The Mono JIT optimizations and evolution

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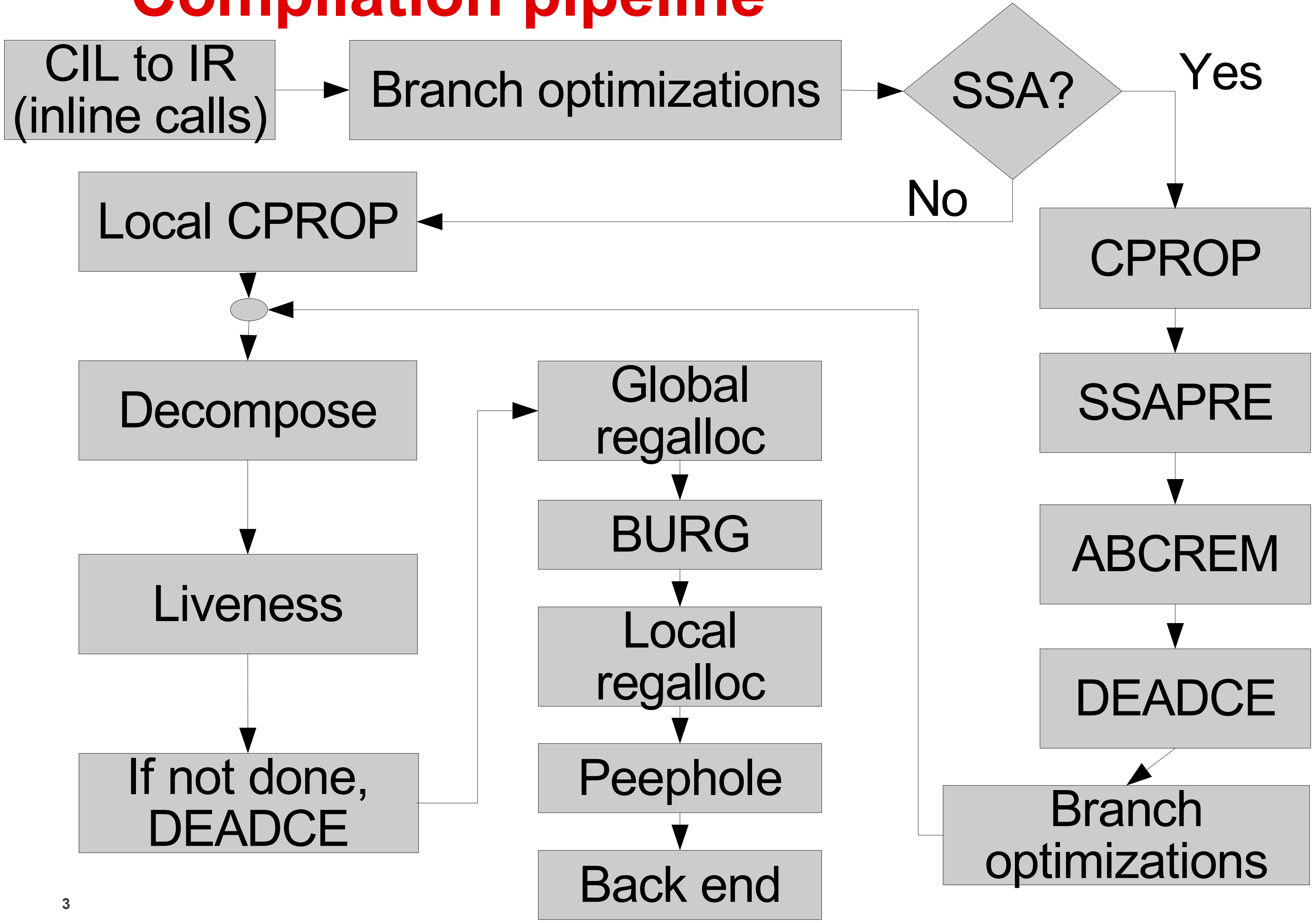
Novell®

