Cloud Native Applications & Cloud Foundry

CLOUD NATIVE, CLOUD NATIVE PLATFORM, CLOUD NATIVE RUNTIME, CLOUD FOUNDRY, TWELVE FACTOR, APPLICATION FRAMEWORKS

Cloud Native Applications

Cloud Native is not about **where**, but **how** you build and run your app!

- Microservices Architecture
- Twelve-Factor Methodology
- Containers
- Continuous Delivery
- Shift from Silo IT to DevOps

Cloud Native Promise

- Automated provisioning & configuration
- Automated scaling
- Infrastructure independence
- Continuous delivery
- Loose coupling
- Rapid recovery
- DevOps
- Security

Cloud Native Platform

Users

Dev

Dev

IT Ops

IT Ops

IT Ops

Cloud Native Platform

Application Frameworks

Contract: **12 Factor App**

Platform Runtime

Contract: **BOSH Release**

Infrastructure Automation

Contract: **Cloud Provider Interface**

Infrastructure

Components

Spring Boot

Spring Cloud

Spring Cloud Dataflow

Steeltoe

.NET Core

.NET

Cloud Foundry

BOSH

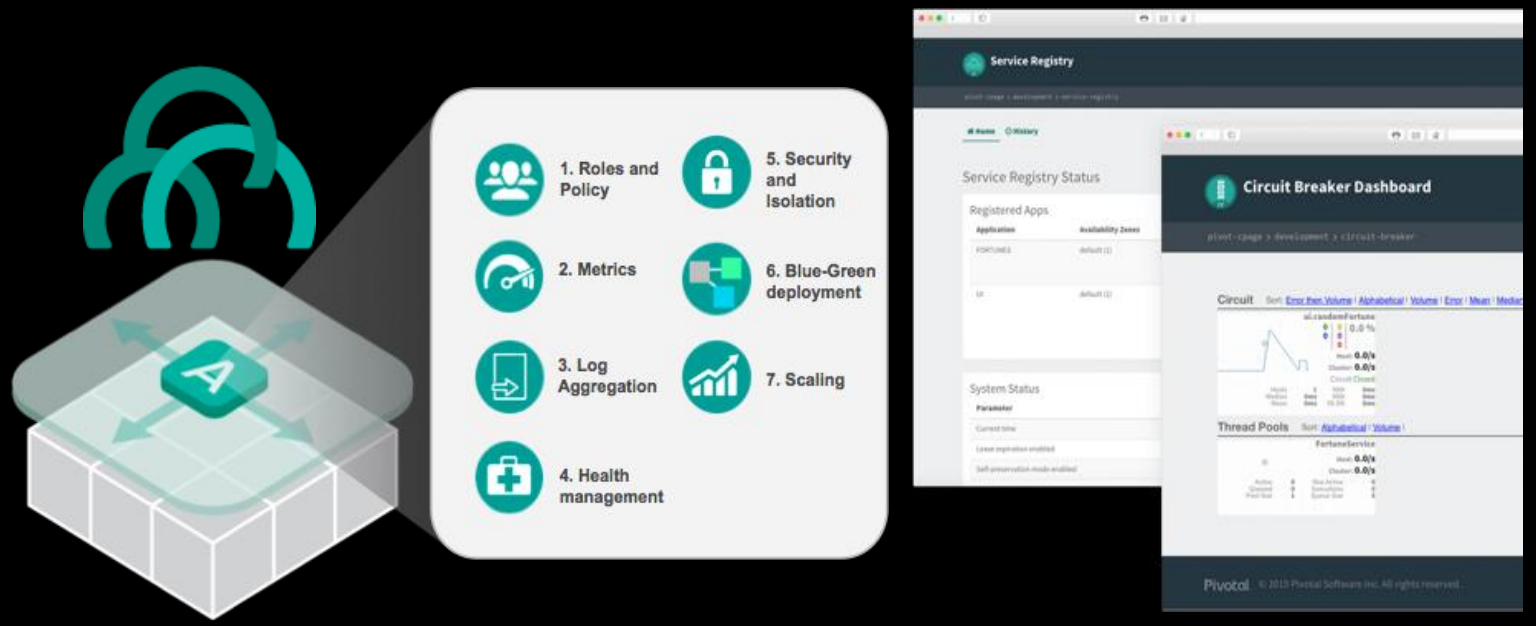
Dev

IT Ops

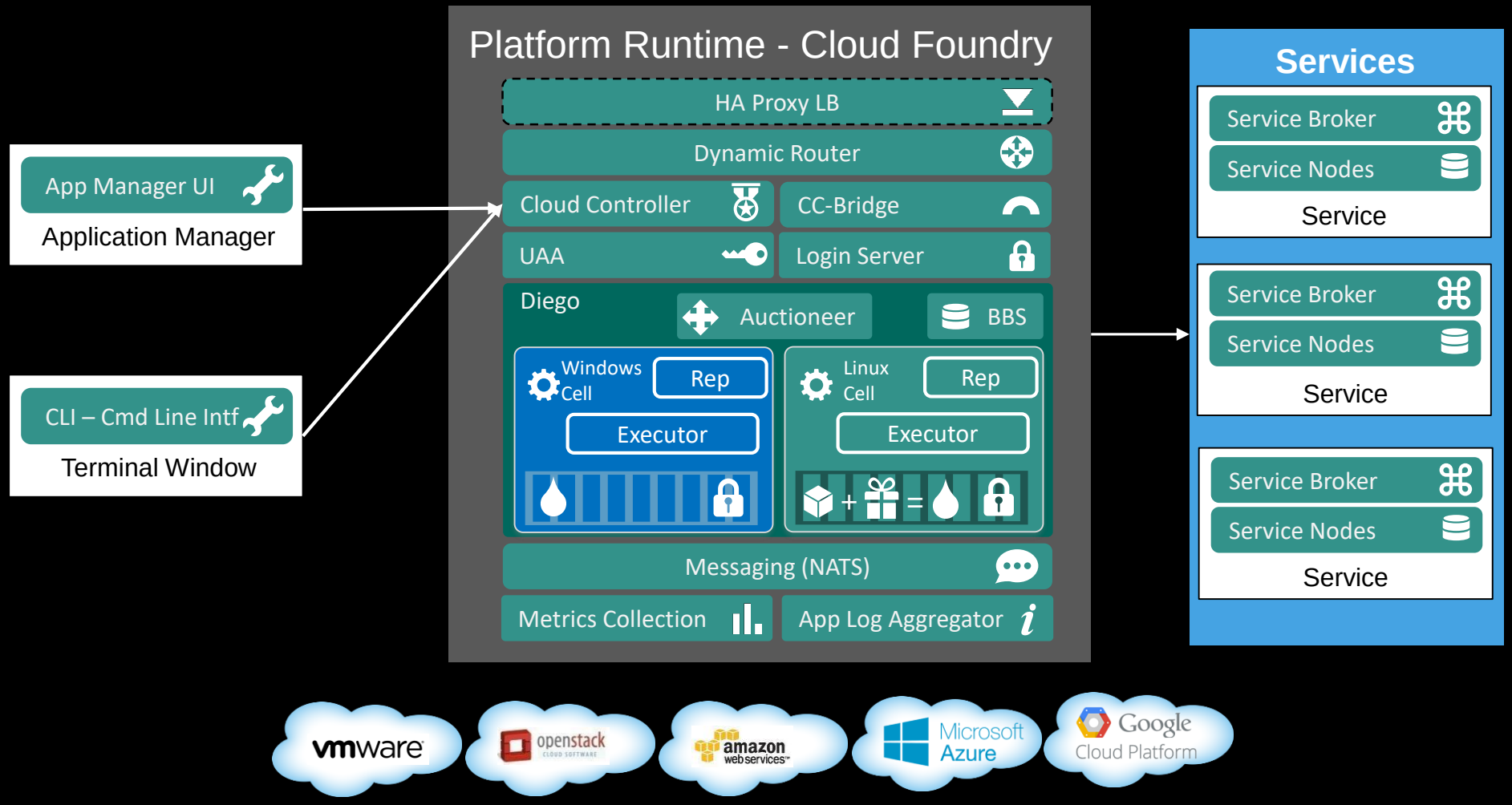
Platform Runtime

Cloud Foundry

Everything Needed to Deploy and Operate Cloud Native Applications



Cloud Foundry Architecture



Twelve Factor Applications – Platform Contract

Architectural and development best practices – http://12factor.net

I. Codebase One codebase tracked in SCM, many deploys	**II. Dependencies** Explicitly declare and isolate dependencies	**III. Configuration** Store config in the environment
IV. Backing Services Treat backing services as attached resources	**V. Build, Release, Run** Strictly separate build and run stages	**VI. Processes** Execute app as stateless processes
VII. Port binding Export services via port binding	**VIII. Concurrency** Scale out via the process model	**IX. Disposability** Maximize robustness with fast startup and graceful shutdown
X. Dev/prod parity Keep dev, staging, prod as similar as possible	**XI. Logs** Treat logs as event streams	**XII. Admin processes** Run admin / mgmt tasks as one-off processes

Application Frameworks


Spring Boot


Spring Cloud Dataflow


Spring Cloud Services


Steeltoe

.NET Core

.NET

Facilitates Twelve-Factor Contract

Spring Cloud Services

Powered by Netflix OSS

- Spring Cloud Services
  - Which is built on Spring Boot simplifies distributed, microservice-style architecture by implementing proven patterns to bring resilience, reliability, and coordination to your microservices.
  - When used with PCF customers have a turnkey, secure solution for production operations of this coordination infrastructure—service registry, config server, and circuit breaker dashboard.
  - Steeltoe enables Spring Cloud Services on .NET

Enabling Cloud Native Applications

Service Registry

A dynamic directory that enables client side load balancing and smart routing

Cloud Bus

Application bus to broadcast state changes, leadership election

Circuit Breaker

Microservice fault tolerance with a monitoring dashboard

OAuth2 Patterns

Support for single sign on, token relay and token exchange

Configuration Server

Dynamic, versioned propagation of configuration across lifecycle states without the need to restart your application

Lightweight API Gateway

Single entry point for API consumers (browsers, devices, other APIs)

Spring Cloud Services

Turnkey microservice operations and security on Pivotal Cloud Foundry

Facilitates Twelve-Factor Contract on .NET

Steeltoe
http://steeltoe.io

NETFLIX OSS

Enabling Cloud Native Applications on .NET

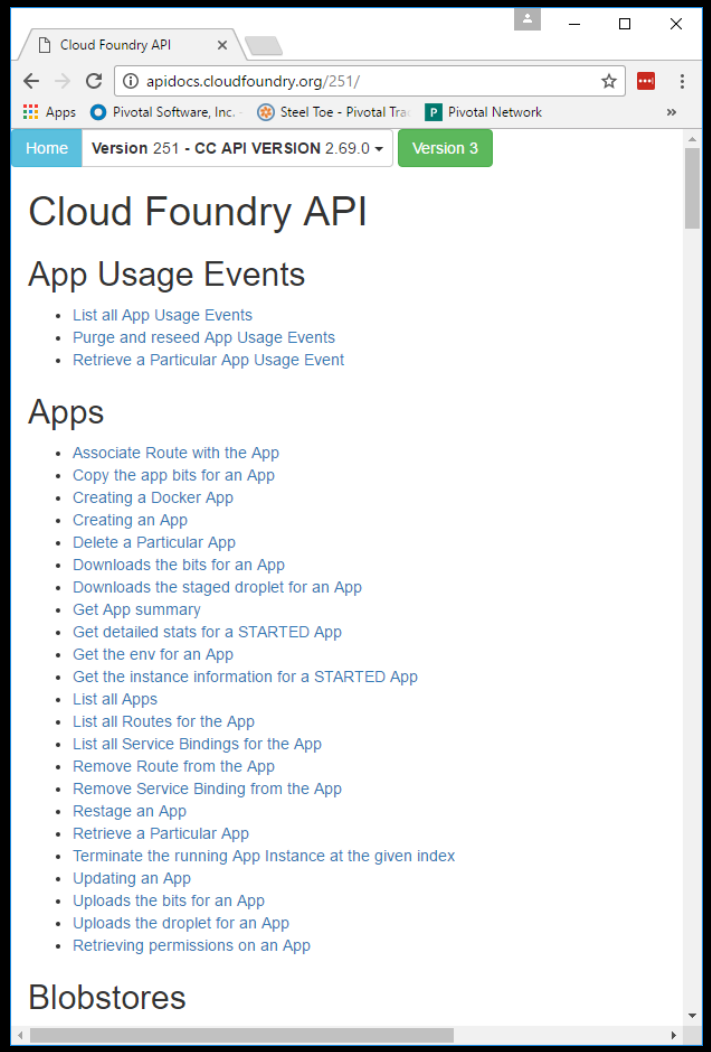
- Simplifies using .NET & ASP.NET on Cloud Foundry
  - Connectors (e.g. MySql, Redis, Postgres, RabbitMQ, OAuth, etc.)
  - Security providers (e.g. OAuth SSO, JWT, Redis KeyRing Storage, etc.)
  - Configuration providers (e.g. Cloud Foundry)
- Simplifies using Spring Cloud Services
  - Configuration server provider (e.g. Config Server, etc.)
  - Service Discovery (e.g. Eureka, etc.)
  - Circuit Breaker (e.g. Hystrix coming)
  - Distributed Tracing (e.g. Slueth coming)

Cloud Foundry Fundamentals

ORGS, SPACES, USERS, ROLES, CLI, API, APPS MANAGER

Cloud Controller API

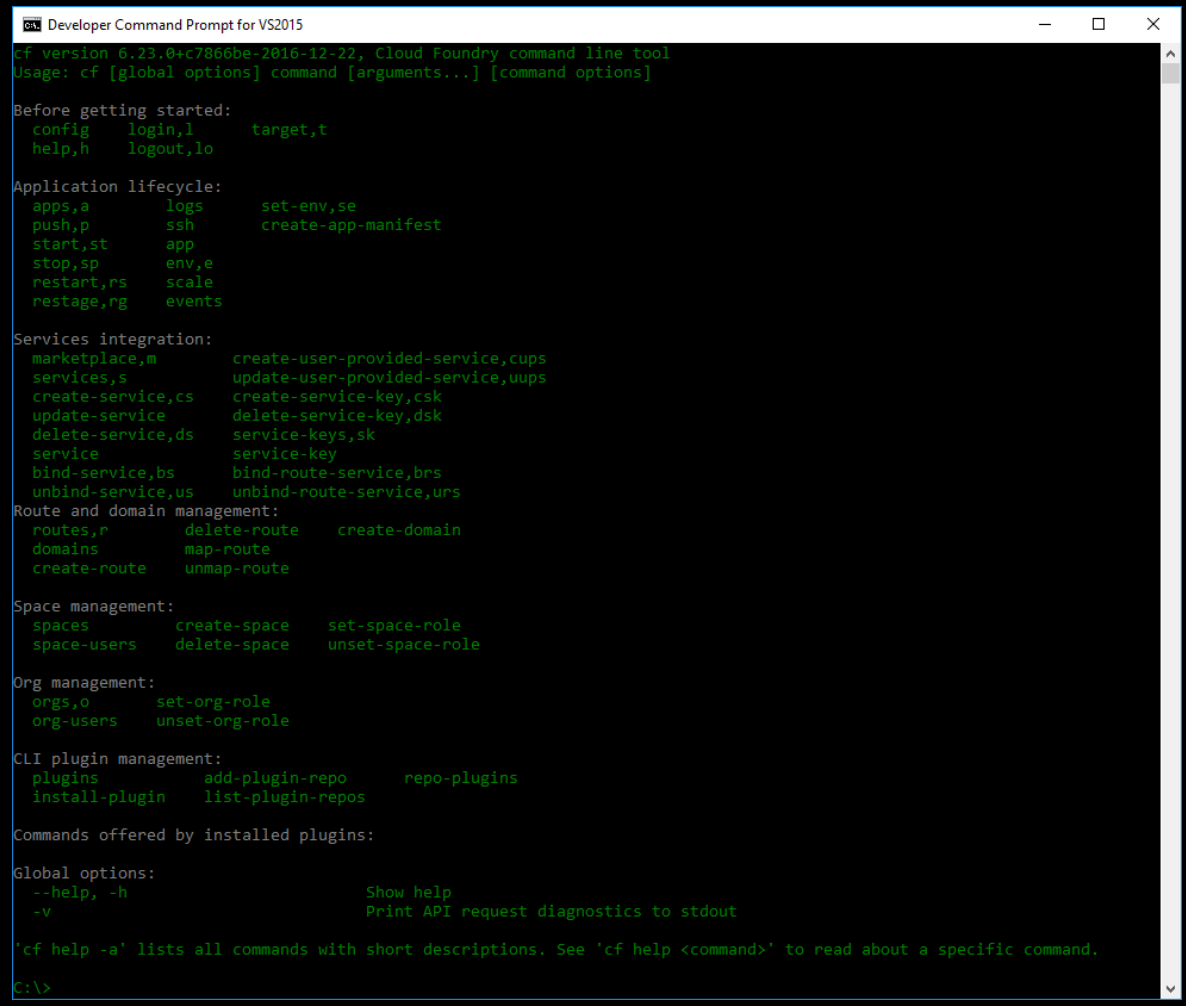
- Cloud Controller (CC) component of Elastic Runtime manages all Cloud Foundry APIs
- CF CLI and other clients like Apps Manager directly call this API
- Before accessing the CC API, you must get an access token from the User Account and Authentication (UAA) server
- http://apidocs.cloudfoundry.org



CLI – Command Line Interface

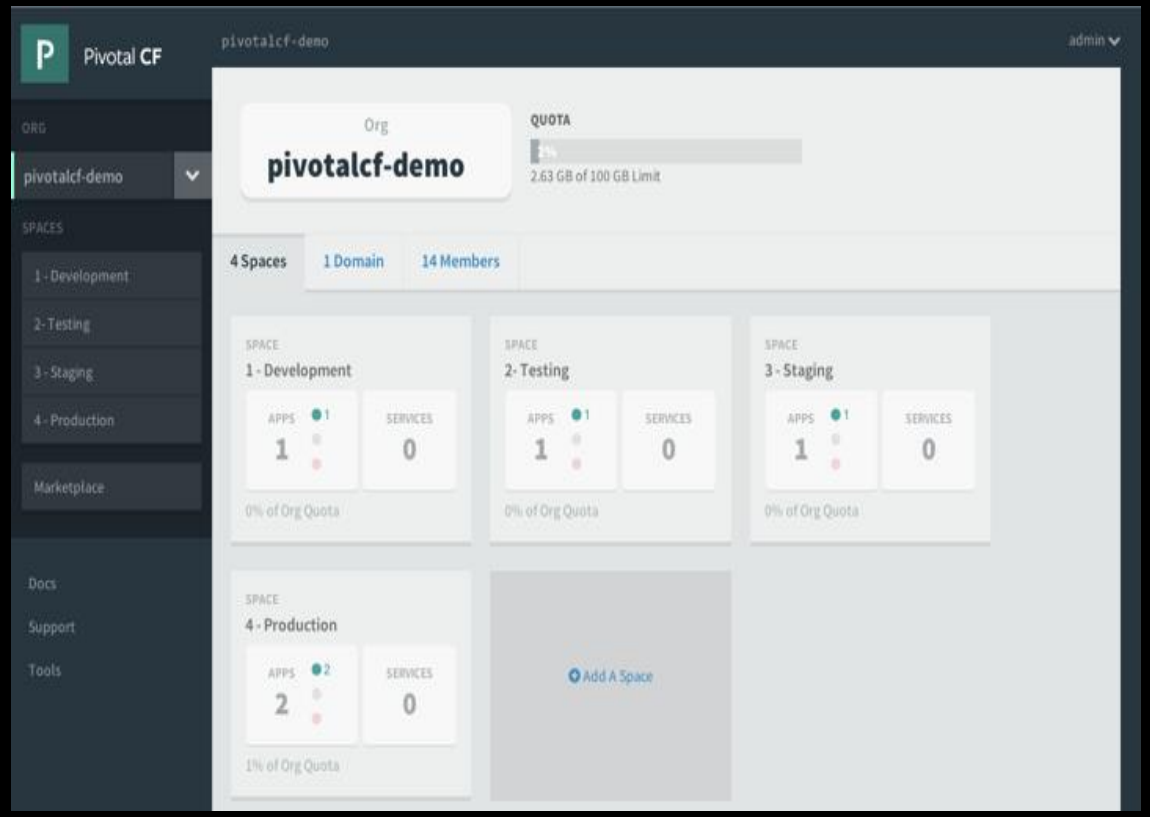
- Command line utility providing easy access to the Cloud Controller API.
- Scriptable
- Fully documented

```
cf help -a

cf help <command>

cf api http://foo.bar.com/

cf login <username>
```

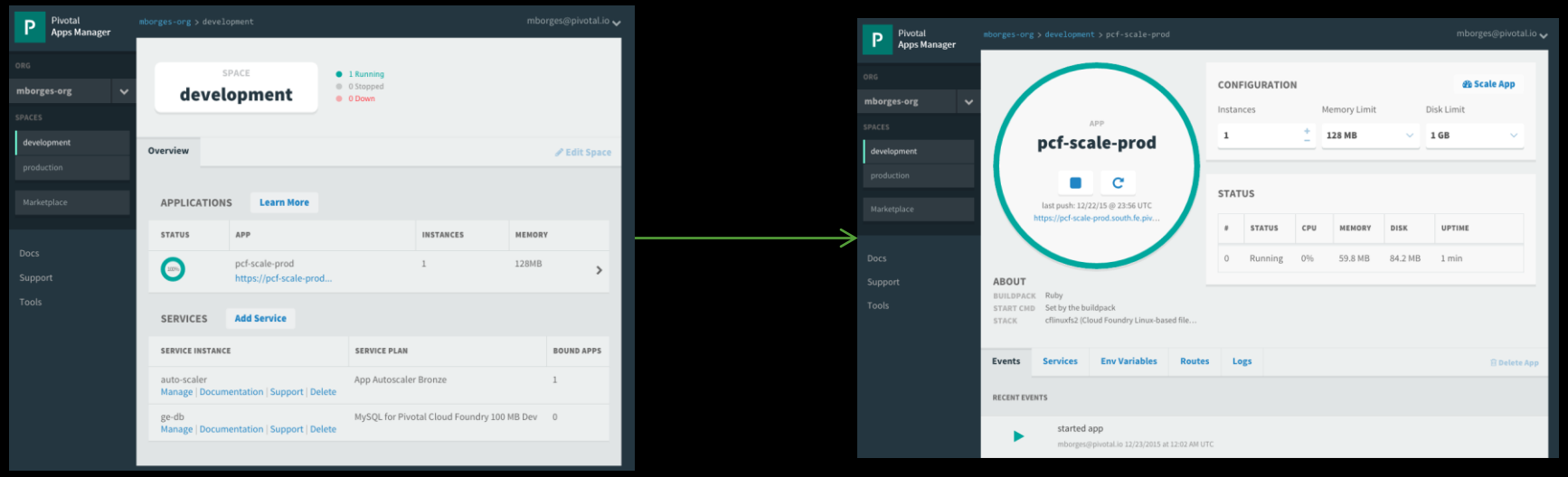


Pivotal Apps Manager

- Manage Organizations, users, applications and Spaces
- Monitor applications logs, services and routes
- Access Service Marketplace, create services and bind to applications

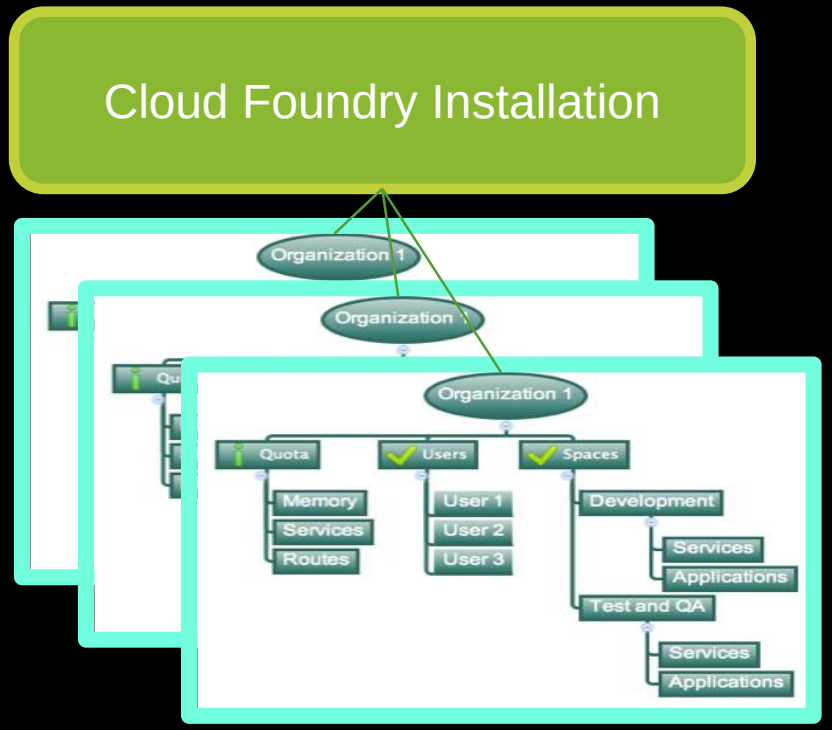


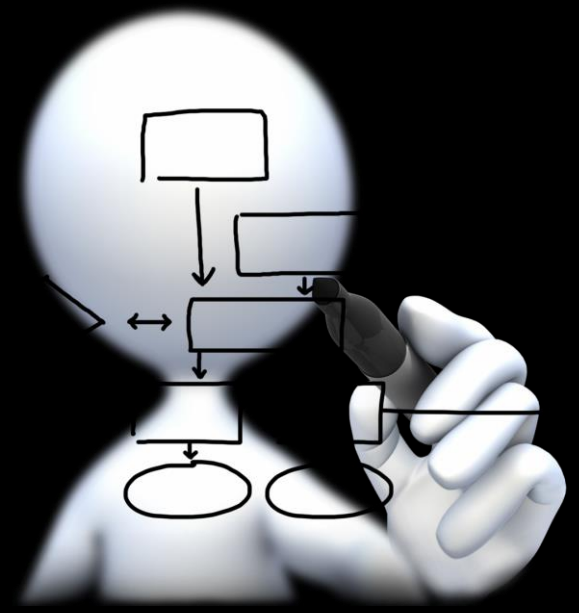
Pivotal Apps Manager – App View



- Drill into a space to see all application and services instances
- Then drill into an application to see configuration, status, event, logging, routes, environment variables and service instances bound to the application

