Free Java Runtimes

自由且更適合研究與自訂化的實做

JavaTwo 2005

Jim Huang (黃敬群 / **jserv**)

http://jserv.sayya.org/

Kaffe.org

Powered By
jserv's lab

To be listed here...

- Stuart Ballard, Mark Benvenuto, Geoff Berry, James E. Blair, Eric Blake, Sascha Brawer, Nic Ferrier, Paul Fisher, Anthony Green, Jochen Hoenicke, Brian Jones, Roman Kennke, Michael Koch, John Keiser, John Leuner, Warren Levy, Bryce McKinlay, Audrius Meskauskas, Aaron M. Renn, Andrew Selkirk, Tom Tromey, Ronald Veldema, Mark Wielaard, Jon A. Zeppieri, Per Bothner, Archie Cobbs, Andrew Haley, Alexandre Oliva, Casey Marshall, David Gilbert, Lillian Angel, Thomas Fitzsimmons, Jeroen Frijters, Guilhem Lavaux, Robert Schuster, Dalibor Topic, Chris Burdess, Audrius Meskauskas, Sven de Marothy, Kim Ho, ...
- Various Hackers !

Agenda

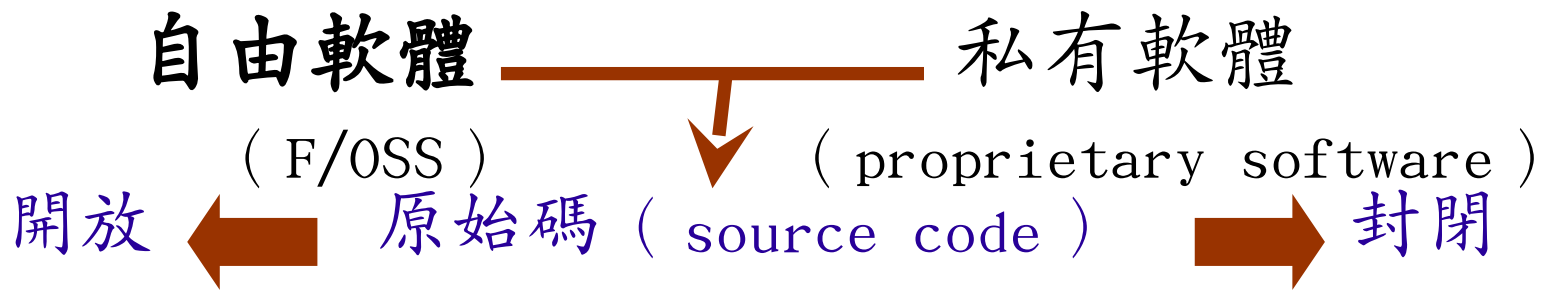
- Why Free Java?
- 目前 Free Java Runtimes 概況
- 如何建構 cleanroom JavaVM
- Case Study
- 展示

Why Free Java?

- Why Free Java?
  - “Free" 的定義
  - Sun JDK 的授權疑慮
- 目前 Free Java Runtimes 概況
- 如何建構 cleanroom JavaVM ？
- Case Study
- 展示

“Free” 的定義

- 法國革命家羅蘭夫人在十八世紀嘗言：
  - 「自由、自由，多少罪惡假汝之名以行。」
- 1985 年 Richard Stallman 成立 Free Software Foundation 貫徹四大自由：(copyleft)
  - 執行程式的自由
  - 研究程式的自由
  - 散佈程式的自由
  - 改良程式的自由



Sun JDK 授權疑慮

- Sun JDK 的授權方式
  - Binary Code License
  - SCSL (Sun Common Source License)
  - JRL (Java Research License)
- 與 OSD (Open Source Definition) 的分野
- Sun Microsystems 逐步釋出善意
  - 2005 年的 **OpenSolaris**
  - Matt Thompson's Talk in Day1
    - Sun Microsystems 的 Open Source 策略
  - SCSL 到 JRL 的轉變

OSD vs SCSL

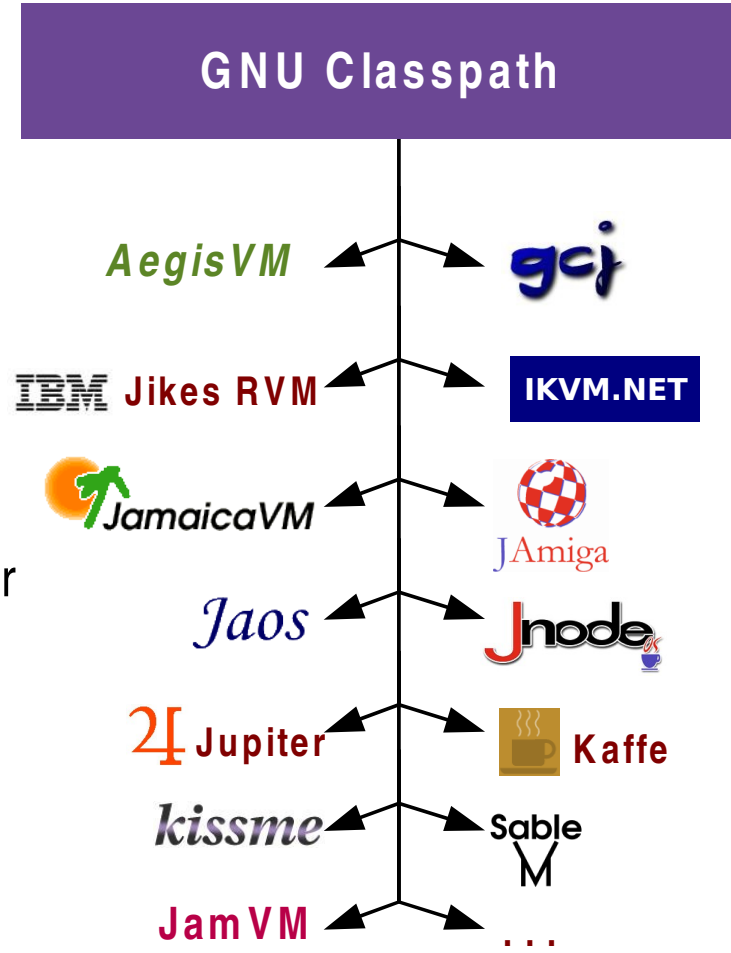
	OSD	SCSL
Free Redistribution	Yes	No
Source Code	允許修改 / 再散布	不允許自由再散布
Derived Work	允許也認可 （原始程式碼的整合性）	**不允許** （也不允許自由散布個別的修改）
Enhancement	鼓勵	**有限度的研究、商業使用，或者個人名義使用**
Forking	授權不得限制其他軟體，也不得有排他性	**一旦同意 SCSL 授權，就不得散布不相容的軟體** （如果有違反 TCK 測試項目疑慮時，無法散布 Kaffe、GCJ，甚至是 Xerces 等軟體）

目前 Free Java Runtimes 概況

- Why Free Java?
- 目前 Free Java Runtimes 概況
  - GNU Classpath 簡介
  - 發展近況與相容度
  - 活躍專案介紹
- 如何建構 cleanroom JavaVM ？
- Case Study
- 展示

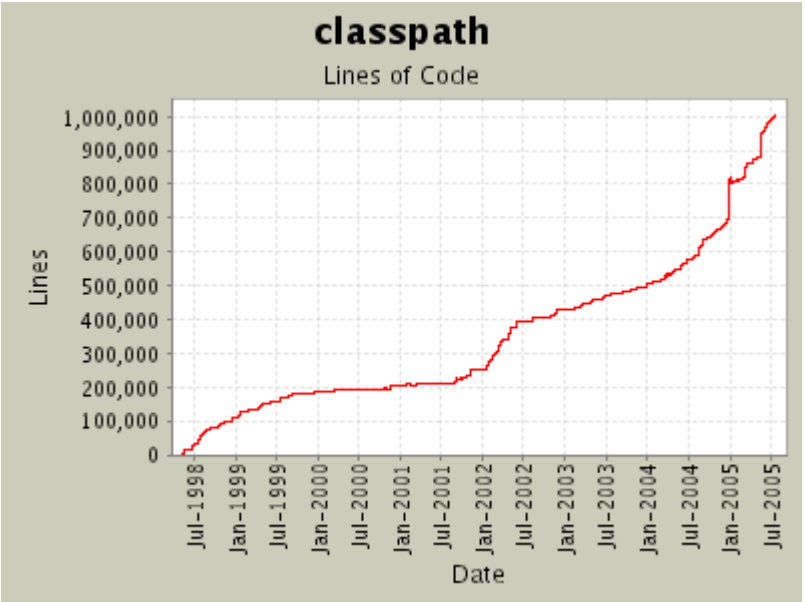
GNU Classpath 簡介

- 以 GNU Classpath 爲發展中樞
  - **Java class library** 的自由實做
  - 爲其他 Free Java Runtimes 的基礎
  - 但不是
    - JDK replacement 、 virtual machine 、 compiler
- 實作 java.* javax.* packages (core API and most extensions)
- 目前實作 J2SE 1.3/1.4/1.5
  - 依據 Sun 的文件實作
  - 沒有 Sun TCK 認證



GNU Classpath 簡介 (2)

- 1998 年計畫創立
- 全球約三十餘位活躍開發者
- 超過一百萬行程式碼 (Java + C)
- 每兩個月有新的釋出版本
  - 目前 0.17
- 許多合作的專案
- 授權方式
  - **GNU GPL with exceptions**



Line of Code 的意義

- LoC (Line of Code) 在許多自由軟體專案用以描述軟體規模
- Edsger W. Dijkstra 在〈Two views of Programming〉提到：

> When a very well-known and widely respected computer scientist recently used [lines of code as a measure of] programmer productivity in a lecture, the suggestion came from the audience that, instead of talking about "the lines of code produced" we should talk about "the lines of code used" and that, therefore, the speaker was booking them on the wrong side of the ledger. The speaker answered that he stuck to his productivity measure, because he did not know of any alternatives that allowed proper quantification!

* 咱們看看 "the line of code used" in GNU Classpath

Free Java Runtimes

AegisVM

Jaos

Jupiter

gcj

IBM Jikes RVM

kissme

JamVM

JAmiga

JamaicaVM

Kaffe

Sable VM

Jnode OS

MAUVE

http://sources.redhat.com/mauve/

IKVM.NET

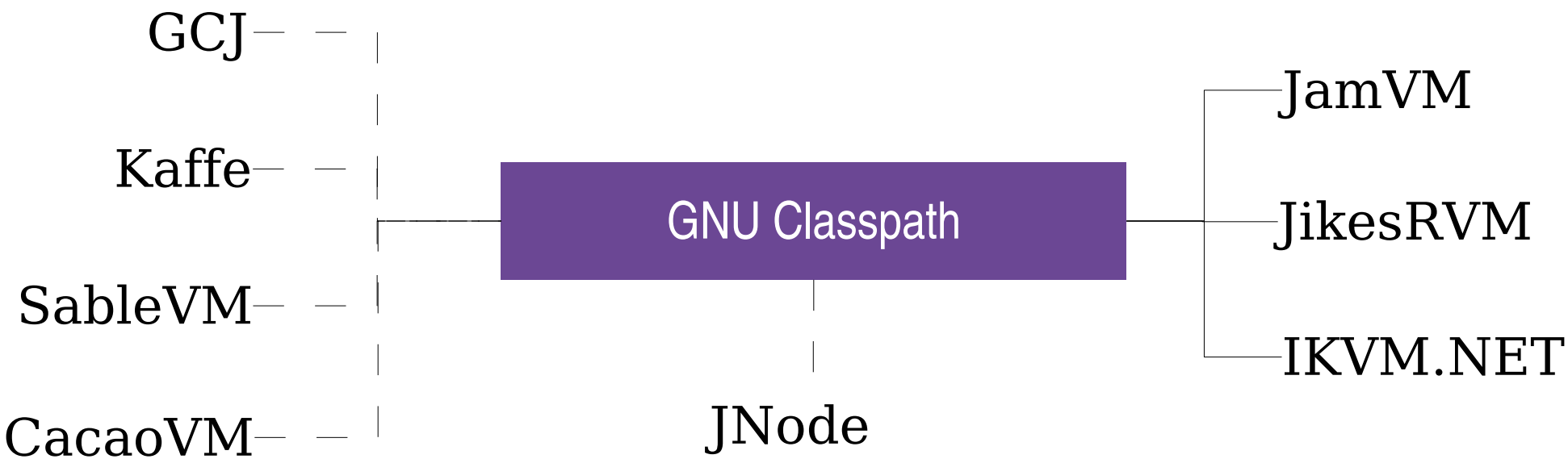
Apache Gump

Apache Harmony

The Apache Software Foundation

http://www.apache.org/

GNU Classpath 發展想法



“out of the box” (goal)

keeps private copy

相容度

- 涵蓋
  - 78% 1.5 Java API
  - 87% 1.4/1.3 Java API
  - 89% 1.2 Java API
  - 99% 1.1 Java API
- 相當成熟的實做
  - java.{ lang | math | io | nio | rmi | security | util }
- 積極發展中
  - AWT peers (GTK+ / Qt4)
  - Swing
  - CORBA

Java 5 support

- *generics-branch* 在 2004 年秋季建立
- 支援 JDK 1.5 所引入的新語言特徵
- new APIs
- 里程碑
  - 2004 年十二月雛型完成
  - 2005 年五月份首度運作於 JamVM 1.3.0
- compilers
  - ECJ (compiler of Eclipse 3.1)
  - GCJX (實驗性的 GCJ Frontend)

活躍專案介紹

Kaffe

gcj

IKVM.NET

Jnode os

Kaffe VM

- 第一個 Free JVM (1996 年一月份)，1997 年 Transvirtual Technologies 提供商業服務
- 能在五十個平台上運作 ("NetBSD of JVMs")
- 自 2002 年以來就開始與 GNU Classpath 整合
- 豐富的 API 實做
  - JacORB, Tritonus, GNU Crypto, ...
- 可作爲完整的 JDK 替換

GCJ

- GNU Compiler for Java
  - part of the GCC
- compiler and runtime environment (GIJ)
- Ahead-Of-Time compiler
  - {source- and bytecode} -> machine language
- CNI (Compiled Native Interface)
  - C++ ∽ Java

IKVM.NET

IKVM.NET

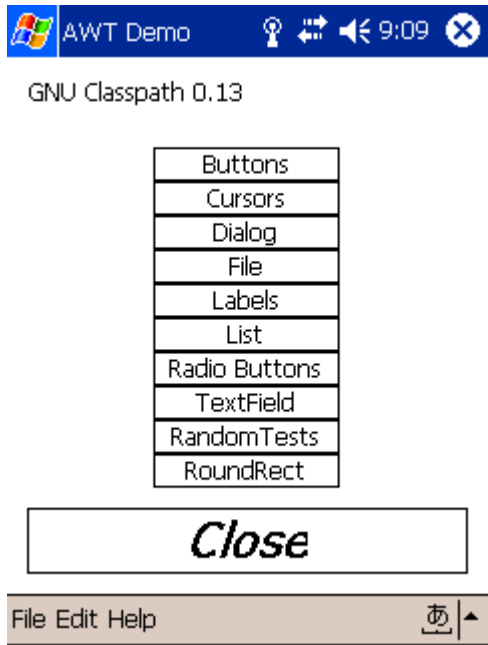
- 建構於 .Net 的 Java environment
  - 同時運作於 Mono 與 Microsoft .NET
- bytecode to CIL translation
  - Bytecode => parse trees => CIL instructions
  - dynamic interpretation at runime
  - compiler (Jar -> .NET Assembly)

JNode

- 以 Java 撰寫的作業系統
- 只有一小部份的 x86/IA64 Assembly 與 Java ，並提供 Java 撰寫的 JIT-compiler
- 提供以 Java 撰寫的 Disk controller driver 、 Graphics driver 、 Keyboard driver 、 NIC driver 、 Input device driver ，以及 USB driver

Mysaifu JVM

- 以 GNU Classpath 爲基礎的 JVM ，運作於 Windows Mobile 2003 (PocketPC 2003)
- 作爲一個 Java SE 的實現
- 支援 AWT/Swing



如何建構 cleanroom JavaVM ？

- Why Free Java?
- 目前 Free Java Runtimes 概況
- 如何建構 cleanroom JavaVM ？
  - "cleanroom" 定義
  - 如何進行相容性測試
  - VM 概況
- Case Study
- 展示

"Cleanroom" 定義

- Cleanroom
  - 讓開發者只由公開文件或程式庫的文件中，獲悉規格，但過程中不得涉及標準實做的原始程式，之後再重新實做，這樣確保相容性與合法性。
  - BSD 與 AT&T 的 UNIX 訴訟就是以 cleanroom 手法擺脫著作權
- 1996 年 Tim Wilkinson 以 BSD-like license 釋出 Kaffe ，這是第一個 Free Java / Cleanroom 實做。

如何進行相容性測試？

- Why not Sun TCK (Technology Compatibility Kit)?

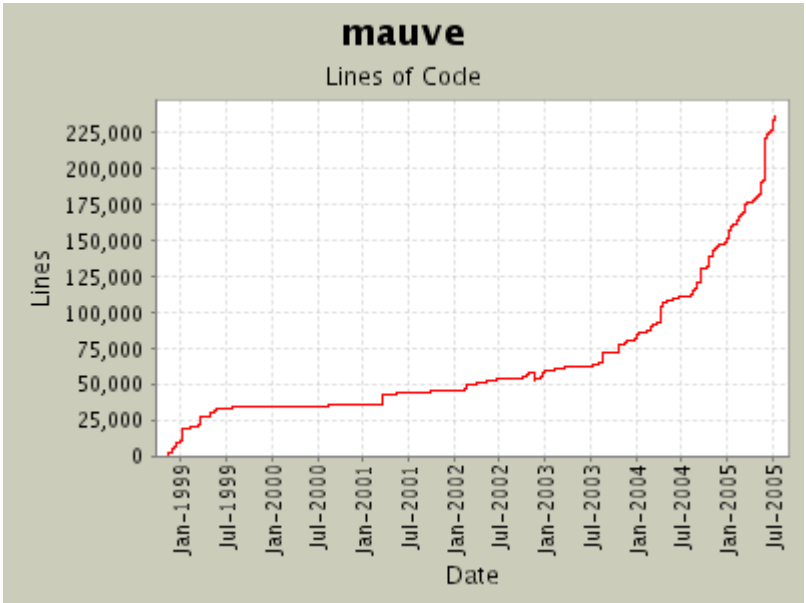
> *ATTACHMENT E TECHNOLOGY COMPATIBILITY KIT, 1. TCK License.:*
>
> *b) TCK Use Restrictions. You are not authorized to create derivative works of the TCK or use the TCK to test any implementation of the Specification that is not Covered Code.* ***You may not publish your test results*** *or make claims of comparative compatibility with respect to other implementations of the Specification. In consideration for the license grant in Section 1.a above* ***you agree not to develop your own tests*** *which are intended to validate conformation with the Specification.*

- 一旦同意 TCK License...
  - 不得公開測試結果
  - 不得發展額外的 test cases
  - 不得發展造成與規格不相容的 code / extensions

如何進行相容性測試？ (2)

- Mauve
  - free test suite (GNU GPL)
  - 超過 175000 個測試案例
  - 已可與 IBM Jikes 計畫的 Jacks compiler suite 交互運作

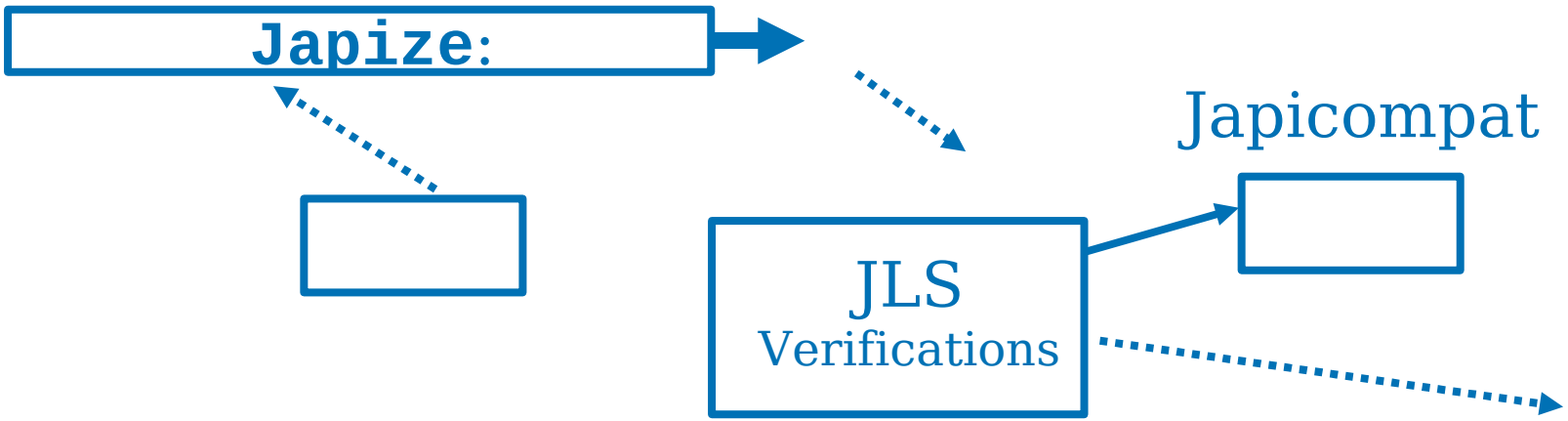
http://sources.redhat.com/mauve/



- Apache Gump
  - 整合性測試
  - 可自動載入軟體測試項目、編譯，然後進行測試
  - 約有 800 個套件 (Jakarta 計畫)

如何進行相容性測試？ (3)