Current status

- ✔ Five years old and fairly mature subsystem
- ✔ Supports various optimizations and AOT compilation
- ✔ Ported to x86, PowerPC, Sparc, AMD64, s390, s390x, ARM, IA64, while Alpha and MIPS are underway
- ✔ During these five years has already been rewritten once

Compilation pipeline



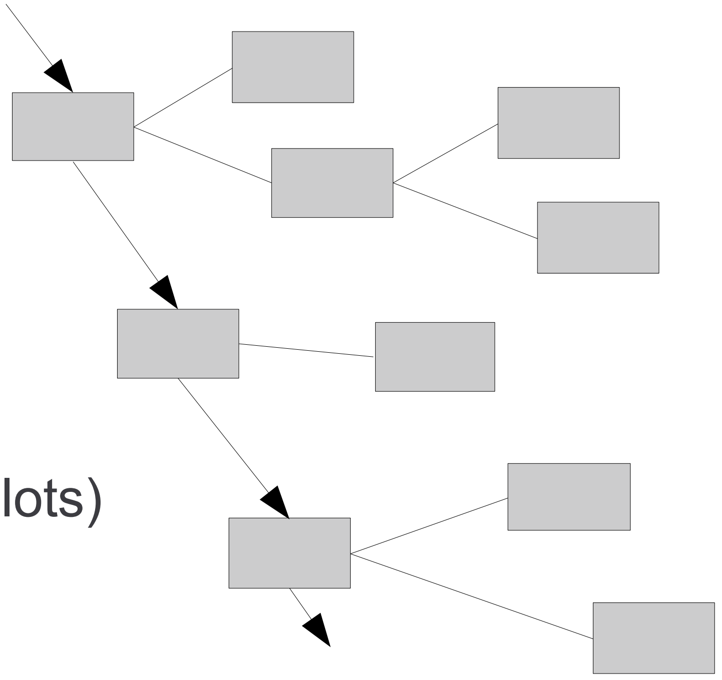
Inline and basic options on by default

- ✔ Cprop, together with deadce, work in synergy and are needed to make inline effective
- ✔ Also a “tree propagation” hack is needed
- ✔ Results
  - ✔ XMLMark/SAX improved by 6%
  - ✔ Fast Fourier Transformation improved by 21% on x86
  - ✔ SciMark improved by 5% on x86 and 2.8% on amd64
  - ✔ Mono bootstrap improved by 2.5%

Partial Redundancy Elimination

- ✔ Includes loop invariant code motion
- ✔ Not enabled by default because it needs tuning and slows the JIT down
- ✔ Results
  - ✔ XMLMark improved by 5% on x86
  - ✔ Fast Fourier Transformation improved by 21% on x86
  - ✔ SciMark improved by 22% on x86 (-7% on amd64)
  - ✔ Mcs bootstrap improved by 3% on hot run (-6% cold)

Intermediate Representation (IR)



- ✔ Tree based IR
  - ✔ CIL arguments and locals correspond to local variables
  - ✔ CIL “homeless values” (stack slots) correspond to tree nodes
- ✔ Opcodes are lower level than CIL ones
- ✔ BURG is used for instruction selection and linearization of the instruction trees

Current issues

- ✔ The regalloc split uses registers suboptimally
  - ✔ Callee saved registers are <u>never</u> used for global variables (and vice-versa)
  - ✔ The “treemover” is needed only because of this
- ✔ Complex optimizations (SSAPRE) need tuning, and interact badly with the regalloc
- ✔ SSA based optimizations are not used by default because they make the JIT slow

