RFP 156 – Native OSGi

Draft

17 Pages

Abstract

Native OSGi is an effort to revive parts of RFP 89 – Universal OSGi. This RFP specifically focusses on the possibility of implementing an OSGi framework in C and C++. The goal is, to be as close to the OSGi Core specification as possible, without restraining the natural usage of the language itself. Interoperability between C and C++ is important and will receive special attention.

0 Document Information

0.1 License

DISTRIBUTION AND FEEDBACK LICENSE, Version 2.0

The OSGi Alliance hereby grants you a limited copyright license to copy and display this document (the “Distribution”) in any medium without fee or royalty. This Distribution license is exclusively for the purpose of reviewing and providing feedback to the OSGi Alliance. You agree not to modify the Distribution in any way and further agree to not participate in any way in the making of derivative works thereof, other than as a necessary result of reviewing and providing feedback to the Distribution. You also agree to cause this notice, along with the accompanying consent, to be included on all copies (or portions thereof) of the Distribution. The OSGi Alliance also grants you a perpetual, non-exclusive, worldwide, fully paid-up, royalty free, limited license (without the right to sublicense) under any applicable copyrights, to create and/or distribute an implementation of the Distribution that: (i) fully implements the Distribution including all its required interfaces and functionality; (ii) does not modify, subset, superset or otherwise extend the OSGi Name Space, or include any public or protected packages, classes, Java interfaces, fields or methods within the OSGi Name Space other than those required and authorized by the Distribution. An implementation that does not satisfy limitations (i)-(ii) is not considered an implementation of the Distribution, does not receive the benefits of this license, and must not be described as an implementation of the Distribution. "OSGi Name Space" shall mean the public class or interface declarations whose names begin with "org.osgi" or any recognized successors or replacements thereof. The OSGi Alliance expressly reserves all rights not granted pursuant to these limited copyright licenses including termination of the license at will at any time.

EXCEPT FOR THE LIMITED COPYRIGHT LICENSES GRANTED ABOVE, THE OSGi ALLIANCE DOES NOT GRANT, EITHER EXPRESSLY OR IMPLIEDLY, A LICENSE TO ANY INTELLECTUAL PROPERTY IT, OR ANY THIRD PARTIES, OWN OR CONTROL. Title to the copyright in the Distribution will at all times remain with the OSGi Alliance. The example companies, organizations, products, domain names, e-mail addresses, logos, people, places, and events depicted therein are fictitious. No association with any real company, organization, product, domain name, email address, logo, person, place, or event is intended or should be inferred.

THE DISTRIBUTION IS PROVIDED "AS IS," AND THE OSGi ALLIANCE (INCLUDING ANY THIRD PARTIES THAT HAVE CONTRIBUTED TO THE DISTRIBUTION) MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT, OR TITLE; THAT THE CONTENTS OF THE DISTRIBUTION ARE SUITABLE FOR ANY PURPOSE; NOR THAT THE IMPLEMENTATION OF SUCH CONTENTS WILL NOT INFRINGE ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADEMARKS OR OTHER RIGHTS.
NEITHER THE OSGi ALLIANCE NOR ANY THIRD PARTY WILL BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATING TO ANY USE OR DISTRIBUTION OF THE DISTRIBUTION.

Implementation of certain elements of this Distribution may be subject to third party intellectual property rights, including without limitation, patent rights (such a third party may or may not be a member of the OSGi Alliance). The OSGi Alliance is not responsible and shall not be held responsible in any manner for identifying or failing to identify any or all such third party intellectual property rights.

The Distribution is a draft. As a result, the final product may change substantially by the time of final publication, and you are cautioned against relying on the content of this Distribution. You are encouraged to update any implementation of the Distribution if and when such Distribution becomes a final specification.

