

# Proteum/AJ: Supporting Mutation Test of OO and AO Programs

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# Collaborators

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- José Carlos Maldonado (USP, Brazil)
- Filipe Gomes Leme (USP, Brazil)
- Awais Rashid (Lancaster University, UK)
  
- Elisa Nakagawa (USP, Brazil) – version 1.0

## Financial support:



# Underlying Research

- Characterisation of fault types for AO software
- Definition of fault taxonomy for AO software
- Definition of mutation operators for AO programs
- Automation of mutation testing for OO and AO programs

[1] Ferrari, F. C.; et al. An exploratory study of fault-proneness in evolving aspect-oriented programs. In: ICSE'2010, Cape Town, South Africa.

[2] Ferrari, F. C.; Burrows, R.; Lemos, O. A. L.; Garcia, A.; Maldonado, J. C. Characterising faults in aspect-oriented programs: Towards filling the gap between theory and practice. In: SBES'2010, Salvador, Brazil.

[3] Ferrari, F. C.; Maldonado, J. C.; Rashid, A. Mutation testing for aspect-oriented programs. In: ICST'2008), Lillehammer - Norway.

[4] Ferrari, F. C.; Nakagawa, E. Y.; Rashid, A.; Maldonado, J. C. Automating the mutation testing of aspect-oriented Java programs. In: AST'2010, Cape Town – South Africa.

# Overview: Proteum/AJ

- Command line-based and GUI-based execution
- Supports all steps of mutation testing
  - Program execution
  - Mutant creation
  - Mutant execution
  - Mutant analysis
- Handles Java and AspectJ programs
- Test projects and results are stored into a relational database
- User Manual

# Dependencies

Library	License
ant-launcher ant ant-junit commons-lang ibatis	Apache v2.0
aspectj-front aterm java-front strategoxt	LGPL v2.1
mysql-connector sdf2-bundle	GPL v2.0

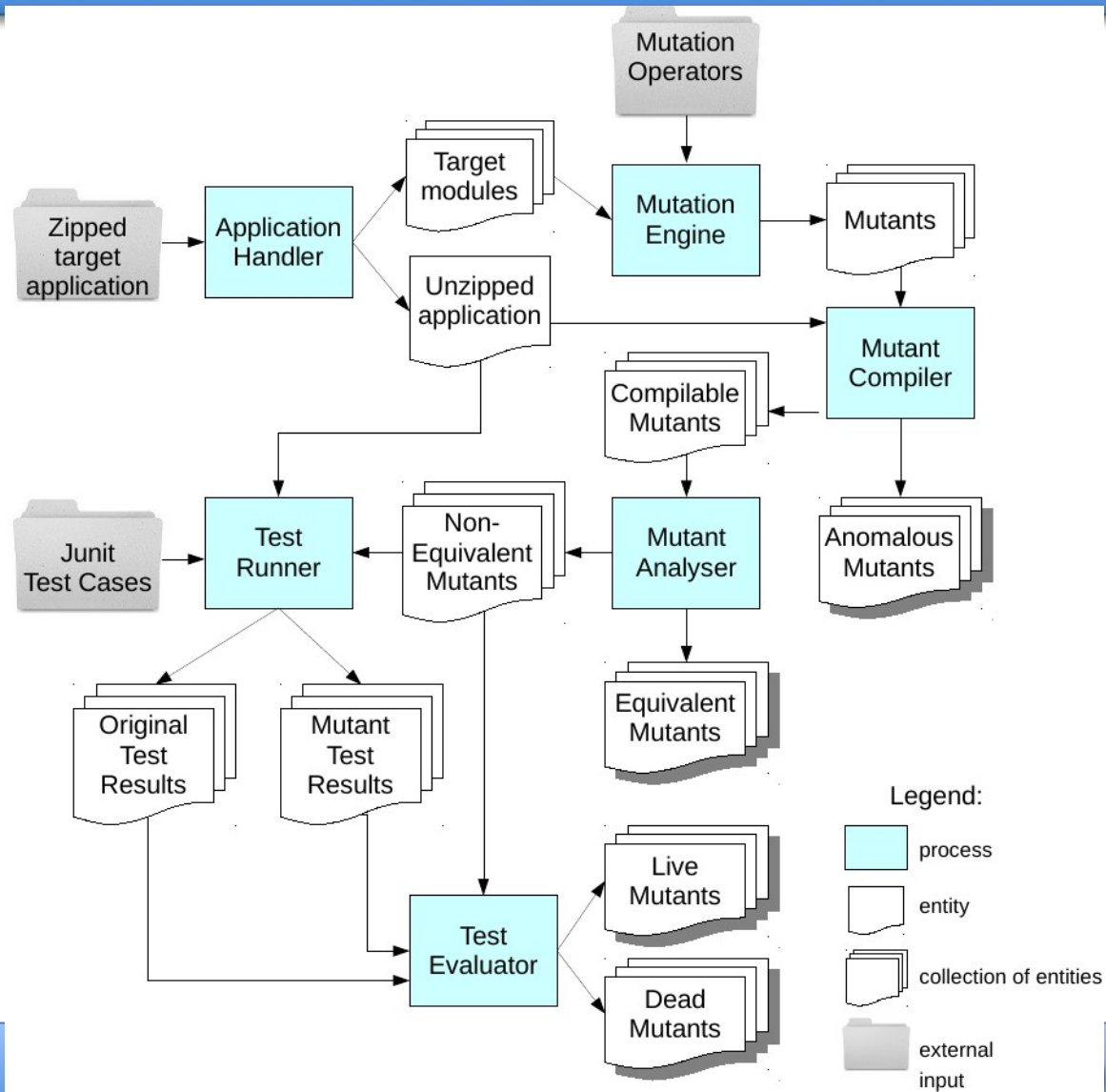
# Licenses: Conflict Analysis

[1]