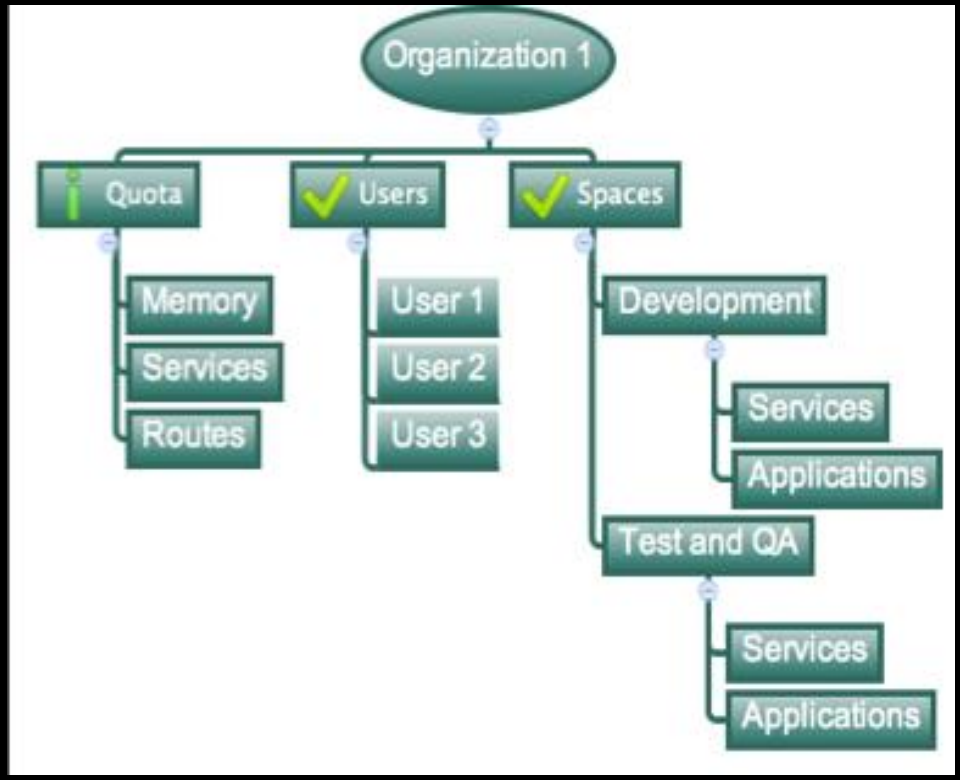
Orgs, Spaces, Users and Quotas





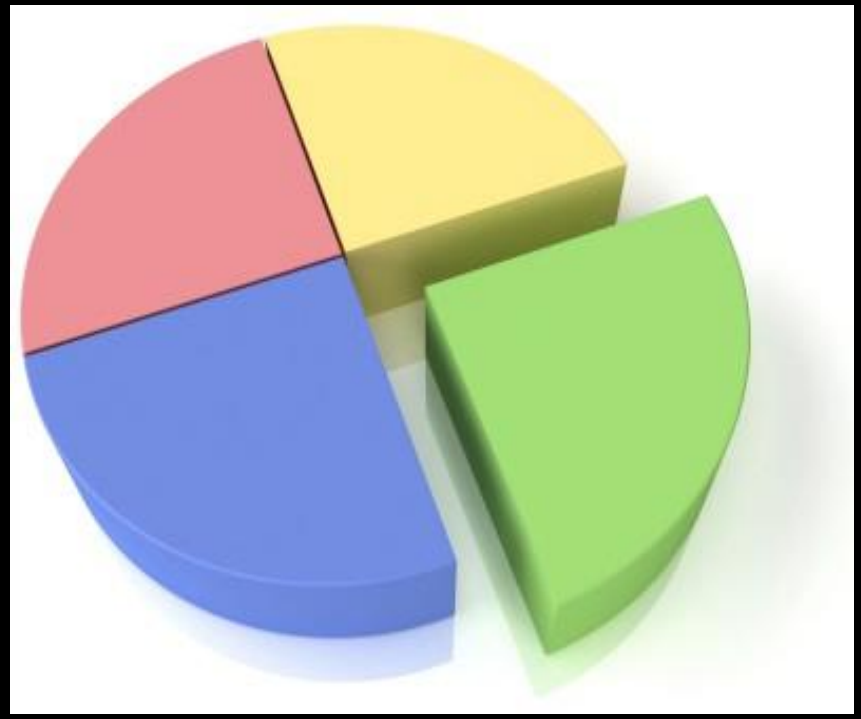
Organizations

- Top-most administrative unit
- Logical division within a Pivotal Cloud Foundry Install / Foundation
  - Typically a company, department, application suite or large project
- Each organization has its own users and assigned quota
- User permissions / Roles are specified per space within an organization
- Sub-divided into spaces



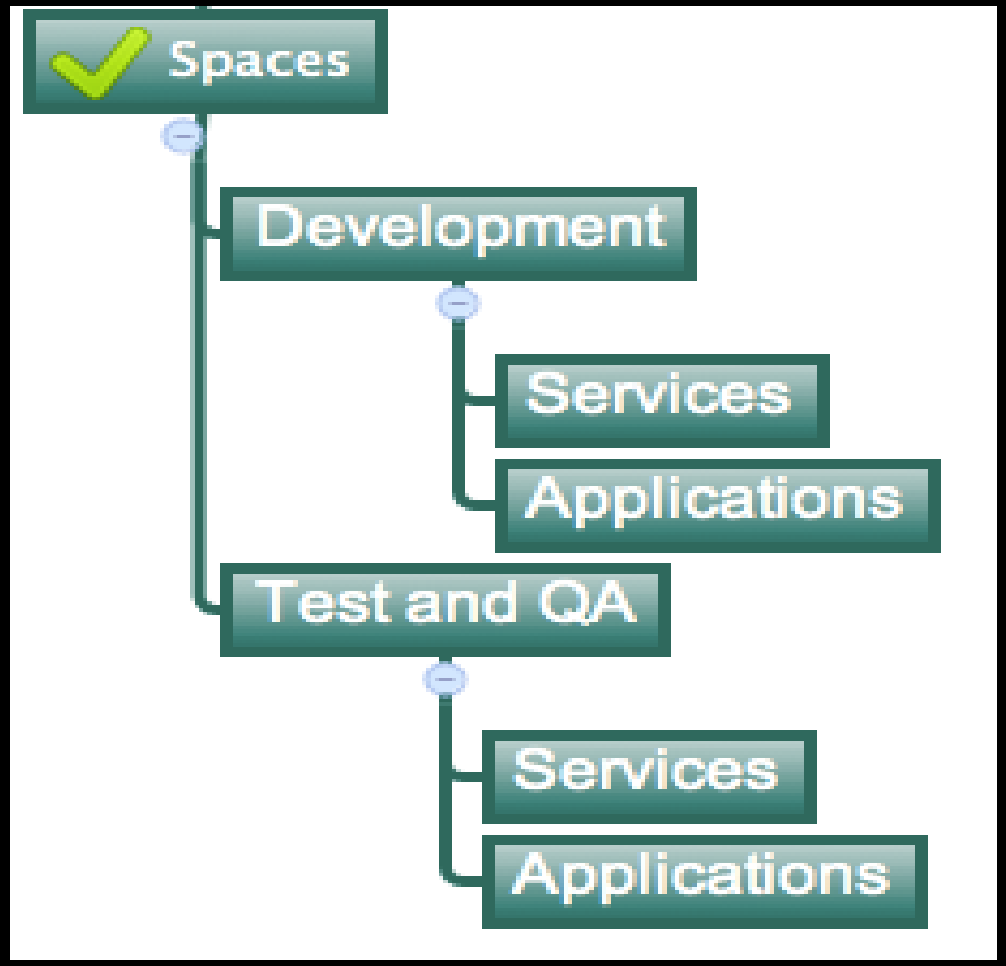
Quotas

- Different quota limits (e.g. small, enterprise, default, runaway) can be assigned per Organization
- Quotas define
  - Total Memory
  - Total # of services
  - Total # of Routes
- Sub-divided into spaces



Spaces

- Logical sub-division within an organization
- Users authorized at an organization level can have different roles per space
- Services and Applications are created / target per Space
- Same service name can have different meaning per space



Users and Roles

- Users are members of an organization
  - Usually they are operators or developers (not application end users)
  - Users are sent an email invite and asked to create an account
- Users have specific organization and space roles
  - Organization roles grant permissions in an organization
  - Space roles grant permissions in a particular space
  - A combination defines the user's overall permissions

Lab0 – Logging into Cloud Foundry (CF)

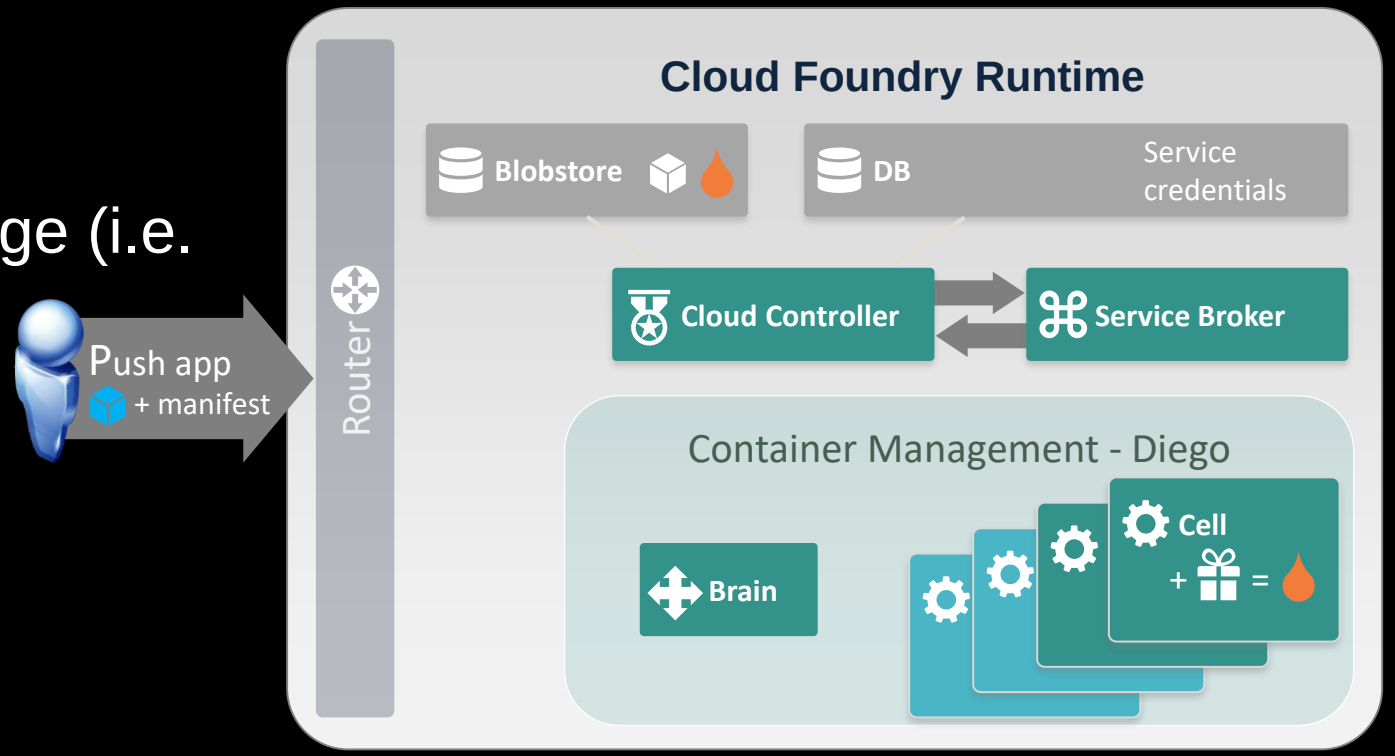
- In this lab we are ensuring we all have access to the Workshop environment
  - Ensuring we have the CLI installed
  - Verifying connectivity & credentials
  - Using the CLI to access CF
  - Accessing CF via the Apps Manager

Running Applications on Cloud Foundry

CF PUSH, MANIFEST, STAGING, BUILD PACKS, CONTAINERS, CELLS, ENVIRONMENT VARIABLES, VCAP_APPLICATION

Pushing an Application

1. Upload app bits and metadata
2. Bind services
3. Stage application
4. Save staged application image (i.e. droplet)
5. Deploy image to container
6. Manage applications health




```
cf push appname -p <path to bits>
cf push appname -f <manifest> -p <pathtobits>
```

Manifest Files

- Application manifests tells `cf push` what to do with applications
- What OS stack to run on: Windows or Linux
- How many instances to create and how much memory to use.
- Helps automate deployment, specially of multiple apps at once
- Can list services to be bound to the application
- YAML format – http://yaml.org

```yaml
---
# all applications use these settings and services
domain: shared-domain.com
memory: 1G
instances: 1
services:
- clockwork-mysql
applications:
- name: springtock
  host: tock09876
  path: ./spring-music/build/libs/spring-music.war
- name: springtick
  host: tick09875
  path: ./spring-music/build/libs/spring-music.war
```

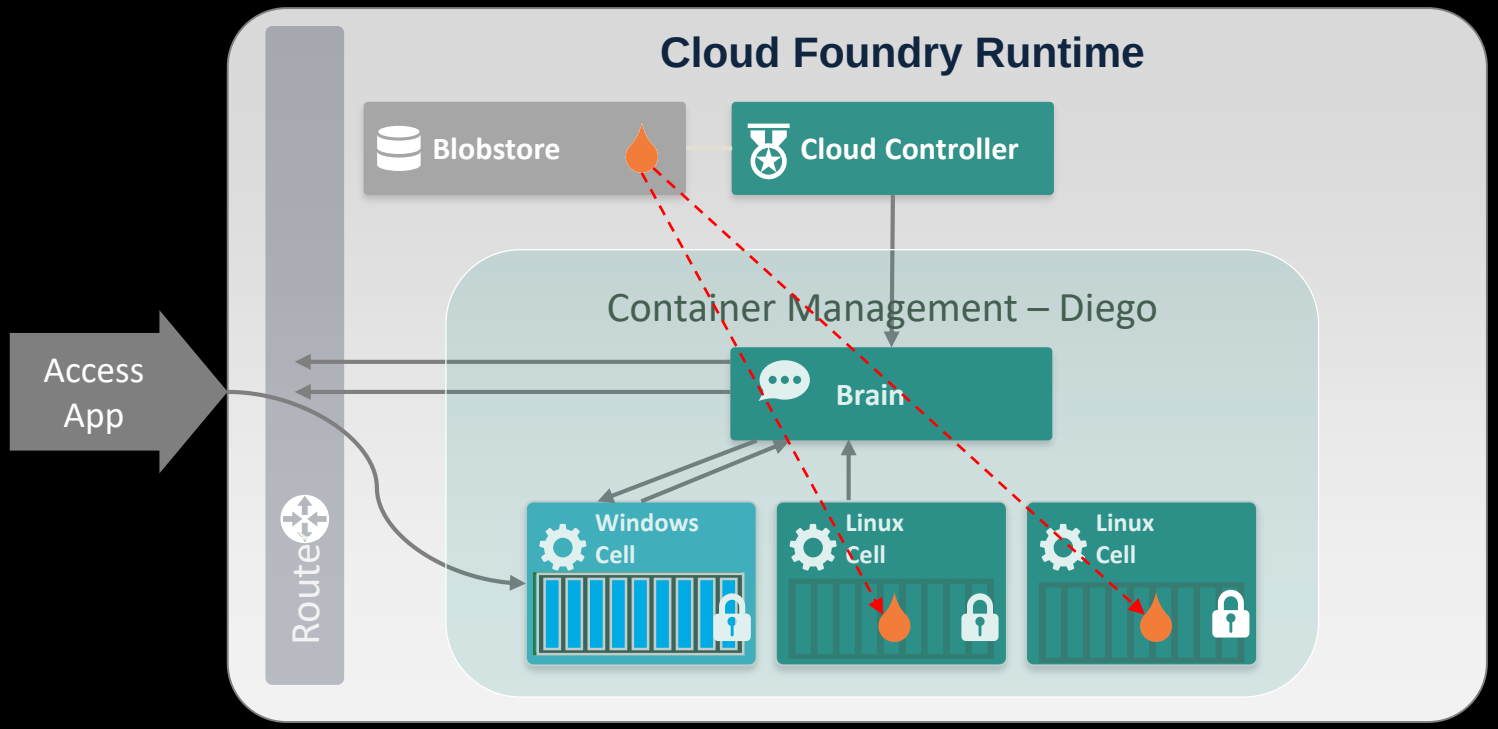
Staging an Application – Appling Buildpacks

- Buildpacks build container images
- Buildpacks take care of
  - Detecting which type of application is being pushed
  - Installing the appropriate run-time
  - Installing required dependencies or other artifacts
  - Creating the command used to start the application
- Lots of Buildpacks
  - Staticfile
  - Java
  - Ruby
  - Nodejs
  - Go
  - Python
  - PHP
  - .NET Core
  - Binary

Why Buildpacks

- Control what frameworks/runtimes are used on the platform
- Provides consistent deployments across environments
  - Stops deployments from piling up at operation’s doorstep
  - Enables a self-service platform
- Eases ongoing operations burdens:
  - Security vulnerability is identified
  - Subsequently fixed with a new buildpack release
  - Restage applications

Deploying Image to Container

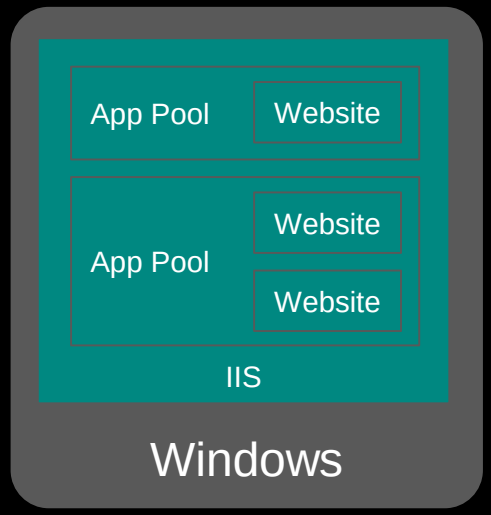


Why Containers

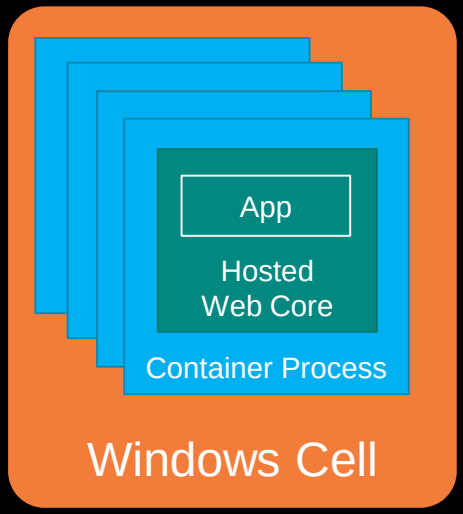
- Containers are OS level virtualization (i.e. process isolation)
- They are small and allow for much higher packing density
- They are easy to move around and to replicate
- They do not have any redundant or unnecessary operating system elements; they don't need the care and feeding of a large OS stack.
- They are lightweight and have fast startup times,
- Well suited for building hyper-scale, highly resilient infrastructure
- Typical container image is 10s of MB
- Containers start in msecs

Windows Cells on Cloud Foundry

Traditional Windows Architecture

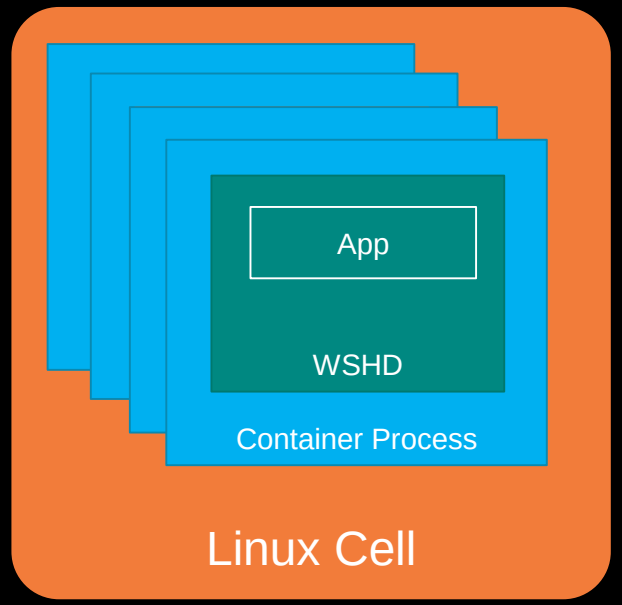


Cloud Foundry Architecture



Linux Cells on Cloud Foundry

Cloud Foundry Architecture



Container Environment Variables

- Used to communicate apps environment/config to deployed container
  - `VCAP_APPLICATION`
    - Application attributes – version, instance index, limits, URLs, etc.
  - `VCAP_SERVICES`
    - Bound services – name, label, credentials, etc.
  - `CF_INSTANCE_*`
    - `CF_INSTANCE_ADDR`, `CF_INSTANCE_INDEX`, etc.

VCAP_APPLICATION


```
"VCAP_APPLICATION": {
   "application_id": "95bb5b8e-3d35-4753-86ee-2d9d505aec7c",
   "application_name": "fortuneService",
   "application_uris": [
      "fortuneservice-glottologic-neigh.apps.testcloud.com"
   ],
   "application_version": "40933f4c-75c5-4c61-b369-018febb0a347",
   "cf_api": "https://api.system.testcloud.com",
   "limits": {
     "disk": 1024,
     "fds": 16384,
     "mem": 512
    },
   "name": "fortuneService",
   "space_id": "86111584-e059-4eb0-b2e6-c89aa260453c",
   "space_name": "test",
   "uris": [
    "fortuneservice-glottologic-neigh.apps.testcloud.com"
   ],
   "users": null,
   "version": "40933f4c-75c5-4c61-b369-018febb0a347"
 }
```

Lab1 – Pushing .NET Application to Cloud Foundry

- Push pre-built ASP.NET 4.x MVC application to Cloud Foundry
  - Makes use of Steeltoe Cloud Foundry Configuration provider
  - Steeltoe Configuration provider is used to parse `VCAP_APPLICATION` and add it to applications configuration information
    - Look at this in more detail in upcoming labs
  - Illustrates using Steeltoe components in ASP.NET 4.x applications
    - Several samples like this on github: https://github.com/SteeltoeOSS/Samples

Using Services on Cloud Foundry

MANAGED, USER-PROVIDED, SERVICE BROKERS, INSTANCE CREATION, APPLICATION BINDING, ENVIRONMENT VARIABLES, VCAP_APPLICATION

What is a Service?

