# The Anatomy of a Secure Web Application Using Java


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# Introductions

- John Field
  - Security Architect at 

 @architectedsec

 https://johnpfield.wordpress.com

*Joint work with Shawn McKinney, Principal at Symas.

# Agenda

- Introduction
  - Quick Demonstration
- Step-by-Step “How To” Security Guidance
  - Based upon the “***FortressDemo2”*** sample application
- Survey of Security Architecture Patterns
  - Requirements, Capabilities
- Conclusion
  - Project coordinates

# Tutorial Approach

- Examine a typical enterprise Java Web application, one architectural layer at a time.
- Goals:
  - Be able to recognize and identify some well-known security architecture patterns.
  - Understand how each pattern contributes to satisfying the overall security requirements.
  - Learn how to implement these patterns via pragmatic, hands-on configuration guidance.

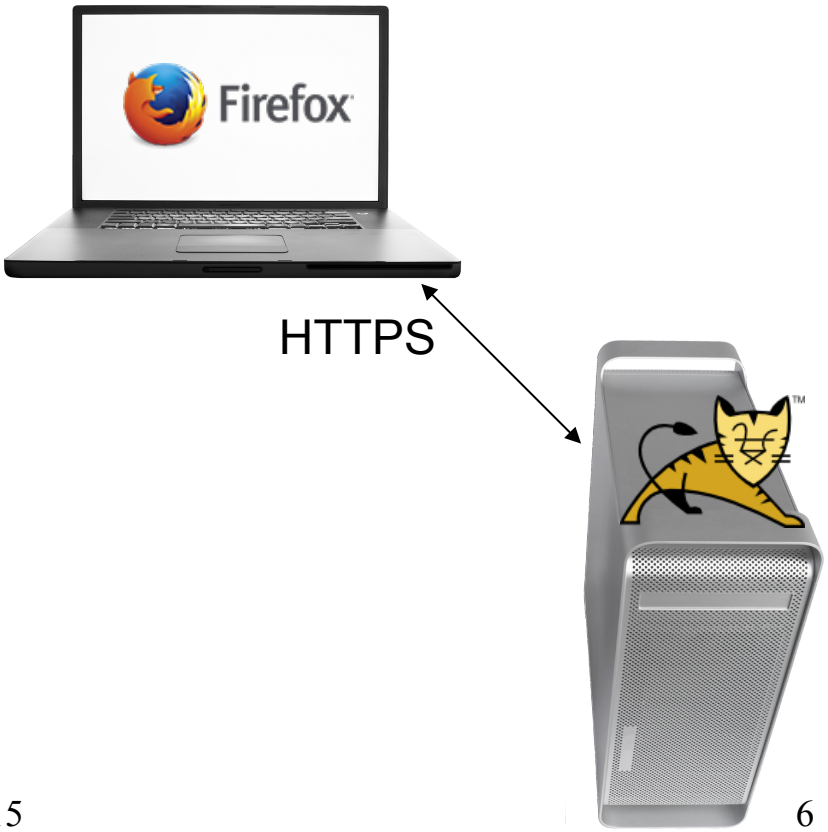

# Be a "Full Stack" Developer

*"No one can know everything about everything, but you should be able to visualize what happens up and down the stack as an application does its thing."*

-- C. Bueno of Facebook, c. 2010

# Our Business Use Case

- Deployment of an Enterprise Java Web Application.
  - Assumes a standard User Agent / Browser-based HTTPS access path.
- We have requirements for:
  - User Authentication
  - User Authorization
  - Audit Logging
  - Confidentiality and Integrity

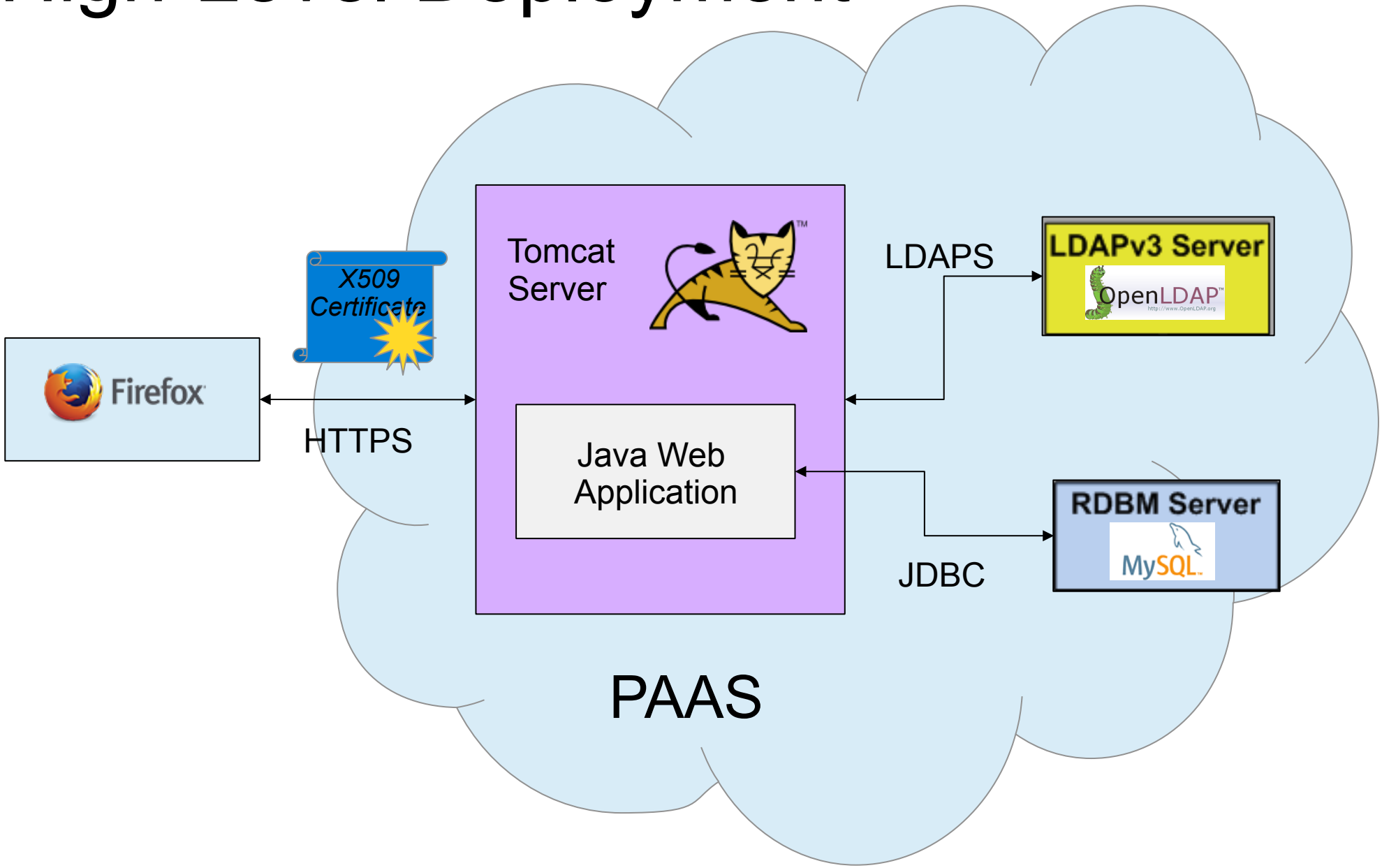


# Core Security Architecture Patterns

1. Use HTTPS / TLS on a shared network.
2. Use Container-based Enforcement
3. Delegate to a Trusted Third Party (TTP).
4. Use RBAC to express access control policy.
5. Create an audit log.

*The patterns remain the same, whether deploying on standalone servers, or to the cloud.*

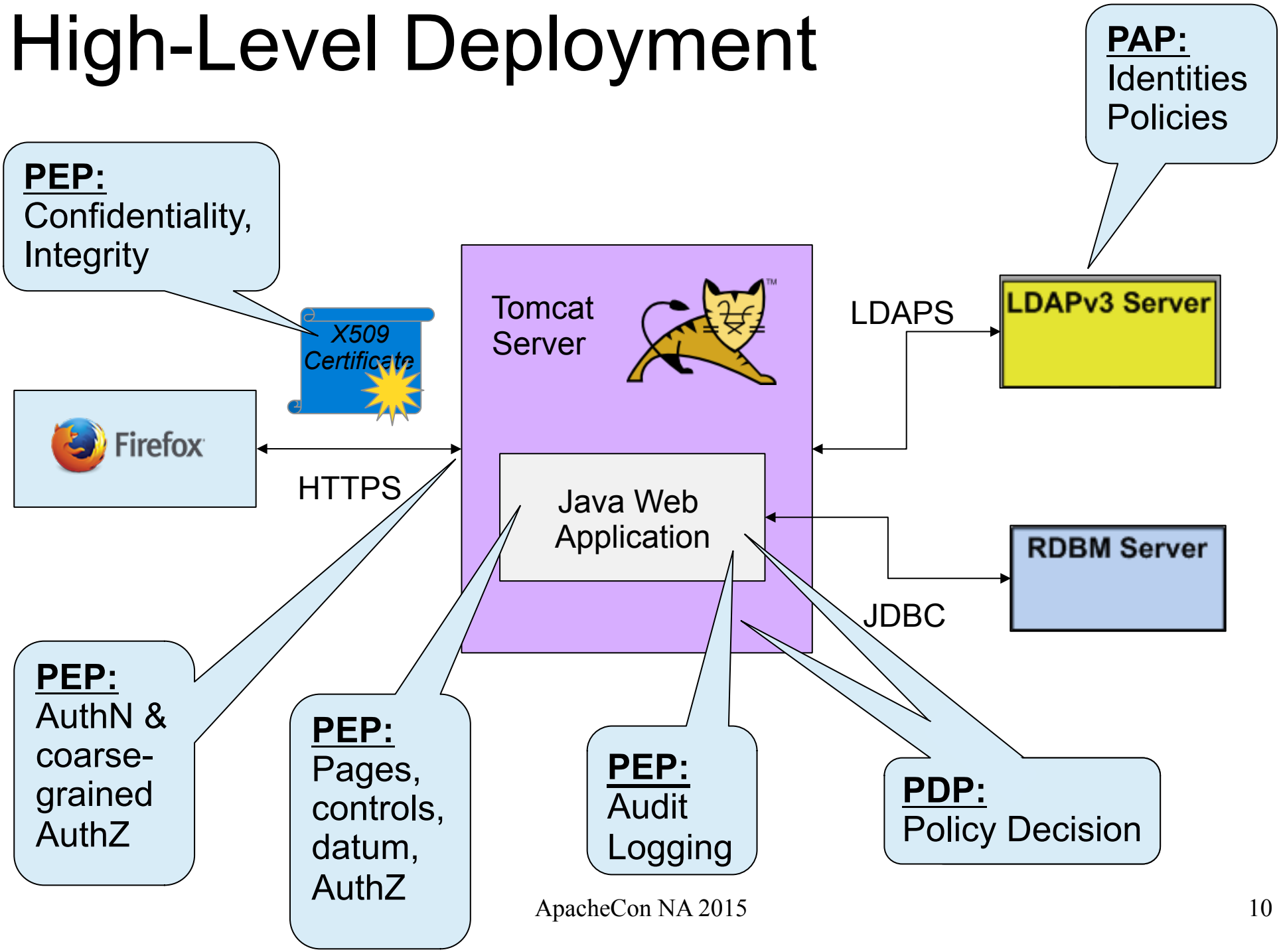
# High-Level Deployment



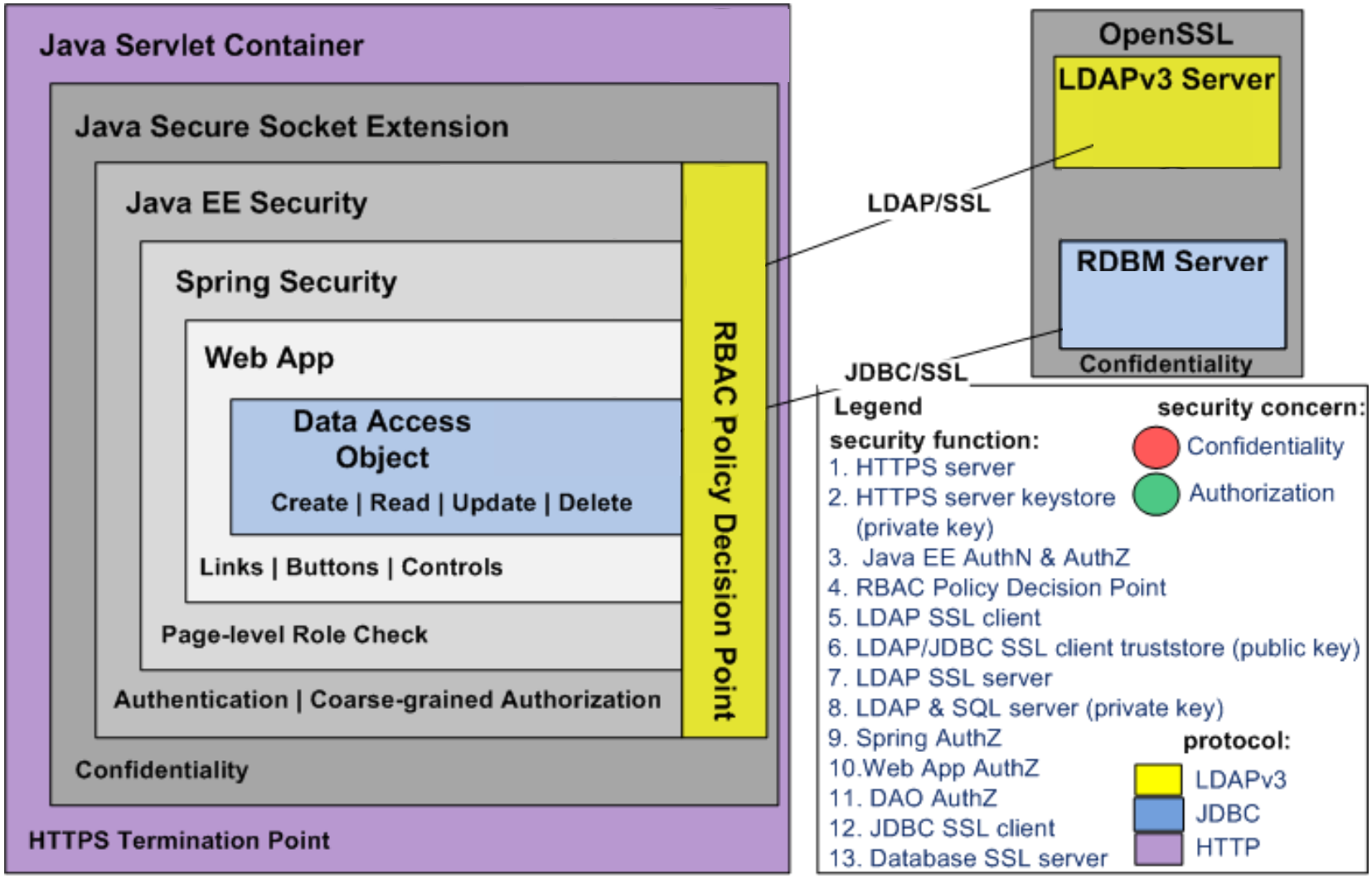
# Demonstration

- Communications secured via SSL/TLS.
- Users authenticate via enterprise LDAP.
- Resource authorization via RBAC.
  - Static (type-based) and dynamic (instance-based)
    - Including Static and Dynamic Separation of Duties
- Audit logging for all application events
  - i.e. any change of state

