over 200,000 vulnerabilities in CloudFormation specifications due to inadequate access controls.
- Another study cited by Accurics found that 93% of specifications had misconfigured cloud storage access controls.

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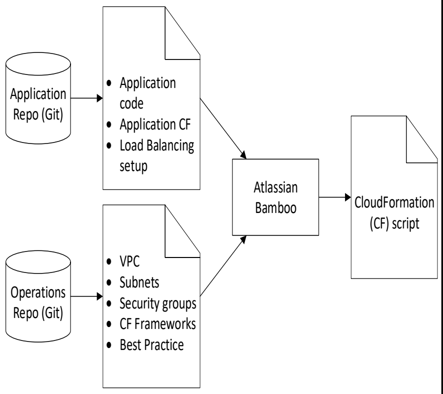
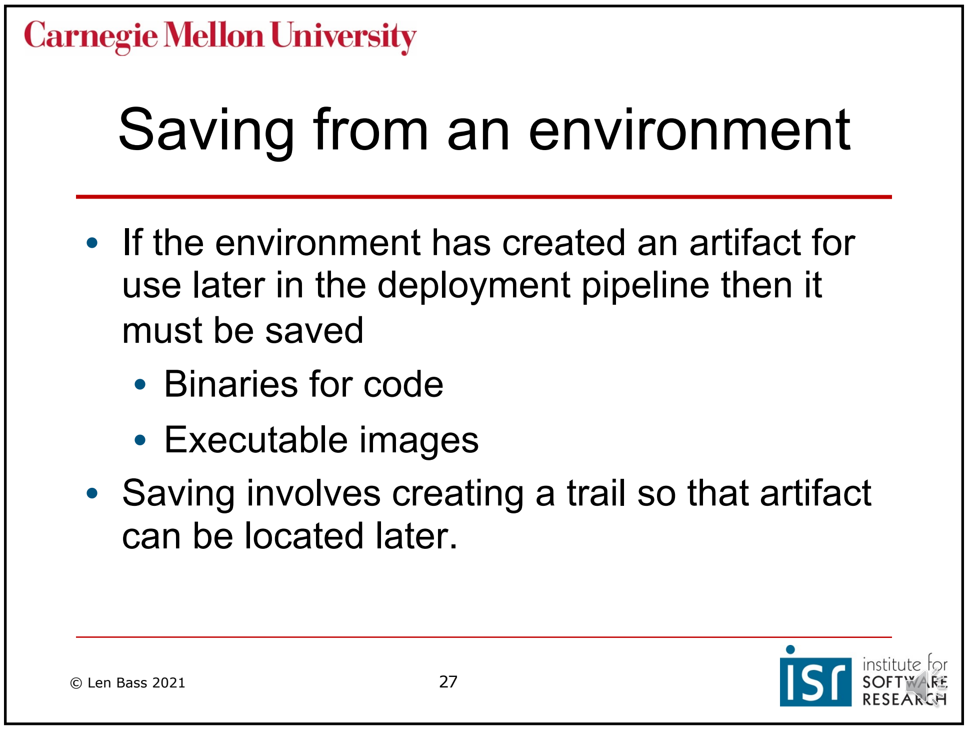
Separating concerns

- Use Cloud Formation (CF) scripts
- App development group maintains app specific CF scripts
- Operations group maintains global CF scripts for access control and other operations concerns
- Merge into a single CF script



Provisioning an environment

- Load created VMs with application specific software
- Done using provisioning tools. E.g.
  - Vagrant
  - CloudFormation has provisioning capabilities
  - Chef, Puppet, Ansible
  - …



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Saving from an environment

- If the environment has created an artifact for use later in the deployment pipeline then it must be saved
  - Binaries for code
  - Executable images
- Saving involves creating a trail so that artifact can be located later.