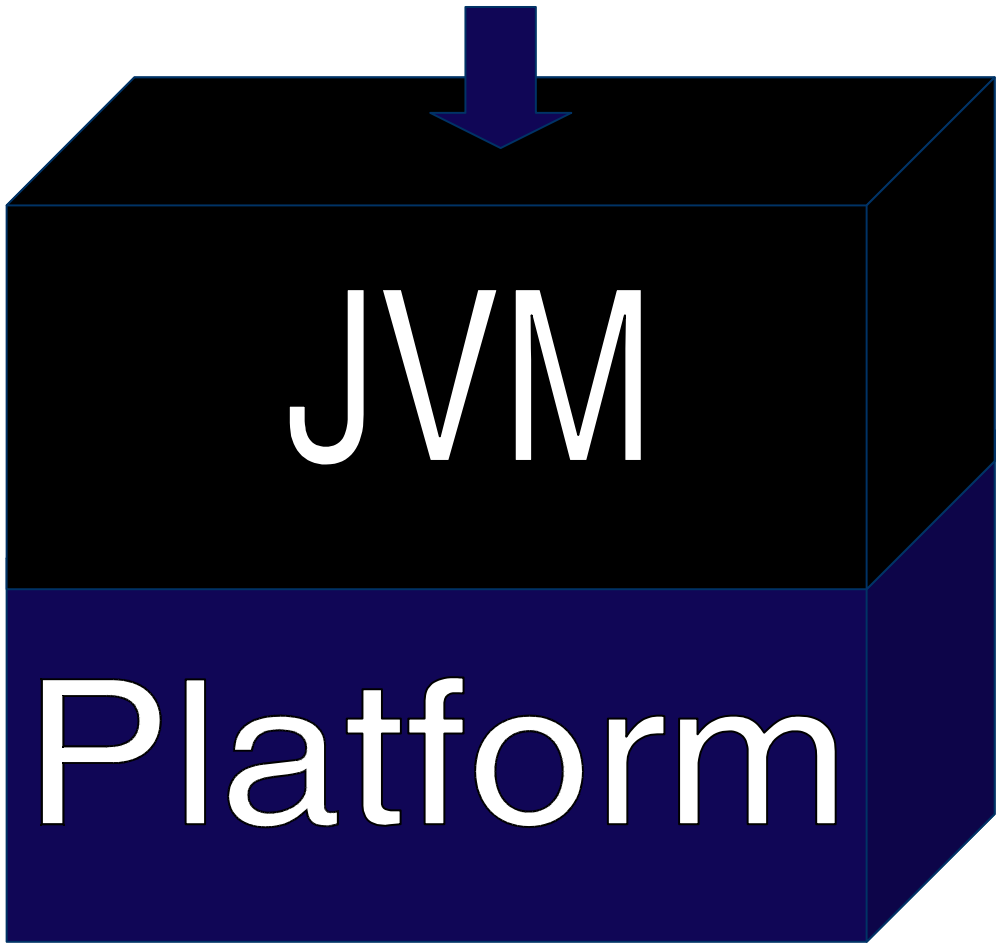
- japitools
  - 驗證 binary compatibility
  - 運作模式
    - 以 Java 撰寫的 Japize 發出一系列 API Listing 的要求
    - 另一隻程式 Japicompat 稍後以 JLS (Java Language Specification) 規範的行爲與該回應比較



JavaVM 概況

- JVM 架構
  - 外在觀點
  - 內在觀點
  - 動態觀點
- Execution Engine
- Interpreted code & JIT compiler

JVM 架構：外在觀點

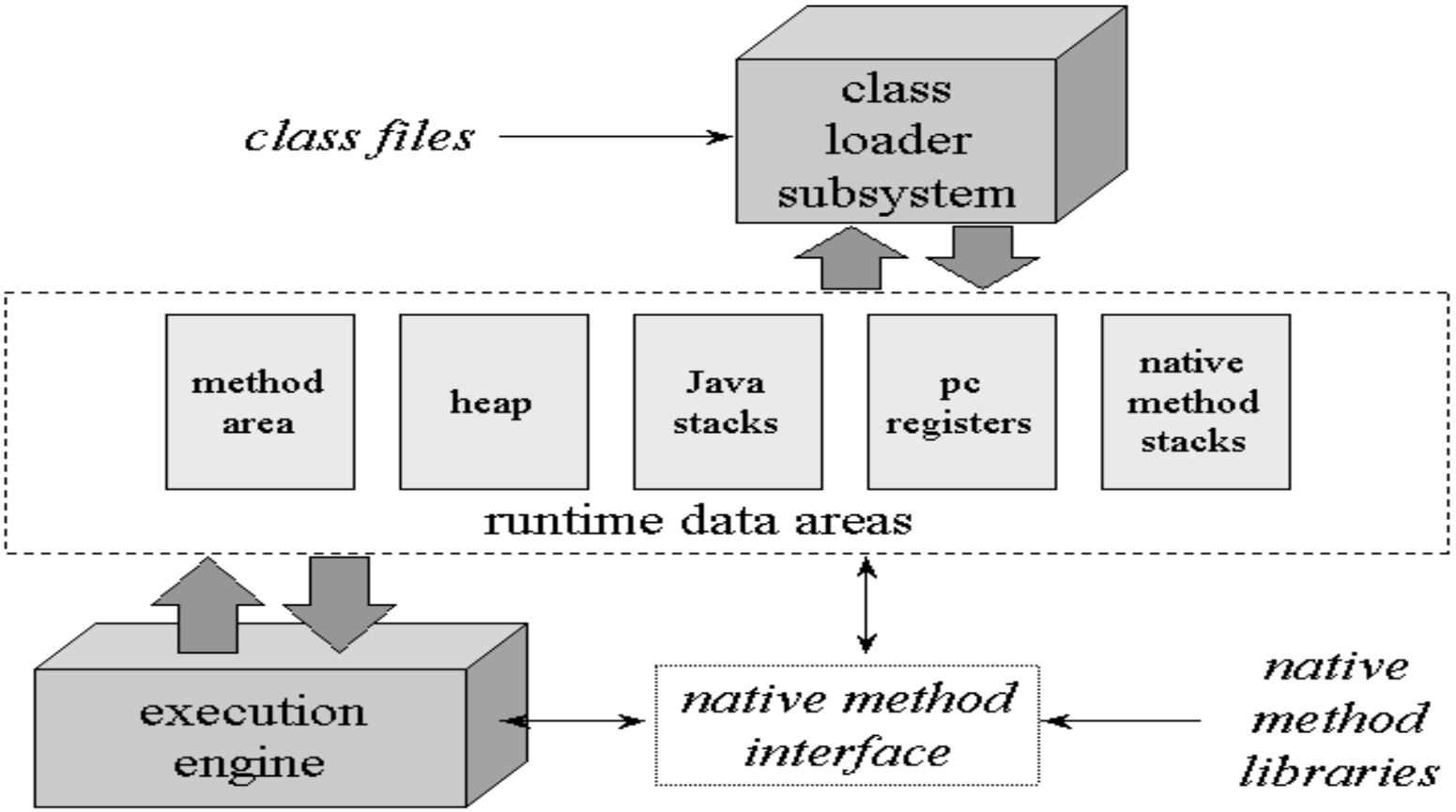


$ javac Greetings.java
產生 Greetings.class 檔

$ java Greetings ”Hello Class”
呼喚 JVM 實做

Hello Class
$
作業系統顯示訊息到終端機

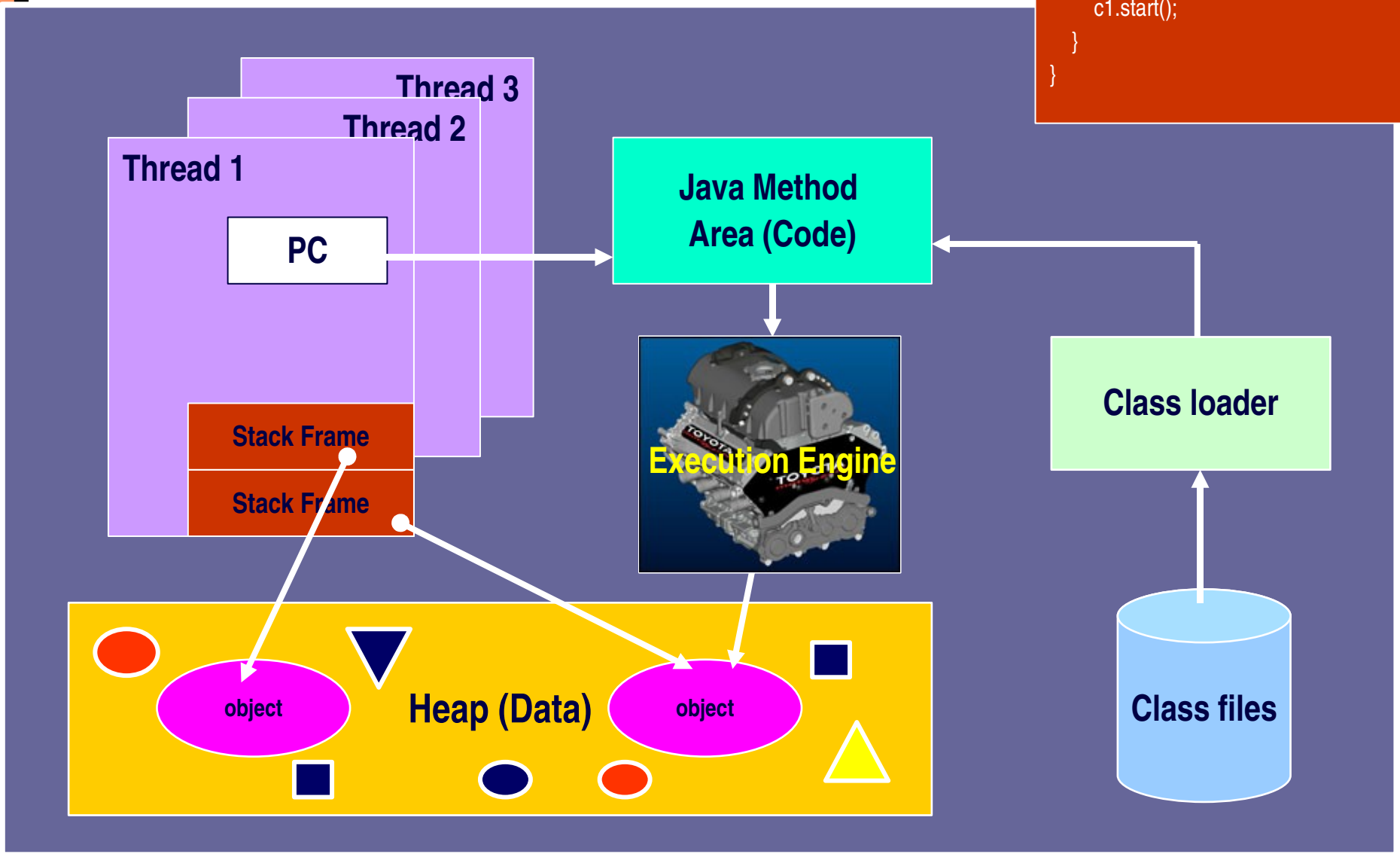
JVM 架構：內在結構


class files
class loader subsystem
method area
heap
Java stacks
pc registers
native method stacks
runtime data areas
execution engine
native method interface
native method libraries

JVM 架構：動態觀點

A Multithreaded Java Program

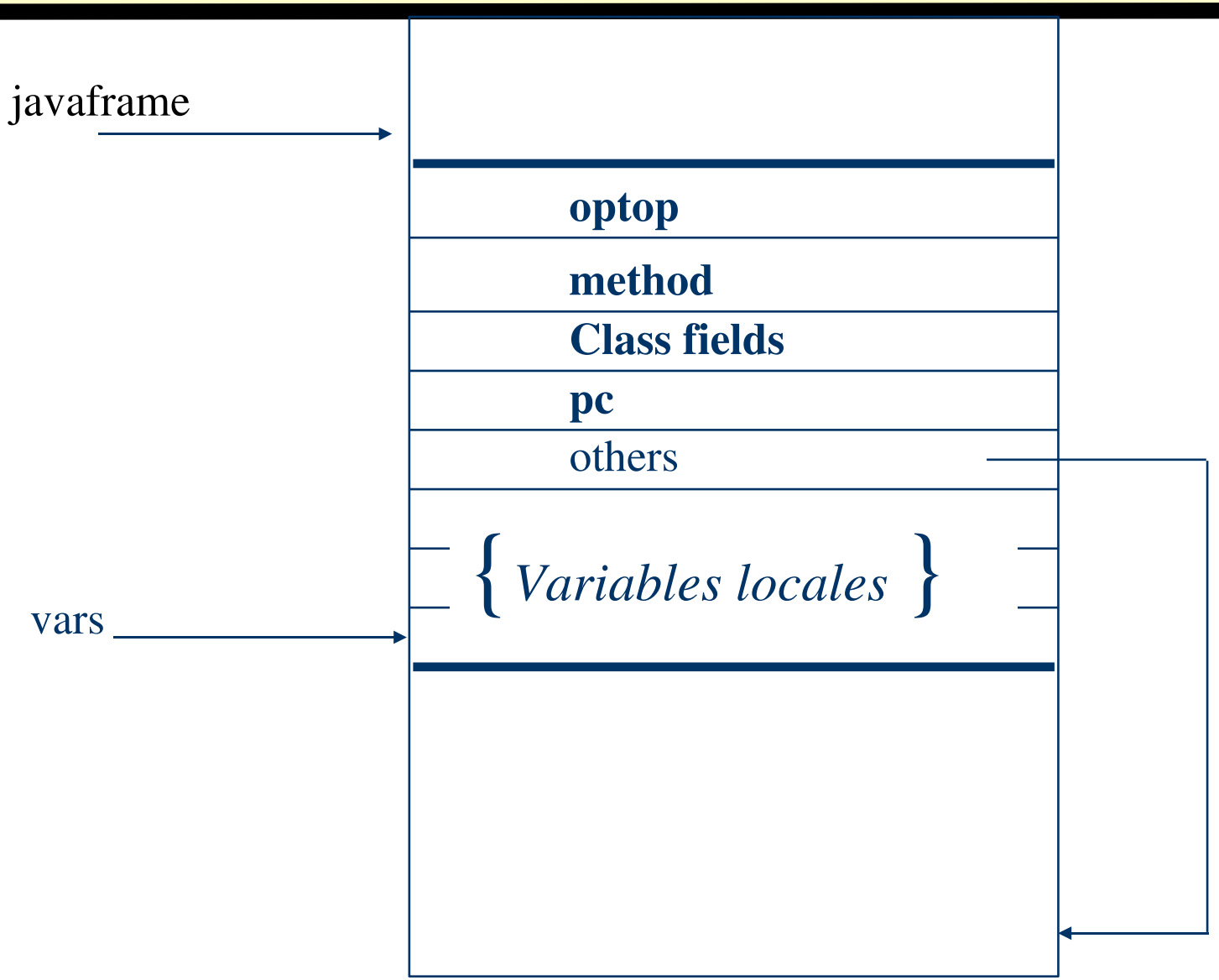
```
public class ProducerConsumerTest {
    public static void main(String[] args) {
        CubbyHole c = new CubbyHole();
        Producer p1 = new Producer(c, 1);
        Consumer c1 = new Consumer(c, 1);

        p1.start();
        c1.start();
    }
}
```



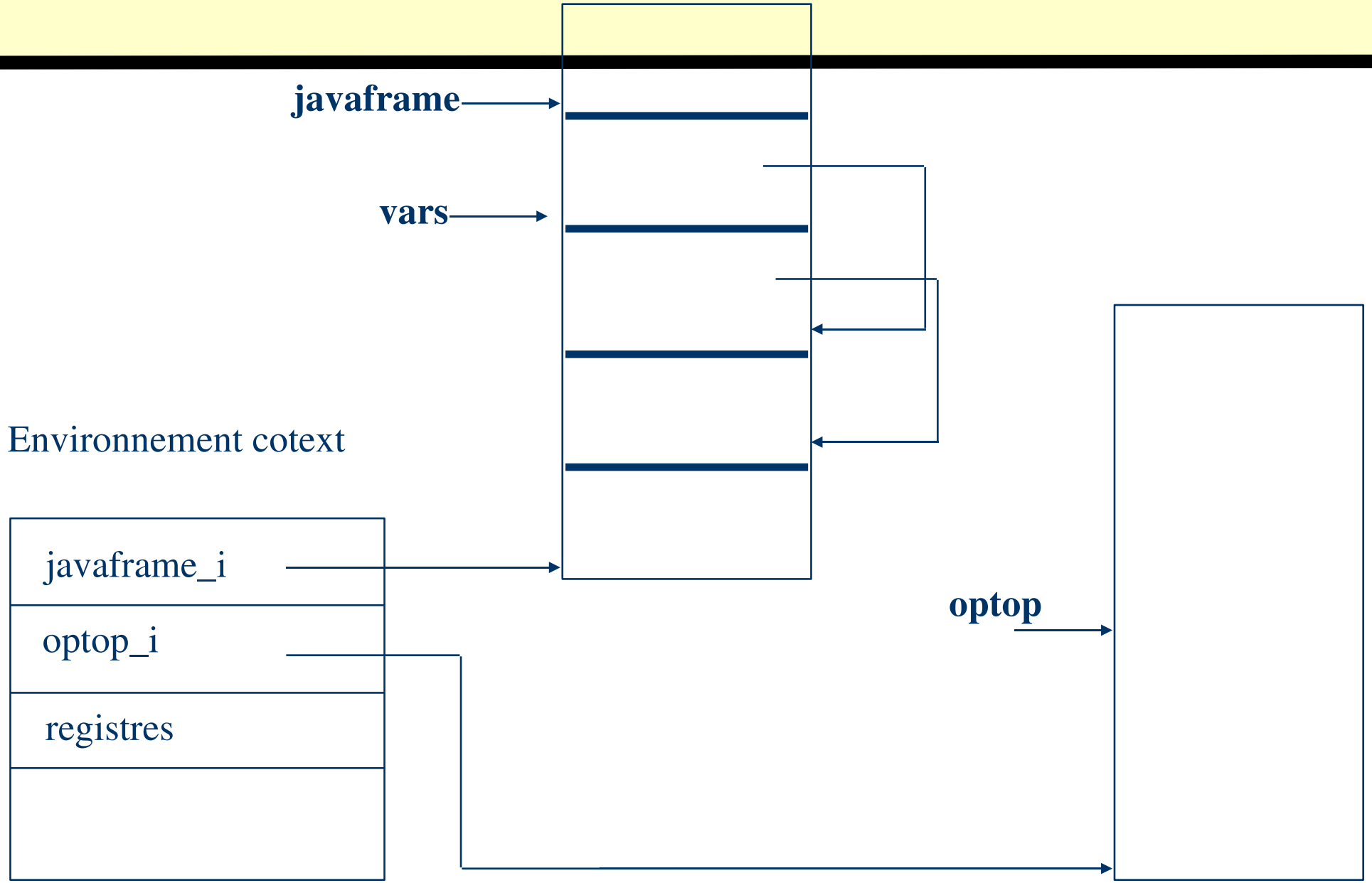
執行引擎

- 執行引擎就是 Java VM 的核心
- 邏輯上切割"frame"以保存 *local variables* 與 *operand stack*（編譯時期就決定型態）
- 指令集
  - **Load/store** between locals and operand stack
  - **Arithmetic** on operand stack
  - **Object creation** and **method invocation**
  - **Array/field** accesses
  - Control transfers and exceptions
- 執行引擎可被視爲以下三種層面：
  - Abstract specification
  - Concrete implementation
  - Run-time instance