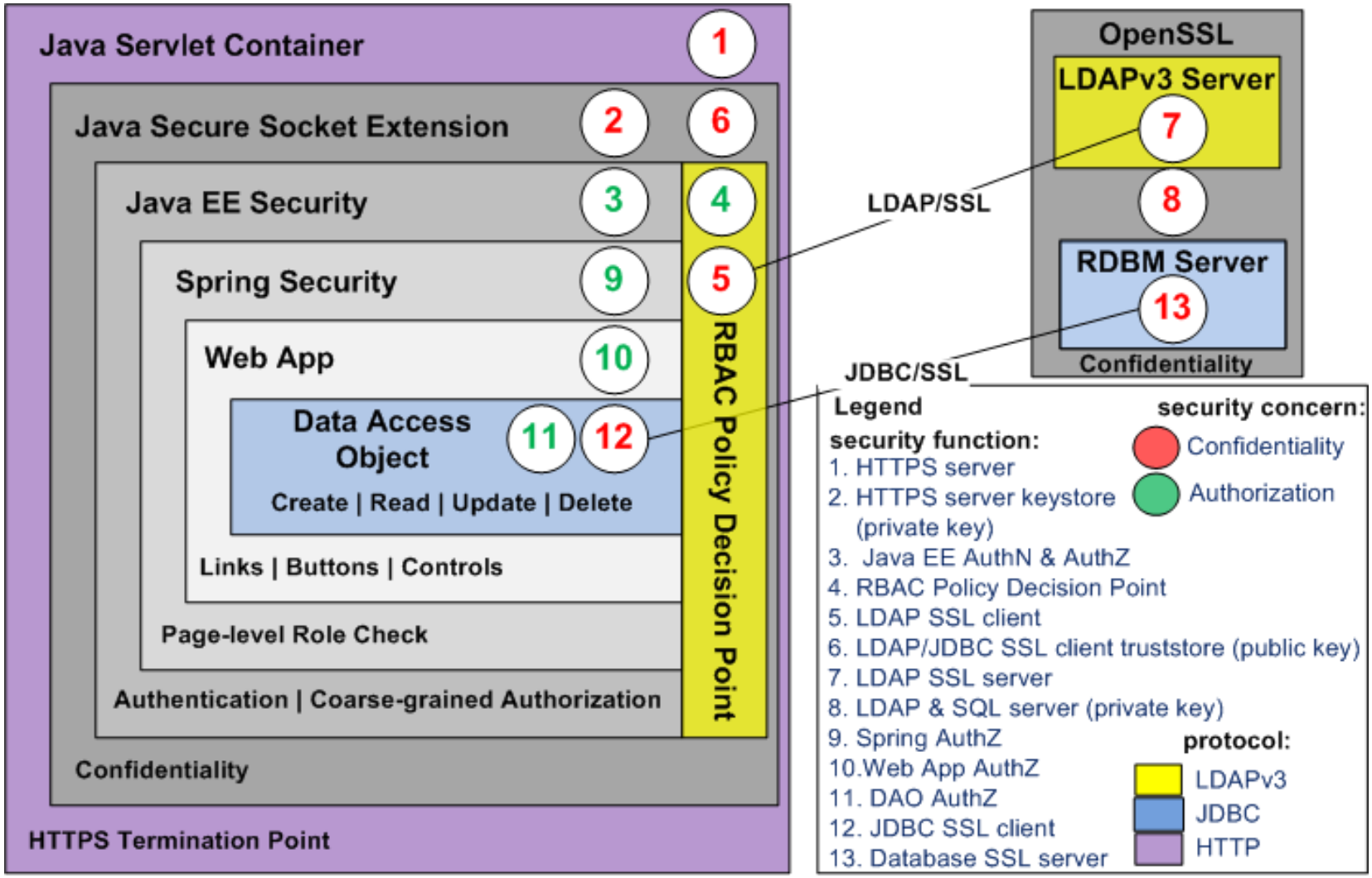
# High-Level Deployment



# The Anatomy of a Secure Java Web Application



# The Anatomy of a Secure Java Web Application



# Here we go!

# Need to:

- Create certificates.
- Put them in the right place.

# Step 1: Issue Certificates

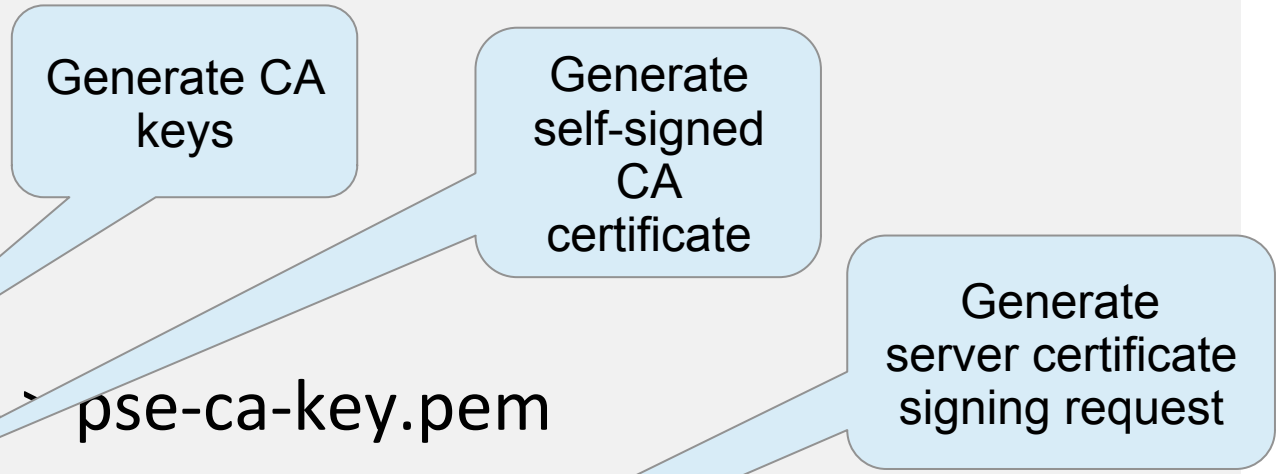
```
# openssl version -b
```

If date < Mon Apr 7 2014, and version = 1.0.1, then installation is vulnerable to Heart Bleed and must be upgraded.

```
# sudo apt-get upgrade openssl
```

# Step 1: Issue Certificates

```
# mkdir certs

# cd certs


# openssl genrsa 2048 > pse-ca-key.pem

# openssl req -new -x509 -nodes -days 3600 -key pse-ca-
key.pem -out pse-ca-cert.pem

# openssl req -newkey rsa:2048 -days 1825 -nodes -keyout
oreo-server-key.pem -out oreo-server-req.pem
```



# Step 1: Issue Certificates

```
# openssl rsa -in oreo-server-key.pem -out oreo-server-key.pem

# openssl x509 -req -in oreo-server-req.pem -days 1825 -CA pse-ca-cert.pem -CAkey pse-ca-key.pem -set_serial 01 -out oreo-server-cert.pem

# openssl pkcs12 -export -name fortressDemo2ServerCACert -in oreo-server-cert.pem -inkey oreo-server-key.pem -out mykeystore.p12
```

Remove passphrase from private key

Sign server certificate request

Generate a temporary PKCS12 keystore.

# Step 1: Issue Certificates

Use Java keytool to import PKCS12 into JKS key store for Web server

```
# keytool -importkeystore -destkeystore mykeystore -srckeystore mykeystore.p12 -srcstoretype pkcs12 -alias fortressDemo2ServerCACert
```

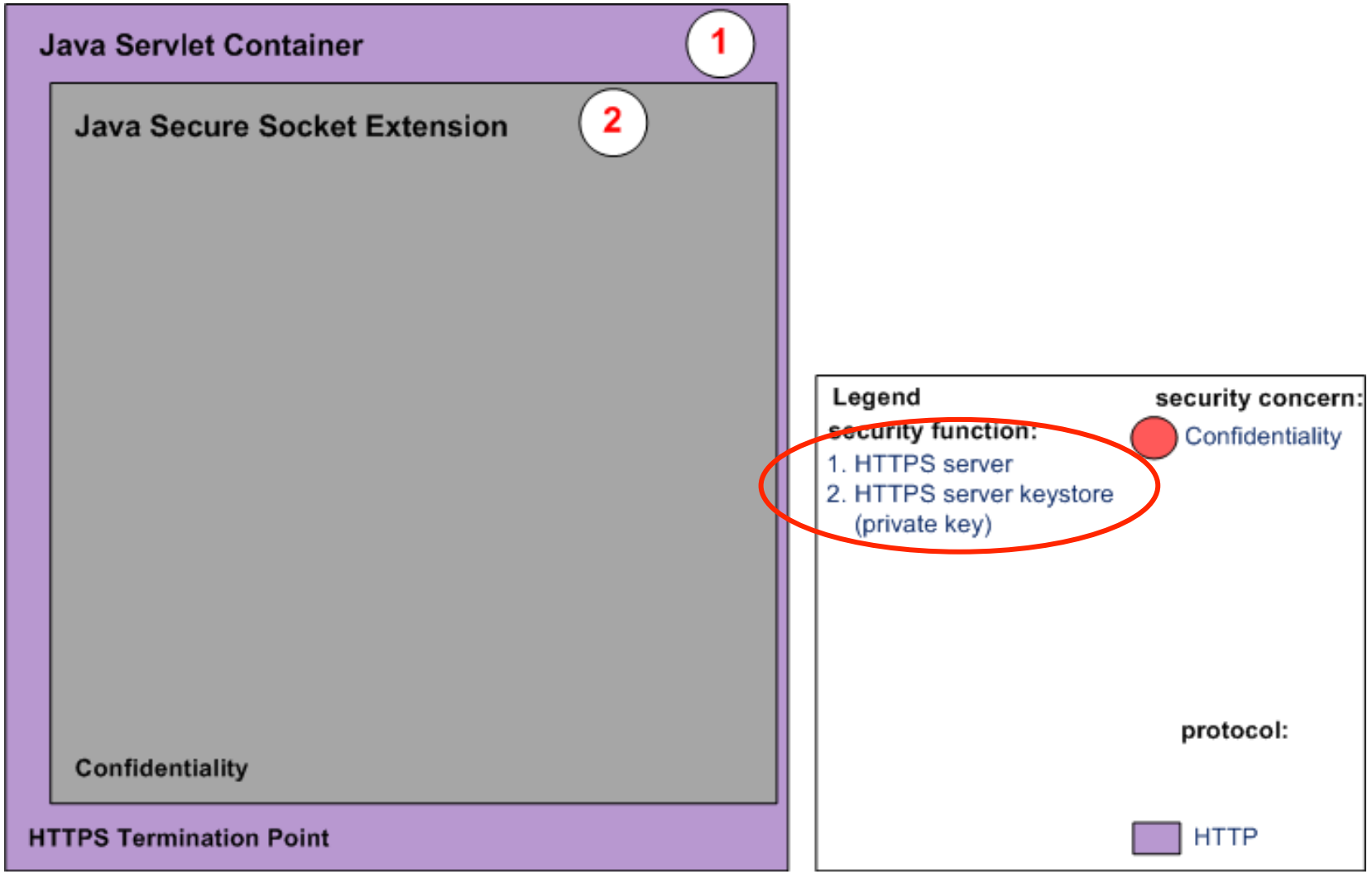
Use Java keytool to import CA cert into JKS truststore for client application

```
# keytool -import -alias fortressDemo2ServerCACert -file pse-ca-cert.pem -keystore mytruststore
```

# Certificate Summary

- Server-side:  4 Files.
  - Used by OpenLDAP and MySQL to offer TLS.
    1. pse-ca-cert.pem
    2. oreo-server-cert.pem
    3. oreo-server-key.pem
  - Used by Tomcat JSSE to offer HTTPS.
    4. mykeystore
- Client-side:  1 File.
  - Used by the Web application JSSE to negotiate HTTPS / TLS with OpenLDAP and MySQL servers.
    - mytruststore

# Step 2: Tomcat HTTPS



# Step 2: Tomcat HTTPS

```
# sudo apt-get install tomcat7 tomcat7-admin tomcat7-docs
# vi /usr/share/tomcat7/conf/server.xml
```

# Step 2: Tomcat HTTPS

- Add the following to **server.xml**:

```
<Connector port="8443" maxThreads="200"
        scheme="https" secure="true"
        SSLEnabled="true“
        keystoreFile= “conf/mykeystore”
        keystorePass=”changeit”
        clientAuth="false" sslProtocol="TLS"/>
```

