By the bye: JNI

JNI vs FFM - a (subjective) comparison

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About me

Birgit Kratz

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- Java-Backend
- More than 25 years experience
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- Co-Organizer of SoCraTes-Conf Germany
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Agenda

A little background story

The old days - JNI in a nutshell

The new days - what is the new FFM API and how does it work?

Comparison by example - the sudoku solver project

(subjective) Assessment

First some questions

My background story

JNI (Java Native Interface) in a Nutshell

- allows classes to declare ‘native’ methods
- used to access platform-specific functionalities
- interact with code written in other programming languages like C or C++
- implemented in a separate native shared library
- bridge between the bytecode running in our JVM and the native code
- part of Java since Java 1.1

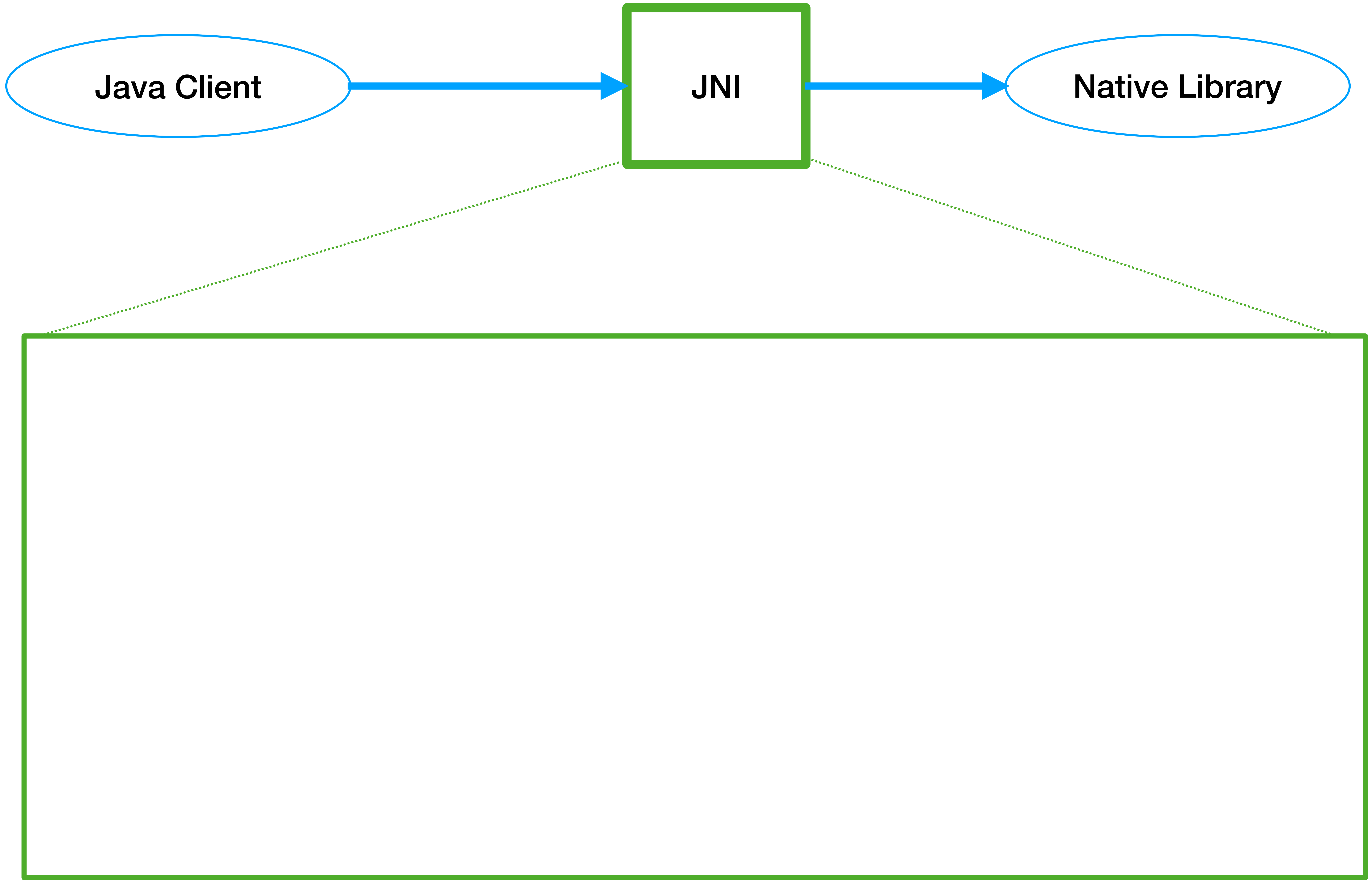
Java Classes containing native Methods

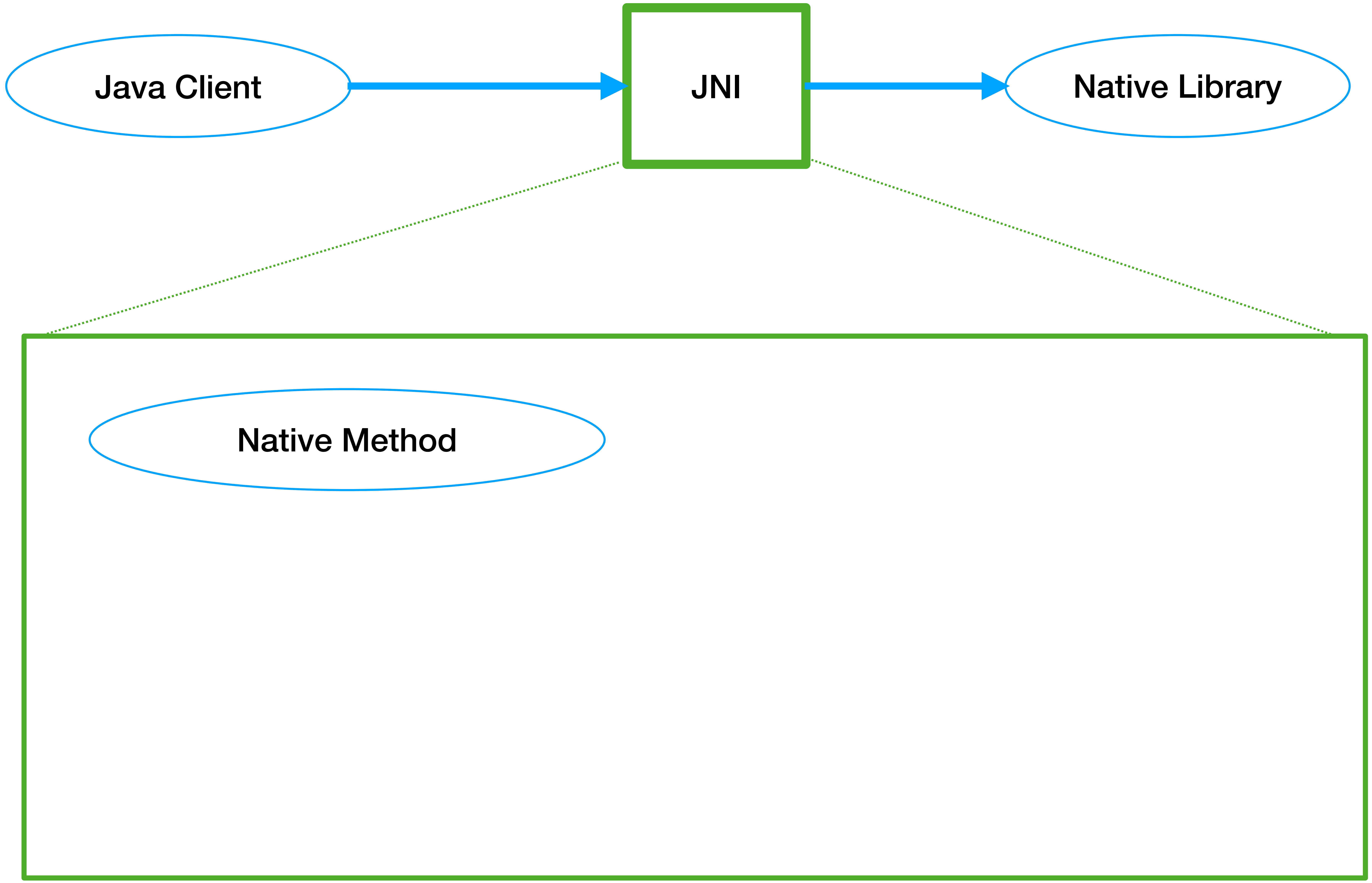
- java.lang.System: ie.e arraycopy(), currentTimeMillis()
- java.io.FileDescriptor
- java.nio.DirectByteBuffer
- java.lang.Thread: i.e. start(), sleep()
- java.util.zip.Deflater, java.util.zip.Inflater
- and others…