The OSGi Alliance is willing to receive input, suggestions and other feedback (“Feedback”) on the Distribution. By providing such Feedback to the OSGi Alliance, you grant to the OSGi Alliance and all its Members a non-exclusive, non-transferable,

worldwide, perpetual, irrevocable, royalty-free copyright license to copy, publish, license, modify, sublicense or otherwise distribute and exploit your Feedback for any purpose. Likewise, if incorporation of your Feedback would cause an implementation of the Distribution, including as it may be modified, amended, or published at any point in the future ("Future Specification"), to necessarily infringe a patent or patent application that you own or control, you hereby commit to grant to all implementers of such Distribution or Future Specification an irrevocable, worldwide, sublicenseable, royalty free license under such patent or patent application to make, have made, use, sell, offer for sale, import and export products or services that implement such Distribution or Future Specification. You warrant that (a) to the best of your knowledge you have the right to provide this Feedback, and if you are providing Feedback on behalf of a company, you have the rights to provide Feedback on behalf of your company; (b) the Feedback is not confidential to you and does not violate the copyright or trade secret interests of another; and (c) to the best of your knowledge, use of the Feedback would not cause an implementation of the Distribution or a Future Specification to necessarily infringe any third-party patent or patent application known to you. You also acknowledge that the OSGi Alliance is not required to incorporate your Feedback into any version of the Distribution or a Future Specification.

I HEREBY ACKNOWLEDGE AND AGREE TO THE TERMS AND CONDITIONS DELINEATED ABOVE.

0.2 Trademarks

OSGi™ is a trademark, registered trademark, or service mark of the OSGi Alliance in the US and other countries. Java is a trademark, registered trademark, or service mark of Oracle Corporation in the US and other countries. All other trademarks, registered trademarks, or service marks used in this document are the property of their respective owners and are hereby recognized.

0.3 Feedback

This document can be downloaded from the OSGi Alliance design repository at https://github.com/osgi/design The public can provide feedback about this document by opening a bug at https://www.osgi.org/bugzilla/.

0.4 Table of Contents

0.5 Terminology and Document Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY" and "OPTIONAL" in this document are to be interpreted as described in 6.1.

```
Source code is shown in this typeface.
```

0.6 Revision History

The last named individual in this history is currently responsible for this document.

Revision	Date	Comments
Initial	*24.10.12*	*Initial document* *Alexander Broekhuis, Luminis, alexander.broekhuis@luminis.eu*
Update	*12.03.13*	*Updates after reviewing the first draft during a OSGi meeting.* • *Added additional authors (Sascha and Steffen)* • *Added overview of current eco-system and frameworks* • *Detail library usage and platforms* • *Verify/rewrite requirements* *Alexander Broekhuis, Luminis, alexander.broekhuis@luminis.eu*

Revision	Date	Comments
Update	*16.03.13*	*nOSGi specific updates.* • *nOSGi specific updates* • *Added related work* • *Module layer updates* • *Use Cases* *Steffen Kächele, University of Ulm, steffen.kaechele@uni-ulm.de*
Update	*22.03.13*	*Updates:* • *CTK Plugin Framework specific updates* • *Added CppMicroServices* • *Module layer updates* *Sascha Zelzer, German Cancer Research Center, s.zelzer@dkfz-heidelberg.de*
Update	*10.04.13*	*Comments from Cologne F2F* *Alexander Broekhuis, Luminis, alexander.broekhuis@luminis.eu*
Update	*11.04.13*	*Comments from Cologne F2F* *Steffen Kächele, University of Ulm, steffen.kaechele@uni-ulm.de*
Update	*29.08.13*	*Restructured document; added a Problem Description chapter* *Sascha Zelzer, German Cancer Research Center, s.zelzer@dkfz-heidelberg.de*
Update	*03.09.13*	*reworked problem description and requirements, polished document - put focus on requirements* *Steffen Kächele, University of Ulm, steffen.kaechele@uni-ulm.de*
Update	*09/10/13*	*Expanded content of "Dependencies and Versioning" and "Compatibility of C and C++ bundles"; Re-ordered the "Requirements"* *Sascha Zelzer, German Cancer Research Center, s.zelzer@dkfz-heidelberg.de*
Update	*10/17/13*	*Addressed comments from the Southampton F2F* *Sascha Zelzer, German Cancer Research Center, s.zelzer@dkfz-heidelberg.de*
Update	*10/18/13*	*Comments from the Southampton F2F, polished document* *Steffen Kächele, University of Ulm, steffen.kaechele@uni-ulm.de*