- Allows resources to be easily provisioned on-demand
- Typically an external “component” necessary for applications
  - Database, cache, message queue, microservice, etc.
- Can be a persistent, stateful layer

Types of Services

- Managed - Fully integrated, with fully lifecycle management
- User-Provided – Created and managed external to the platform

Managed Services

- **I**ntegrated with Cloud Foundry
  - Implements a required API for which the cloud controller is the client
- **Service Broker** implements the required API
  - Advertise a catalog of service offerings and service plans
  - Handle calls from the Cloud Controller
  - Fetch catalog
  - Create service instances
  - Bind applications to service instances
  - Unbind applications from service instances
  - Delete service instances

User Provided Services

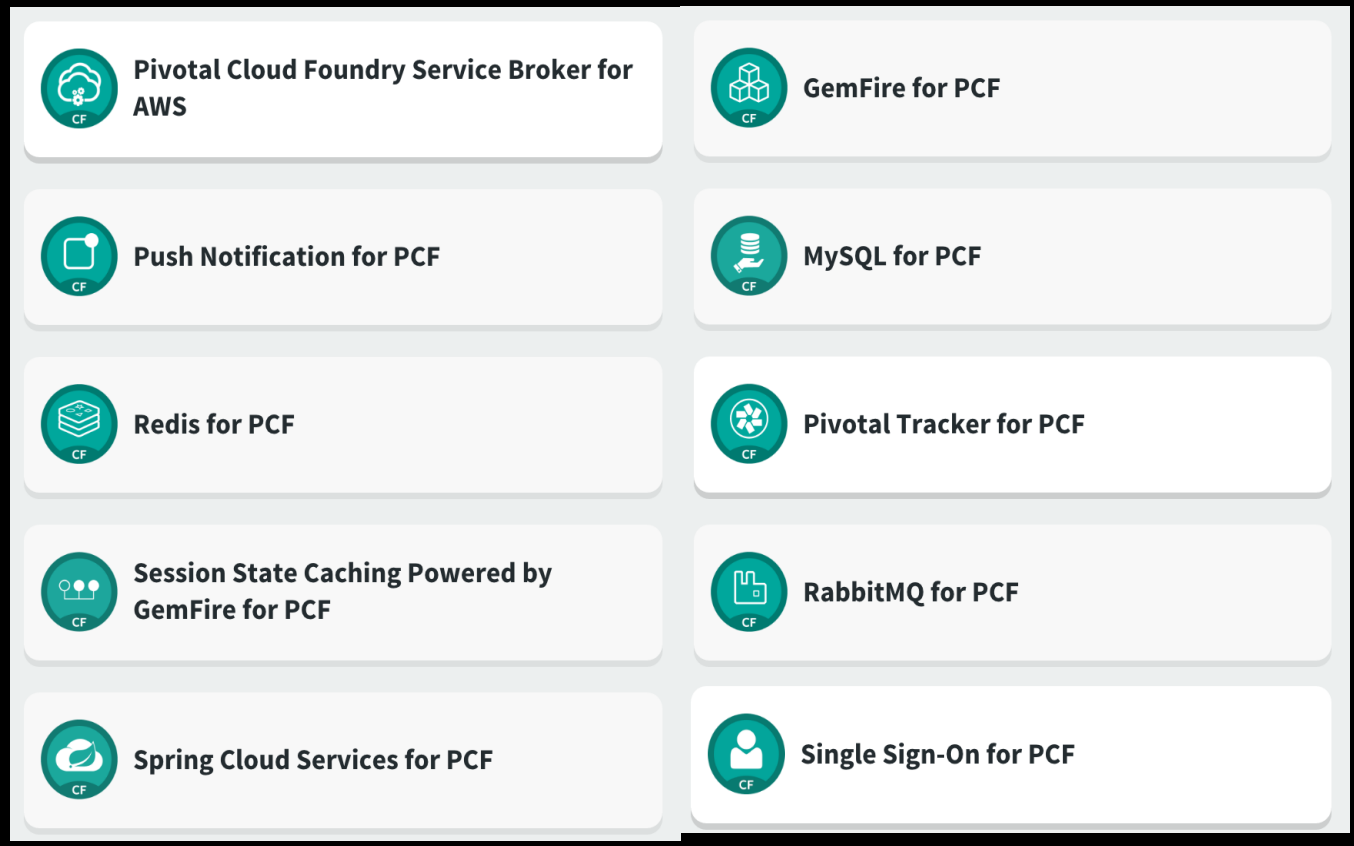
- Service instances managed outside of Cloud Foundry
- Behave like other service instances once created
- Familiar CLI commands (‘create-service’) provide service instance configuration

EXAMPLE: AN ORACLE DATABASE MANAGED OUTSIDE OF, AND UNKNOWN TO CLOUD FOUNDRY

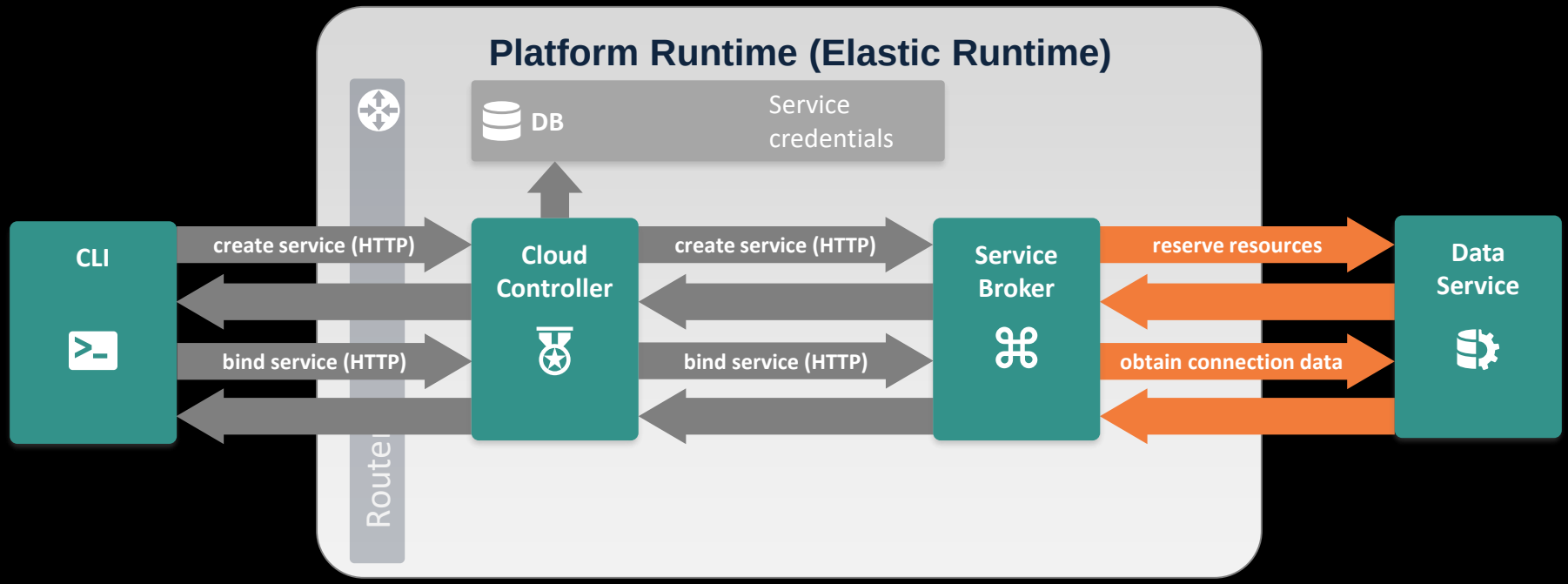
Examples of Managed Services

Pivotal Network

https://network.pivotal.io/



Creating and Binding Services



Container Environment Variables

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  - `VCAP_SERVICES`
    - Bound services – name, label, credentials, etc.
  - `CF_INSTANCE_*`
    - `CF_INSTANCE_ADDR`, `CF_INSTANCE_INDEX`, etc.

VCAP_SERVICES


```
"VCAP_SERVICES": {
  "p-identity": [
    {
      "credentials": {
        "client_id": "e3ca311d-999b-4e4f-b056-b50138cfff9f",
        "client_secret": "a995365e-d7b7-4727-95b8-463df2842f64",
        "auth_domain": "https://sso1.login.run.haas-76.pez.pivotal.io"
      },
      "syslog_drain_url": null,
      "label": "p-identity",
      "provider": null,
      "plan": "sso1",
      "name": "sso",
      "tags": []
    }
  ]
}
```

Lab2 – Creating and Binding Services

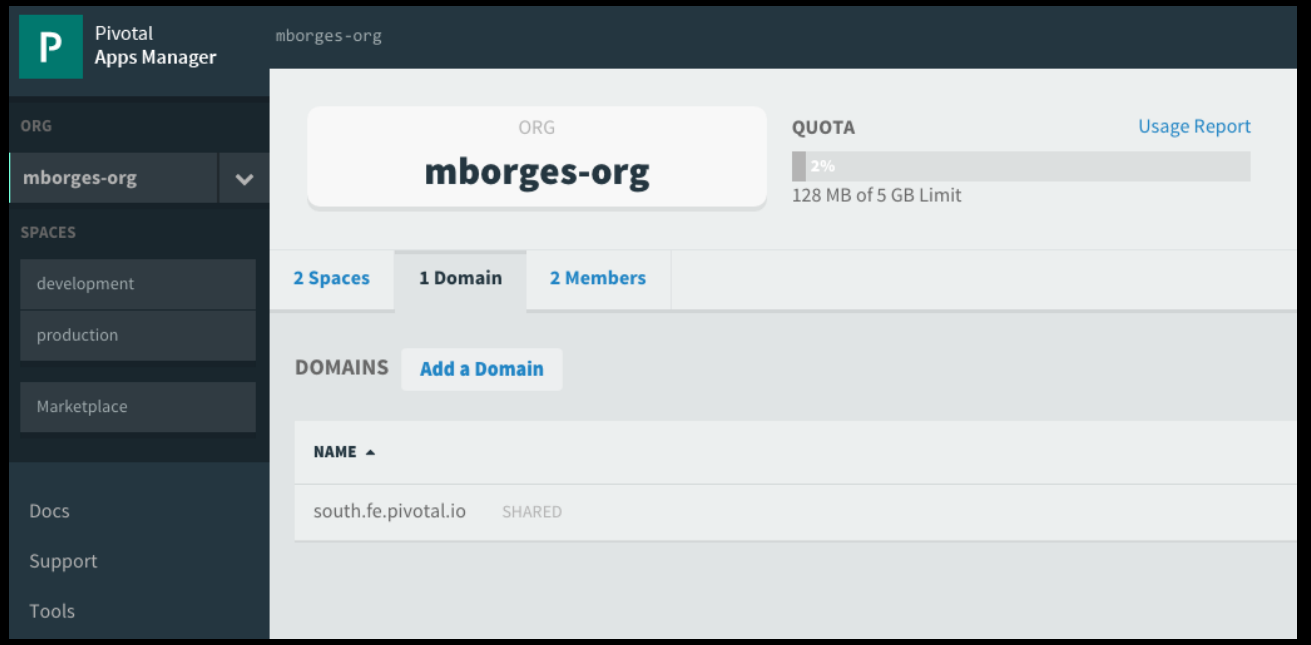
- Use same pre-built ASP.NET 4.x MVC application
  - Illustrates how Steeltoe Configuration provider can be used to parse `VCAP_SERVICES` and add it to applications configuration information
    - Look at how Steeltoe Connectors make use of this provider in future labs

Configuring Application Routes and Instances on Cloud Foundry

DOMAINS, DNS, ROUTES, SCALING VIA CLI, SCALING VIA APP MANAGER

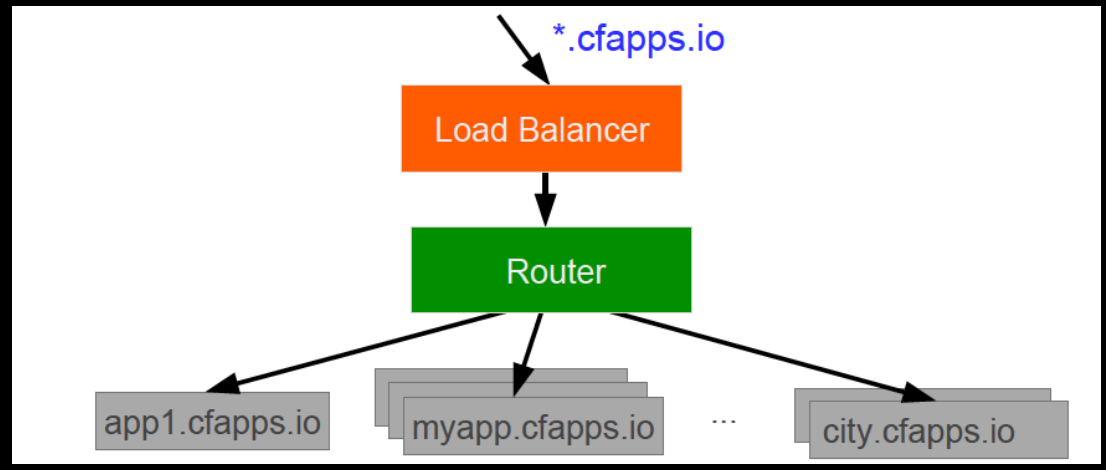
Domains

- Each Cloud Foundry installation has a default app domain
- Domains provide a namespace from which to create routes
- Requests for any routes created from the domain will be routed to Cloud Foundry.
- Domains can be shared or private in regards to PCF organizations



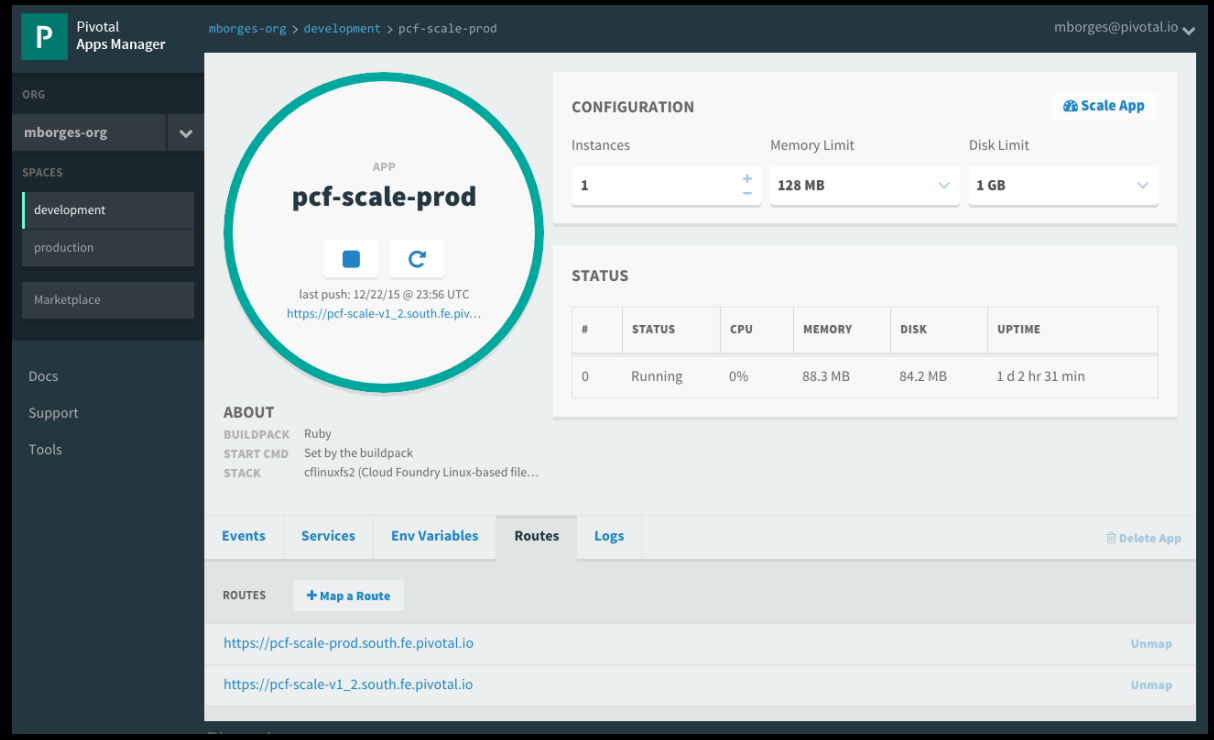
Domains – Behind the Scenes

- A wildcard entry (*) is added to the DNS for the app domain
- That DNS entry points to a load balancer (or Cloud Foundry's HA Proxy), which points to the Cloud Foundry Router
- The Router uses the subdomain to map to application instance(s)

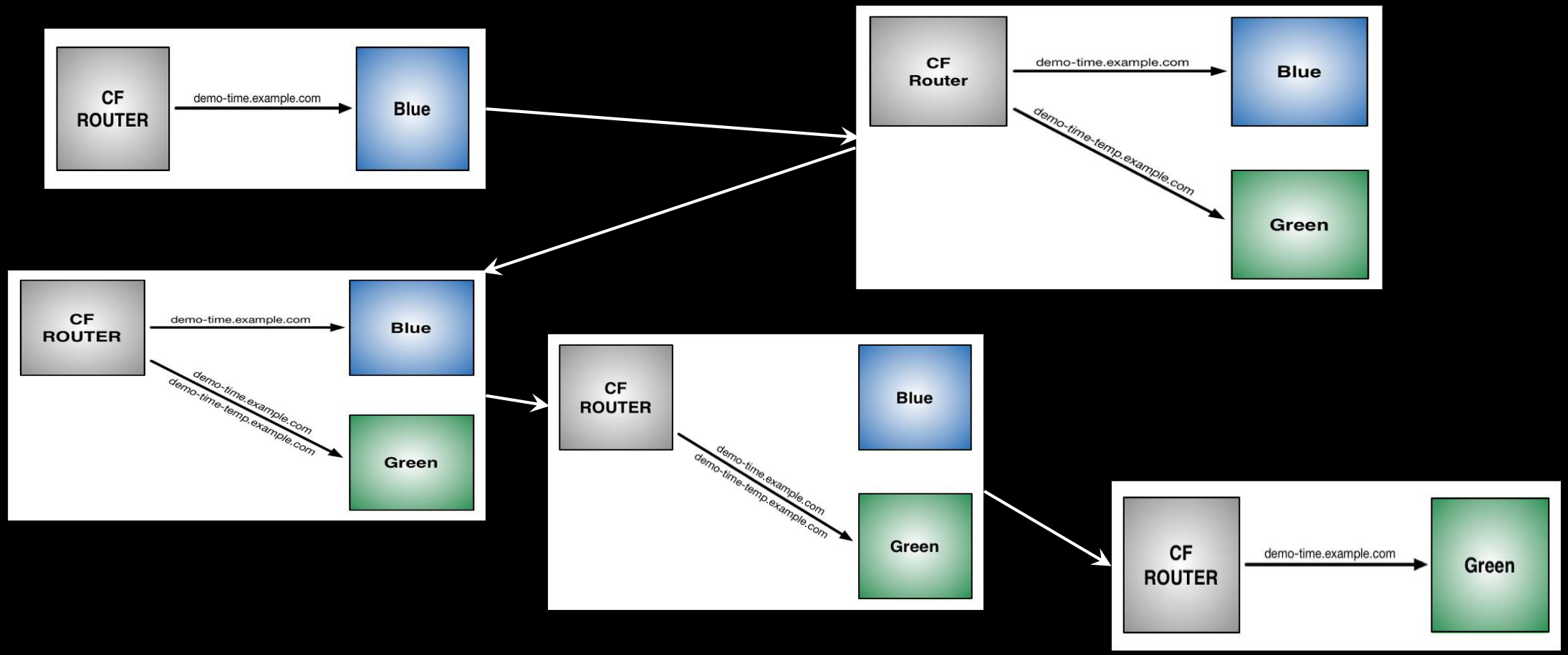


Routes

- HTTP requests are routed to apps pushed by associating a URL with an application, know as route
- Many app instances can be mapped to a single route resulting in load balanced requests
- Routes belong to a space
- Application can have multiple routes



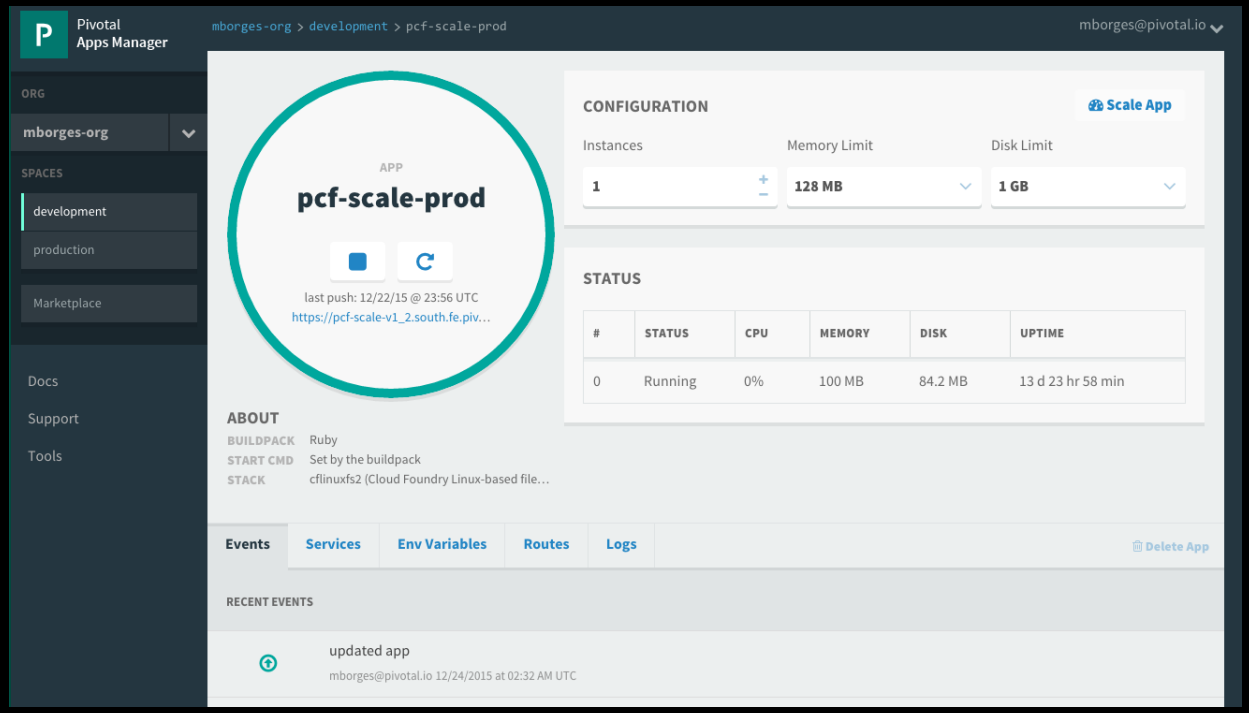
Blue-Green Deployments



https://docs.pivotal.io/pivotalcf/1-8/devguide/deploy-apps/blue-green.html

Scaling

- Can be done via CLI
  - At deployment time (via manifest.yml or as a modifier to cf push)
  - During run time without interrupting operations (via cf scale --instances 10)
- Can also be done via Apps Manager
- Container image started on other available cells



Lab3 – Creating Routes and Scaling

- Use same pre-built ASP.NET 4.x MVC application

Monitoring Applications on Cloud Foundry

LOGGING, TAILING LOGS, HEALTH, EVENTS, CLI

Logs

- Cloud Foundry aggregates an applications logs
  - Application logs should be written to STDOUT /STDERR
- Use the CLI to view an applications logs
  - `` `cf logs APP_NAME` `` – allows you to tail and applications logs
  - `` `cf logs APP_NAME –recent` `` – allows you to view recent logs

```
[-> cf logs pcf-scale-prod --recent
Connected, dumping recent logs for app pcf-scale-prod in org mborges-org / space development as mborges@pivotal.io...

2015-12-23T20:32:08.97-0600 [API/0]      OUT Updated app with guid b02f5b0c-1e9b-495f-80c8-540f4239795e ({"route"=>"4d5d20e4-e1c3-4cda-ae82-150ed3564d23"})
2015-12-23T20:41:02.81-0600 [RTR/0]      OUT pcf-scale-v1_2.south.fe.pivotal.io - [24/12/2015:02:41:02 +0000] "GET / HTTP/1.1" 200 5355 "https://apps.south.fe.pivot
al.io/organizations/691dc08d-91bd-4bf8-80cf-1e28f158c00a/spaces/de43df54-ad24-4dcb-beee-60ba842e7f46/applications/b02f5b0c-1e9b-495f-80c8-540f4239795e" "Mozilla/5.0
 (Macintosh; Intel Mac OS X 10_11_2) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/47.0.2526.80 Safari/537.36" 192.168.5.10:41871 x_forwarded_for:"192.168.5.1" vcap
_request_id:ba548a80-dc76-4cdb-59bc-4b072e9dcecb response_time:0.100964736 app_id:b02f5b0c-1e9b-495f-80c8-540f4239795e
2015-12-23T20:41:02.81-0600 [App/0]      ERR 192.168.5.1, 192.168.5.10 - - [24/Dec/2015 02:41:02] "GET / HTTP/1.1" 200 5355 0.0465
2015-12-23T20:41:02.91-0600 [App/0]      ERR 192.168.5.1, 192.168.5.10 - - [24/Dec/2015 02:41:02] "GET /css/bootstrap.min.css HTTP/1.1" 200 103314 0.0207
2015-12-23T20:41:02.91-0600 [RTR/0]      OUT pcf-scale-v1_2.south.fe.pivotal.io - [24/12/2015:02:41:02 +0000] "GET /css/bootstrap.min.css HTTP/1.1" 200 103314 "http
s://pcf-scale-v1_2.south.fe.pivotal.io/" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_2) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/47.0.2526.80 Safari/537.36"
192.168.5.10:41872 x_forwarded_for:"192.168.5.1" vcap_request_id:65a07c84-2fd7-4bbc-4628-928a7b1839f3 response_time:0.031567972 app_id:b02f5b0c-1e9b-495f-80c8-540f4
239795e
2015-12-23T20:41:02.96-0600 [App/0]      ERR 192.168.5.1, 192.168.5.10 - - [24/Dec/2015 02:41:02] "GET /js/bootstrap.min.js HTTP/1.1" 200 31596 0.0139
2015-12-23T20:41:02.96-0600 [RTR/0]      OUT pcf-scale-v1_2.south.fe.pivotal.io - [24/12/2015:02:41:02 +0000] "GET /js/bootstrap.min.js HTTP/1.1" 200 31596 "https:/
/pcf-scale-v1_2.south.fe.pivotal.io/" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_2) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/47.0.2526.80 Safari/537.36" 192
.168.5.10:41874 x_forwarded_for:"192.168.5.1" vcap_request_id:129e0f87-4b70-45b1-54cb-300c197485f5 response_time:0.027457693 app_id:b02f5b0c-1e9b-495f-80c8-540f4239
795e
```

Health

- Cloud Foundry proactively monitors health of application containers
  - Restarts them if they fail
- Use the CLI to view an applications health & status
  - `` `cf app APP_NAME` `` – allows you view health status of an application

```
-> cf app pcf-scale-prod
Showing health and status for app pcf-scale-prod in org ■borges-org / space development as ■borges@pivotal.io...
OK

requested state: started
instances: 1/1
usage: 128M x 1 instances
urls: pcf-scale-prod.south.fe.pivotal.io, pcf-scale-v1_2.south.fe.pivotal.io
last uploaded: Tue Dec 22 23:56:50 UTC 2015
stack: cflinuxfs2
buildpack: Ruby

     state     since                  cpu    memory          disk          details
#0   running   2015-12-22 06:02:59 PM   0.1%   88.3M of 128M   84.2M of 1G
```

Application Events

- Cloud Foundry records all changes to an application as events
  - Container state changes
  - Configuration changes
- Use the CLI to view an applications events
  - `` `cf events APP_NAME` `` – allows you view recent events of an application

```
[-> cf events pcf-scale-prod
Getting events for app pcf-scale-prod in org mborges-org / space development as mborges@pivotal.io...

time                          event                actor                description
2015-12-23T20:32:08.00-0600   audit.app.update     mborges@pivotal.io
2015-12-23T20:32:08.00-0600   audit.app.map-route  mborges@pivotal.io
2015-12-22T18:02:56.00-0600   audit.app.update     mborges@pivotal.io   state: STARTED
2015-12-22T18:02:56.00-0600   audit.app.update     mborges@pivotal.io   state: STOPPED
2015-12-22T17:56:55.00-0600   audit.app.update     mborges@pivotal.io   state: STARTED
2015-12-22T17:56:45.00-0600   audit.app.update     mborges@pivotal.io
2015-12-22T17:56:45.00-0600   audit.app.map-route  mborges@pivotal.io
2015-12-22T17:56:44.00-0600   audit.app.create     mborges@pivotal.io   instances: 1, memory: 128, state: STOPPED, environment_json: PRIVATE DATA HIDDEN
```

Lab4 – Monitoring Applications

- Use same pre-built ASP.NET 4.x MVC application

Cloud Native Application Development

CLOUD NATIVE, TWELVE FACTOR, MICROSERVICES

Cloud Native Applications

Cloud Native is not about **where**, but **how** you build and run your app!