Sometimes you just have to go ‘native’

- Off-CPU computing (Cuda, OpenCL)
- Deep learning (Blas, cuBlas, cuDNN, Tensorflow, …)
- Graphic processing (OpenGL, Vulkan, DirectX)
- others (OpenSSL, SQLLite, V8, …)

Quelle: https://www.youtube.com/watch?v=cfxBrYud9KM


Java Client
JNI
Native Library


Java Client
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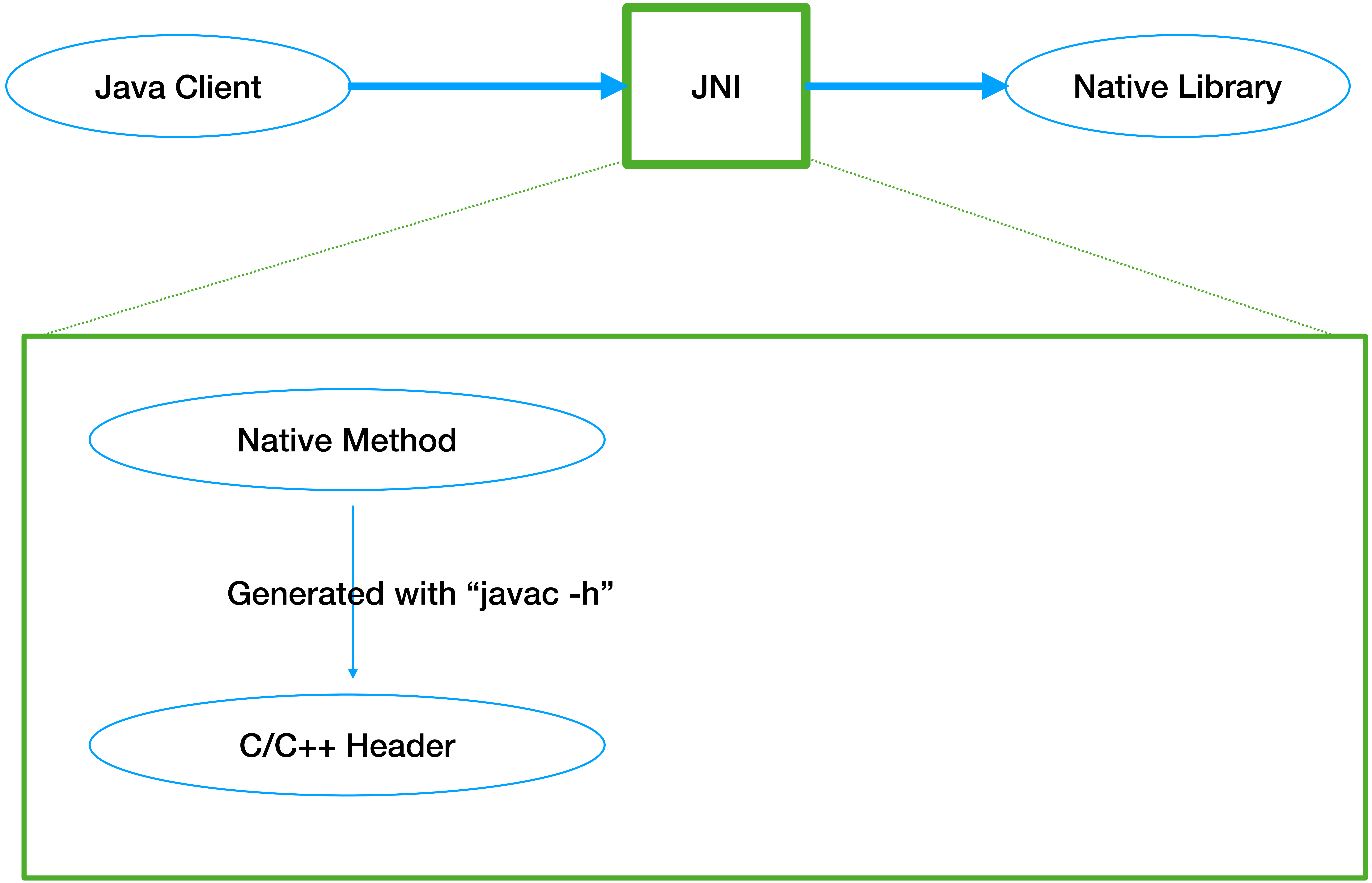
Java Client
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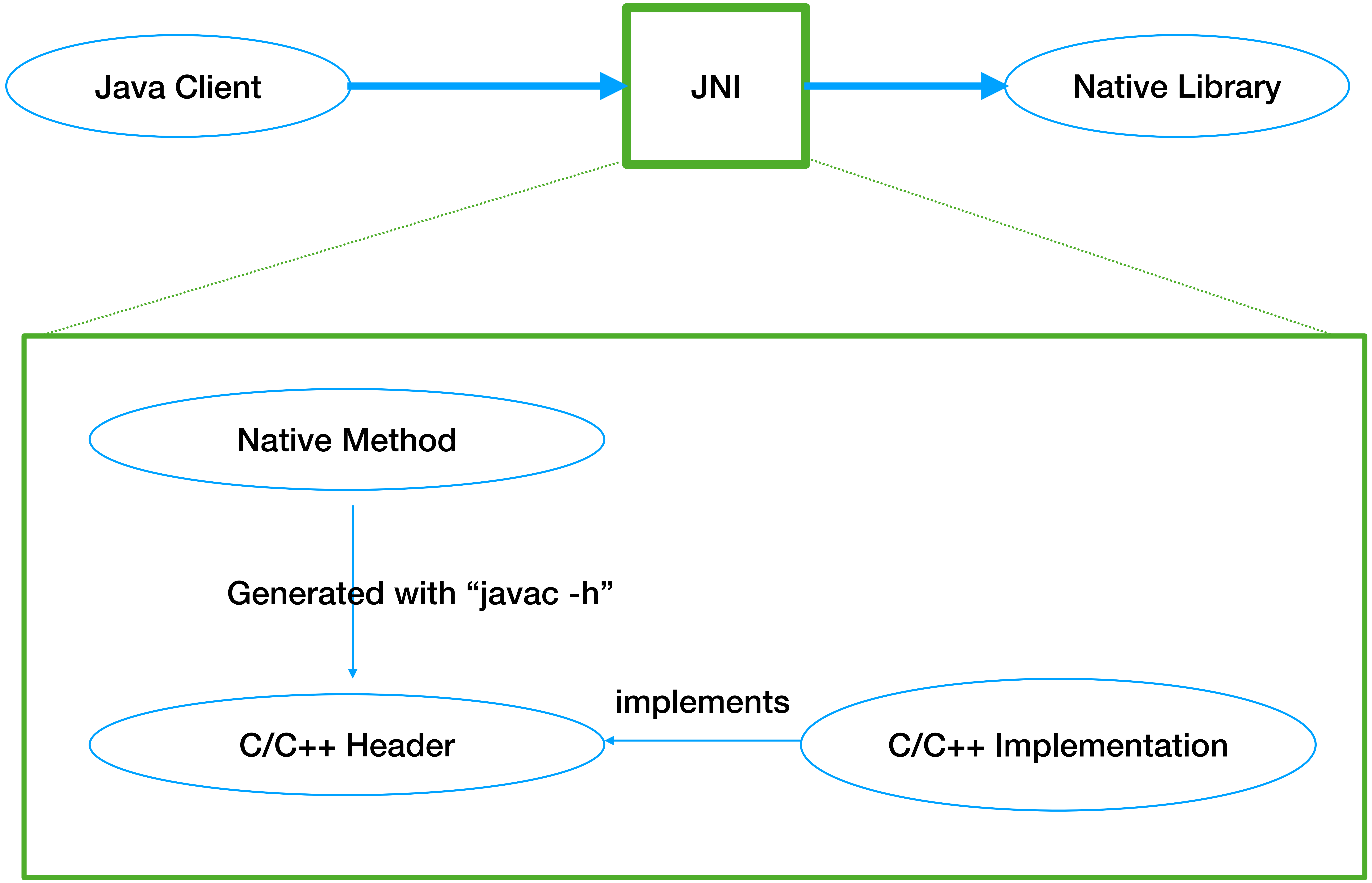
Native Method
Generated with “javac -h”
C/C++ Header