Ongoing work: linear IR

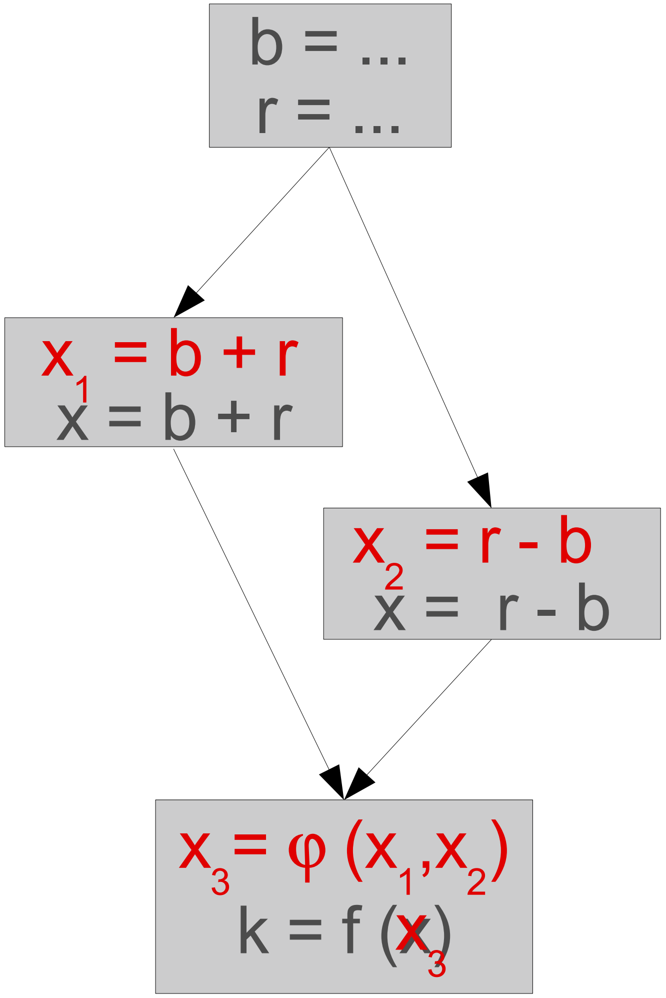
- ✔ No more trees of instructions
  - ✔ All CIL values go into virtual registers (vregs)
  - ✔ BURG is no longer used
  - ✔ All opcodes are decomposed early (low level IR)
- ✔ Vregs are handled uniformly by all passes
- ✔ This makes a unified regalloc possible

Ongoing work: GREG (Global REGalloc)

- ✔ Unifies the current global and local ones
- ✔ Is more accurate
  - ✔ Live ranges are exact, taking holes into account
  - ✔ Can easily split live ranges at any point
  - ✔ Uses “second chance binpacking” to exploit registers as much as possible
  - ✔ The information to tune it (weight number of uses, spill costs...) is easily available
- ✔ Works on code in SSA form

What's this SSA thing?

- ✔ A “refined” form of IR, where each variable use can be reached by exactly one definition
- ✔ Is generally considered expensive to build, but...
- ✔ ...makes everything easier and faster!



How does SSA help GREG?

- ✔ In SSA use-definition relations are very natural
- ✔ Representing each move (also spills) as an SSA definition takes advantage of this simplicity
- ✔ With SSA, high level information on values (think register rematerialization) is readily available
- ✔ A register allocator already does the job of “undoing SSA form”, and actually benefits from SSA while doing this job

Profiling the SSA code on which GREG is based (mono –compile-all mscorlib.dll)

- ✔ With callgrind
  - ✔ SSA, liveness computation and deadce add 15.68%
  - ✔ Old liveness 7.86%, local deadce 6.83%, local cprop 6.16%
- ✔ With oprofile
  - ✔ SSA, liveness computation and deadce add 7.23%
  - ✔ Old liveness 3.96%, local deadce 3.69%, local cprop 3.77%
- ✔ With 'time' (wall clock measurement)
  - ✔ SSA, liveness computation and deadce add 11.84%

Advantages of going fully SSA

- ✔Global optimizations available by default (instead of the local versions we have now)
- ✔No more separate pilelines when more powerful optimizations are enabled
- ✔Every data flow analysis pass gets faster (also liveness computation)

Multilevel IR

- ✔Alias analysis becomes feasible
- ✔High level reasoning becomes faster
- ✔JIT code becomes cleaner
- ✔Eventually, the results of high level analysis passes will be used for interprocedural optimizations

Wrapping up:

- ✔Lots of nice things to do!
- ✔In little time... (we want them all and now)
- ✔Which means: *business as usual*

- ✔For discussion:
  - ✔ Post on “mono-devel-list@ximian.com”
  - ✔ Or to me, at “massi@ximian.com”
  - ✔ ...or let's just talk now!