1 Introduction

The OSGi specification currently exclusively focuses on the Java runtime and languages. In the past RFP 89 – Universal OSGi has been started to extend this scope to different languages; C++, C# and ActionScript/JavaScript. Even though RFP 89 is still relevant, it has a very broad scope. This RFP is started to limit the scope to the native languages C and C++. From this point of view, RFP 89 can be seen as an umbrella RFP.

This document intends to describe the requirements that a native C/C++ OSGi Core specification must meet. This problem is specifically mentioned in RFP-89 as “Native OSGi”. The following description is an update of the content from RFP-89.

“Having a Native OSGi will make it possible to use legacy C/C++ code and more easily than with JNI have it coexist with Java bundles. It would also make it possible to port Java bundles to more efficient C/C++ bundles. It is clear however, that a native OSGi will not support the full set of Java and/or OSGi R5 features (e.g. reflection).”

Even though this section mentions coexistence with Java bundles, this RFP will focus solely on the Core specification. Interoperability with Java bundles can be achieved using e.g. Remote Services.

The scope of this RFP is limited to C and C++ although there are many other languages and compilers that create native binaries. While the focus will be on C and C++, the requirements described in this document should be open enough for these other languages. In other words, requirements not directly related to C and C++ should not force solutions which would block other native languages.

1.1 Rationale

The need for component based development is not new to the native world, several concepts have been introduced to solve these problems (CORBA, COM, etc), but very few have been successful. Over the years OSGi has proven itself to be a stable and accepted solution to this problem, but it focuses specifically on the Java runtime. As of today, many large projects covering all application domains are still written in native languages like C or C++ for various reasons. In certain application domains, modularity and dynamic extensibility are key requirements and being able to use a common native dynamic module system within such projects would be highly beneficial. For these projects it makes sense to be able to use OSGi concepts in a native environment.

For certain areas a binding from Java to C/C++ is enough, but for projects with a greater focus on native languages it makes more sense to have an actual native implementation. For example, if 90% of the codebase is native, it doesn't make any sense to use a Java OSGi framework.

Many of the reasons mentioned in RFP 89 still apply, amongst others:

- Broaden scope of OSGi in other domains
- Ease the introduction of OSGi concepts in non-Java environments

Additionally, there is also re-newed interest in bringing OSGi to other languages besides C and C++, as is demonstrated by the publication of other RFPs like the *Javascript Microservices RFP 159*.

1.2 Participants

Since the initiation of RFP-89 a lot has changed, and several Native OSGi-like implementations have been written. This RFP is an effort of several of these projects with a common goal:

- Combine the effort to reach a greater audience
- Write a common specification which makes it possible to share bundles

At this moment the following projects are participating:

- Apache Celix – A C implementation based on OSGi 4.3 with a focus on Java interoperability and remote services.
- CTK Plugin Framework – A C++ implementation based on OSGi 4.3 using the Qt toolkit. Focuses on adhering to the Core API as close as possible.
- NOStrum (formally called nOSGi [4]) – A C++ implementation based on OSGi 4.* with a unique bundle wiring mechanism and a focus on embedded devices.
- CppMicroServices – A C++ implementation based on the ideas of “OSGi Lite”, i.e. without the dynamics of the module layer. Its focus is on a type-safe service layer API in C++.

1.3 Existing Eco-System

These participating projects already provide a fairly extensive collection of services and bundles. The expectation is that these bundles will be adapted to be compatible with the Native-OSGi specification. This provides an extensive eco-system that can and will be leveraged by the Use-Cases described in Chapter 4.

