Native OSGi

Modular Software Development in a Native World

Alexander Broekhuis
alexander.broekhuis@luminis.eu

Sascha Zelzer
s.zelzer@dkfz-heidelberg.de

Agenda

- Introduction
- Motivation
- History
- Current State
- Native OSGi
- Outlook

Alexander Broekhuis

- Software Developer
  - Started as a Java Engineer
  - Programming C since 2010
  - At Luminis since 2008
    - Software House
    - Research and innovation oriented
    - Involved in Open Source (Apache)
  - Apache committer since 2010

Sascha Zelzer

- Software Developer
  - 15 years of experience with Java, Eclipse, C++
  - Current focus on modular C++ systems
    - For research environments
- Since 2005 at the German Cancer Research Center (DKFZ)
  - Large multi-disciplinary research environment
  - Mainly cancer research and medical imaging
  - Long open-source history within the department

OSGi is:

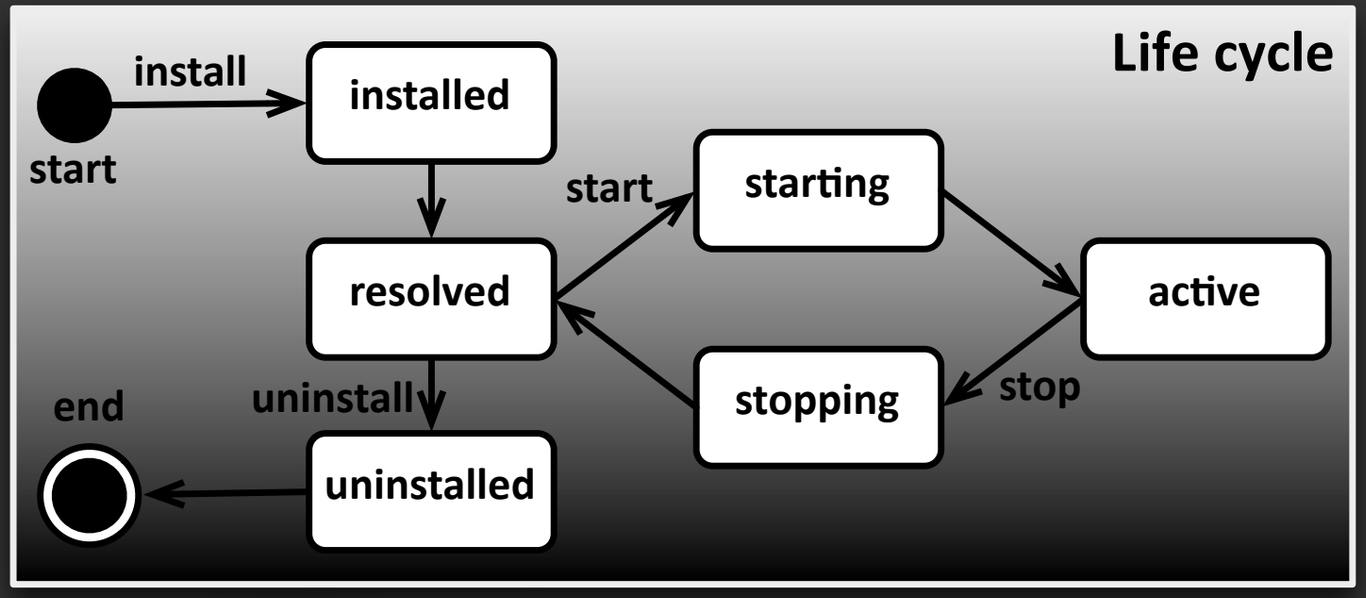
- component based framework
- allows dynamic assembly of components
- Java, so independent of operating system

OSGi technology is the dynamic module system for Java™

OSGi technology is Universal Middleware.