- Microservices Architecture
- Twelve-Factor Methodology
- Containers

- Continuous Delivery
- Shift from Silo IT to DevOps

Twelve Factor Applications – Platform Contract

Architectural and development best practices – http://12factor.net

I. Codebase One codebase tracked in SCM, many deploys	**II. Dependencies** Explicitly declare and isolate dependencies	**III. Configuration** Store config in the environment
IV. Backing Services Treat backing services as attached resources	**V. Build, Release, Run** Strictly separate build and run stages	**VI. Processes** Execute app as stateless processes
VII. Port binding Export services via port binding	**VIII. Concurrency** Scale out via the process model	**IX. Disposability** Maximize robustness with fast startup and graceful shutdown
X. Dev/prod parity Keep dev, staging, prod as similar as possible	**XI. Logs** Treat logs as event streams	**XII. Admin processes** Run admin / mgmt tasks as one-off processes

Microservice Definition

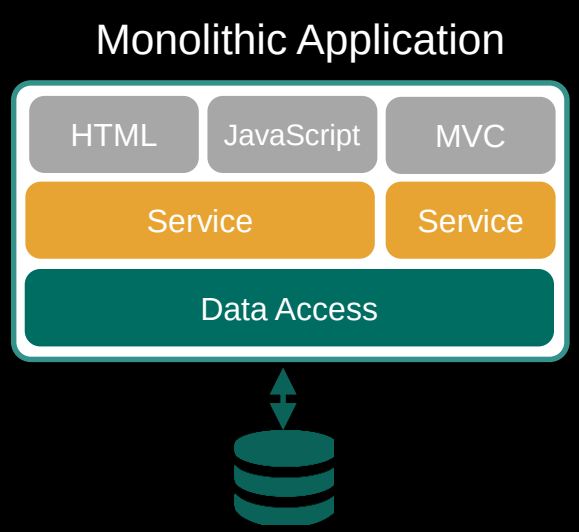
If every service has to be updated in concert,
it's not loosely coupled!

" Loosely coupled service oriented architecture with bounded contexts"

If you have to know about surrounding services you don't have a bounded context.

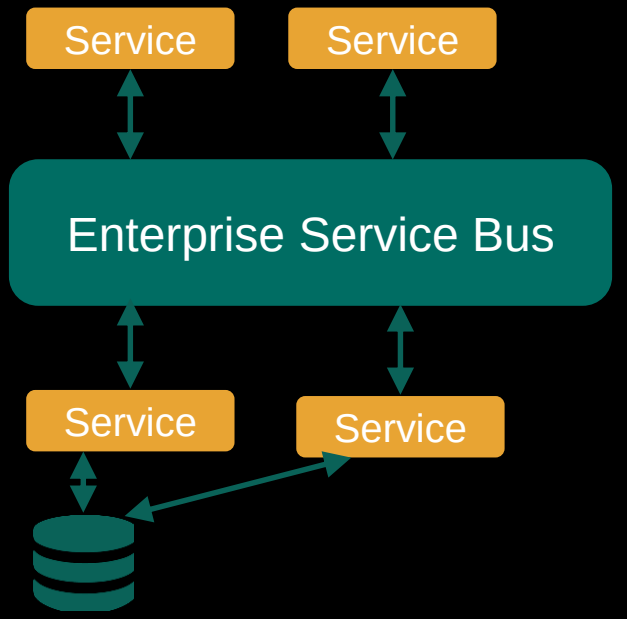
- Adrian Cockcroft

Microservices are NOT



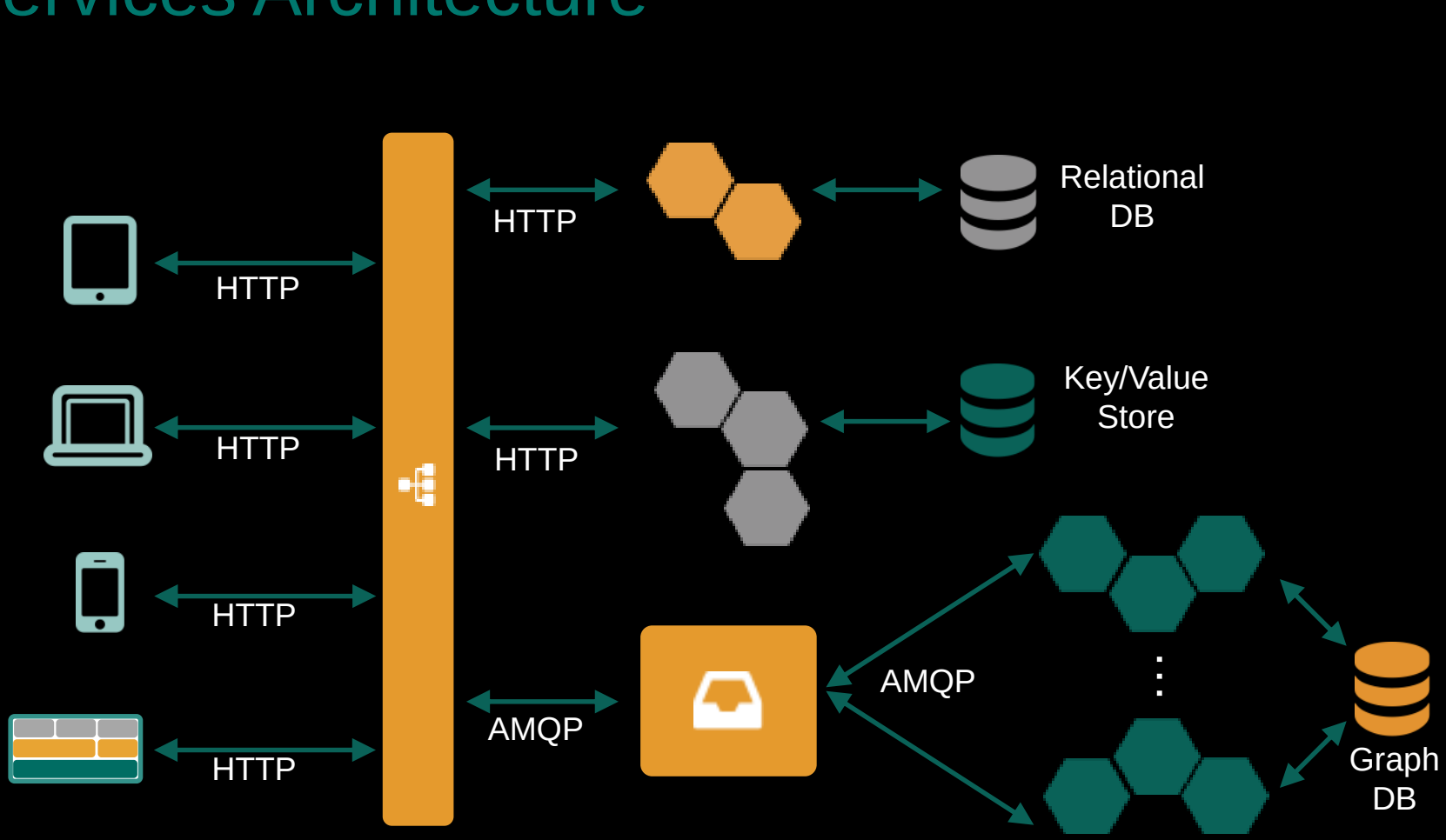
Tightly Coupled

OR

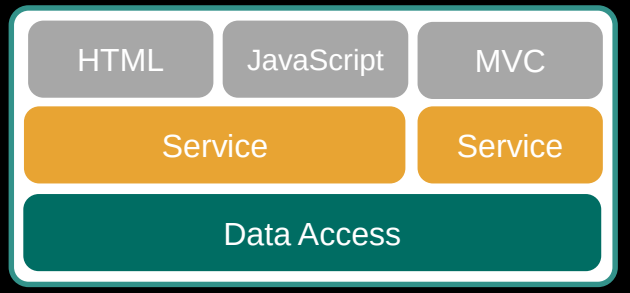


Centralized

Microservices Architecture



Monolith Challenges



- Traditional monolithic design patterns are not appropriate for the cloud.
- Monoliths couple change cycles together.
- Monoliths services can’t be scaled independently.
- Difficult coordination: too many developers in one code base.
- Developers struggle to understand a large codebase.
- Long term commitment to the tech stack.

Microservice Benefits

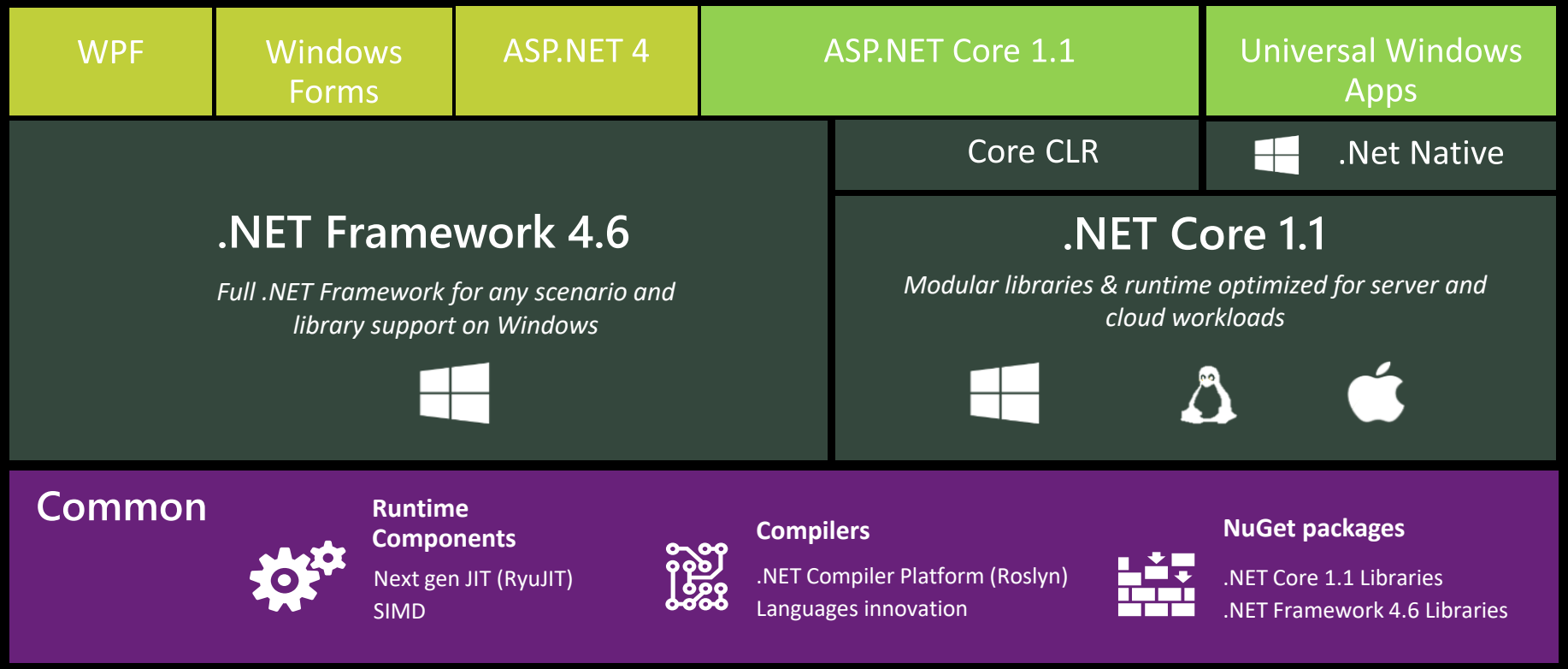
- Change cycles are decoupled: Enabling frequent deploys
- Allow for efficient and independent scaling
- Developers learn a smaller codebase faster
- Better coordination and scaling of development: Fewer developers in each code base
- Eliminate long-term commitment to technical stack

Cloud Native .NET Development on Cloud Foundry

.NET, .NET CORE, ASP.NET, ASP.NET CORE, MICROSERVICES, CONTAINERS, CLOUD FOUNDRY

Pivotal

.NET Today


WPF
Windows Forms
ASP.NET 4
ASP.NET Core 1.1
Universal Windows Apps
Core CLR
.Net Native
.NET Framework 4.6
Full .NET Framework for any scenario and library support on Windows
.NET Core 1.1
Modular libraries & runtime optimized for server and cloud workloads
Common
Runtime Components
Next gen JIT (RyuJIT)
SIMD
Compilers
.NET Compiler Platform (Roslyn)
Languages innovation
NuGet packages
.NET Core 1.1 Libraries
.NET Framework 4.6 Libraries

.NET Core

- Runs cross platform
  - Runtimes, Libraries and Compilers for Windows, Linux, OSX
  - .NET Core tooling for Windows, Linux, OSX
    - Command Line Interface (CLI) – '`dotnet`'
    - `` `project.json` `` file is the new `` `.csproj` `` (soon to be old)
    - Cross platform Code editor – Visual Studio Code
    - Visual Studio 2015/2017 - IDE (Windows and Mac only)
- Fully open source
  - Runtime (i.e. CoreCLR) - https://github.com/dotnet/coreclr
  - Framework Libraries (i.e. CoreFx) - https://github.com/dotnet/corefx
  - Compilers (i.e. Roslyn) - https://github.com/dotnet/roslyn
- Installers for Windows, Linux, OSX
  - Binaries = Runtime & Libraries only
  - SDK = Development Tools + Runtime & Libraries

.NET Core

- Modular – built on NuGet packaging system
  - Packaged and distributed as lots and lots of NuGets
    - CoreCLR, Libraries & Compilers
  - Packages include everything needed to run
    - Even native code dependencies
  - Enables ‘a la carte’ .NET development
- Application types
  - .NET Console applications
- Missing various .NET Framework classes
  - .NET Core Framework libraries are an API Subset/Superset
  - NET Standard Library – effort to standardize BCL for cross platform
    - Current -> .NET Standard 1.6 -> .NET Core 1.0 & .NET 4.6.?
    - Future -> .NET Standard 2.0 -> .NET Core vNext & .NET 4.6.1

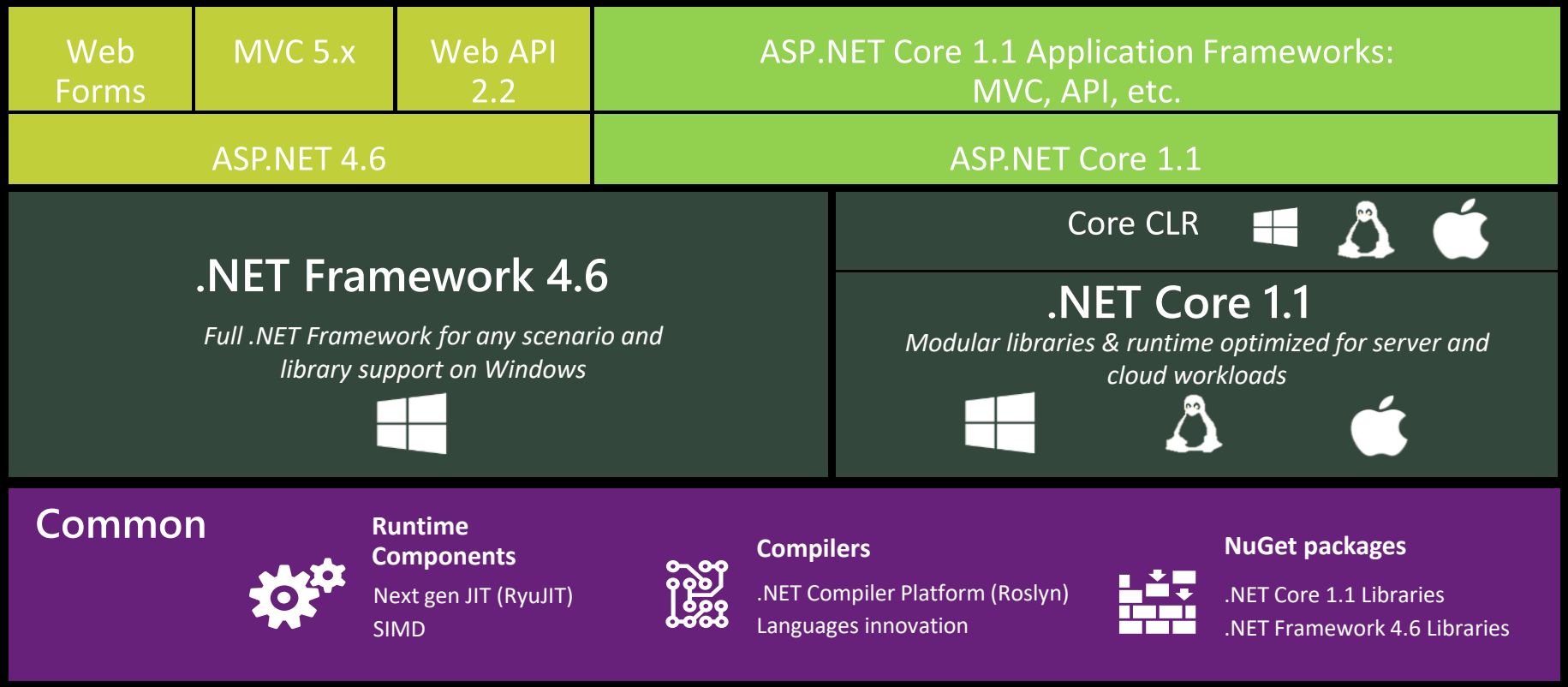
.NET Core

- .NET Core tooling
  - ‘`dotnet <command> <args>`’ – Command Line Interface (CLI)
    - `` `new` `` - create a new project
    - `` `restore` `` – restore dependencies declared in `` `project.json` ``
    - `` `build` `` – compile code to assembly – debug or release
    - `` `run` `` – compile (if necessary) and run the assembly (i.e. launcher)
    - `` `publish` `` – package app and all dependencies for deployment
  - `` `project.json` `` - it is the project `recipe` (i.e. defines target frameworks & runtimes, compile info and NuGet dependencies, etc.)
    - `` `frameworks` `` - section specifies the target frameworks the app/project supports (e.g. .NET Framework 4.5.2, .NET Standard Library 1.6, UWP, etc.)
      - Specified via a TFM (Target Framework Moniker) – e.g. (net452, netcoreapp1.0, netstandard1.6)
    - `` `runtimes` `` - section specifies the runtimes supported – used when publishing self-contained deployments
      - Specified via RIDs (Runtime Identifiers) e.g. (win7-x64, ubuntu.14.04-x64, osx.10.11-x64)
    - `` `dependencies` `` - section specifies package dependencies, can be specified per framework and globally
  - `` `global.json` `` - optional, can specify the .NET Core SDK to use

.NET Core

- Application deployment options (i.e. `dotnet publish`)
  - Self-contained: Application = .NET Core runtime + App dependencies + App code
  - Portable: Application = App dependencies + App code
- .NET Core != ASP.NET Core
- Lets look at some code!

ASP.NET Core


Web Forms
MVC 5.x
Web API 2.2
ASP.NET Core 1.1 Application Frameworks: MVC, API, etc.
ASP.NET 4.6
ASP.NET Core 1.1
.NET Framework 4.6
Full .NET Framework for any scenario and library support on Windows
Core CLR
.NET Core 1.1
Modular libraries & runtime optimized for server and cloud workloads
Common
Runtime Components
Next gen JIT (RyuJIT)
SIMD
Compilers
.NET Compiler Platform (Roslyn)
Languages innovation
NuGet packages
.NET Core 1.1 Libraries
.NET Framework 4.6 Libraries

ASP.NET Core

- Runs cross framework
  - .NET Core – Windows, Linux & OSX
  - .NET Framework 4.x - Windows
- Fully open source - https://github.com/aspnet
- Modular
  - Packaged and distributed as lots of NuGets
    - Host, Server, Configuration, Dependency Injection, Session, Static Files, etc.
  - Separate from .NET Core or .NET Framework
  - Enables ‘pay for play’ ASP.NET development
- Use .NET Core CLI – ‘`dotnet <command> <args>`’ (i.e. build, run, publish, etc)
- Deployment options when targeting .NET Core
  - Application can be fully self-contained
    - Application = .NET Core NuGets + ASP.NET Core NuGets + App dependencies + App code
  - Application can be portable
    - Application = .ASP.NET Core NuGets + App dependencies + App code

ASP.NET Core

- Hosting – self hosting
  - It's just a console application
  - Kestrel – a cross platform web server
  - WebListener – windows only web server (built on http.sys)
  - IIS – used as reverse-proxy with Kestrel
    - ACM – native IIS module used
- Dependency Injection (DI) baked in
- Middleware handles request processing
  - Routing, Static Files, Session, Authentication, Authorization, etc.
- Configuration – separate application config from `web.config`
  - Multiple configuration sources (i.e. JSON, INI, XML files, Environment Variables, etc.)
- Startup class
  - Builds Configuration
  - Configures the Service Container (i.e. DI)
  - Configures the Middleware
- Logging

ASP.NET Core

- Application frameworks
  - MVC – Integrated UI and Web API framework
    - Layered on top of ASP.NET Core
      - Uses DI, Logging, Self-hosting, etc.
    - Controllers, Actions, Views, Filters, Model binding
    - Razor Views & new Tag Helpers
  - WebSockets
  - SignalR – release coming
- Lets look at some code!