The following overview lists all the bundles/services provided by the different participating projects:

- Apache Celix
  - OSGi Compendium Chapter 101 – Log Service
  - OSGi Compendium Chapter 103 – Device Access
  - OSGi Enterprise Chapter 122 – Remote Service Admin
  - Log Writer
  - Shell Service
  - Shell Textual User Interface (TUI)
  - Dependency Manager (based on the Apache Felix Dependency Manager)
- CTK Plugin Framework
  - OSGi Compendium Chapter 101 – Log Service
  - OSGi Compendium Chapter 104 – Configuration Admin

  - OSGi Compendium Chapter 105 – MetaType Service
  - OSGi Compendium Chapter 113 – Event Admin
- NOStrum (nOSGi)
  - Support for Module Layer
  - Shell Service
  - Remote Shell Service
  - Job Scheduling Service (cron bundle)
  - Bus Access Service (1-wire bundle)

1.4 Technical Background

The participating projects already provide partial implementations of the concepts described in the OSGi Core specifications. Each implementation has different strengths and may differ from the others in the choice of solutions and techniques for implementing certain Core features. Within Native-OSGi the experience gained while developing these solutions and techniques will be used to create a common OSGi Core specification for the C and C++ languages.

In the following, distinct features of each OSGi-like implementation existing today and being part of the Native-OSGi efforts are listed:

- Apache Celix uses a ZIP-based bundle format and provides a C API covering large parts of the Core specifications.
- NOStrum (nOSGi [4]) provides a module layer implementation with a wiring model for dynamic updates of versioned shared libraries, based on runtime ELF header patching.
- CTK Plugin Framework provides an almost complete C++ API for the module, life-cycle, and service layer including support for bundle resources.
- CppMicroServices provides a C++ service layer implementation with a focus on type-safety.

Combining these efforts and taking advantage of the already acquired expertise is assumed to be highly beneficial for the development of a Native-OSGi specification.

1.5 Existing Alternatives

Alternatives to Native OSGi are:

- CORBA and the CORBA Component Model
- Service Component Architecture (SCA)
- Open API Platform (OpenPlug) from Alcatel-Lucent

The CORBA component model proposes an alternatives to OSGi. It was designed to support composition and deployment of applications on distributed resources. The component standard defines the interfaces (ports), dependencies, and rules managing interaction between components as well as their lifecycle. However, the tight coupling between code modules with respect to dependencies hinders flexibility and adaptability of applications.

Lifecycle management of Open-Plug is quite similar to the one proposed in Native OSGi. However, to run code on devices, it uses proprietary technology that interprets code. A Native OSGi implementation should use open standards and execute code natively on devices. Moreover, Native OSGi uses standard method invocation for inter-component communication, whereas Open-Plug uses a more heavyweight message bus.

2 Application Domain

Native OSGi can be applied in any domain which has/wants to rely on native code. Common examples are:

- Embedded software vendors
- (Medical) Imaging solutions
- Sensor Networks

Since this RFP focuses on a C/C++ OSGi Core Specification, it is difficult to list the final application domain. A few usage examples are:

- A software vendor has a large distributed (embedded) software stack, and wants to be able to dynamically (re)configure a running system. For this they need a module based system which has the ability to replace a module at runtime.
- A software vendor has a mixed software base of Java and C/C++ software. The Java software already uses OSGi. To be able to leverage the same benefits, they want to have a similar solution for their native code.

2.1 Advantages

Compared to the traditional way of writing shared libraries, a Native OSGi system has the following advantages:

1. Service – oriented modularity concepts for native developers, benefiting from years of experience gathered within the Java OSGi community.
2. Dynamic updates and reconfigurability of native code in a standardized way.
3. Alternative to JNI for Java and native code interoperability.
4. Having a standard bundle format to package and ship native code.

2.2 Disadvantages

1. C/C++ lacks development tools when compared to Java, which could make the usage of OSGi concepts difficult for the average programmer.

2. The lack of language features like reflection will limit the scope of a Native OSGi specification.

2.3 Terminology + Abbreviations

ABI: Application Binary Interface

Native OSGi: Working title for a C/C++ OSGi specification.

N-OSGi: Shorthand for Native OSGi.