Java Client
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implements
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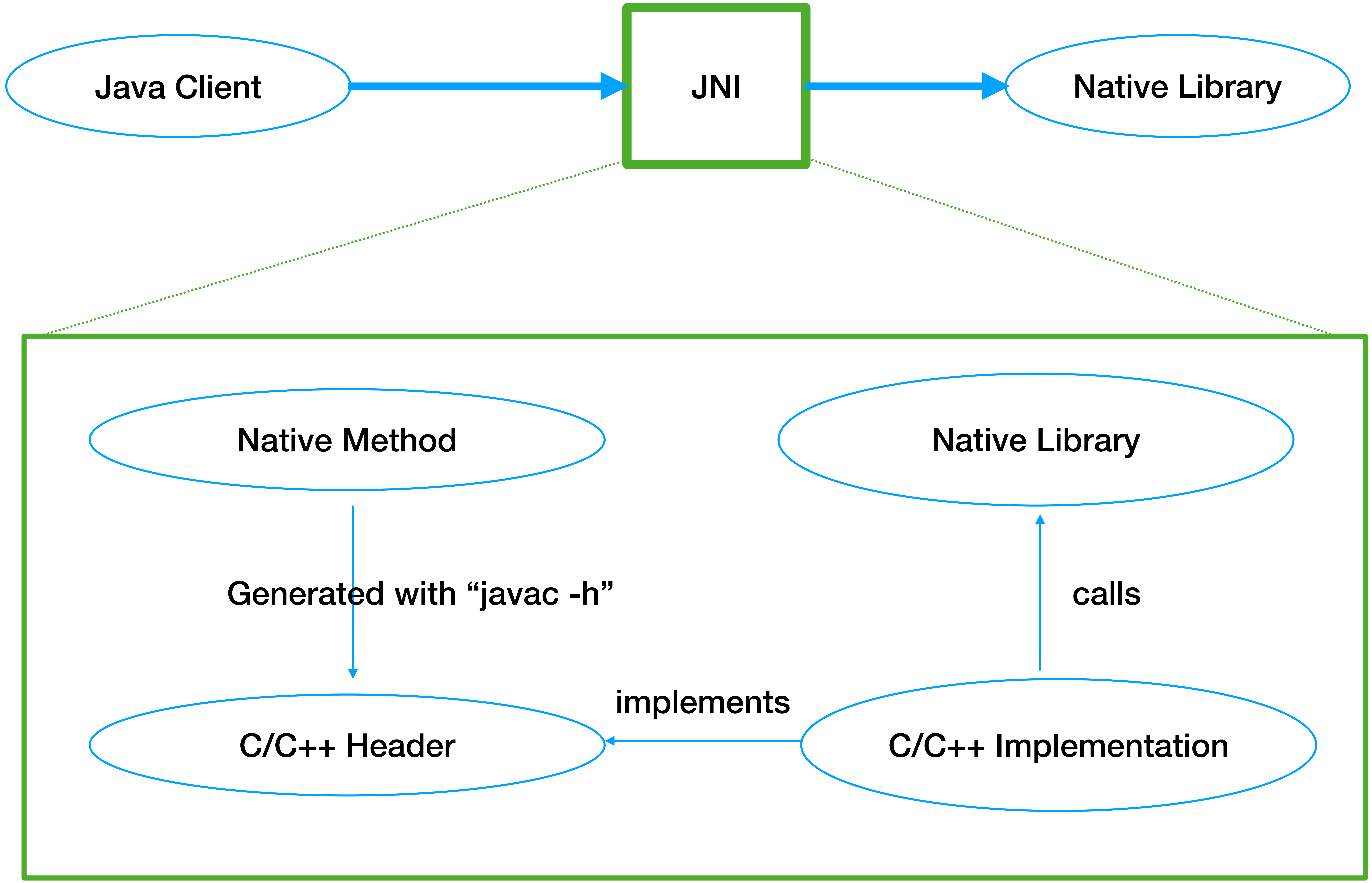
C/C++ Implementation