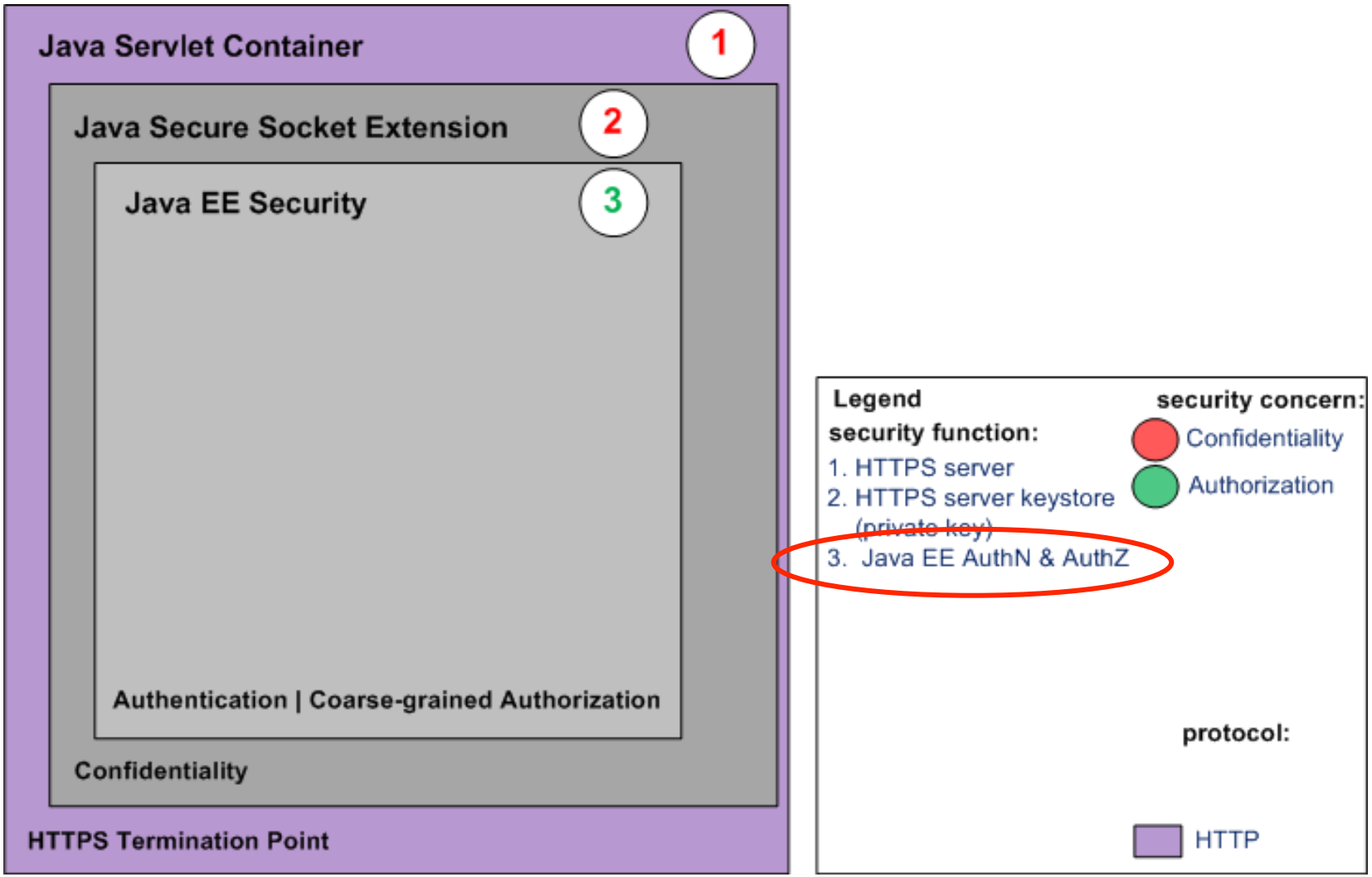
# Step 2: Tomcat HTTPS

Put mykeystore in the indicated place

```
# sudo cp certs/mykeystore  /usr/share/tomcat7/conf

# sudo cp sentry-1.0-RC39-proxy.jar /usr/share/tomcat7/lib


# sudo service tomcat7 restart
```

While you are at it, add the JEE Security Realm Provider Proxy jar.

# Step 3: Enable Java EE Security



# Add JEE Security To Web.xml

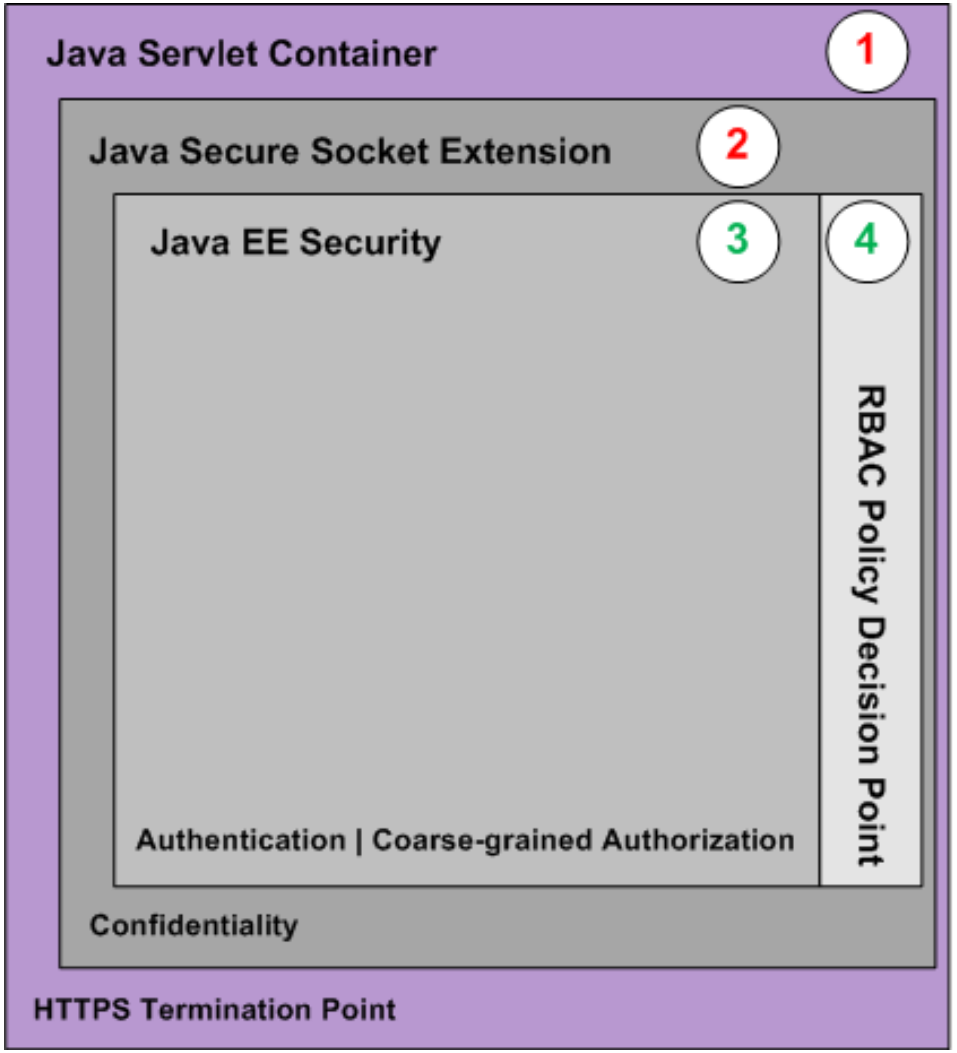
```
<security-constraint>
   <display-name>My Security Constraint</display-name>
   <web-resource-collection>
      <web-resource-name>Protected Area</web-resource-name>
      <url-pattern>/secured/*</url-pattern>
   </web-resource-collection>
   <auth-constraint>
      <role-name>ROLE_DEMO_USER</role-name>
    </auth-constraint>
</security-constraint>
<login-config>
   <auth-method>FORM</auth-method>
   <realm-name>MySecurityRealm</realm-name>
   <form-login-config>
      <form-login-page>/login/login.html</form-login-page>
      <form-error-page>/login/error.html</form-error-page>
   </form-login-config>
</login-config>
```

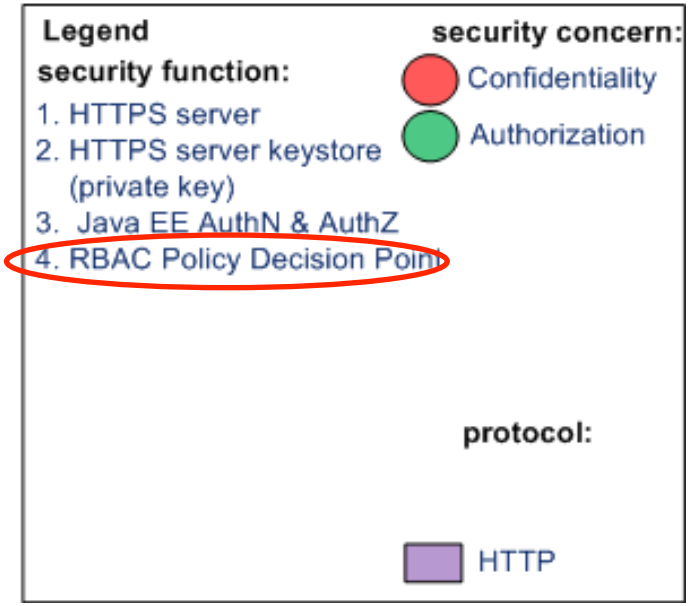
Declarative coarse-grained authorization.

Enforced high in the stack.

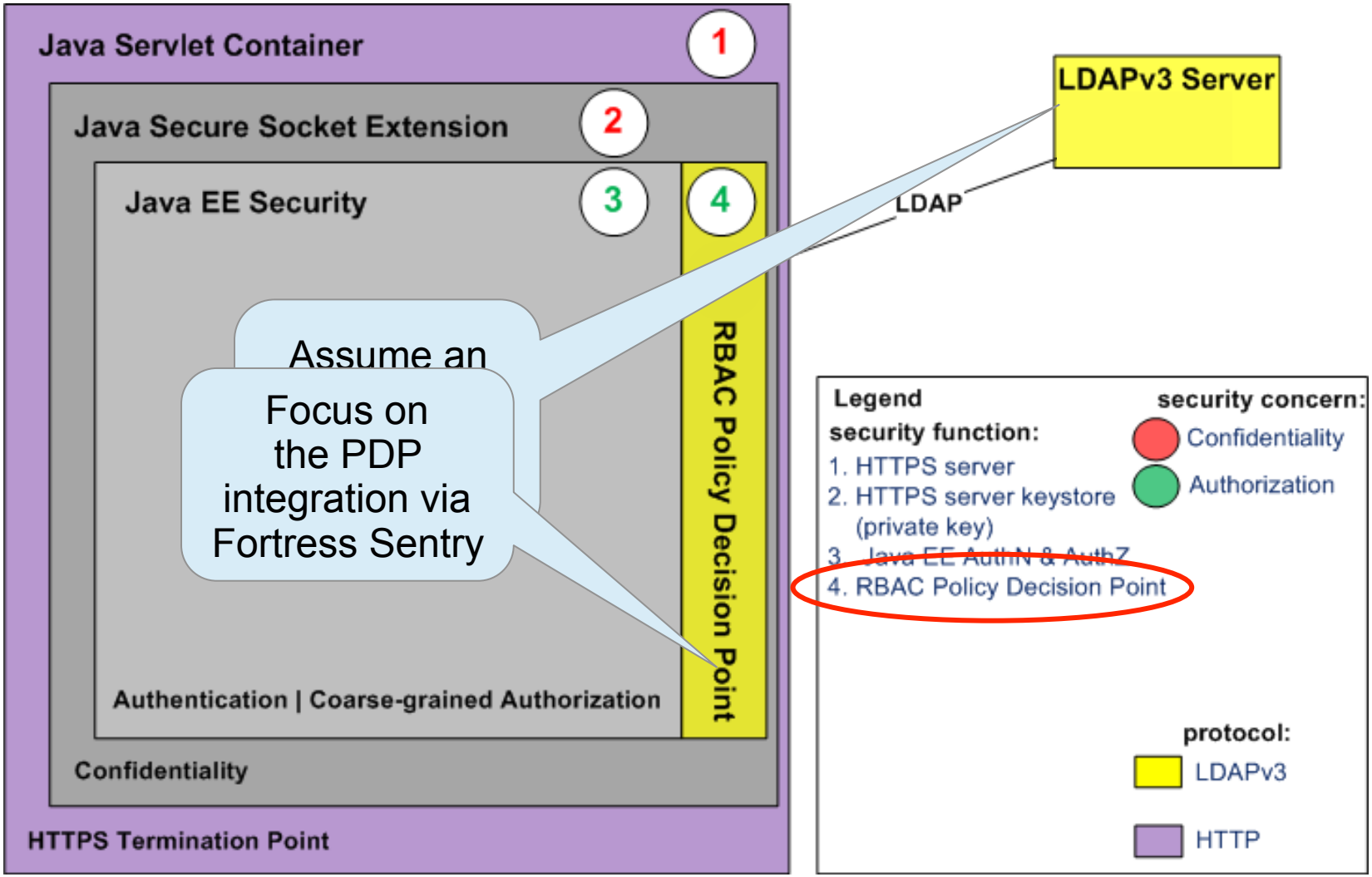
HTML Form-based Authentication

# Step 4: Enable Policy Decision Point



# Step 4: Enable Policy Decision Point



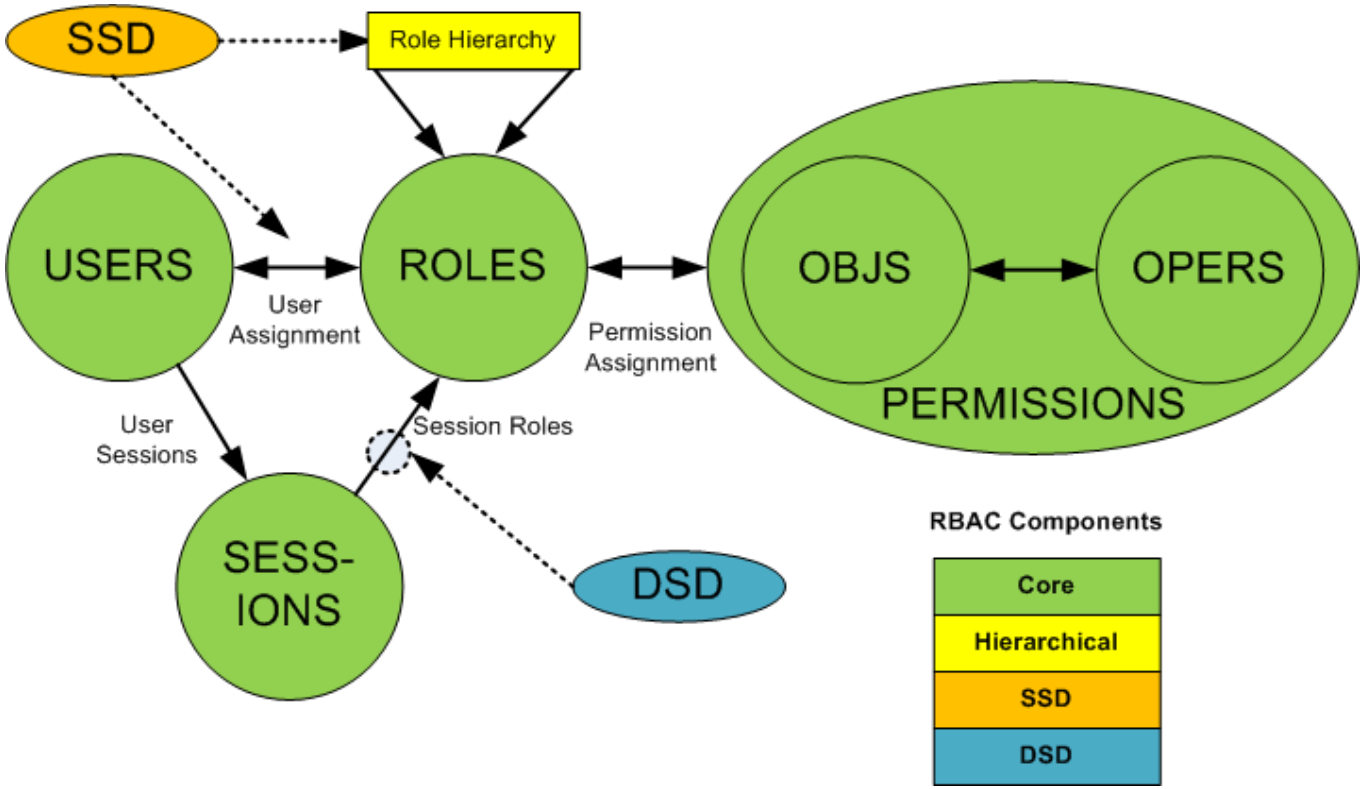
# Fortress Sentry RBAC PDP

- Sentry is a standards-compliant RBAC PDP
  - Conforms to NIST / ANSI / INCITS 359
- Integrates into Tomcat
  - JEE Custom Realm Provider
- Integrates into application
  - As a standard Java component.
    - Add the dependency to Maven pom.xml
    - Add the Bean definition to Spring applicationContext.xml