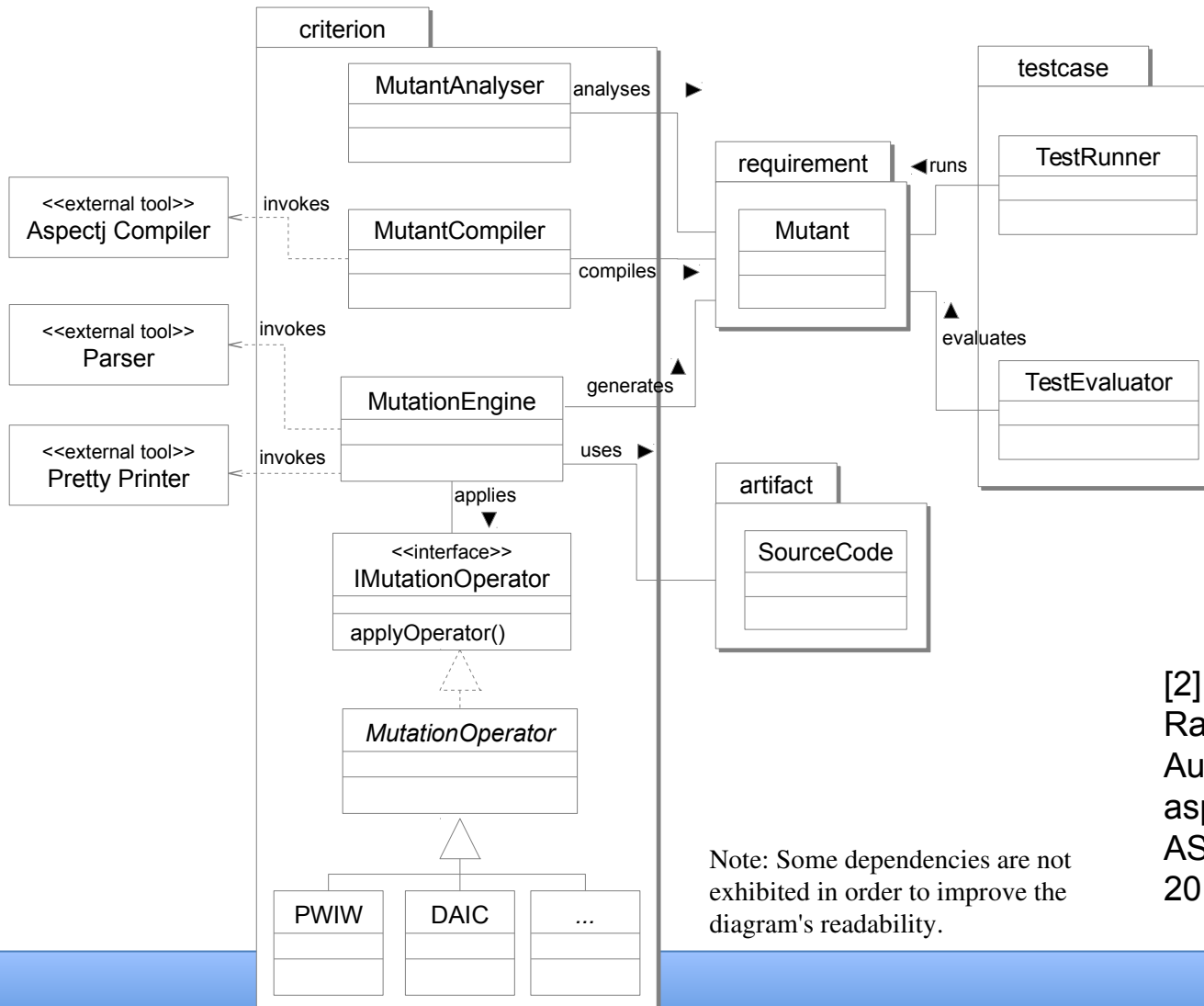
- Compatibility between Apache v2.0 and and GPL v3.0
- **Incompatibility between GPL v2.0 and GPL v3.0**
- **Incompatibility between GPL v2.0 and Apache v2.0**
- Compatibility between LGPL v2.1 and GPL v3.0
- For Proteum/AJ, libraries licensed as GPL v2.0 may be distributed as GLP v3.0:
  - *"This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, **or (at your option) any later version**"*

[1] Buzachero, H. O.; Ferrari, F. C.; Maldonado, J. C.: Defining a set of guidelines for licensing open source software. In: SIICUSP'11, São Carlos/SP - Brasil, 2011.