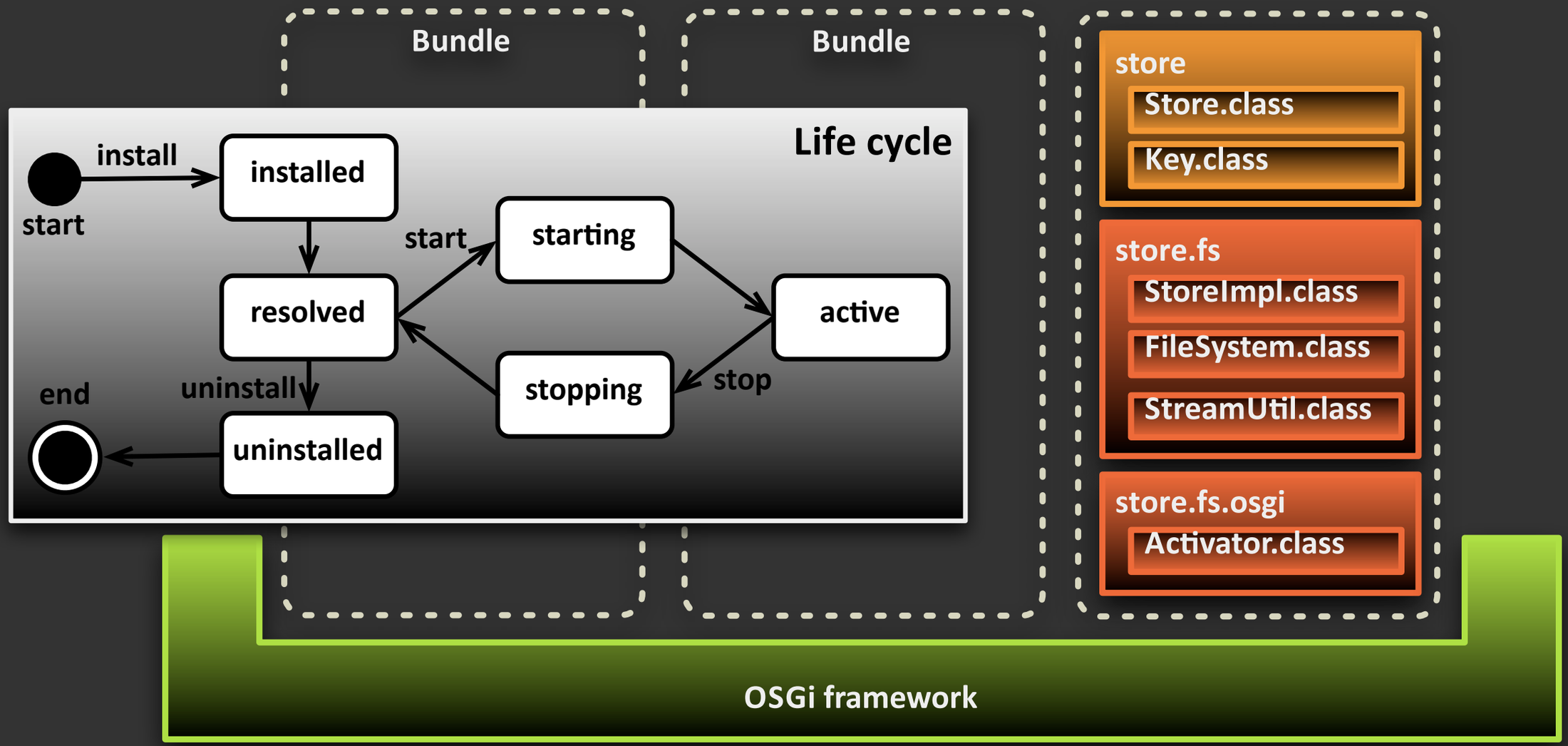
OSGi technology provides a service-oriented, component-based environment for developers and offers standardized ways to manage the software lifecycle. These capabilities greatly increase the value of a wide range of computers and devices that use the Java™ platform.