Shared Library: This document consistently uses the term "shared library" for code loadable at runtime. On Windows, they are called Dynamic Link Libraries (DLL), on UNIX systems Dynamic Shared Objects (DSO), and on Mac OS platforms Dynamic Libraries (DyLib).

Loader: A platform-specific program responsible for loading shared libraries into memory and resolving their dependencies.

Platform: A combination of processor architecture, operating system, shared library format, and compiler.

3 Problem Description

The Native OSGi specifications are assumed to be mostly written in a platform-independent way. They should refer to the supported C and C++ language standard, with the exception of specifying the resolving process. The resolving process will likely need to take platform-specific and/or object file format features into account.

3.1 C and C++ Language Standard

As every language, the C and C++ languages evolve over time. A Native OSGi specification requires a definition of a language standard. Due to the large amount of different compilers and platforms, a suitable language version is required to not restrict the usage of Native OSGi too much.

3.2 Supported Platforms

A platform for native systems typically is a combination of processor architecture, operating system, and compiler. While the JVM provides a standardized runtime platform for OSGi, this will not be the case for Native OSGi. Native OSGi requires a minimum set of platforms on which compliant implementations are required to run, similar to the concept of Java *execution environments*.

3.3 Memory Management

Java relies on a garbage collector to reclaim memory from unused objects whereas C/C++ does not impose any kind of memory management system. Especially with regard to service objects, memory management of these objects is an important issue. It is also necessary to specify the life-time and ownership of all objects specified in Native OSGi.

3.4 Packaging and bundle format

OSGi ships bundles in the JAR format. However, JAR is explicitly bound to Java. Native OSGi has to specify a comparable ZIP-like bundle format.

As bundles contain native code, they are bound to a specific platform. Native OSGi bundles thus require meta data describing the platform architecture and needed runtime environment. Platform-independent bundles require source code. Native OSGi has to specify how to build such bundles.

In the native world, libraries (e.g. ELF format on Linux, Mach-O format on MacOSX, and PE format on Windows) are a standard way to split applications. Yet, there are multiple ways to package code into libraries. Libraries could represent a complete bundle, single packages (a logical group of classes within a bundle) or individual classes. Using libraries to represent packages in a bundle has a couple of advantages:

- Have multiple libraries per bundle
- Have exported and private libraries

  Just like Java Packages this makes it possible to make a distinction between the private implementation and the exported services.

- Allow code sharing

  Using exported libraries it is possible to share code between bundles.

Another issue is the search path of libraries. A Native OSGi solution has to set up the search path in a way that it can fully control wiring of libraries and bundles.

3.5 Dependencies and versioning

The Module Layer of the OSGi Core specification defines several dynamical code loading features, but relies on Java classloading mechanisms. The NOStrum project [4] already presents solutions for many native specific issues. native OSGi has to take care of loading and wiring the different libraries by either relying on platform specific mechanisms ior by providing a custom mechanism on all supported platforms. The details of either approach must be invisible to the user and the wiring process must lead to the same results on all supported platforms.

An important aspect of OSGi is versioning of packages, and the wiring needed to find the correct version of a dependency. Whereas Java by itself does not provide any default versioning mechanism, the different native linkers do. These versioning mechanisms usually allow to load and access code libraries in different version at the same time. Unix differentiates between a library's name (the SONAME) and the library file name on disk. By convention, the SONAME of a library includes a numerical major version number and at runtime, the dynamic loader resolves such names encoded in depending libraries by choosing a library with a matching file name and optional minor version number appended to it (if multiple such files exist, the one with the highest minor version number is loaded). Libraries which differ only in their minor version are assumed to be fully backwards