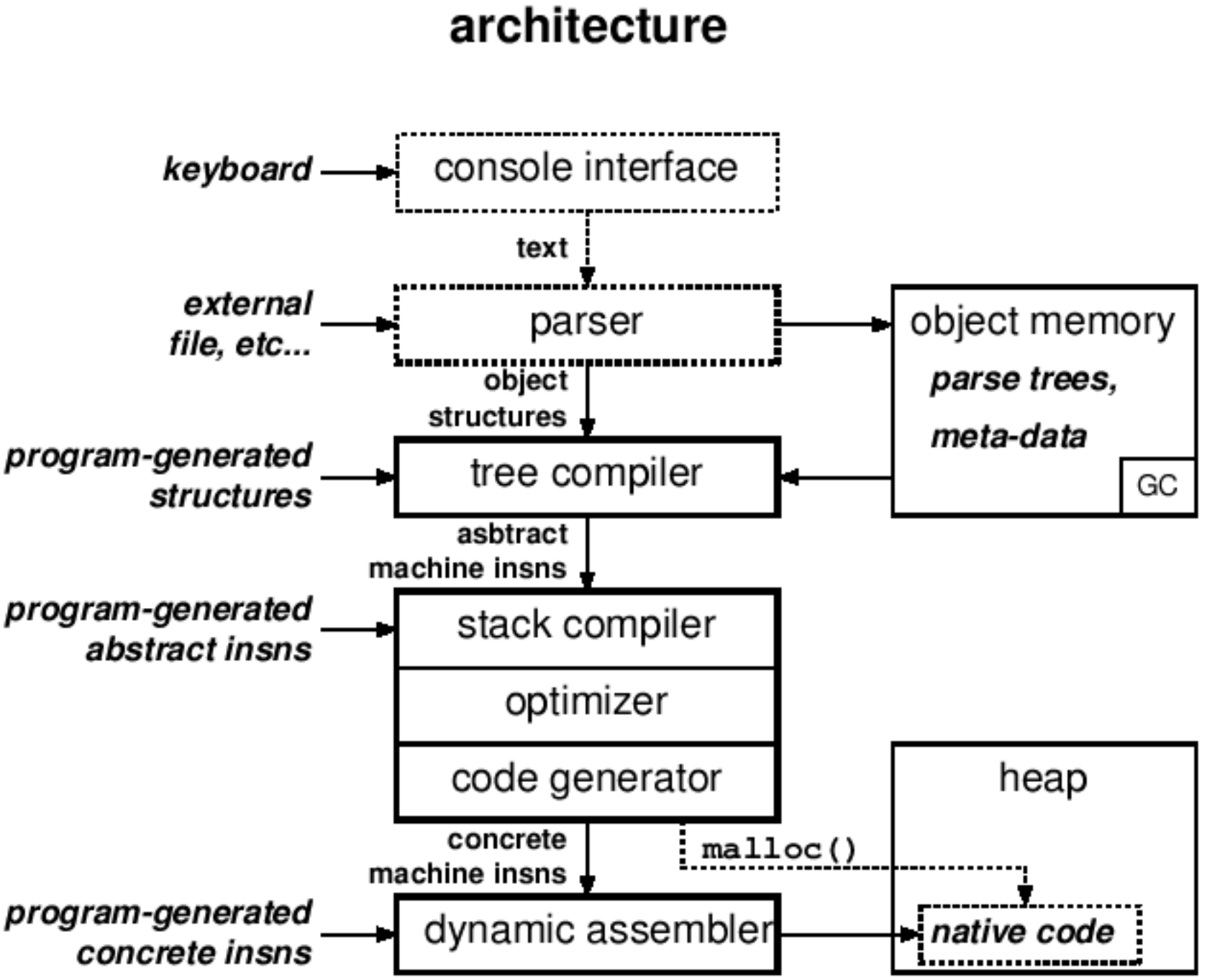
Segment


javaframe
optop
method
Class fields
pc
others
{ Variables locales }
vars

Environnement Execution

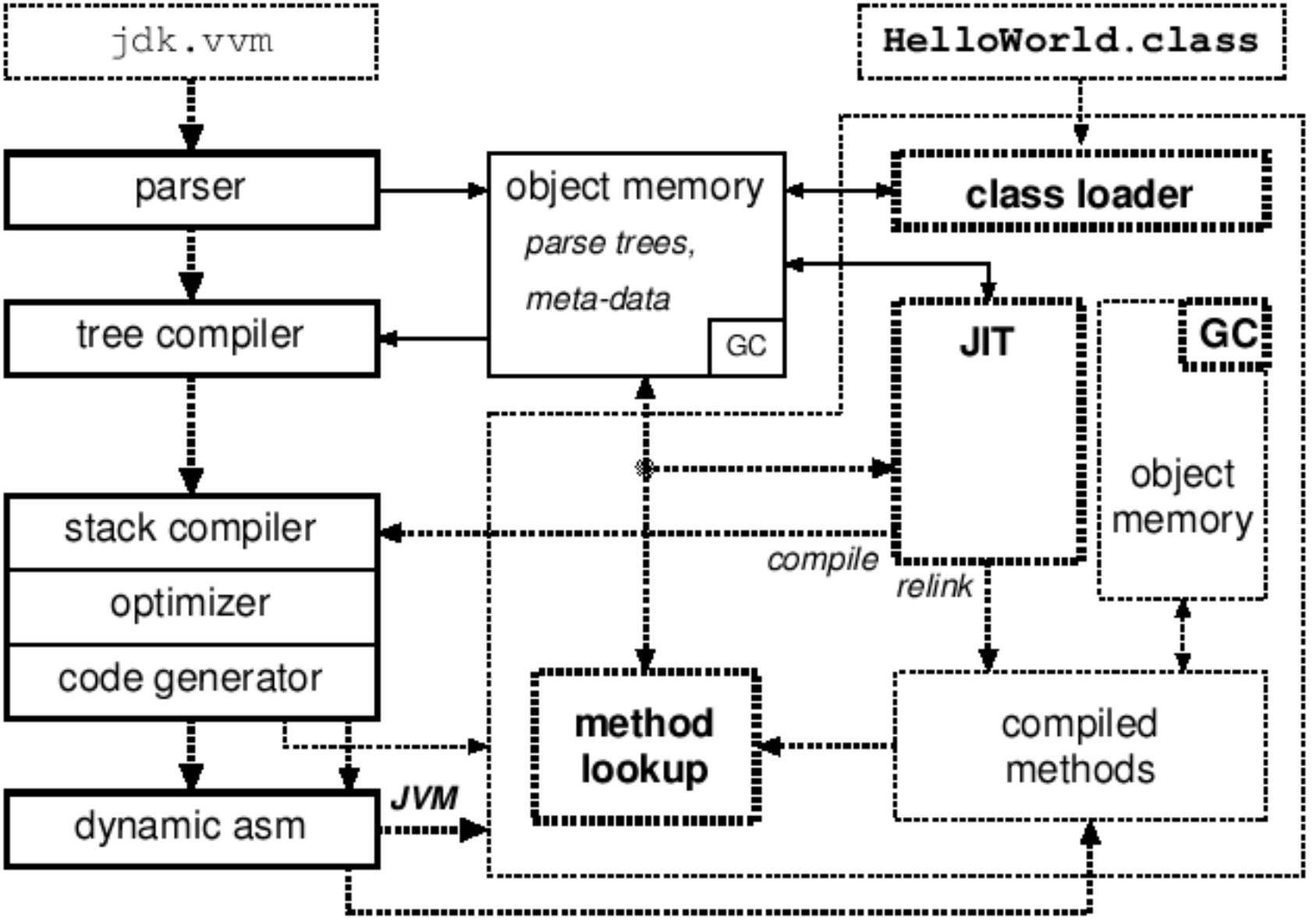


一般化的 VM / Dynamic compiler 設計



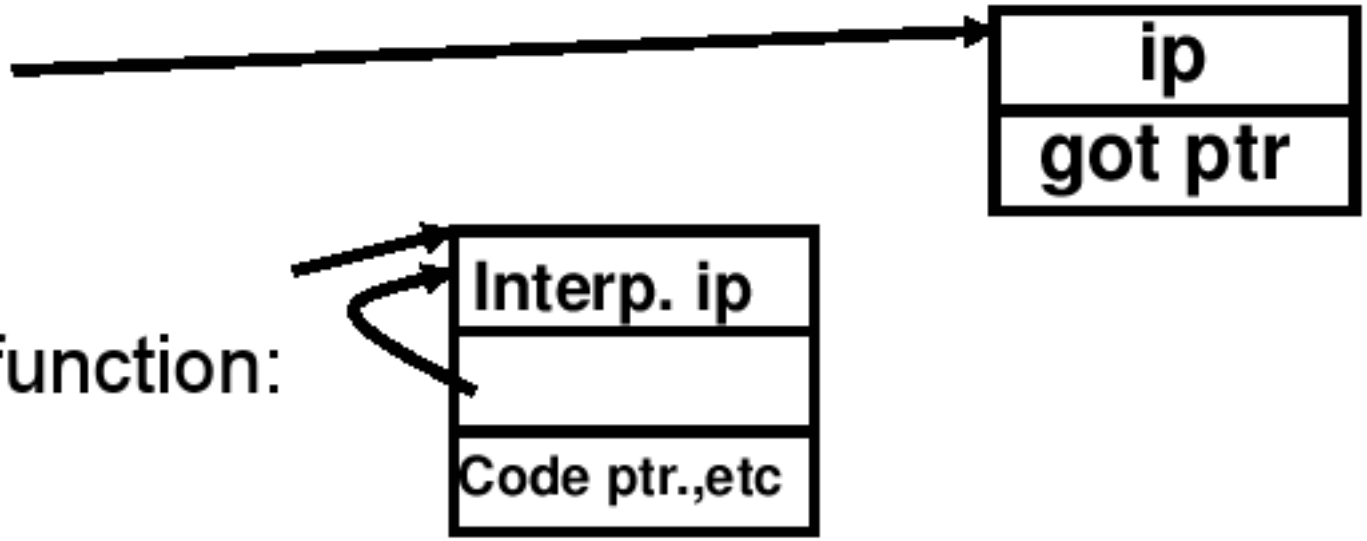
JVM 特化的結構，強化 ..

- .ClassLoader
- JIT feedback
- Method Lookup



Interpreted Code 展現

- 考慮到 JIT(Just-In-Time) Compiler 整合的議題
- GCJ 與 Kaffe-GCJ bridge 將已經 interpreted code 視同 compiled C functions ，並透過 libffi（GNU GCC 的一部分）處理平台相關的 calling conventions 。
- 邏輯上來看：
  - C function:
  - Interpreted function:



Case Study

- Why Free Java?
- 目前 Free Java Runtimes 概況
- 如何建構 cleanroom JavaVM ？
- Case Study
  - Kaffe
  - GCJ (GNU Compiler for Java)
- 展示

Kaffe 概況

- GNU GPL 授權，爲許多研究計畫採用
- 眾多平台移植
- 眾多分支
  - KaffeOS
  - JESSICA2
  - LaTTe
- 多種 AWT backend
- 成功案例
- KOE (Kaffe-based Operating Environment)

Kaffe 多平台移植

Processors

- X86
  - IA32
  - IA64
- ARM
  - StrongARM
  - Xscale
- MIPS
- PowerPC

Processors

- Sparc
- m68k
- S390
- Alpha
- Pseudo Platform

Operating Systems

GNU/Linux, **GNU/Hurd**

BSDs

FreeBSD, **NetBSD**, **OpenBSD**, **Darwin/Mac OS X**

Proprietary Unixes

NeXTStep, **Solaris**, **SunOS**, **IRIX**, **AIX**, etc.

Microsoft OSes

Windows/Cygwin, **Windows CE** (KaffeCE), **DOS**

Embedded OSes / RTOSes:

eCOS, **VxWorks**, **pSOS**, **ThreadX**, **SMX**, **Nucleus**, **RTEMS**

Research OSes: **KaffeOS / OSKit / L4**

Other OSes

AtheOS, **BeOS**, **AmigaOS**, **MiNT**, **Plan9**

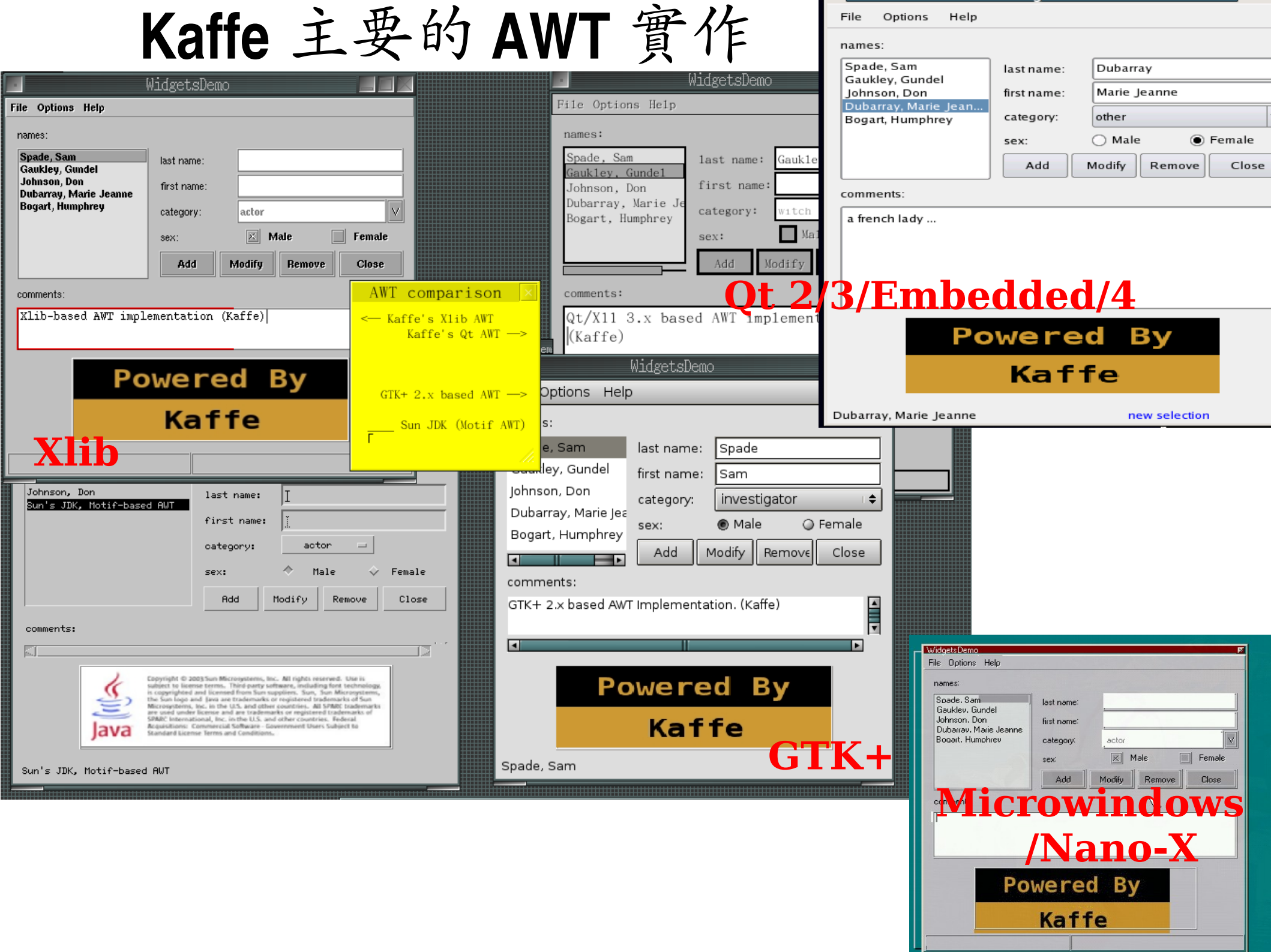
Kaffe 支援多種 AWT backends

- 主要的 AWT backends（可動態切換）
  - Xlib
    - I18n Ready
  - Qt
    - Qt/X11 2.x/3.x
    - Qt/Embedded 2.x/3.x 與 Qtopia
    - Qt4
  - GTK+ 2 based
  - Nano-X / MicroWindows
- Win32
- BeOS (BeKaffe)
- DirectFB
- VNC/SDL/pure X11/Framebuffer (Odonata)

Kaffe 的 peerful & peerless AWT

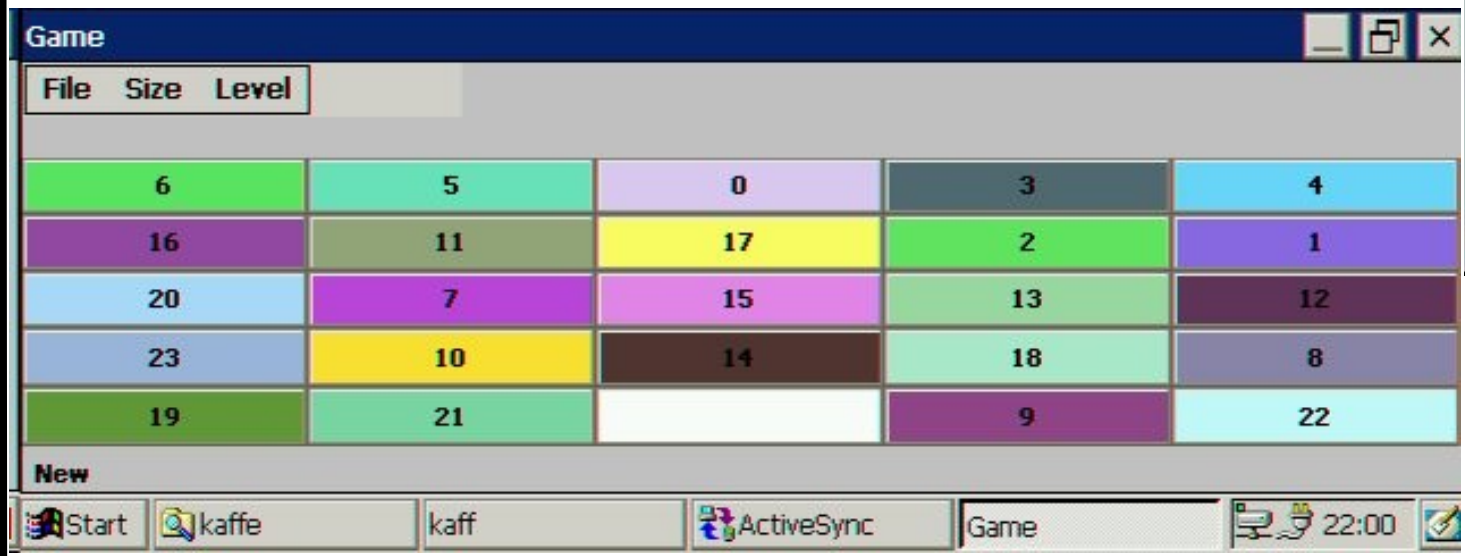
- Peerful
  - •GTK+ 2.x (GNU Classpath)
  - •Qt4（發展中）
- Peerless
  - •取自 Swing 的 “ pluggable L&F” 的概念
  - •支援 PersonalJava
  - •直接在 peerless AWT 實作
    - 高效率
    - 節省資源
    - 眾多變化

