A Dependability Framework for building secure Dynamic Component Systems

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Introduction

- 2 Types of Component Systems
  - Static Components
    - Guaranteed Properties, Strong Specifications, QoS
    - Ex: Paladio
    - Design Time Validation
  - Dynamic Components
    - Runtime extension (and removal)
    - Handheld, Embedded and Automotive Systems, Application Servers
    - Ex: JavaCard, MIDP, OSGi in the Java world
    - Install Time Validation

Introduction

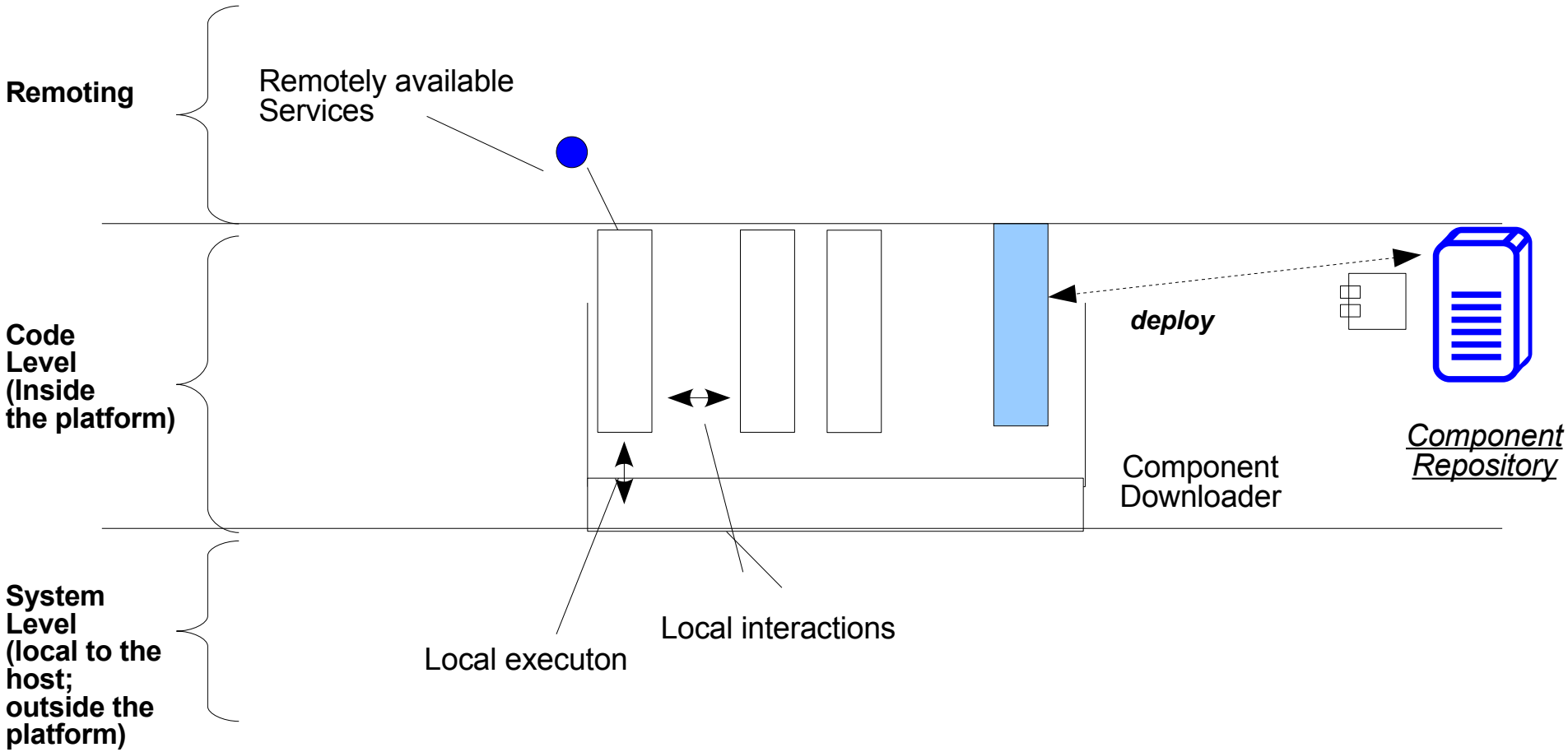
- Security Models for Extensible Component Middleware
  - Identify the Issues
  - Propose first Solutions
  - Make (some) Tools available
- Target System
  - OSGi Platform over Java
    - Even broader use
    - Likely to be integrated in Java 7
    - Object study of the Middleware Team of the CITI Lab.

Summary

- **Extensible Component Platforms**
- Dependability for Extensible Component Systems
- Secure Deployment
- Secure Execution
- Achievements and Open Issues

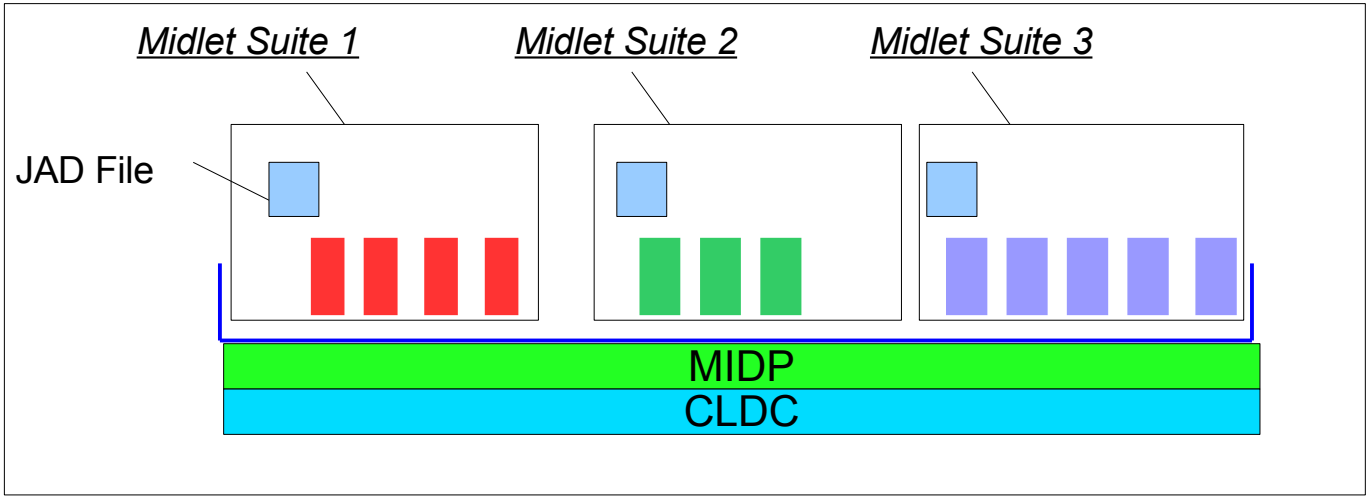
Extensible Component Platforms

- Structure



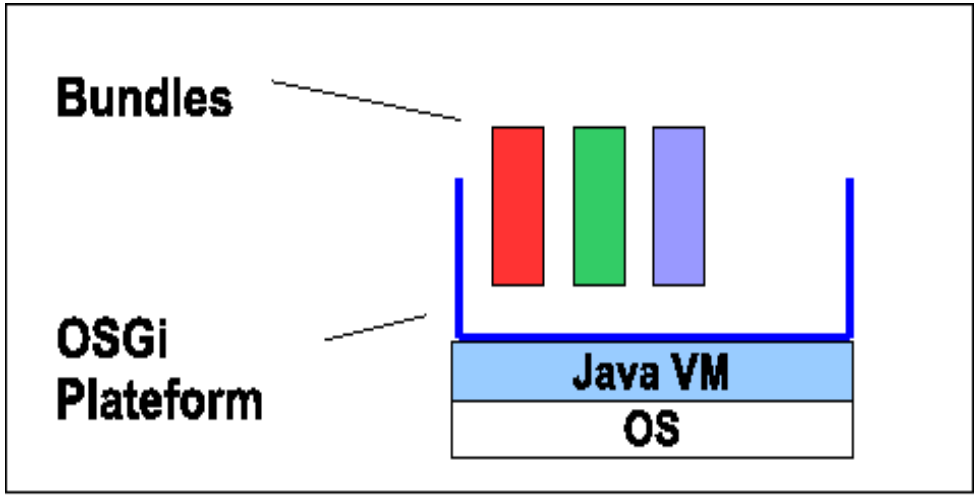
Extensible Component Platforms

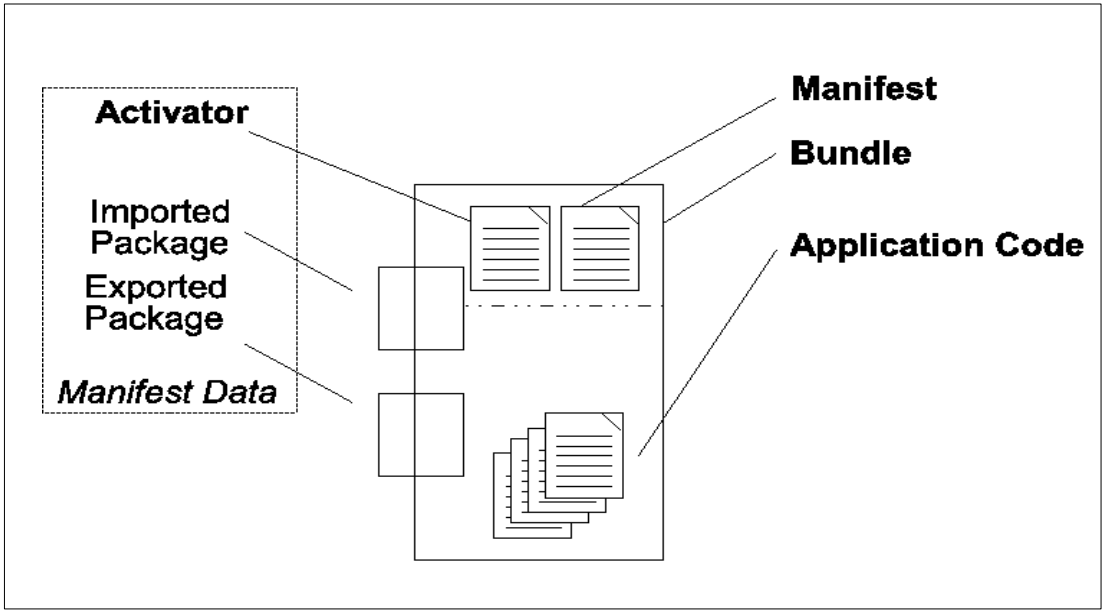
- Example 1: MIDP
  - Mobile Information Device Profile
  - Defined by Sun
  - Applications
    - Middlet Suites
    - Defined in an external JAD File
      - Java Application Descriptor



