Spring and JMX

Manageability for Spring-based Applications

Scott W. Ruch
Inventa Technologies
www.inventa.com

Goals

- Understand why manageability is important
- Review the basics of JMX
- Learn how to leverage Spring's simple and transparent JMX integration

Topics

- Introduction
- Management
- JMX Overview
- Hosting Spring in JBoss
- Spring JMX Support
- Q&A

Introduction

Scott W. Ruch

sruch@inventa.com

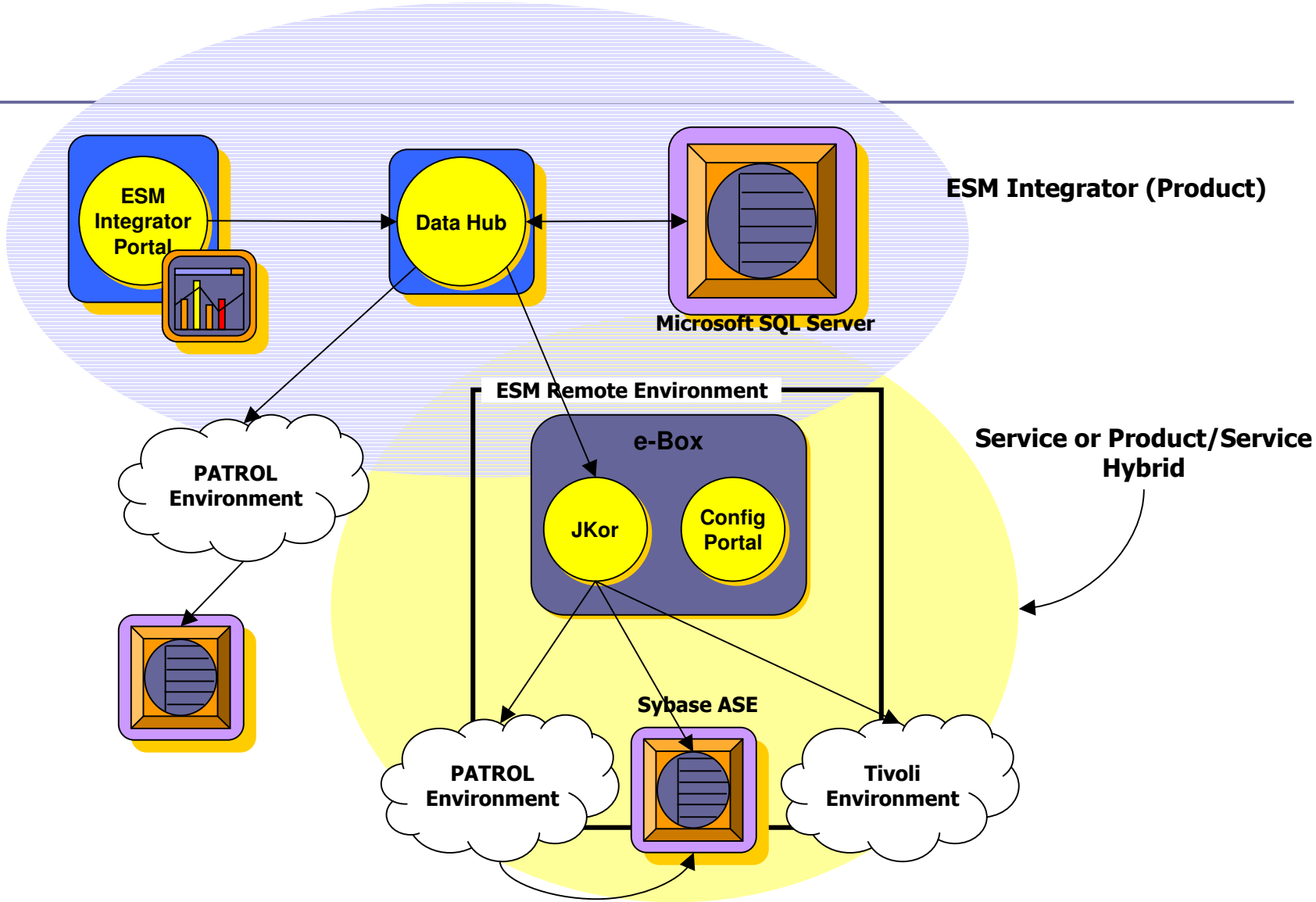
- Software Architect, Inventa Technologies
- Software Architect, HP-Bluestone Middleware Division
  - I18n, Manageability
  - JSR 77, 160 Expert Group Member
- Application Server Technology (1999)
- Java Technology (1997)
- Telecommunications, Distributed Object Systems
- UNIX Kernel, Device Drivers, Communications Protocols
- I/O Subsystems Hardware Design / Qualification