# ANSI RBAC – the TL;DR

# ANSI RBAC – INCITS 359

**RBAC0**:
Users, Roles,
Perms, Sessions
**RBAC1**:
Hierarchical Roles
**RBAC2**:
Static Separation
of Duties
**RBAC3**:
Dynamic Separation of Duties



# ANSI RBAC Object Model

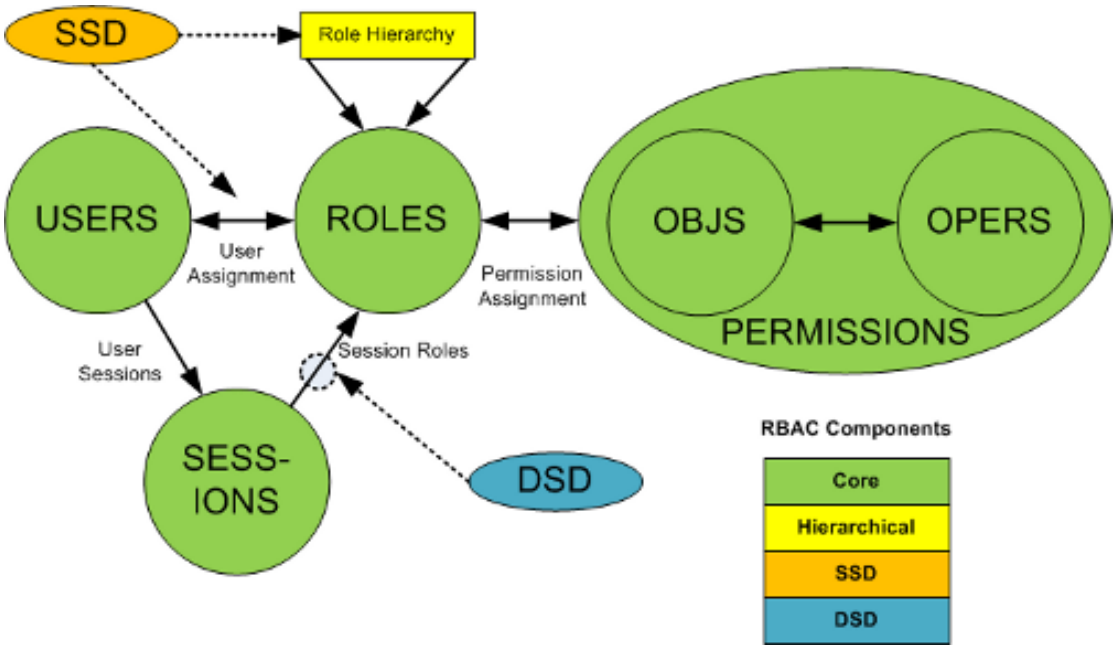
Six basic elements:

1. User – human or machine entity
2. Role – a job function within an organization
3. Object – maps to system resources
4. Operation – executable image of program
5. Permission – approval to perform an Operation on one or more Objects
6. Session – contains set of activated roles for User

# ANSI RBAC Functional Model

Three standard interface definitions:

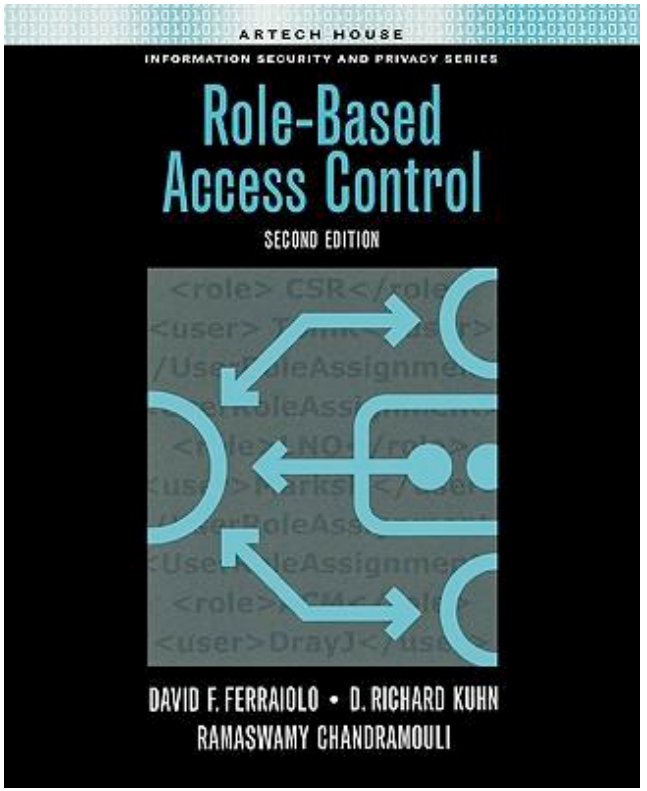
1. Administrative
   - Policy CRUD
2. Review
   - Policy Interrogation
3. System
   - Policy Enforcement



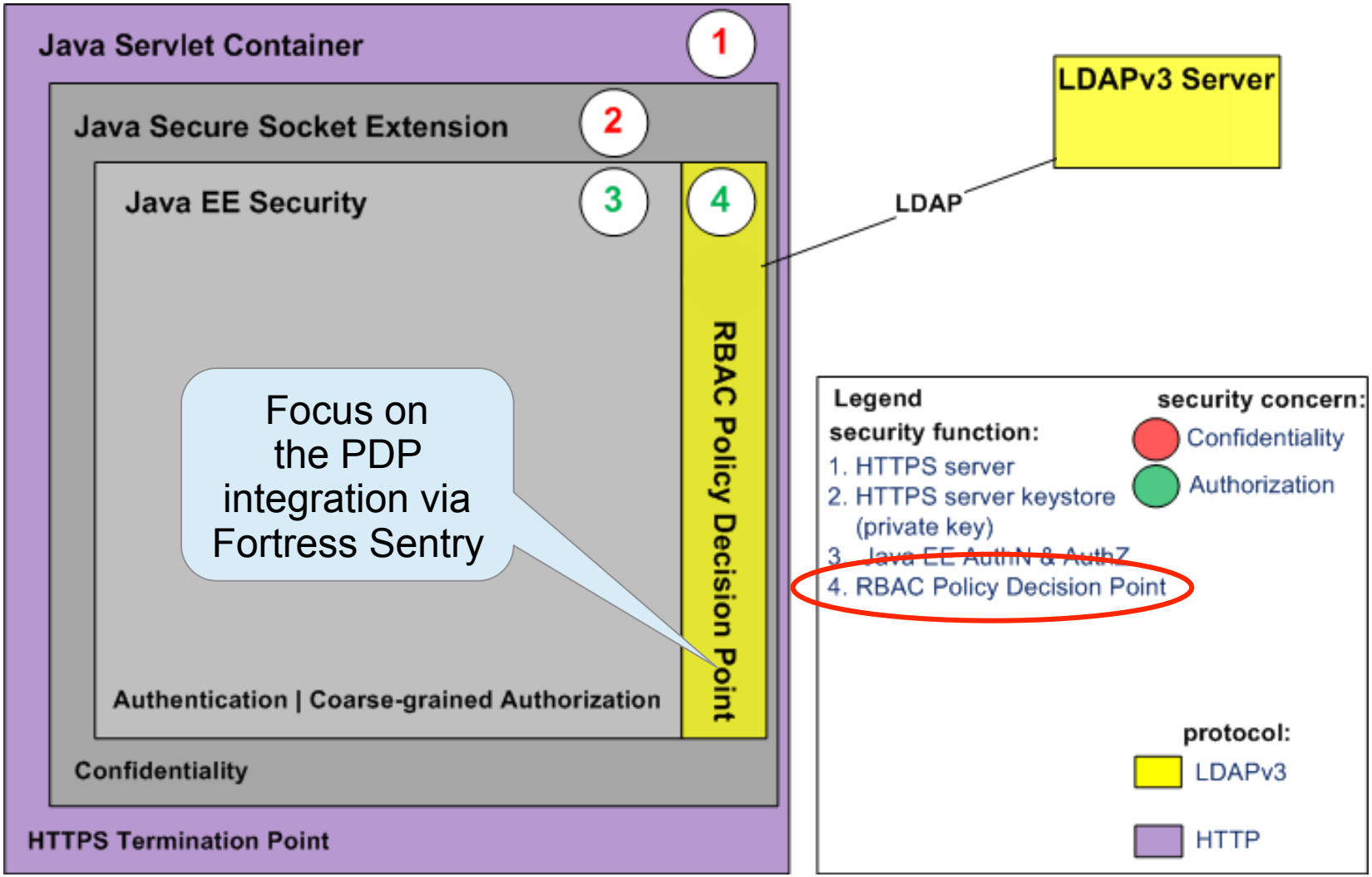
# ANSI RBAC PDP

Standards-compliant System Interface Definition:

1. createSession
2. checkAccess
3. sessionPermissions
4. sessionRoles
5. getUser
6. addActiveRole
7. dropActiveRole



# Step 4: Enable Policy Decision Point



# Configure Tomcat Custom Realm

- Add context.xml file to the META-INF folder:

```
<Context reloadable="true">
   < Realm className= "org.openldap.sentry.tomcat.Tc7AccessMgrProxy"
      debug="0"
      resourceName="UserDatabase"
      defaultRoles="ROLE_DEMO2_SUPER_USER,
      DEMO2_ALL_PAGES, ROLE_PAGE1, ROLE_PAGE2,
      ROLE_PAGE3"
      containerType="TomcatContext"
      realmClasspath="" />
</Context>
```

- Copy sentry jar (cf. slide 23):

```
# sudo cp sentry-1.0-RC39-proxy.jar  /usr/share/tomcat/lib
```

# Configure Application Dependency

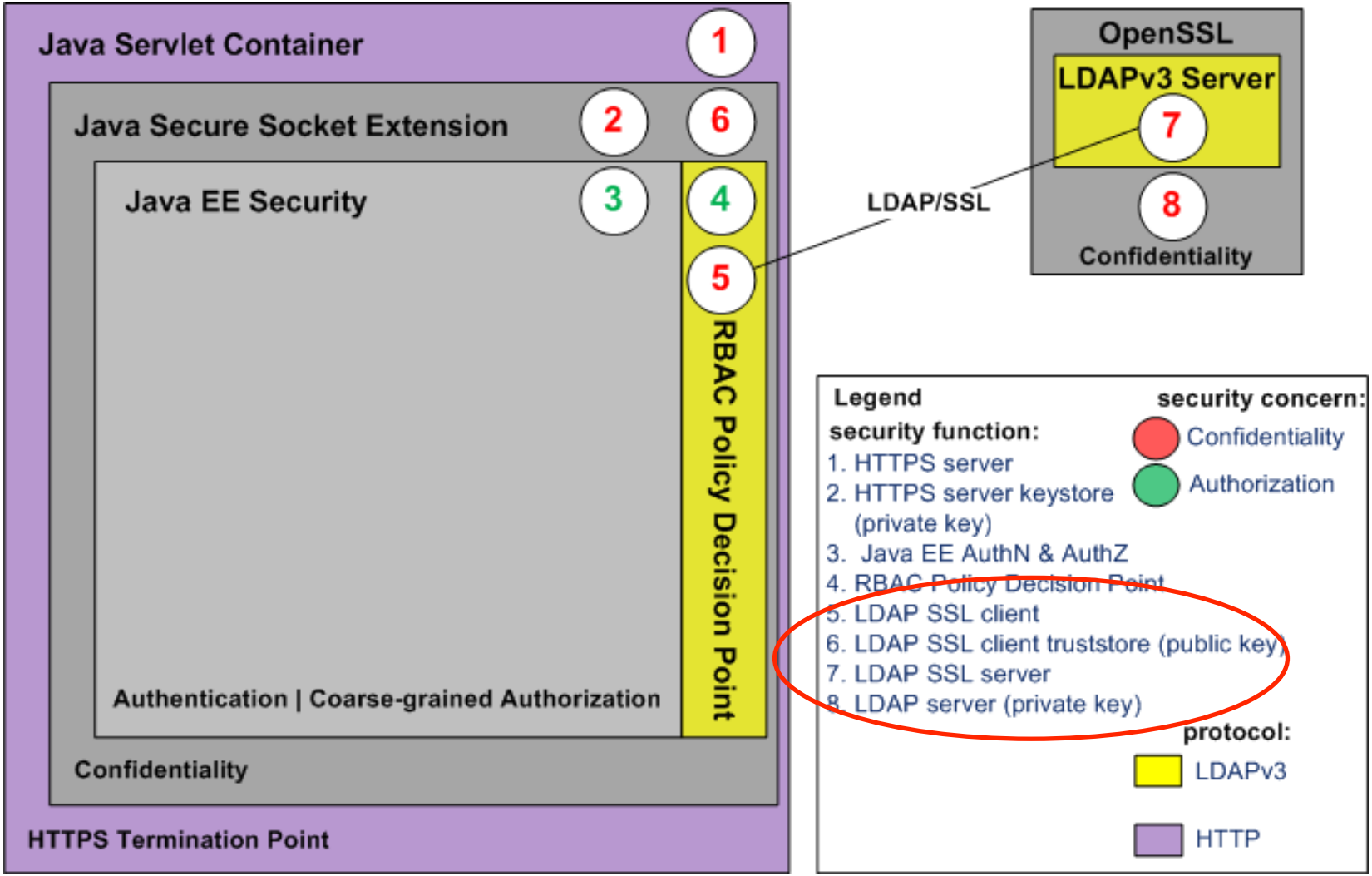
- Add Maven dependency to application pom.xml:

```
<dependency>
    <groupId> org.openldap </groupId>
    <artifactId> sentry </artifactId>
    <version> 1.0-RC39 </version>
</dependency>
```

- Add bean definition to applicationContext.xml

```
<bean id= "accessMgr"
 class= "org.openldap.fortress.AccessMgrFactory"
 scope="prototype"
 factory-method="createInstance">
 <constructor-arg value="HOME"/>
</bean>
```

# Enable LDAP SSL



# Enable OpenLDAP SSL Server

- Add certificate artifacts to OpenLDAP slapd.conf:

```
# sudo vi  /opt/symas/etc/openldap/slapd.conf

TLSCACertificateFile  /path/pse-ca-cert.pem
TLSCertificateFile  /path/oreo-server-cert.pem
TLSCertificateKeyFile  /path/oreo-server-key.pem
```