Extensible Component Platforms

- Example 2: OSGi
  - Was 'Open Service Gateway Initiative'
    - Is now an adjective
  - Forstered by the OSGi Alliance
  - The Platform - The Bundles





Summary

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- **Dependability for Extensible Component Systems**
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Dependability for Extensible Component Systems

- The Dependability Approach to Security

concurrent existence of
a) availability for authorized users only,
b) confidentiality, and
c) integrity

  - Motivation
    - A robust system must withstand Attacks
    - A secure system must withstand Faults

⇒ Both aspects must be considered when building a real system

⇒ Both aspects must are the two faces of the same coin
- different techniques
- different communities
- same target systems

Dependability for Extensible Component Systems

- Protection against Attacks
  - For Dynamic Component Systems

	Deployment	***Execution***
Attack Prevention	Digital signature	Intrusion Benchmarking Code validation Access Control
Attack Tolerance	Network IDS	Host IDS
Attack Removal	Protocol Patching	Platform patching
Attack Forecasting	Audit based on network-level Security logs	Audit based on host-level Security logs

My work

Dependability for Extensible Component Systems

- Dependability Properties for Execution
  - For Dynamic Component Systems
  - First Consider Prevention

	Fault Prevention	***Attack Prevention***
Availability	Prevent stopping/destruction of Platforms and Components	
Reliability	Prevent Erroneous Method Calls	
Safety	- (No full guarantee on Java-based Systems)	
Confidentiality	Ressource Isolation Access Control	
Integrity		
Maintainability	Component Life-Cycle by default in OSGi Separation of Management and Applicative level required	

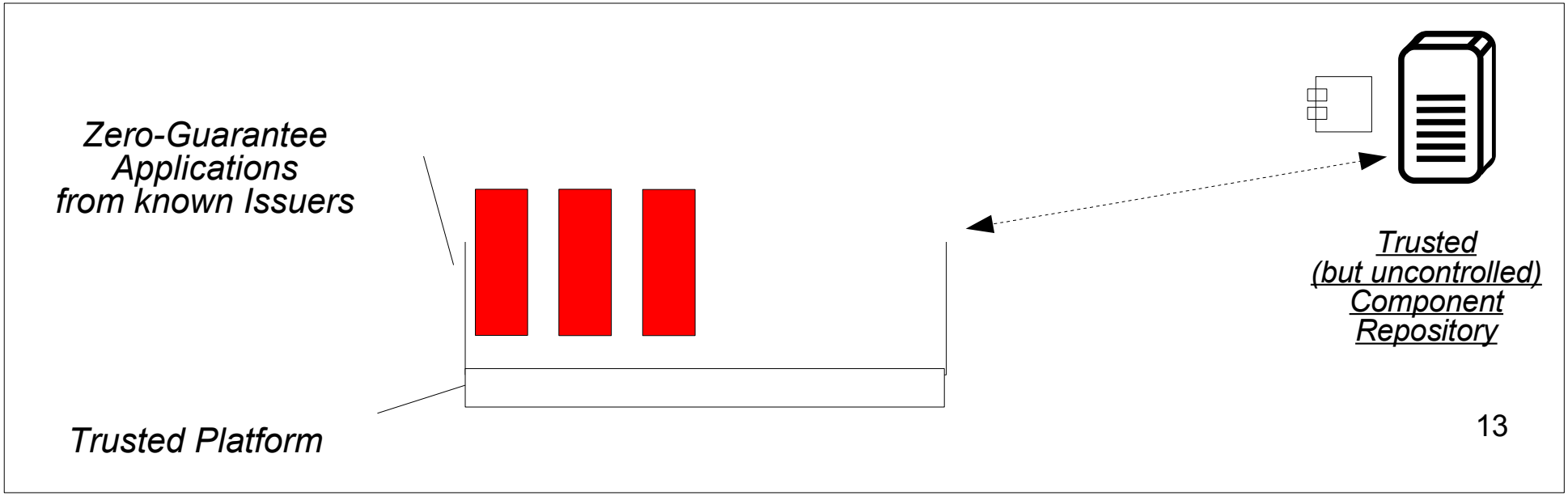
Dependability for Extensible Component Systems

- The Opportunities with Java-based Systems
  - JVM is designed to be safe
- The Problem with Java-based Systems
  - Components have not been taken into account when designing Java Security
  - Complex Systems
  - Constraint unaware developpers
    - The community likes to build functionnal stuff
    - The community does not like security, pre/post conditions

→ An easy-to-use solution is required for Java Extensible Component Platforms

Dependability for Extensible Component Systems

- The Trust Model for Extensible Component Platforms
  - Trusted Platform, Untrusted Network
  - Components with trusted origin, issuer does his best to provide 'satisfactory' components
  - 'Satisfactory' is highly subjective – characterization is needed (performance, safety, security, etc.)



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- **Secure Deployment**
- Secure Execution
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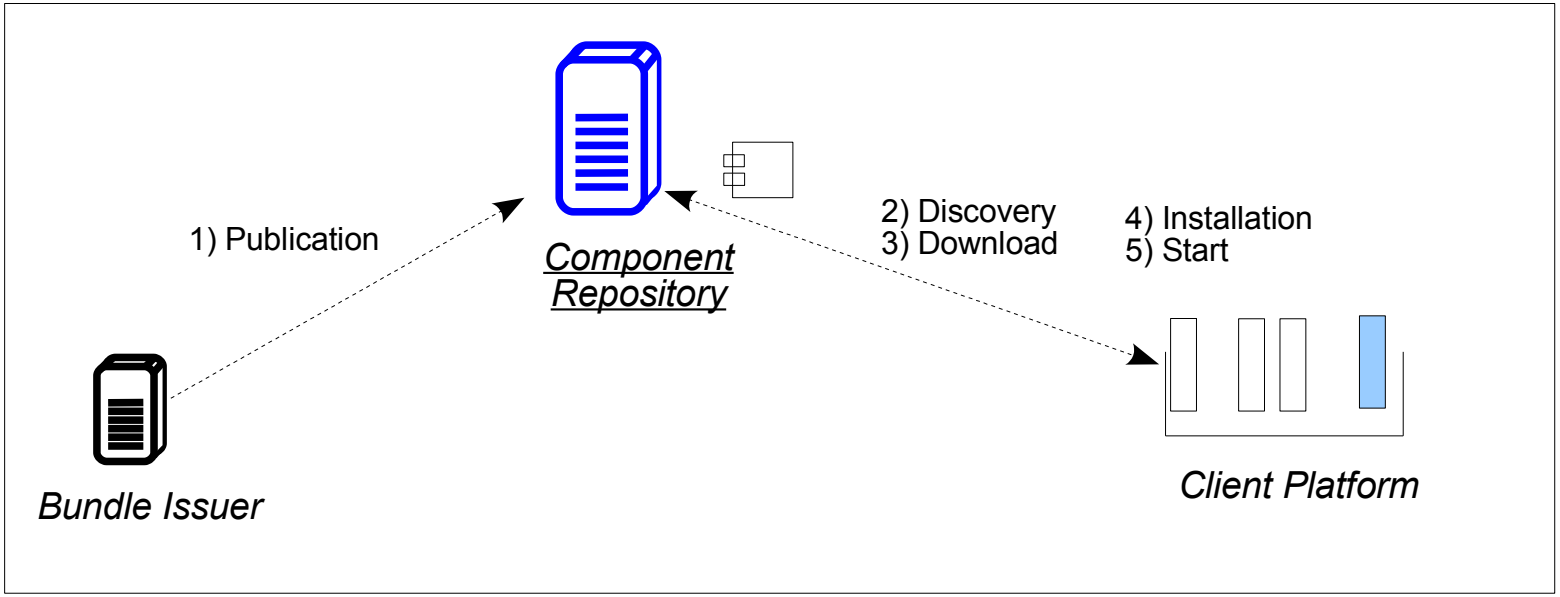
Secure Deployment