Kaffe 主要的 AWT 實作

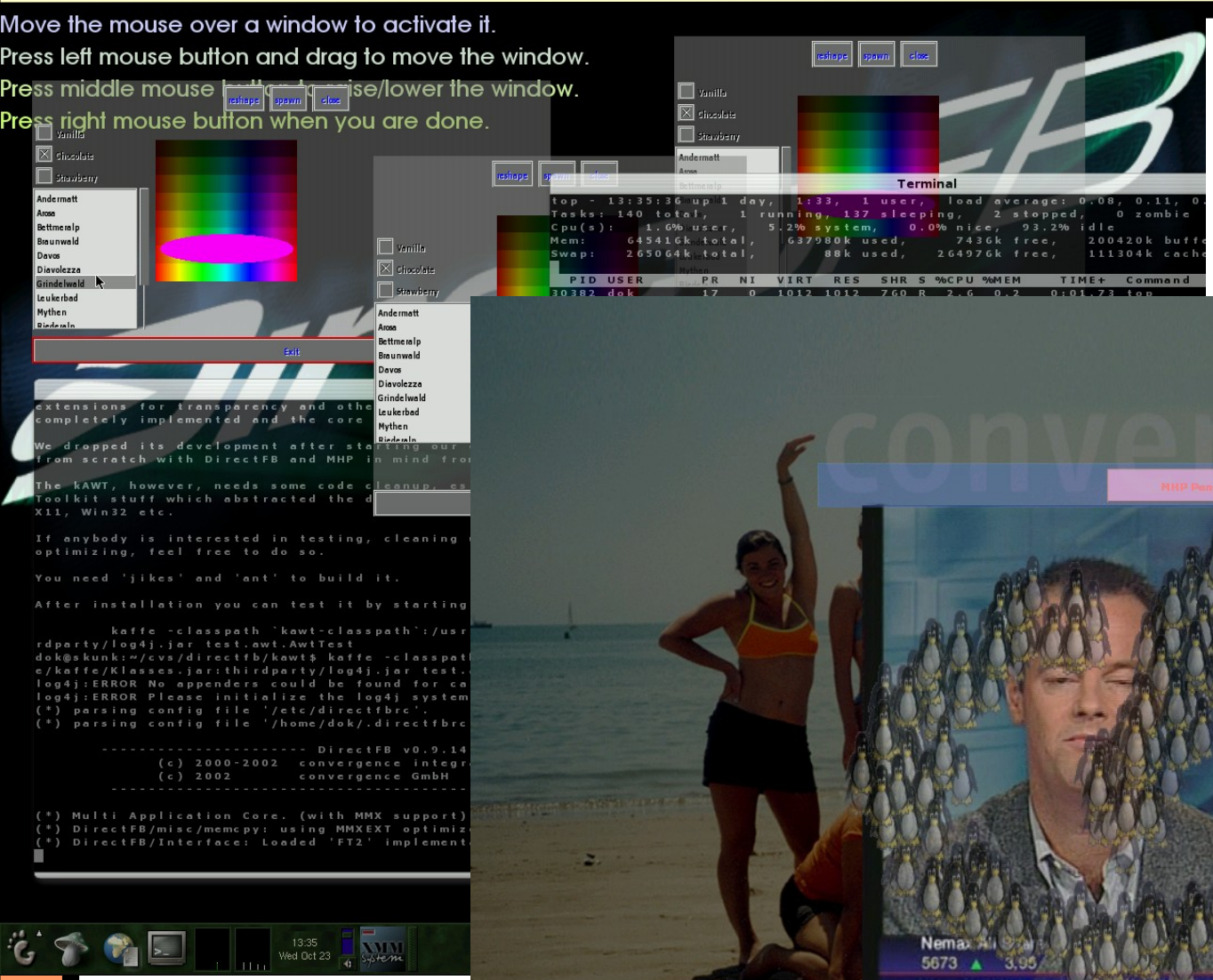


KaffeCE

- KaffeCE 以 Kaffe 1.0.5 爲基礎
  - 支援 Win32 與 WinCE
    - PersonalJava

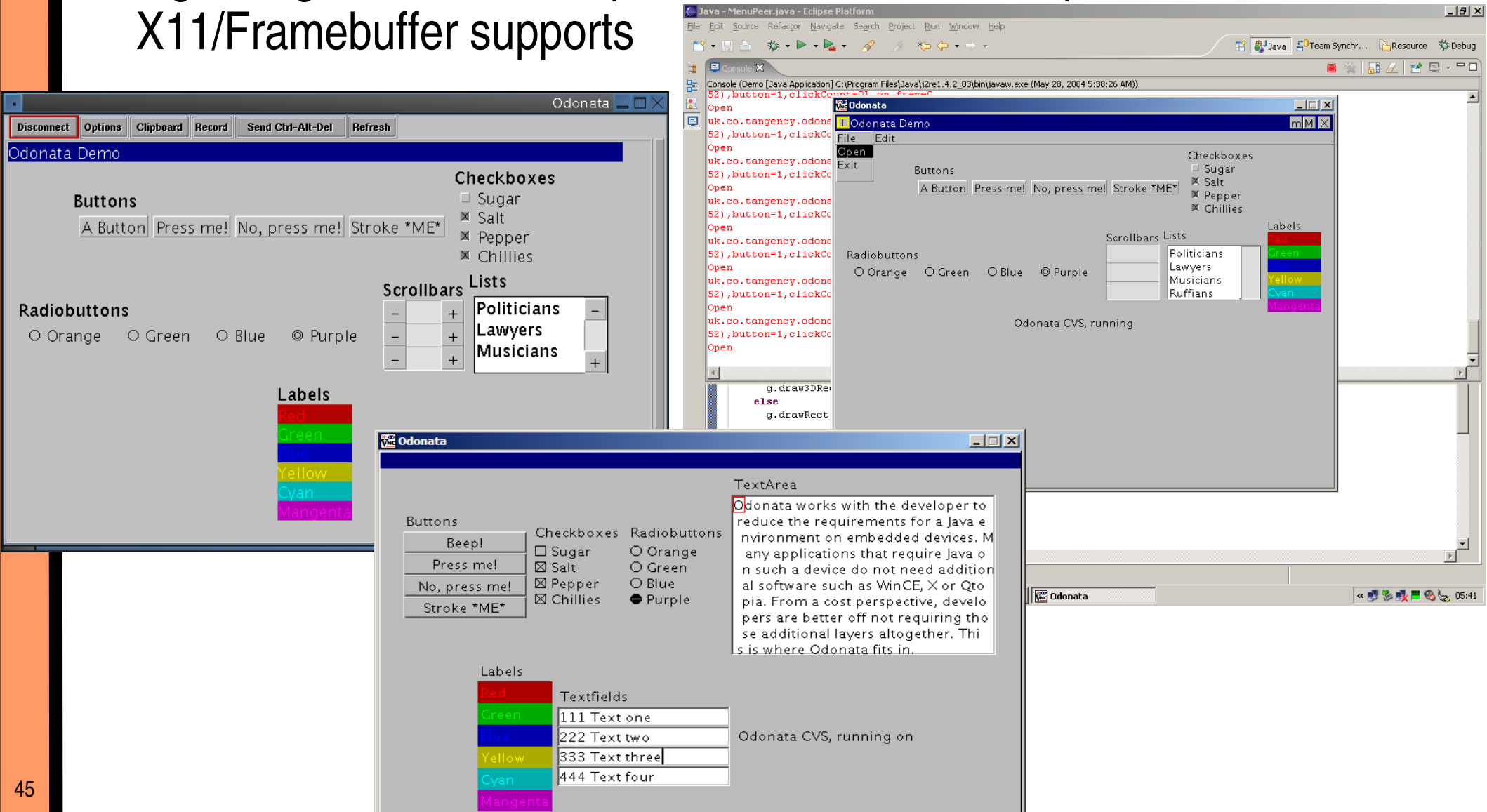


kawt : DirectFB AWT backend



Odonata

- Lightweight AWT Toolkit provider with VNC/SDL/pure X11/Framebuffer supports

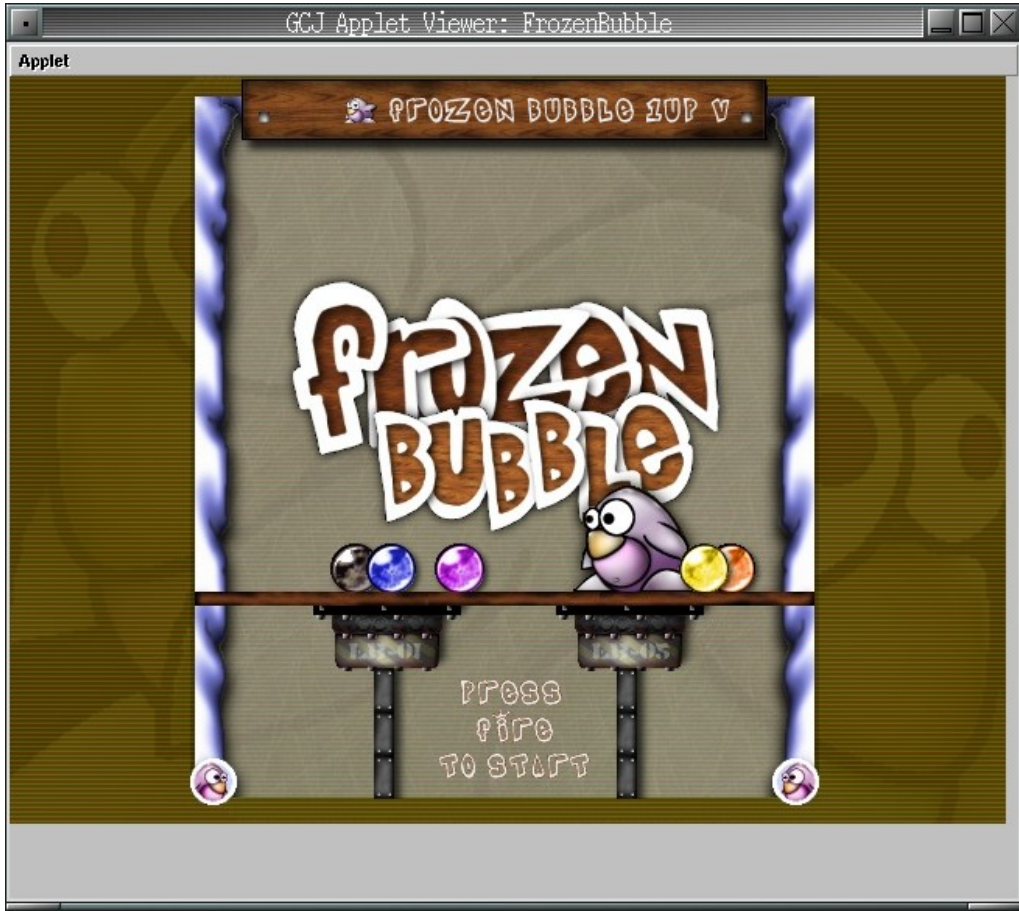


Kaffe 成功案例

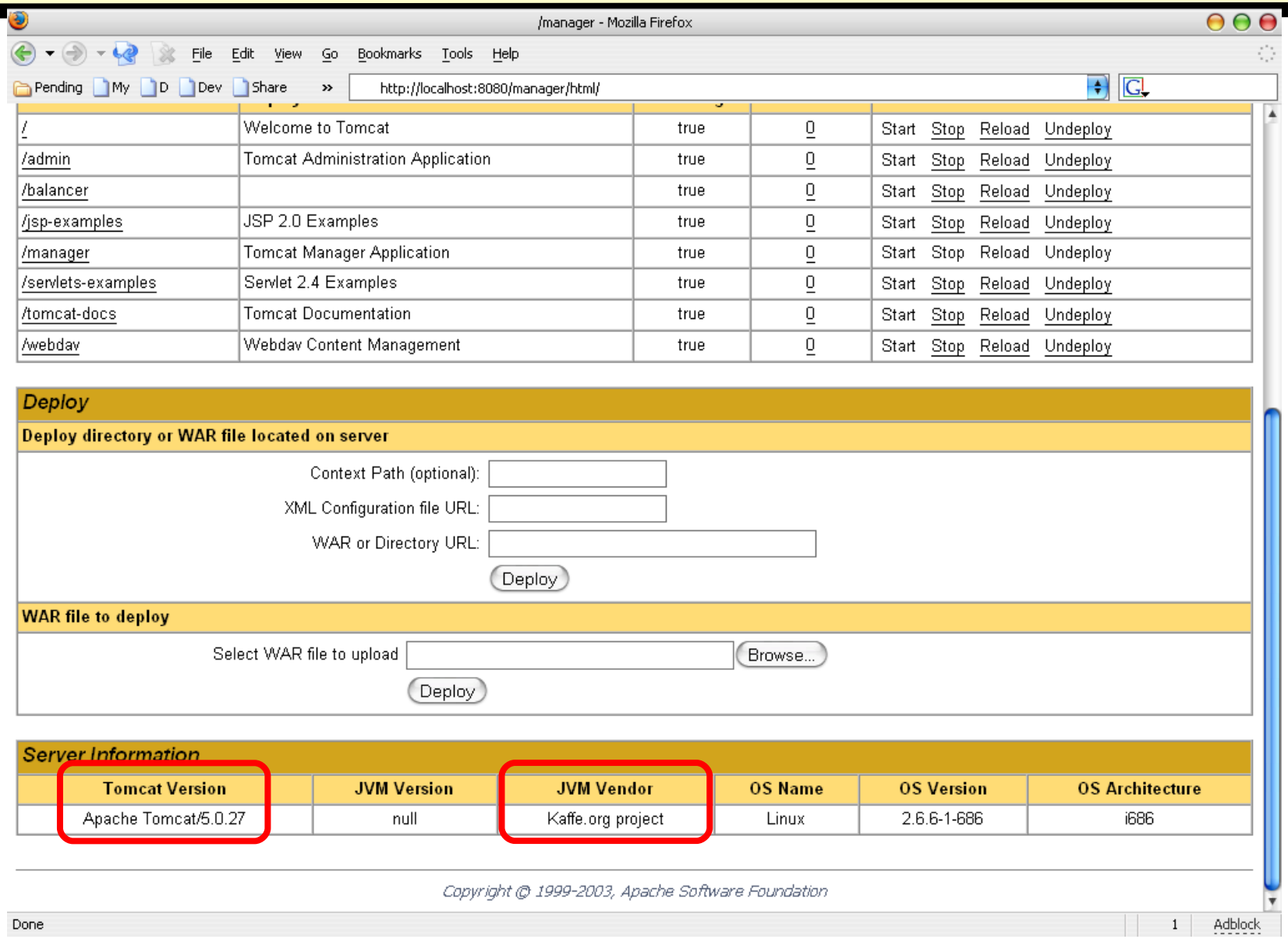
- GCJWebPlugin
- Tomcat/JBoss
- Eclipse
- SwingWT
- OpenGL/SDL
- SMIL/JavaTV
- JMP
- Escher (pure Java X11 Implementation)

GCJWebPlugin

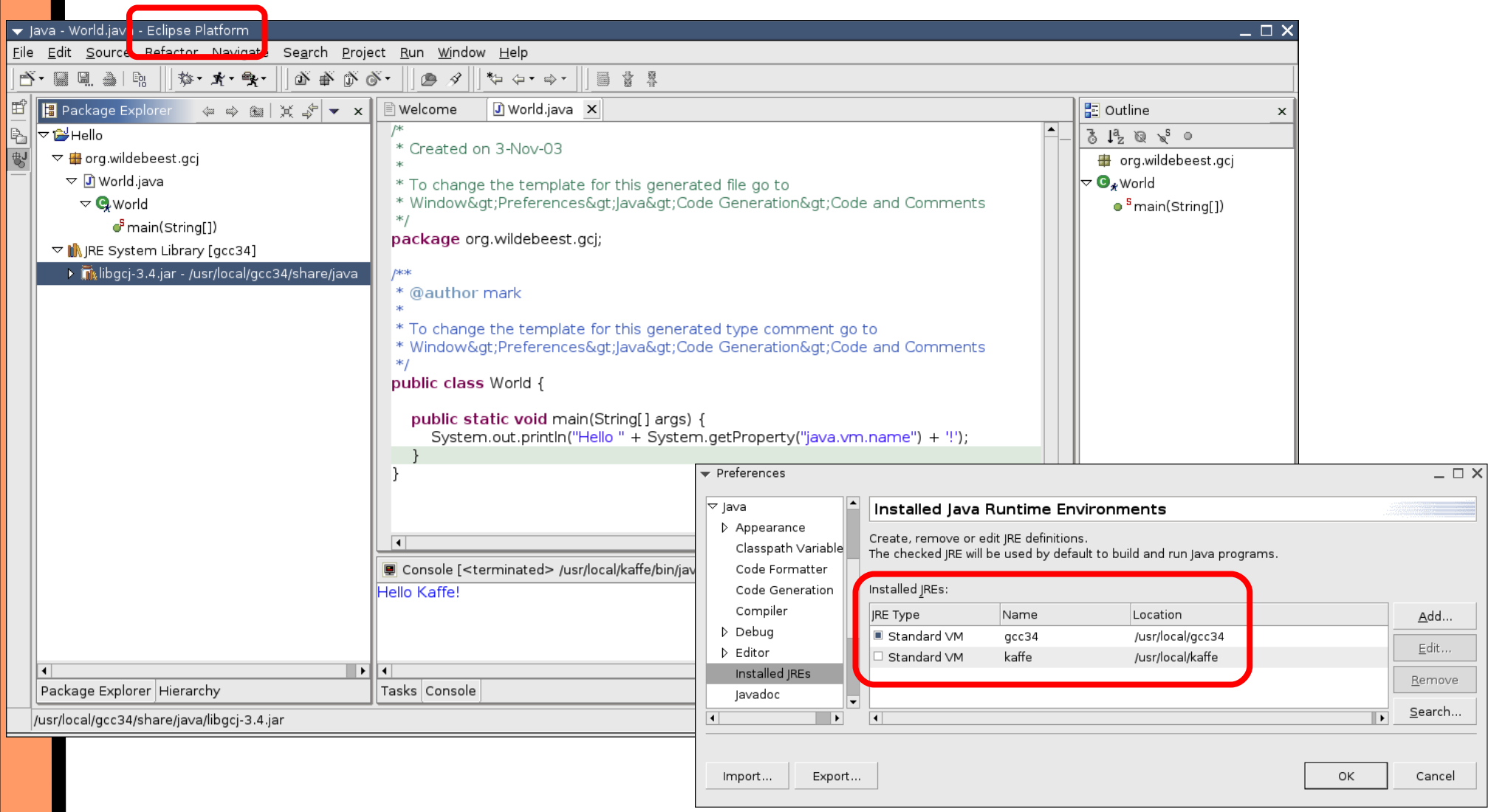
- GCJWebPlugin 目標是建立 Free/Open-Source Java Browser Plugin 解決方案
- 一開始只支援 GCJ ，0.3.0 版之後加入對其他 GNU Classpath 爲基礎 JavaVM 實作的支援
  - Kaffe
  - JamVM



Tomcat 5 + Kaffe

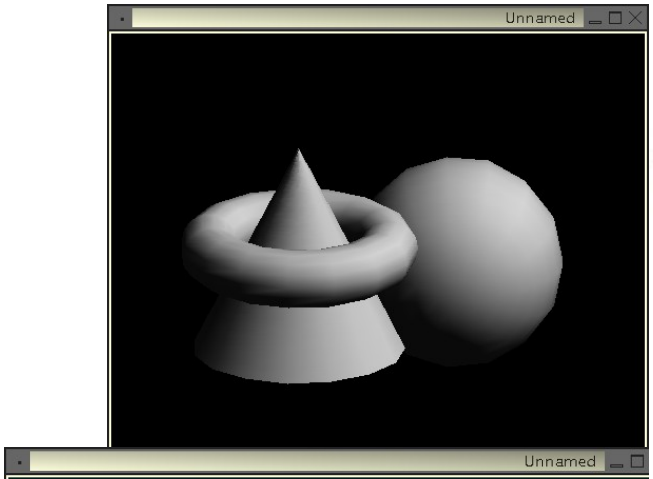


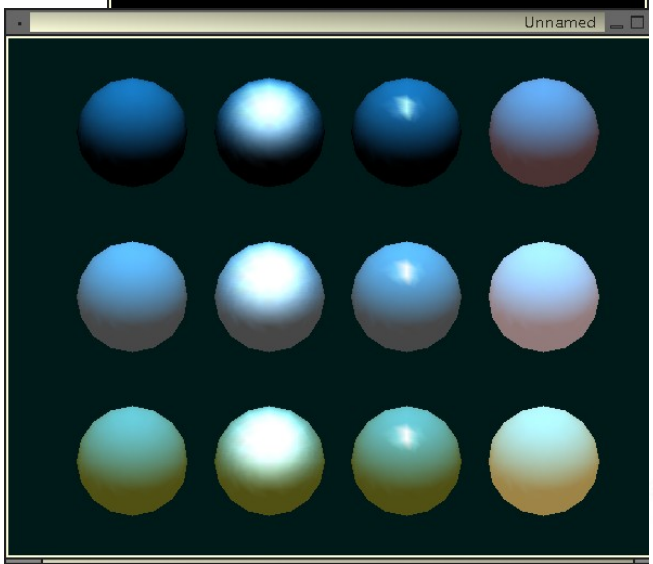
Eclipse on Kaffe

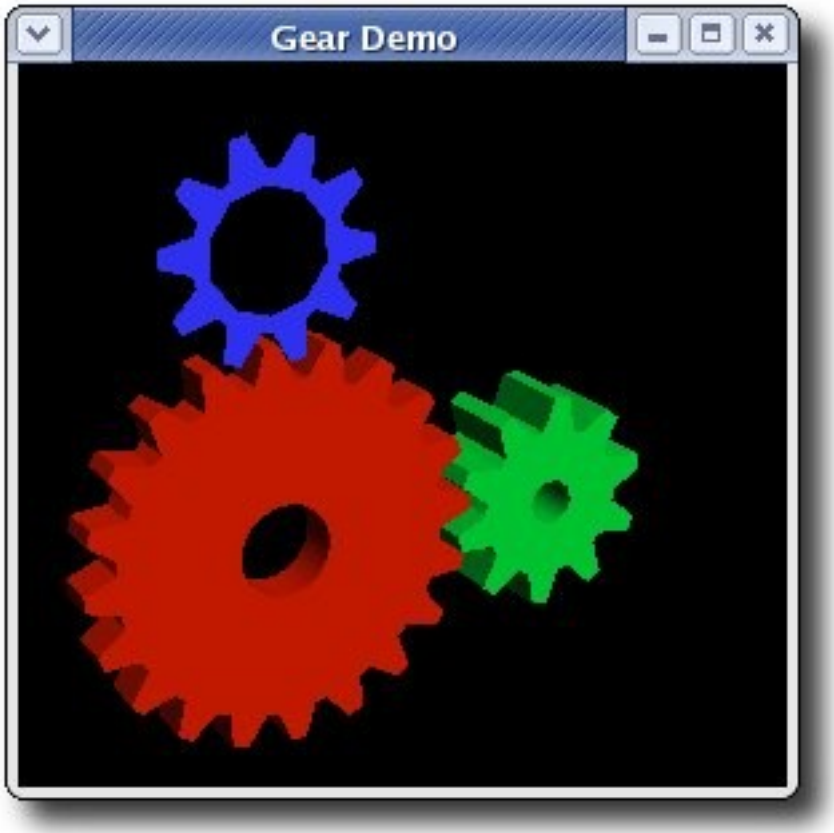


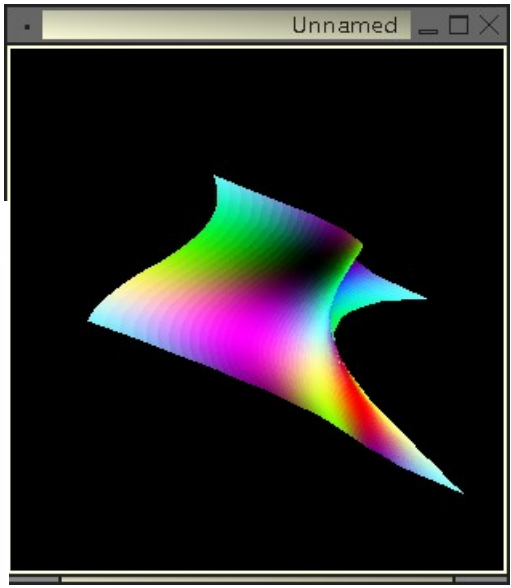
Kaffe 的 OpenGL/SDL 支援

- 2005 年二月份開始支援 jawt (Java Native Interface) ，開始能運作 JoGL (Java on GL) 與 SDLJava 兩項專案