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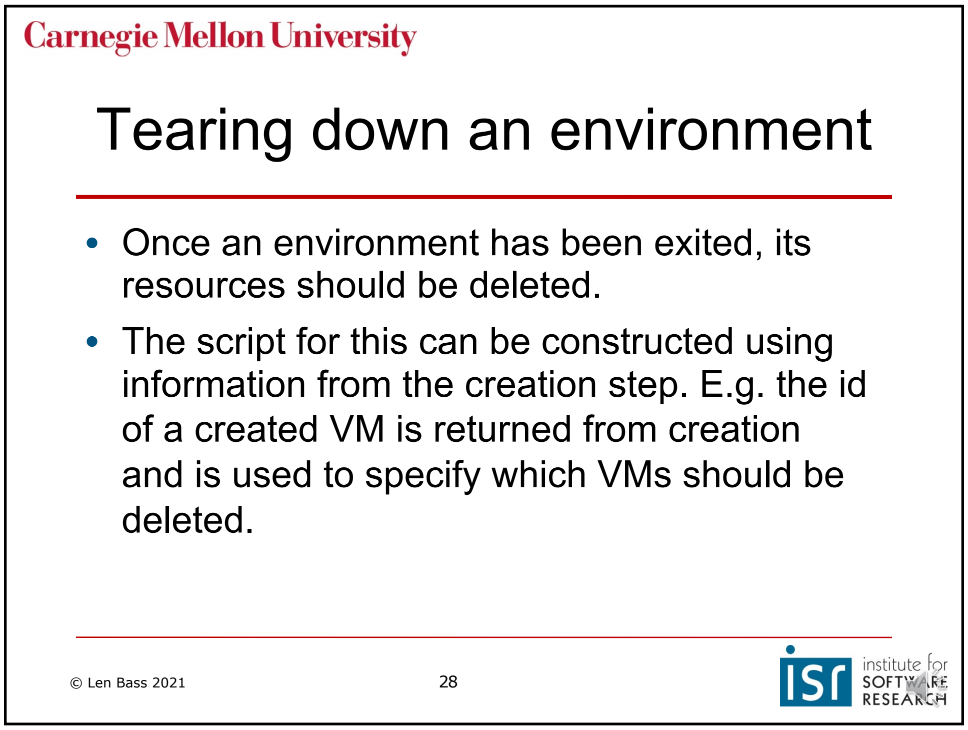

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Tearing down an environment

- Once an environment has been exited, its resources should be deleted.
- The script for this can be constructed using information from the creation step. E.g. the id of a created VM is returned from creation and is used to specify which VMs should be deleted.

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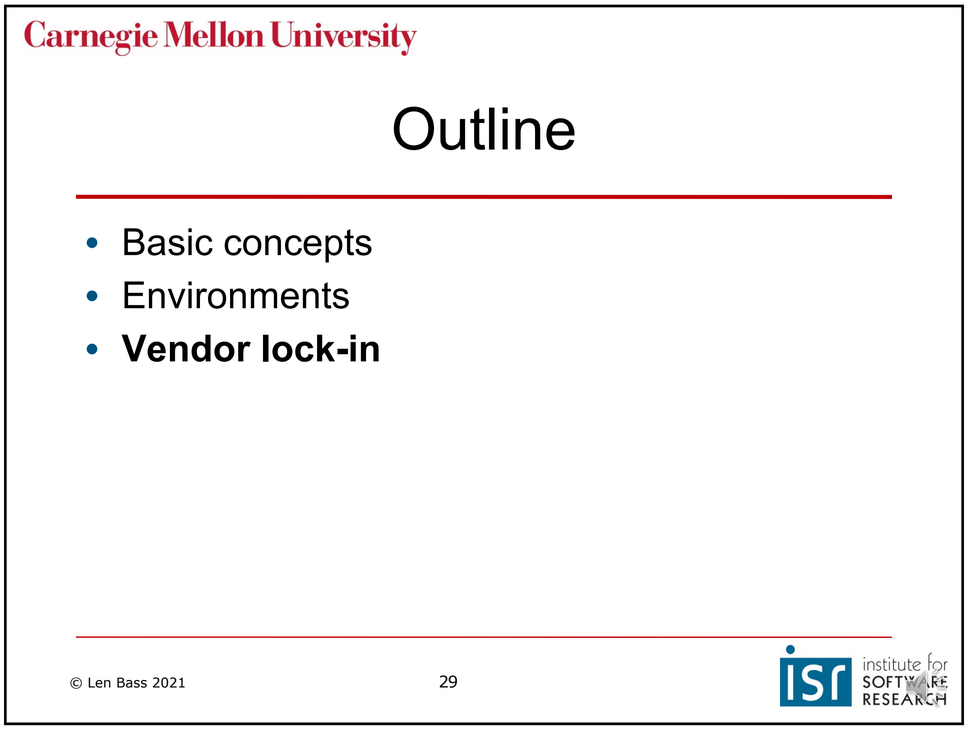