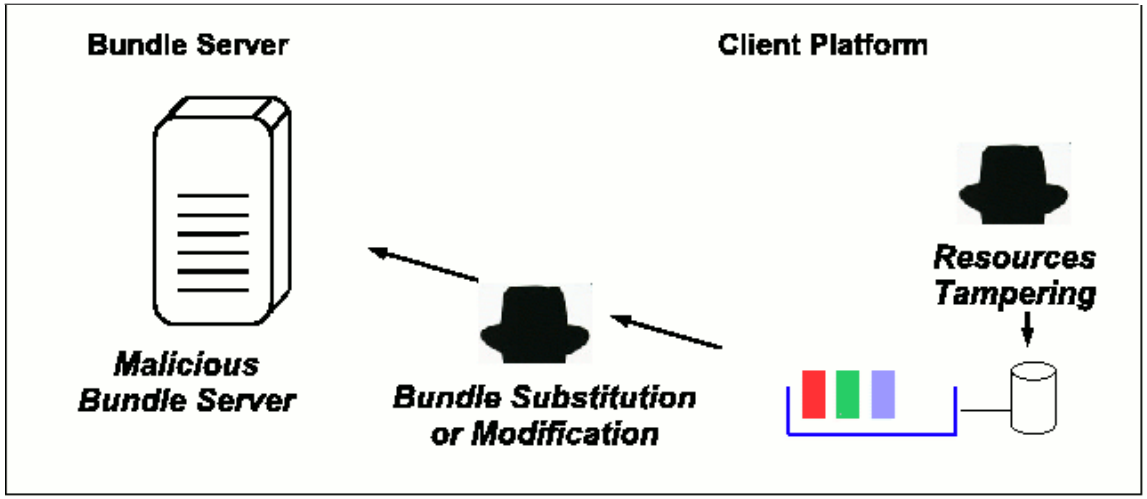
- The Deployment Process in the OSGi Platform



- Deployment Stakes
  - Threats on Deployment
  - Key Management

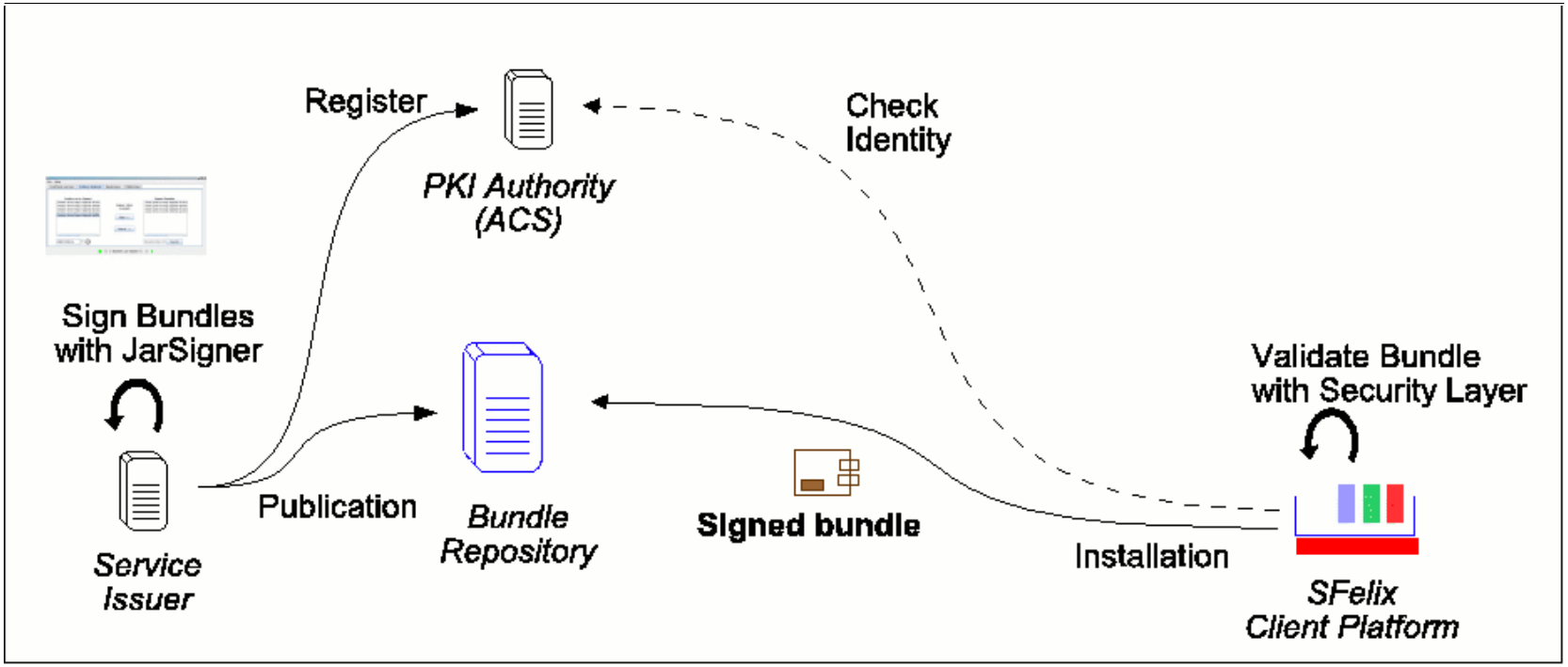
Secure Deployment

- Threats on Deployment



Secure Deployment

- Key Management



Secure Deployment

- Required Development
  - OSGi Platform that is able to check Digital Signature
  - Bundle Signer and Publisher
  - Not a research topic, but an urgent requirement !

Secure Deployment

- SFelix – Secure OSGi Platform
  - http://sfelix.gforge.inria.fr/
  - SFelix v0.1
    - OSGi Release 4 Implementation of the Bundle Signature Validation Process
    - Beware of JVM-only solutions !
  - SFelix v0.2
    - Robust against ill-coded Bundles
    - Code is not yet released publicly

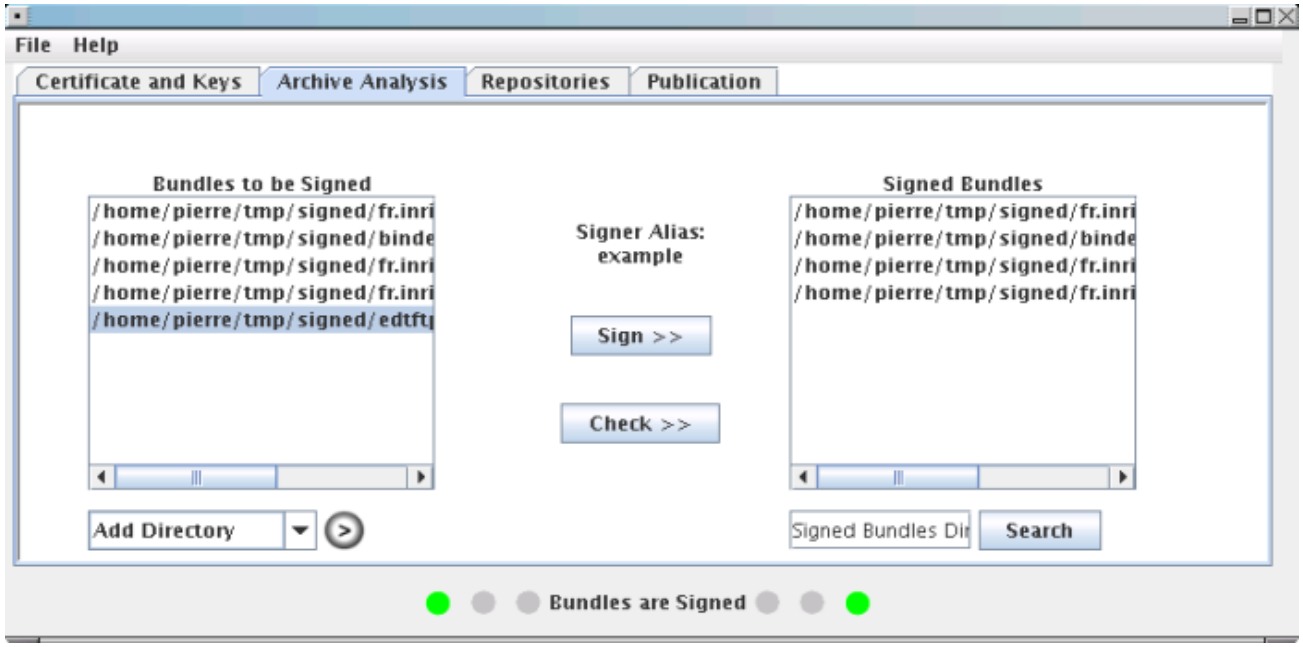
Secure Deployment

- SFelix – Secure OSGi Platform

```
-> obr start "HTTP Service"
Target resource(s):
-------------------
   HTTP Service (0.8.0.SNAPSHOT)

Deploying...Resolver: Install error - org.apache.felix.http.jetty
org.osgi.framework.BundleException: Could not create bundle object.
        at org.apache.felix.framework.Felix.installBundle(Felix.java:1347)
        at org.apache.felix.framework.Felix.installBundle(Felix.java:1322)
        at org.apache.felix.framework.BundleContextImpl.installBundle(BundleContextImpl.java:90)
        at org.apache.felix.bundlerepository.ResolverImpl.deploy(ResolverImpl.java:457)
        at org.apache.felix.bundlerepository.ObrCommandImpl._deploy(ObrCommandImpl.java:356)
        at org.apache.felix.bundlerepository.ObrCommandImpl.deploy(ObrCommandImpl.java:294)
        at org.apache.felix.bundlerepository.ObrCommandImpl.execute(ObrCommandImpl.java:108)
        at org.apache.felix.shell.impl.Activator$ShellServiceImpl.executeCommand(Activator.java:253)
        at org.apache.felix.shell.tui.Activator$ShellTuiRunnable.run(Activator.java:165)
        at java.lang.Thread.run(Thread.java:595)
Caused by: org.osgi.framework.BundleException: Bundle Unsecure
        at fr.inria.ares.framework.cache.DefaultSecuredBundleArchive.checkArchiveValidity(DefaultSecuredBundleArchive.java:73)
        at org.apache.felix.framework.Felix.installBundle(Felix.java:1323)
        ... 9 more
done.
->
-> 
```

Secure Deployment

- SF-JarSigner – Bundle Signer and Publisher
  - http://sf-jarsigner.gforge.inria.fr/
  - The Archive Analysis Panel



