Recent Advances in Extended Static Checking

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Contract n° IST 015905

This work was funded in part by the Information Society Technologies programme of the European Commission, Future and Emerging Technologies under the IST-2005-015905 MOBIUS Project.

Extended Static Checking for Java

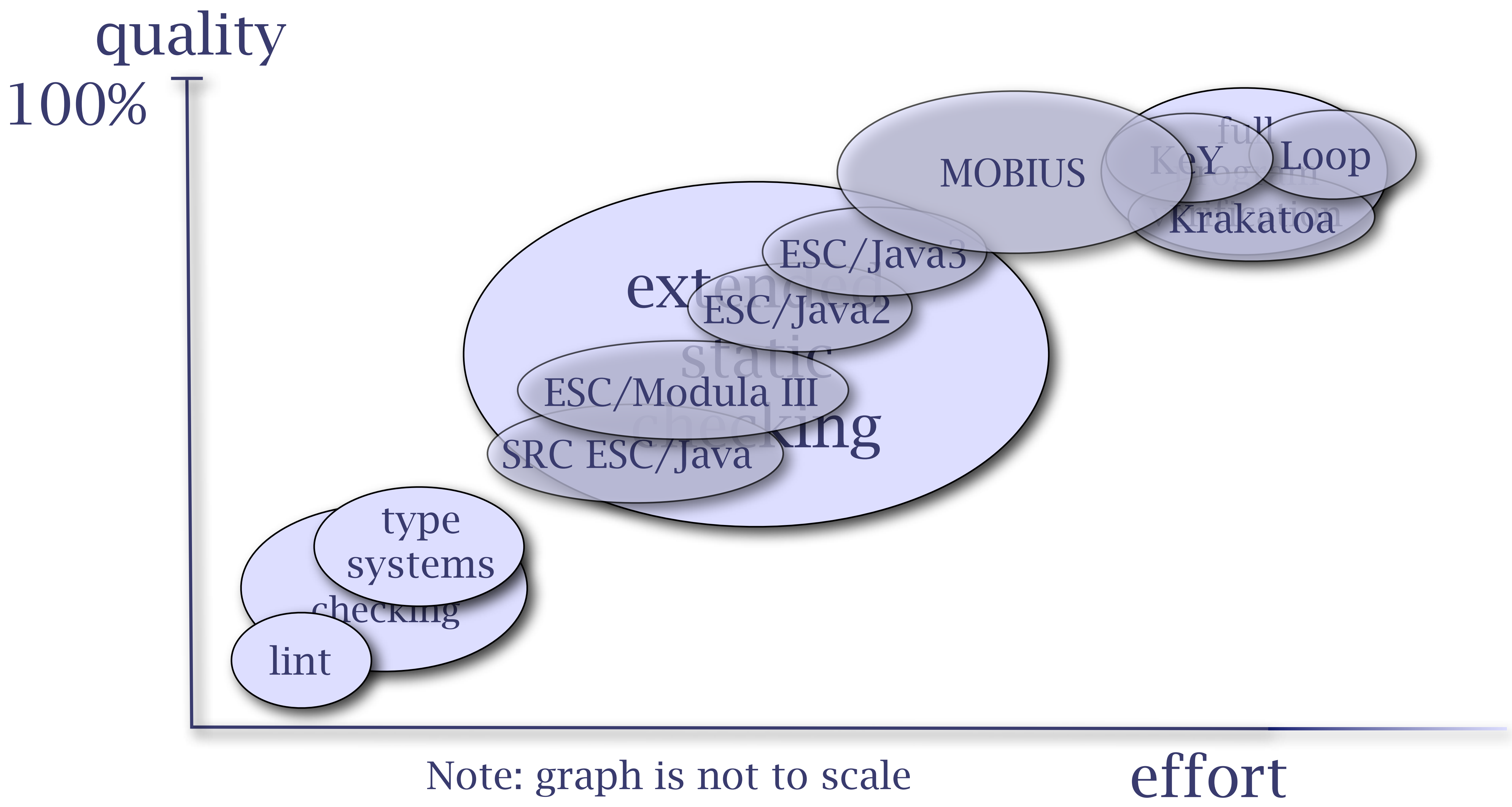
- ESC/Java is an *extended static checker*
  - originated with DEC/Compaq SRC
  - used a minimal annotation language
  - behaves like a compiler
    - error messages similar to javac & gcc
    - completely automated
    - hides enormous complexity from user
- ESC/Java2: an *über*-extended static checker for JML-annotated Java
  - includes about a dozen new ESCers
  - integrated with Eclipse
  - supports multiple logics and provers
  - represents the work of dozens of people