Java Client
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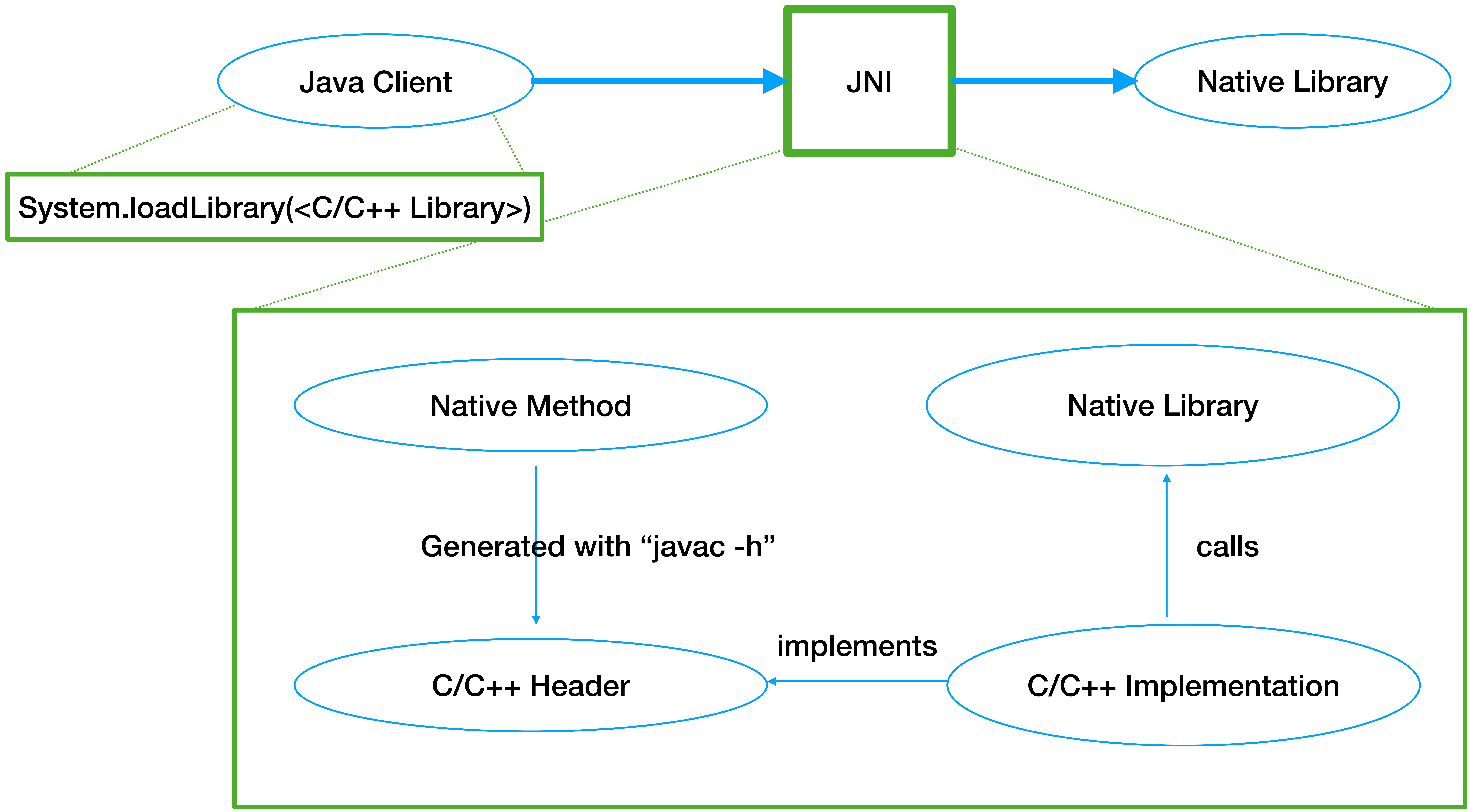
Java Client
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System.loadLibrary(<C/C++ Library>)
Native Method
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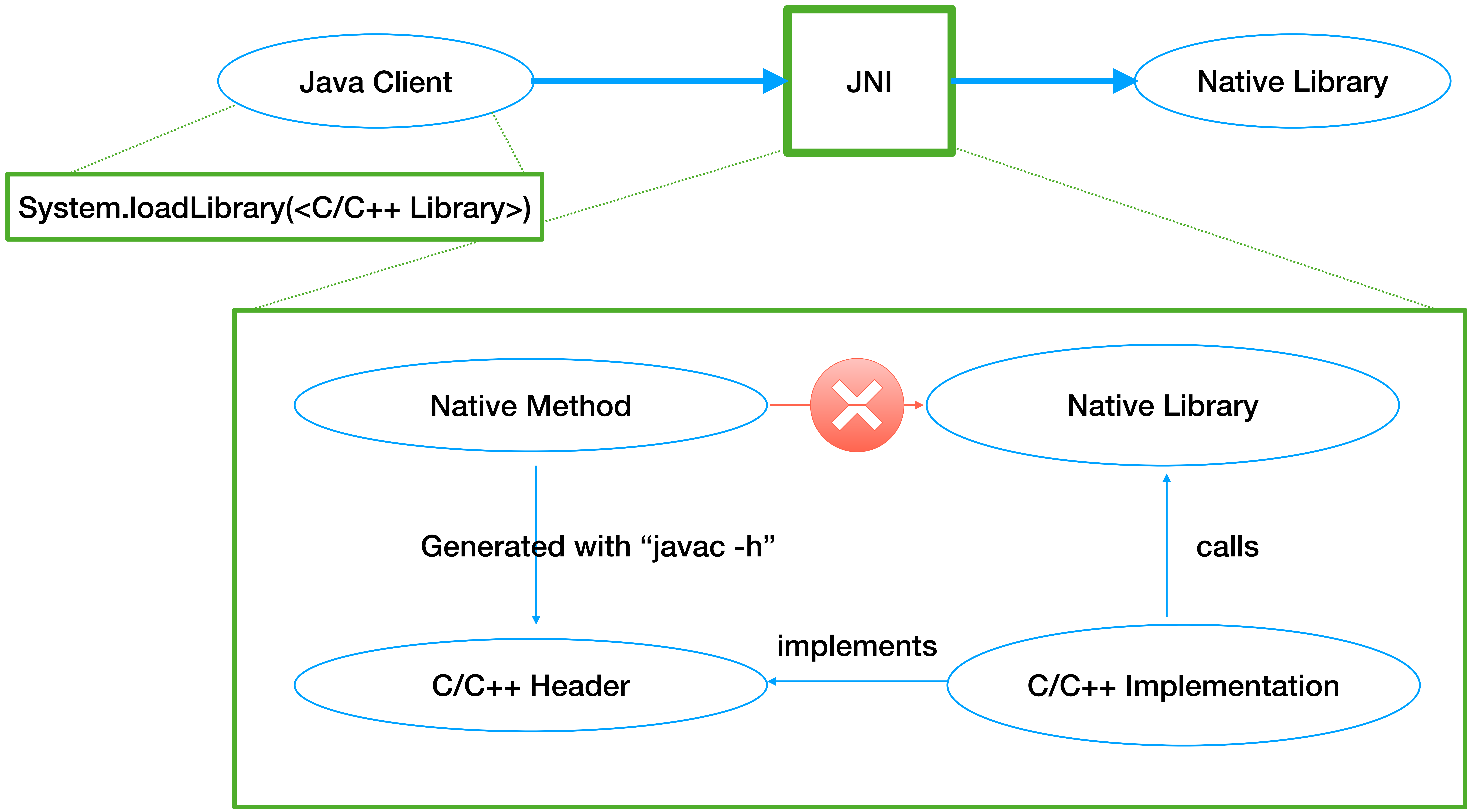
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Problems