- Add ldaps to OpenLDAP startup params:

```
# slapd … –h “ldaps://oreo:636”
```

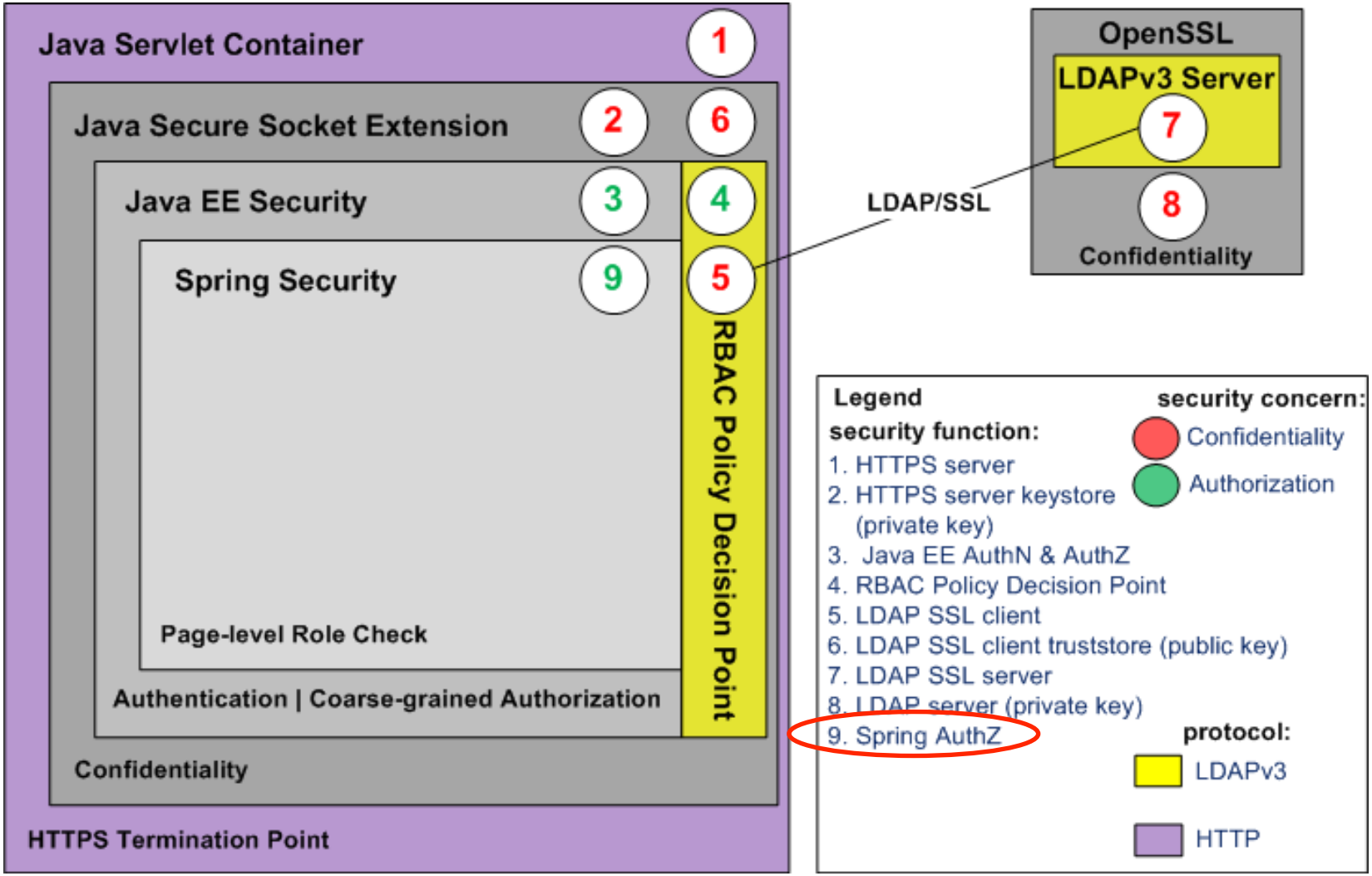
# Enable LDAP SSL Client

- Import CA PKI certificate into Java truststore
  - Cf. slide 16

- Tell client where to find LDAP

```
# vi  /src/main/resources/fortress.properties
host=oreo
port=636
enable.ldap.ssl=true
trust.store=/path/mytruststore
trust.store.password=changeit
```

# Enable Spring Security



# Enable Spring Security

- Add URL pattern(s) and corresponding role(s) to Spring Security to applicationContext.xml:

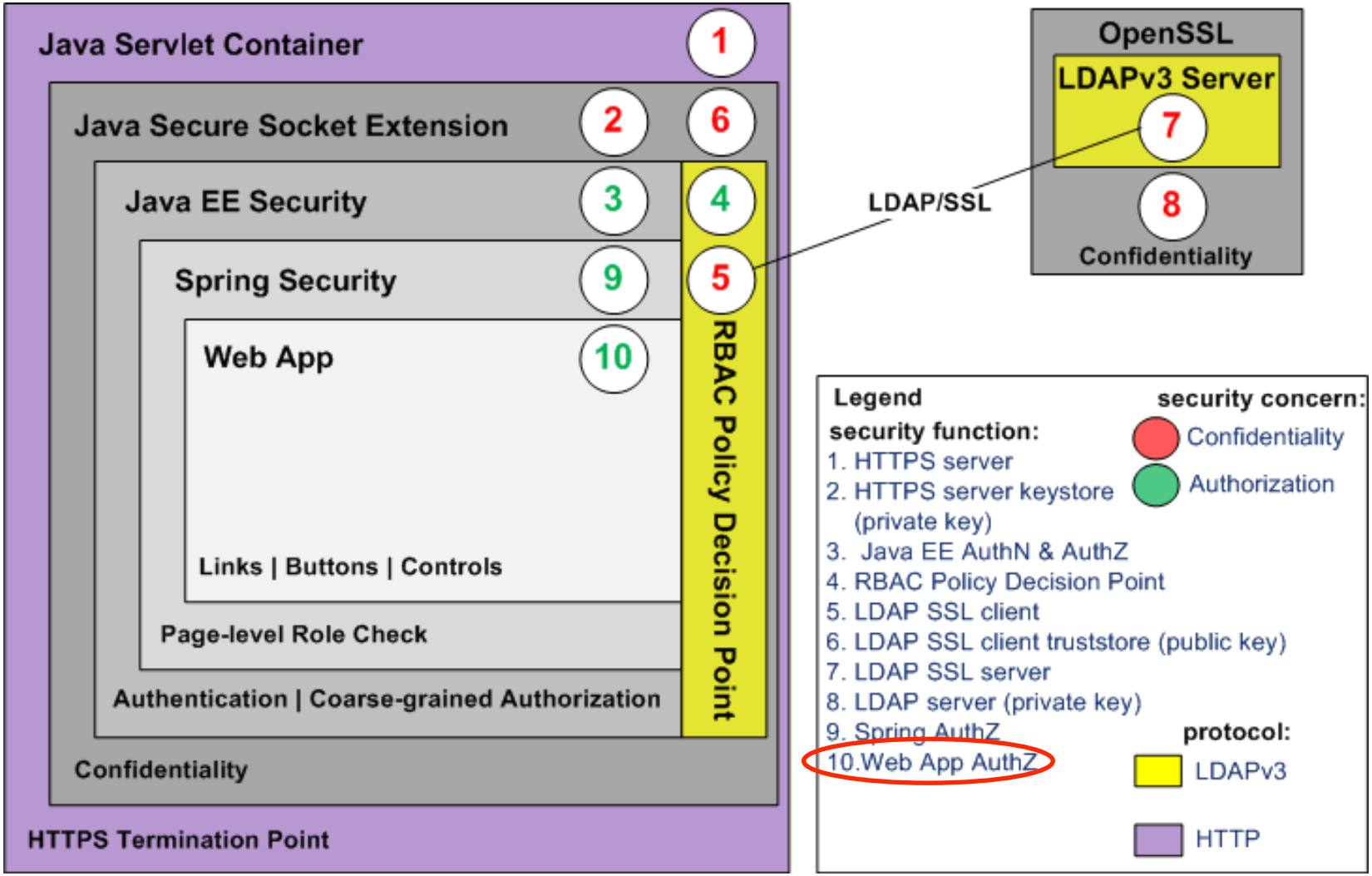
```
<bean id="fsi" class=
      "org.springframework.security.web.access.intercept.FilterSecurityInterceptor">

  <property name="authenticationManager" ref="authenticationManager"/>
  <property name="accessDecisionManager" ref="httpRequestAccessDecisionManager"/>
  <property name="securityMetadataSource">
    <sec:filter-invocation-definition-source>
          <sec:intercept-url pattern="/com.mycompany.page1"
                             access="ROLE_PAGE1"/>
    </sec:filter-invocation-definition-source>
  </property>
</bean>
```

# Enable Spring Security

- Add Maven dependencies for Spring Security to web app's pom.xml:

```
<dependency>
  <groupId>org.springframework.security</groupId>
  <artifactId> spring-security-core </artifactId>
  <version>${spring.security.version}</version>
</dependency>
<dependency>
  <groupId>org.springframework.security</groupId>
  <artifactId> Spring-security-config </artifactId>
  <version>${spring.security.version}</version>
</dependency>
<dependency>
  <groupId>org.springframework.security</groupId>
  <artifactId> spring-security-web </artifactId>
  <version>${spring.security.version}</version>
</dependency>
```

# Add Security-Aware Web Framework Components



# Add Security-Aware Web Framework Components

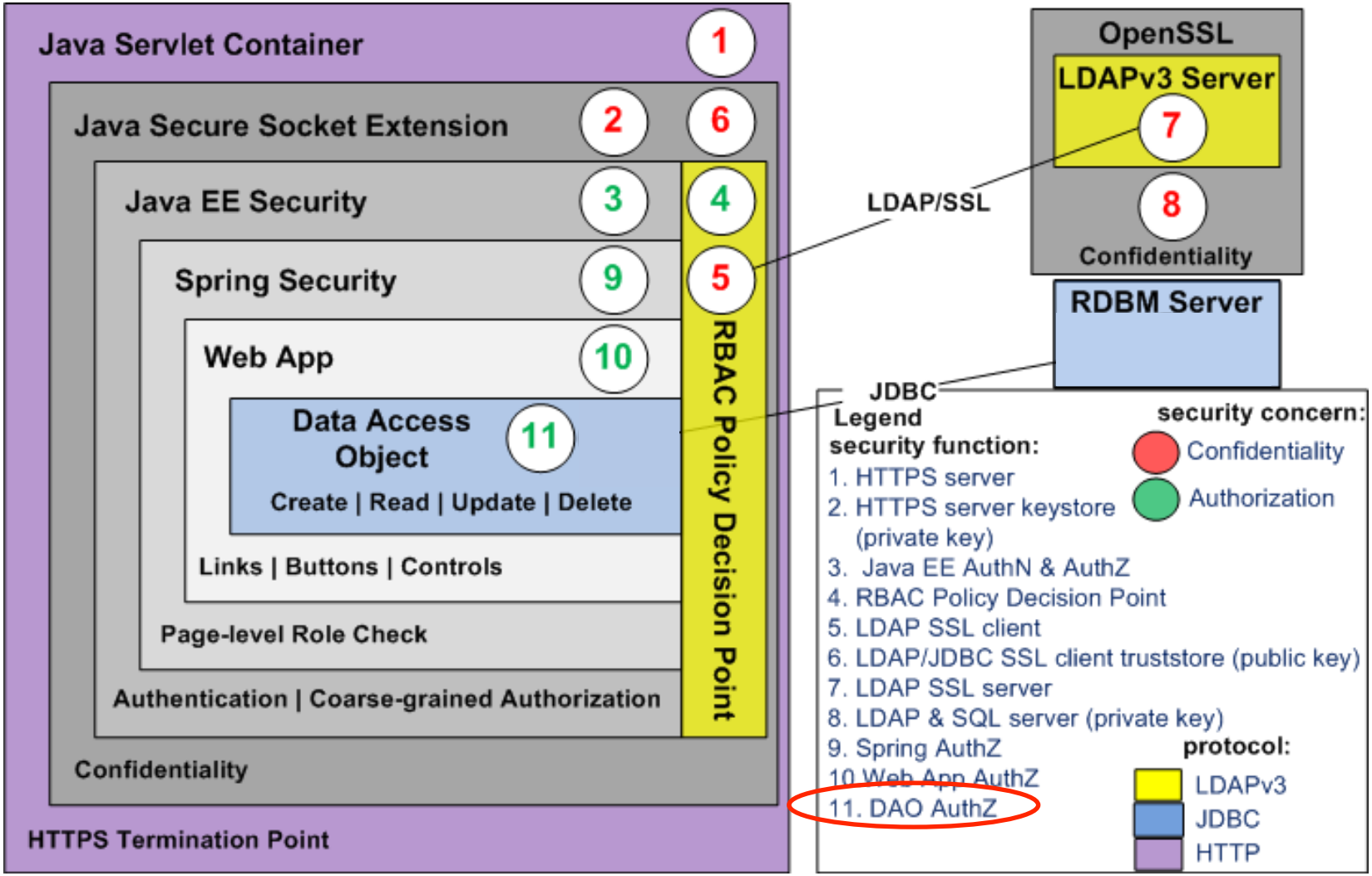
Page1.java, addButtons() private method

```
add( new SecureIndicatingAjaxButton( "Page1", "Add" )
 {
 @Override
 protected void onSubmit( ... )
 {
   if( checkAccess( customerNumber )
   {
     // do something here:
   }
   else
   {
         target.appendJavaScript( ";alert('Unauthorized');" );
   }
 }
 });
```

As page is rendered, buttons are activated, per the user's cached permissions.