.NET 4.x Support on Cloud Foundry

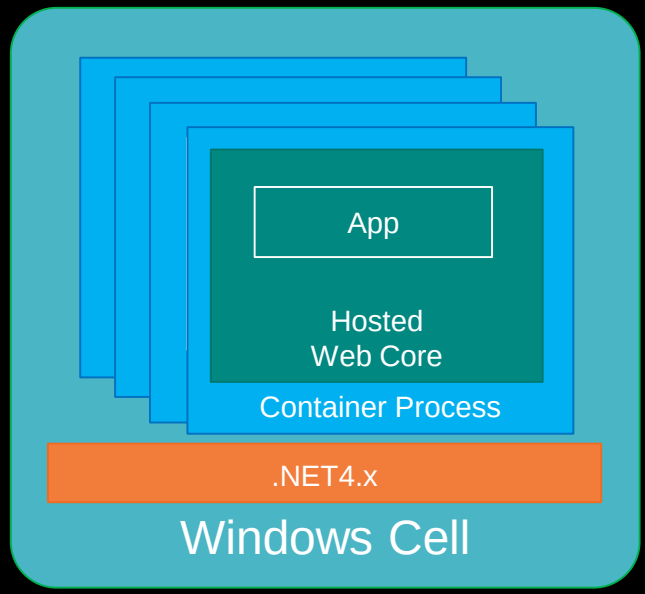
- Always push to Windows cell - `stack: windows2012R2`
  - Uses `binary` build pack (default)
- Application types
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET OWIN based apps
  - ASP.NET Core web apps
    - Targeting .NET Framework
  - .NET “Background processes”
    - Command line/Console apps

```
---
applications:
- name: env
  random-route: true
  health-check-type: none
  memory: 1G
  stack: windows2012R2
  env:
    MY_ENVIRONMENT: production
```

.NET 4.x on Windows Cell

- Container image created using
  - Binary buildpack
- .NET 4.x shared by all container processes
- Resource isolation
  - Kernel job object
  - Disk quotas
- Namespace isolation
  - User accounts
  - Hosted Web Core

Windows Cell Architecture



.NET Core Support on Cloud Foundry

- Push to windows cell - `stack: windows2012R2`
  - Use `binary` build pack (default)
  - Publish & push self-contained application
- Push to Linux cell - `stack: cflinuxfs2` (manifest default)
  - Use .NET Core build pack
  - Publish & push either self-contained, portable, or source
- Application types
  - ASP.NET Core web apps
  - .NET Core “Background processes”
    - Command line apps/Console apps

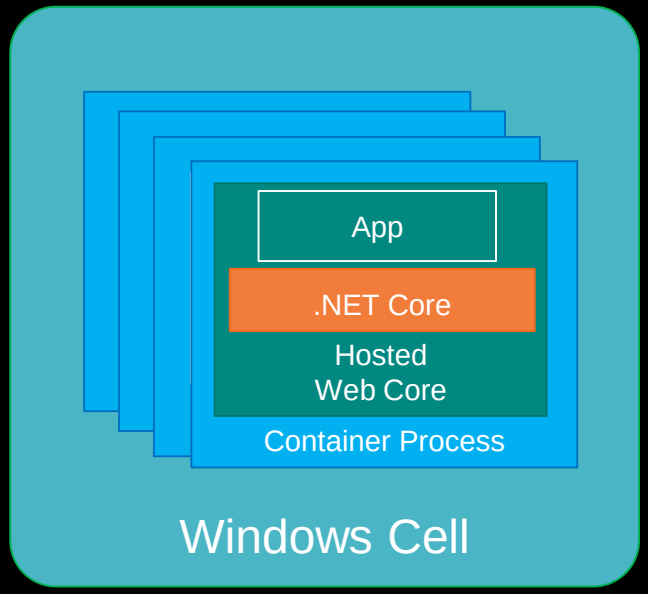
```
applications:
- name: env
  random-route: true
  health-check-type: none
  memory: 512M
  stack: windows2012R2
  command: cmd /c .\env
  env:
    MY_ENVIRONMENT: production
```

```
applications:
- name: env
  random-route: true
  memory: 512M
  buildpack: dotnet_core_buildpack
  command: ./env
  env:
    MY_ENVIRONMENT: production
```

.NET Core on Windows Cell

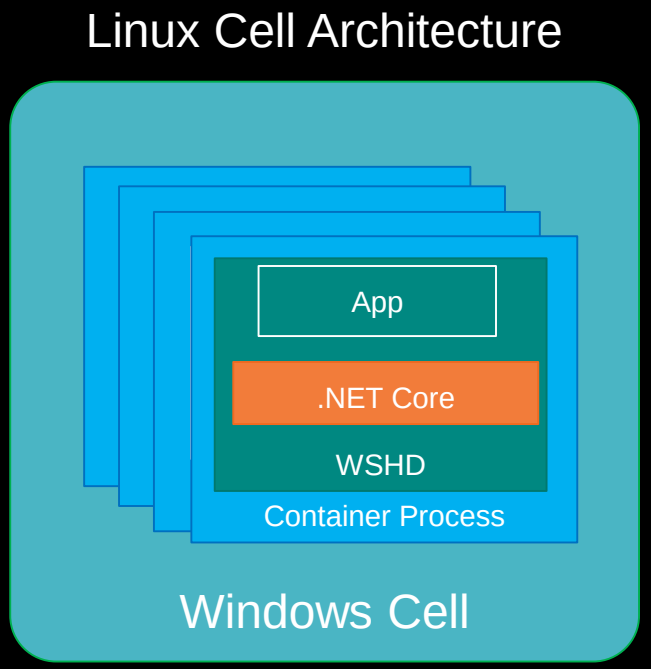
- Isolation same as .NET 4.x on Windows cell
- Container image created using binary buildpack
- .NET Core not shared by all container processes
  - Different versions possible per container

Windows Cell Architecture



.NET Core on Linux Cell

- Isolation same as any other language/runtime
- Container image created using .NET Core buildpack
- .NET Core not shared by all container processes
  - Different versions possible per container



.NET Core Buildpack – Linux Cells

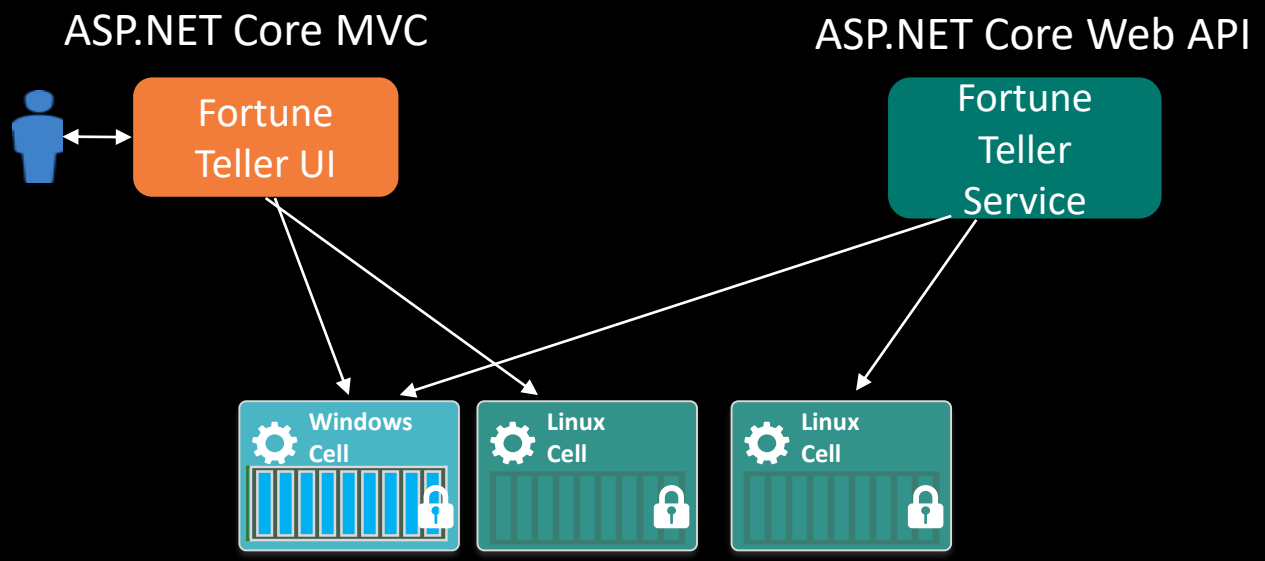
- Creates container images ready to run .NET Core applications on Linux cells
  - Supports running app from pushed source
    - Pushed source directory must contain `project.json`
  - Supports running app from pushed binaries
    - Pushed directory contains NO `project.json` and is a self-contained or portable app
- Pushing source
  - Installs .NET Core runtime – version specify via `global.json`, else build pack chooses
  - Restores application dependencies
  - Generates the command to run the application
- Pushing binaries
  - Portable applications
    - Installs .NET Core runtime – version specify via `global.json`, otherwise build pack chooses
    - Generates the command to run the application
  - Self-contained applications
    - Installs `libunwind.so`
    - You specify command to run

Writing Twelve Factor ASP.NET Applications

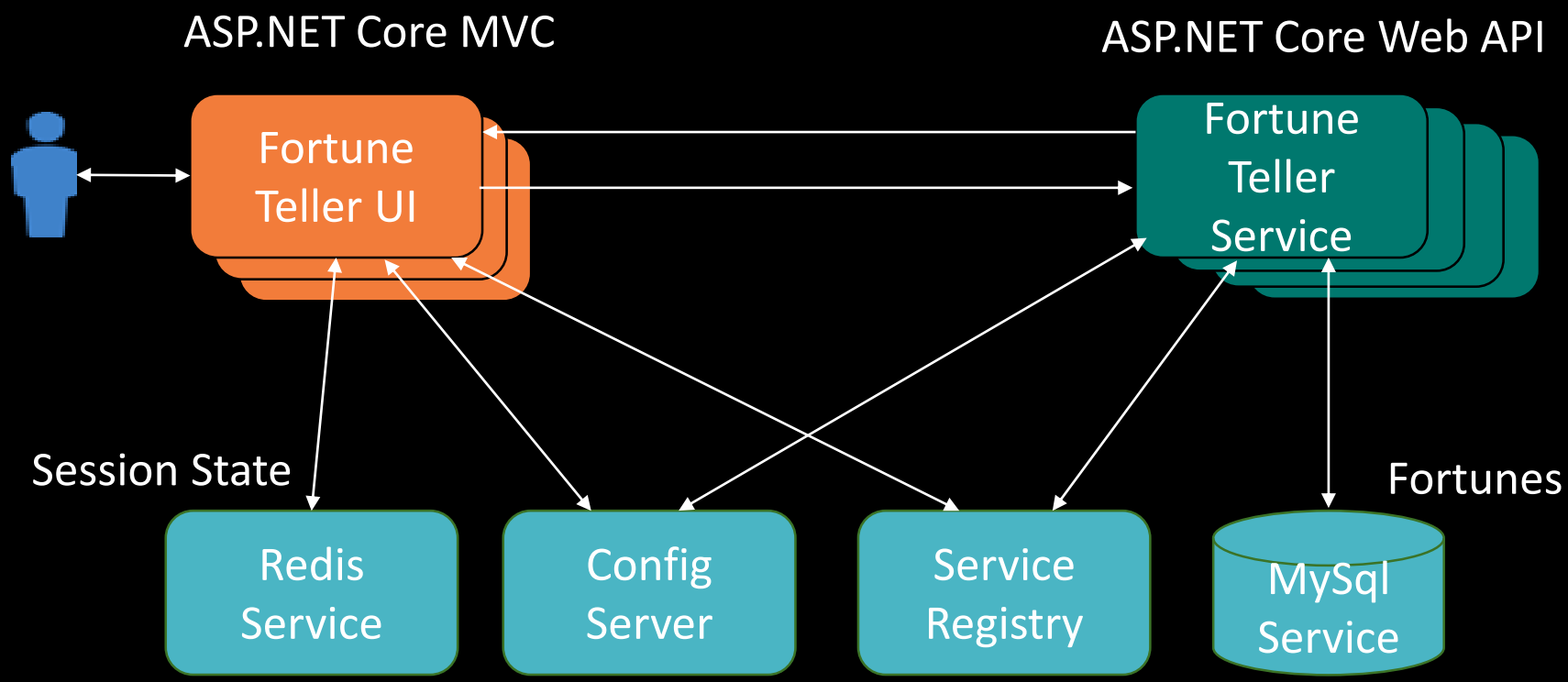
- Avoid in-process session state
- For ASP.NET override `MachineKey` in `web.config` and on ASP.NET Core avoid persisting keyring to filesystem
- On ASP.NET avoid environment specific configuration in `web.config`
- Avoid Integrated Windows Authentication
- Avoid the GAC
- Avoid custom IIS handlers
- Avoid anything that uses the Windows registry
- Avoid using local disk for storing application state
- Avoid using any Windows specific or disk based logging
- Avoid any 32-bit specific libraries or libraries that can’t be bin deployable

Lab5 – Running .NET Core Locally & On Cloud Foundry

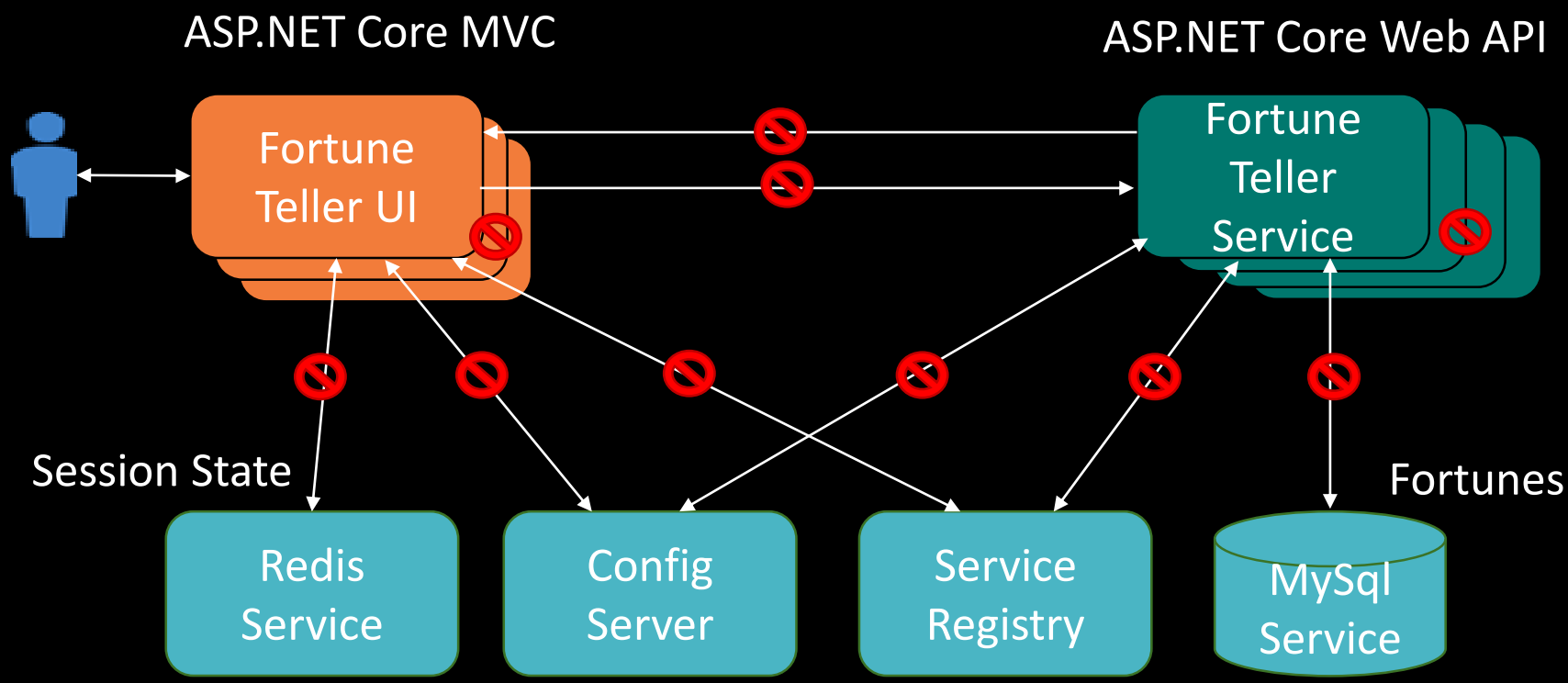
- Become comfortable with restoring, running and publishing .NET Core applications
  - From command line
  - From within Visual Studio



Lab5 – Fortune Teller App – When done!



Lab5 – Fortune Teller App - Current State



ASP.NET Core Programming Fundamentals

HOST, SERVER STARTUP, DENDENCY INJECTION, SERVICES, MIDDLEWARE

ASP.NET Core Startup

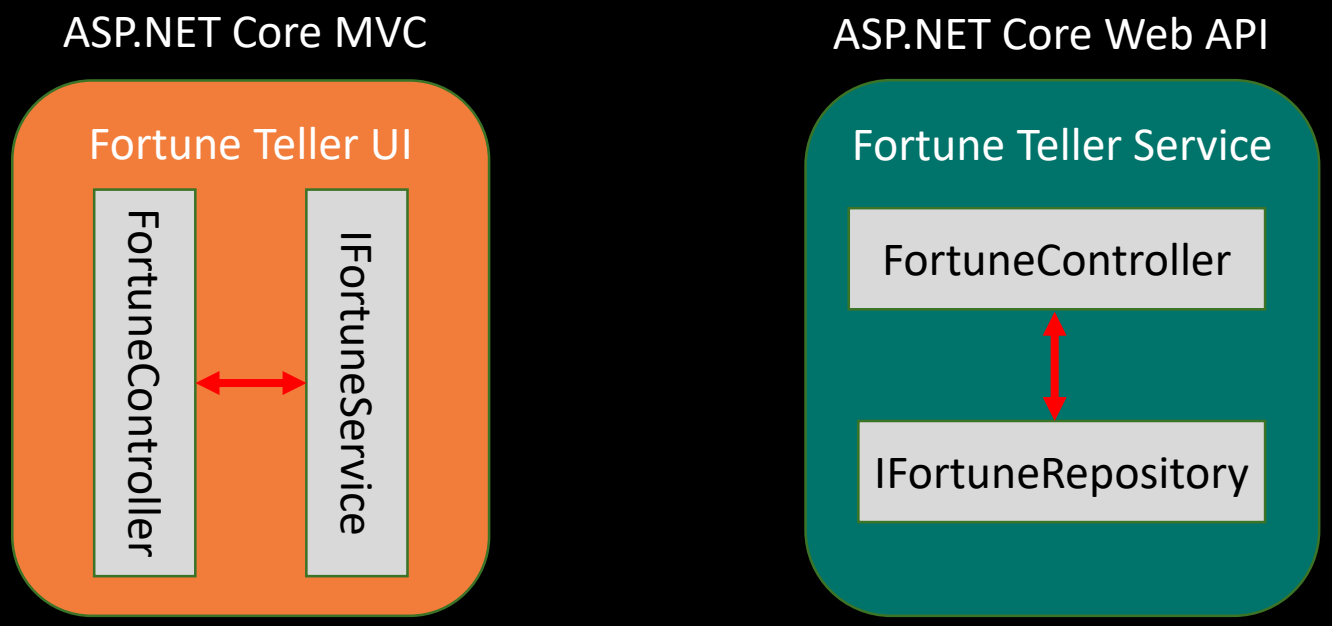
- Everything starts in `Program.cs`
  - Build a host using `WebHostBuilder`
    - Configure web server, listen address, etc.
    - Specify startup class
- Startup class
  - `Startup()` - constructor builds applications configuration
  - `ConfigureServices()` - configures the service collection (Dependency Injection)
  - `Configure()` - configures the middleware pipeline

ASP.NET Core Dependency Injection

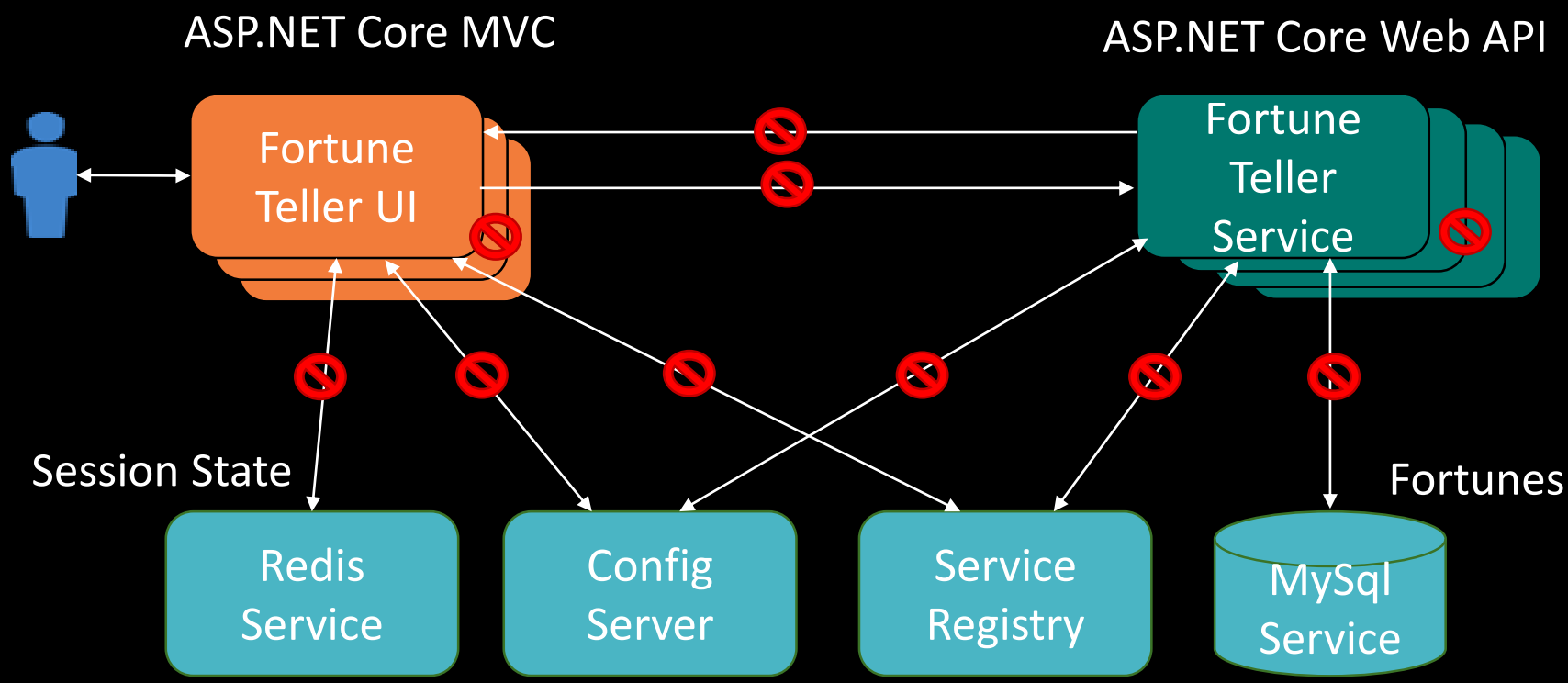
- Basic, minimal feature set, but fundamental to operation of ASP.NET Core
  - Can be replaced with other DI systems (e.g. Autofac, etc.)
  - Supports constructor based injection (i.e. specify dependencies via arguments)
- `IServiceProvider` – is the container
  - Manages `services`
- Use `IServiceCollection` to add services at startup (i.e. inside `ConfigureServices()`)
  - Add framework services via `Add`**`ServiceName`**`()` extension methods
    - e.g. `services.AddMvc()`, `services.AddSession()`, etc.
  - Add application services via `AddTransient()`, `AddSingleton()` & `AddScoped()`
    - e.g. `services.AddSingleton<IFortuneRepository,FortuneRepository>()`
- Lets look at the code!

Lab6 – Programing ASP.NET Core Dependency Injection

- Become comfortable with ASP.NET Core Dependency Injection
  - Use it to hook up application components



Lab6 – Fortune Teller App – After Lab



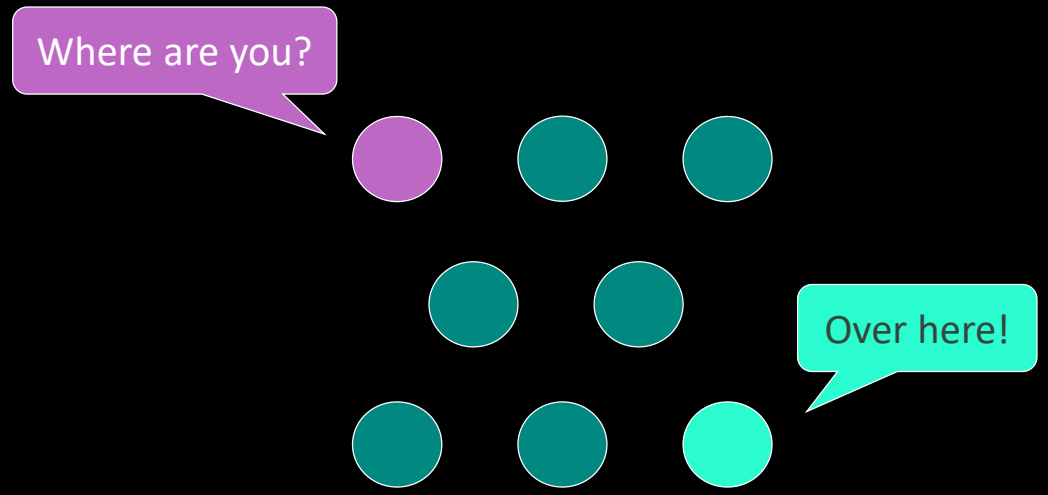
Cloud Native Applications and Spring Cloud Services

Cloud Native Architectures

- Light Side of the Cloud
  - Scalability
  - High Availability
  - Velocity: Continuous Delivery
  - On-Demand Provisioning