- Need to have good knowledge of native language such as C/C++ (as a Java programmer)
- Need to know memory management in these languages
- Potential memory leaks -> allocated memory is never freed
- Memory freed too early -> use-after-free

Code example

FFM API - Java Foreign Function & Memory API

- JEP 454
- Part of project Panama
- Final since Java 22

Managing Memory in Java

- Arena
  - models the lifecycle of Memory Segments
  - it’s closable
  - deterministic deallocation of Memory Segments
  - no out-of-bounds access
  - no use-after-free access

Arena Characteristics

Kind	Bounded lifetime	Explicitly closeable	Accessible from multiple threads
Global	No	No	Yes
Automatic	Yes	No	Yes
Confined	Yes	Yes	No
Shared	Yes	Yes	Yes

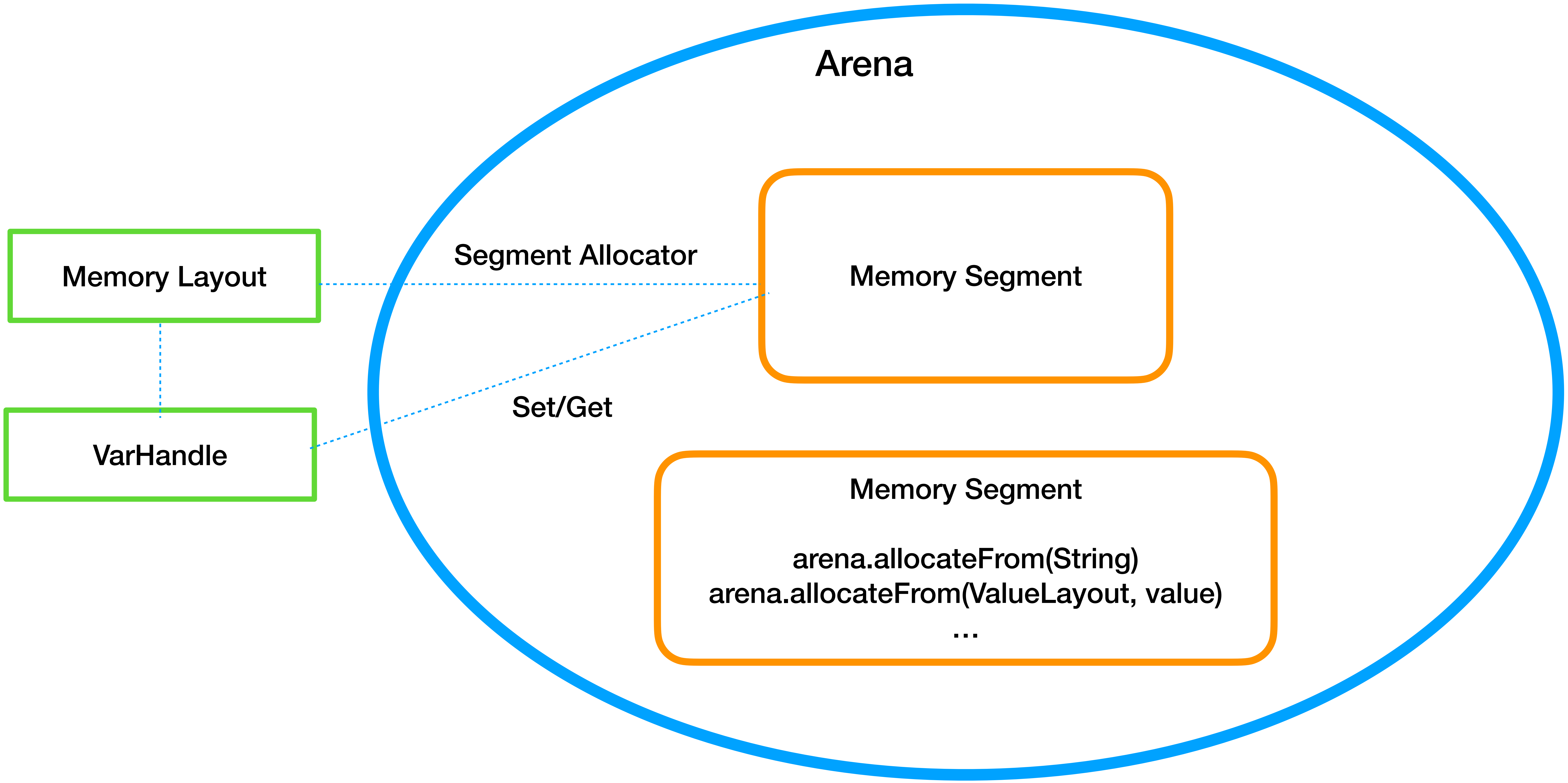
Quelle: https://docs.oracle.com/en/java/javase/22/docs/api/java.base/java/lang/foreign/Arena.html

Managing Memory in Java

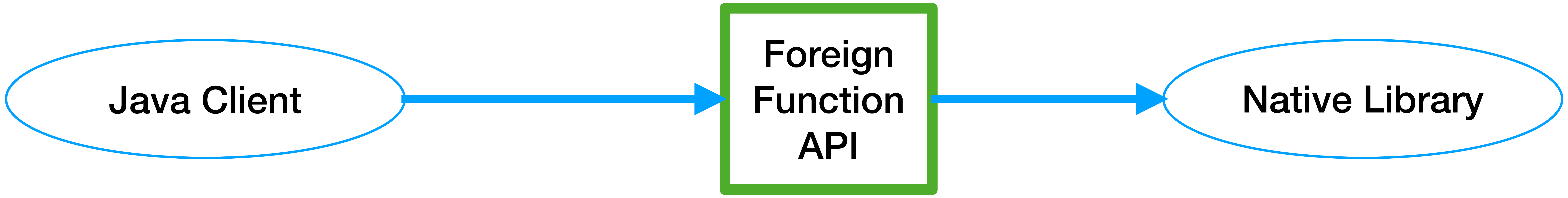
- **Memory Segment**
  - can represent on-heap or off-heap memory regions
  - off-heap Memory Segments belongs to an Arena
  - all Memory Segments of an Arena share the same lifetime
  - cannot be used after being freed
  - when an Arena is closed, all of it’s Memory Segments are automatically invalidated