# Workflow



# Version 1's Main Modules [2]

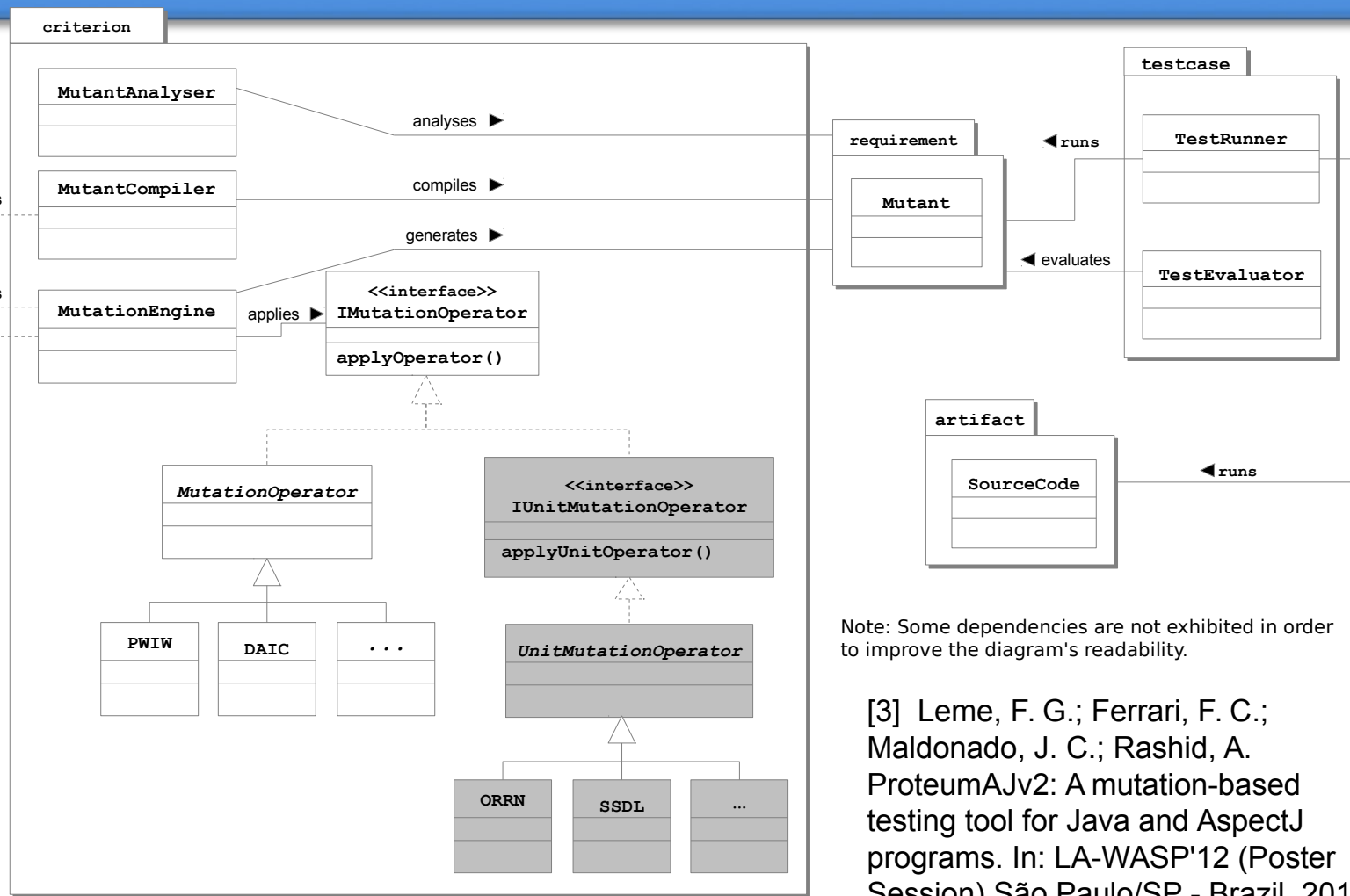


Note: Some dependencies are not exhibited in order to improve the diagram's readability.

[2] Ferrari, F. C.; Nakagawa, E. Y.; Rashid, A.; Maldonado, J. C. Automating the mutation testing of aspect-oriented Java programs. In: AST'10, Cape Town - South Africa, 2010, p. 51–58.