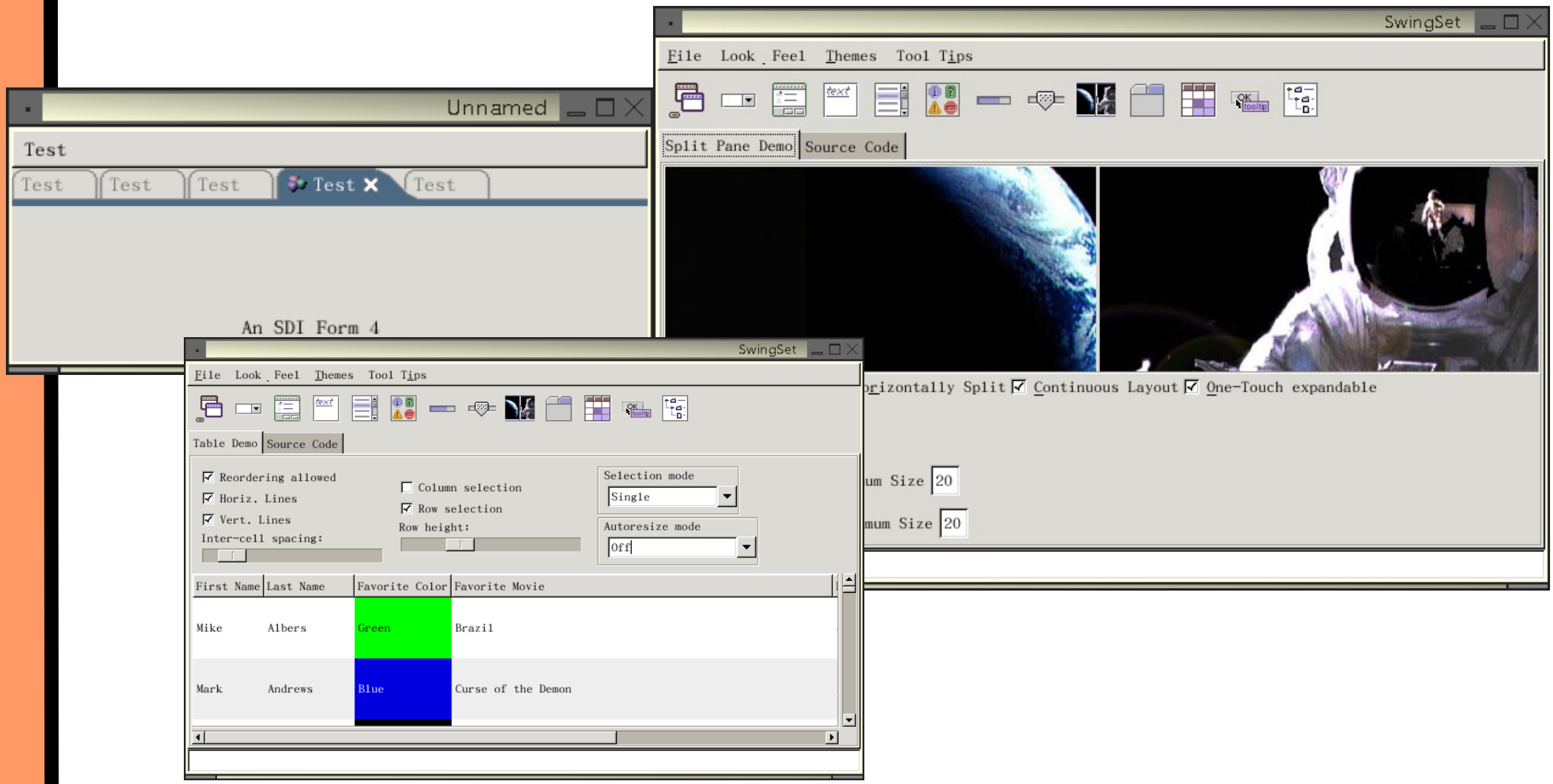




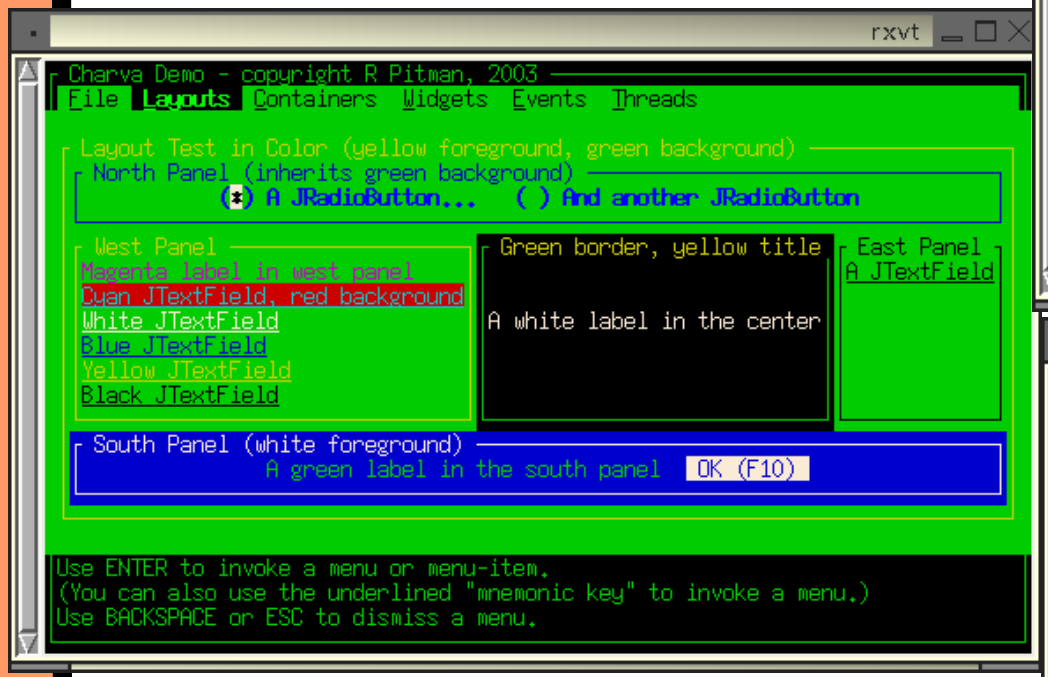


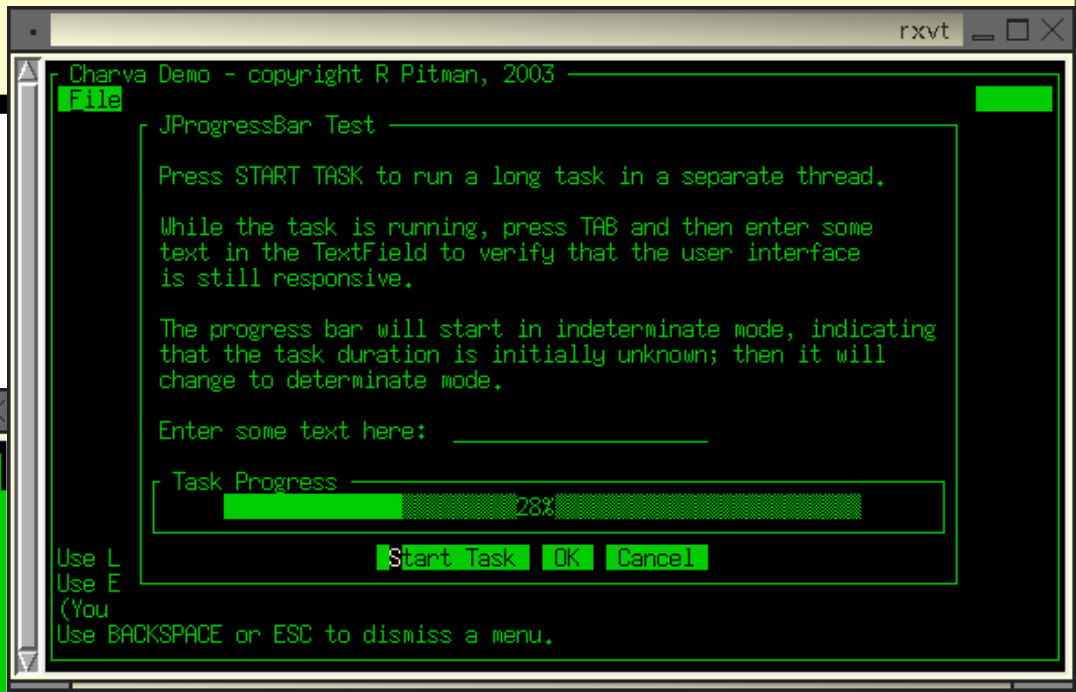


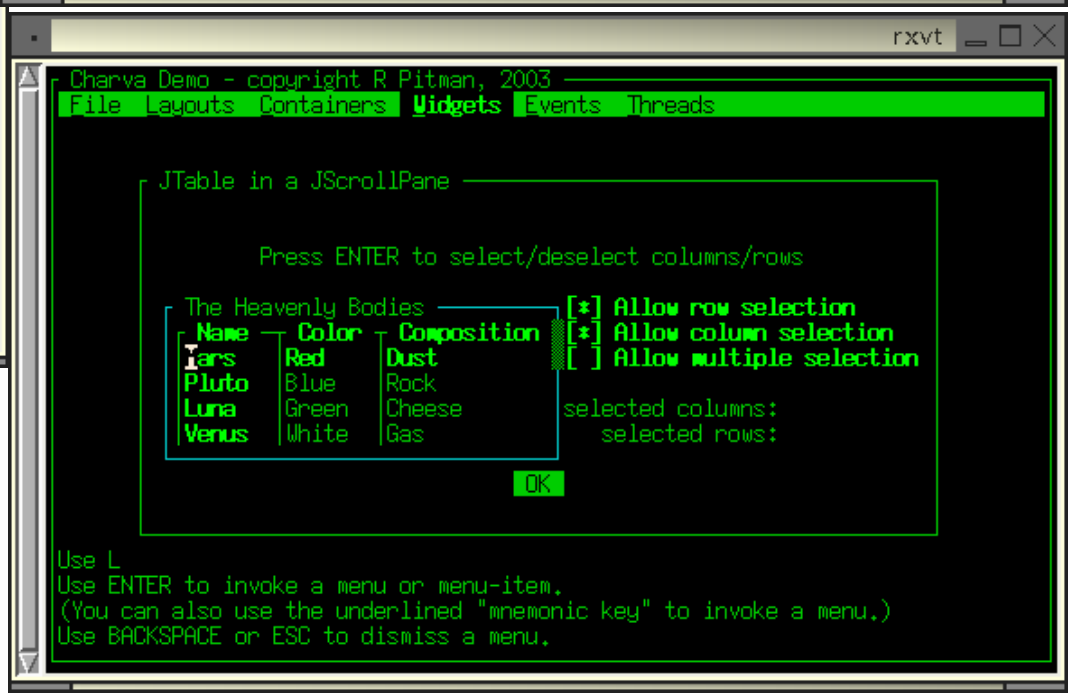
Kaffe + SwingWT (Swing over SWT)



Kaffe + Charva



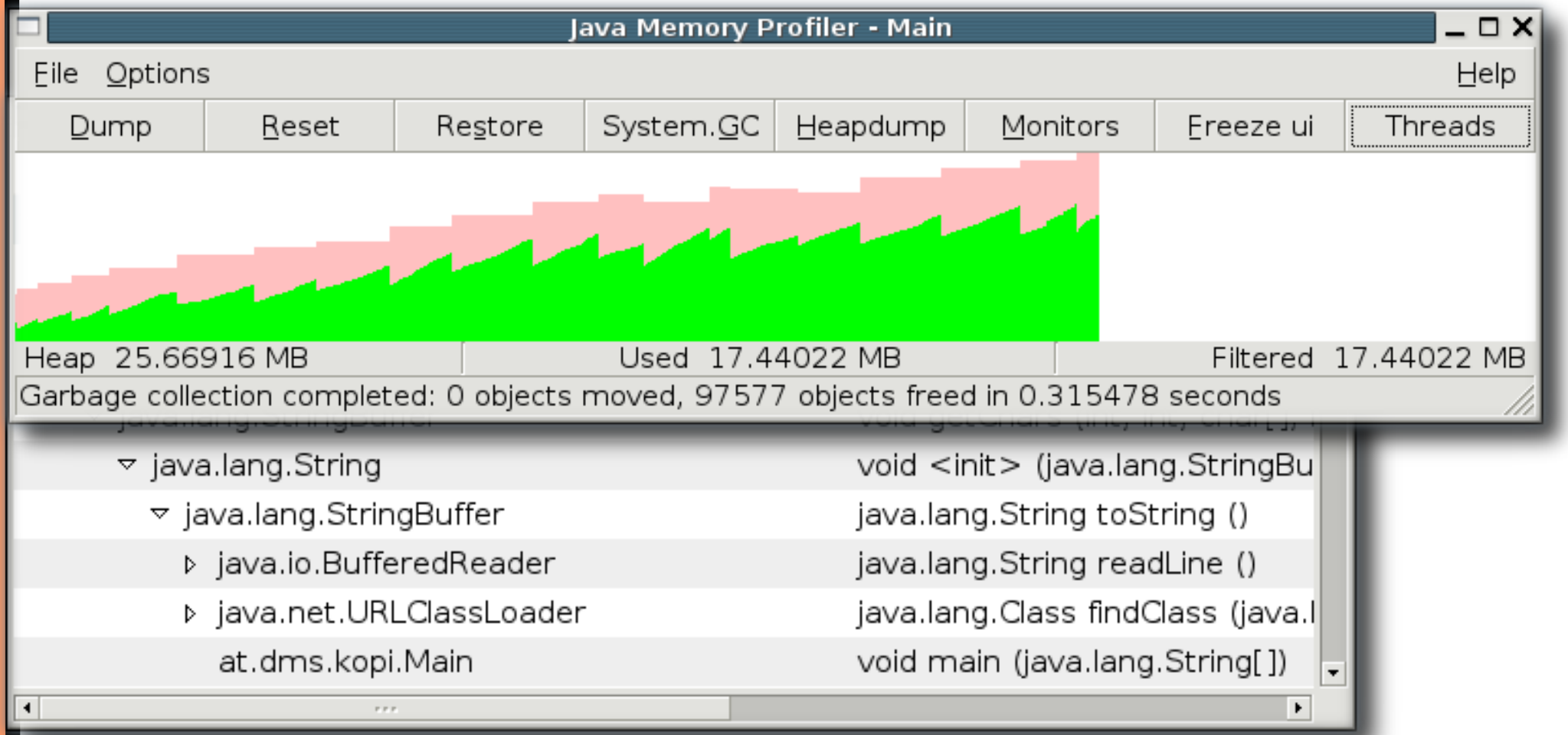




Kaffe-based MHP (Multimedia Home Platform)

JMP

- JMP 使用 JVMPI (Java VM Profiler Interface) 來追蹤 Object 、 Method ，以及 Call-Graph 使用量與狀態，並提供 GTK+ 輸出的介面

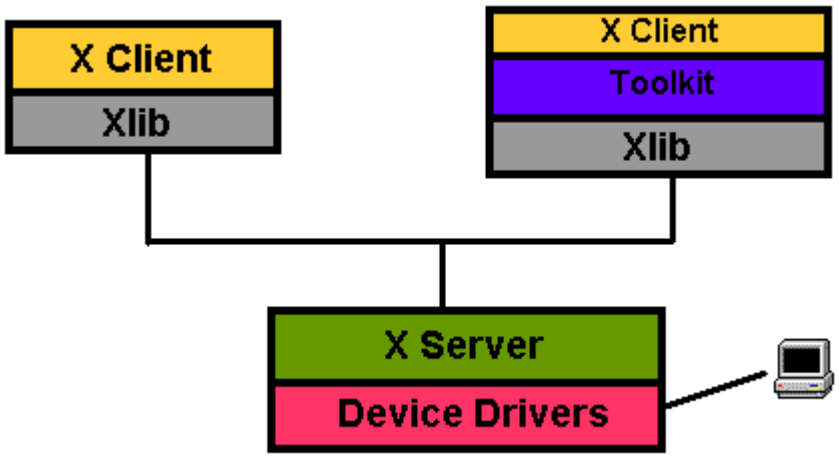


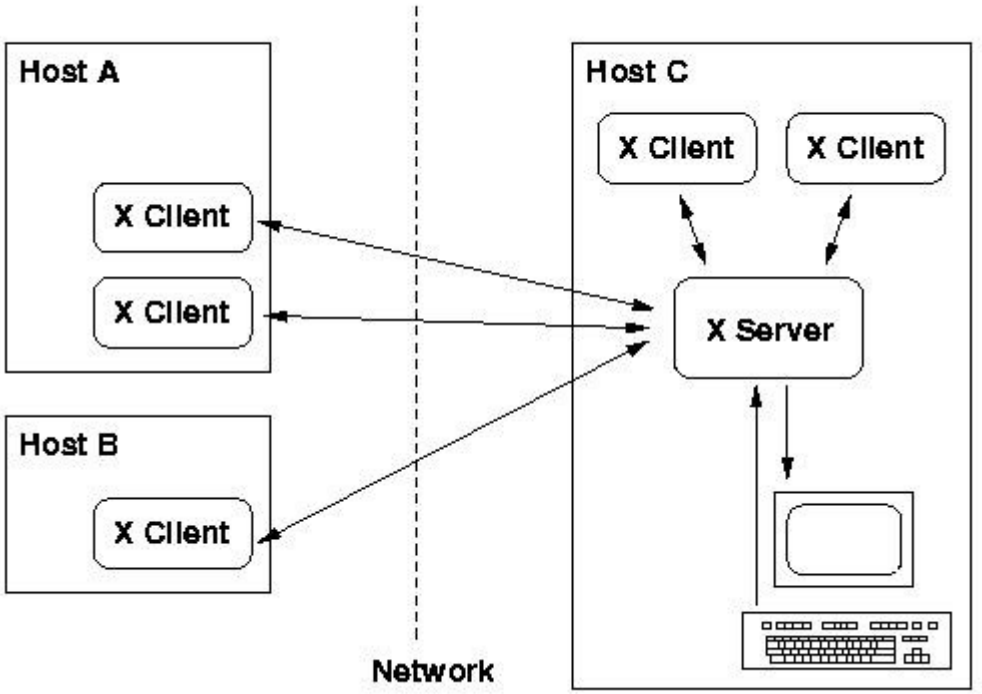
Escher

X Protocol
Device Independent Layer

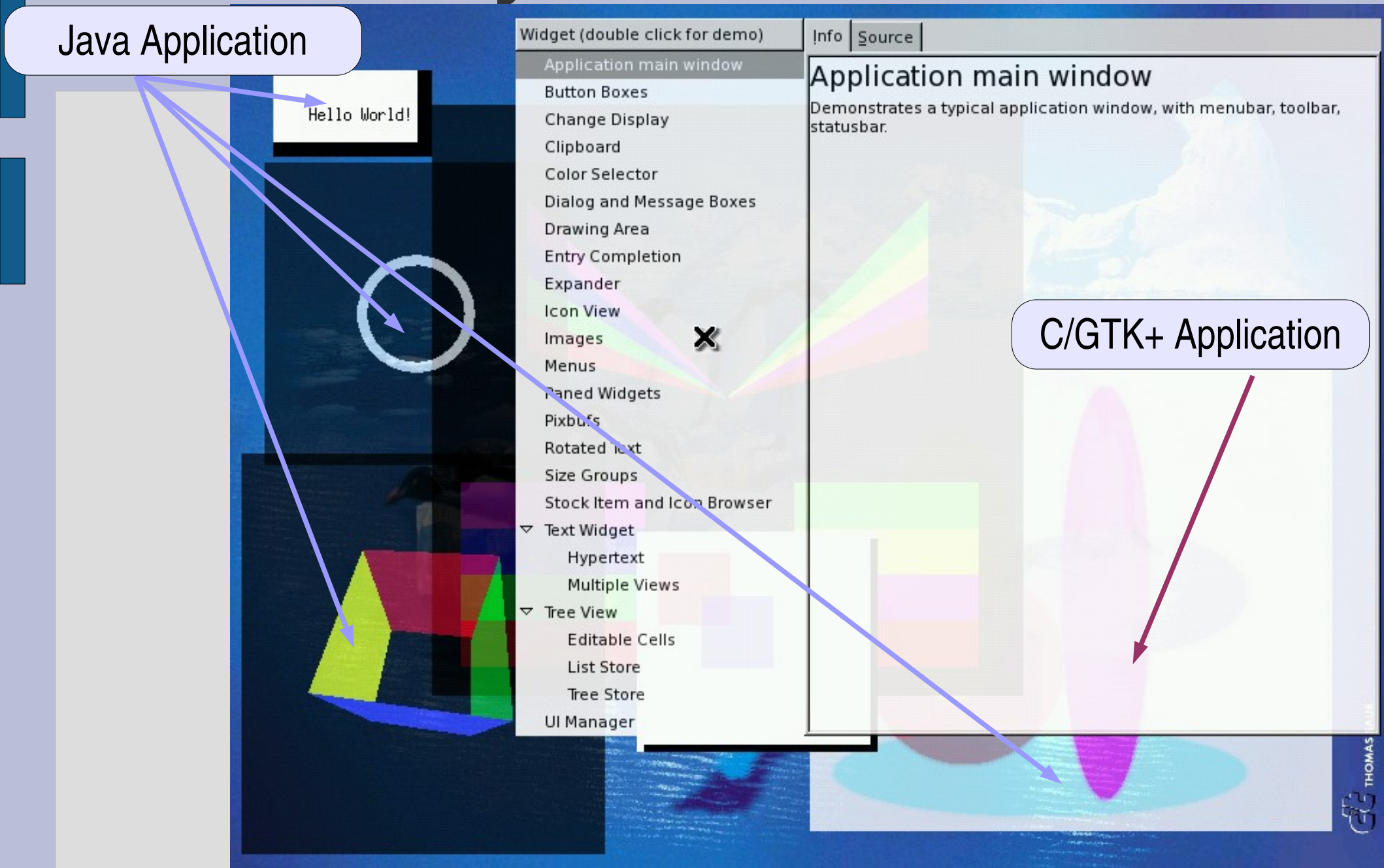
X Protocol
Device Dependent Layer

- Sun Looking Glass 計畫使用修改過的 Xserver 搭配 Escher (pure Java Xlib 實做)，並透過 Java 3D 建構 3D Living World
- X Window System 的精髓在於 X Protocol ，以 Message-based 驅動 client-server 架構



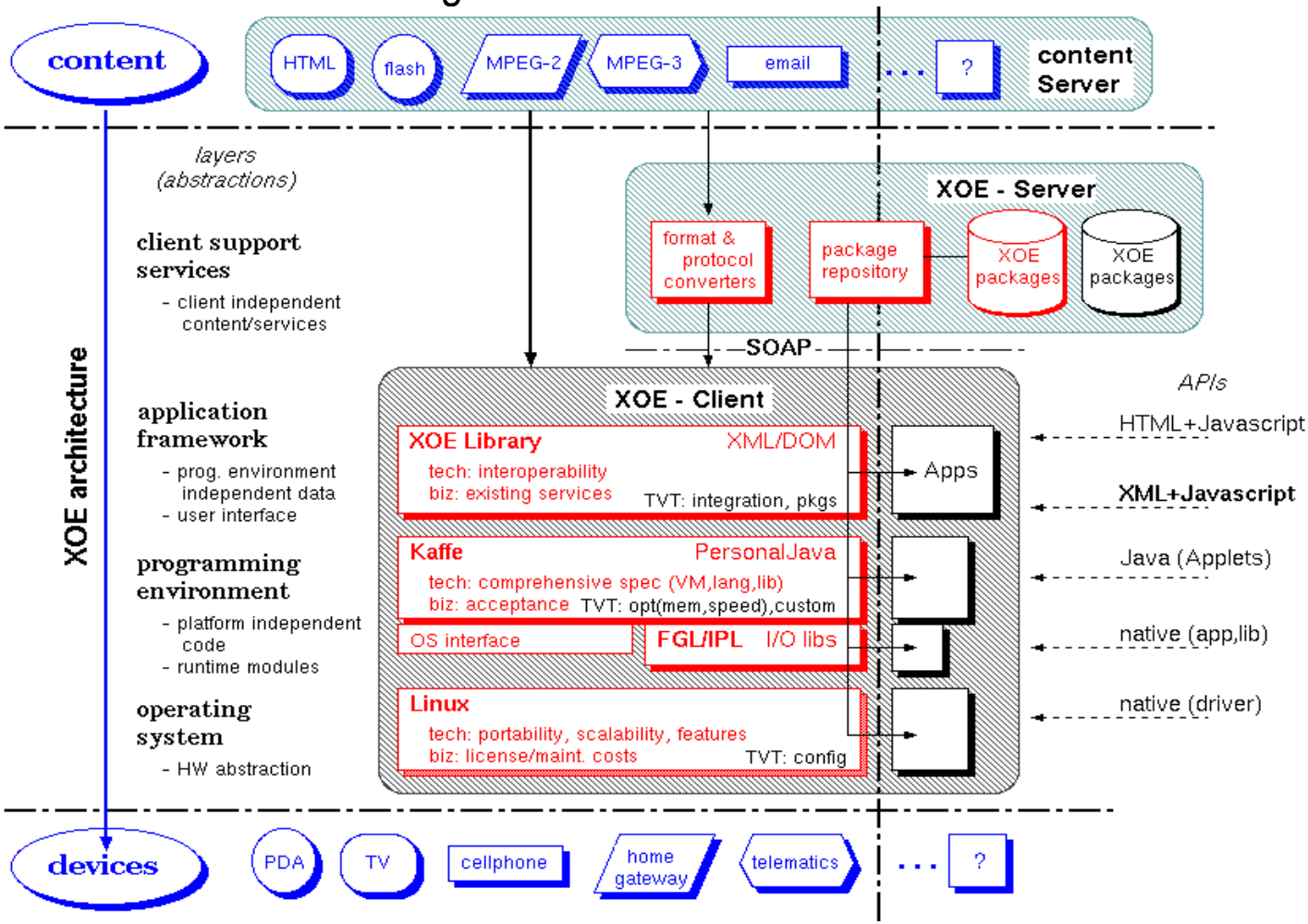


Direct Access X Protocol via Java/Kaffe



KOE (Kaffe-based Operating Environment)

- 源自 Transvirtual Technologies 的 **PocketLinux (XOE)** 產品
  - 2002 年 Transvirtual 結束營運
  - 2004 年重新啓動，並整合到 Kaffe.org



ect to create free core class libraries for use with
anguage.