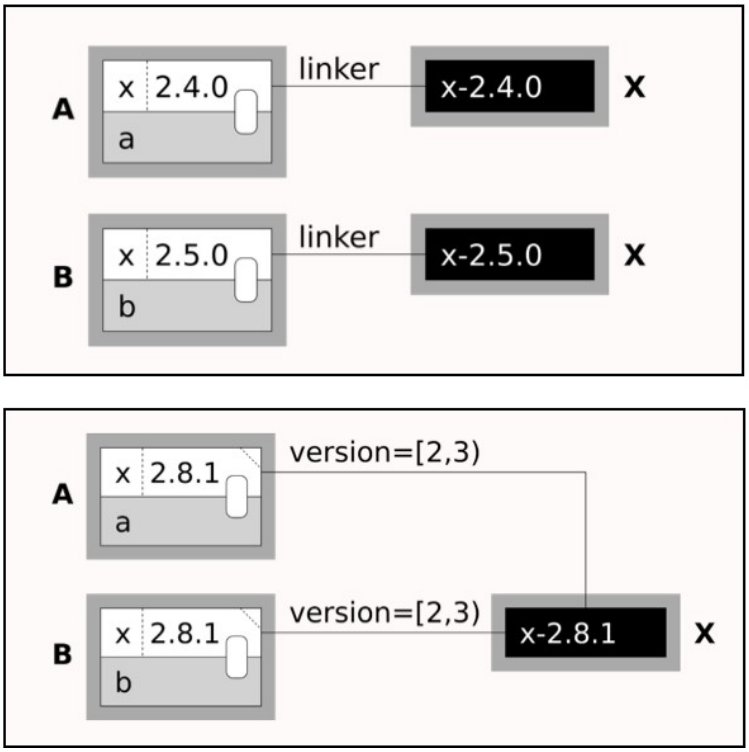
compatible. MacOS mach-o file format also provides version information comparable to Unix. The windows Portable Executable format also has version information. Yet, it is not used during loading the DLL.

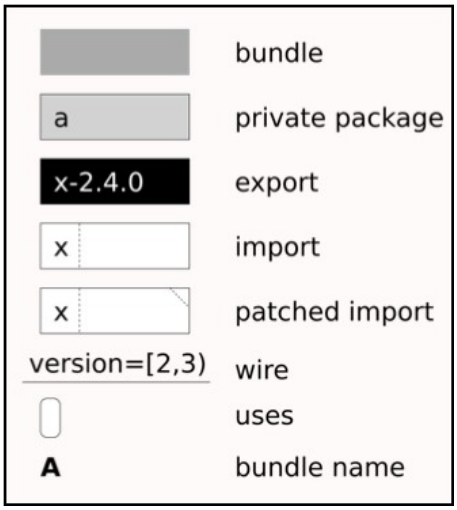
Native-OSGi should use an abstract version scheme that is compatible with popular platforms and allows libraries (packages) to be dynamically wired together at runtime, It must also support multiple library versions and dynamic bundle updates.

Exports And Imports

The following diagram depicts the wiring process for ELF shared libraries in NOStrum, where the full library version is additionally encoded in the library's file name . In the upper diagram the situation at link-time is detailed. The library dependencies are hard-coded by the linker during the linking process, using the SONAME of the dependencies (which includes the full version number). This results in a situation where Library A depends on version 2.4.0 of Library X, while Library B, developed with a different set-up, depends on version 2.5.0 of Library X.

If in the Meta-Data of the bundle providing library A or B the version range [2, 3) is provided, the module layer (resolver) looks for any bundles which fit in this range. Since the linker already has embedded the version info in the library itself (using the SONAME), this information has to be updated. So the version of the providing bundle/library (found by the resolver) is used to patch the version required by library A and B.





Alternative

Even though the model depicted above works, it might be worthwhile to investigate different solutions. A possible alternative is to extend the used linker (or linkers) to solve this. This would mean that instead of linking to a fixed version, the version range can be used. In this case there is no need to update the libraries at runtime. However, this might introduce restrictions to the target environment, e.g. a proper linker has to be supplied for every

operating system, runtime environment and possible versions. This solution would also exclude Windows from the list of supported platforms, since the Windows dynamic loader is part of the Kernel and cannot be modified or substituted (see [6]).

A much more complex solution might be the usage of one dedicated linker on all platforms. This linker can be bundled together with the framework which means the platform linker is ignored. Benefits of this are:

- No different library format, which means no different solutions (bundles or anything else) for different platforms.
- Only need for one common solution for wiring.