OSGi

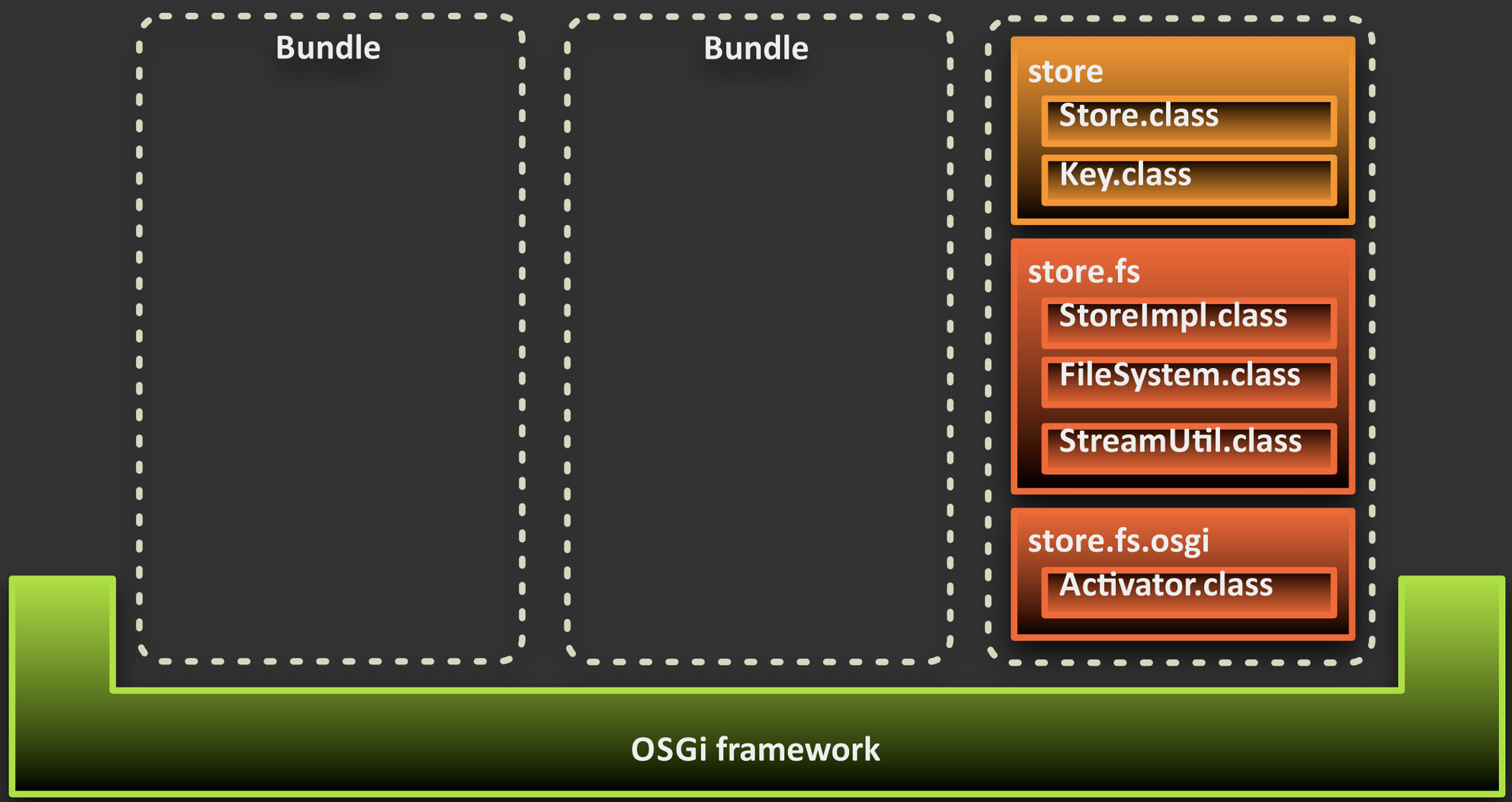

Life cycle
install
start
installed
start
starting
resolved
active
stopping
stop
uninstall
end
uninstalled