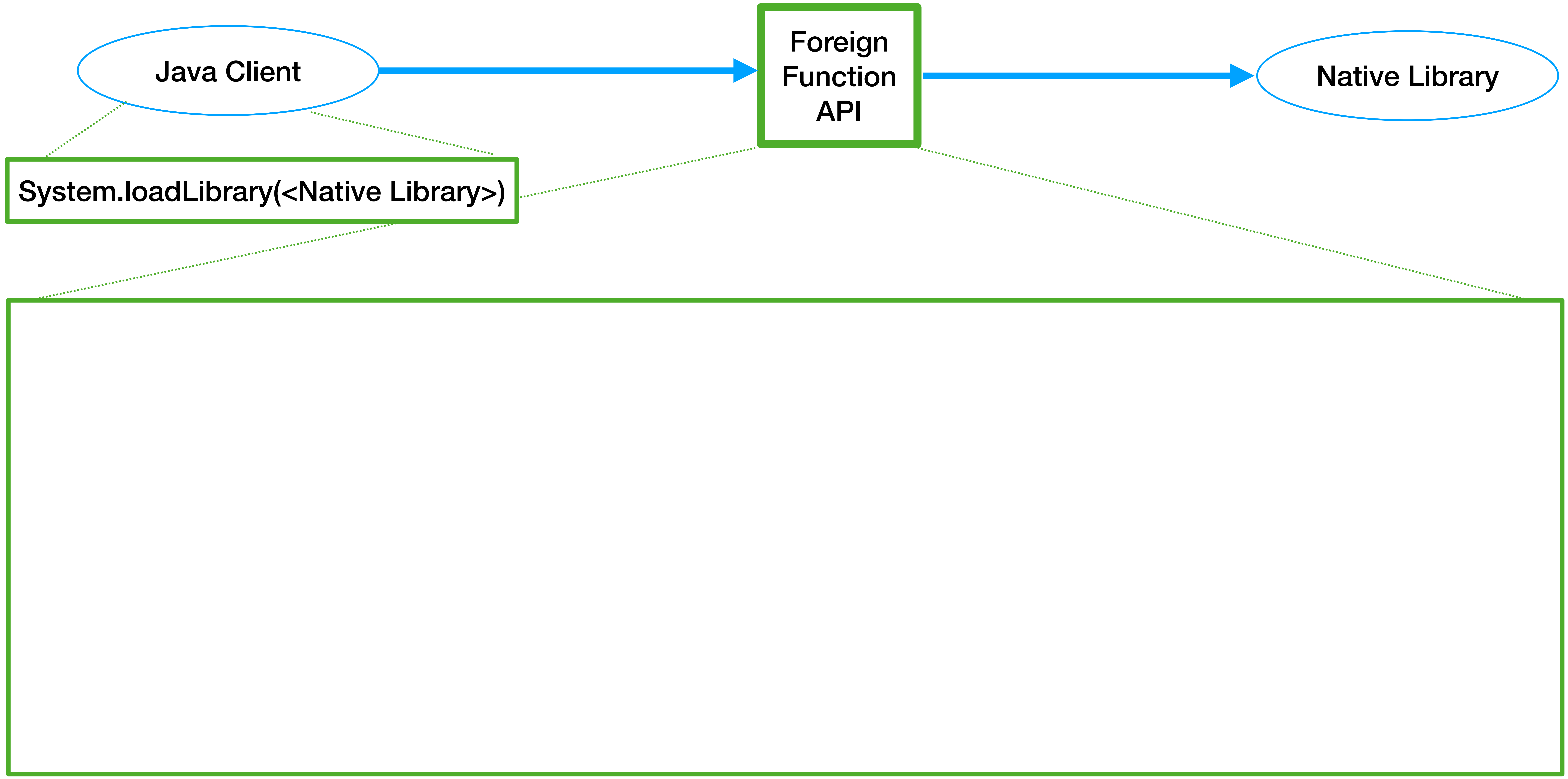
Managing Memory in Java

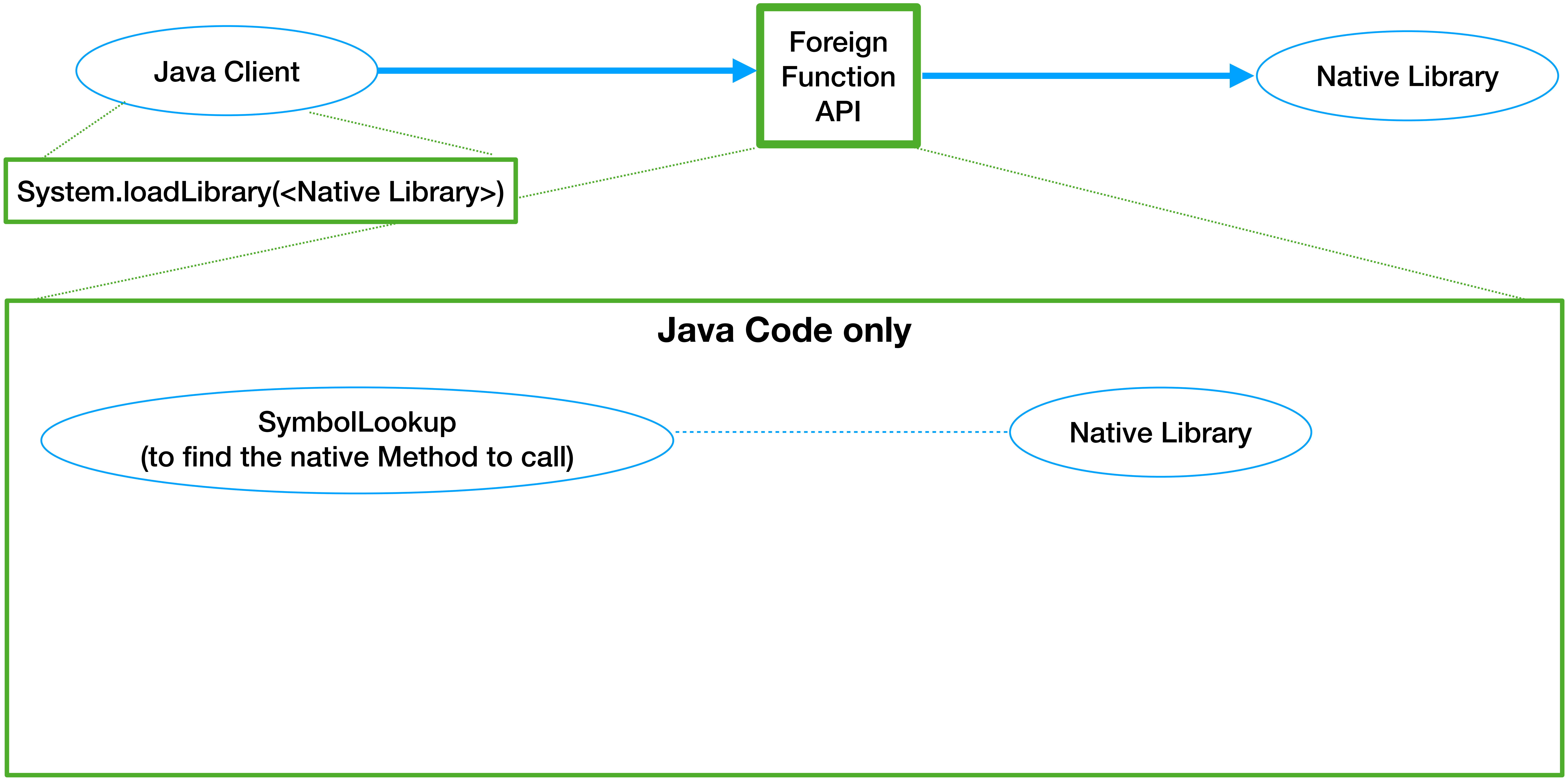
- **Memory Layout**
  - programmatically describe contents of a memory region
  - can be queried for size, alignment and access expressions
  - has subtypes like:
    - Group Layout (i.e. for describing structs
    - Sequence Layout (i.e. for lists)
    - Value Layout (i.e. for pointers, boolean, byte, char, int, long, etc.)
- **VarHandle** - to simplify offset handling


Arena
Memory Layout
Segment Allocator
Memory Segment
VarHandle
Set/Get
Memory Segment
arena.allocateFrom(String)
arena.allocateFrom(ValueLayout, value)
...