However, this would again exclude Windows from the list of supported platforms.

3.6 Security Layer

Isolation in native code is not a trivial task. There is no integrated security manager that can limit access to resources for parts of application code. Using pointers memory can be arbitrarily modified.

3.7 ABI Compatibility

C++ (in contrast to C) does not specify an ABI standard. In a Native OSGi setup, interoperability will therefore be reduced when using C++ compilers of different vendors or same vendors but different versions, which usually produce libraries with different ABIs. A careful library API design and refraining from using the STL or other third-party C++ libraries may in theory yield a cross-compiler compatible ABI. However, the restrictions on the API would severely limit its ease of use. As a consequence, it is expected that in a Native OSGi system only C++ bundles that were compiled with the same compiler (same vendor and compiler version) may share code via their C++ API. Hence bundles will need to be compiled from source for a specific Native OSGi target platform or provide appropriate meta-data when being published as pre-compiled binaries. Using an intermediate binary format such as LLVM may allow to mix bundles that were compiled with different compilers (see [4]).

3.8 Compatibility of C and C++ Bundles

Although C is a subset of C++, Native OSGi should provide a native C++ API for bundles written in C++ (In addition to a pure C API). Code sharing between a C and a C++ bundle will only be straight forward for a C++ bundle depending on a C bundle. It is out of the scope of Native OSGi to specify a mechanism for sharing code of a C++ bundle with C bundles. However, bundles collaborating via the service layer should not need to be aware of the programming language (C or C++) the providing or consuming bundle is written in. Thus, Native OSGi has to specify a way to call a C service via a C++ interface and vice versa.

Using a mixed set of C and C++ bundles requires Native OSGi to provide both a C and C++ API. Bundle writers providing service interfaces also need to provide C and C++ versions of these interfaces for maximum interoperability. While the creation of a C service interface wrapper for a C++ service interface or vice versa can be supported by tools from Native OSGi and need only be done for the interface and not for each service implementation, such wrappers should remain optional.

4 Use Cases

4.1 Dynamic (Re)Configuration [3]

A software vendor has a large distributed (embedded) software stack used for a sensor network. To be able to react to a changing environment it must be possible to reconfigure software. Since this can happen during actual usage this must be done dynamically and with little impact on the running network.

To be able to do this, a module based architecture is defined. This architecture will be realized using Native-OSGi. OSGi provides a clear component based model, as well as all aspects needed to be able to reconfigure the system at runtime (through the module and life cycle layer).

4.2 Updating and bug-fixing in home automation systems

A number of software modules for a security system or an home gateway router have been developed. The system should provide support for dynamical updates e.g. in term of bug-fixing or to add new functionality. End-users should further be able to extend their system with additional software (i.e. plugins) with no need to restart the entire platform. To keep the hardware costs low, software is typically developed in native languages and for exotic hardware architectures such as Mipsel. A native OSGi implementation can bring the dynamical aspects to these devices without increasing the Bill of Material.

4.3 High performance computing software

A developer wants to extend mathematical software with a new algorithm. He is able to implement his algorithm according to an existing interface, and can deploy his algorithm to the OSGi-based existing software.

4.4 Medical Imaging

A medical imaging related research group or company wants to create an application which integrates different components to achieve a complex work-flow. This work-flow includes preprocessing of image data on a server, the retrieval of the preprocessed data from the server, the loading of the data into memory, suitable visualization of the data, specific user interaction, followed by the calculation of some parameters and storing them in a database. Because the computational complexity of some of these components is very high and the execution time of the complete work-flow is critical (cost factor), the components are written in C++ and highly optimized. Ideally, each component would communicated with the others through well-defined interfaces implemented as OSGi services to increase their reusability and lower update and maintenance efforts for deployed systems.

5 Requirements

5.1 OSGi Compatibility

Module Layer

OSGI-1 Native OSGi MUST detail how the Module Layer should be supported. This support SHOULD be based on the module layer described in a chosen specification [5] with at least r4.