Classpath is still a work in progress. The first public release will be version 1.0. There have been no public releases; however, pre-release source code is available via GNU's anonymous CVS server , and snapshots of the Classpath tree have been released and are available from ftp://alpha.gnu.org/gnu/classpath/ (older releases can be found in the archive).

Documentation

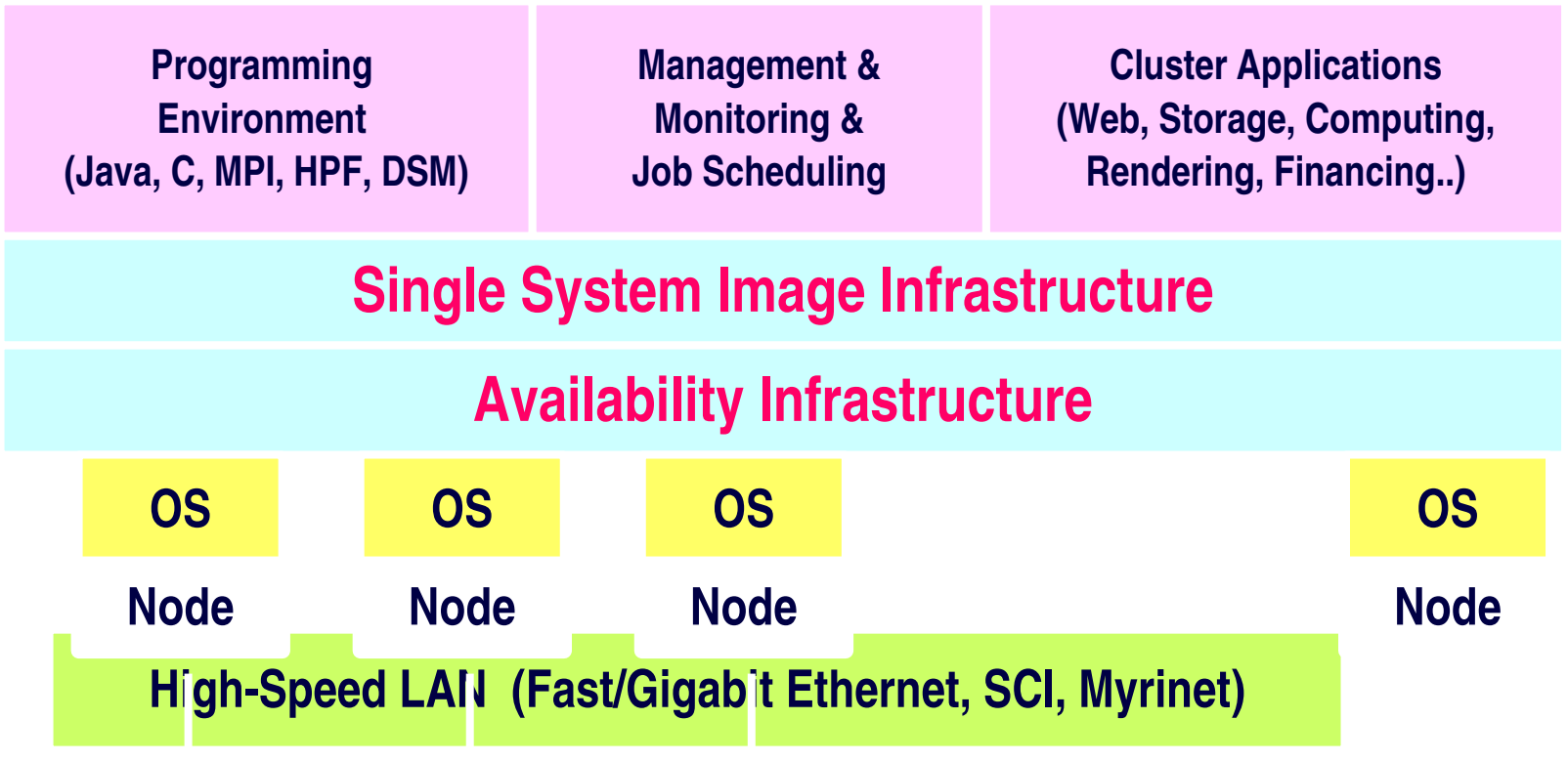
- Current Documentation
- Old News

Status

GNU Classpath 1.0 will be fully compatible with the 1.1 and largely compliant with the 1.2 API specification and

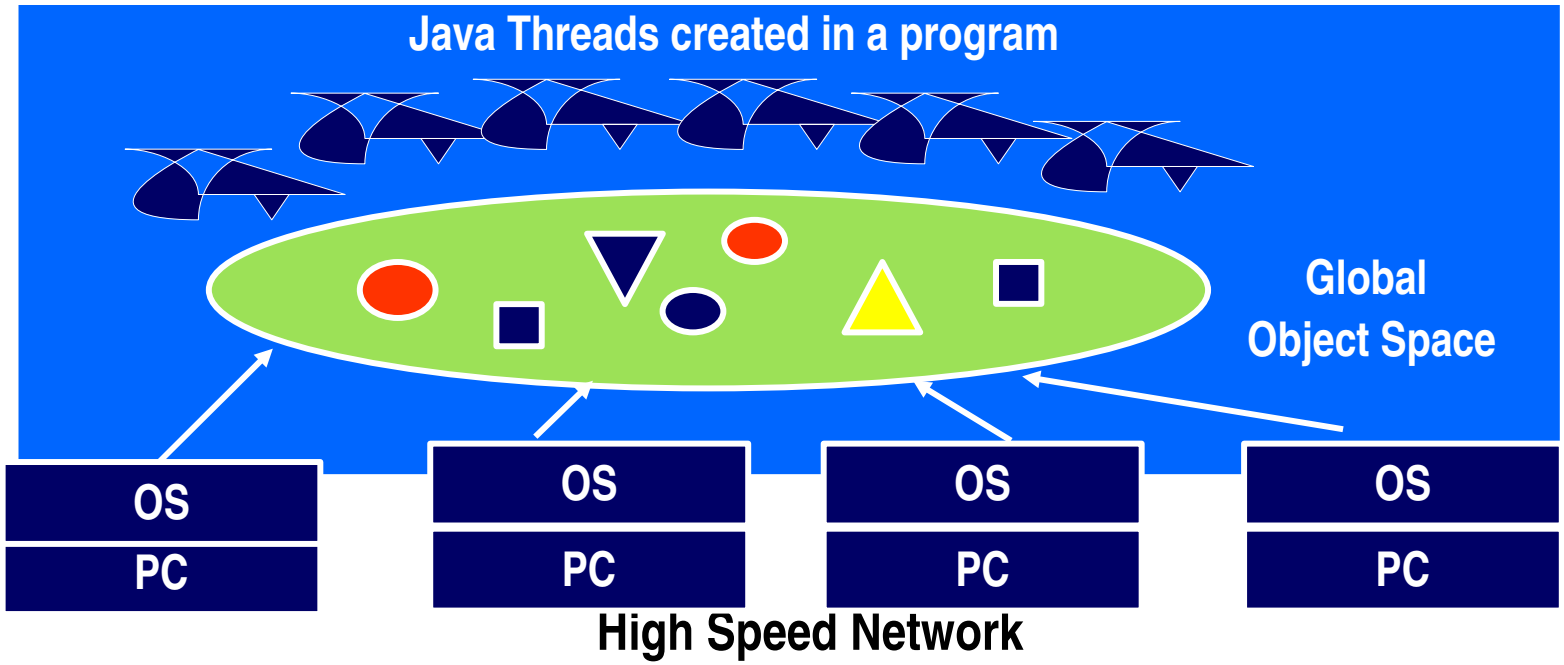
JESSICA2

- JESSICA – Java-Enabled Single-System-Image Computing Architecture ，香港大學
- 修改 Kaffe (Version-1: Interpreter only, Version-2: modified JIT) ，著眼於 Cluster computing 環境中，建立 SSI 的 middleware ，以便能夠透明的作平行 multithreadded Java 運算



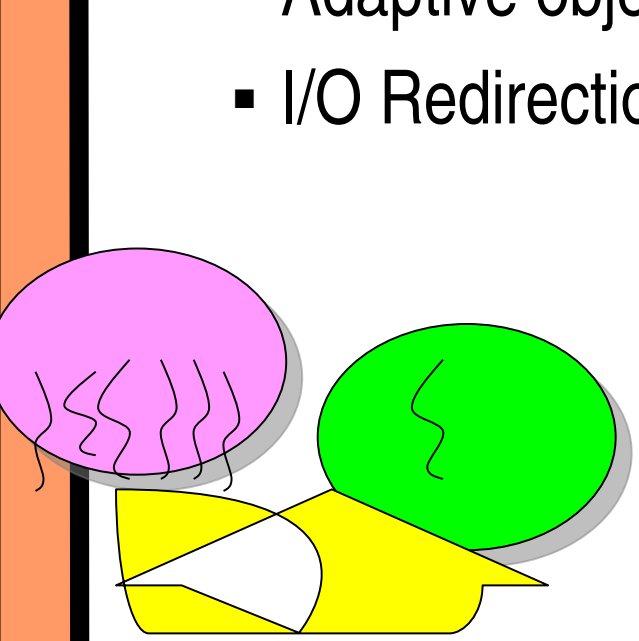
JESSICA2 巨觀

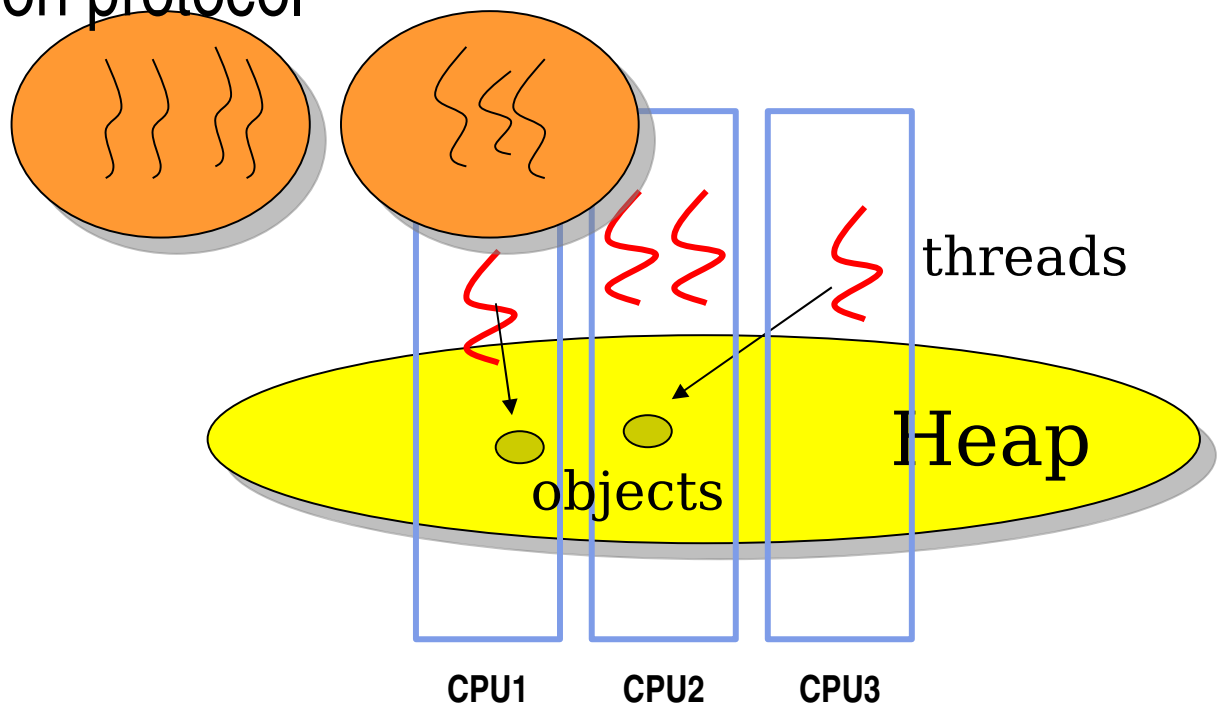
- 採用 Java 在 Clustering computing 的考量
  - Code mobility (Dynamic Class Loading)
  - Data mobility (Object Serialization)
  - 在語言層面支援 Multithread
- 重要的設計考量
  - Preemptive thread migration



JESSICA2 & Java Threads

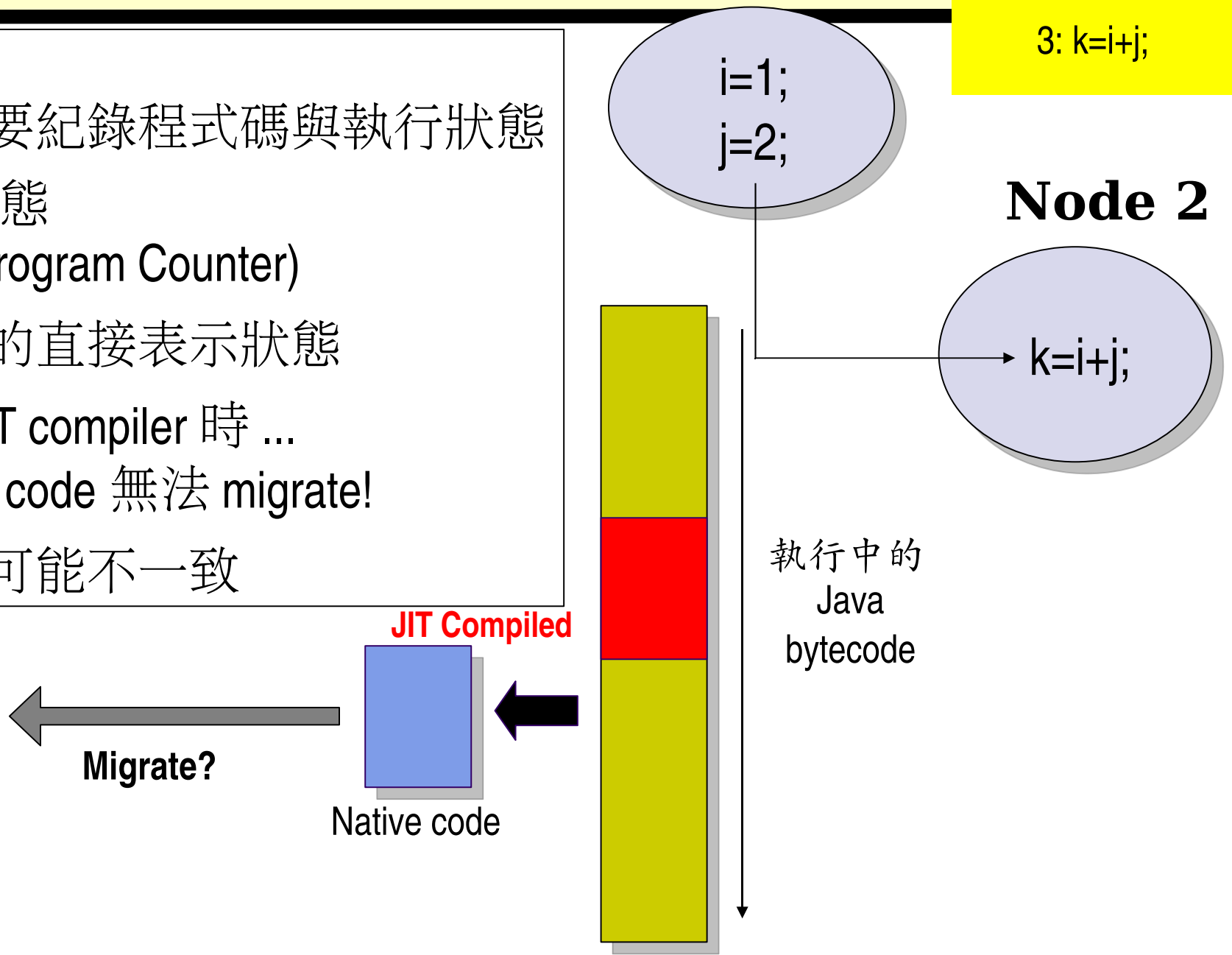
- Java Threads 本質上來看 ...
  - Lightweight 計算單元
  - 具備 Java 語言層面的支援，並使用 shared memory
- 引入" Global Object Storage" 的概念來解決
  - 共享的 Global Heap
  - Adaptive object migration protocol
  - I/O Redirection

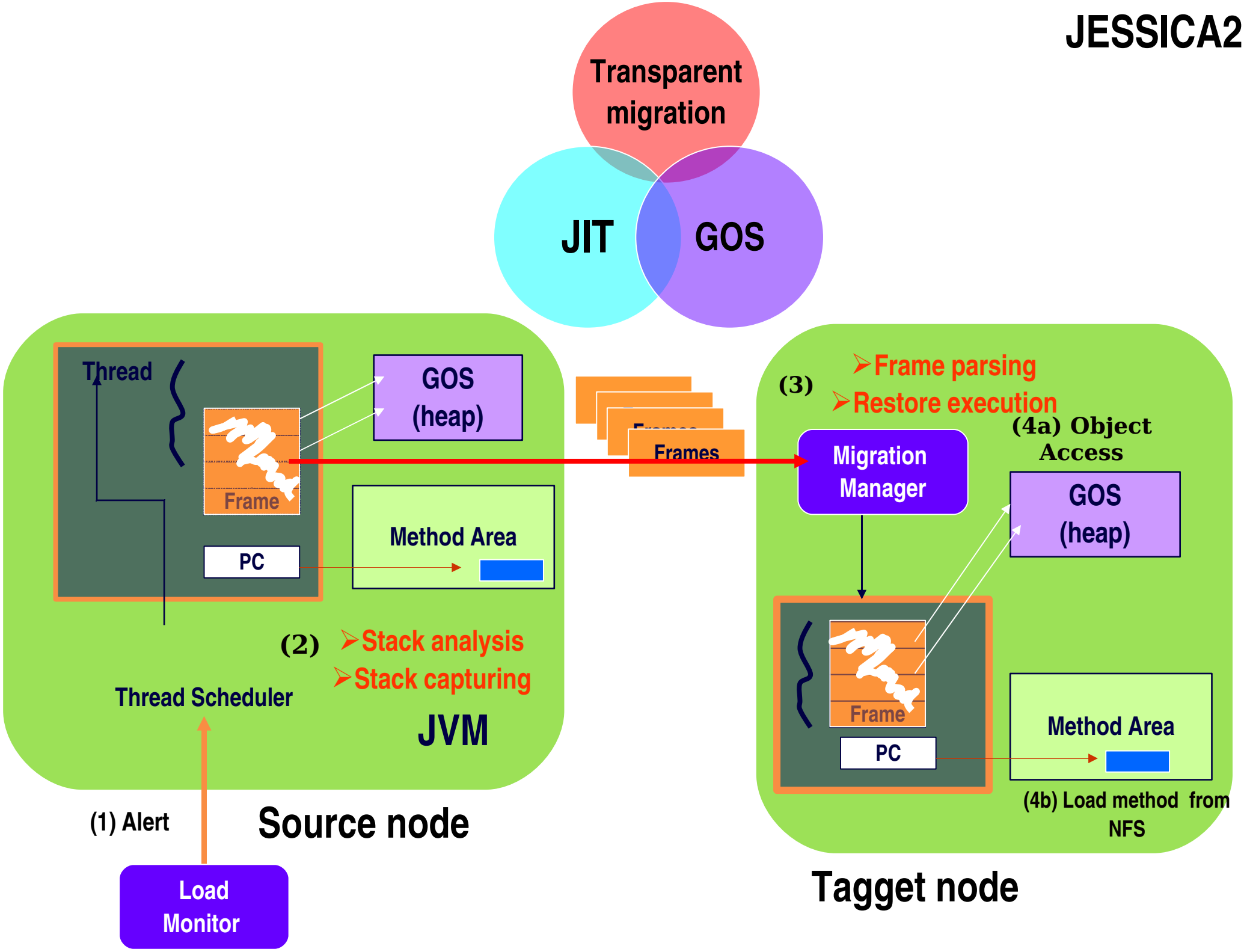




Thread Migration

- 思考 ...
  - 至少要紀錄程式碼與執行狀態
- 執行狀態
  - PC (Program Counter)
  - 變數的直接表示狀態
- 考慮 JIT compiler 時 ...
  - native code 無法 migrate!
  - 機器可能不一致