Who We Are

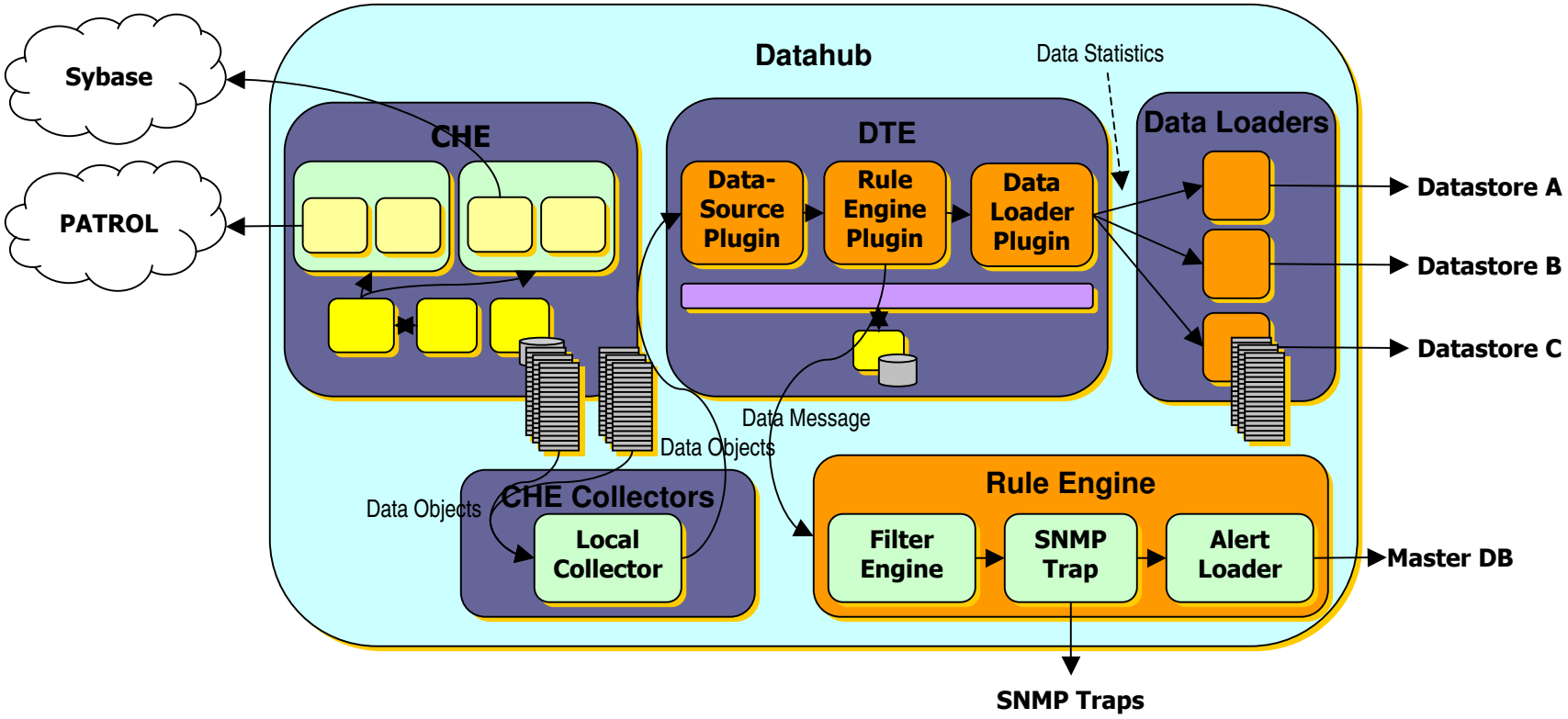
- Performance Management
- Monitoring
- Capacity Planning

- Partner with ESM Vendors (BMC, HP, CA,…)
  - Help customers leverage software investments
  - Integrate
  - Collect Management Data
  - Analysis / Planning / Reporting

- ESM Integrator™ Platform
  - Service / Product


ESM Integrator Portal
Data Hub
Microsoft SQL Server
ESM Integrator (Product)
ESM Remote Environment
e-Box
JKor
Config Portal
PATROL Environment
Service or Product/Service Hybrid
Sybase ASE
PATROL Environment
Tivoli Environment

ESM Integrator™ Datahub



Management

Management: What is it?

- Configuring
  - Initialization (DI)
  - Runtime / Operational
- Controlling
  - Life-cycle: start, stop, suspend, resume
  - Availability (load-balancing, capacity)
- Monitoring
  - Performance
  - Health
  - State

Why is Manageability Important?

- `logger.setLevel(Level.DEBUG) ?`
- Analogy: Internationalization
  - Retrofitting can be difficult
  - Cost prohibitive
- Static configurations are limiting
- Integration
  - Expose counters / operations / state
  - Event notification
  - Remote management

JMX Overview

JMX: A Brief History

- JSR 3: Java Management eXtensions
  - Initiated: 1998
  - Precursors: JMAPI, JDMK
  - 1.0 RI released: 12/2000
  - 1.2 → Java 1.5
- JSR 160: JMX Remote API
  - Initiated: 2001
  - RMI + Generic Protocol (JMXMP)
  - 1.0 Release: 10/2003
  - 1.0 → Java 1.5

JMX: A Brief History

- JSR 77: J2EE Management
  - Initiated: 2000
  - Standard J2EE management model for
    - Server resource management
    - Application lifecycle control
    - Performance monitoring
  - Defines:
    - Managed Object naming conventions
    - "Standard" J2EE Managed Objects
  - Access via:
    - Management EJB (MEJB) (required)
    - SNMP Agent (optional)
    - CIM / WBEM (optional)
  - 1.0 → J2EE 1.4

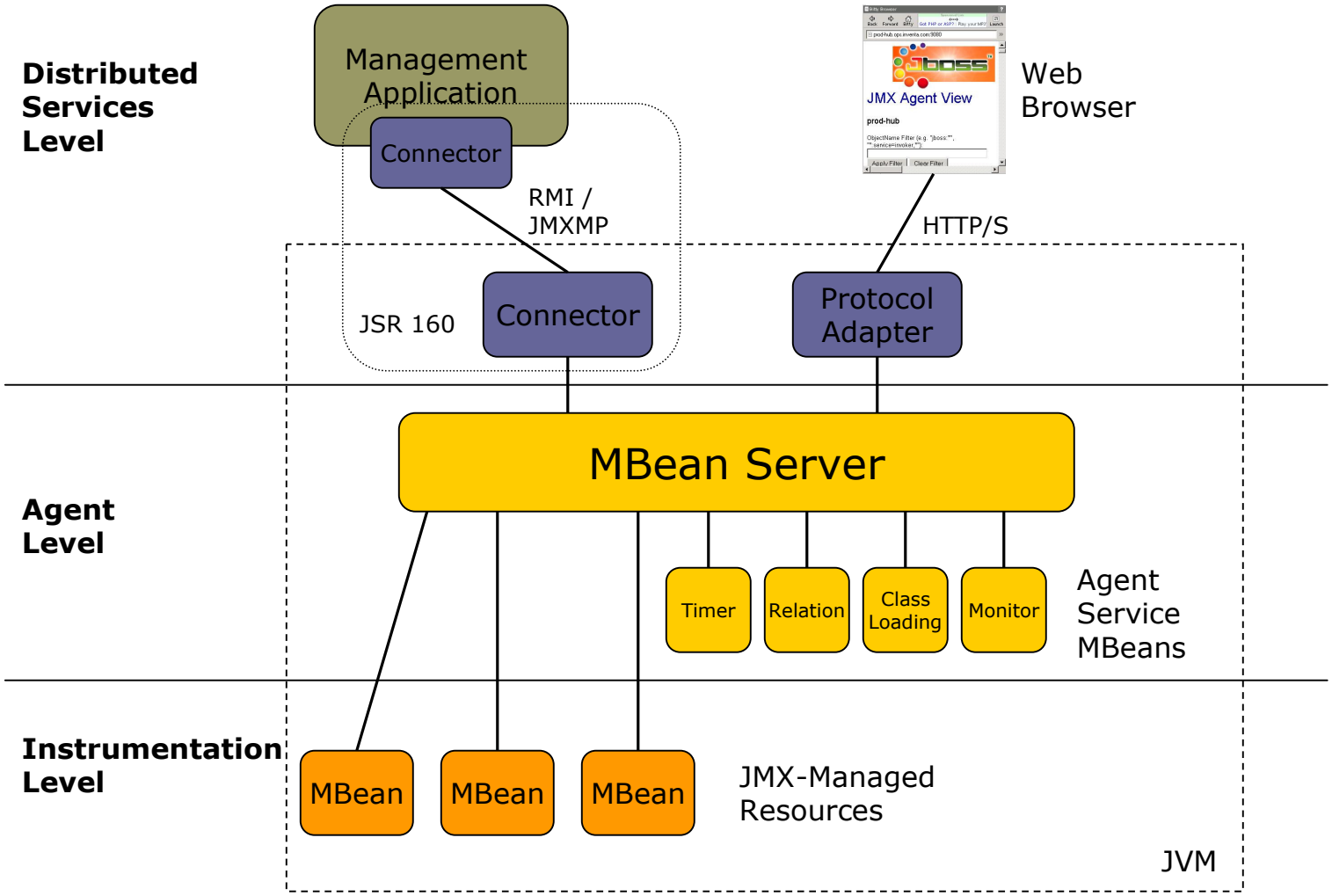
What is JMX?