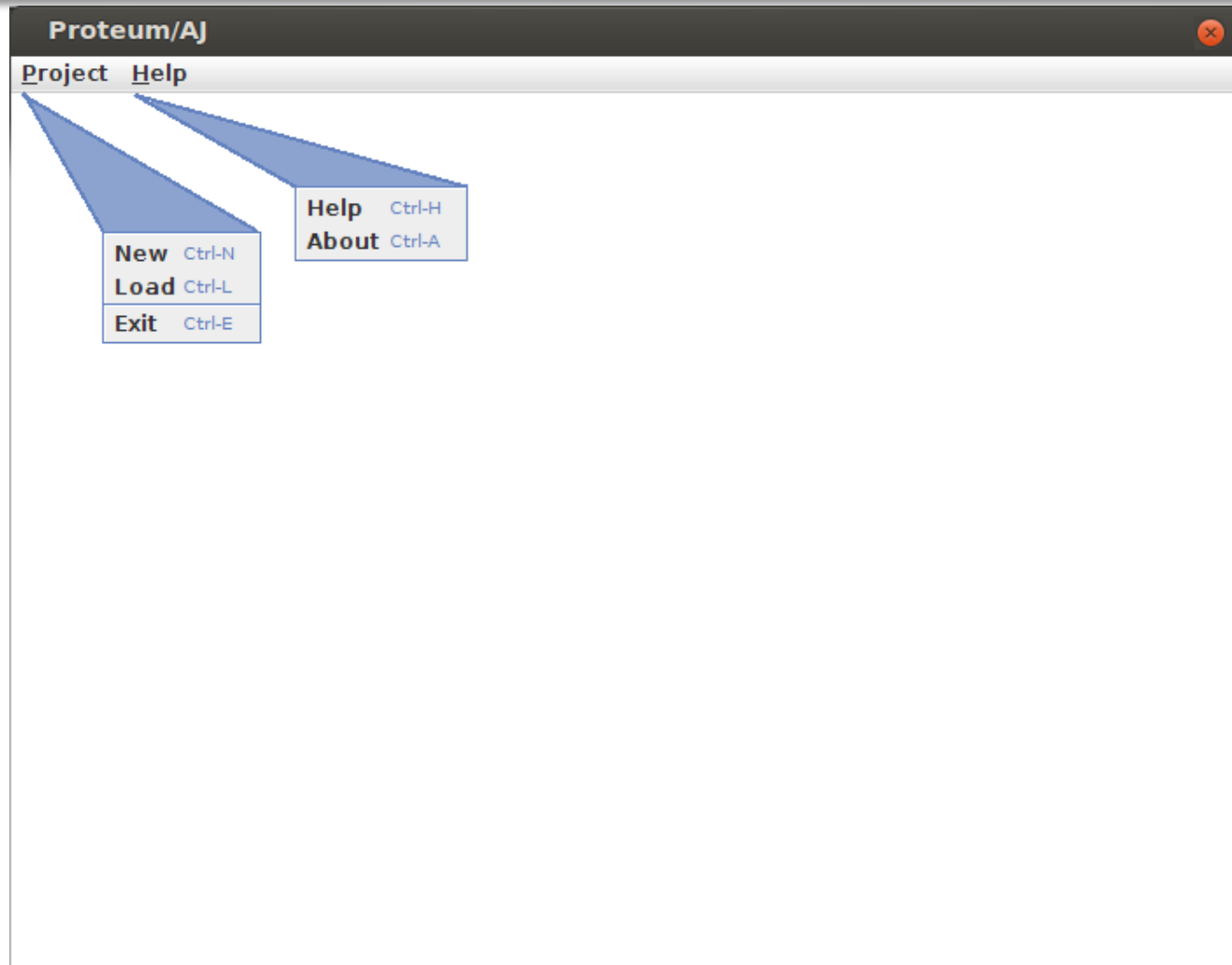
# Version 2's Main Modules [3]



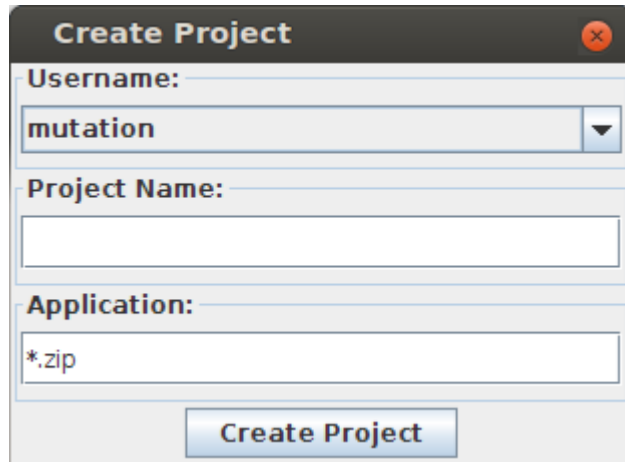
Note: Some dependencies are not exhibited in order to improve the diagram's readability.

[3] Leme, F. G.; Ferrari, F. C.; Maldonado, J. C.; Rashid, A. ProteumAJv2: A mutation-based testing tool for Java and AspectJ programs. In: LA-WASP'12 (Poster Session) São Paulo/SP - Brazil, 2012, p. 47–48.

# Main Window

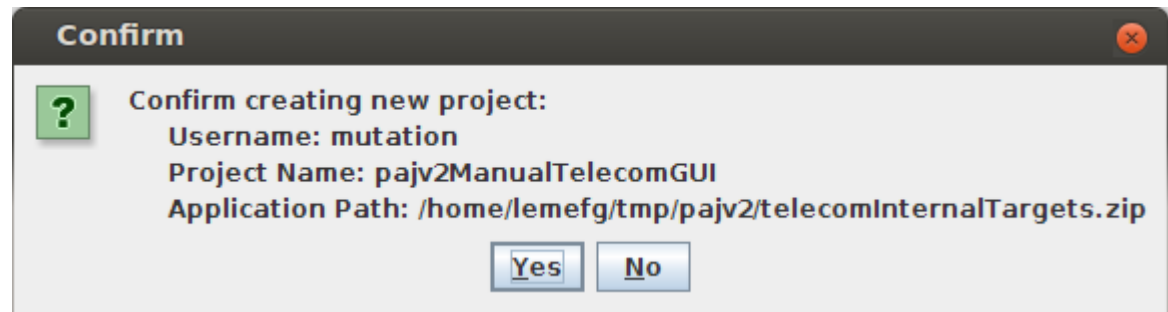


# Project Creation



The 'Create Project' dialog box contains the following fields and controls:

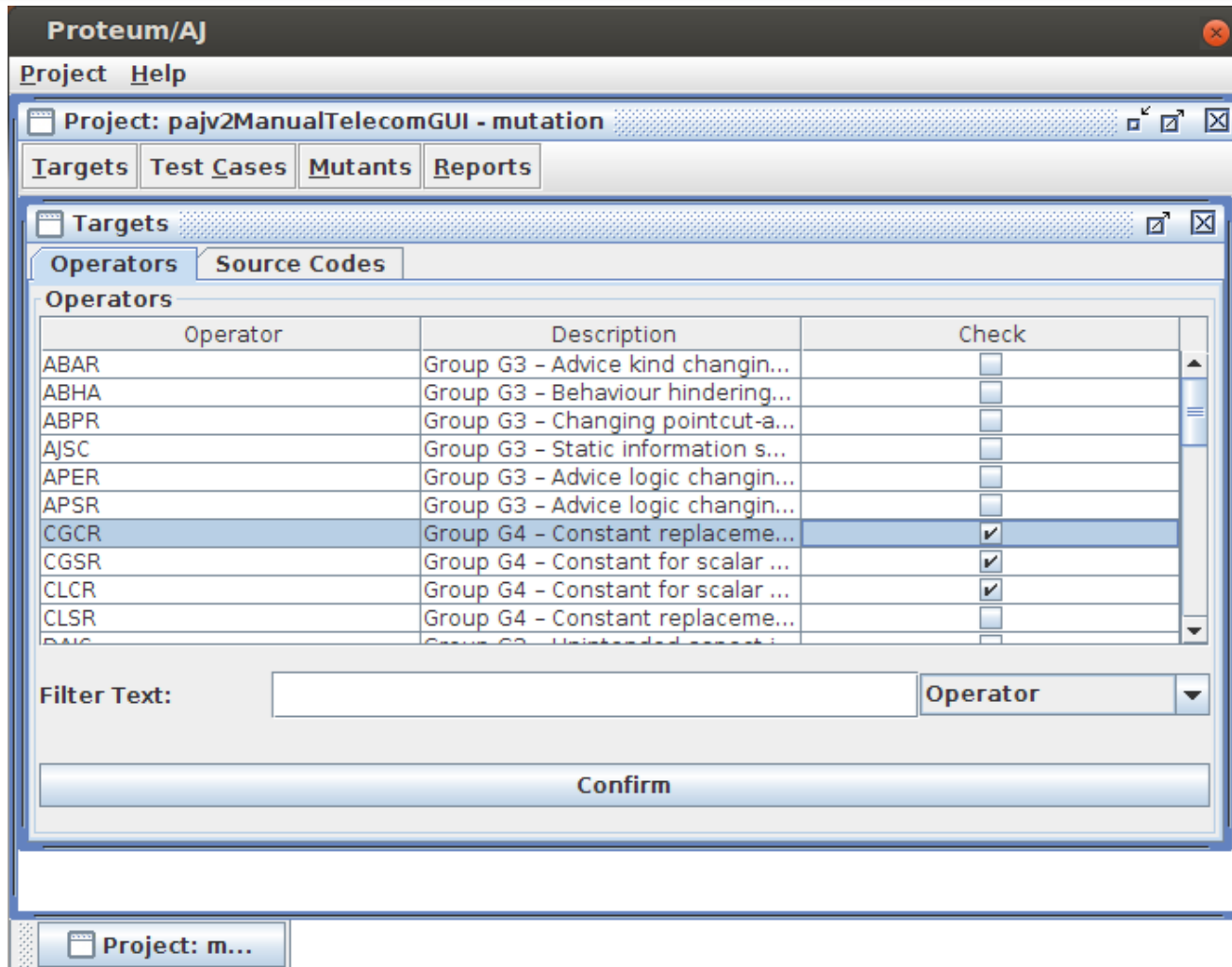
- Username:** A dropdown menu with 'mutation' selected.
- Project Name:** An empty text input field.
- Application:** A text input field containing '\*.zip'.
- Create Project:** A button at the bottom of the dialog.



The 'Confirm' dialog box displays the following information:

- Confirm creating new project:** The main title of the dialog.
- Username: mutation**
- Project Name: pajv2ManualTelecomGUI**
- Application Path: /home/lemefg/tmp/pajv2/telecomInternalTargets.zip**
- Yes** and **No** buttons for confirmation.

# Mutation Operator Selection



# Target Selection

**Proteum/AJ**

Project Help

Project: pajv2ManualTelecomGUI - mutation

Targets Test Cases Mutants Reports

Targets

Operators Source Codes

Source Codes

Source Code Id	Name	Content	Available
1	Billing.aj	/*Copyright (c) Xer...	addCharg
2	TimerLog.aj	/*Copyright (c) Xer...	AfterAdvic
3	Timing.aj	/*Copyright (c) Xer...	getTotalC
4	Timer.java	/*Copyright (c) Xer...	stop getT

Filter Text:  Source

Add/Remove Source Codes

Project: m...