The Mobius Program Verification Environment

- general-purpose architecture for JML/ Java-centric program analysis and verification
- formalized toolbus and architecture based upon existing component model
- integration of automatic and interactive provers (e.g., Simplify, CVC3, and Coq)

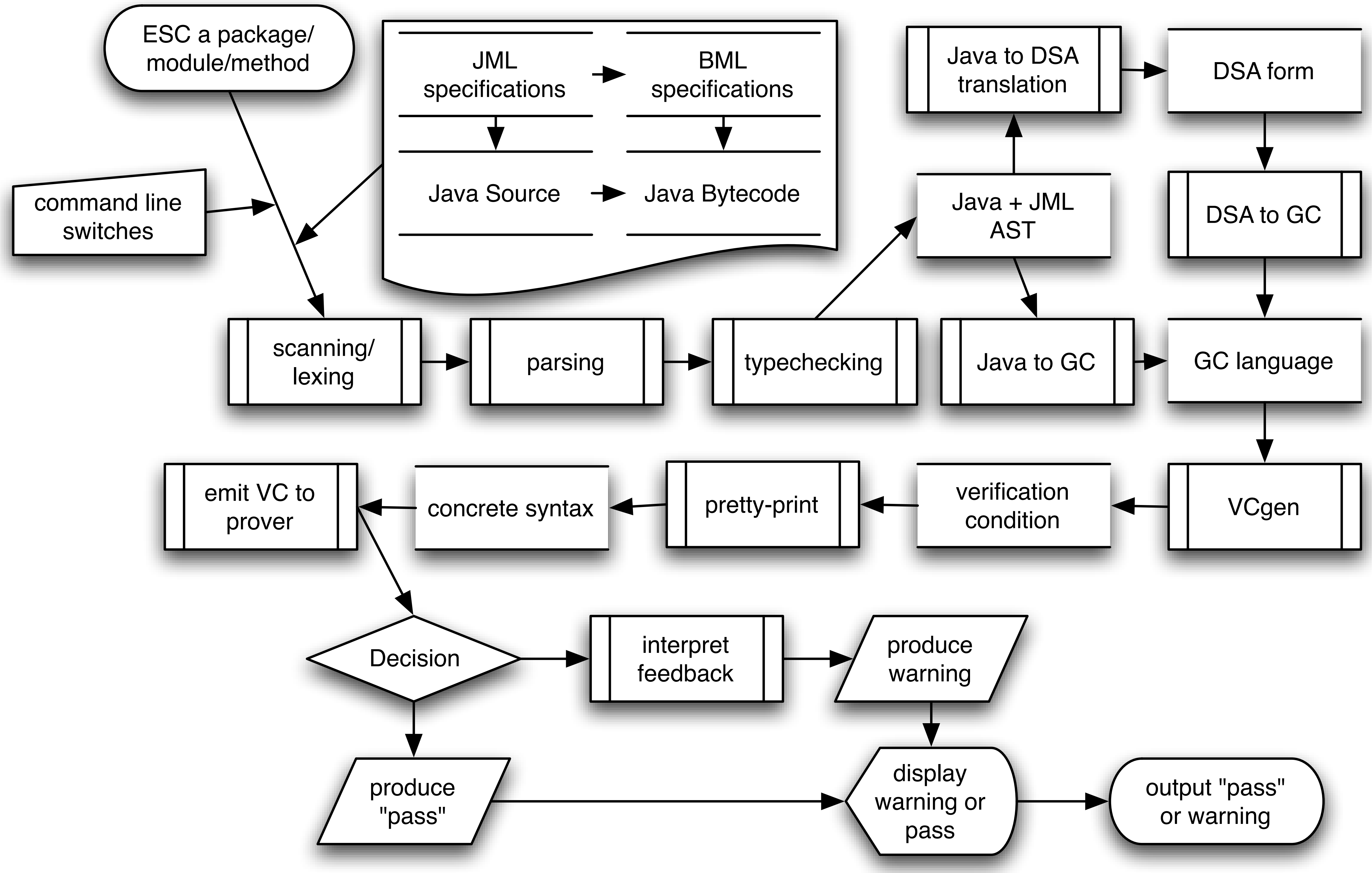
- ESC/Java2 is evolving into ESC/Java3 within this framework

Evolution of Static and Interactive Checkers/Verifiers



Note: graph is not to scale

ESC/Java2 Architecture



ESC’s Key Strengths

- push-button automation
- tool robustness
- user feedback with no user specifications
- integration with popular IDE (Eclipse)
- large amounts of decent documentation
- availability of slides, examples, tutorials
- community size and involvement
- popularity amongst FM community