- Architecture, APIs, Design Patterns
- Components:
  - Managed (Instrumented) Resources
  - Agents (and their services)
  - Connectors / Adapters
- Goals:
  - Instrument Java Code
  - Create Smart Java Agents
  - Implement Management Middleware
  - Integrate with Industry Standard Management Platforms

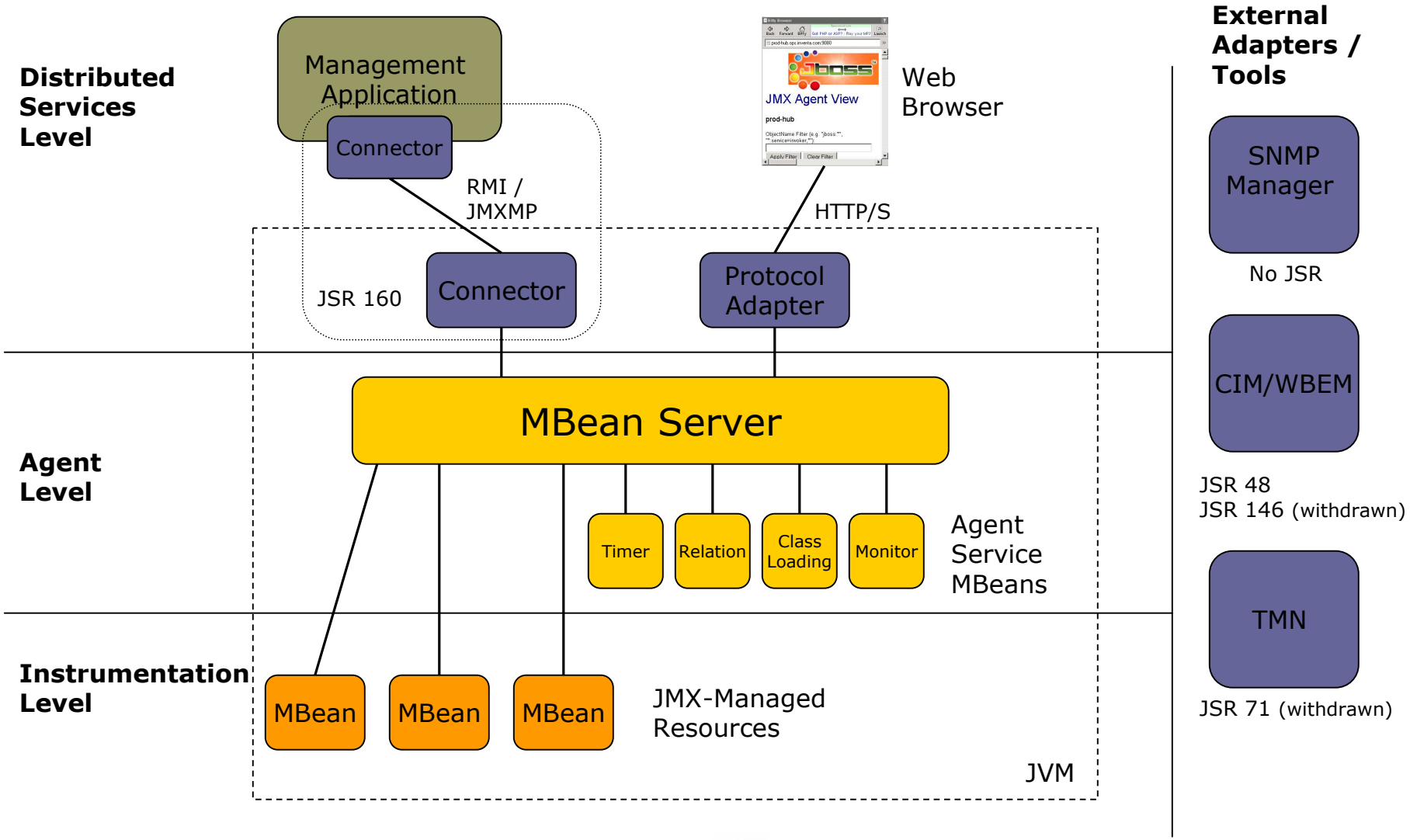
JMX Summarized

- Resources are instrumented with Management Beans (MBeans)
- MBeans expose the interface that is used to manage the resource:
  - Attributes (getter/setter)
  - Operations
  - Notifications (events)
- MBeans are registered in an agent (**`javax.management.MBeanServer`**)
- Registered MBeans are visible to local or remote management applications through the agent.