Secure Deployment

- Secure OSGi Deployment and Java Security

Table 1. Behavior of several tools and frameworks in the presence of unvalid archives

Error Type	Sun Jarsigner	Java with Security Manager	Felix	SFelix
Unsigned Archive	W	A	R	R
Unknown Signer	A	A	R	R
Addition of Resource	A	A	A	R
Removal of Resource	A	A	A	R
Modification of Resource	R	R	W	R
Unvalid Order of Resources	A	A	A	R
Signature of Embedded Archive Unvalid	R	R	W	R
Time Of Check	Test	Exec	Exec	Install

A: Accept; R: Reject; W: Warning;

Summary

- Extensible Component Platforms
- Dependability for Extensible Component Systems
- Secure Deployment
- **Secure Execution**
- Achievements and Open Issues

Secure Execution

- Why is OSGi a potentially very secure Platform
  - Java is designed to be secure
    - Type Safety
    - Garbage Collection
    - Bytecode verification
    - Secure class-loaders
  - OSGi provides a sound programming model
    - Namespace isolation between bundles
    - Very convenient management model
      - 'Maintainability' properties of the Dependability Framework
    - Anchor for install time checks

Secure Execution

- Why is OSGi currently NOT a secure Platform
  - No serious development effort from the community
  - Designed for secure single app execution
  - Opens a new attack Vector
    - Dynamic installation of unknown (malicious ?) code
    - Not an issue in Open Source projects
      - Everybody is benevolent
      - Ready to bet NO Eclipse plugin contains malware ??
    - Not an issue in Industrial projects
      - Never load untrusted code
      - Never load confidential code over the Internet ??
    - Not an issue until one realy needs Security
  - First Requirement
    - Identifies the weaknesses

Secure Execution

- OSGi Vulnerabilities - Identification
  - Black Hat Approach
  - How to get
    - Denial of Service
    - Data/Code exposure
    - Erroneous output
  - Take the Specification and Code Malicious Bundles
    - That exploit the Java framework
    - That exploit OSGi specific features

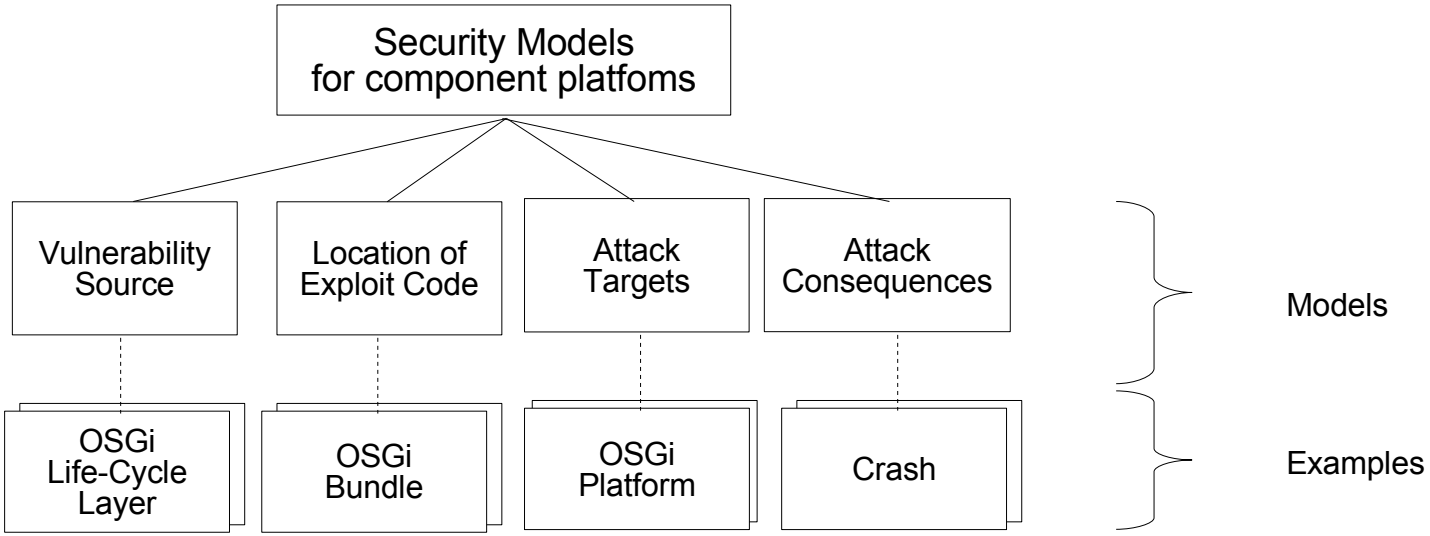
Secure Execution

- OSGi Vulnerabilities – Identification
  - Recursive Thread Creation

```
public class Stopper extends Thread
{
        Stopper(int id, byte[] payload)
        {
                this.id=id;
                this.payload = payload;
        }

        public void run()
        {
                System.out.println("Stopper id: "+id);
                Stopper tt = new Stopper(++id, payload);
                tt.start();

                Stopper tt2 = new Stopper(++id, payload);
                tt2.start();

                Stopper tt3 = new Stopper(++id, payload);
                tt3.start();
        }
}
```

Secure Execution

- OSGi Vulnerabilities – Classifications
  - Security Taxonomies for the OSGi Component Platform



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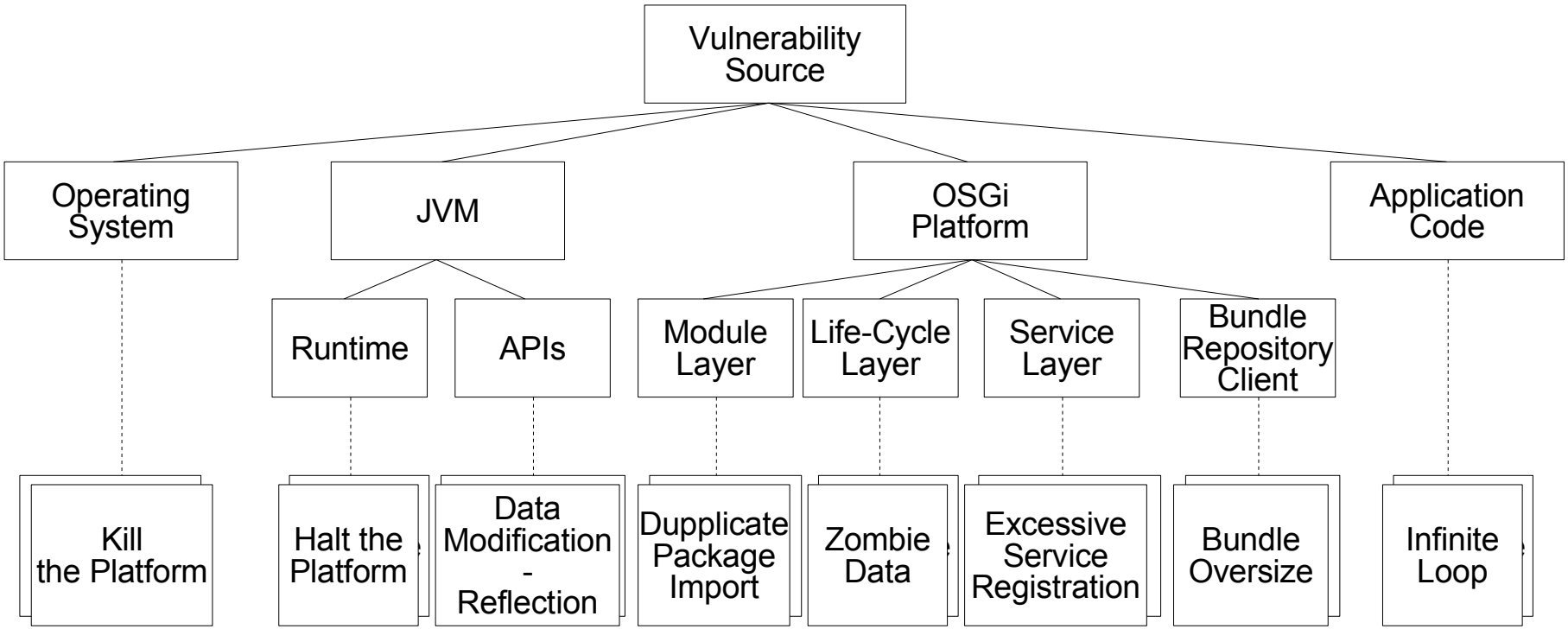