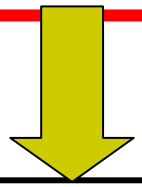



Transparent migration
JIT
GOS
Thread
Frame
PC
GOS (heap)
Method Area
Frames
(2)
Stack analysis
Stack capturing
Thread Scheduler
JVM
(1) Alert
Load Monitor
Source node
(3)
Frame parsing
Restore execution
Migration Manager
(4a) Object Access
GOS (heap)
Frame
PC
Method Area
(4b) Load method from NFS
Tagget node

JESSICA2 的解決方案

自原始 RTC (Raw Thread Context) 規範可攜性的 BTC
(Bytecode-orented Thread Context)

Source node

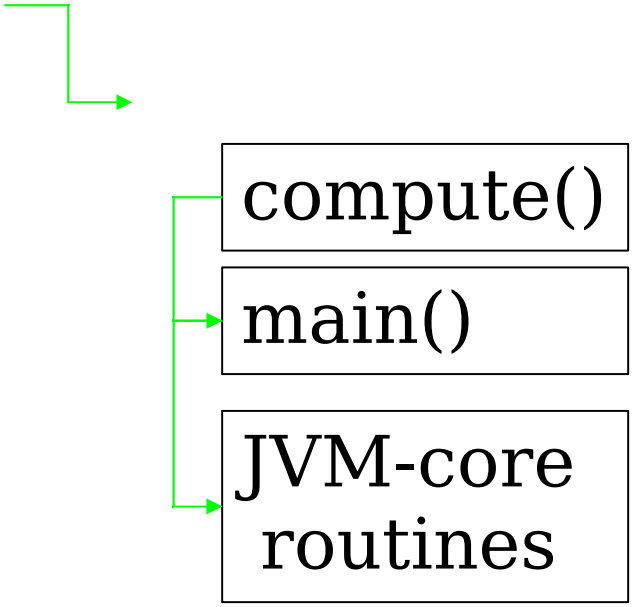


Migration 後， BTC 還原回 RTC

Target node

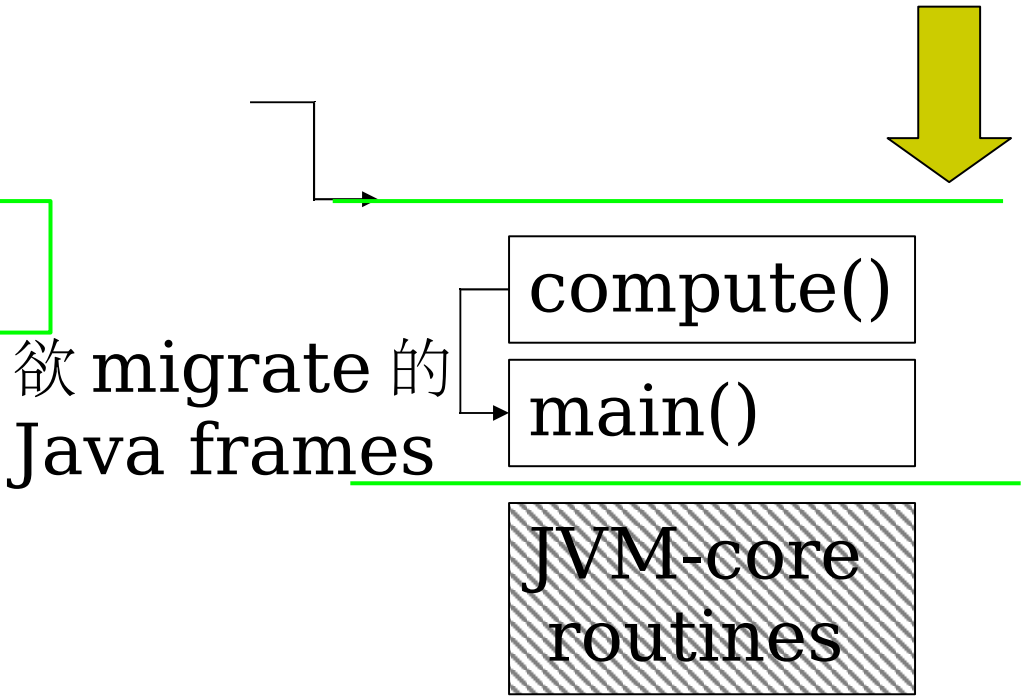
對兩邊的 thread context 執行 JIT re-compilation

Stack walk



Stack walk

Frame segmentation



- Branching instructions
  - if_icmplt (Bytecode)
  - cmpl (x86)
- 具體意義：改變 Excution state / Flow control / Thread Context

Stack walk

Frame segmentation

Bytecode PC positioning

compute()

incl %ebx

cmpl $0x1e, %ebx

jl 0x82512432

iinc 1, 1

iload_1

bipush 30

if_icmplt 5

Mapping

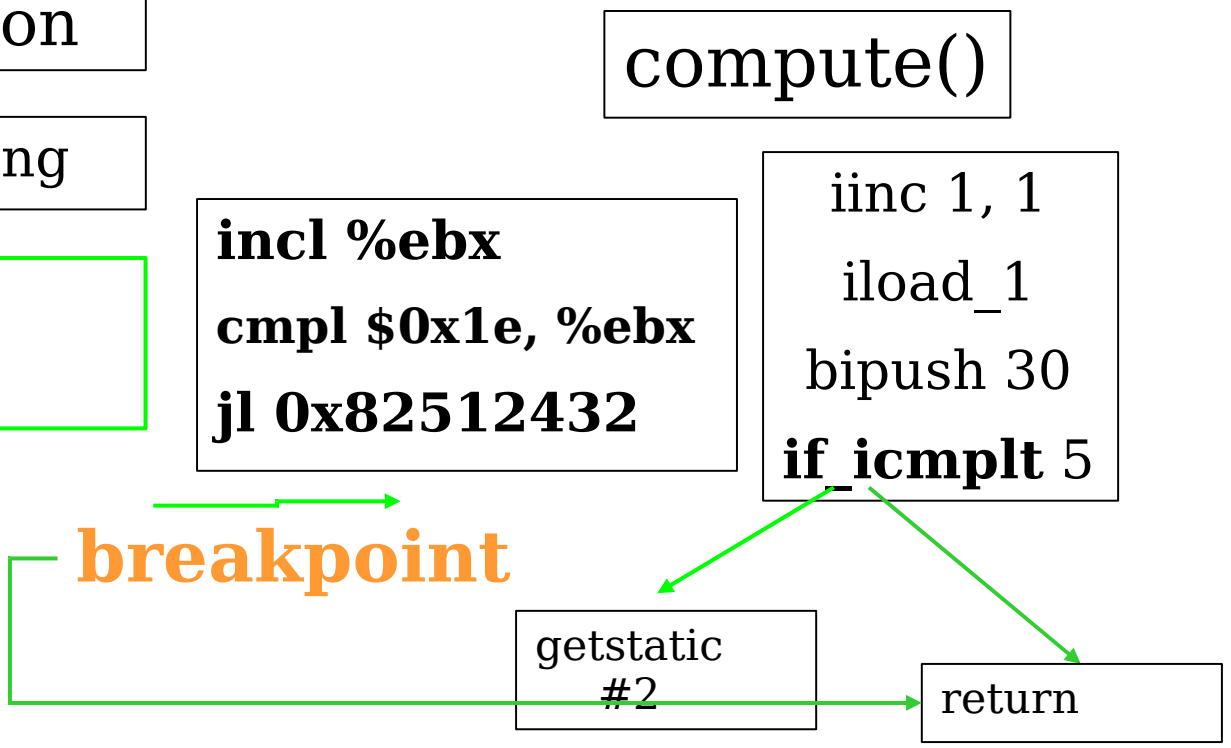
main()

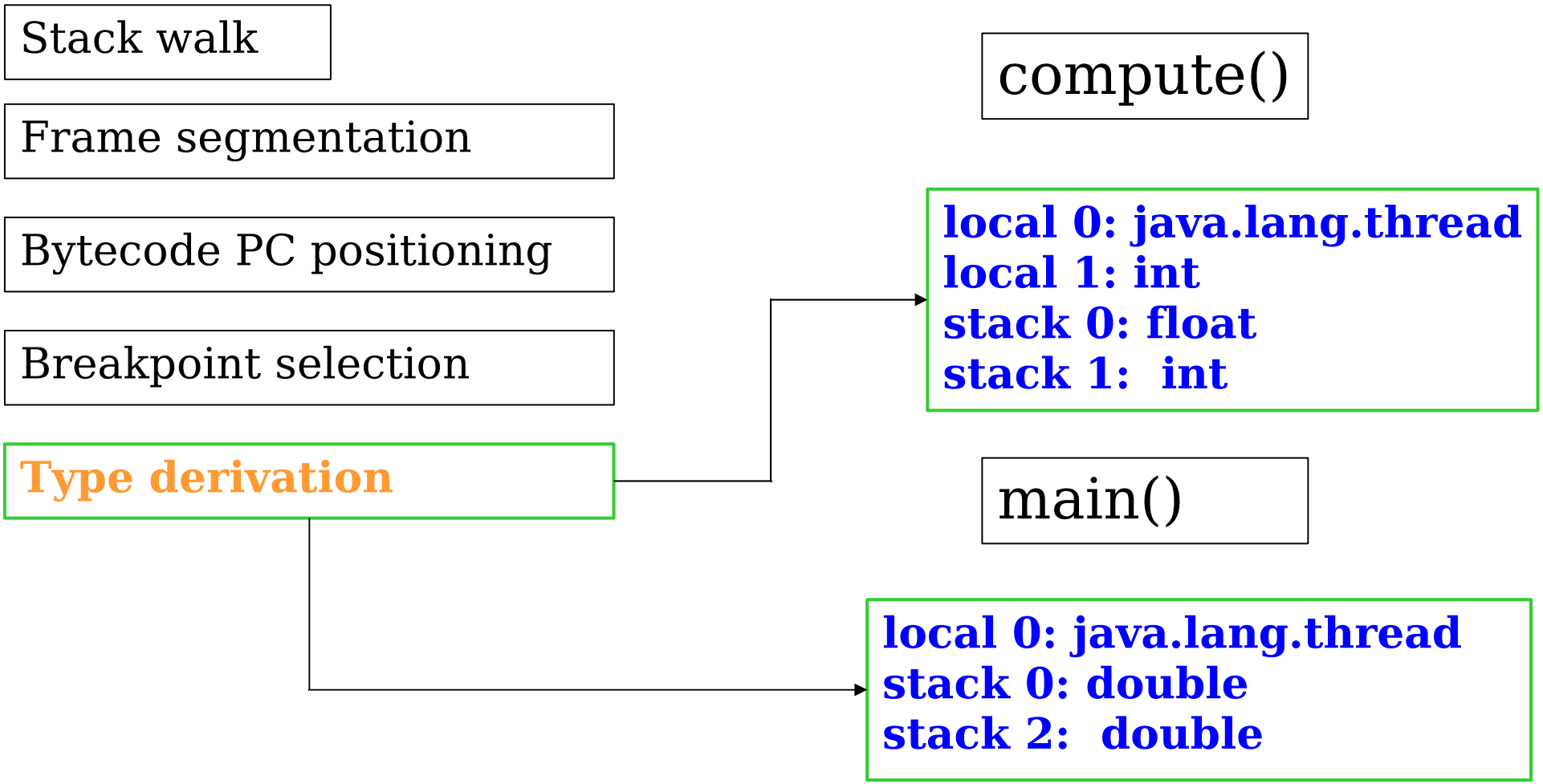
Stack walk

Frame segmentation

Bytecode PC positioning

Breakpoint selection




Stack walk
Frame segmentation
Bytecode PC positioning
Breakpoint selection
Type derivation
compute()
local 0: java.lang.thread
local 1: int
stack 0: float
stack 1: int
main()
local 0: java.lang.thread
stack 0: double
stack 2: double

- 依據 Breakpoint 重新產生 native code
- 在 Translation 階段已準備 Migration

Stack walk

Frame segmentation

Bytecode PC positioning

Breakpoint selection

Type derivation

Translation

```
getstatic #2
Iload_1
```

compute()

```
inc %ebx
cmpl $1e, %ebx
jl 0x82512432

0x82512432:
... capture frames...
--- save local var/type
return
```

main()

```
...other native code...
jmp start_migration
```

- 將原本儲存的 return address 替換為剛剛產生的 native code

Stack walk

Frame segmentation

Bytecode PC positioning

Breakpoint selection

Type derivation

Translation

Native code patching

compute()

saved return address

activation record of compute()

main()

```
inc %ebx
cmpl $1e, %ebx
jl 0x82512432

0x82512432:
... capture frames...
--- save local var's
and their type
return
```

```
...other native code...
jmp start_migration
```

JESSICA2 的解決方案

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(Bytecode-orented Thread Context)

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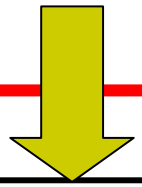
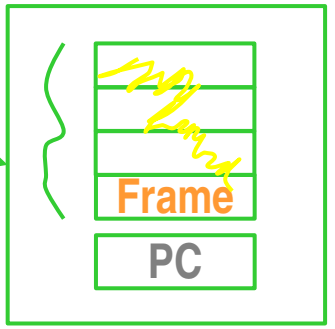


Migration 後， BTC 還原回 RTC

Target node

對兩邊的 thread context 執行 JIT re-compilation

Thread creation



Thread creation

Dynamic register patching

compute()

Register recovering stub:
movl %0x1234, %eax
movl %0x5678, %ebx

- 透過 JIT compiler 處理 register
- 建立還原點的 code stub

main()

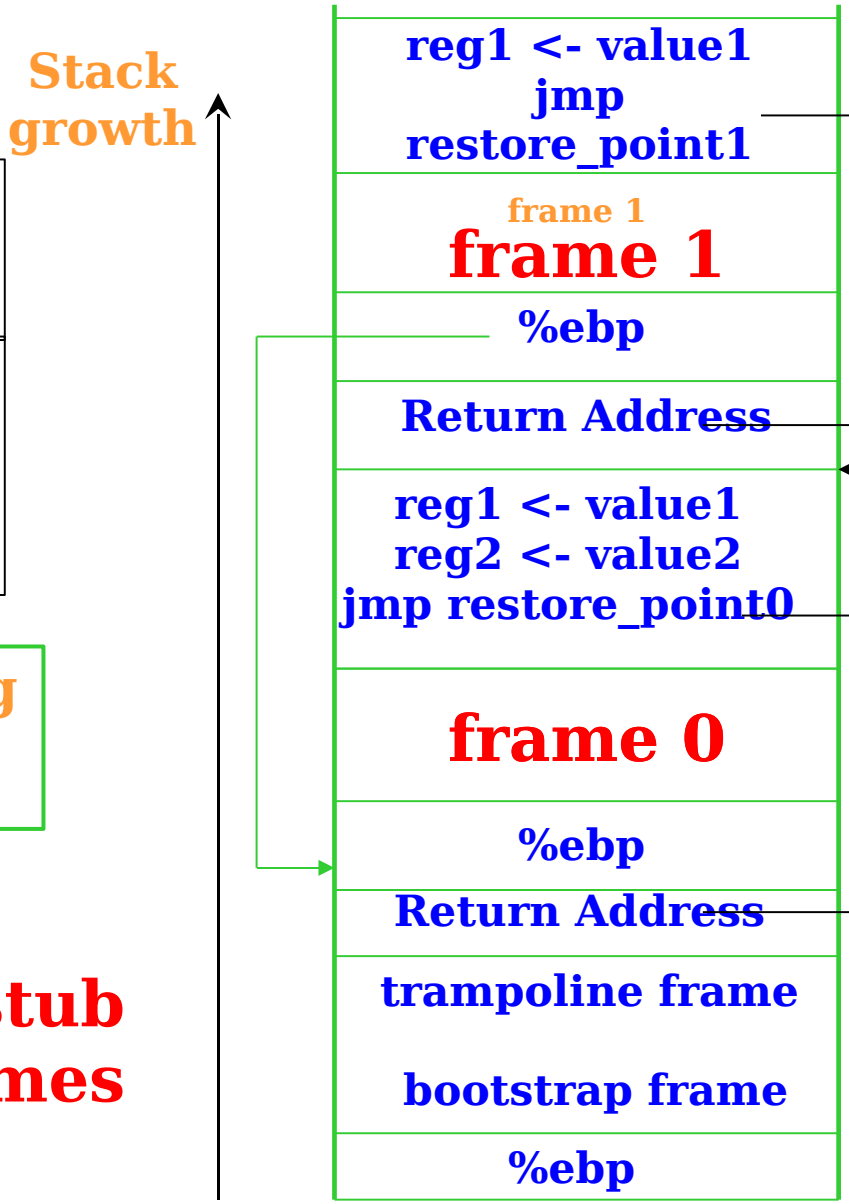
Register recovering stub:
movl %0x1111, %eax
…

Thread creation

Dynamic register patching

Stack rebuilding

Linking code stub and native frames



Compiled methods:

```
compute(){
...
retore_point1:
}
```

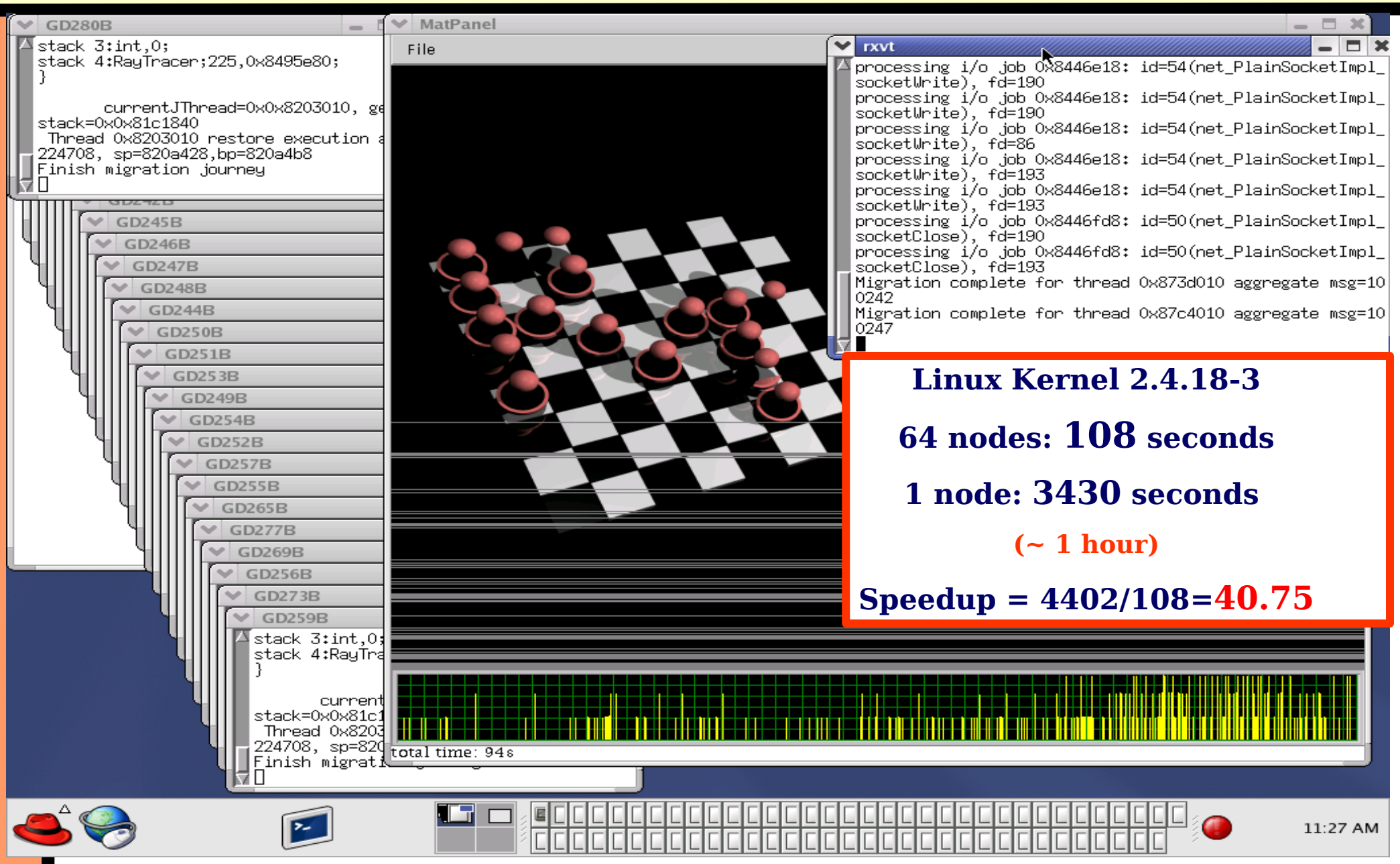
```
main(){
...
retore_point10:
}
```

trampoline

```
bootstrap(){
  trampoline();
closing handler();
}
```

Parallel Ray Tracing on JESSICA2

(Running at 64-node Gideon 300 cluster)