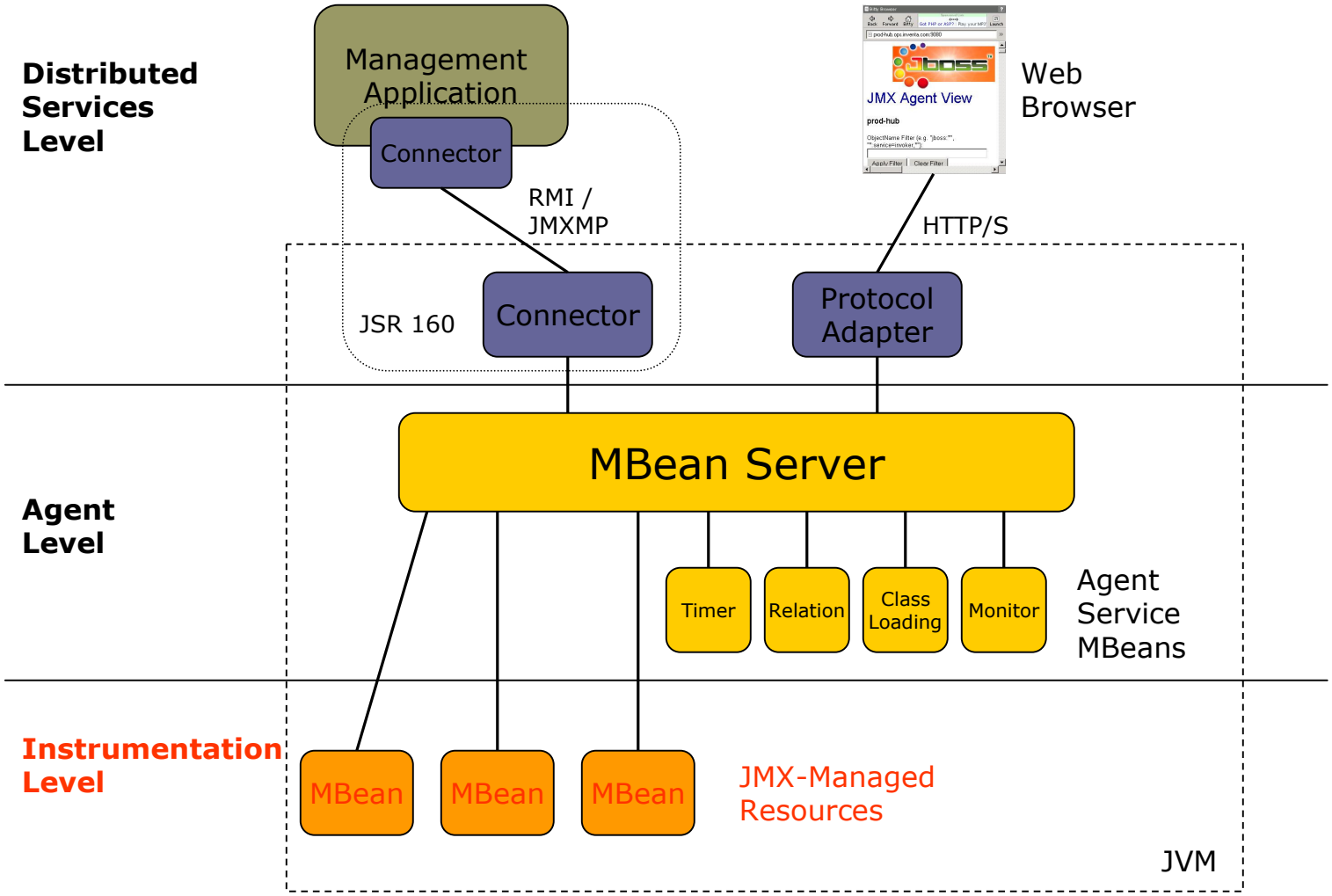
JMX Architecture



JMX Architecture



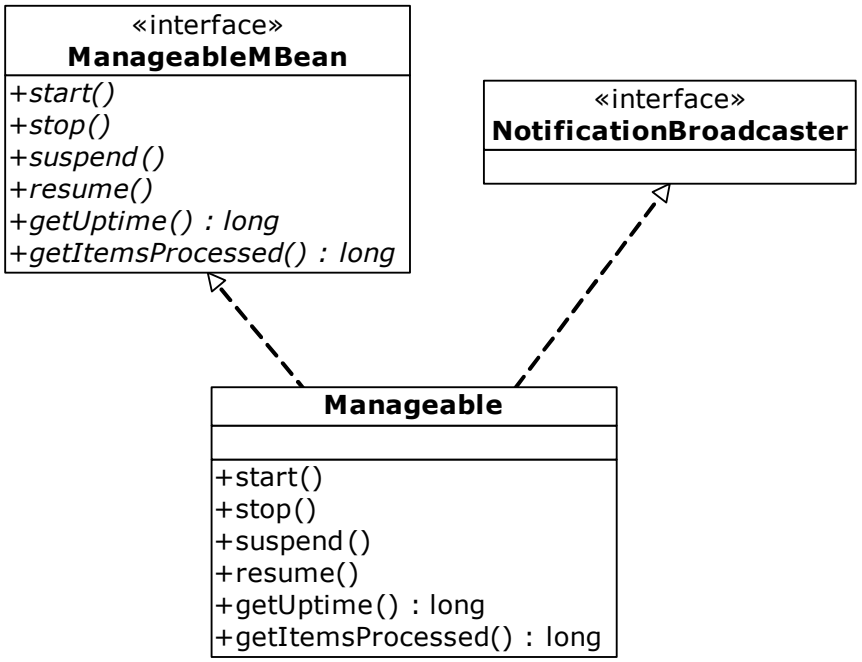
JMX Architecture



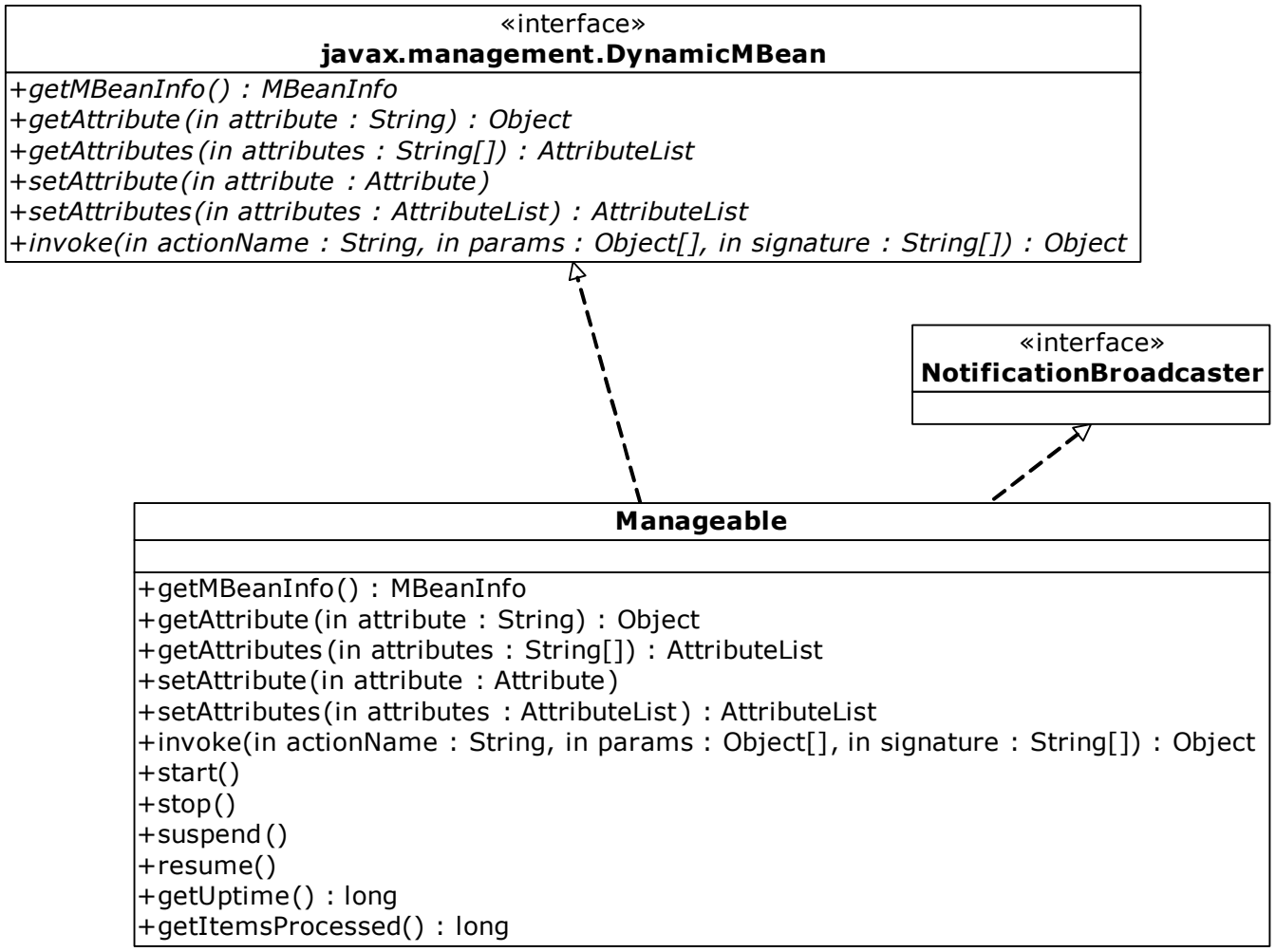
JMX Instrumentation Level

- Standard MBean
  - Concrete Java class providing:
    - Implementation of its corresponding static MBean interface e.g.: **`class Manageable implements ManageableMBean`**
    - Optionally, an implementation of the **`NotificationBroadcaster`** interface
- Dynamic MBean
  - Concrete Java class providing:
    - Implementation of the **`DynamicMBean`** interface
    - Optionally, an implementation of the **`NotificationBroadcaster`** interface
- Only difference is development model!