OSGi framework

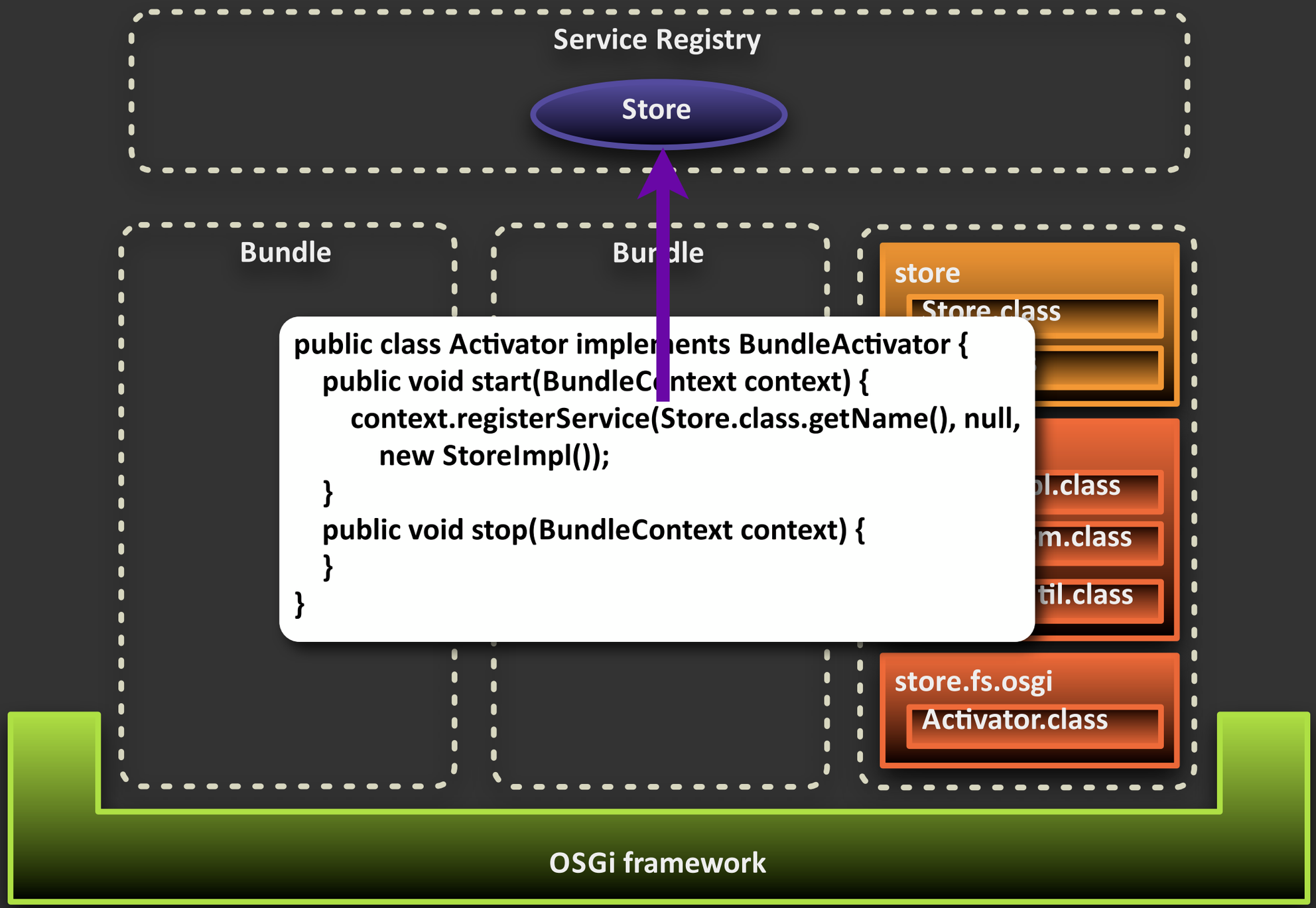
OSGi


Bundle
Bundle
Life cycle
install
start
installed
resolved
start
starting
active
stopping
stop
uninstall
end
uninstalled
store
Store.class
Key.class
store.fs
StoreImpl.class
FileSystem.class
StreamUtil.class
store.fs.osgi
Activator.class
OSGi framework

OSGi


Bundle
Bundle
store
Store.class
Key.class
store.fs
StoreImpl.class
FileSystem.class
StreamUtil.class
store.fs.osgi
Activator.class
OSGi framework

OSGi


Service Registry
Store
Bundle
Bundle
store
Store.class
public class Activator implements BundleActivator {
public void start(BundleContext context) {
context.registerService(Store.class.getName(), null,
new StoreImpl());
}
public void stop(BundleContext context) {
}
}
store.fs.osgi
Activator.class
OSGi framework

Benefits

- Making products with many variations
- Improving quality through re-use
- Speed: time to market

Native OSGi

"The Native OSGi project is a collaborative effort to write, test, and implement the Java OSGi specifications in C and C++ with a focus on interoperability between C, C++ and Java"

Motivation - Why?

- C and C++ are NOT obsolete
  - C++11 is a big step forward
- Traditional Application Domains
  - Embedded Devices
  - Medical Imaging
  - Sensor Networks
- Lightweight Native Module System
  - Benefits native developers

C/C++ Modularization

- Examples
  - CORBA and CCM: Portable, heavy-weight
  - Service Component Architecture (SCA)
- Problems
  - Find a C/C++ implementation with an appropriate license
  - Scope can be too broad/overwhelming

Benefits

- Mature API
  - OSGi is around since 1999
- Core Specifications are small
- Enables hybrid Java/C/C++ solutions
  - as an alternative to JNI
- Eases migration
  - From Native to Java
- Embedded Performance

Challenges

- Dynamic Module Layer
  - Code Sharing
  - Linking and Versioning
- Different Platforms
  - Posix/Win32/...

History - Universal OSGi

- RFP-89
  - Proposed to the mailing in 2007
  - Since then remained silent
  - Ongoing (slow) effort to pick up again
- Focused on
  - Supporting different languages in OSGi
  - Supporting framework in different languages
  - Languages mentioned:
    - Native (C and C++), .NET (C#), Scripting (Javascript/Actionscript)

History - Universal OSGi

- Completely Different Languages
  - Native, Managed, Scripting
- Limit Scope
  - Focus on C/C++
- Makes it easier to progress
- Keeps Focus on Common Runtime

"Native-OSGi"

Current State

- OSGi-like Implementations
- CTK Plugin Framework
- Apache Celix
- nOSGi
- Service Oriented Framework (SOF)

Current State

- Small Communities
- No Interoperability
  - Different bundle format
  - API differences
  - Wiring solved differently
    - Module layer

CTK Plugin Framework

Developed at the German Cancer Research Center (DKFZ)