On submit, do programmatic authorization (instance-based)

# Add Security Aware DAO components



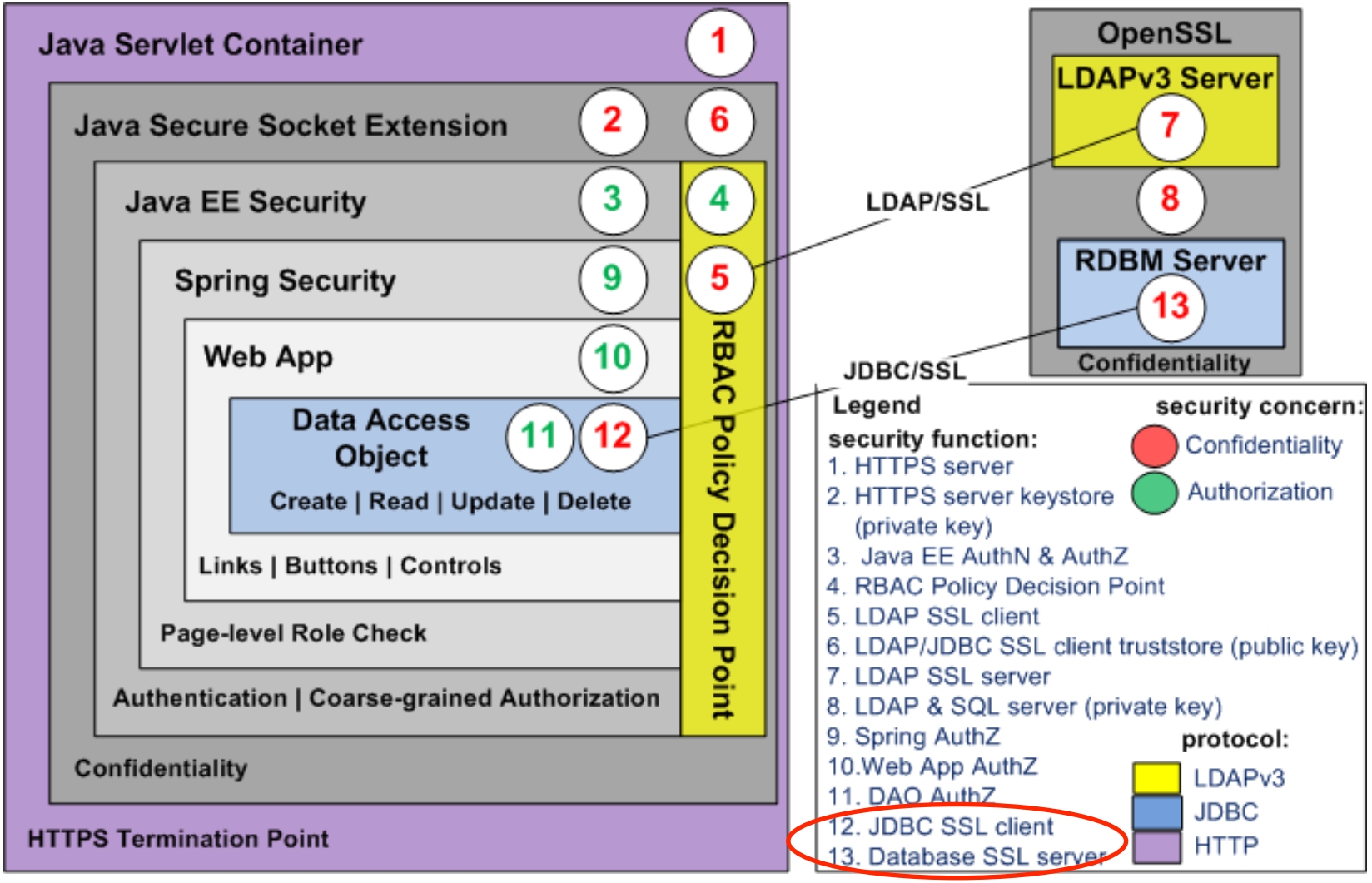
# Add Security-Aware DAO Components

Page1DaoMgr.java, updatePage1() public method

```
public Page1EO updatePage1( Page1EO entity )
{
  ...
    if(checkAccess(“Page1”,“Update”,entity.getCust()))
     {
       // Call DAO.update method...
     }
else
   throw new RuntimeException("Unauthorized”);
...
return entity;
}
```

Just prior to database update, re-verify authorization for this instance.

# Enable DB SSL



# Enable MySQL SSL Server

```
#  sudo  vi  /etc/mysql/my.cnf
```

- In the MySQL my.cnf file, instruct listener to use host name in certificate:

```
bind-address = oreo
```

- Add the certificate artifacts generated previously:

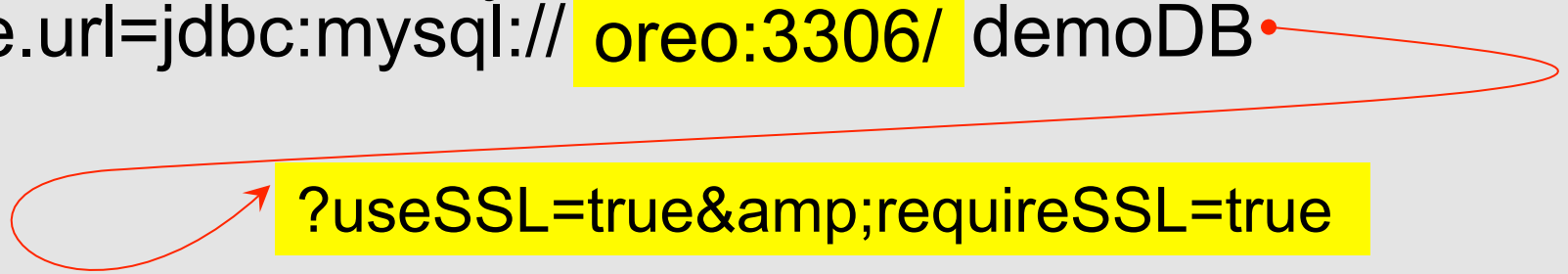
```
ssl-ca=/path/pse-ca-cert.pem
ssl-cert=/path/oreo-server-cert.pem
ssl-key=/path/oreo-server-key.pem
```

# Enable MySQL SSL Client

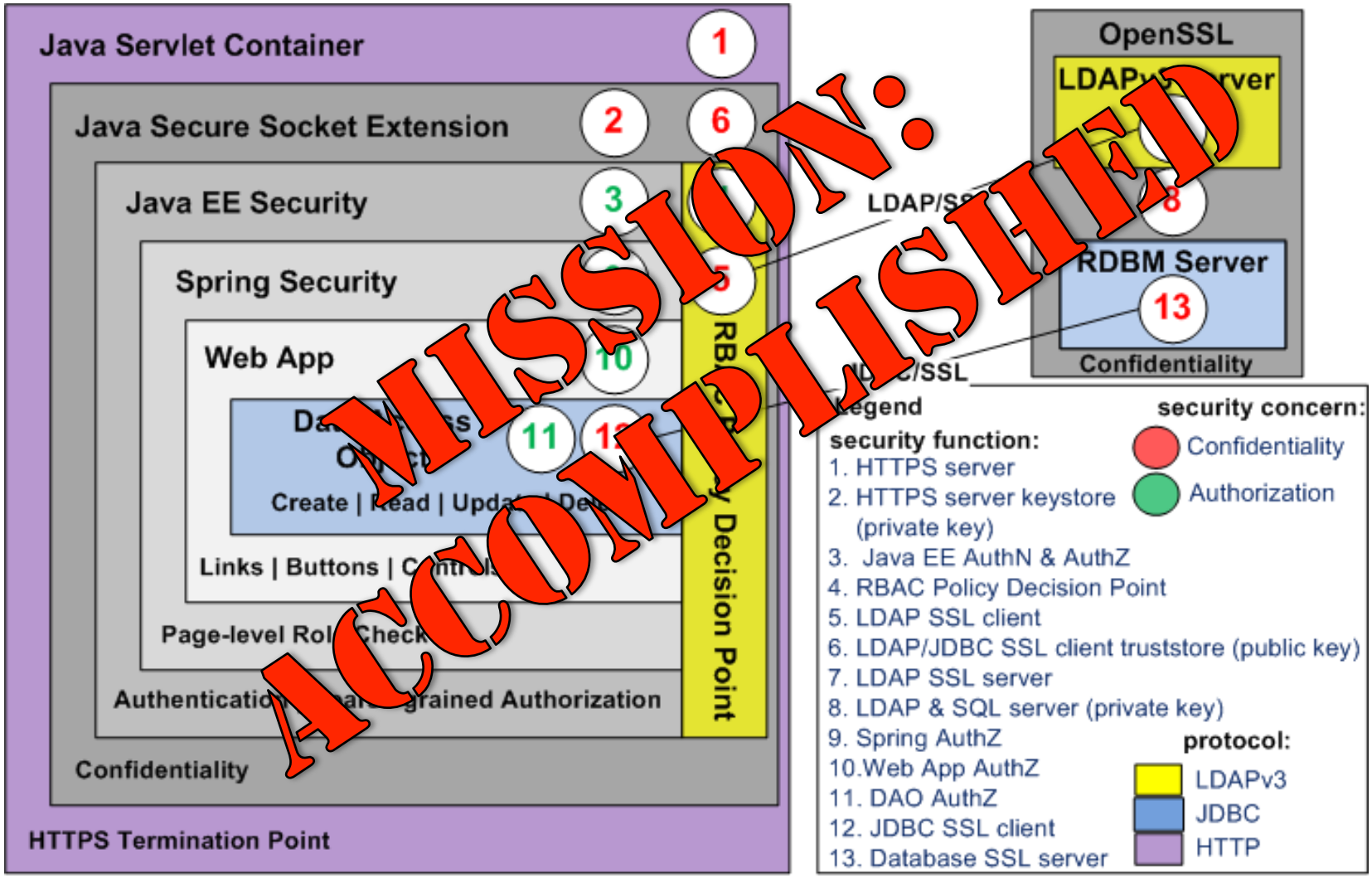
- Edit the fortress.properties in Web application:

```
#  sudo  vi  fortressdemo2/src/main/resources
```

```
trust.store.set.prop=true
database.driver=com.mysql.jdbc.Driver
database.url=jdbc:mysql:// oreo:3306/ demoDB
```



# The Anatomy of a Secure Java Web Application



# Core Security Architecture Patterns

1. Use HTTPS / TLS on a shared network.
2. Use Container-based Enforcement
   - As appropriate, at each architectural layer.
     - Declarative for static (type-based) resources.
     - Programmatic for dynamic (instance-based) resources.
3. Delegate to a Trusted Third Party (TTP).
   - User Authentication, and Container-based Authorization
4. Use RBAC to express access control policy.
5. Create an audit log record for every application state change.

# Part 2

How is it different in Cloud Foundry?

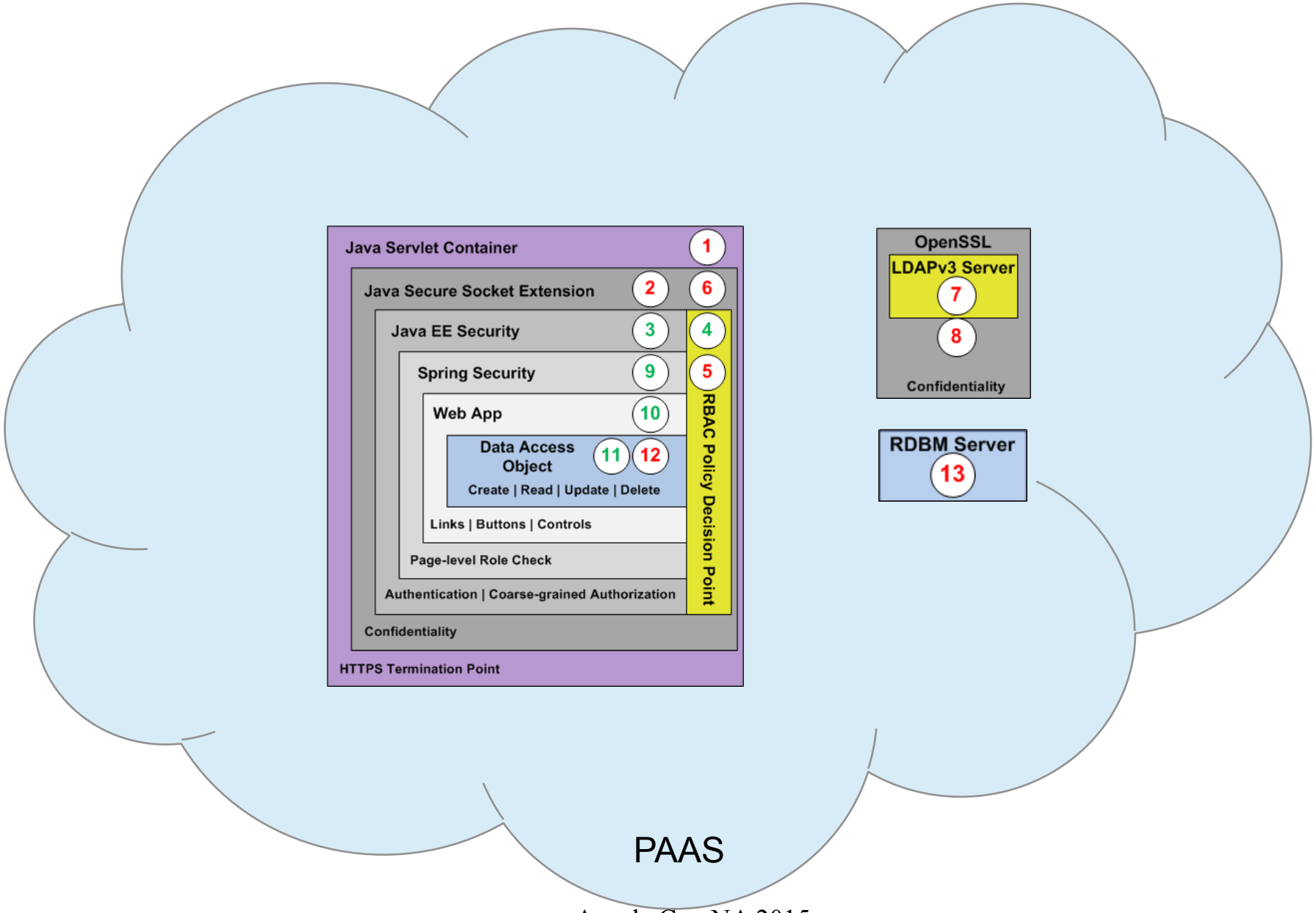
# FortressDemo2 in Cloud Foundry

- Cloud Foundry
  - a **P**latform **A**s **A** **S**ervice offering.