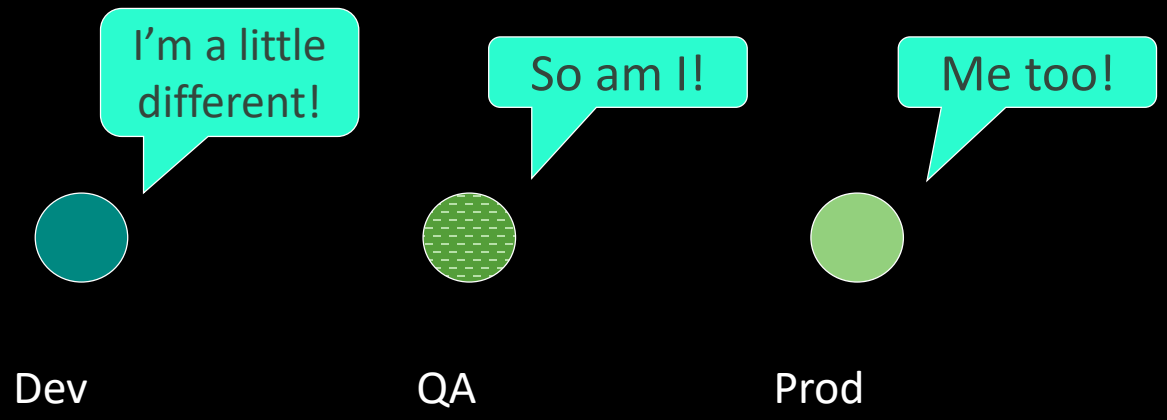
Cloud Native Architectures

- Dark Side of the Cloud
  - Services: Finding them



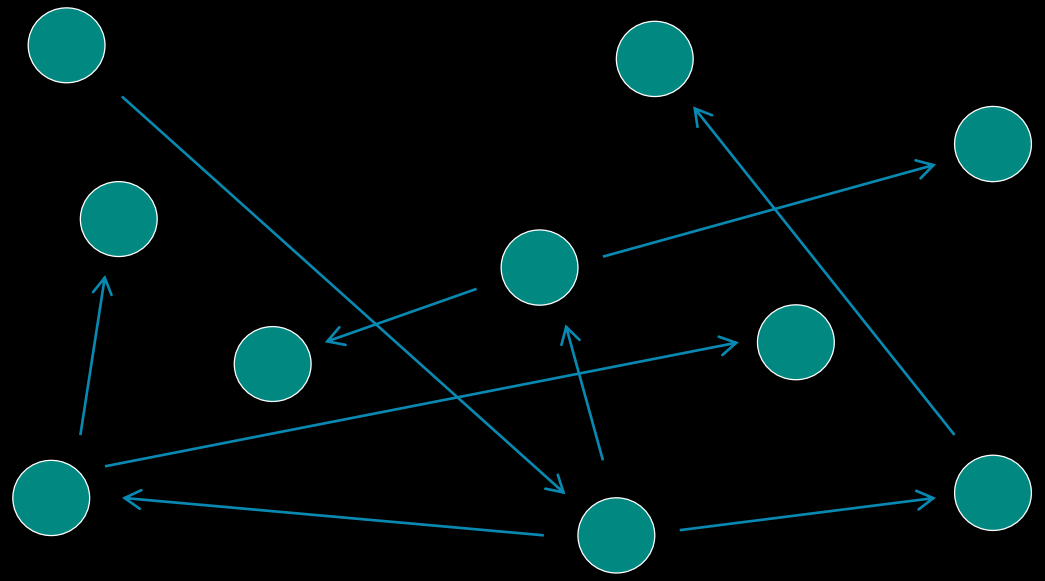
Cloud Native Architectures

- Dark Side of the Cloud
  - Configuration: Managing Differences



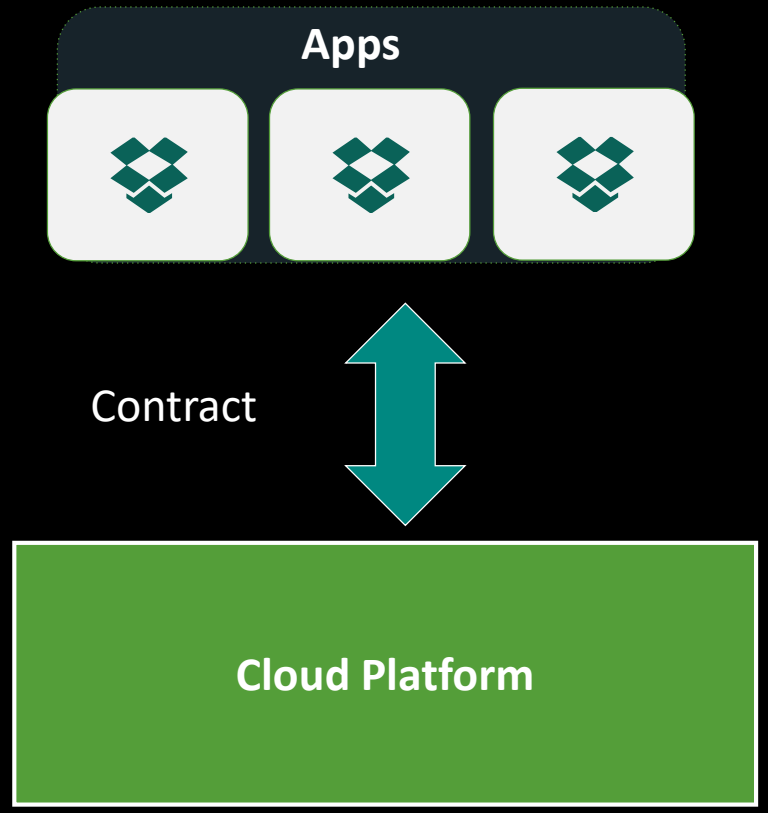
Cloud Native Architectures

- Dark Side of the Cloud
  - Failures: Following call graphs



Cloud Native Principles

- Twelve-Factor App (http://12factor.net) principles popular and important
- Twelve Factors include Dependencies, Config, Processes, and Disposability
- Cloud native apps recognize they are ephemeral, and minimize dependencies on the underlying platform
- Principles establish a contract between cloud native apps and the underlying platform



Netflix Cloud Libraries

- Netflix needed to be faster to win/disrupt
- Pioneer and vocal proponent of microservices
  - Key to speed and success
- Neflix OSS supplies parts, but its not a full solution

Open Source Cloud Libraries

- Twitter, Facebook and Hashicorp have open-sourced other cloud infrastructure libraries
- Complementary and competing solutions
  - Form a bazaar of ideas and solutions

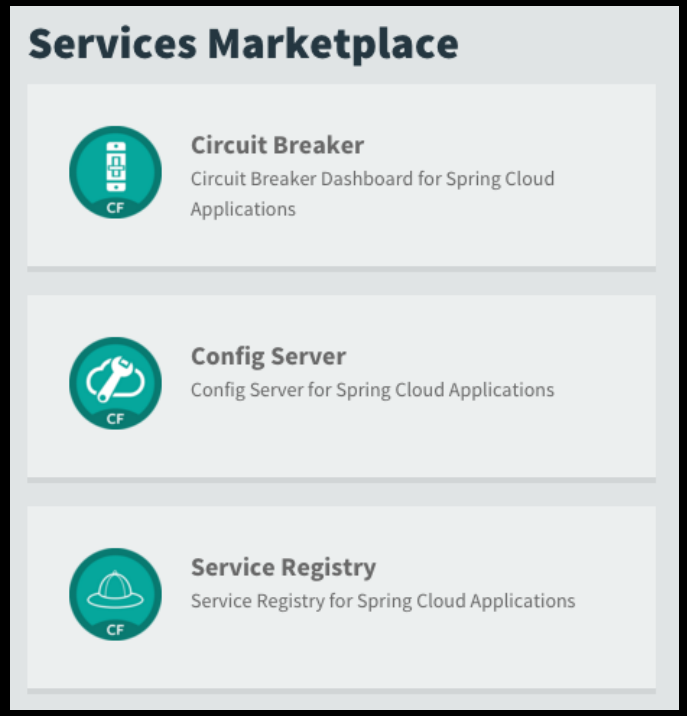
Spring Cloud

- Easy developer access to curated selection of open source cloud infrastructure
- Spring Cloud API encapsulates access to underlying libraries
  - Pluggable implementations
  - Allows best of breed

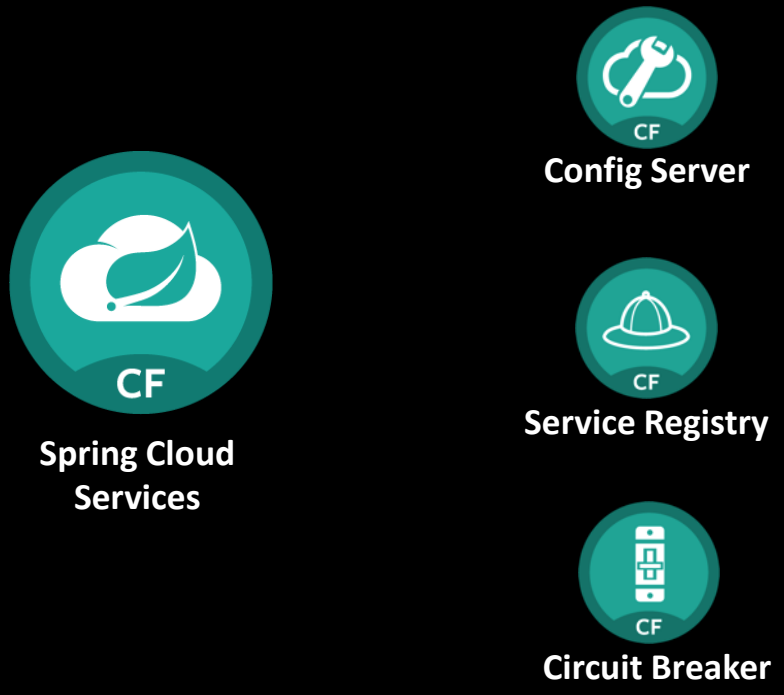
Spring Cloud

- Additional capabilities include
  - Cloud Connectors
  - Config Server
- Spring philosophy
  - Convention over configuration
  - Opinionated defaults
  - Developer simplicity

Spring Cloud Services

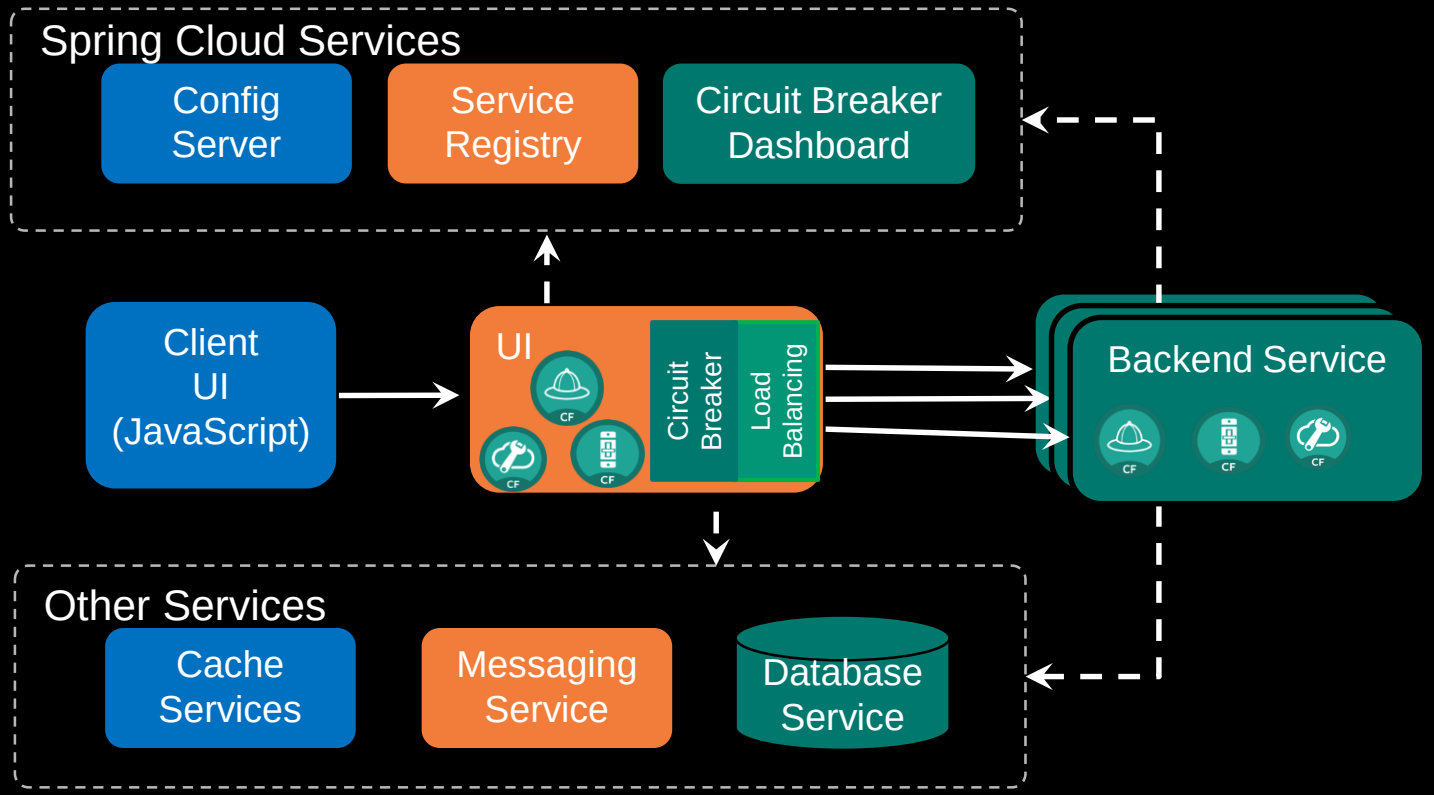


Spring Cloud Services



- Config Server
  - Centrally manage app configuration
  - Single tenant, scope to CF Space
- Service Registry
  - Registration/Discovery via Netflix Eureka
  - Registration via CF Route
- Circuit Breaker
  - Via Netflix Turbine and Hystrix Dashboard
  - Aggregation via AMQP (RabbitMQ)

Example Spring Cloud Services Application Architecture



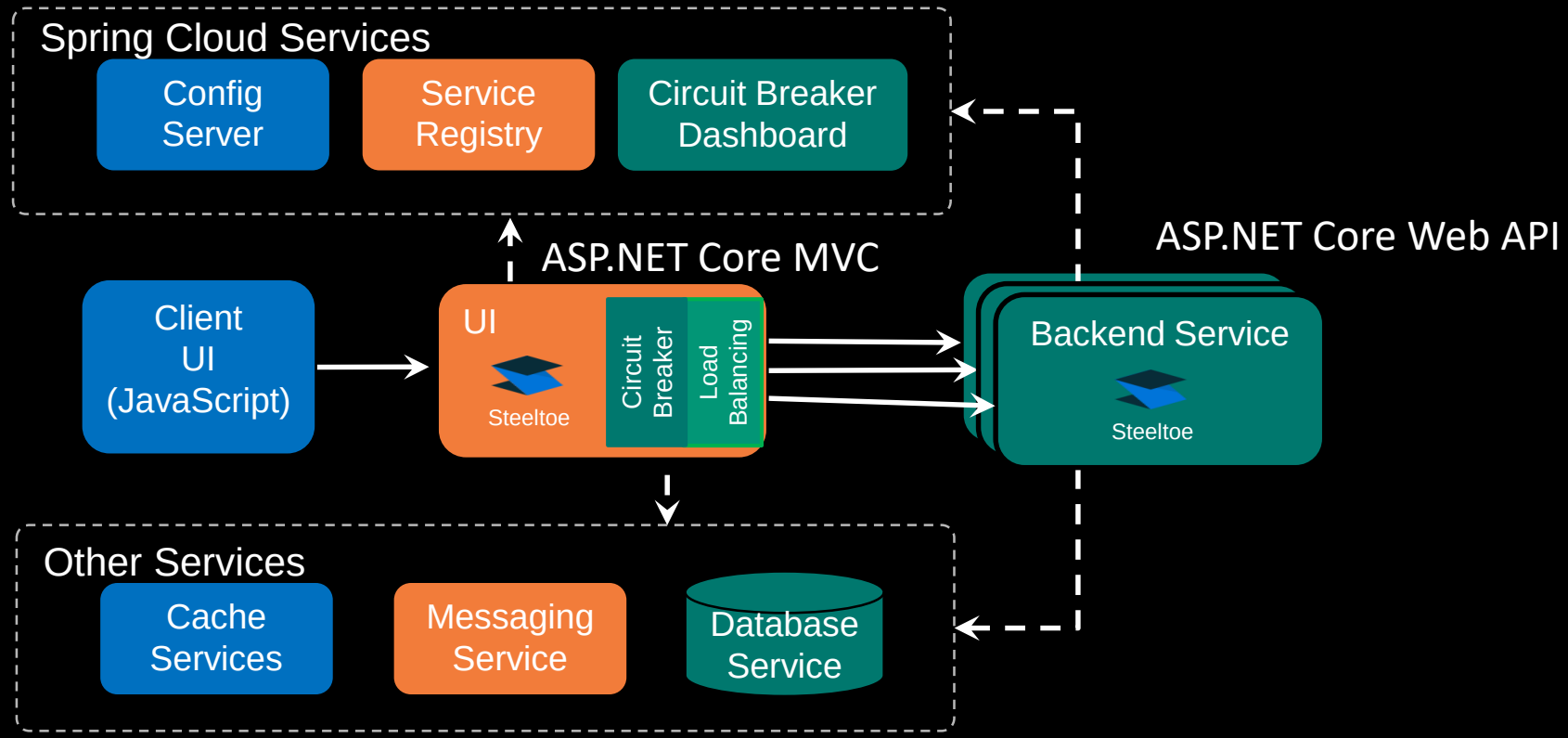
Spring Cloud Services

- Battle tested infrastructure, out of the box
- High availability, Enterprise class implementations
- Integrated with logging, monitoring and administration of Pivotal Cloud Foundry

Steeltoe Overview

CONNECTORS, CONFIGURATION, DISCOVERY, SECURITY

Example Spring Cloud Services Application Architecture on .NET



Facilitates Twelve-Factor Contract on .NET

Steeltoe
http://steeltoe.io

NETFLIX OSS

Enabling Cloud Native Applications on .NET

- Simplifies using .NET & ASP.NET on Cloud Foundry
  - Connectors (e.g. MySql, Redis, Postgres, RabbitMQ, OAuth, etc.)
  - Security providers (e.g. OAuth SSO, JWT, Redis KeyRing Storage, etc.)
  - Configuration providers (e.g. Cloud Foundry)
- Simplifies using Spring Cloud Services
  - Configuration server provider (e.g. Config Server, etc.)
  - Service Discovery (e.g. Eureka, etc.)
  - Circuit Breaker (e.g. Hystrix coming)
  - Distributed Tracing (e.g. Slueth coming)

Steeltoe Overview

- Open Source
  - https://github.com/SteeltoeOSS
  - Lots of documentation in Readmes
  - Functionally organized (Configuration, Discovery, Connectors, etc.)
- .NET support
  - .NET Core (Windows, Linux & OSX)
  - .NET Framework
- Application type support
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET Core
  - Console apps (.NET Framework and .NET Core)

Steeltoe Overview

- Connectors – simplifies configuring and injecting the following as services
  - MySql, MySql EF6, MySql EFCore – Connections and `DbContexts`
  - Postgres, Postgres EFCore – Connections and `DbContexts`
  - RabbitMQ – Connections
  - Redis – Microsoft `IDistributedCache` & StackExchange `ConnectionMultiplexor`
  - OAuth – access connection details from CF UAA & Pivotal SSO Service
- Configuration – additional `ConfigurationBuilder` providers
  - CloudFoundry – parse `VCAP_*`, `CF_*` and add to apps configuration
  - Config Server Client – access to Config Server

Steeltoe Overview

- Discovery – service registry clients
  - Netflix Eureka Client – registration and discovery via Eureka Server
- Security – providers for Cloud Foundry and ASP.NET Core security integration
  - OAuth2 provider – Cloud Foundry integration with UAA/Pivotal SSO
  - JWT provider - Cloud Foundry integration with UAA/Pivotal SSO
  - Redis DataProtection KeyStorage connector – use Cloud Foundry Redis service for key ring storage
- Samples – functional area & full featured samples available
  - All samples: https://github.com/SteeltoeOSS/Samples
  - MusicStore – micro-services app built from the ASP.NET Core reference app
  - FreddysBBQ a polyglot (i.e. Java and .NET) micro-services based sample app

Steeltoe Overview

- NuGet feeds:
  - Development: https://www.myget.org/gallery/steeltoedev
  - Stable: https://www.myget.org/gallery/steeltoemaster
  - Release & Release Candidates: https://www.nuget.org/

Steeltoe Coming Soon

- Circuit Breaker (CB) – enables implementing CB pattern in .NET
  - Netflix Hystrix – full integration with Spring Cloud Circuit Breaker dashboard
- Distributed Tracing – tracing support for micro-services based apps
  - Slueth – full integration with Spring Cloud Tracing dashboard

Steeltoe Configuration Providers

ASP.NET CORE CONFIGURATION, OPTIONS, STEELTOE PROVIDERS

Steeltoe Configuration Providers

- Built on ASP.NET Core Configuration & Options extensions
  - https://github.com/aspnet/Configuration
  - https://github.com/aspnet/Options
  - https://docs.microsoft.com/en-us/aspnet/core/fundamentals/configuration
- Two providers
  - Steeltoe.Extensions.Configuration.CloudFoundry
  - Steeltoe.Extensions.Configuration.ConfigServer
- Application type support
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET Core
  - Console apps (.NET Framework and .NET Core)
- Steeltoe sample applications
  - https://github.com/SteeltoeOSS/Samples/tree/master/Configuration
  - https://github.com/SteeltoeOSS/Samples/tree/master/FreddysBBQ
  - https://github.com/SteeltoeOSS/Samples/tree/master/MusicStore

Understanding ASP.NET Core Configuration

- Configuration built using `ConfigurationBuilder`; usually in `Startup` constructor
  - Add configuration sources to the builder via `Addxxx()` methods
  - Call `Build()` to actually read in and construct configuration
  - Results in a `IConfigurationRoot`
- Several configuration sources available
  - File based (e.g. INI, JSON and XML)
  - Command line arguments
  - Environment variables
  - Custom (e.g. Steeltoe source providers)
- Sources read in order added
  - Later sources override any settings from previous
- Keys are name-value pairs grouped into multilevel hierarchy – hierarchy separated by ":"
  - e.g. `` `section:subsect:key` ``
  - Access values via `IConfigurationRoot` indexer (e.g. `var v=root["section:subsect:key"]`

Understanding ASP.NET Core Environments

- ASP.NET Core has support for multiple `environments`
  - Built in understanding of `production`, `staging` & `development` - case sensitive on Linux only
  - Set via environment variable `ASPNETCORE_ENVIRONMENT`
- Use `IHostingEnvironment` to access environment
  - Injectable
  - Use `env.IsEnvironment("Cloud")` to test – case insensitive way
  - Use `env.IsDevelopment()`, `IsProduction()`, or `IsStaging()` also
- Lets look at some code!

Understanding ASP.NET Core Options

- Enables using custom classes to hold related configuration settings
  - Class must have public parameter-less constructor and attributes to hold values
  - Built in binder for binding configuration to class; attribute names -> config keys
- To bind configuration data to a class and add it to DI container:
  - Use `services.Configure<SomeClass>(config)` method on `IServiceCollection` to bind configuration to `SomeClass`
  - This also adds an `IOptions<SomeClass>` and `IOptionsSnapshot<SomeClass>` to the container for injection
  - Can also bind subsections of a configuration
    - e.g. `services.Configure<SomeClass>(root.GetSection("subsection"));`
- Lets look at some code!

Steeltoe CloudFoundry Configuration Provider

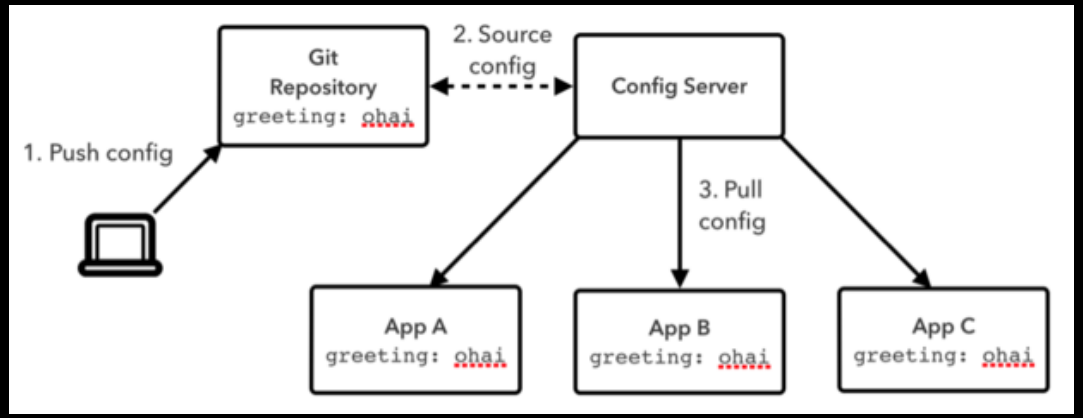
- Parses Cloud Foundry environment variables; adds them to Configuration
  - NuGet: `Steeltoe.Extensions.Configuration.CloudFoundry`
  - Parses `VCAP_APPLICATION`, `VCAP_SERVICES`, `CF_INSTANCE_*`
- Use `AddCloudFoundry()` extension method with `ConfigurationBuilder`
  - `VCAP_APPLICATION` & `CF_INSTANCE_*` -> section `` `vcap:application` ``
  - `VCAP_SERVICES` -> section `` `vcap:services` ``
  - Access values using the indexer
- Optionally, use Options feature with configuration data
  - `services.Configure<CloudFoundryApplicationOptions>(config);`
  - `services.Configure<CloudFoundryServicesOptions>(config);`
- Lets look at some code!

Steeltoe ConfigServer Client Provider

- Enables Spring Cloud Config Server to be used as a configuration source
  - OSS Config Server - `Steeltoe.Extensions.Configuration.ConfigServer`
  - SCS Config Server - `Pivotal.Extensions.Configuration.ConfigServer`
- Application type support
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET Core
  - Console apps (.NET Framework and .NET Core)

Spring Cloud Config Server Overview

- Supports different back ends
  - Local or remote git repos
  - File System
- Exposes resource HTTP API
  - Default starts on port=8080
- Configuration pulled by
  - AppName
  - Profile
  - Label – optional



Spring Cloud Config Server Overview

- Serves resources:
  - /application.yml
  - /application.properties
  - /application-{profile}.yml
  - /application-{profile}.properties
  - /{appname}-{profile}.yml
  - /{appname}-{profile}.properties
  - /{appname}/{profile}[/{label}]
  - /{label}/{appname}-{profile}.yml
  - /{label}/{appname}-{profile}.properties
- For a git backend
  - Configure URL of git repo
  - {appname} & {profile} maps to file & directory in repo
  - {label} -> git branch

- Git backend example:
  - Repo contains files:
    - application.yml
    - application-development.yml
    - foo.yml
    - foo-development.yml
    - bar.yml
  - Client request contains:
    - {appname}=foo
    - {profile}=development
  - Config server returns in precedence order:
    - foo-development.yml
    - foo.yml
    - application-development.yml
    - application.yml

Steeltoe Config Server Client Provider

- Use `AddConfigServer(environment)` extension method on `ConfigurationBuilder` to add Config Server client provider
  - At `Build()`, client calls Config Server and retrieves configuration data
- Must configure the Config Server client settings
  - Easiest to put settings in `` `appsettings.json` `` or other file based config source
  - Must add the settings provider before `` `AddConfigServer(environment)` `` so client can find settings
  - Two settings are required at minimum
    - `` `spring:application:name` `` defines the `{appName}` portion of the Config Server request
    - `` `spring:cloud:config:uri` `` defines the REST endpoint of the Config Server
  - `IHostEnvironment.EnvironmentName` is used for `{profile}` portion of Config Server request

Steeltoe Config Server Client Settings

- Config Server Client settings:
  - `spring:cloud:config:enabled` - enable/disable Config Server client, default(true)
  - `spring:cloud:config:uri` - endpoint of Config Server, default("http://localhost:8888")
  - `spring:cloud:config:validate_certificates` - enable/disable cert validation, default(true)
  - `spring:cloud:config:label` - comma separated list of labels to request, default(empty)
  - `spring:cloud:config:failFast` - enable/disable failure at startup, default(false)
  - `spring:cloud:config:retry:enabled` - enable/disable retry logic, default(false), failFast enabled
  - `spring:cloud:config:retry:maxAttempts` - max number retries if retry enabled, default(6)
  - `spring:cloud:config:retry:initialInterval` - starting interval, default(1000)
  - `spring:cloud:config:retry:multiplier` - retry interval multiplier, default(1.1)
  - `spring:cloud:config:retry:maxInterval` - maximum interval, default(2000)
  - `spring:cloud:config:username` - username for Basic auth, default(empty)
  - `spring:cloud:config:password` - password for Basic auth, default(empty)

Using Config Server on Cloud Foundry

- Create instance of Config Server using CF CLI
  - `` `cf create-service p-config-server standard cserver -c config.json` ``
  - Spins up config server in org: `p-spring-cloud-services`, space: `instances`
  - `` `config.json` `` specifies URL of git repo it uses for configuration data
  - Use `` `cf service` `` to check status of service
- Bind instance to applications
  - `` `cf bind-service appName cserver` ``
  - Also specify binding in `manifest.yml`
    - `` `services:` `` section-> add `` `cserver` ``
- Steeltoe Config Server Client detects `p-config-server` binding
  - Overrides `` `appsettings.json` `` client settings with binding information
  - Enables easier development and testing locally; and then push to CF with no changes
- Lets look at some code!