Largest biomedical research institute in Germany

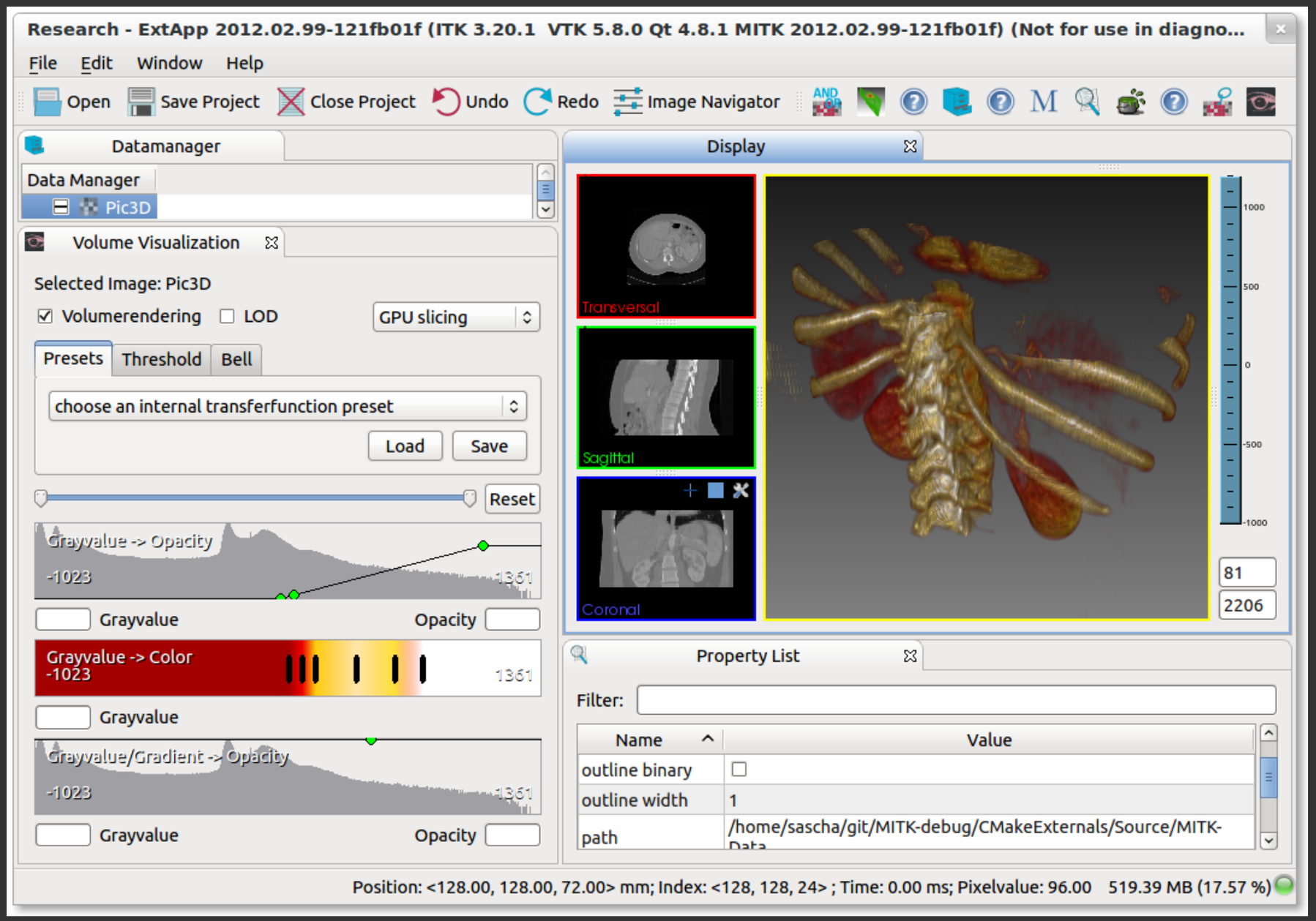
Founded in 1964, ~2200 employees

CTK Plugin Framework

- Part of “Common Toolkit”
  - Large international initiative (medical imaging)
- C++ API is very close to the OSGi Specification
- Provides Implementations
  - Log
  - Configuration Admin
  - Metatype
  - Event Admin
- Runs on: Windows, Linux, MacOS

CTK Plugin Framework

Powers an “Eclipse RCP”-like C++ platform



Apache Celix

- Development started at Thales Netherlands
  - Open Sourced / Donated by Luminis to Apache
- Embedded distributed systems
  - Dynamic (Re)Configuration
- Used as middleware in large research project

Apache Celix

- Implemented in C
  - API close to the specification
  - Adapted to Non-Object Oriented use
- Donated to the Apache Incubator
- Provides
  - Log Service
  - Devices Access
  - Shell
  - Remote Service Admin
  - Deployment Admin

nOSGi

- Research project at University of Ulm
  - Steffen Kächele
- Very lightweight and fast implementation (only requires c++ runtime and unzip)
- Runs on POSIX systems
- Features
  - Wiring of shared objects for code-sharing
  - Service registry with filters
  - Supports source bundles (compiled at runtime)
  - Comes with a Shell implementation

Service Oriented Framework (SOF)

- Mature open-source project (BSD)
    - Matthias Grosam
- Shared libraries model bundles
- Runs on Windows and Linux
- Features
    - Service registry, trackers and listeners
    - Provides a command shell
    - Remoting capabilities (using CORBA)
        - Remote services and service listeners
        - Command shell for each process

Specification

- Members
- Goal
- Bundle Format
- Module Layer
- Life Cycle Layer
- Service Layer
- C and C++ Interoperability

Members

- CTK Plugin Framework
- Apache Celix
- nOSGi

Initial/startup meeting took place in Hengelo in May this year

Goal

- Follow OSGi Specification
- Allow Interoperability
  - Bundles
  - Remote Services
- Seamless C and C++ Interoperability
  - E.g. provide a C service, consume via C++ interface

Goal

- Grow Communities
- Combine where possible
- Channel efforts
- Write Open Source reference
  - All feedback is welcome!

