

## **Wikiprint Book**

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## Mango

Mango is a [Java™](#) assurance tool, deployed as an [Eclipse workbench](#) plugin. Mango is developed as the [jpf-mango](#) extension of [JPF](#).

### Capability

Mango builds a [functional model](#) of Java code, exposed as navigable browser pages. When used as a sanity checker, Mango will halt at every case-split, allowing the programmer to compare code versus model. The functional view of code is often quite different from the code itself, and potentially reveals hidden flaws.

Mango may be of value as an educational tool. Those learning Java as a first programming language now have the opportunity to compare procedural and functional views of code in real time. This comparison facilitates the exposition of formal modeling concepts. For this purpose, the Mango installation contains a comprehensive set of first year Java code [examples](#), together with the corresponding Mango formal models.

Mango may potentially be used to generate and apply filters for known Java security issues. [Oracle](#) has published a set of secure programming [guidelines](#). Use these guidelines to write code snippets exposing potential security problems, apply Mango, and observe the corresponding formal model. From such observations, and possible adjustments to the formal model, develop rules to recognize security issues. Mango has a highly sophisticated rule-based generalized pattern matching capability to enable such rule development. This is currently an active area of Mango development.

The Mango formal model may be translated into [ACL2](#), an automated theorem proving language. In the past, formal proofs of Mango generated conjectures have been accomplished. Mango was originally created for this purpose, and this direction represents the future. But in all honesty a lot of work remains before tangible results may emerge. Anyone interested in pursuing this line of thought should contact the principle Mango developer, frankrimlinger+mango at gmail.com.

Mango was presented as a "formal advisor" at the [2011 JFP Workshop](#). The paper [A Formal Advisor for Eclipse Java Development](#) and corresponding [slides](#) give a technical overview of Mango.

### Installation

To use Mango, it is only necessary to install the plugin. Certainly this will suffice for learning the basic operation of Mango. Actual application of Mango to a real project will probably require the feedback and flexibility of the Mango development platform. The recommendation at this point is to first install the plugin to learn the Mango basics, and then switch to the development platform for more serious work.

### System requirements

The plugin and development platform for Mango have been tested on the most current versions, as of April 27, 2012, of MacOSX, RedHat, and Ubuntu, using the latest release of the Eclipse workbench, Indigo. Mango should run anywhere the Eclipse workbench can be installed, assuming the underlying file system has Unix-like capabilities. Unfortunately, on Windows there is a hard limit of 260 characters on the length of a path name, which currently is a show-stopper for Mango. Mango relies on internals of jpf-core and the Eclipse platform itself, and these change over time, requiring changes in Mango. Every reasonable attempt will be made to keep Mango compatible with previous versions of its own database structure, but no guarantees. The plan is for active Mango development to support the most recent versions of jpf-core and the Eclipse workbench running on MacOSX, RedHat, and Ubuntu. However, the project is officially provided "as is", see the [license](#) for details.

### Installing the Mango plugin

1. Install the most recent version of the Eclipse Workbench from the [Eclipse downloads](#) page. Mango is explicitly developed with the "Eclipse for RCP and RAP Developers" package, but there are no known conflicts with other packages. If you plan to install Mango into an existing Workbench, consider using a new workspace, at least until you have confidence in the stability of the plugin.
2. Switch to the Java perspective of the Eclipse Workbench.
- 3. Install the Mango plugin at update site <http://babelfish.arc.nasa.gov/trac/jpf/raw-attachment/wiki/projects/jpf-mango/update/>
  1. Go to Help>"Install new Software..."
  2. Enter <http://babelfish.arc.nasa.gov/trac/jpf/raw-attachment/wiki/projects/jpf-mango/update/> in the "Work with: " box and hit carriage return, do not press the "Add..." button.
  3. Check the box next to "Mango" when it appears in the window. Hit "Next>".
  4. The feature version will display. Hit "Next>".
  5. License terms must be accepted to acquire the plugin. If acceptable, select "I accept ..." and hit "Finish".
  6. There will be an "unsigned content" security warning. Mango is still developing and there is no content security. Hit "OK".
  7. Hit "Restart Now". Mango currently will not install hot, as this leads to window rendering errors.

- 4. Upon reboot of Eclipse, the "Mango Explorer" and "Specification" views should appear in the java perspective. If these views do not appear or have been closed, they can always be recovered as follows (see figure below):
  1. Go to Window>"Show View">Other... and open the "Mango" folder.
  2. Double-click on "Mango Explorer". The "Mango Explorer" view will appear in the java perspective.
  3. Repeat step a, and double-click on "Specification". The "Specification" view will appear in the java perspective.