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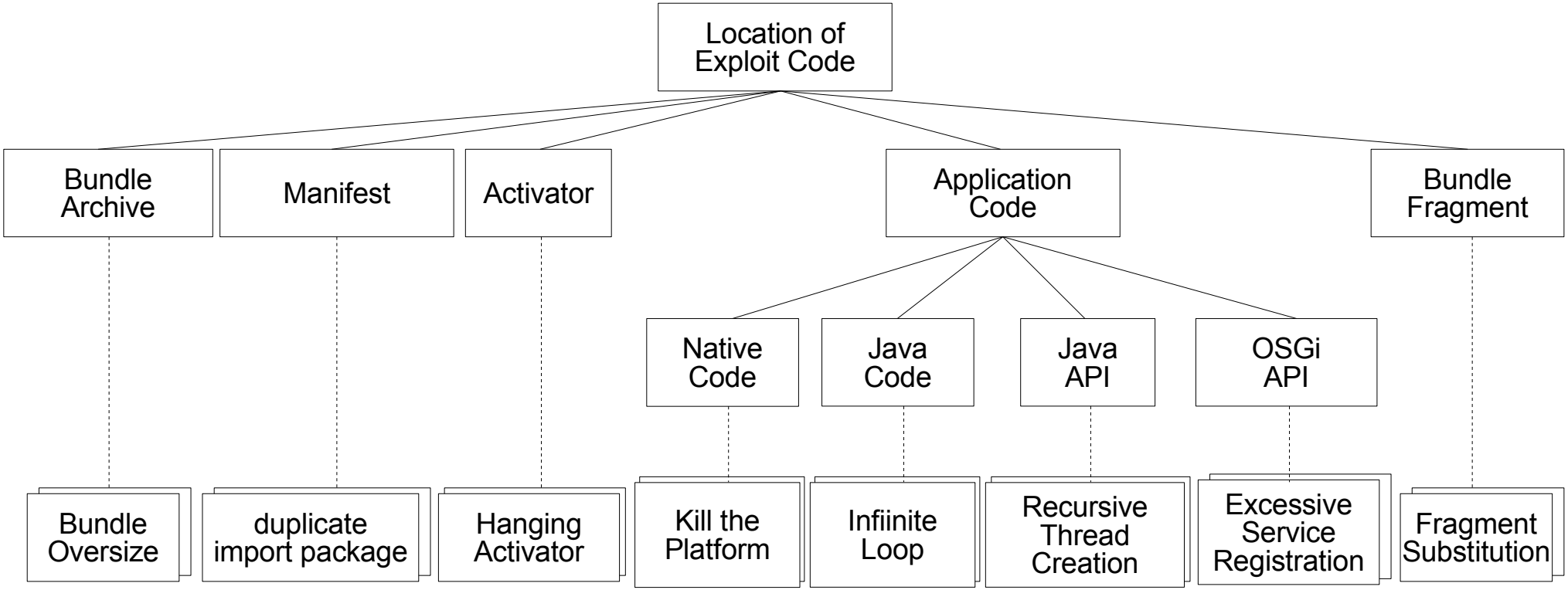

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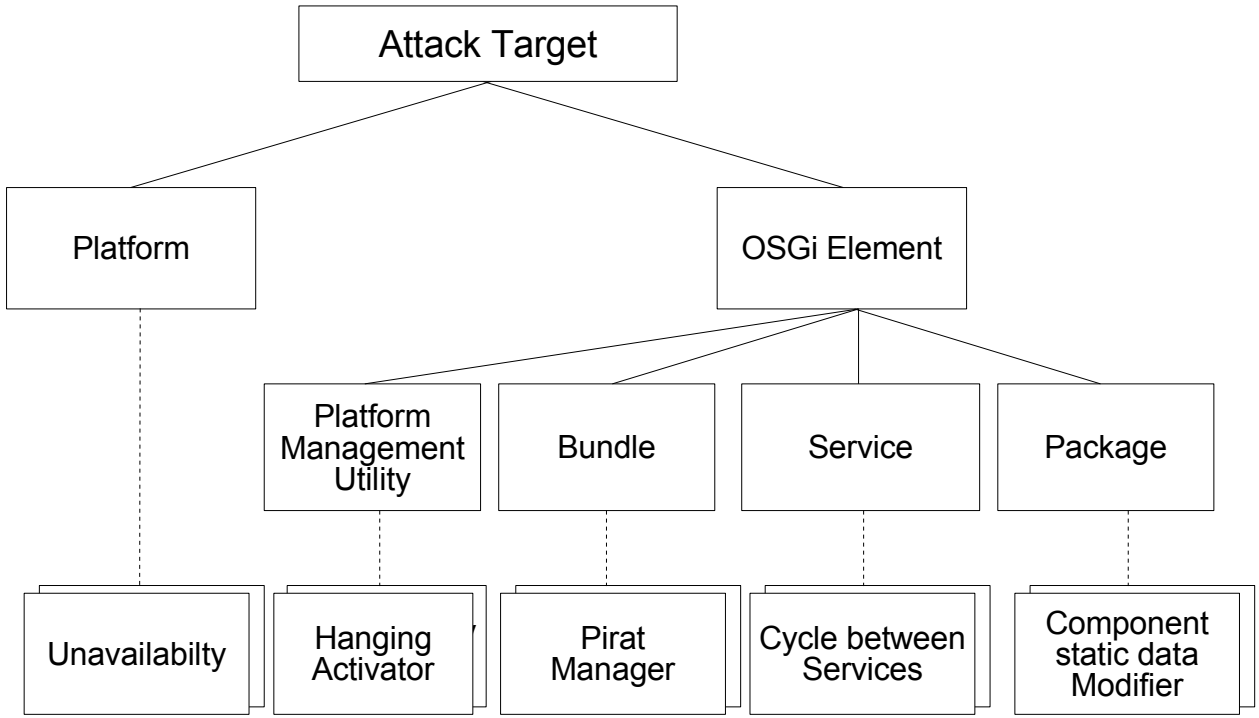

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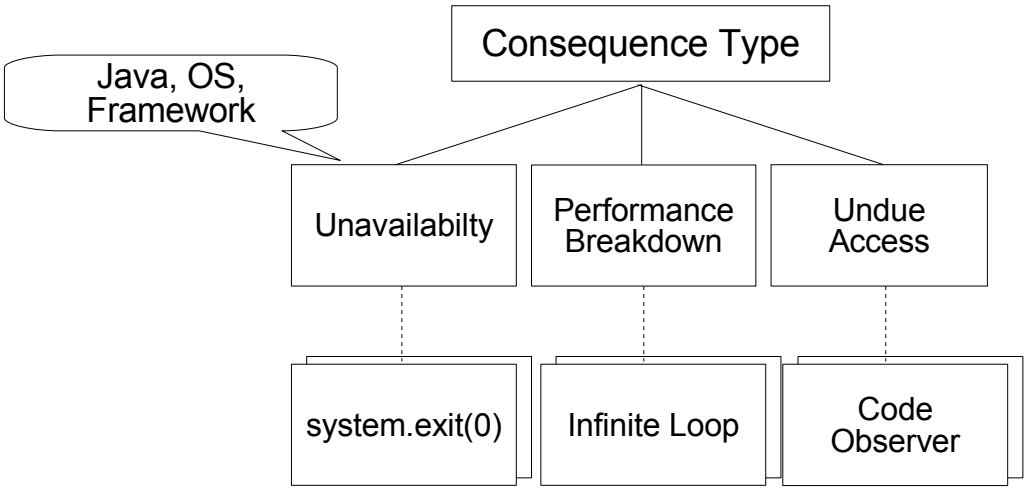


Secure Execution

- OSGi Vulnerabilities – Characterization
  - The Semi-formal Vulnerability Pattern for the OSGi Extensible Component Platform
  - Reference
    - Vulnerability Pattern (VP) Id
    - Taxonomy-based characterization
  - Description
    - More Text
  - Protection
    - Actual Protection
    - Potential ones
  - Implementation
    - Robust and Vulnerable platforms
    - Implementation case coverage

Secure Execution

- OSGi Vulnerabilities – Characterization
  - Freezing Management Utility – Hanging Thread

Vulnerability Reference

- **Vulnerability Name:** Management Utility Freezing - Thread Hanging
- **Extends:** Hanging Thread
- **Identifier:** Mb.osgi.5
- **Origin:** Ares research project 'malicious-bundle'
- **Location of Exploit Code:** Bundle Activator
- **Source:** OSGi Platform - Life-Cycle Layer (No safe Bundle Start)
- **Target:** OSGi Element - Platform Management Utility
- **Consequence Type:** Unavailability
- **Introduction Time:** Development
- **Exploit Time:** Bundle Start

Secure Execution

- OSGi Vulnerabilities – Characterization
  - Freezing Management Utility – Hanging Thread

Vulnerability Description

- **Description:** A hanging thread in the Bundle Activator makes the management utility freeze
- **Preconditions:** -
- **Attack Process:** -
- **Consequence Description:** Block the OSGi Management entity (the felix, equinox or knopflerfish shell; when launched in the KF graphical interface, the shell remain available but the GUI is frozen).
- **See Also:** Management Utility Freezing - Infinite Loop, Hanging Thread

Secure Execution

- OSGi Vulnerabilities – Characterization
  - Freezing Management Utility – Hanging Thread

Protection

- **Existing Mechanisms:** -
- **Enforcement Point:** -
- **Potential Mechanisms:** OSGi Platform Modification - Bundle Startup Process (launch the bundle activator in a separate thread); Code static Analysis
- **Attack Prevention:** -
- **Reaction:** -

Secure Execution

- OSGi Vulnerabilities – Characterization
  - Freezing Management Utility – Hanging Thread