Realization

Same Format, Different Layout

Packages equal Shared Libraries

Class Loader replaced by Dynamic Linker

Bundle Format

- Like Java Archives (JAR)
  - Using ZIP format
- Bundle Manifest
  - .cmf vs .mf
  - Headers
- Optionals
- Libraries
- Resources

Layout:

-META-INF/

-MANIFEST.CMF

-OSGI-OPT

-share/

-include/

-src/

-lib/

-resources/

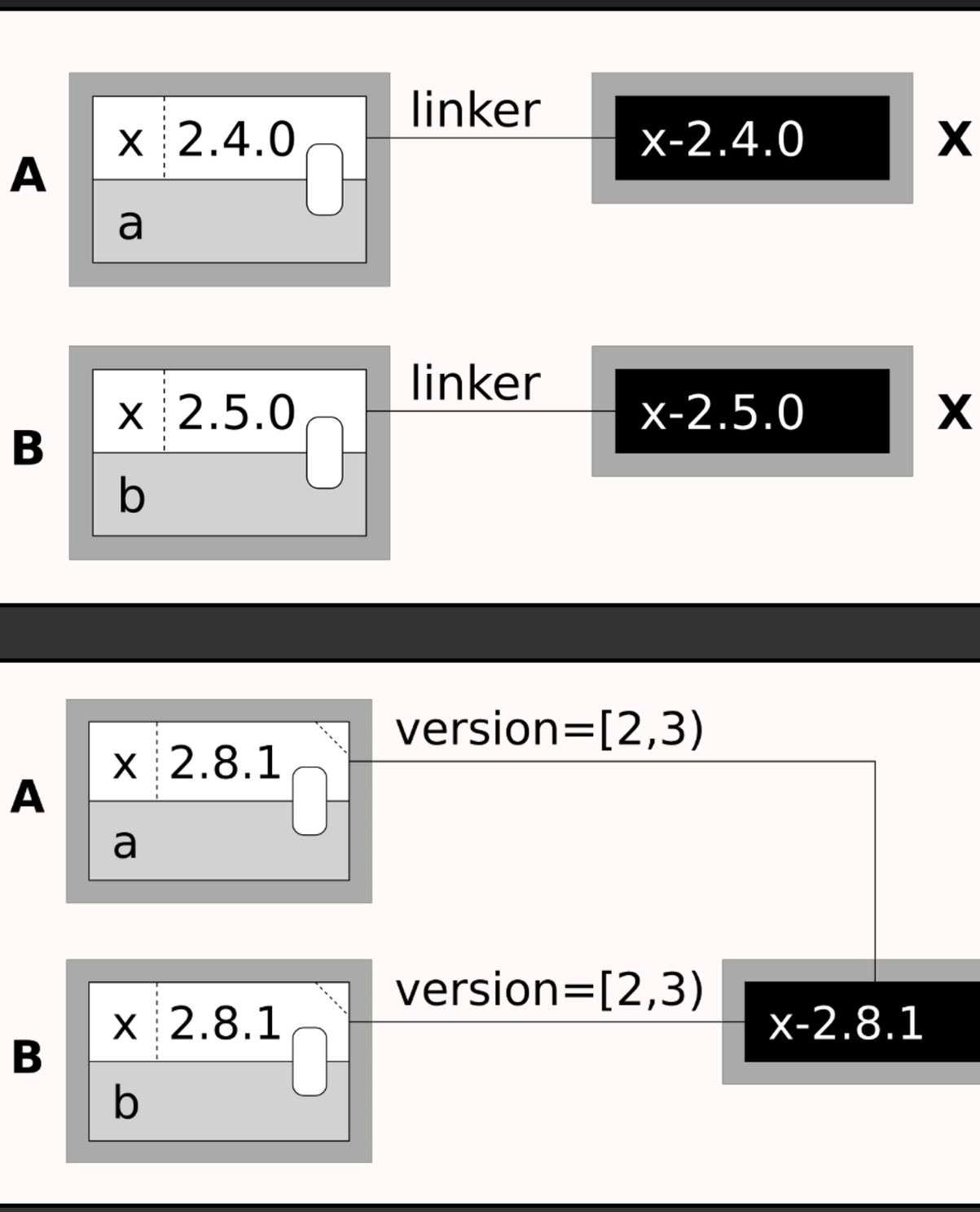
Module Layer

- Shared Libraries model Java Packages
  - Allows Code Sharing
  - Multiple Libraries per Bundle
    - Symbols must be exported explicitly
      - Additional visibility control
    - Symbol Searching Handled by Linker
- Meta-data
  - Import/Export Headers
  - Execution Environment for Additional Requirements