Using Self-signed Certificates on Cloud Foundry

- Communications between Config Server Client and Config Server on PCF uses TLS/SSL.
  - Default behavior for Steeltoe Client is to attempt to validate server certificate
- Can disable server certificate validation using client setting:
  - `` `spring:cloud:config:validate_certificates` `` - enable/disable cert validation, default(true)
- .NET apps running in Linux containers can use `Trusted System Certificate` feature on PCF
  - .NET Core on Linux uses OpenSSL
  - Install the custom root certificate using Bosh
- .NET apps running in Windows containers can NOT uses this feature
  - Must manually install the custom root certificate on each Windows cell

Diagnosing Problems

- Turn on logging in Steeltoe Config Server Client
  - Inject `ILoggerFactory` into `Startup` constructor
  - Add Console logger and set minimum level to Debug for most verbose output
    - e.g. `logFactory.AddConsole(minLevel: LogLevel.Debug)`
  - Add `ILoggerFactory` to `AddConfigServer()` call
    - E.g. `AddConfigServer(env, logFactory)`
  - Restart application and look at log output upon startup
- Look at log output for Config Server instance
  - Instances run in org: `p-spring-cloud-services` space: `instances`
  - Use log output from client to determine which server instance to view
  - Look for all of the: `Adding property source: < some path>`
    - Tells you what properties/yaml files were fetched/returned

Example Steeltoe Client Log Output

2017-03-14T07:51:28.28-0600 [APP/PROC/WEB/0]OUT info: Steeltoe.Extensions.Configuration.ConfigServer.ConfigServerConfigurationProvider[0]
2017-03-14T07:51:28.28-0600 [APP/PROC/WEB/0]OUT Fetching config from server at: https://config-74ea3e4f-6438-4f80-b19d-9edc827b2acc.apps.testcloud.com
2017-03-14T07:51:31.57-0600 [APP/PROC/WEB/0]OUT info: Steeltoe.Extensions.Configuration.ConfigServer.ConfigServerConfigurationProvider[0]
2017-03-14T07:51:31.57-0600 [APP/PROC/WEB/0]OUT Located environment: foo, development, master, 324992ddee5c4300dab2caee962dd85ed4ab994c

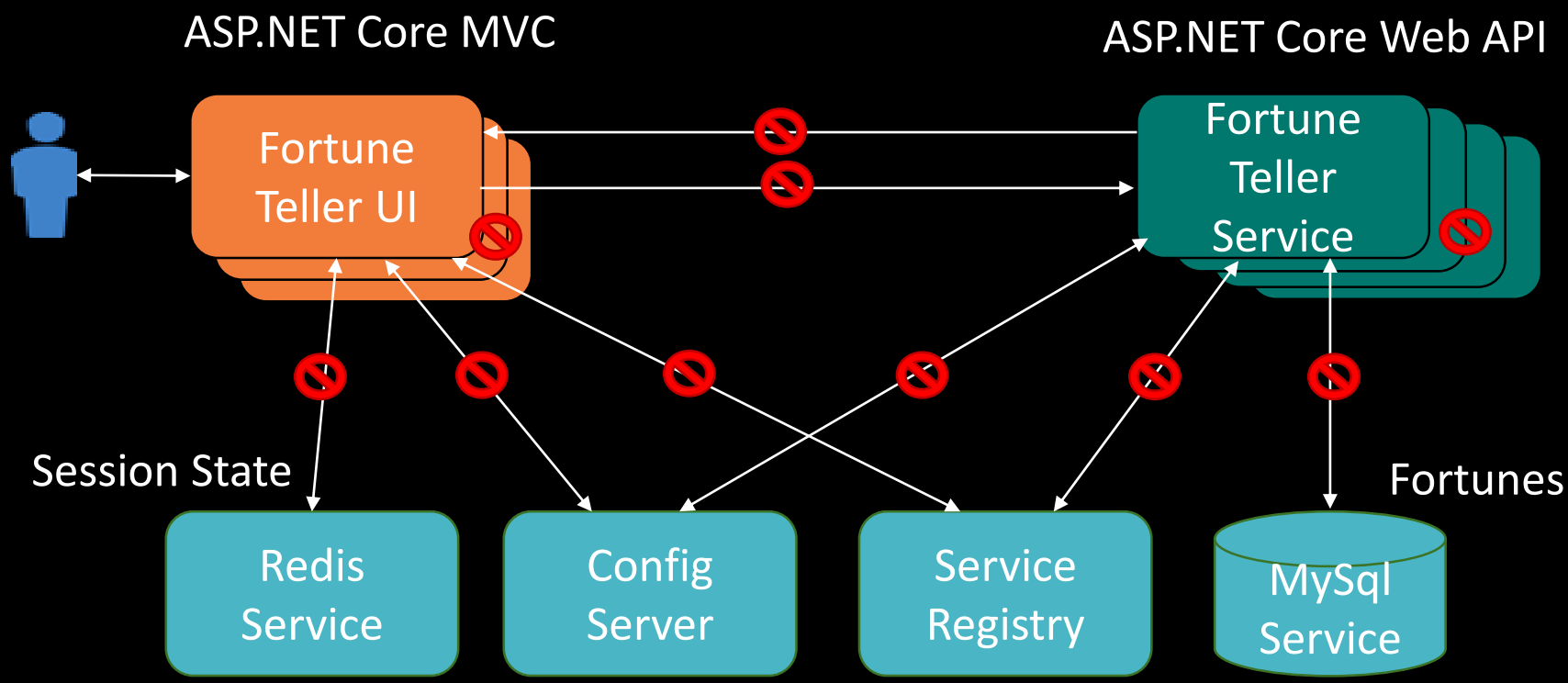
Diagnosing Problems

- Look at log output for Config Server instance
  - Instances run in org: `p-spring-cloud-services` space: `instances`
  - Use log output from client to determine which server instance to view
  - Look at logs for all of the: `Adding property source: < some path>`
    - Indicates what properties/yml files were fetched/returned to client

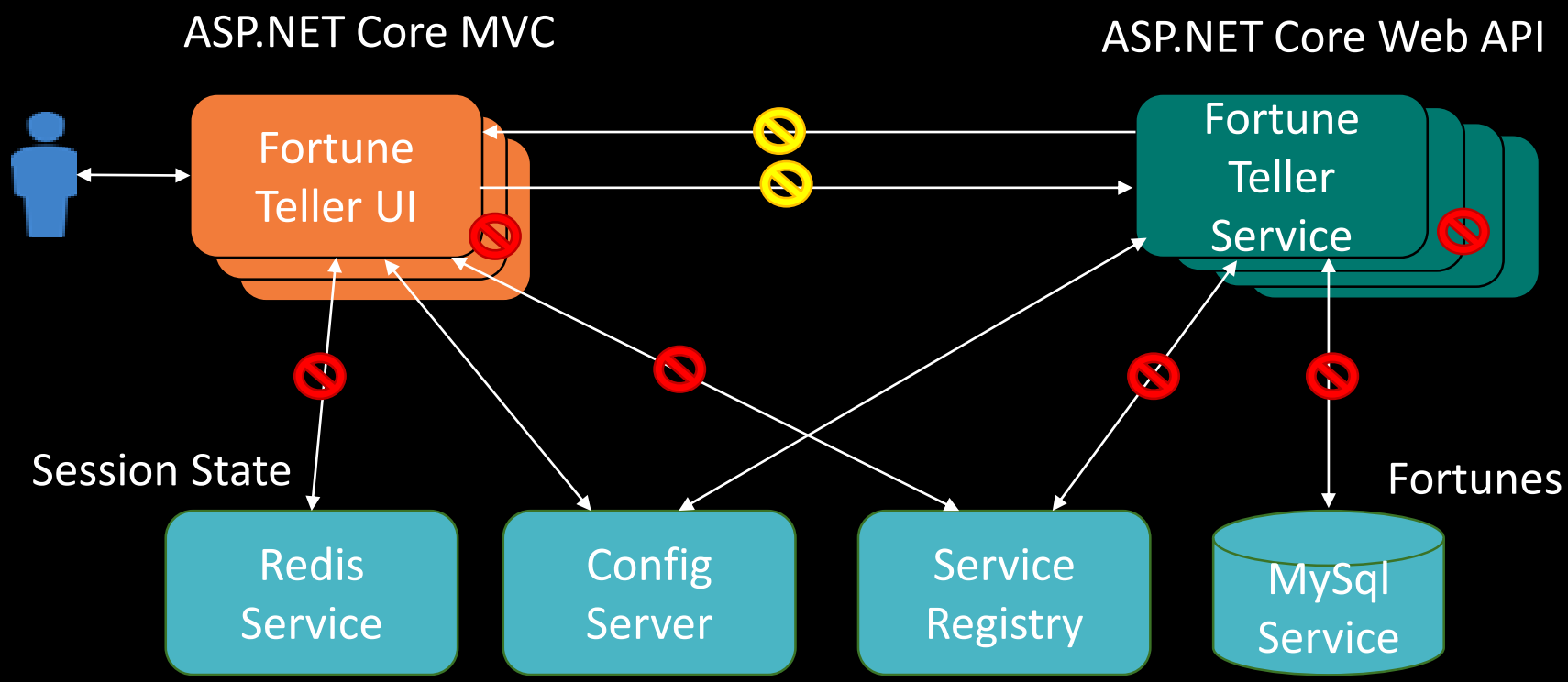
Lab7 – Fortune Teller App

- Multiple Exercises:
  - Setup and use different configurations for development and production
    - Want to use full debug logging when in development mode
  - Use Configuration & Options to configure `FortuneServiceClient`
    - Use it to configure the REST endpoint of the Fortune Teller Service
    - `FortuneServiceClient` can then communicate with it
  - Use Steeltoe and Spring Cloud Config Server
    - Move as much configuration as possible to Config Server
    - Run Config Server locally for test/development
  - Deploy to Cloud Foundry
    - Move local Config Server data to git repo
    - Does app still work?

Lab7 – Fortune Teller App – Before Lab



Lab7 – Fortune Teller App – After Lab



Steeltoe Service Discovery

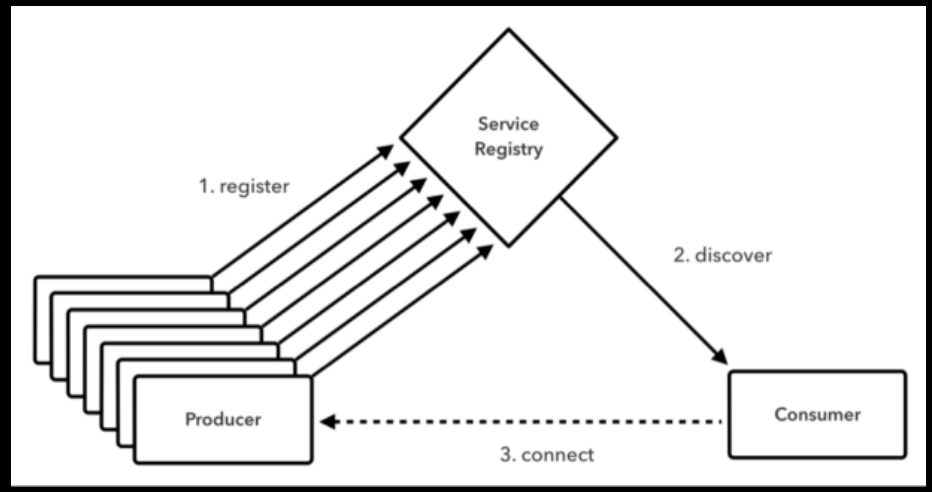
ASP.NET CORE CONFIGURATION, OPTIONS, STEELTOE PROVIDERS

Steeltoe Service Discovery Client Overview

- Provides configurable generalized interface for Service Registry interaction
  - Steeltoe.Discovery.Client
- Single configurable provider today:
  - Steeltoe.Discovery.Eureka.Client – client for Netflix Eureka Service registry
- Application type support
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET Core
  - Console apps (.NET Framework and .NET Core)
- Steeltoe sample applications
  - https://github.com/SteeltoeOSS/Samples/tree/master/Discovery
  - https://github.com/SteeltoeOSS/Samples/tree/master/FreddysBBQ
  - https://github.com/SteeltoeOSS/Samples/tree/master/MusicStore

Spring Cloud Service Registry Basics

- Use Service IDs, not URLs, to locate services
- Client-side or server-side load balancing



Steeltoe Eureka Client

- Enables interaction with Netflix Eureka Service Registry
  - OSS Netflix Eureka Server – use `` `Steeltoe.Discovery.Client` ``
  - PCF Netflix Eureka Server - use `` `Pivotal.Discovery.Client` ``
- Three step process to enable the Steeltoe Eureka client
  - Configure Discovery client settings – use values from the built Configuration
  - Add Discovery client to service container - `` `AddDiscoveryClient(Configuration)` ``
  - Use Discovery client – `` `UseDiscoveryClient() - `starts up client background thread ``
    - For Eureka, registered services are pulled from Eureka Server
- Service Discovery client settings
  - Normally just add settings to Configuration
    - Put in `` `appsettings.json` ``, or Config Server repo, etc.
  - Settings for discovering services: `` `eureka:client:...` ``
  - Settings for registering as a service: both `` `eureka:instance:...` `` & `` `eureka:client:...` ``

Steeltoe Eureka Client Settings

- Some of the many Eureka settings:
  - `eureka:client:serviceUrl` - Eureka server URL, default(http://localhost:8761/eureka/)
  - `eureka:client:shouldRegisterWithEureka` - enable/disable registering as a service, default(true)
  - `eureka:client:shouldFetchRegistry` - enable/disable fetching registry periodically, default(true)
  - `eureka:client:validate_certificates` - enable/disable cert validation, default(true)
  - `eureka:client:registryFetchIntervalSeconds` - fetch interval, default(30)
  - `eureka:client:shouldFilterOnlyUpInstances` - only UP instances, default(true)
  - `eureka:instance:name` - name to register under, default(`spring:application:name`)
  - `eureka:instance:instanceId` - unique ID scoped to `name`, default(hostname)
  - `eureka:instance:port` - port number to register on, default(80)
  - `eureka:instance:hostName` - host name to register on, default(hostname)
  - `eureka:instance:leaseRenewalIntervalInSeconds` - how often heartbeats are sent, default(30)
  - `eureka:instance:leaseExpirationDurationInSeconds` - heartbeat lost delay, default(90)
- Lets look at some code!

Using Steeltoe Eureka Client

- When `AddDiscoveryClient(config)` is done in Startup class:
  - Adds Steeltoe `IDiscoveryClient` as a Singleton to service container
  - Can be injected into Controllers, Views, etc.
  - Can use the interface to access registered services by name – `GetInstances`(name)
- When `UseDiscoveryClient()` is done in Startup class:
  - Starts background thread fetching and registering services

Using Steeltoe Eureka Client to Find Services

- Inject `IDiscoveryClient` into your Controller, View, etc.
  - Can use the interface to access registered services by name – `GetInstances`(name)
- Alternatively, use `DiscoveryHttpClientHandler` – an `HttpClientHandler` for use with `HttpClient`
  - Integrates service lookup with issuing `HttpClient` requests
  - Handler intercepts requests and attempts to resolve `host` portion of the request URL as a service name
    - Replaces it with resolved address if successful
    - Leaves alone if not

Using Eureka Server on Cloud Foundry

- Create instance of Eureka Server using CF CLI
  - `` `cf create-service p-service-registry standard myDiscoveryService` ``
  - Spins up eureka server in org: `p-spring-cloud-services`, space: `instances`
  - Use `` `cf service` `` to check status of service
- Bind instance to applications
  - `` `cf bind-service appName myDiscoveryService` ``
  - Also specify binding in `manifest.yml`
    - `` `services:` `` section-> add `` `myDiscoveryService` ``
- Steeltoe Discovery Client detects `p-service-registry` binding
  - Overrides `` `appsettings.json` `` client settings with binding information
- Use Eureka Server dashboard to examine registered services - http://localhost:8761/
- Lets look at some code!

Using Self-signed Certificates on Cloud Foundry

- Communications between Discovery Client and Eureka Server on PCF uses TLS/SSL.
  - Default behavior for Steeltoe Client is to attempt to validate server certificate
- Can disable server certificate validation using client setting:
  - `` `eureka:client:validate_certificates` `` - enable/disable cert validation, default(true)
- .NET apps running in Linux containers can use `Trusted System Certificate` feature on PCF
  - .NET Core on Linux uses OpenSSL
  - Install the custom root certificate using Bosh
- .NET apps running in Windows containers can NOT uses this feature
  - Must manually install the custom root certificate on each Windows cell

Diagnosing Problems

- Turn on logging in Steeltoe Eureka client:
  - Modify `appsettings.json` to look like:

```
"Logging": {
  "IncludeScopes": false,
  "LogLevel": {
    "Default": "Debug",
    "System": "Debug",
    "Microsoft": "Debug",
    "Pivotal": "Debug",
    "Steeltoe":  "Debug"
  }
```

Example Steeltoe Eureka Client - Registering

2017-03-14T08:26:58.46-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:26:58.46-0600 [APP/PROC/WEB/0]OUT GetRequestContent generated JSON:
{"instance":{"instanceId":"fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1","app":"FORTUNESERVICE","appGroupName":null,"ipAddr":"10.254.0.10","sid":"na","port":{"@enabled":"True","$":80},"securePort":{"@enabled":"False","$":443},"homePageUrl":"http://fortuneservice.apps.testcloud.com:80/","statusPageUrl":"http://fortuneservice.apps.testcloud.com:80/info","healthCheckUrl":"http://fortuneservice.apps.testcloud.com:80/health","secureHealthCheckUrl":null,"vipAddress":"fortuneService","secureVipAddress":null,"countryId":1,"dataCenterInfo":{"@class":"com.netflix.appinfo.InstanceInfo$DefaultDataCenterInfo","name":"MyOwn"},"hostName":"fortuneservice.apps.testcloud.com","status":"UP","overriddenstatus":"UNKNOWN","leaseInfo":{"renewalIntervalInSecs":30,"durationInSecs":90,"registrationTimestamp":0,"lastRenewalTimestamp":0,"renewalTimestamp":0,"evictionTimestamp":0,"serviceUpTimestamp":0},"isCoordinatingDiscoveryServer":false,"metadata":{"instanceId":"46b9f44c-e1d4-4a5a-75d3-1637abc518f1"},"lastUpdatedTimestamp":1489501616905,"lastDirtyTimestamp":1489501616905,"actionType":"ADDED"}}
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT RegisterAsync https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/eureka/apps/FORTUNESERVICE, status: NoContent
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT RegisterAsync https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/eureka/apps/FORTUNESERVICE, status: NoContent
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.DiscoveryClient[0]
2017-03-14T08:26:58.65-0600 [APP/PROC/WEB/0]OUT Register FORTUNESERVICE/fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1 returned: NoContent

Example Steeltoe Eureka Client - Heartbeat/Renew

2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT SendHeartbeatAsync https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/eureka/apps/FORTUNESERVICE/fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1?status=UP&lastDirtyTimestamp=1489501616905, status: OK, instanceInfo: null
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT SendHeartbeatAsync https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/eureka/apps/FORTUNESERVICE/fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1?status=UP&lastDirtyTimestamp=1489501616905, status: OK, instanceInfo: null
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.DiscoveryClient[0]
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT Renew FORTUNESERVICE/fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1 returned: OK
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.DiscoveryClient[0]
2017-03-14T08:30:58.74-0600 [APP/PROC/WEB/0]OUT Renew FORTUNESERVICE/fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1 returned: OK

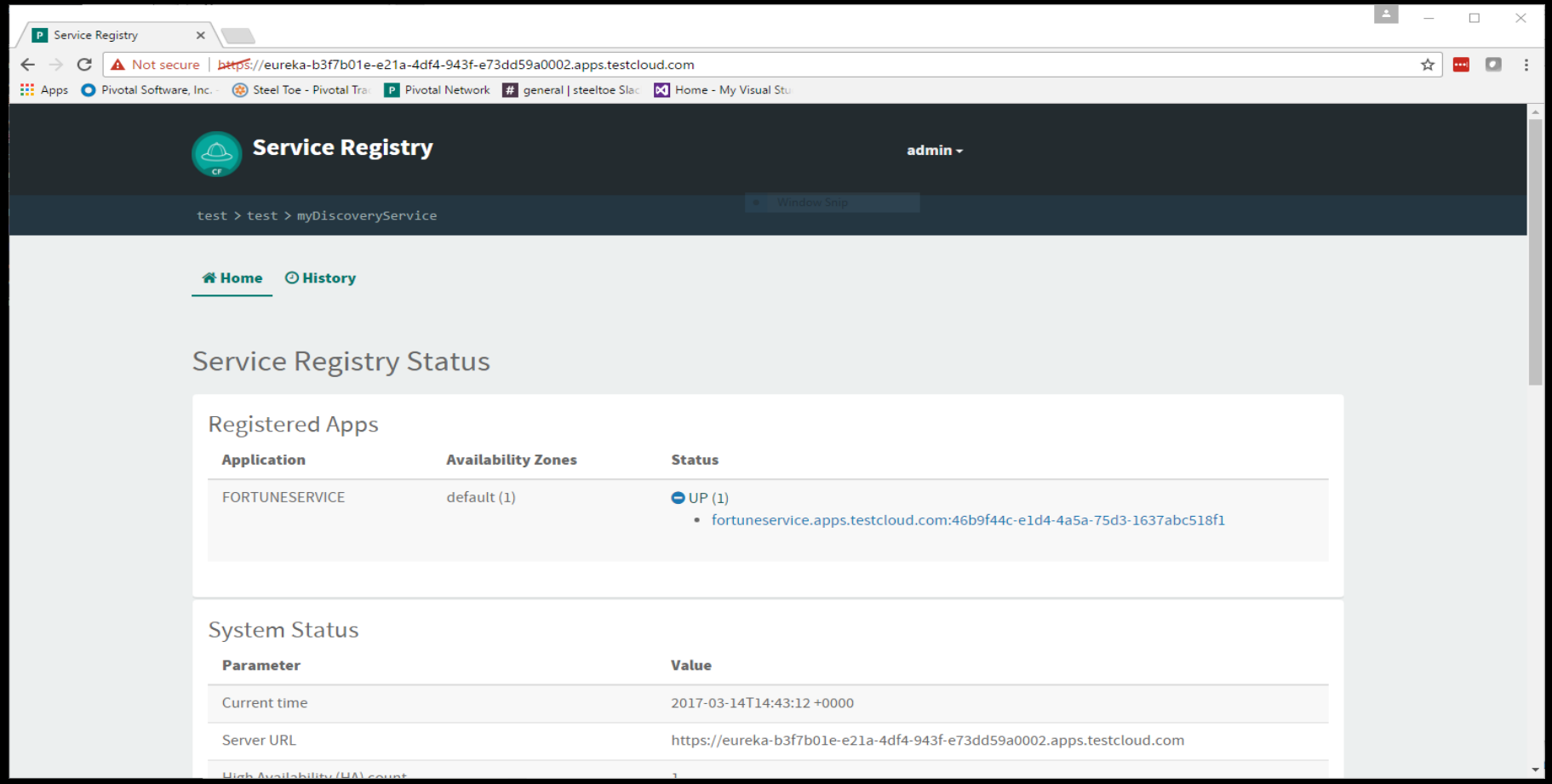
Example Steeltoe Eureka Client – Registry Fetch

2017-03-14T08:37:02.91-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.Transport.EurekaHttpClient[0]
2017-03-14T08:37:02.91-0600 [APP/PROC/WEB/0]OUT DoGetApplicationsAsync https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/eureka/apps/, status: OK, applications: Applications[Application[Name=FORTUNESERVICE,Instances=Instance[InstanceId=fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1,HostName=fortuneservice.apps.testcloud.com,Port=80],]]
2017-03-14T08:37:02.91-0600 [APP/PROC/WEB/0]OUT dbug: Steeltoe.Discovery.Eureka.DiscoveryClient[0]
2017-03-14T08:37:02.91-0600 [APP/PROC/WEB/0]OUT FetchFullRegistry returned: OK, Applications[Application[Name=FORTUNESERVICE,Instances=Instance[InstanceId=fortuneservice.apps.testcloud.com:46b9f44c-e1d4-4a5a-75d3-1637abc518f1,HostName=fortuneservice.apps.testcloud.com,Port=80],]]