Standard MBean



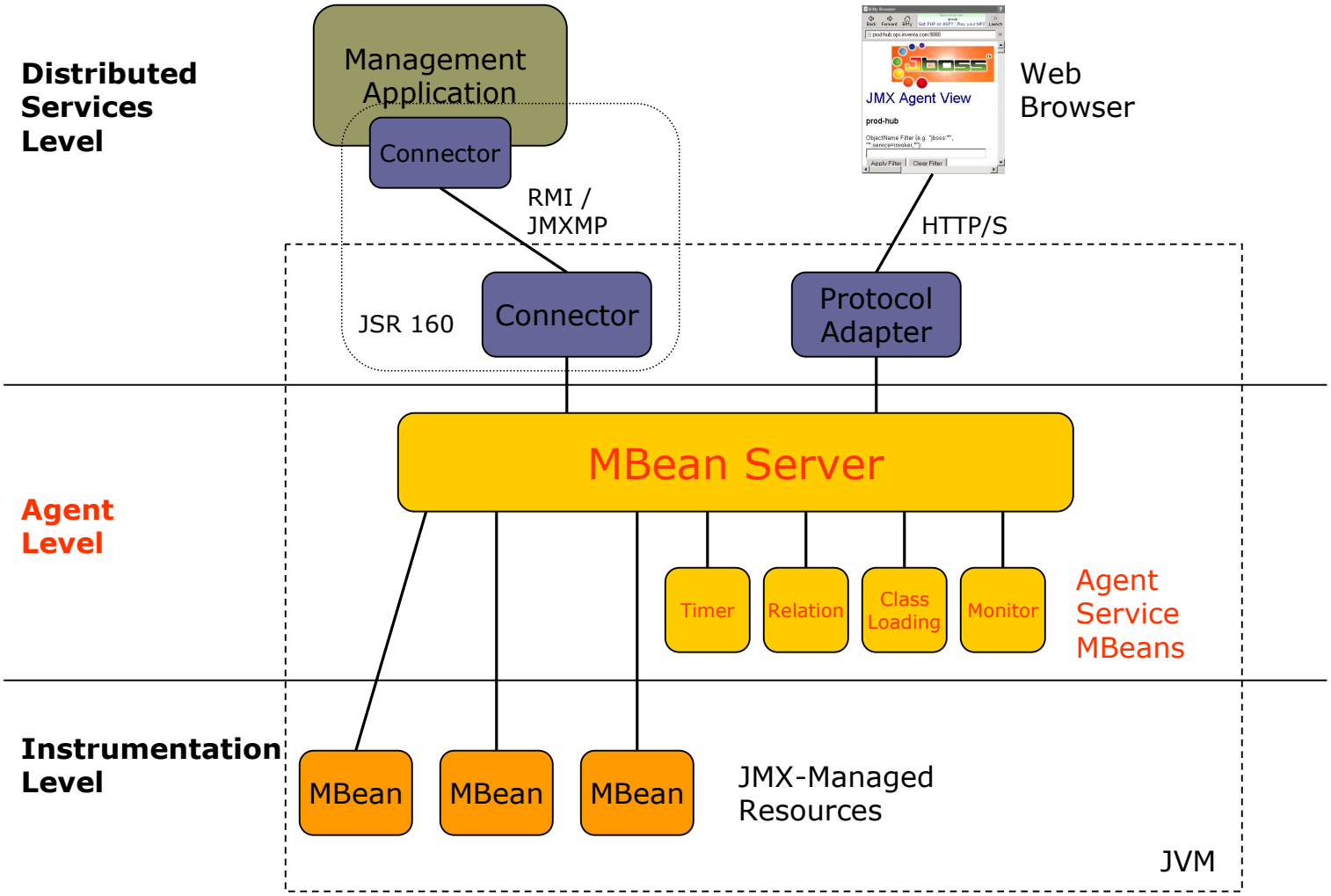
Dynamic MBean



Other Dynamic MBeans

- Open MBeans
  - "Open" to the widest range of management applications
  - Use a small set of universal Java types.
  - Fully advertise / describe their functionality
  - Useful when management application does not have access to the agent's Java classes
- Model MBeans
  - Truly dynamic
  - Allows "on-the-fly" creation of MBeans
  - Instantiate **`RequiredModelMBean`**, Configure, Register

JMX Architecture



JMX Agent Level

- Foundation Classes
- MBean Server
- Agent Services

Foundation Classes

- API argument types, return values
  - `ObjectName`
  - `ObjectInstance`
  - `Attribute, AttributeList`
- Metadata classes:
  - `MBeanInfo`
  - `MBeanFeatureInfo`
  - `MBeanAttributeInfo`
  - `MBeanOperationInfo`
  - `MBeanConstructorInfo`
  - `MBeanParameterInfo`
  - `MBeanNotificationInfo`

Object Names

- **`javax.management.ObjectName`**
- Uniquely identifies MBean within MBeanServer
- Consists of:
  - Domain (optional)
    - If omitted, MBeanServer supplies default
  - Unordered set of one or more property pairs
  - Any characters except **`",=*?:`**
  - Case-sensitive!
  - Syntax: **`[domainName]:property=value[,property=value]*`**
- Example: **`myDomain:type=Service,Service=scheduler`**
- Conventions
  - Domain: **`com.inventa.services`**
  - Include "type" property to aid searches
- Canonical form
  - Properties sorted lexicographically for comparison

Object Names – Pattern Matching

- Domain
  - File globbing conventions (*, ?)
- Properties
  - No wildcard matching on name / value
  - Wildcard for unspecified properties
- Examples
  - All MBeans in all domains: `"*:*"`
  - All MBeans in default domain: `"*"`
  - All MBeans of type "Service": `"*:type=Service,*"`

MBean Server

- Registry for MBeans in the agent, provides all services for manipulating MBeans
- **`interface javax.management.MBeanServer`**
- Implementation(s) obtained via **`MBeanServerFactory.findMBeanServer()`**
- Object Name: **`JMImplementation:type=MBeanServerDelegate`**

MBean Registration

- Instantiate and register
  - `createMBean(String className, ObjectName name)`
  - `createMBean(String className, ObjectName name, Object params[], String signature[])`
- Register pre-existing
  - `registerMBean(Object object, ObjectName name)`
- Unregister
  - `unregisterMBean(ObjectName name)`

MBean Queries

```
/* Find all the JBoss JMS Queue MBeans */

MBeanServer server = ...

ObjectName name = new
   ObjectName("jboss.mq.destination:service=Queue,*");

Set queueNames = server.queryNames(name, null);
Set queues = server.queryMBeans(name, null);
```

MBean Operations

- Metadata
  - `getMBeanInfo(ObjectName name)`
- Attributes
  - `getAttribute(ObjectName name, String attribute)`
  - `getAttributes(ObjectName name, String[] attributes)`
  - `setAttribute(ObjectName name, Attribute attribute)`
  - `setAttributes(ObjectName name, AttributeList attributes)`
- Operations
  - `invoke(ObjectName name, String operationName, Object params[], String signature[])`

Method Calls, JMX 1.1

```
public interface CachingManagerMBean {
   String[] getManagerNames();
   void clearCache(String managerName);
}
```

```
MBeanServer server = ...

ObjectName name = new
   ObjectName("inventa:type=Service,service=CachingManager");

String[] managers = (String[])server.getAttribute(name, "ManagerNames");

for (String manger : Managers) {

   Object result = server.invoke(
                                  name, "clearCache",
                                  new Object[]{manager},
                                  new String[]{String.class.getName()});
}
```

Method Calls, JMX 1.2

```
MBeanServer server = ...

ObjectName name = new
    ObjectName("inventa:type=Service,service=CachingManager");

CachingManagerMBean cachingManager = (CachingManagerMBean)
   MBeanServerInvocationHandler.newProxyInstance(
                                                  server,
                                                  name,
                                                  CachingManagerMBean.class,
                                                  false);

String[] managers = cachingManager.getManagerNames();

for (String manger : Managers) {

   cachingManager.clearCache(manager);
}
```

Notifications

- MBeans can optionally implement **`NotificationBroadcaster`**
  - Allows listeners to register with MBean
  - MBeans should implement **`getNotificationInfo()`**
- In practice: MBeans extend **`NotificationBroadcasterSupport`**
  - Raise notifications with **`sendNotification()`**
  - Base class delivers to all registered listeners
- Listeners register via MBeanServer
  - **`addNotificationListener(ObjectName name,`**
    `NotificationListener listener,`
    `NotificationFilter filter,`
    `Object handback)`