“Package” Wiring

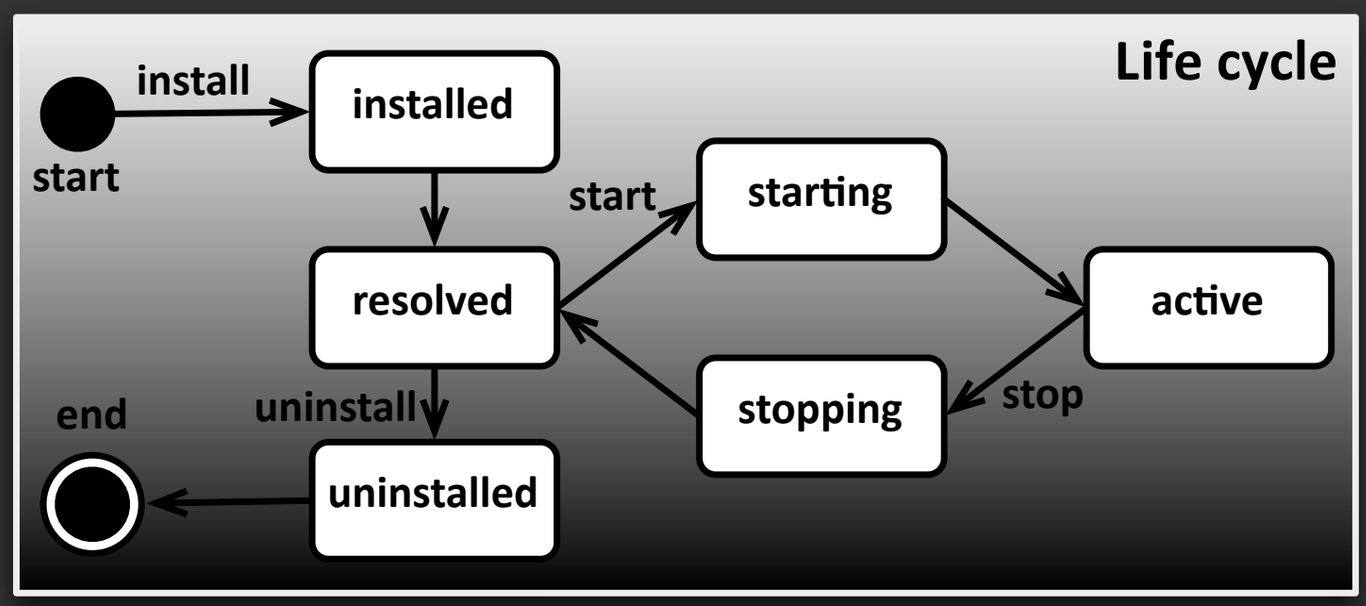
- Mechanism from nOSGi
- Library Dependencies Patched at Runtime
  - To match with available exports
- Allows Multiple Versions
  - Of the same package
- Allows Bundle Updates

“Package” Wiring



Life Cycle Layer

- Follows Specification
  - Resolves Dependencies using Manifest
- Bundle Activator API
  - Start Activator
  - Stop Activator
- Native Specific
  - Create Activator
  - Destroy Activator



Service Layer

- Native API Close to the Specification
  - Especially C++
  - C API is adapted to Non-Object Oriented use
- Requirements for C++
  - Be Type-Safe
    - Avoid exposing void* where possible
  - Do not require a Service base class
  - Allow multiple inheritance of Service interfaces

Service Layer

- Requirements for C
  - Use Struct with Function pointers for Services
  - Components are represented as void*
  - Return value only used for error codes
    - Return values via arguments