1. Recommendation: Drag the "Mango Explorer" tab so that both "Package Explorer" and "Mango Explorer" views are visible, next to each other (see figure below). If you have never moved views around before by dragging their tabs, this will require some experimentation. You can always go to Window>"Reset Perspective..." if things don't work out on the first try.



===Installing the Mango development platform===

The Mango development platform allows you to extend Mango functionality and/or fix bugs. If you are new to Mango, you may wish to go directly to [Getting Started](#).

1. Install the most recent version of [Mercurial](#).
1. Install the [Mercurial Eclipse](#) plugin into the Eclipse workbench. The site for this plugin is <http://cbes.javaforge.com/update>

## Getting started

## Examples

## Users Manual

## Bugs

## Current Development

## Contributing to Mango

## History of Mango

jpf-mango

**NEW!** [Case splits now enhanced with boolean semantics](#)

[Native Resolution and Opaque Links \(DiceRolls\)](#)

[Mango Eclipse plugin High School Code example \(CarRecall\)](#)

[Mango Eclipse plugin introductory demo](#)

[Mango paper for JPF Workshop 2011](#)

[Screen shot: Mango "wakes up" inside the Workbench](#)

[EclipseCon 2011 Slides and Transcript](#)

[Archived Examples](#)

**Purpose:** To provide a case by case specification of Java™ source code, analogous to Javadoc but more rigorous. To provide "proof artifacts" to a theorem prover, enabling the mathematical proof of code properties.

**Ultimate Goal:** To integrate the generation of code, specification, and correctness proofs so that a programmer may produce a more reliable product with the same level of effort.

**Theory of Operation:** The code is first converted to a large graph of vertices (instructions) and directed edges (branch conditions), often referred to as the flow control diagram. This conversion occurs at the byte code level, which is convenient because the byte codes are described very succinctly in

terms of the state of the Java Virtual Machine (JVM). This conversion is essentially accomplished by the JPF core engine. The Mango formal peer code then generates for each byte code a description in terms of the Mango formal model. A graph subdivision algorithm is applied to the control flow, generating a hierarchical sequence of graphs required to describe the loops within the code as recursive functions. JPF is then used to walk these graphs for the purpose of generating the specification and proof artifacts. The backtracking ability of JPF is utilized to generate cases, and the ability to trace back along trails is leveraged in order to compute loop invariants. Ideally, the process would be fully automated, but in practice when Mango requires guidance from the user, JPF will block and a gui thread will interact with the user to obtain the information required to proceed. The specification and proof artifacts are stored in persistent form exposed to the user in a rule base format, enabling reuse and incremental, distributed operation.

**Limitations:** Mango only specifies "good" cases, exposing input constraints required to satisfy such cases. Some user guidance is required to determine what constitutes a good case. It may happen that even the number of good cases grows exponentially. The user must then provide case generalization logic to abstract away explosive case growth. Such abstractions must also be accompanied by type and translation logic, which the user must provide. Although Mango does generate loop termination conjectures, such conjectures are generally in terms of loop output. Typically the user must provide guidance to form hypotheses for loop termination in terms of loop inputs. Correctness of such hypotheses may be confirmed by an automated theorem prover, which typically requires expert guidance.

**Status:** Mango is based on technology released by the Nasa/Ames Software Release Authority in September, 2008. Much of the original code base was written in C++. By Spring, 2009, the code base was migrated to 100% pure Java, and integrated with Eclipse RCP, the rich client platform. The original code base did not use JPF. Full integration with JPF commenced in the Summer of 2009 and should be complete by January 2010. The tool should achieve an initial operational capability by Spring 2010. Ultimately, the tool will be deployed as an Eclipse workbench plugin.

**Research:** Previous versions of the tool did generate artifacts for the ACL2 theorem prover and substantial proofs were accomplished. Efforts are just getting started to lightly embed the current Mango model in ACL2. However, the proof artifacts are essentially just expressions in the Mango model of definitions, hypotheses and conjectures, and as such are theorem prover neutral. There is no automatic facility for generation of hypotheses on loop inputs required to prove termination. Needless to say, this is a fundamental tool weakness and contributions in this area would be most welcome. (Caveat emptor: there is no general purpose algorithm for determining loop termination, but constructive solutions exist for typical circumstances.)

(Jan 9, 2012) An alpha version of the Eclipse plugin should be released in Feb, 2012. The update site is

<http://babelfish.arc.nasa.gov/trac/jpf/raw-attachment/wiki/projects/jpf-mango/update/>