ESC's Main Weaknesses

- IP issues because of non-standard license
- platform design, implementation, and documentation problems
- the need for fairly complete specs
- insufficient developer involvement (for all the ideas we have)
- false positives and false negatives; aka soundness and completeness issues
- sometimes complex user feedback

Some Features Available in ESC/Java2 in the Mobius PVE

- nearly full JML coverage (with refinement)
- purity checking
- frame axiom checking
- soundness & completeness warning system
- specification consistency checker
- specification-aware dead code detection
- under-defined specification checking
- universes type checking
- AST and GC graphical rendering
- generic automatic prover interface
- sorted and unsorted verification condition representation
- support for multiple automated and interactive provers
- proof generation from an automated prover
- incorporation of other lightweight static checkers
- process integration

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Mobius PVE *Verification Bus* Features

- Mobius VC back-end
  - unsorted and sorted VC representation
  - logic-aware syntax generation to several automatic and interactive theorem provers
    - generation of Mobius VCs in Base Logic in Coq
- Mobius ESC VC back-end
  - generation of ESC VCs in ESC Logics
  - generate ESC VCs for several automatic and interactive theorem provers
  - extended static checking of ESC VCs with rich in-editor feedback

Mobius PVE *Verification Bus* Features

- Mobius Prover back-end
  - generic interaction with a variety of automatic and interactive theorem provers
    - automatic provers supported
      - Simplify, SMT, CVC3, Yices, Fx7
    - interactive provers supported
      - Coq and PVS
  - proof status maintenance
  - proof unit/smoke testing
  - automatic and seamless proof sharing amongst distributed collaborators

Mobius PVE *Verification Bus* Features

- integration of other lightweight static checkers
  - e.g., CheckStyle, FindBugs, and PMD
  - tune rules to guide programmer toward writing code that is easier to ESC and verify
  - regular, lightweight checking early is dramatically better than heavyweight checking late
- help system and process management
  - task and feature tracking
  - online hypertext architecture docs and help

Focus of Current Work

- completely FLOSS software foundation
- complete documentation
- rich platform integration
- multiple provers and multiple logics
- FreeBoogie integration
- improved developer feedback
- full integration into software process
- integration with full verification and refinement-based modeling languages
- new, complex case studies

Ongoing Work

- new JML model classes
  - pure, immutable, functional, executable, referential equality-centric, fully unit tested and ESCed, tuned for static checking
- FreeBoogie subsystem
  - FreeBoogiePL = structured and unstructured BoogiePL + explicit heap + separation logic
  - FreeBoogie VC generation to target Mobius VC back-end, thus support multiple provers

Ongoing Work

- reflective unit testing
  - new generation of JMLunit that is specification, source, and bytecode-aware
- EBON-JML bicompiler
  - seamless and reversible translation to/from EBON to JML
  - refinement will support informal and formal documentation, system events, scenarios, allocation, and ownership
  - domain-specific annotations with formal semantics integrated into refinement

Ongoing Work

- ESC/Java3
  - use new JML front-end (JML[345])
  - reason about Java 1.5 source *and* bytecode
  - target FreeBoogie as IR
  - leverage recent work in separation logic
  - support automated multiple provers
  - selectively target interactive provers
  - perform contextually aware, cross-prover, cross-logic checking
  - deeper process integration, particularly across large teams as architecture evolves

ESC/Java as a Research Vehicle for Static Checking

- dozens of groups use ESC/Java2 for teaching and research
  - use in teaching
    - Java programming
    - software engineering
    - formal methods
  - examples of external research
    - specification under-definedness checker
    - PVS VC generation
    - Houdini "rebirth"
    - Daikon + ESC/Java2 integration

Mobius PVE Status

- full support available for:
  - all Java and nearly all JML features
    - editing, compilation, doc generation, etc.
  - code complexity and style checking
  - source and bytecode-level static checkers
  - partial BML support
    - no editing of BML or bytecode
  - Mobius VC back-end
  - Mobius Prover back-end
  - interactive proof support for Coq

Mobius PVE Next Steps

- next version to integrate the subsystems:
  - full BML support
  - Universe type inference
  - FreeBoogie and the Race Condition Checker
  - user feedback of proof state in JML/Java
  - proof status and unit/smoke testing
  - Mobius VC generator (in Coq)
  - interactive proof support for PVS
  - Coq PCC certificate generation
  - basic help system and process management

Integrating KeY and Mobius and ESC/Java

- integrate the Mobius prover interface in the KeY system
  - KeY can use new SMT provers “for free”
  - provers run locally or remotely
- JML to JavaDL bicompiler
  - theory-aware translation to/from a fragment of JavaDL and JML
- an ESC-centric sublogic
  - understand what kinds of VCs are automatically discharged and build new VCgen that targets that sublogic

Questions or Comments?

Mobius