Vulnerability Implementation

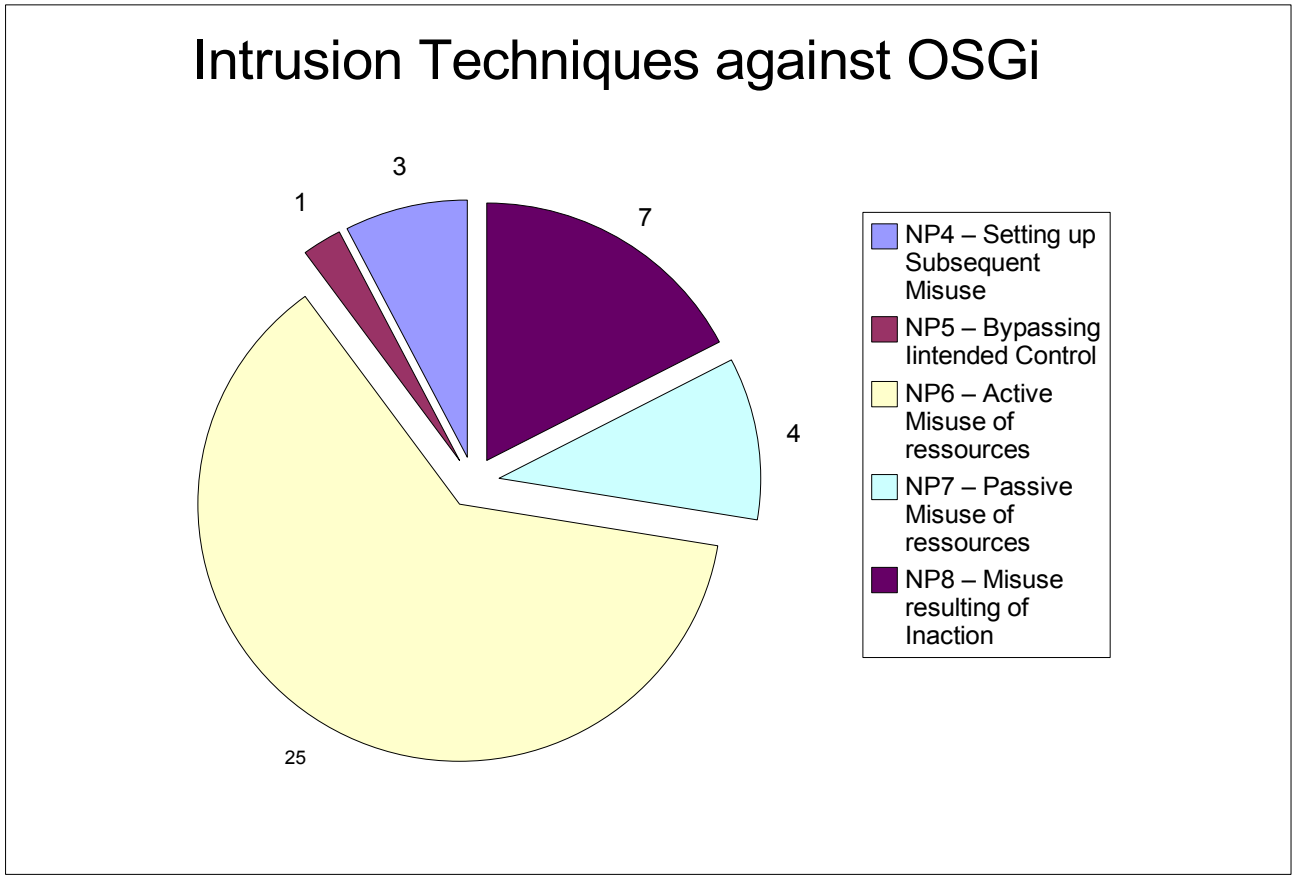
- **Code Reference:** Fr.inria.ares.hangingthread-0.1.jar, fr.inria.ares.hangingthread2-0.1.jar
- **OSGi Profile:** J2SE-1.5
- **Date:** 2006-08-24
- **Test Coverage:** 20%
- **Known Vulnerable Platforms:** Felix; Equinox; Knopflerfish; Concierge
- **Known Robust Platforms:** SFelix

Secure Execution

- OSGi Vulnerability Catalog
  - Bundle Archive
    - 3 occurrences
  - Bundle Manifest
    - 3 occurrences
  - Bundle Activator
    - 2 occurrences
  - Bundle Code - Native
    - 2 occurrences
  - Bundle Code - Java
    - 13 occurrences
  - Bundle Code – OSGi API
    - 6 occurrences
  - Bundle Fragment
    - 3 occurrences

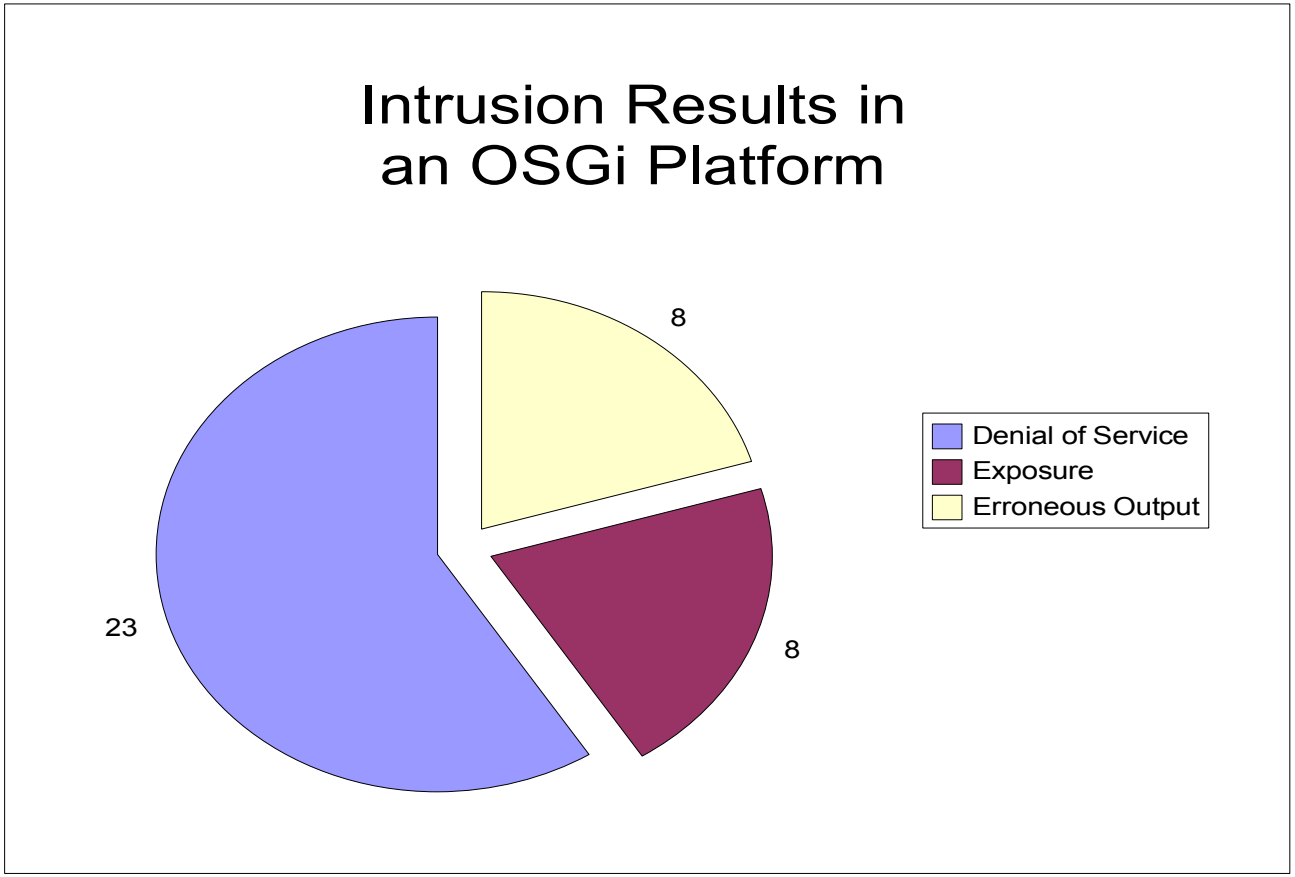
Secure Execution

- OSGi Vulnerability Catalog
  - Neuman and Parker's classification



Secure Execution

- OSGi Vulnerability Catalog
  - Linqvist's classification



Secure Execution

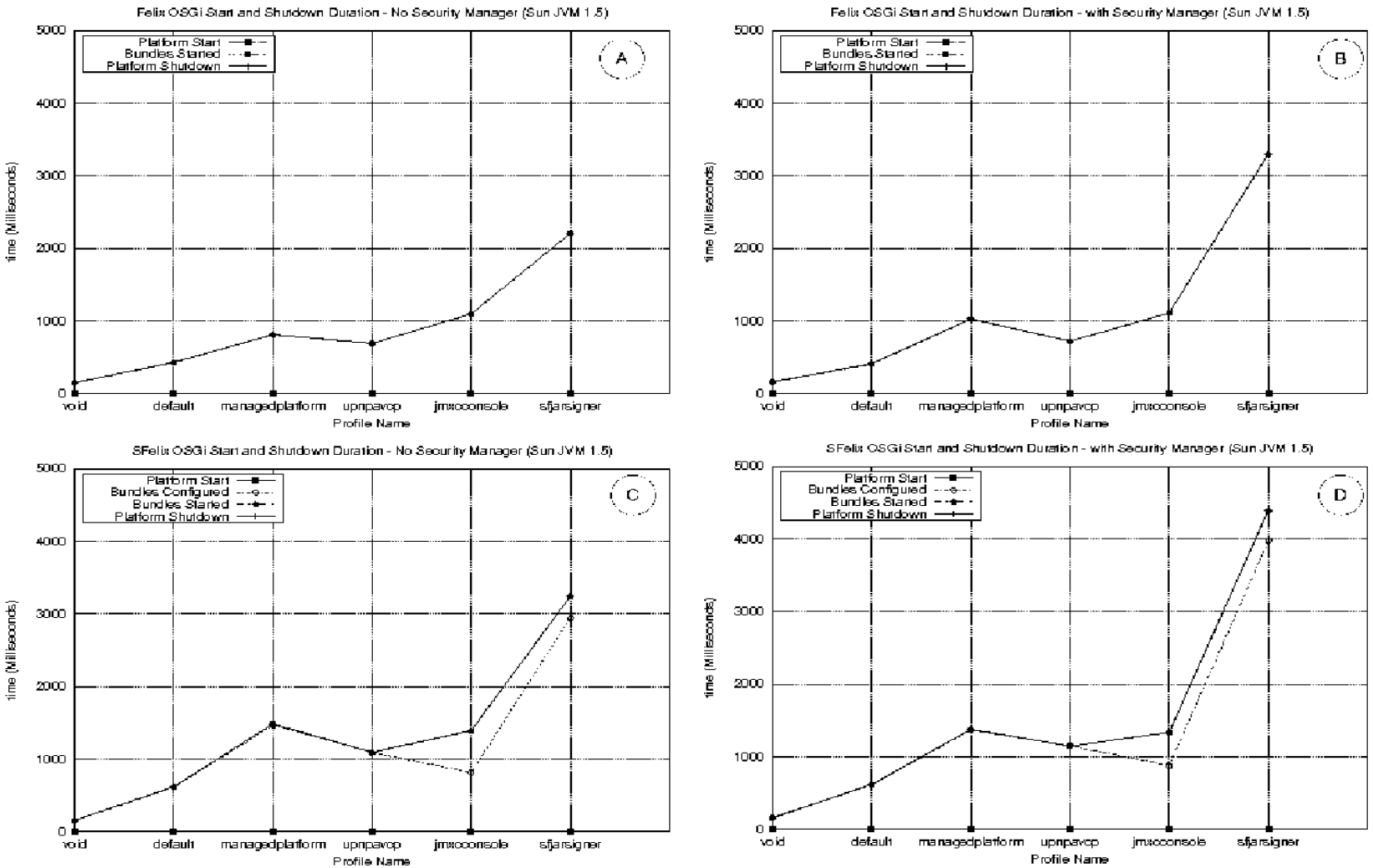
- Potential Security Mechanisms
  - Hardened Platform
    - Adapt the behavior of the Platform to prevent identified flaws
  - Execution Permission
    - Specified, hardly available
    - Give execution rights to trusted Bundle Provider only
  - Code analysis (PCC-like)
    - No memory leak, no infinite loops