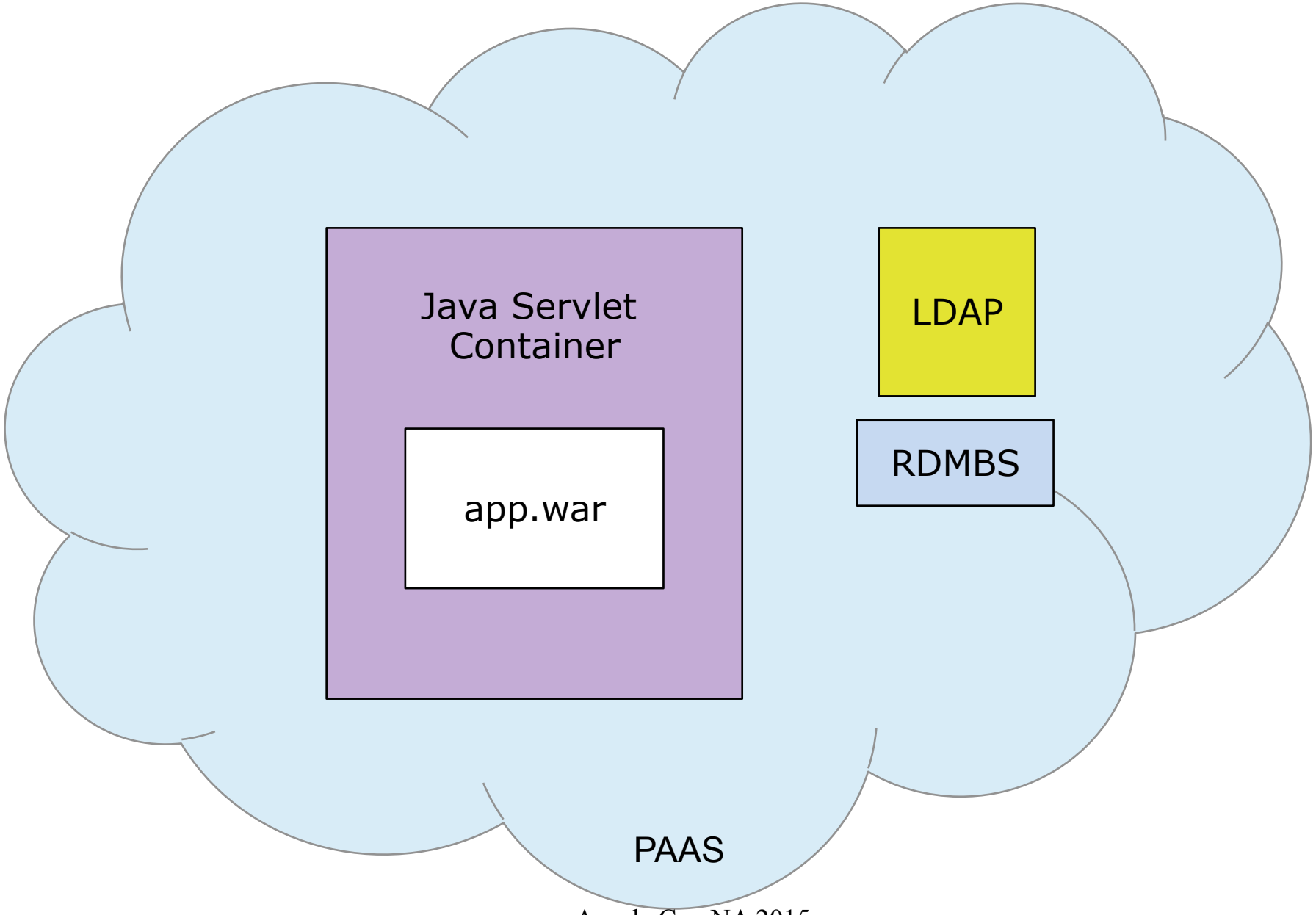

- Enables enterprises to optimize:
  - Infrastructure utilization
  - Application developer productivity

- What changes when deploying to Cloud?

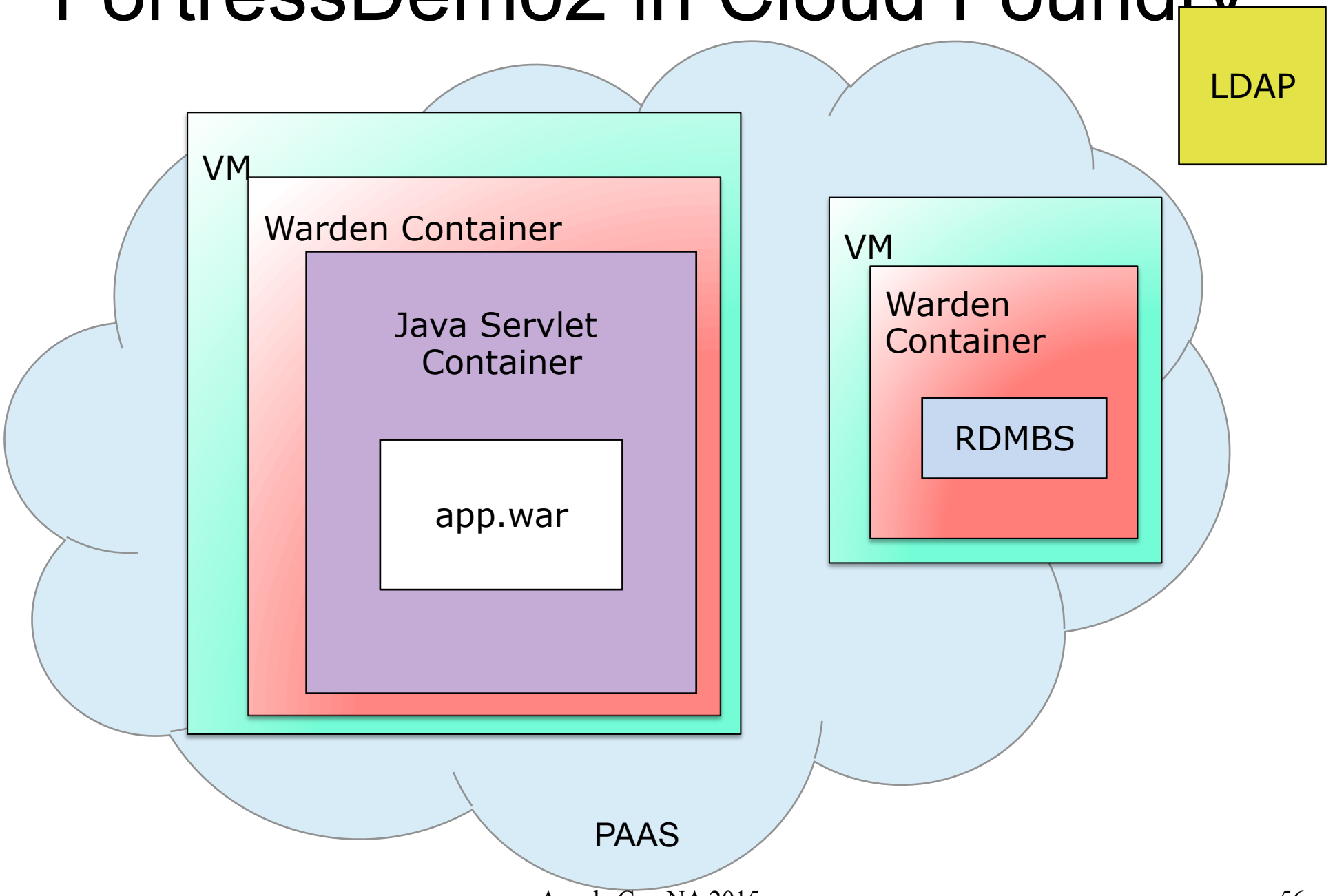
# FortressDemo2 in Cloud Foundry



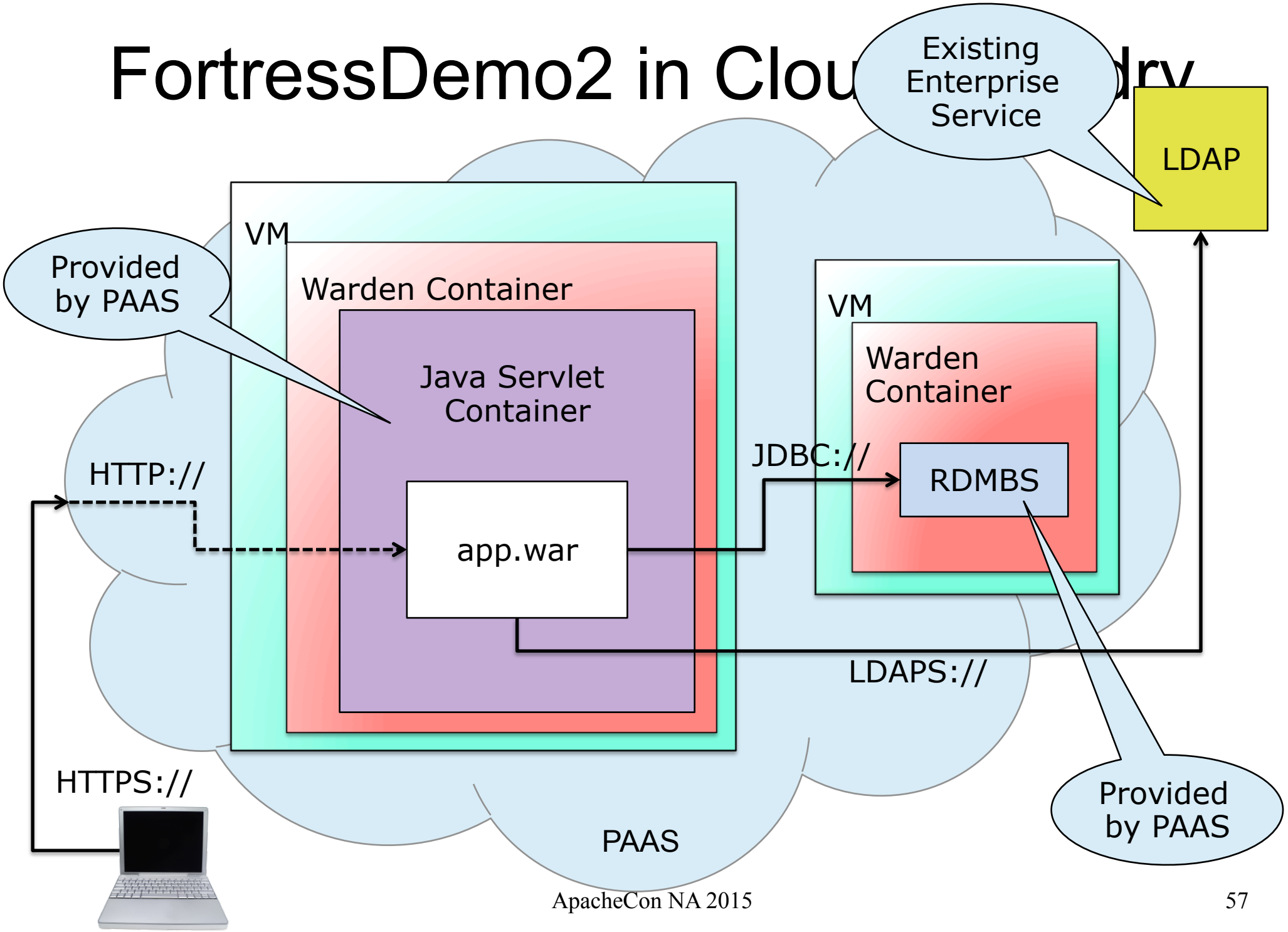
# FortressDemo2 in Cloud Foundry



# FortressDemo2 in Cloud Foundry



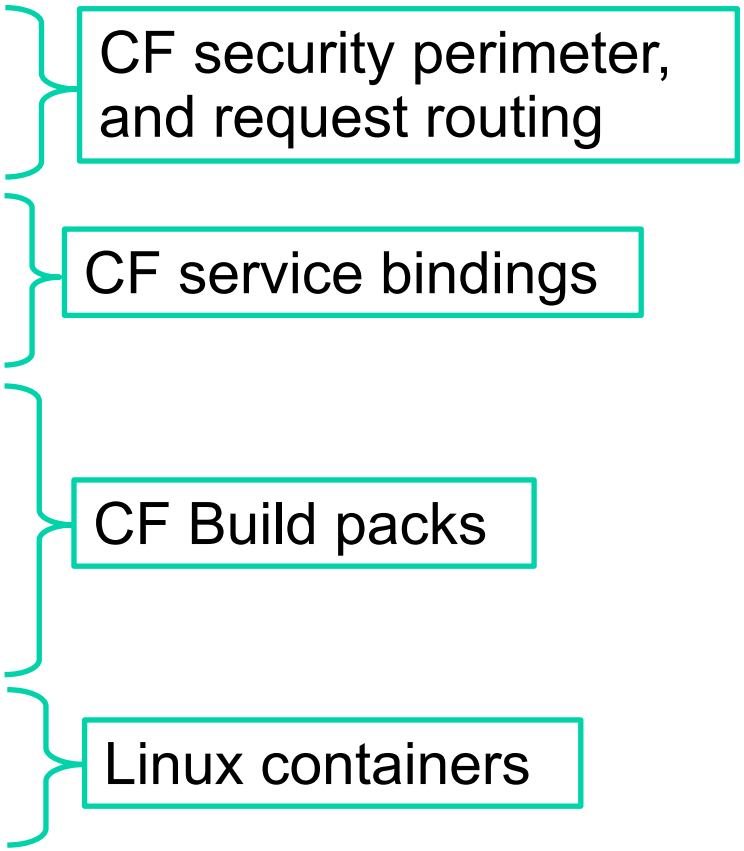
# FortressDemo2 in Clou dry



# Summary of Differences

***What We Need to Understand:***

1. SSL Termination
2. MySQL Credential Provisioning
3. JEE Realm Configuration
4. JSSE Truststore Management
5. Warden Container Isolation