OSGI-2 Native OSGi MUST use a well defined, ZIP-like platform independent format for bundles similar to the format described in a chosen specification [5] with at least r4.

OSGI-3 The bundle format with its specific native metadata should be as closest as possible to Java OSGi [5].

OSGI-4 The module layer in Native OSGi MUST support multiple libraries even of the same name but in different versions.

OSGI-5 The module layer in Native OSGi MUST support export control of libraries through the use of export/import headers in the bundle manifest. It MUST support exported and private libraries.

OSGI-6 The module layer MUST support versioning using export versions and import version ranges.

Life Cycle Layer

OSGI-7 Native OSGi MUST follow the life cycle for bundles as defined in a chosen specification [5] with at least r4.

Service Layer

OSGI-8 Native OSGi MUST detail a service layer and registry similar/equal to the chosen specification. This support SHOULD be based on the service layer described in a chosen specification [5] with at least r4.

5.2 Compatibility of C and C++ Bundles

CPPC-1 Native OSGi MUST support C and C++. This support has to be in a language natural manner. C++ developers should be able to use C++ constructs, whereas C developers should be able to do the same using C constructs.

CPPC-2 Native OSGi SHOULD support consumption of C services from C++ bundles and vice versa. Services SHOULD be handled in a transparent way without any additional work on the consuming end.

CPPC-3 The Native OSGi service registry SHOULD be able to handle C as well as C++ services.

5.3 Native language issues

LANG-1 Native OSGi MUST define a language standard. Due to the large amount of different compilers and platforms, a suitable language version must be chosen to not restrict the usage of Native OSGi too much.

LANG-2 The Native OSGi specification MUST state a minimum set of platforms on which compliant implementations are required to run, similar to the concept of Java *execution environments*.

LANG-3 Native OSGi MUST NOT rely on functions of specific operating systems NOR alter the standard system environment (e.g. standard runtime libraries).

LANG-4 Native OSGi MUST address memory management of all object specified in Native OSGi, in particular with regard to service objects. This covers both, the life-time and ownership of objects.

LANG-5 Native OSGi SHOULD introduce no or little overhead when issuing calls between bundles. Where possible wrappers must be avoided. The case of C – C++ interaction will be an exception to this requirement.

LANG-6 Native OSGi MUST define how to build platform independent bundles (i.e. source bundles).

LANG-7 The Module Layer in Native OSGi MUST take care of loading and wiring the different libraries.

LANG-8 Native OSGi SHOULD use shared libraries on the level of Java Packages.

LANG-9 Native OSGi SHOULD use a version scheme that is compatible with library version schemes of popular platforms.

6 Document Support

6.1 References

[1] Bradner, S., Key words for use in RFCs to Indicate Requirement Levels, RFC2119, March 1997.

[2] Software Requirements & Specifications. Michael Jackson. ISBN 0-201-87712-0

[3] Sensor Technology Applied in Reconfigurable Systems, http://starsproject.nl/

[4] S. Kächele, J. Domaschka, H. Schmidt, and F.J. Hauck, nOSGi: a posix-compliant native OSGi framework. In Proceedings of COMSWARE. 2011, 4-4.

[5] OSGi Alliance Core Specifications, http://www.osgi.org/Specifications/HomePage

[6] John R. Levine, Linkers & Loaders, Academic Press, 2000.

6.2 Author's Address

Name	Alexander Broekhuis
Company	Luminis BV
Address	IJsselburcht 3 6825 BS Arnhem
Voice	+31 622393303
e-mail	alexander.broekhuis@luminis.eu

Name	Steffen Kächele
Company	University of Ulm
Address	Albert-Einstein-Allee 11 89081 Ulm
Voice	
e-mail	steffen.kaechele@uni-ulm.de

Name	Sascha Zelzer
Company	German Cancer Research Center
Address	Im Neuenheimer Feld 280 69120 Heidelberg
Voice	
e-mail	s.zelzer@dkfz-heidelberg.de

6.3 End of Document