Secure Execution

- Hardened OSGi
  - INRIA Sfelix Project Prototype, V0.2
  - 9 vulnerabilities out of 32 patched
  - 13 more are protected with Java Permissions
  - 69 % of vulnerabilities prevented
  - Felix + permissions: 44%
  - Equinox + permissions: 53%

Secure Execution

- Hardened OSGi



Secure Execution

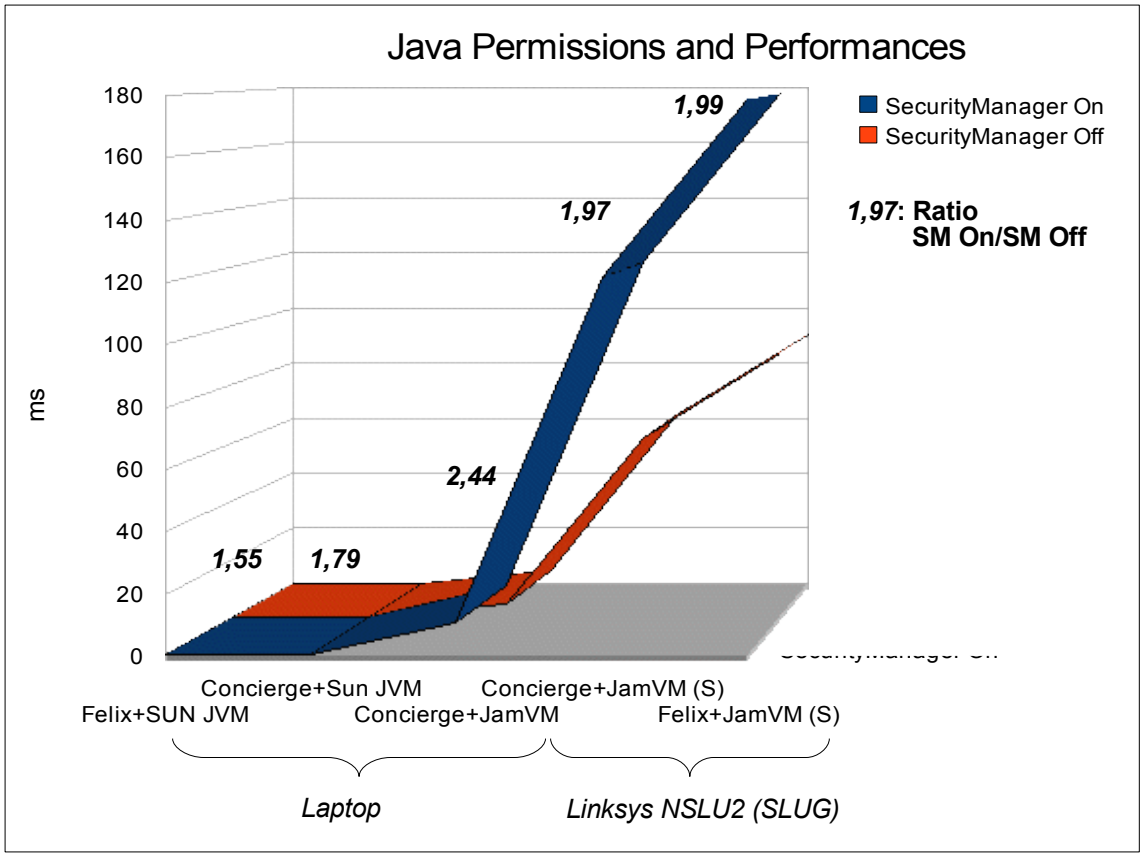
- Recommandations for the OSGi Specifications
  - Do not rely on the embedded Java Archive verifier
  - Bundle Resolution Process should be robust
    - Ignore duplicate imports
    - Handle large manifests without radical performance breakdown
  - Bundle Start Process
    - Start the Bundle Activator in a separate process
  - OSGi Service Registration
    - Explicit limitation of the number of registered services
    - Absolute Maximum could be 50 ?

Secure Execution

- Recommandations for the OSGi Specifications
  - Bundle Installation process
    - Maximum storage size of bundle archive (for embedded devices)
    - Should be performed before download when relevant
  - Bundle Uninstallation process
    - Remove Bundle data on the local file system

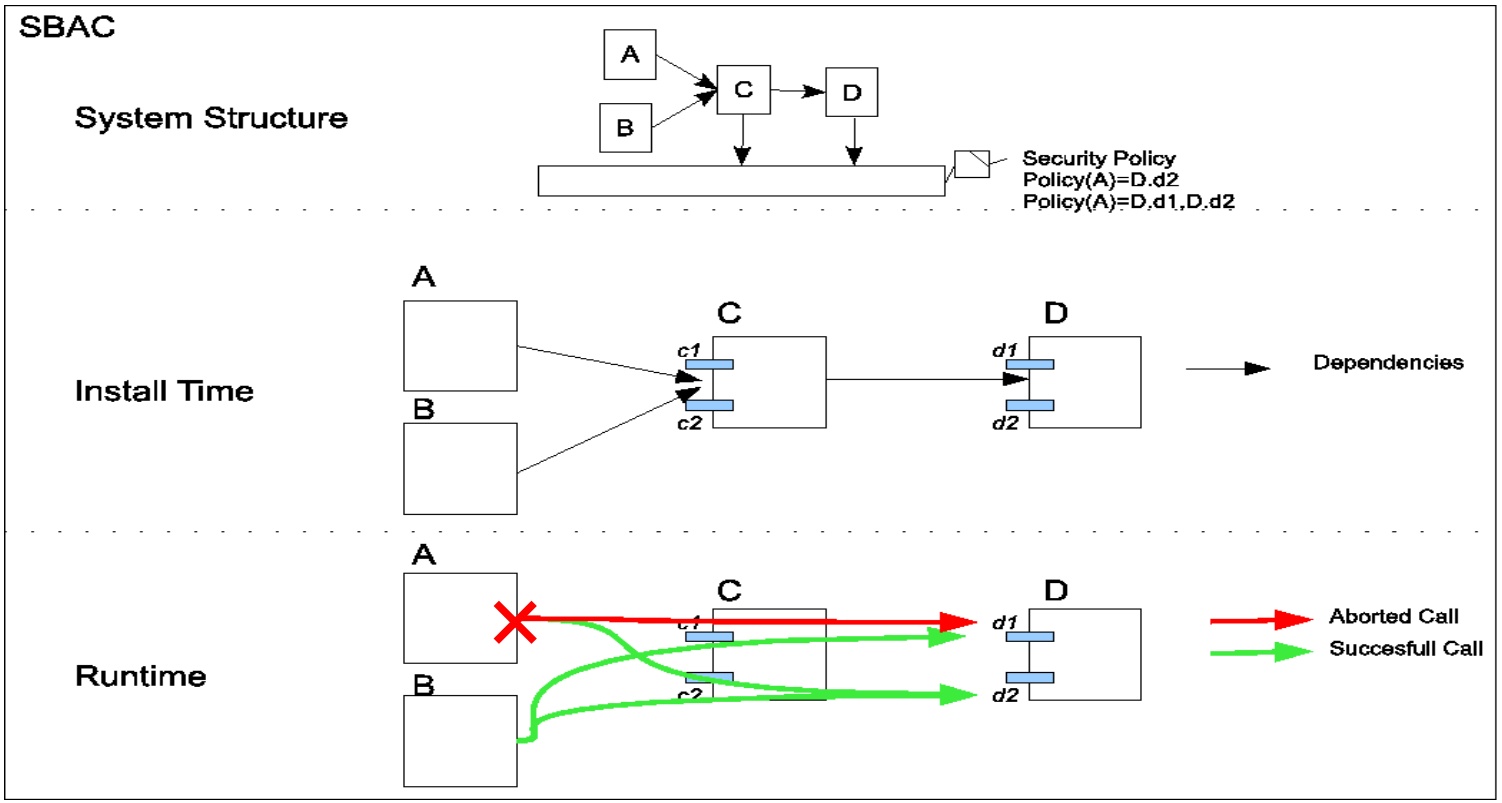
Secure Execution

- CBAC - Component-based Access Control
  - Java permissions are not a panacea for Components
    - Example: single RMI Call