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Outline

- Basic concepts
- Environments
- **Vendor lock-in**

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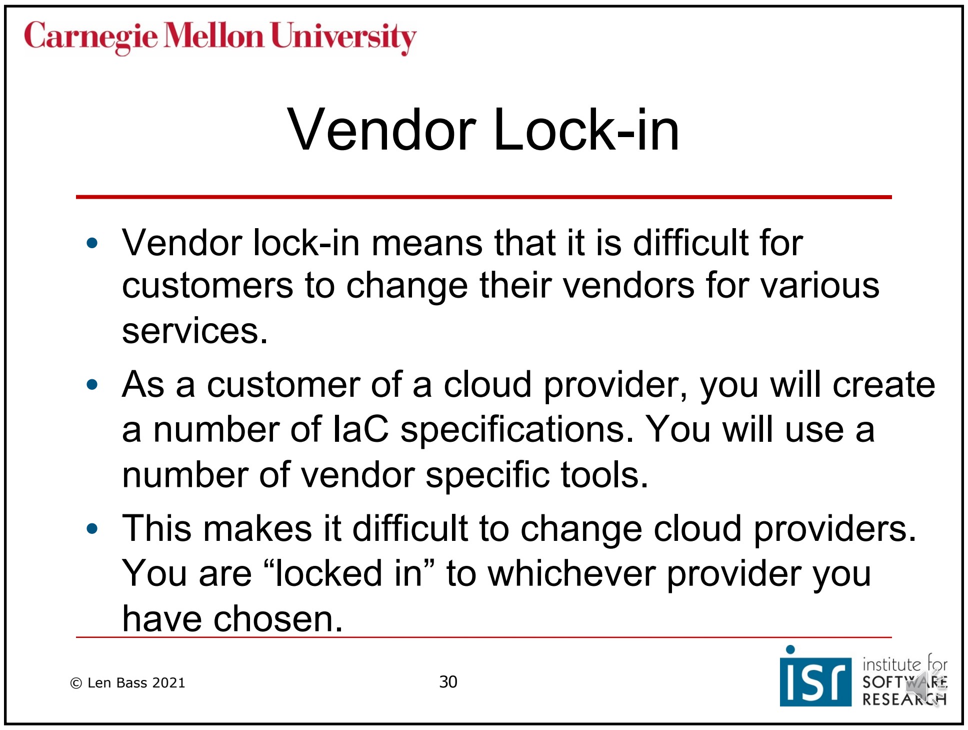

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Vendor Lock-in

- Vendor lock-in means that it is difficult for customers to change their vendors for various services.
- As a customer of a cloud provider, you will create a number of IaC specifications. You will use a number of vendor specific tools.
- This makes it difficult to change cloud providers. You are “locked in” to whichever provider you have chosen.

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Techniques to avoid vendor lock-in

- Use tools that work for various vendors
- Use intermediaries to specify access to various resources. Means that if you change vendors, only the intermediaries must be changed.

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Summary

- IaC involves the creation of a number of specifications to manage infrastructure
- These specifications should be managed as code – version controlled and tested
- IaC specifications are used to create and manage environments throughout an environment’s lifecycle.
- Use of IaC may lock you into a specific cloud vendor.

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