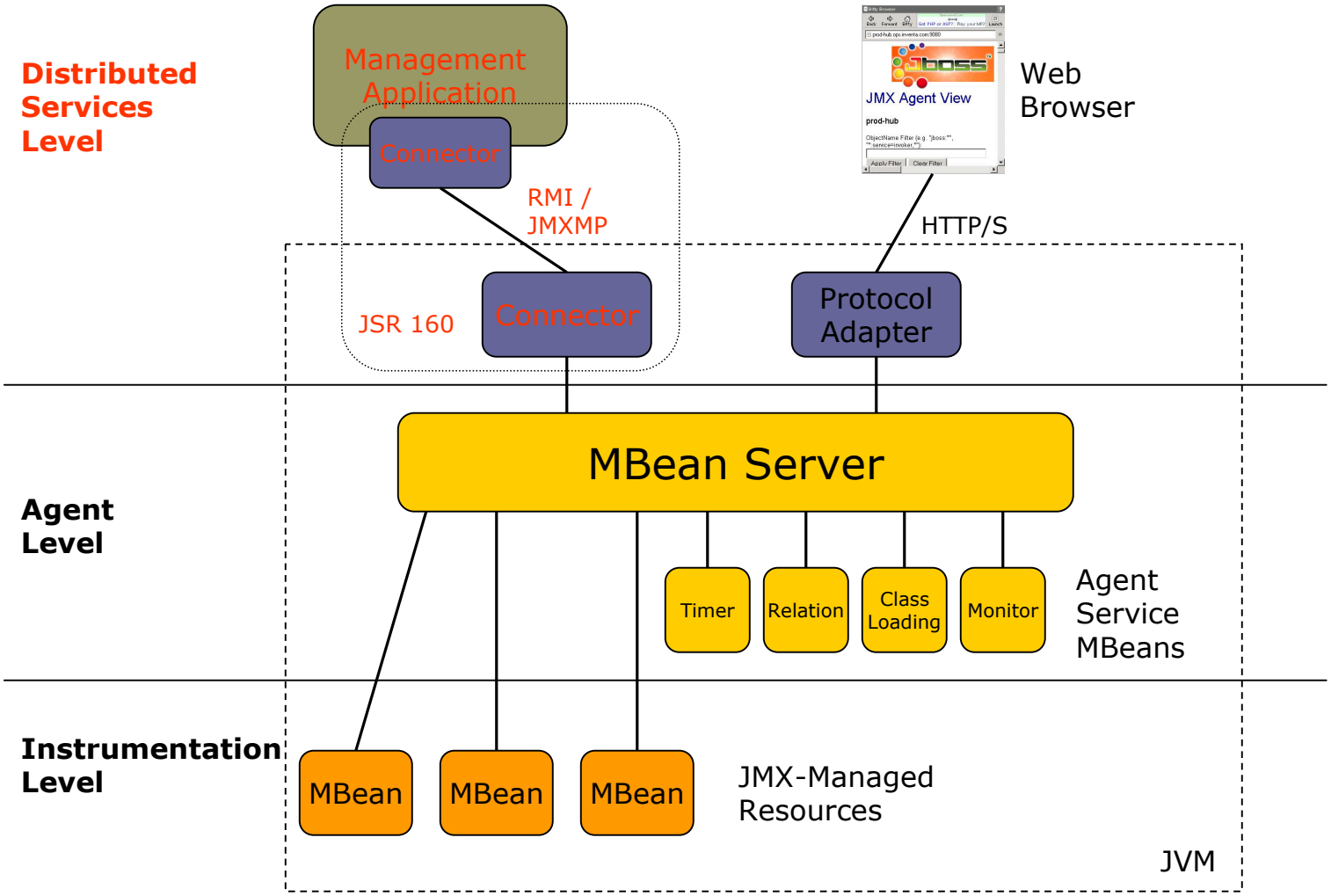
Notifications

```
class NotifyingService
   extends NotificationBroadcasterSupport
   implements NotifyingMBean {
   .
   .
   .
   private void raiseAlert() {

      Notification n = new Notification(ALERT_EVENT_TYPE, this,
         getNextNotificationSequenceNumber());

      /* Add notification-specific information */
      Map context = new HashMap();
      context.put(...);
      n.setUserData(context);

      sendNotification(n);
   }
}
```

Agent Services

- Timer
  - Scheduling facility for single or periodic notifications
- Monitoring
  - Allows observation of other MBean's attributes
  - Receive notification when attribute satisfies certain conditions
- Class Loading
  - Provides remote class-loading when registering MBeans external to the MBeanServer.
- Relationship
  - Allows definition of multiplicity relationships between registered MBeans. (1..1, 1..n, etc)
  - Service maintains consistency, blocks creation of invalid relationships.
  - Relationships are separate from MBean registration – they can be added or removed but the MBeans are unaffected.

JMX Architecture



Distributed Service Level

- Connectors
  - JMX (JSR 3) defined the concept
  - JSR 160 defines Connector APIs
    - Default protocols are RMI, JMXMP
    - Other implementations: SOAP, Burlap, Hessian, …
    - Good news: API independent of serialization protocol / transport
- Client interface: **`JMXConnector`**
  - Factory: **`JMXConnectorFactory`**
- Server interface: **`JMXConnectorServer`**
  - Factory: **`JMXConnectorServerFactory`**
- **`JMXServiceURL`** identifies server
  - **`service:jmx:`*`<protocol>`*`://[[[`*`<host>`*`]:`*`<port>`*`]/`*`<path>`*`]`**

Using Connectors

- Connector server is created / started either:
  - Standalone
  - By registering it as an MBean within the target MBeanServer

- Creating connector client:

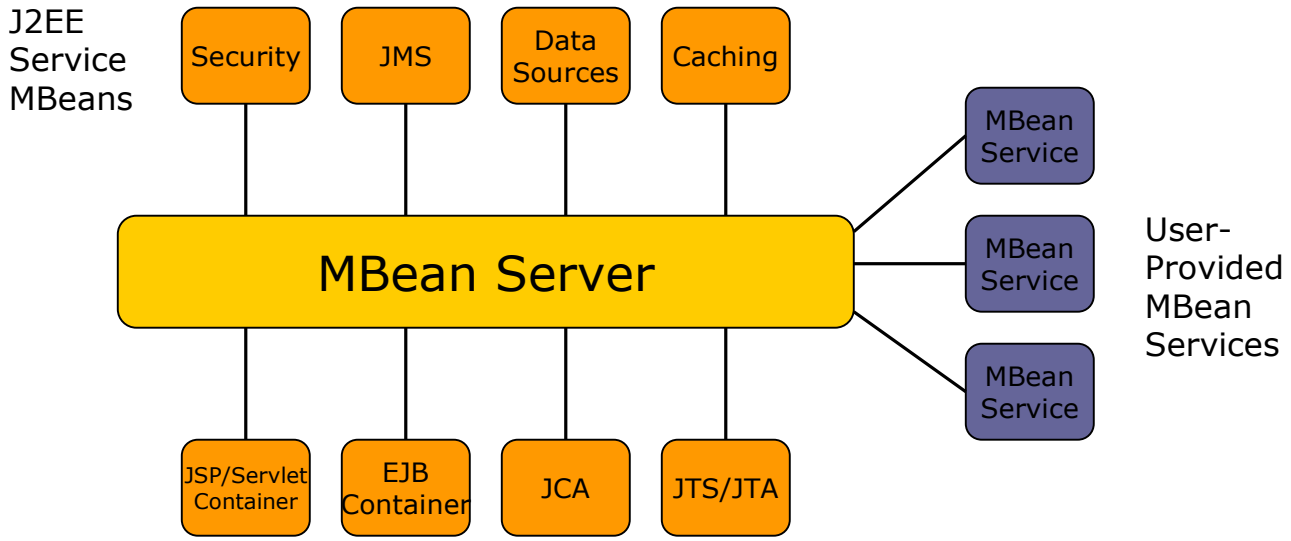
```
JMXServiceURL address = new
   JMXServiceURL("service:jmx:rmi://remoteHost");
connector = JMXConnectorFactory.connect(address, null);

MBeanServerConnection server =
   connector.getMBeanServerConnection();
```

- **MBeanServer implements MBeanServerConnection**

Hosting Spring in JBoss

JBoss 4

- JMX Microkernel, modular architecture



JBoss JMX Console / MBean Services

Demonstration

Spring JMX Support

Spring's Core JMX Features

- Automatic registration of *any* Spring bean as a JMX MBean
- Flexible control of the management interface
- Flexible control of Object Names
- Declarative exposure of MBeans over remote, JSR-160 connectors
- Proxying of both local and remote MBeans

- New features in Spring 2.0
  - Control of MBean registration behavior
  - Notification support

MBean Registration

- Core class **`MBeanExporter`**:
  - Registers Spring beans as JMX MBeans
- Explicit registration of any Spring bean:
  - Valid JMX MBeans
  - POJOs
- Automatic detection / registration of valid JMX MBeans

Explicit Registration

```
<bean id="exporter"
      class="org.springframework.jmx.export.MBeanExporter"
        lazy-init="false">
    <property name="beans">
        <map>
            <entry
key="inventa.service:type=Service,service=Manageable"
                value-ref="Manageable"/>
            <entry key="inventa.service:type=Person"
                value-ref="John"/>
        </map>
    </property>
</bean>
```

Automatic Registration

- **`MBeanExporter`** detects all valid JMX MBeans

```
<bean id="exporter"
  class="org.springframework.jmx.export.MBeanExporter"
        lazy-init="false">

    <!-- Auto register any standard MBeans -->
    <property name="autodetect" value="true"/>
  </bean>
```

Spring 2.0 Feature – Registration Behavior

- Use **`MBeanExporter`** "registrationBehaviorName" property

```
<property name="registrationBehaviorName"
          value="REGISTRATION_FAIL_ON_EXISTING"/>
```

- **`REGISTRATION_FAIL_ON_EXISTING`**
- **`REGISTRATION_IGNORE_EXISTING`**
- **`REGISTRATION_REPLACE_EXISTING`**

Spring MBean Registration

Demonstration

Management Interface Control

- Powerful and comprehensive facilities
- Many ways to control the exposed interface

- **`MBeanExporter`** delegates to implementations of **`MBeanInfoAssembler`** for creating management interfaces at runtime
  - Reflection-based (default, exposes everything)
  - Source Level Annotation–based
    - Commons Attributes
    - JDK 5.0 Annotations
  - Java Interface-based
  - Method name-based

Method Name-Based Interface Assembly

```
<bean id="exporter"
        class="org.springframework.jmx.export.MBeanExporter"
        lazy-init="false">

     <property name="beans">
        <map>
           <entry key="inventa.service:type=Person"
                  value-ref="John"/>
        </map>
     </property>
     <property name="assembler">
        <bean
   class="org.springframework.jmx.export.assembler.MethodNameBasedMBeanInfo
   Assembler">
           <property name="managedMethods">
              <value>setName,getName,setAge,getAge</value>
           </property>
        </bean>
     </property>
</bean>
```

Spring MBean Interface Control

Demonstration

Object Name Control

- Many ways to control ObjectNames as well…
- **`MBeanExporter`** delegates to implementations of **`ObjectNamingStrategy`** for creating ObjectNames
  - Based on key from "beans" property map (default)
  - Based on external Properties file
  - Based on JVM's notion of object identity
  - Based on source-level annotation

JSR 160 Connectors / Proxies

- Spring JMX supports creating both server and client Connector beans.
- A client Connector bean could point to any remote MBeanServer
- Spring can proxy remote objects:

```
<bean id="clientConnector"
    class="org.springframework.jmx.support.MBeanServerConnectionFactoryBean>
    <property name="serviceUrl" value="service:jmx:rmi://remotehost:9875"/
</bean>

<bean id="proxy"
    class="org.springframework.jmx.access.MBeanProxyFactoryBean">
    <property name="objectName" value="bean:name=testBean"/>
    <property name="proxyInterface"
    value="org.springframework.jmx.IJmxTestBean"/>
    <property name="server" ref="clientConnector"/>
</bean>
```

Thanks!

Questions?

References / Resources

- JMX Home: http://java.sun.com/products/JavaManagement
- JMX Best Practices:
  http://java.sun.com/products/JavaManagement/best-practices.html
- Harold, Ward et. al, Java™ and JMX: Building Manageable Systems, Addison-Wesley Professional, 2003.
- Spring Framework 2.0.x Reference:
  http://static.springframework.org/spring/docs/2.0.x/reference/index.html
- JBoss 4 Application Server Guide:
  http://docs.jboss.org/jbossas/jboss4guide/r5/html/