**Modify Source Codes**

Source Code:

- executionFiles/execution/mutationpajv2ManualTelecomGUI/original
  - build
    - build.properties
    - build.xml
    - internalTargets.lst
  - lib
  - src
    - telecom
      - Billing.aj
      - Call.java
      - Connection.java
      - Customer.java
      - Local.java
      - LongDistance.java
      - Timer.java
      - TimerLog.aj
      - Timing.aj
    - targets.lst

src/telecom/LongDistance.java

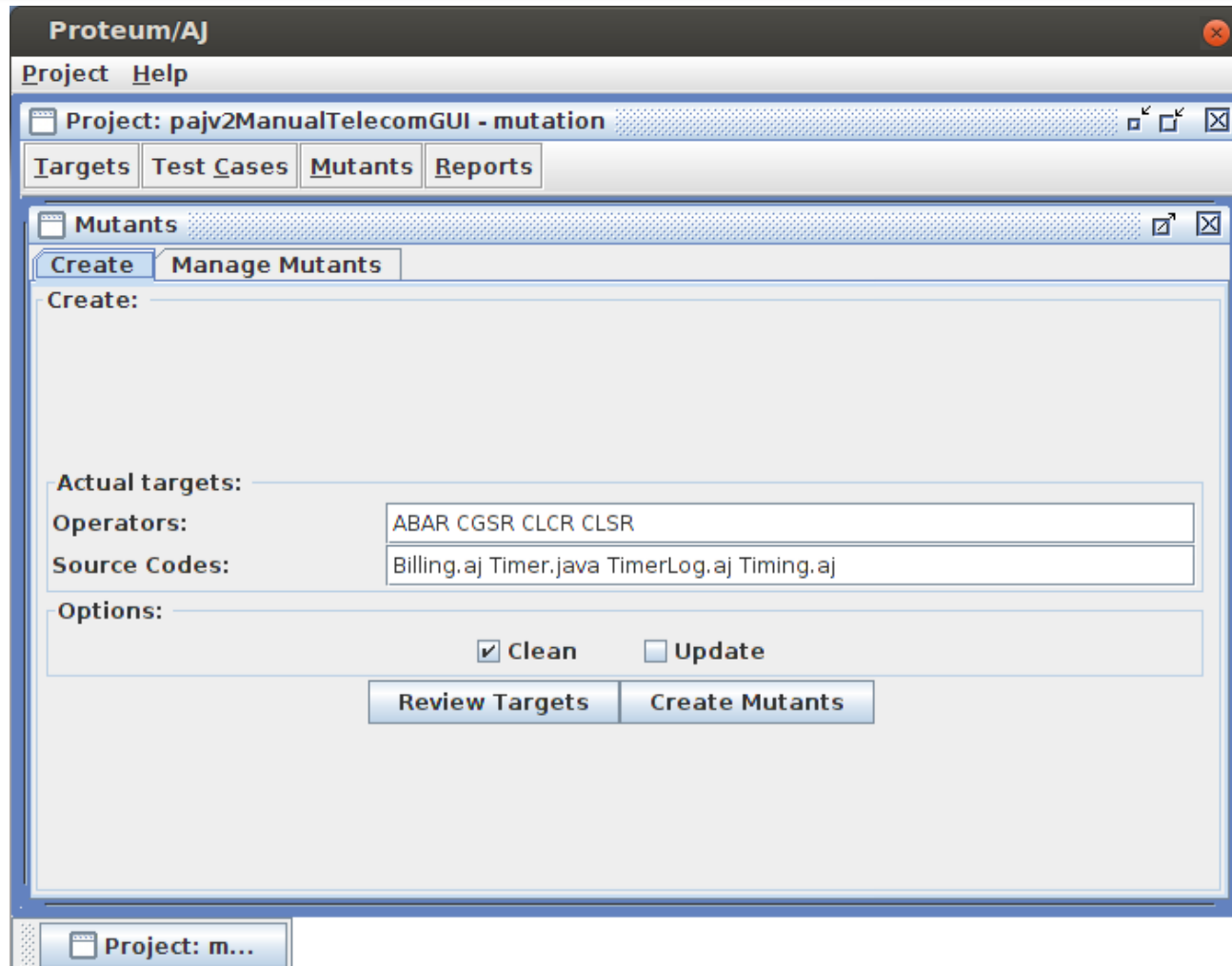
Operation:

Add  Remove

Internal Targets:

Confirm

# Mutant Creation



# Mutant Management

Project: pajv2ManualTelecomGUI - mutation

Targets Test Cases **Mutants** Reports

Mutants

Create Manage Mutants

Management:

Muta...	Sourc...	Sourc...	Opera...	Target	Content	Differ...	Status	Check
1	1	Billing...	ABAR		packa...	31 < ...	alive	<input type="checkbox"/>
2	1	Billing...	ABAR		packa...	52 < ...	alive	<input type="checkbox"/>
3	2	Timer...	ABAR		packa...	5 < ...	alive	<input type="checkbox"/>
4	2	Timer...	ABAR		packa...	10 < ...	alive	<input type="checkbox"/>
5	3	Timin...	ABAR		packa...	19 < ...	alive	<input type="checkbox"/>
6	3	Timin...	ABAR		packa...	26 < ...	alive	<input type="checkbox"/>

Operations:

Compile:

Residue

Compile (Selected)

Set status to:

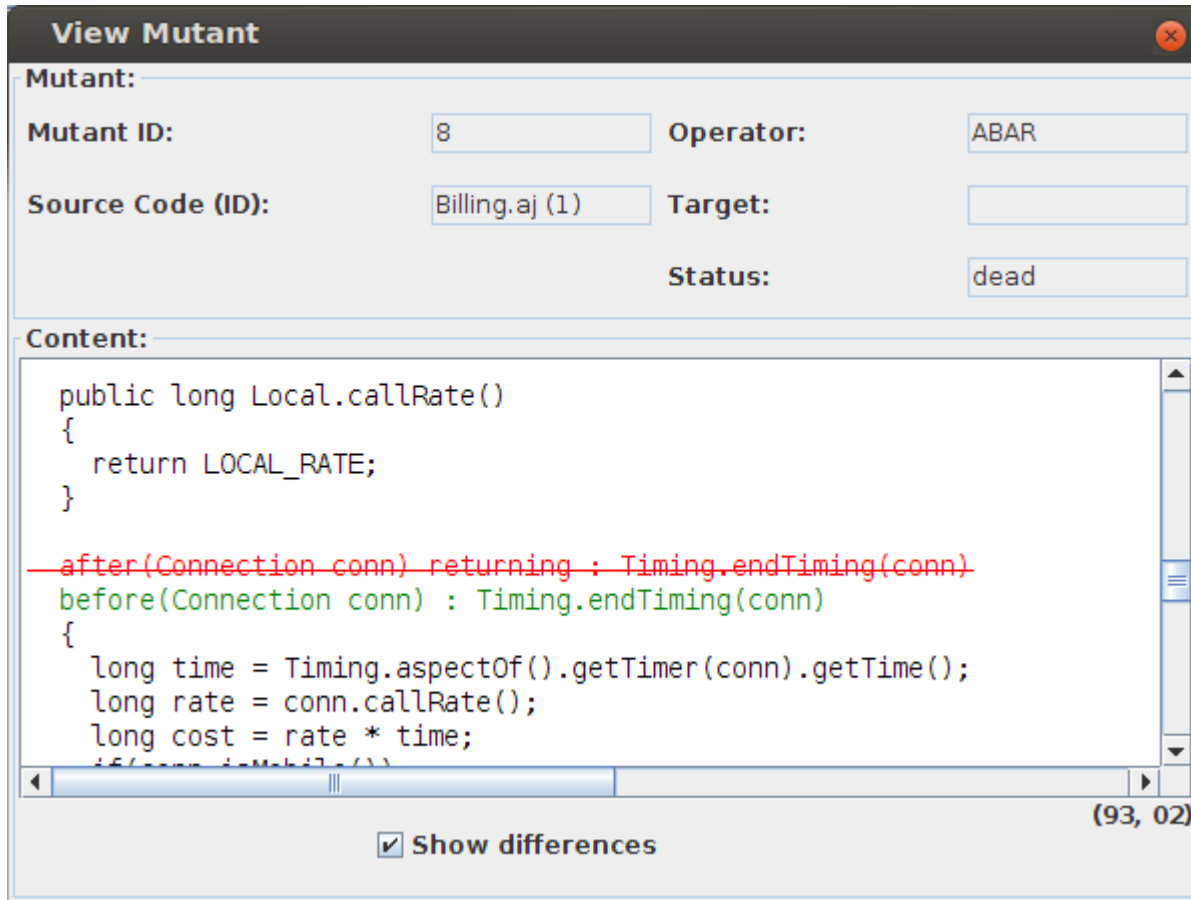
Alive  Equivalent

Change (Selected)

Filter Text:  Mutant ID

Project: m...

# Mutant Visualisation



The screenshot shows a window titled "View Mutant" with a close button in the top right corner. The window is divided into two main sections: "Mutant:" and "Content:".

**Mutant:**

- Mutant ID:** 8
- Operator:** ABAR
- Source Code (ID):** Billing.aj (1)
- Target:** (empty)
- Status:** dead

**Content:**

```
public long Local.callRate()
{
    return LOCAL_RATE;
}
after(Connection conn) returning : Timing.endTiming(conn)
before(Connection conn) : Timing.endTiming(conn)
{
    long time = Timing.aspectOf().getTimer(conn).getTime();
    long rate = conn.callRate();
    long cost = rate * time;
    if (conn.isMobile())
```

At the bottom of the window, there is a checkbox labeled "Show differences" which is checked. The coordinates "(93, 02)" are displayed in the bottom right corner of the content area.



# Test Case Management

Proteum/AJ

Project Help

Project: pajv2ManualTelecomGUI - mutation

Targets Test Cases Mutants Reports

Tests Case

Manage

Test case id	Name	Class name	Status	Check
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Filter Text:  Test case id ▼

Import Test Cases

Project: m...

Run Selected Options

- Original
- Mutants
- No selected mutants.
- Alive
- Residue
- Timeout

Check Selected Mutants

Run

Add Test

Test file:

Import tests

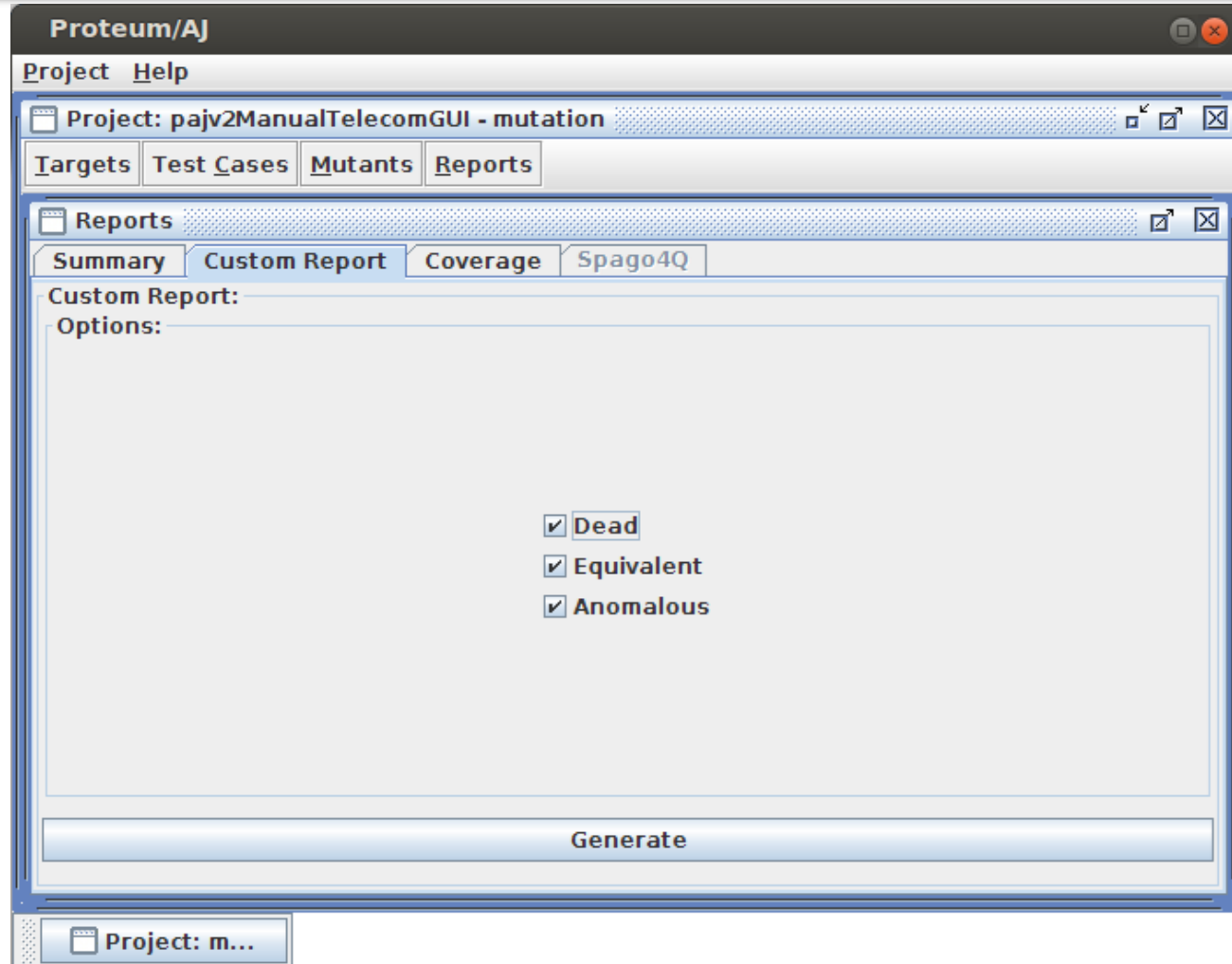
# Test Report

The screenshot shows the Proteum/AJ application window. The title bar reads 'Proteum/AJ'. Below it is a menu bar with 'Project' and 'Help'. The main window has a tabbed interface with 'Project: pajv2ManualTelecomGUI - mutation' selected. Underneath are buttons for 'Targets', 'Test Cases', 'Mutants', and 'Reports'. The 'Reports' window is open, showing tabs for 'Summary', 'Custom Report', 'Coverage', and 'Spago4Q'. The 'Summary' tab is active, displaying the following data:

Total Mutants:	127	
Anomalous Mutants (# / %):	16	12.60%
Compilable Mutants (# / %):	111	87.40%
Live Mutants (# / %):	27	21.26%
Dead Mutants (# / %):	38	29.92%
Equivalent Mutants (# / %):	46	36.22%
Mutation Score:	0.5846154	

At the bottom of the window, there is a 'Project: m...' button.

# Test Report - Custom Reports



# Test Report - Custom Reports

Proteum/AJ

Project Help

Project: pajv2ManualTelecomGUI - mutation

Targets Test Cases Mutants Reports

Reports

Summary Custom Report Coverage Spago4Q

Operator   ...	# Mutants	# Anomalo...	# Live Mut...	# Compila...	# Equivale...	# Dead Mu...	Operator ...
ABAR	6	1	2	5	0	3	0.6
ABHA	7	0	1	7	0	6	0.857
ABPR	10	6	2	4	0	2	0.5
AJSC	0	0	0	0	0	0	0
APER	2	0	1	2	0	1	0.5
APSR	2	0	0	2	0	2	1
CGCR	0	0	0	0	0	0	0
CGSR	0	0	0	0	0	0	0
CLCR	0	0	0	0	0	0	0
CLSR	0	0	0	0	0	0	0
DAIC	0	0	0	0	0	0	0
DAPC	1	0	0	1	0	1	1
DAPO	1	0	0	1	0	1	1

Filter Text:  Operator | Test Case

Options:

By Test Cases  By Operators

Project: m...

# Issues and Limitations

- Known issues:
  - Required fixes:
    - mutant visualisation (some mutants are not properly displayed)
    - mutant creation (SSDL operator does not work for some applications)
- Limitations:
  - Complex infrastructure to install the tool
  - Support to a subset of unit-level mutation operators

# Future Improvements

- Purely Java-based mutation engine to eliminate dependency with AspectJ-front
- Support to higher order mutations
- Support to class level mutation operators

# Current Work

- Support for Experimentation:
  - Infrastructure (IDE, Proteum/AJ, database etc.) installed in a virtual machine.
- Support for cost reduction strategies
  - MSc Thesis defense on Monday, 20/10/2014.