Diagnosing Problems

- Look at Service Registry Dashboard
  - Use log output from Eureka client to determine which server instance to connect to:
    - e.g. https://eureka-b3f7b01e-e21a-4df4-943f-e73dd59a0002.apps.testcloud.com/
  - See what services are currently registered
    - See history of registrations
- Look at log output for Eureka Server instance
  - Instances run in org: `p-spring-cloud-services` space: `instances`
  - Use log output from client to determine which server instance to view

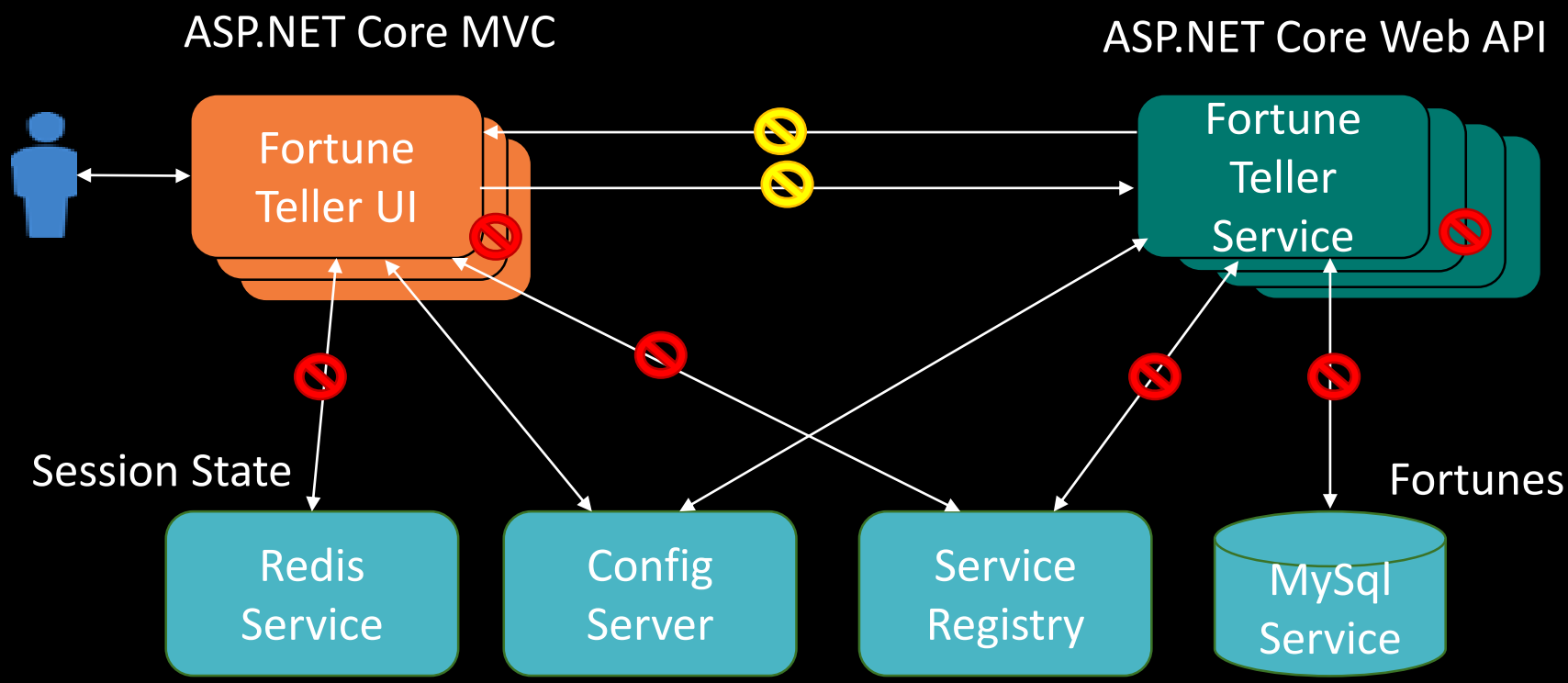
Service Registry Dashboard



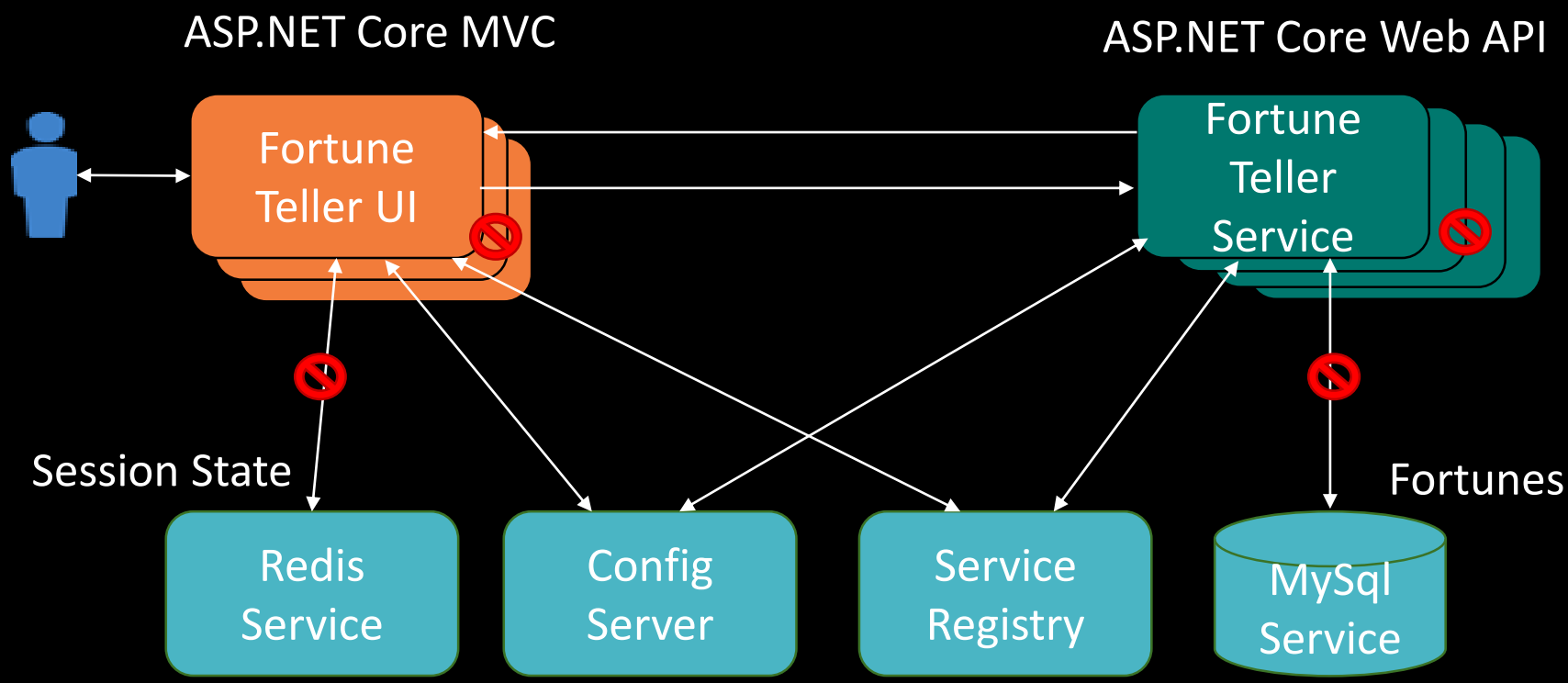
Lab8 – Fortune Teller App

- Use Steeltoe and Spring Cloud Eureka Server
  - Update configuration for Eureka
  - Update code to use Steeltoe Discovery client
  - Run Eureka Server locally for test/development
  - Deploy to Cloud Foundry

Lab8 – Fortune Teller App – Before Lab



Lab8 – Fortune Teller App – After Lab



Steeltoe Connectors

ASP.NET CORE SESSION, KEY RING, CONNECTORS

Steeltoe Connectors Overview

- Simplify using Cloud Foundry services
  - Can configure settings for local usage (e.g. `appsettings.json`, Config Server, etc.)
  - When app pushed to Cloud Foundry bindings auto detected and override settings
  - Adds `Connection` or `DbContext` objects to service container
- Several connector NuGets
  - `Steeltoe.CloudFoundry.Connector.MySql`
  - `Steeltoe.CloudFoundry.Connector.Postgres`
  - `Steeltoe.CloudFoundry.Connector.Rabbit`
  - `Steeltoe.CloudFoundry.Connector.Redis`
  - `Steeltoe.CloudFoundry.Connector.OAuth`
- Application type support
  - ASP.NET - MVC, WebForm, WebAPI, WCF
  - ASP.NET Core
  - Console apps (.NET Framework and .NET Core)

Steeltoe MySql Connector Usage

- Configures and adds a `MySqlConnection` or `DbContext` to the container
  - Built on latest version of Oracle Connector/NET
  - Supports both EntityFramework and EntityFrameworkCore `DbContexts`
- Usage
  - Add `Steeltoe.CloudFoundry.Connector.MySql` NuGet
  - Add CloudFoundry config provider to Configuration Builder (i.e. `AddCloudFoundry()`)
    - Not needed if already using Steeltoe Config Server client (i.e. `AddConfgServer()`)
  - Configure MySql client settings
  - Add `MySqlConnection` or `DbContext` to service container
- MySql client settings
  - Add settings to Configuration via `` `appsettings.json` ``, Config Server, etc.
  - Settings for configuring client-> `` `mysql:client:...` ``

Steeltoe MySql Connector Usage

- MySql client settings:
  - `mysql:client:server` - hostname/address of server, default(localhost)
  - `mysql:client:port ` - port number for server, default(3306)
  - `mysql:client:username` - username for authentication, default(empty)
  - `mysql:client:password` - password for authentication, default(empty
  - `mysql:client:database` - schema to connect to, default(empty)
  - `mysql:client:connectionString` - full connection string, default(empty), use instead of the above
- Add to the service container
  - `AddMySqlConnection(Configuration)` – to inject `MySqlConnection`
  - `AddDbContext<YourContext>(Configuration)` – for EF 6
  - `AddDbContext<YourContext>(o => o.UseMySql(Configuration))` – for EF Core

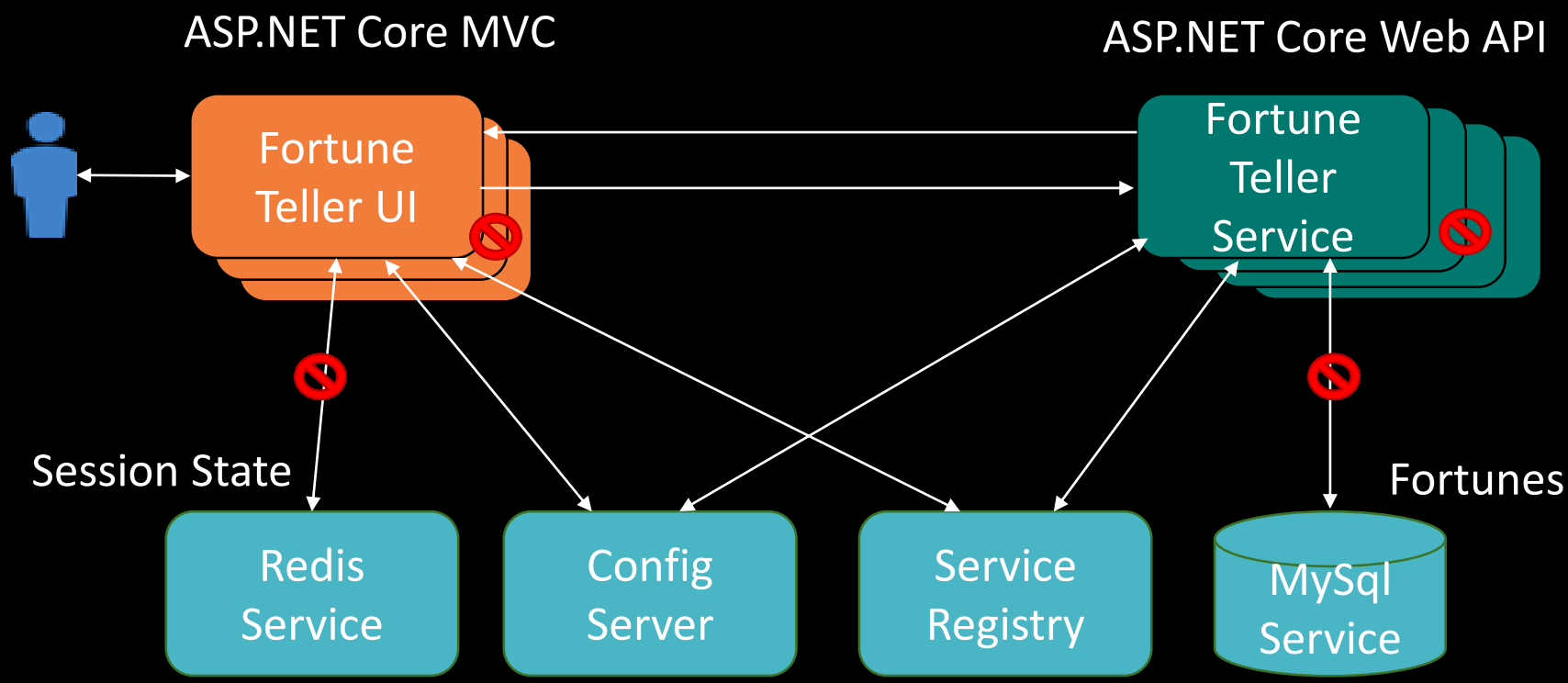
Using MySql Service on Cloud Foundry

- Create instance of MySql service using CF CLI
  - `` `cf create-service p-mysql 100mb myMySqlService` ``
  - Creates a database tenant in server
- Bind instance to applications
  - `` `cf bind-service appName myMySqlService` ``
  - Also specify binding in `manifest.yml`
    - `` `services:` `` section-> add `` `myMySqlService` ``
- Steeltoe MySql connector detects `p-mysql` binding
  - Overrides any "`appsettings.json`" client settings with binding information
- Lets look at some code!

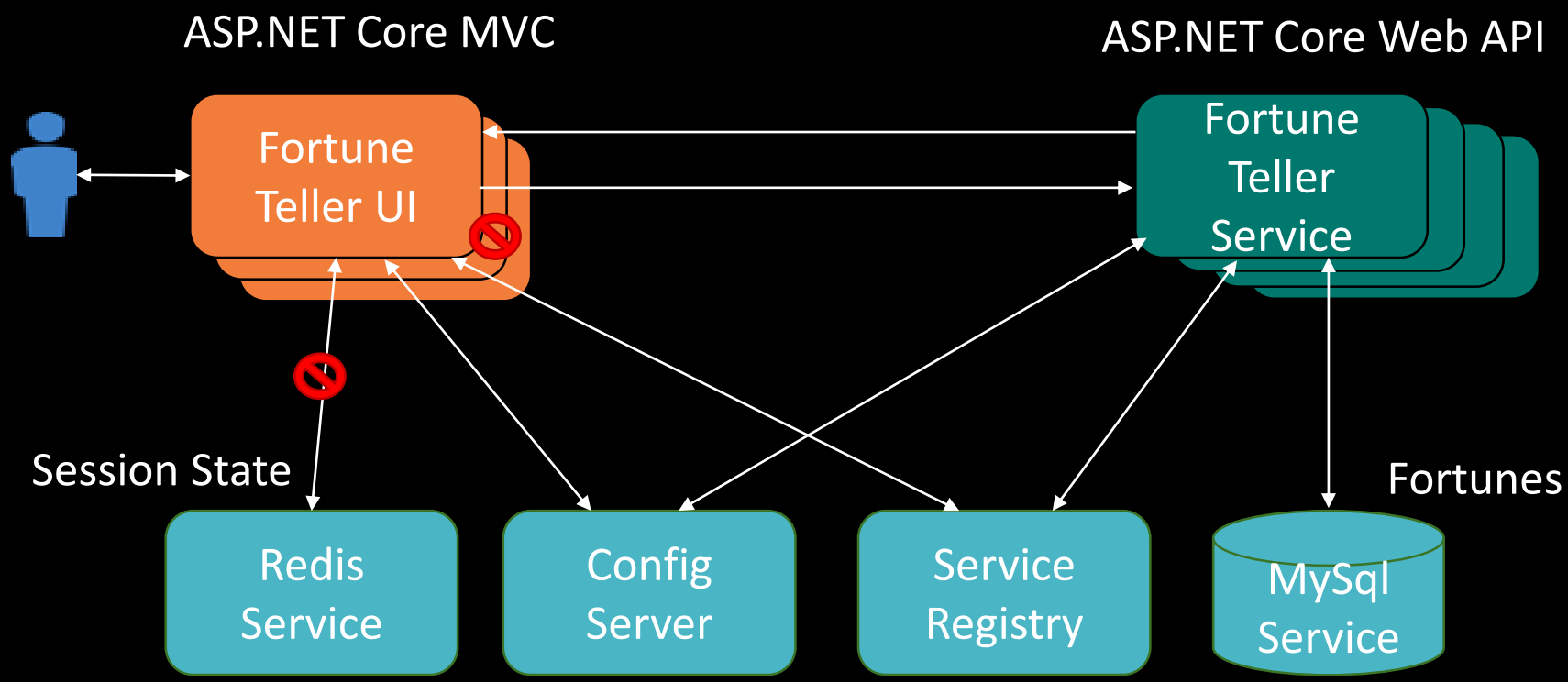
Lab9a – Fortune Teller App

- Use MySql Connector to connect to MySql service
  - When running in development mode use a `FortuneContext` configured using in-memory database
  - When running in any other mode use a `FortuneContext` configured using Steeltoe MySql connector
- Deploy to Cloud Foundry

Lab9a – Fortune Teller App – Before Lab



Lab9a – Fortune Teller App – After Lab



Understanding ASP.NET Core Session

- ASP.NET Core has middleware (i.e. Session) for managing session state
  - Session added as a service – `AddSession()`
  - Session added as middleware to pipeline – `UseSession()`
  - Session service expects to find an `IDistributedCache` in container for storage
- Session state
  - Stored in dictionary
  - Dictionary saved in `IDistributedCache`, defaults to In-Memory cache
  - Session ID used to save and fetch state
  - Session IDs stored in cookie & sent to browser
  - Session IDs are encrypted using `DataProtection` services before adding to cookie
- Access to session is via `HttpContext.Session`
  - `GetXXX`/`SetXXX` methods

Understanding ASP.NET Core DataProtection

- Crypto services for protecting data and for key management
  - Used both internally and optionally by application code
  - Added as a service using `AddDataProtection()`
  - Extension methods used to configure its behavior:
    - `PersistKeysToFileSystem(..)`
    - `PersistKeysToRedis(…)`
- Keys generated and held in key-ring and then stored in a repository
  - Default is to store key ring in local file system repo

Steeltoe Redis Connector Usage

- Configures and adds a ASP.NET Core `RedisCache` and/or StackExchange `IConnectionMultiplexor` to the container
  - `RedisCache` built on top of StackExchange NuGets
- Usage
  - Add `Steeltoe.CloudFoundry.Connector.Redis` NuGet
  - Add CloudFoundry config provider to Configuration Builder (i.e. `AddCloudFoundry()`)
    - Not needed if already using Steeltoe Config Server client (i.e. `AddConfgServer()`)
  - Configure Redis client settings
  - Call `AddDistributedRedisCache()` or `AddRedisConnectionMultiplexor()` to add to service container
- Redis client settings
  - Add settings to Configuration via `` `appsettings.json` ``, Config Server, etc.
  - Settings for configuring client-> `` `redis:client:...` ``

Steeltoe Redis Connector Usage

- Some of the Redis client settings:
  - `redis:client:host` - hostname/address of server, default(localhost)
  - `redis:client:port` - port number for server, default(6379)
  - `redis:client:password` - password for server, default(empty)
  - `redis:client:clientName` - id for connection within server, default(stackexchange)
  - `redis:client:connectRetry` - number times to retry connect, default(stackexchange)
  - `redis:client:connectionString` - stackexchange connection string - default(empty), use instead of
  - `redis:client:instanceId` - RedisCache instanceid for partitioning- default(empty), only RedisCache
- Add to the service container
  - `AddDistribuedRedisCache(config)` – to inject a `RedisCache` as an `IDistributedCache`
  - `AddRedisConnectionMultiplexer(Configuration)` – to inject a StackExchange `IConnectionMultiplexer`

Using Redis Service on Cloud Foundry

- Create instance of Redis service using CF CLI
  - `` `cf create-service p-redis shared-vm myRedisService` ``
  - Creates Redis server instance in a shared VM
- Bind instance to applications
  - `` `cf bind-service appName myRedisService` ``
  - Also specify binding in `manifest.yml`
    - `` `services:` `` section-> add `` `myRedisService` ``
- Steeltoe Redis connector detects `p-redis` binding
  - Overrides any "`appsettings.json`" client settings with binding information
- Lets look at some code!

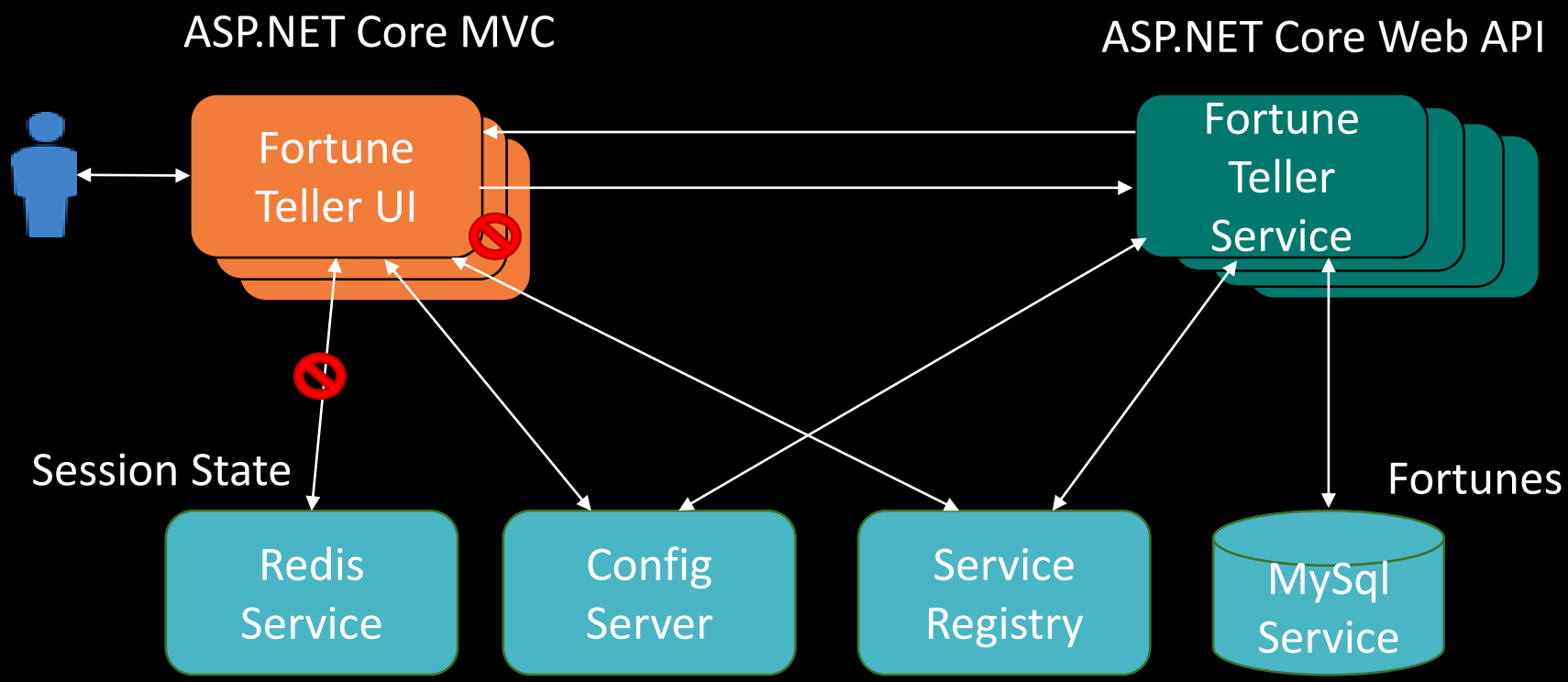
Steeltoe Redis KeyStorage Connector Usage

- Configures `DataProtection` to use a Cloud Foundry Redis service for Key Ring storage
  - Takes a StackExchange `ConnectionMultiplexor` as constructor argument
- Usage
  - Add `Steeltoe.Security.Dataprotection.Redis` NuGet
  - Add CloudFoundry config provider to Configuration Builder (i.e. `AddCloudFoundry()`)
    - Not needed if already using Steeltoe Config Server client (i.e. `AddConfgServer()`)
  - Configure Redis client settings
  - Call `AddRedisConnectionMultiplexor()` to add to service container
  - Call `PersistKeysToRedis()` to use Redis for Key Storage
- Redis client settings
  - Same as discussed earlier
- Lets look at some code!

Lab9b – Fortune Teller App

- Use Redis Connector to connect to Redis service and setup Session cache storage as follows:
  - When running in development mode use default in-memory cache for session storage
  - When running in any other mode use the Redis based cache for session storage
- Use Redis KeyStorage Connector to configure the DataProtection service to use Redis for key ring storage as follows:
  - When running in development mode use default file system key ring storage
  - When running in any other mode use the Redis based cache for key ring storage
- Deploy to Cloud Foundry

Lab9b – Fortune Teller App – Before Lab



Lab9b – Fortune Teller App – After Lab