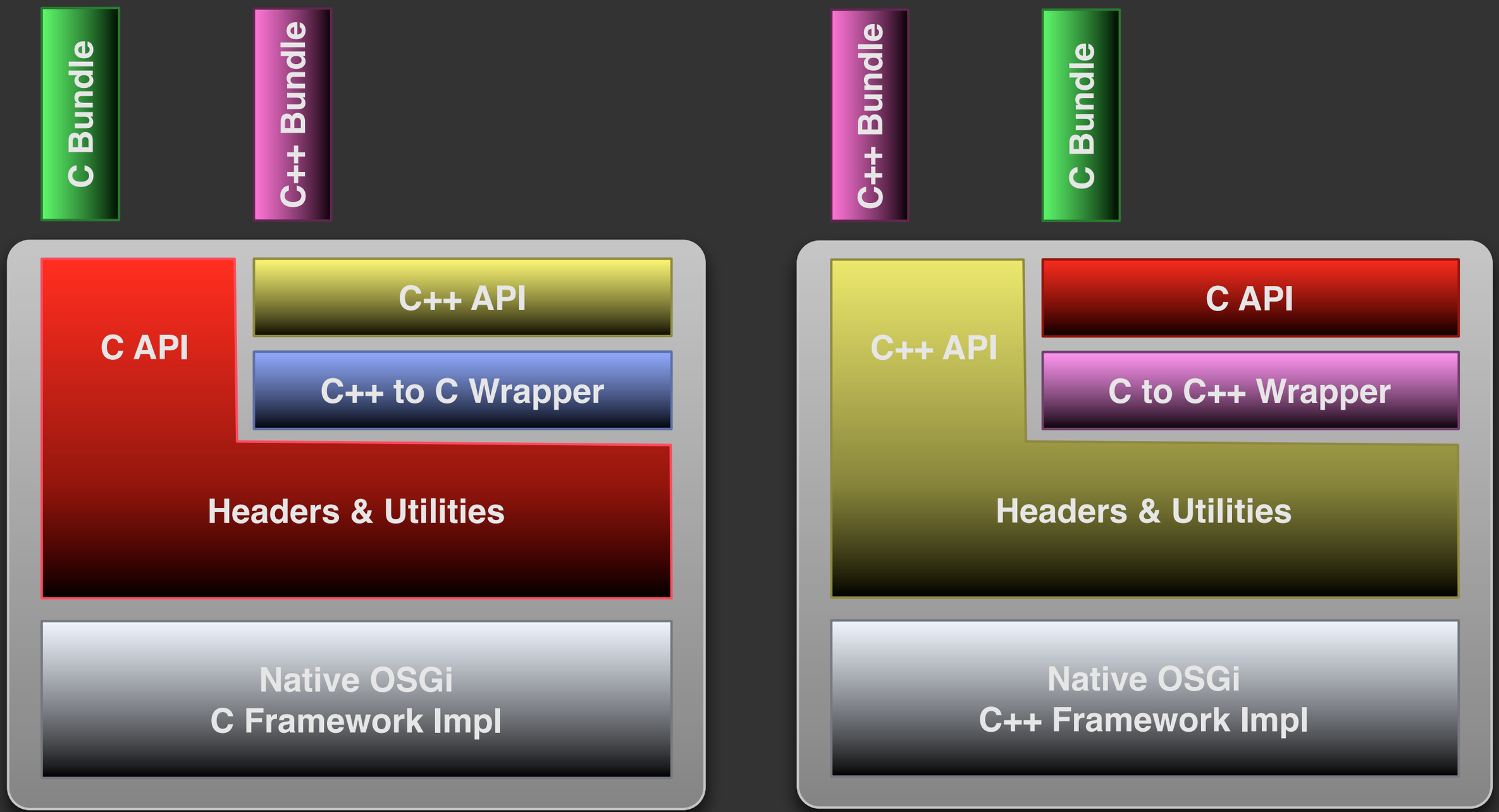
C / C++ Interoperability

- Native-OSGi
  - Provides both C and C++ headers
  - Provide thin bi-directional wrapping
- Service Interfaces
  - Should provide C and C++
    - C++ Services implemented using Interfaces
    - C Services implemented using Structs and Function Pointers

C / C++ Interoperability

- Service Interfaces
  - Provide bindings for C -> C++ and C++ -> C
  - IDL for Service description and code generation
- Service Provider
  - Implement either the C or C++ header
- Service Consumer
  - Use either the C or C++ API

C / C++ Interoperability



Code Examples - Interface Declaration

greeting_service.h

```
typedef struct greeting *greeting_t;
typedef struct greeting_service
                    *greeting_service_t;

#ifdef __cplusplus
extern "C"
#endif

struct greeting_service {
 greeting_t instance;
 void (*greeting_sayHello)
      (greeting_t instance);
};
```

IGreetingService.h

```
struct IGreetingService {
 virtual ~IGreetingService();
 virtual void sayHello() const = 0;
};

OSGI_DECLARE_SERVICE_INTERFACE(
    IGreetingService, IGreetingService_NAME)
```

Code Examples - Service Registration

greeting_impl.c

```
#include "greeting_service.h"
struct greeting {
 char *name;
};
void greeting_sayHello(greeting_t instance) {
  printf("Greetings from %s\n", instance->name);
}
void register_services() {
  BUNDLE_CONTEXT context = ...
  greeting_service_t greeter = malloc(...);
  greeter->instance = malloc(...);
  greeter->instance->name = "C greeter";
  greeter->greeting_sayHello =
      greeting_sayHello;
  bundleContext_registerService(context,
      IGreetingService_NAME, greeter, NULL, NULL);
}
```

GreetingImpl.cpp

```
#include <IGreetingService.h>

struct CppGreeter : public IGreetingService {
  std::string name;
  void sayHello() const {
    std::cout << "Greetings from " << name << std::endl;
 }
};

void register_services() {
  osgi::BundleContext* context = ...

  CppGreeter* greeter = new CppGreeter;
  greeter->name = "C++ greeter";
  context->registerService<IGreetingService>(greeter,
      osgi::ServiceProperties());
}
```

Code Examples - Service Consumption

consumer_impl.c

```
BUNDLE_CONTEXT context = ...
SERVICE_REFERENCE serviceRef = NULL;

bundleContext_getServiceReference(context, IGreetingService_NAME, &serviceRef);

void* serviceHandle = NULL;
bundleContext_getService(context, serviceRef, &serviceHandle)

greeting_service_t service = (greeting_service_t)serviceHandle;
service->greeting_sayHello(service->instance);
```

ConsumerImpl.cpp

```
osgi::BundleContext* context = ...

typedef osgi::ServiceReference<IGreetingService> ServiceReferenceType;

ServiceReferenceType greetingRef = context->getServiceReference<IGreetingService>();
IGreetingService* greetingService = context->getService(greetingRef);

greetingService->sayHello();
```

Outlook

- Write Specification
  - Test ideas/solutions
  - As part of the OSGi Alliance
- Define Reference Implementation
- Look into Compendium Services
  - Remote Service as alternative to JNI
  - Adapt other Services to Native-OSGi
- Community!

Resources

- Native-OSGi: www.nativeosgi.org
- Apache Celix:
  - incubator.apache.org/celix
- CTK Plugin Framework:
  - www.commontk.org/index.php/Documentation/Plugin_Framework
- nOSGi:
  - www.uni-ulm.de/in/vs/proj/nosgi/
- SOF:
  - sof.tiddlyspot.com/