

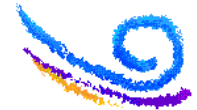
IBM's Mixed-Mode Interpreter

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What is the Mixed-Mode Interpreter?

"The mixed-mode interpreter (MMI) is a new, high-speed profiling interpreter which completely replaces the existing interpreter within the Java Virtual Machine (JVM). It is separate but complementary to the JIT."



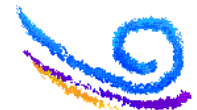
MMI Releases

- ▶ First appeared in JDK 1.1
 - Windows NT/98 JDK 1.1.7
 - OS/390 JDK 1.1.8
 - OS/2 JDK 1.1.8
- ▶ Java 2
 - Improved portability
 - Greater maintainability
 - Supported Platforms
 - AIX, Windows NT/98, OS/390, OS/2, Linux



Why "Mixed-Mode"?

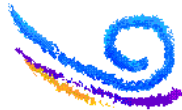
- ▶ C/Assembler Interpreter
 - All methods interpreted as bytecodes
- ▶ With JIT
 - <clinit> interpreted
 - All other methods compiled on first use
- ▶ MMI and JIT
 - Truly mixed-mode of execution
 - JIT-insensitive methods are interpreted
 - Hot methods compiled



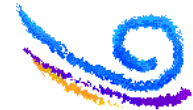
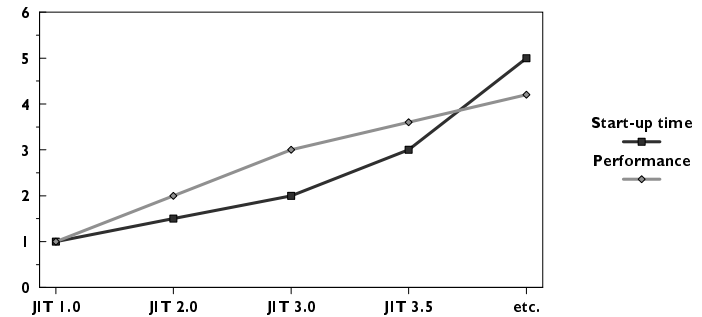
Why Do we Need MMI?

► The Start-up Time Problem

- Each Technology Improvement
 - C interpreter, Assembler, JIT 1.0, JIT 2.0, JIT 3.0, JIT 3.5, etc.
- Performance increases
- Start-up time longer and longer



Start-up time versus Performance



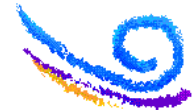
Reducing Start-up Time

- Pre-compile bytecodes to native code
 - native code already available at start-up
 - Fat Classes
 - pre-compiled bytecodes contained within class file
 - JIT caching
 - native code cached to disk as JVM runs
- Selective Compilation
 - select the best sub-set of methods to compile
 - delays method compilation at start-up



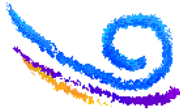
Selective Compilation

- Select Methods Based on Usage
 - Profile Count
 - Decrement on each invocation
 - Compile method when count reaches zero
 - MMI uses initial value of 500
 - Problems
 - What do you do with methods that contain loops?
 - ◊ Method invocation count weights these methods too low



Loop Detection

- ▶ When MMI encounters a bytecode of the form
 - `opc_ifxx`
 - `opc_if_icmpxx`
- ▶ Checks if it is a loop backedge by comparing with specific bytecode pattern
- ▶ Modifies profile count depending on
 - computed loop count
 - distance of backward branch

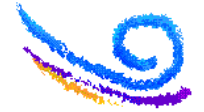


Loop Detection Example

Bytecodes		Java
...		...
loop:		...
...		for(i = 0; i < 1000; i++) {
iinc 1 1		...
iload 1		}
sipush 1000		...
if_icmplt loop		...
...		...

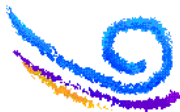


Predict iteration count = 1000



Loop Detection (Cont)

- ▶ MMI Loop Thresholds
 - Count < 3 => Profile count unchanged
 - Count < 50 => Profile count decreased
 - Count < 200 => Compile next Invocation
 -
- ▶ Problem:
 - Methods with loops which never exit
 - ♦ Symantec benchmark
 - ♦ Scanning of last 20 bytecodes



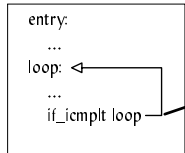
Long-Running Loops

- ▶ JIT Compilation with Transfer Point
 - JIT compiler produces two entry points:
 - Method entry
 - Loop backedge
 - Glue code to compute compiler-generated local variables at transfer point
- ▶ Direct Control Transfer
 - MMI re-creates stack frame for JIT and jumps to glue code