Direct Native Function call with Foreign Function API




Java Client
Foreign Function API
Native Library
System.loadLibrary(<Native Library>)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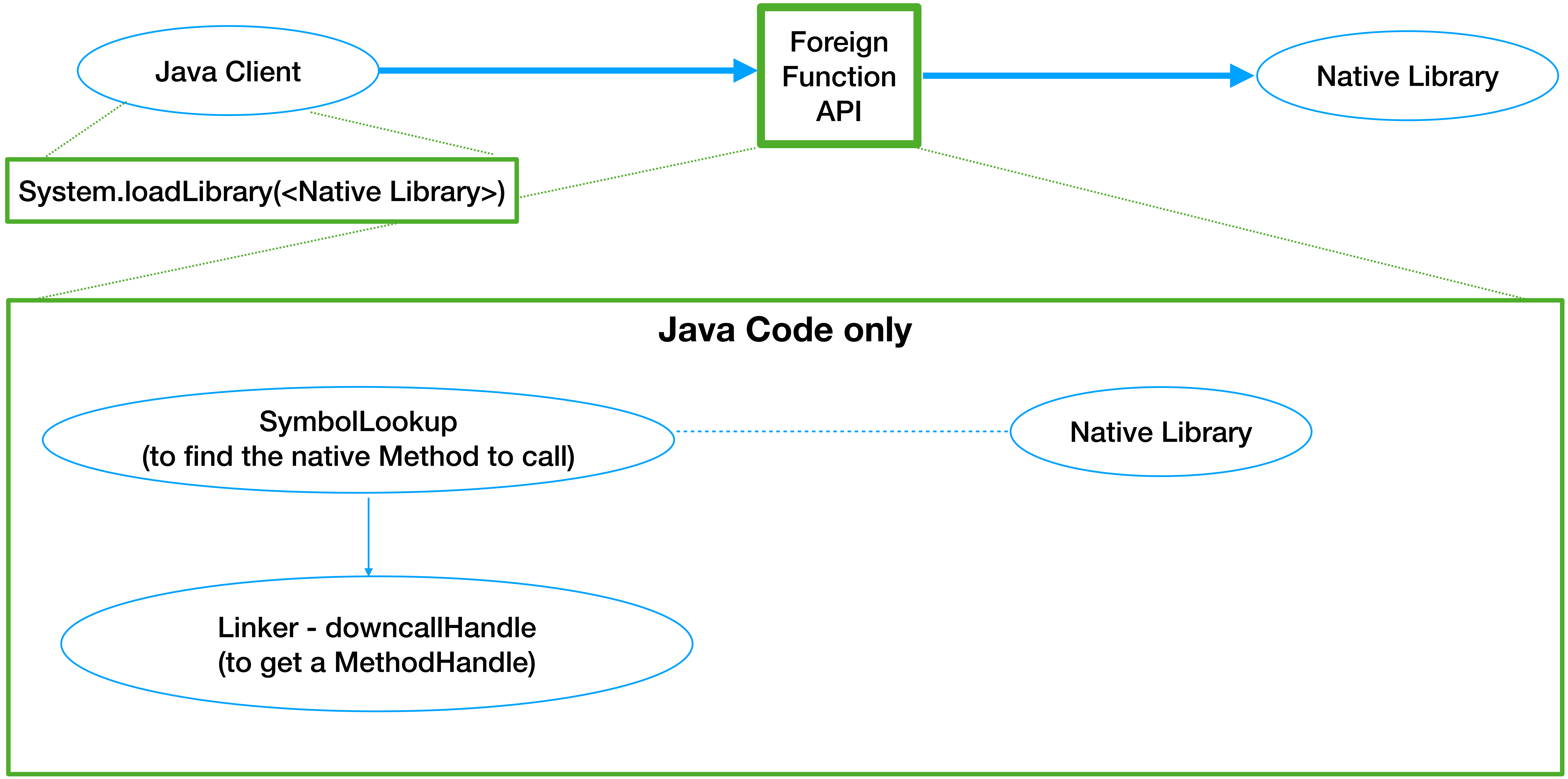
Java Code only
SymbolLookup
(to find the native Method to call)
Native Library