Linux Kernel 2.4.18-3

64 nodes: 108 seconds

1 node: 3430 seconds

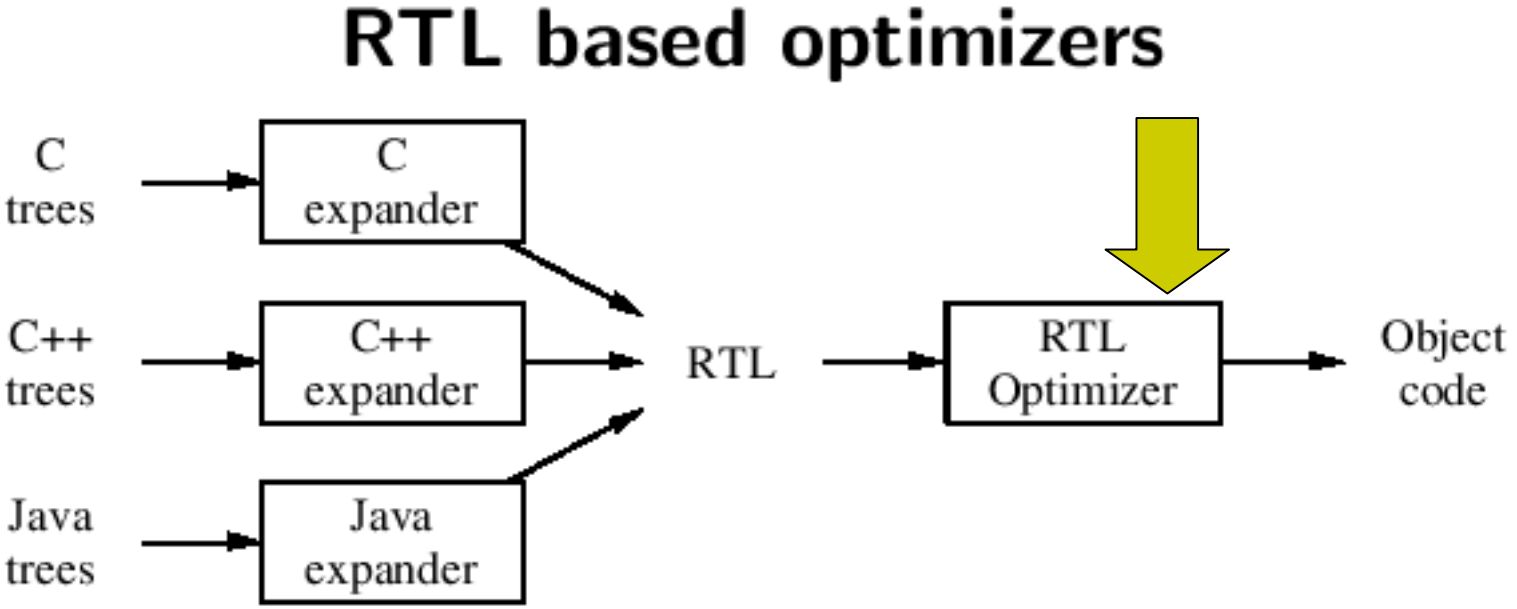
(~ 1 hour)

Speedup = 4402/108=40.75

GCJ 簡介

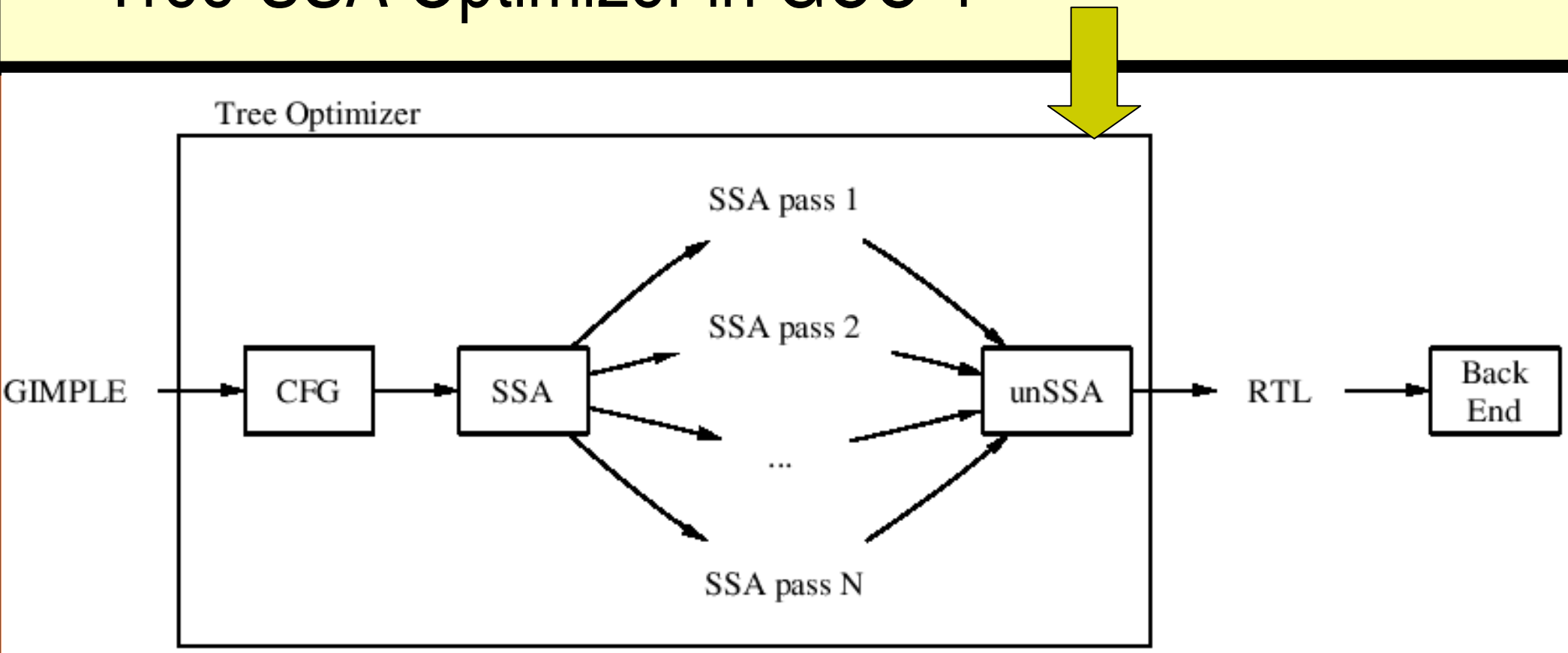
- GNU Compiler for Java
  - not Java !
  - but it does run a great many applications written in Java !
- 里程碑
  - 1996 年十月份由 Per Bothner 開始 (與 Transvirtual 合作)
  - 1999 年八月第一個釋出版本現身
  - 2000 年三月份展開與 GNU Classpath 的整合工作
  - 2005 年七月完成與 GNU Classpath 的整合
- GCC4 後引入新機制

反省



- GNU GCC 一直以眾多硬體平台支援爲訴求
  - RTL-based optimizer
- 盲點
  - RTL 不適合高階轉換
  - 必須遷就特定硬體平台而改變整體設計
  - RTL 喪失原始資料型態與控制結構的資訊
  - Addressing model 被一系列的變數指標所替換

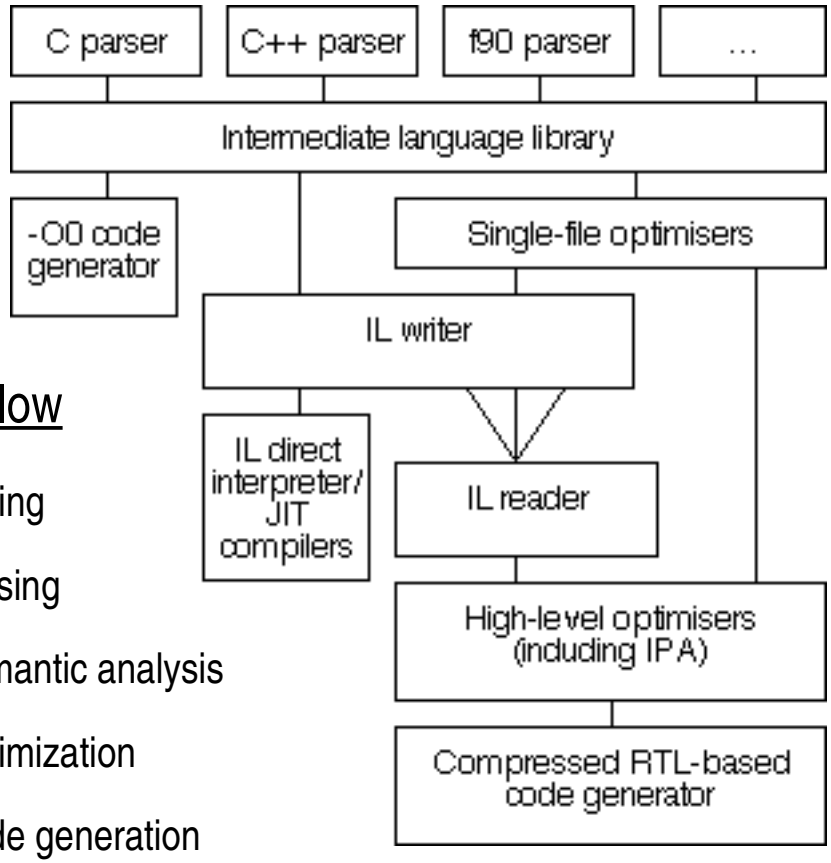
Tree-SSA Optimizer in GCC 4



- GIMPLE tree 是語言 / 硬體平台無關的設計
- 所有的型別資料都被保存

GCC4 新革命

- 過去 GCC 一直採用 GENERIC 途徑
- parser -> IL Library -> middle-end
- IL Library 透過 SSA(Static Single Assignment) 建立內部的最佳化表示法
- 可施行更多最佳化的途徑
  - CSE / SSA
- 允許 JIT 機制的引入



Compiler Flow

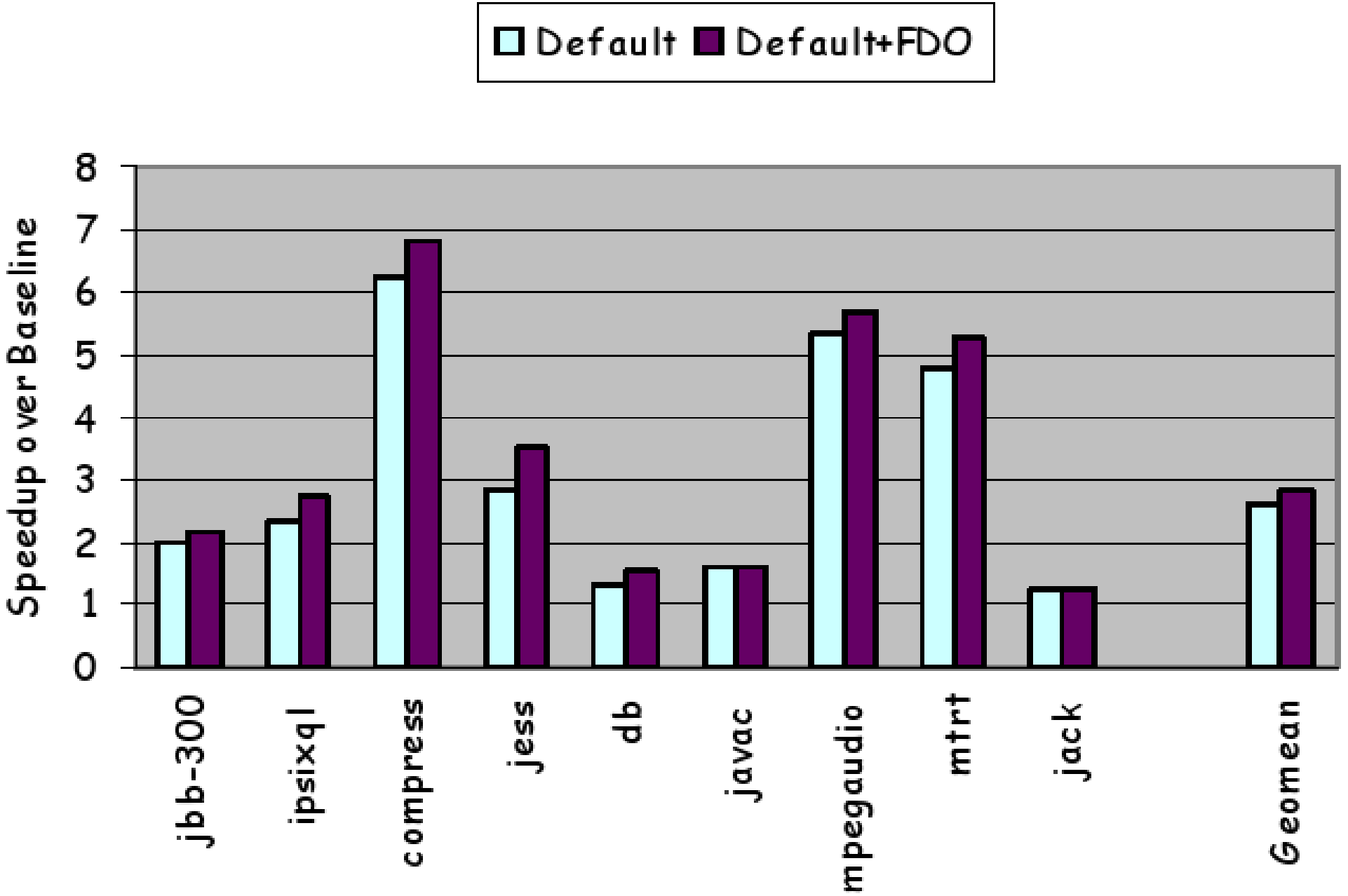
- Lexing
- Parsing
- Semantic analysis
- Optimization
- Code generation

破除迷思

- 誤解：Static compiler 因爲少去分析的時間，所以效能絕對比 Dynamic compiler 來得好
- 眞相：
  - 良好設計的 JIT compiler 在許多層面可以實做出 Static compiler 所不能達到的最佳化設計
  - FDO (Feedback-Directed Optimization) 能夠比沒有 profiling 資訊的 IPA 來得有效率
  - 傳統 C compiler backends 喪失 JIT 能夠最佳化的類型與語言層次的資訊
  - AOT compilation 缺乏快速的啓啓動時間與 small footprint

FDO (Feedback-Directed Optimization)

- 簡單來說：利用執行時期 (Runtime) 所獲取的資訊作進一步的最佳化執行
  - "selective optimization": WHAT to optimize.
  - "FDO": HOW to optimize.
- FDO 的特性
  - 可獲取 Static compilation 所未知的 Runtime info
  - 系統可以更動或反悔原先的 policy ，如果情況改變的話 (如： CPU bound vs. I/O bound)
  - 允許 Runtime 建構爲更有彈性的設計



- JikesRVM 的測試報告顯示 ...
  - FDO 可增進 long execution process 的效能

在 GCJ4 之前 ...

- 過去以 C++ 類似的方式建構 ABI (Application Binary Interface)
  - 亦即 DWARF2 Exception Handling
  - Static field/method references resolved by linker
  - [instance_field:instance_method] -> [offset:vtable]
- 面臨的問題
  - user-defined ClassLoaders 無法正確運作，更無法 precompiled
  - 無法允許 precompiled classes 繼承自 interpreted classes
  - ELF linkage model 無法確保 Java 語言層面的 namespace 議題
  - C++ linkage model 不適合 Dynamic Lanuages

GCJ4 新特徵

- New ABI
  - 所有的 field offset 採用 indirect access
  - 所有的 method table 都在執行時期產生
- User-defined class loaders
  - gcc/libjava/java/lang/ClassLoader.java
- defineClass(byte[])
  - 產生 byte 的 MD5 檢查碼
  - 在系統資料庫查詢 symbol entry
  - 找到的話，載入適當的 shared library
  - 符合 JIT compiler 的行爲

GCJ4 新特徵 (cont)

- New ABI
  - 可在不需重新編譯應用程式的前提下，升級 GCJ Library
  - Class <--> Shared_Library Map
    - 完全隱蔽 Class 生成資訊
    - Old-ABI code call virtual method
      - ((vtable *) obj)[index]) (obj, ...)
    - New-ABI
      - (((vtable *) obj)[otable[index]) (obj, ...)
- 範例
  - gcj foo.jar -shared -fPIC -o foo.jar.so
  - gcj-dbtool -a system-java-symbols.db foo.jar.so

GCJX ： GCJ 實驗性計畫

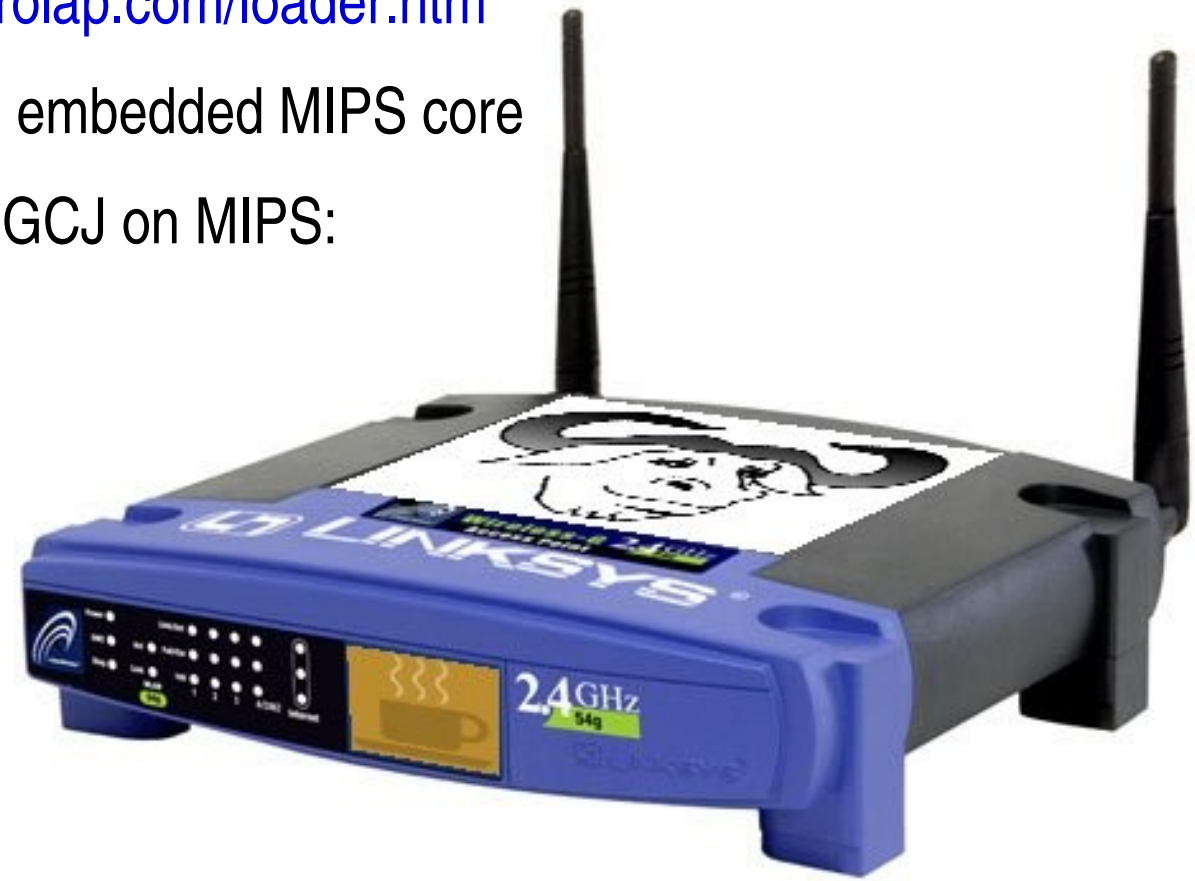
- 以 C++ 撰寫的新 GCC Frontend
- GCC 內部設計
  - RTL
  - Tree
    - Language-specific
    - GENERIC
    - GIMPLE
  - High-level Optimizations
- 著眼點
  - Language-specific Model
  - Static typing
  - Lower model to tree
  - Multiple backends

展示

- Why Free Java?
- 目前 Free Java Runtimes 概況
- 如何建構 cleanroom JavaVM ？
- Case Study
- 展示

In Actions !

- platform support
  - http://controlap.com/loader.htm
  - Broadcom embedded MIPS core
  - Kaffe and GCJ on MIPS:



結論

- GNU Classpath 匯集許多專案，眾多開發者得以累積成果並相互受益
- 基礎建設逐漸完備，欲擴展或研究者可以專注於 VM 設計本身
- Mauve 是相當好的相容性驗證工具
- Free Java Hackers around the World !
- 開放原始碼創造無限可能，而整體來說，更是一種新契機

參考資源

- GNU Classpath
  - www.classpath.org
- news
  - planet.classpath.org
- Kaffe
  - www.kaffe.org
  - http://latte.snu.ac.kr/
  - http://i.cs.hku.hk/~wzzhu/j2/
- GCJ
  - http://gcc.gnu.org/java/

- Any help is greatly appreciated
  - Test Java programs on free Virtual Machines
  - Write test cases for Mauve
  - Write intellegible documentation
  - Implement library classes
  - Fund development
- How to proceed
  - Look at the task list in GNU Classpath
  - Copyrights must get assigned to FSF

Thanks!

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