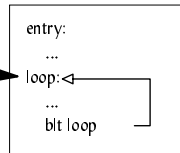


Direct Control Transfer

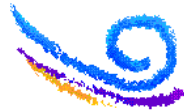
Bytecode of Method A



JITted code of Method A

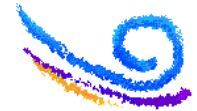


JIT transfer glue

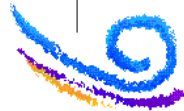
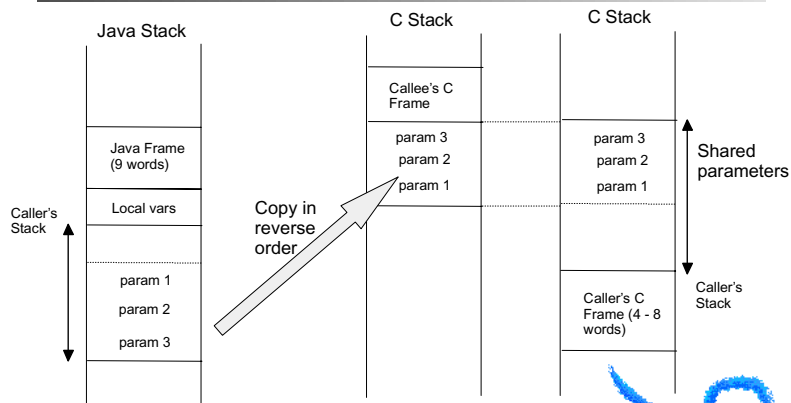


Implications of Mixed-Mode Execution

- ▶ Transfer Between Modes Must be Low-Cost
 - Interpreter and JIT uses different stacks
 - Interpreter uses "JavaStack"
 - JIT uses native stack
 - MMI must share stacks
- ▶ Low-Cost Exceptions
 - Interpreter and JIT use different exception handlers
 - Rethrowing of exceptions at boundary
 - MMI must share exception handlers
- ▶ High-Speed

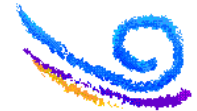


Shared Native Stack

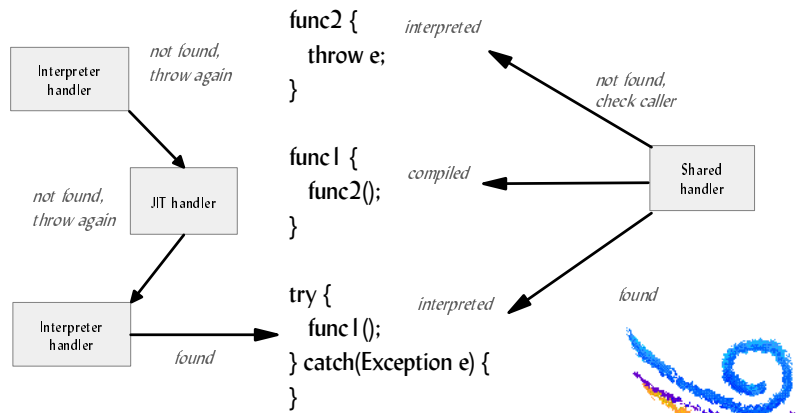


High-Speed

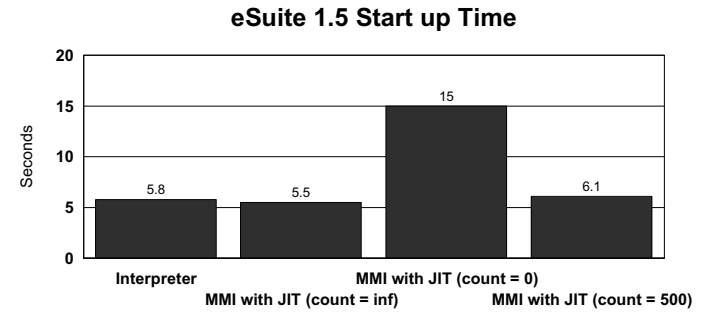
- ▶ Hand-written assembler
 - PowerPC approx 14,000 lines
 - Intel approx 18,000 lines
- ▶ Architecture tuning
 - PowerPC
 - Bytecode prefetch
 - 'Free' bytecode decode
 - Intel
 - Instruction cache balancing



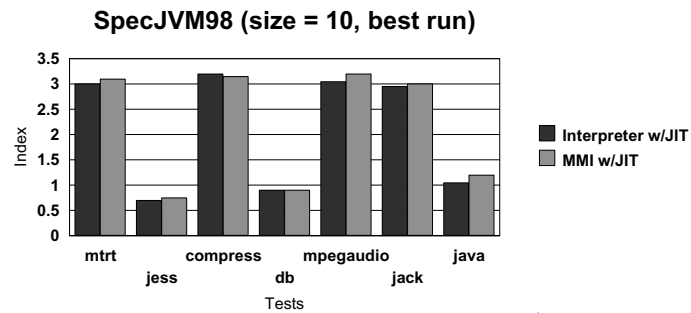
Shared Exception Handler



Start Up Times With MMI



MMI with JIT Performance



Conclusions

- ▶ MMI is extremely effective at reducing start-up times
 - MMI avoids JITting all methods
 - MMI delays compilation at load-time
- ▶ MMI improves performance
 - MMI is twice as fast as existing interpreter
 - MMI works as an efficient profiler to find JIT sensitive code
 - MMI generates execution profile that enables JIT to apply more effective optimisations