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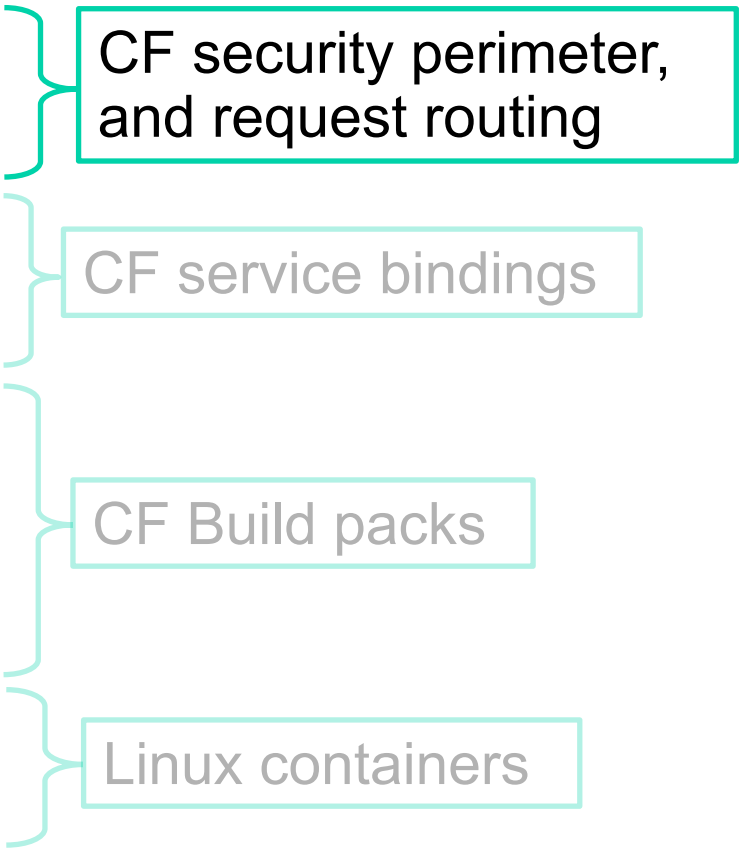
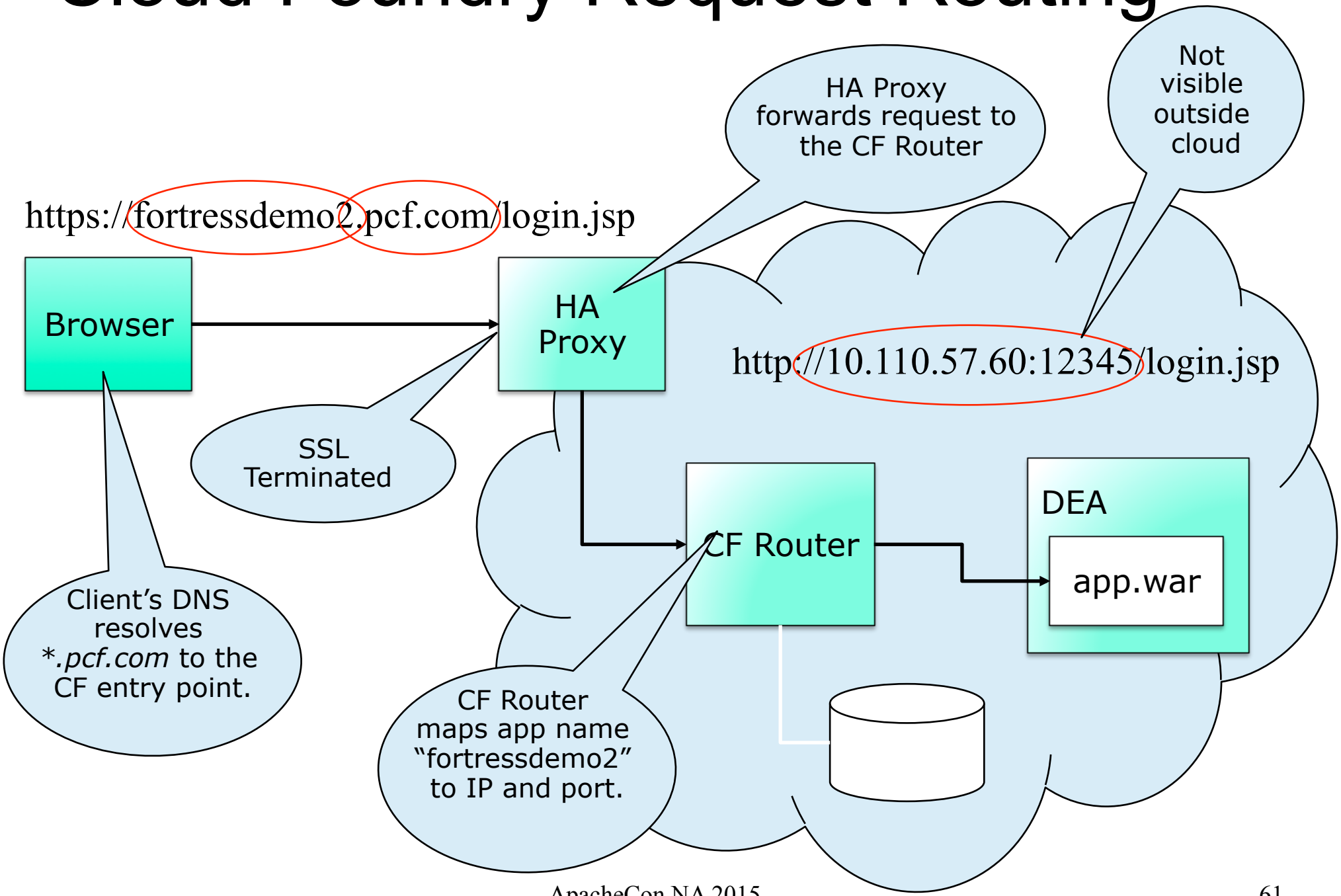


# Cloud Foundry Request Routing

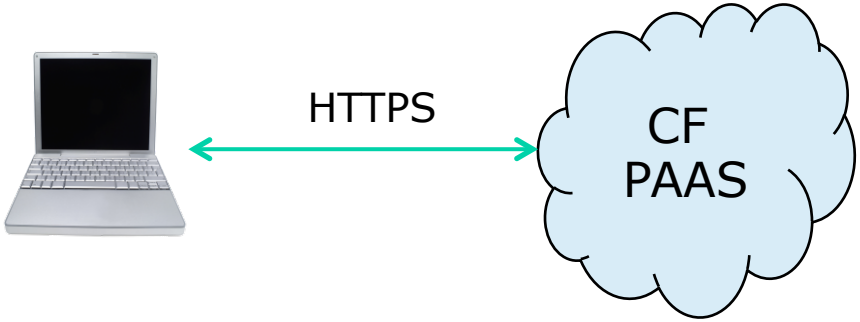
***Remapping of Application URLs***

- Original deployment URL:
  - https://host.enterprise.com:8443/fortressdemo2/login.jsp
- Cloud Foundry URL:
  - https://fortressdemo2.pcf.com/login.jsp
- What does this imply?
  - Application context becomes a subdomain.
    - No host or port specified
  - DNS configured to resolve *.pcf.com to IP address of the Cloud Foundry entry point.

# Cloud Foundry Request Routing



# 1. SSL Termination




- The SSL connection from user's browser terminates at the Cloud Foundry HA Proxy.
- Only one certificate needed for all applications hosted in the PAAS
- No SSL from HA Proxy to our Tomcat instance.
  - All PAAS VMs on the same virtual subnet.
  - No access to application ports from outside cloud.

# Summary of Differences

***What We Need to Understand:***

1. SSL Termination
2. MySQL Credential Provisioning
3. JEE Realm Configuration
4. JSSE Truststore Management
5. Warden Container Isolation

CF security perimeter, and request routing

CF service bindings

CF Build packs

Linux containers

# Cloud Foundry Service Bindings

## *Enabling Distributed Dependency Injection*

- Cloud Foundry has the concept of a ***Service***
  - Services enable on-demand provisioning of resources.
  - Services can be Managed or User-Provided.
- Developers declare app's external service dependencies
  - using ***cf bind-service <app> <svc>***.
- At deployment time, war file is scanned
  - Determine the required runtime stack, (i.e. `JRE` + tomcat)
  - Inject any required connection strings, service credentials

# 2. MySQL Credential Provisioning

***"Auto-Reconfiguration" eliminates hardcoded credentials***

- In CF, there are no hardcoded JDBC credentials
  - i.e. in application-Context.xml or fortress.properties.
- Required database credentials are randomly generated and injected at deployment time.
  - e.g.: **User** = 5GhaoxJwtCymalOI / **Password** = 9Bg4tIrEuInZQFVs
- Feature requires an explicit JDBC DataSource
  - Needed a minor (back-compatible) change to FortressDemo2 application source code

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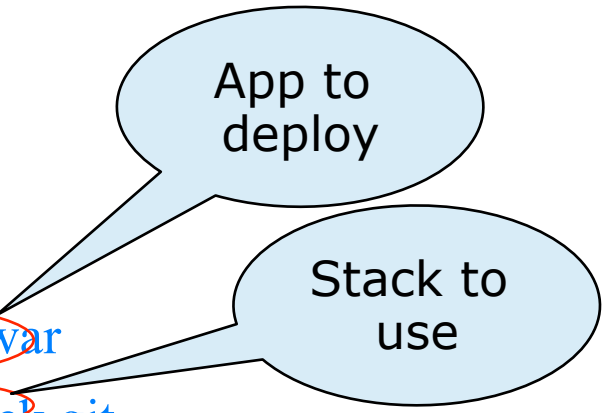
# Cloud Foundry Buildpacks

***What are they? And Why do I care?***

- The artifact that contains your runtime stack.
  - Can be auto-detected, or explicitly specified.
  - Example:

```
shell> mvn clean package

shell> cf push fortressdemo2 -p target/fortressdemo2.war
          –b https://github.com/johnpfield/java-buildpack.git
```




- Deployed application = app.war + buildpack.
  - Intended to support a class of applications, not a single application.

# Cloud Foundry Buildpacks

***Customizing the Java Buildpack***

- The Buildpack is essentially a structure for your runtime libraries.
  - Plus a small amount of “glue code” for interface contract.
- Deployment modes:  Easy, Expert, Offline.
  - Tradeoff of having somewhat tighter configuration control, versus using latest-and-greatest.
- Enterprise-specific customizations expected
  - Clone the repo, make changes, & re-bundle archive.
  - Put enterprise-specific jars or security artifacts in the designated place.

# 3. JEE Realm Configuration
# 4. JSSE Truststore Management

***Configuring the Java Buildpack***

- For FortressDemo2 application, we needed 2 configurations of the CF Java Buildpack:
  - Added Sentry jar into the designated place
    - E.g. java-buildpack/resources/tomcat/lib/fortressProxyTomcat7-1.0-RC39.jar
  - Specified our enterprise-specific Truststore in JRE
    - E.g. java-buildpack/resources/open_jdk_jre/lib/security/mycacerts

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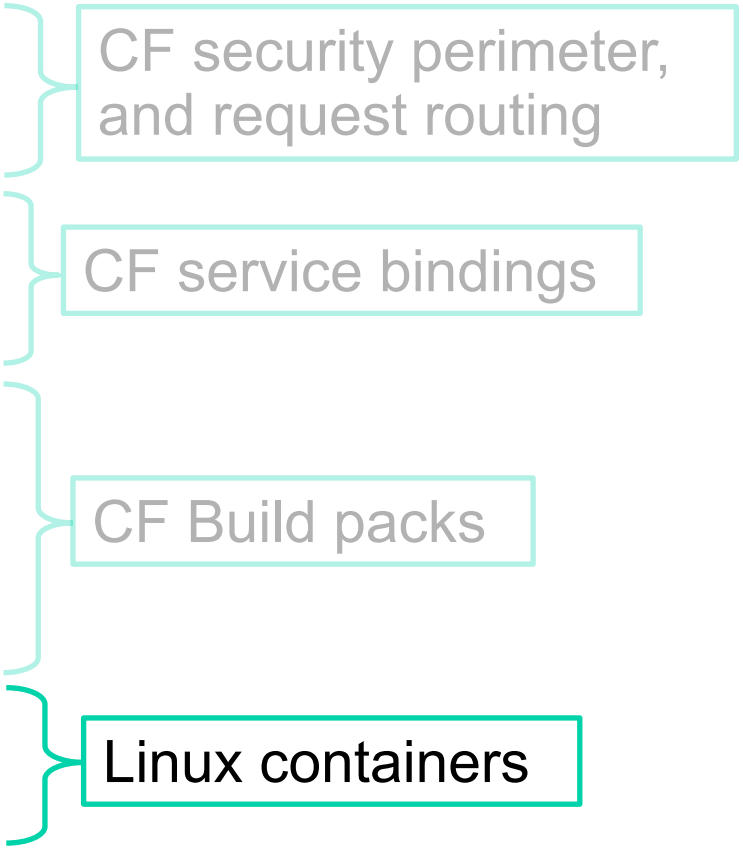

# Warden Container Isolation

***Providing runtime partitioning and resource control***

- Cloud Foundry apps are deployed inside a Warden container.
  - Multiple managed & isolated runtime environments on a single host. (a.k.a: Linux Container, LXC)
- Isolation is via the name-spacing of kernel resources.
  - CPU, memory, disk, & network access.
- Think: “chroot on steroids”
  - Management API integrates:  cgroups, iptables, & overlayfs.

# Warden Container Isolation

## *Secure Cloud Multi-tenancy at a glance*

PAAS (ESX Node)

DEA VM

Hostname: vm-09bf580a-69a0-431c-9741-bb49c4f318b8
VNIC: eth0
Filesystem: /var/vcap/data/warden/depot/
IP: 10.110.57.60
Memory: 4Gb

VNIC: w-17ruu5224qa-0
IP: 10.254.0.1
Filesystem: ./w-17ruu5224qa/tmp/rootfs

VNIC: w-17ruu5334qb-0
IP: 10.254.0.5
Filesystem: ./17wruu5224qb/tmp/rootfs

**Warden Container "A"**

Hostname: 17ruu5224qa
VNIC: w-17ruu5224-qa-1
Filesystem: /home/vcap
IP: 10.254.0.2
Memory: 1Gb

**Warden Container "B"**

Hostname: 17ruu5224qb
VNIC: w-17ruu5224-qb-1
Filesystem: /home/vcap
IP: 10.254.0.6
Memory: 1Gb

# Summary of Differences

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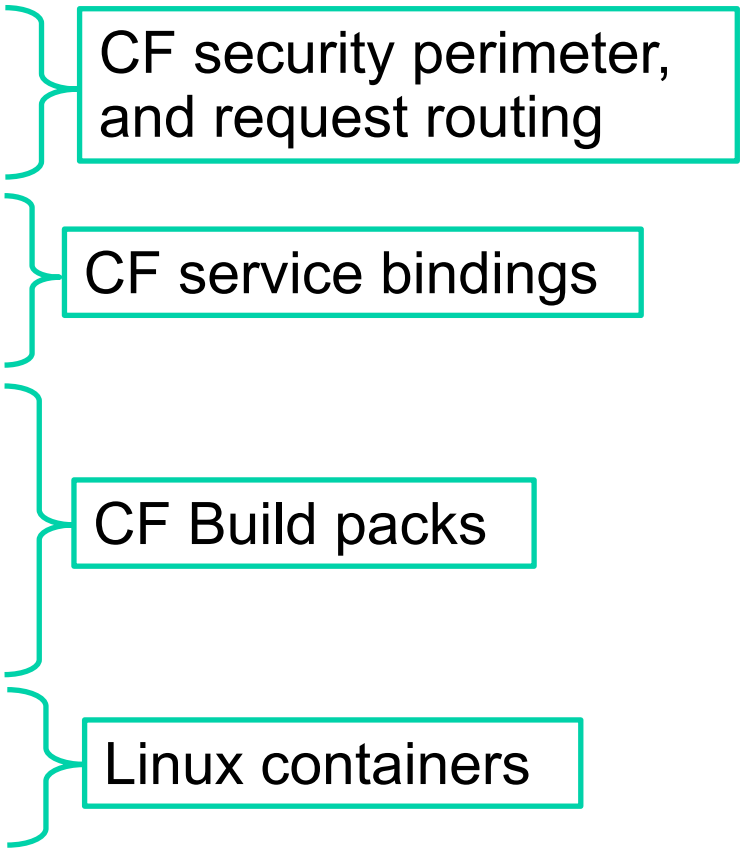

# Network Isolation

- Is like oregano…
  - …you can never have too much.
- You don't need PCF to do this, but it's much easier.
  - PCF v1.3 features:
    1. Security Groups: management of iptables egress rules (whitelists).
    2. Multiple Networks: separate infrastructure VMs from application VMs.
    3. Availability Zones: improved DR availability across geographic locations.

# Conclusions from Cloud Deployment

- Core application security patterns are the same, whether doing standalone, or cloud.
  - Application-Container contract is unchanged.
- No changes to the internal security architecture of the application itself.
  - Layered security design is motivated by use cases, and maintainability, not the deployment environment.
- Less platform config. required in a CF deploy.
  - Configure a class of container, rather than an instance.

# Coordinates

@architectedsec mailto: jfield@pivotal.io

https://johnpfield.wordpress.com

https://github.com/johnpfield/fortressdemo2

https://github.com/shawnmckinney/apache-fortress-demo

http://directory.apache.org/fortress/

https://symas.com/downloads/

https://github.com/cloudfoundry