Java Client
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Native Library
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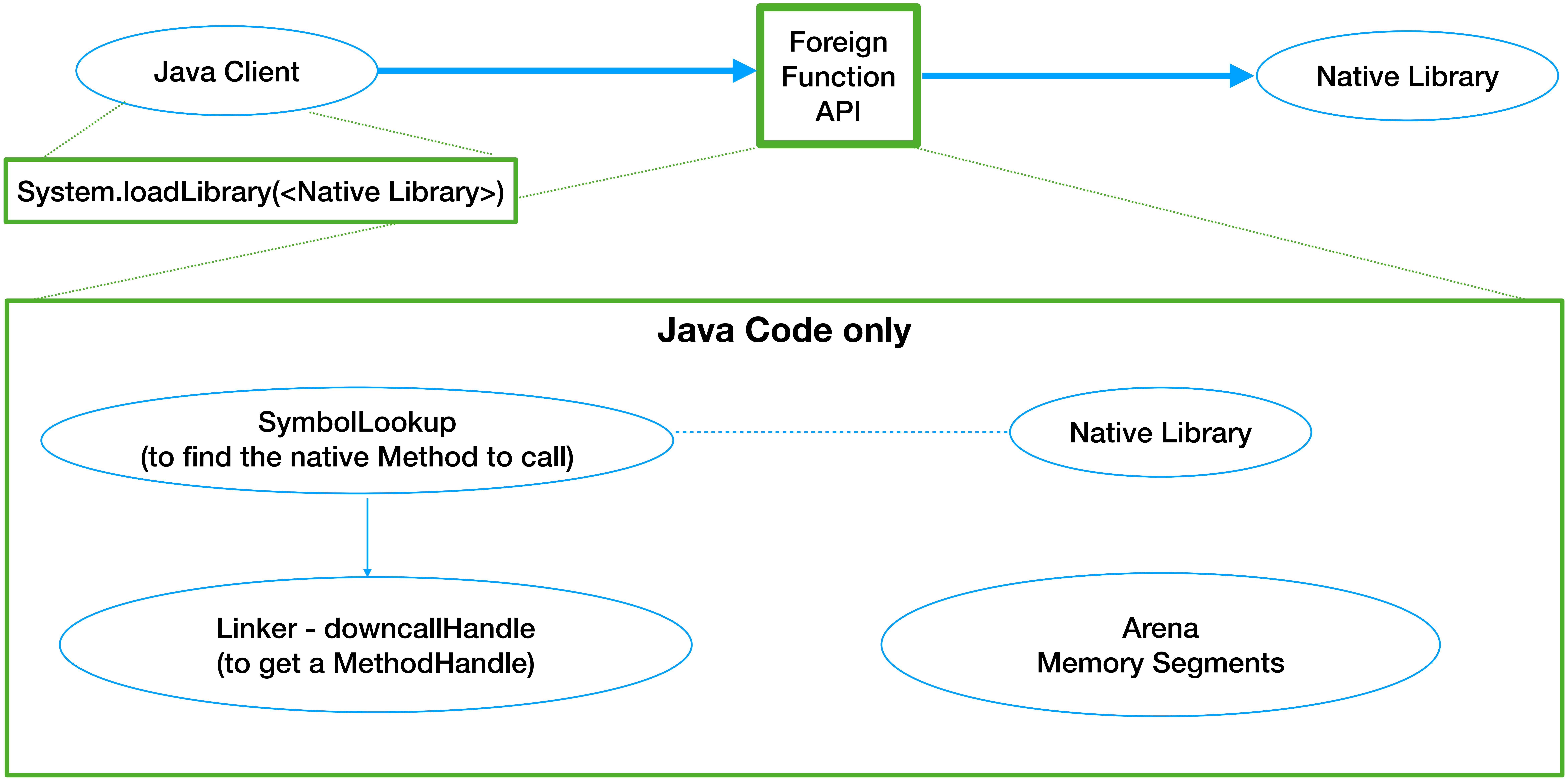
Java Code only
SymbolLookup (to find the native Method to call)
Native Library
Linker - downcallHandle (to get a MethodHandle)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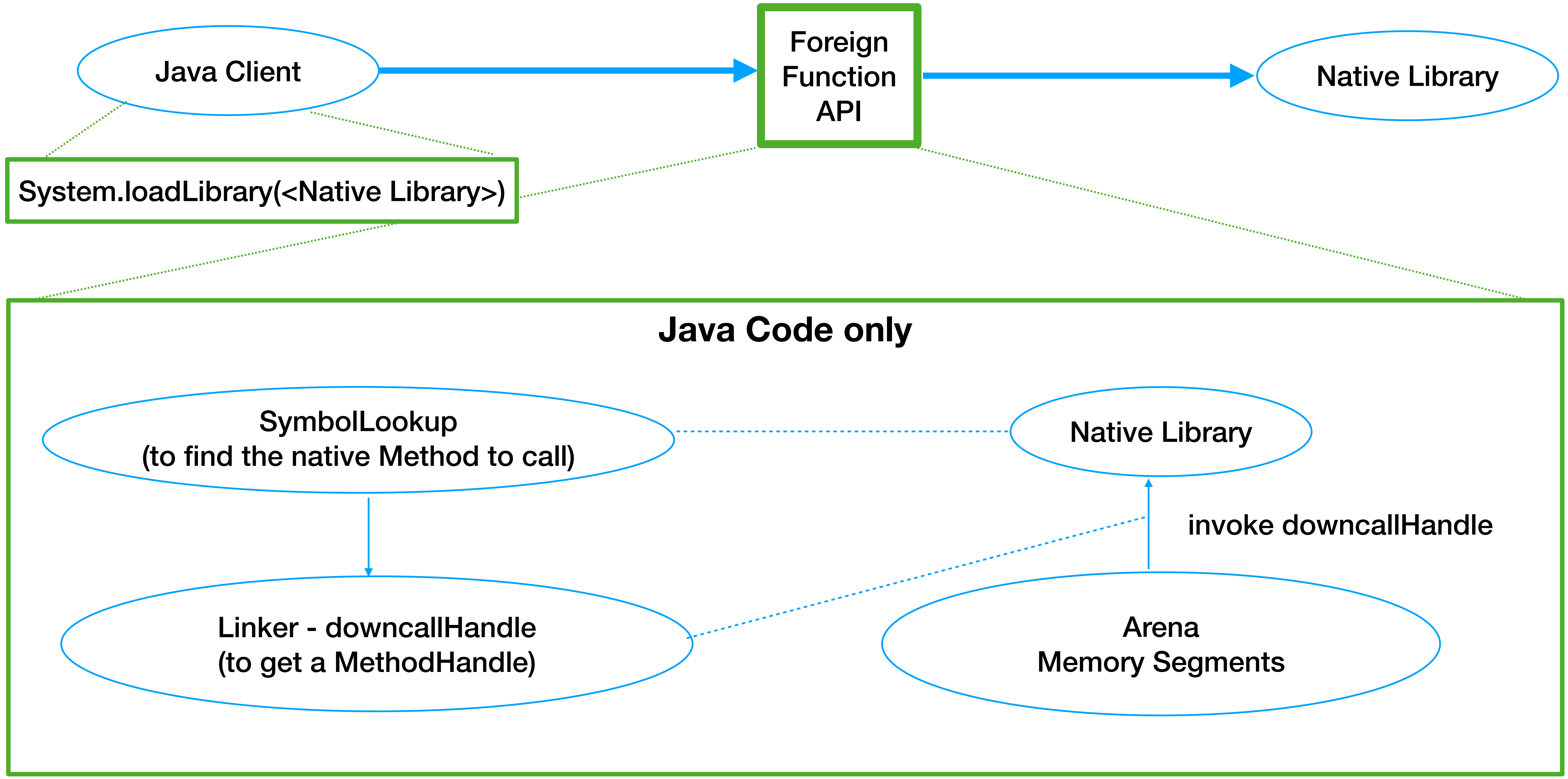
Linker - downcallHandle (to get a MethodHandle)
Arena Memory Segments


Java Client
Foreign Function API
Native Library
System.loadLibrary(<Native Library>)
Java Code only
SymbolLookup (to find the native Method to call)
Native Library
invoke downcallHandle
Linker - downcallHandle (to get a MethodHandle)
Arena Memory Segments

Code example

jextract

- is a tool which mechanically generates Java bindings from a native library headers
- leverages the clang C API in order to parse the headers associated with a given native library, and the generated Java bindings build upon the Foreign Function & Memory API
- was originally developed in the context or Project Panama

Quelle: https://github.com/openjdk/jextract

Code example

My subjective Assessment

- Both approaches are not platform independent, the native library has to be available for each platform the Java program is running on
- FFM is only available with Java 22 or later, or as a preview-version also with version prior to Java 22
- With FFM I can completely stay in the Java development environment
- Significantly less code compared to JNI, especially when using ‘jextract’
- The programming with MemorySegments and Arenas needs some getting used to
- Do not need to worry about memory-leaks or use-after-freed anymore

Questions?

Thank you

Slides: https://www.birgitkratz.de/uploads/Javaland_2024_ByTheByeJNI.pdf

Sample code repositories:
https://github.com/bkratz/SudokuSolverNative
https://github.com/bkratz/SudokuSolverCPP
https://github.com/bkratz/SudokuSolverJNI
https://github.com/bkratz/SudokuSolverFFM

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