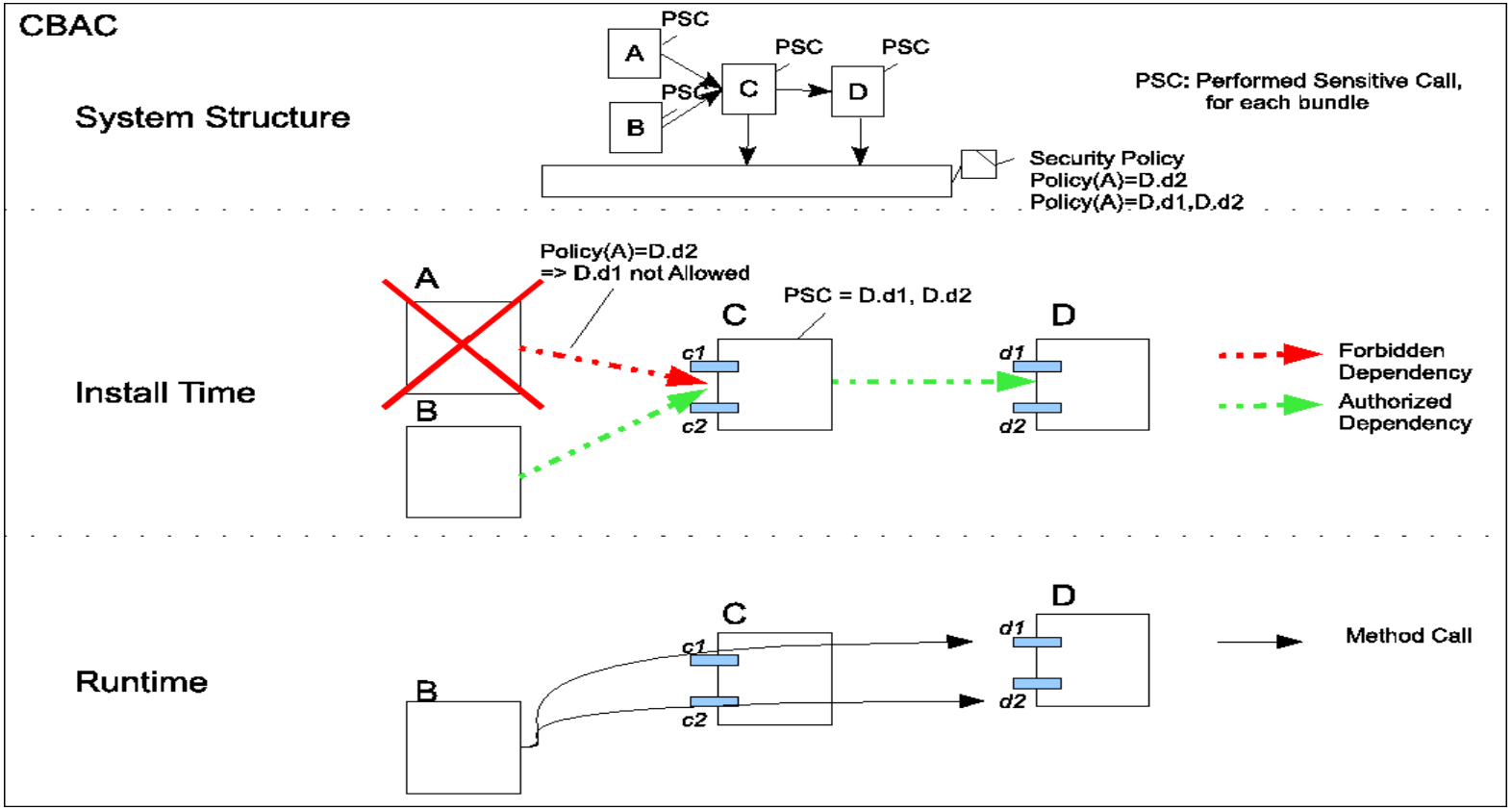
Secure Execution

- CBAC
  - Java permissions are not a panacea for Components
    - Performance, runtime abortion of applications, undefined management process
    - Simply not used in the real life



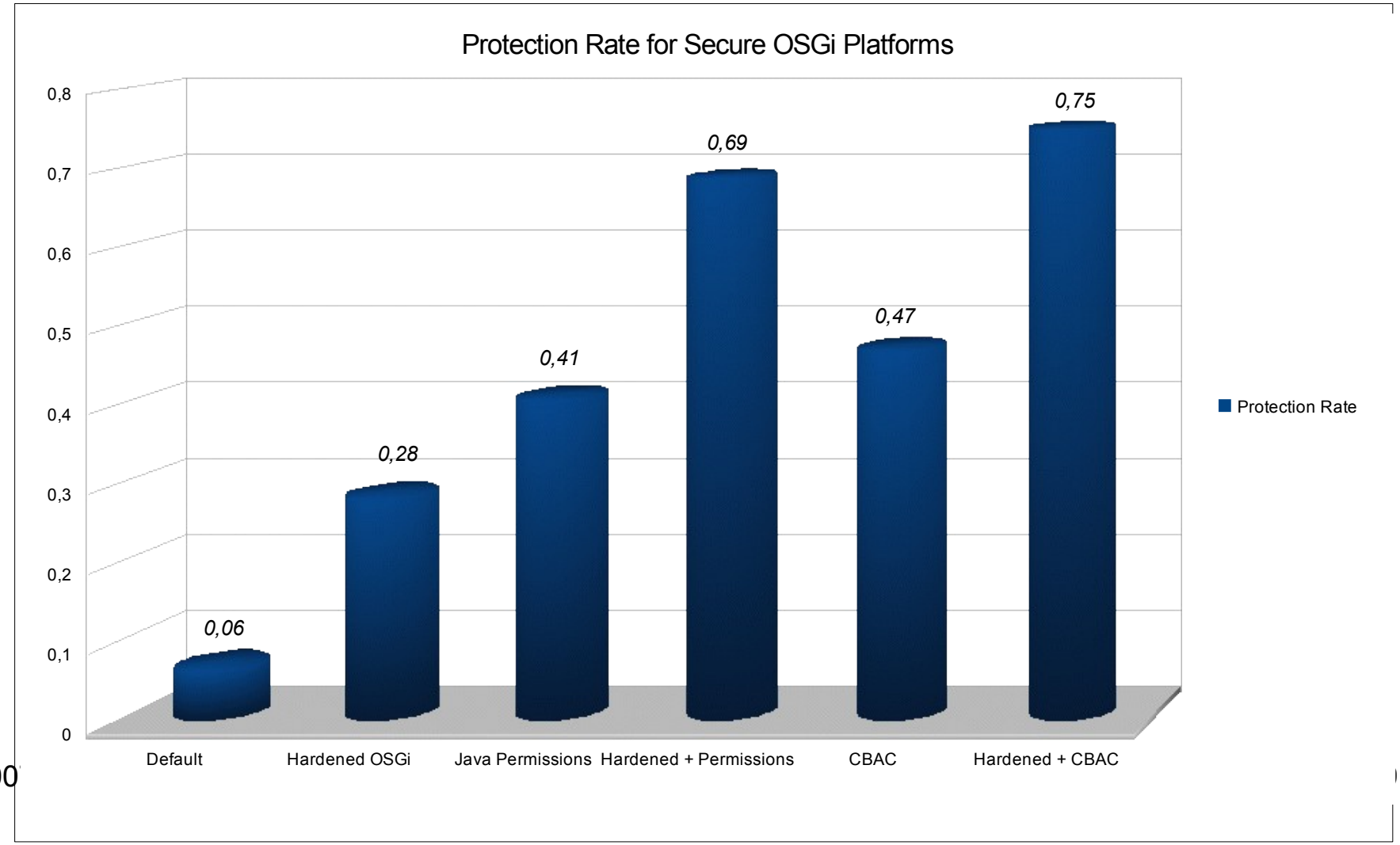
Secure Execution

- CBAC
  - Validation of execution permission at install time



Secure Execution

- Comparison of Security Mechanisms for OSGi



Secure Execution

- 5 Challenges for Secure OSGi Platforms
  - Infinite loop in method call/hanging Thread
    - Method does not return (Java)
  - Memory Load Injection
    - If Pointers to object are kept, GC does not help (Java)
  - Decompression Bomb
    - (Java)
  - Exponential Thread Number
    - Crashes the JVM (Java)
  - Service Short Circuit
    - SOP-level vulnerability (OSGi)

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- Dependability for Extensible Component Systems
- Secure Deployment
- Secure Execution
- **Achievements and Open Issues**

Achievements and Open Issues

- Dependability Properties for Execution
  - For Dynamic Component Systems

Contribution: enhancement

	Fault Prevention	***Attack Prevention***
Availability	Prevent stopping/destruction of Platforms and Components	
Reliability	Prevent Erroneous Method Calls	
Safety	- (No full guarantee on Java-based Systems)	
Confidentiality	Ressource Isolation Access Control	
Integrity		
Maintainability	Component Life-Cycle by default in OSGi Separation of Management and Applicative level required	

Current Work

Default

Achievements and Open Issues

- OSGi Security is not yet mature
- 5 security profiles that need to be supported
  - Specifications
    - An implementation of the OSGi R4
  - Life-Cycle
    - Supporting Bundle Deployment
  - Management
    - Secure Connection to the management utilities
  - Critical Applications
    - Banking Applications
  - Multi-User Applications ... soon
    - Access Control and isolation

Improvement brought ... a complete solution is still to be implemented

Conclusions

- Dependability Framework for secure systems
  - An all-encompassing overview
  - Identification of research and development requirements
- Two aspects of Component Security
  - Deployment
  - Execution
- Much work is still required in order to provide secure Extensible Component Platforms
  - PCC-like Code analysis to support execution of code from unknown Providers

Questions ?