Interactive fixes for software configuration

Yingfei Xiong, Peking University

Cooperation with:

Peking University	Bo Wang, Hansheng Zhang, Jie Wang, Haiyan Zhao, Wei Zhang
University of Waterloo	Leonardo Passos, Steven She, Krzysztof Czarnecki
University of Namur	Arnaud Hubaux

2013

北京大学软件工程研究所

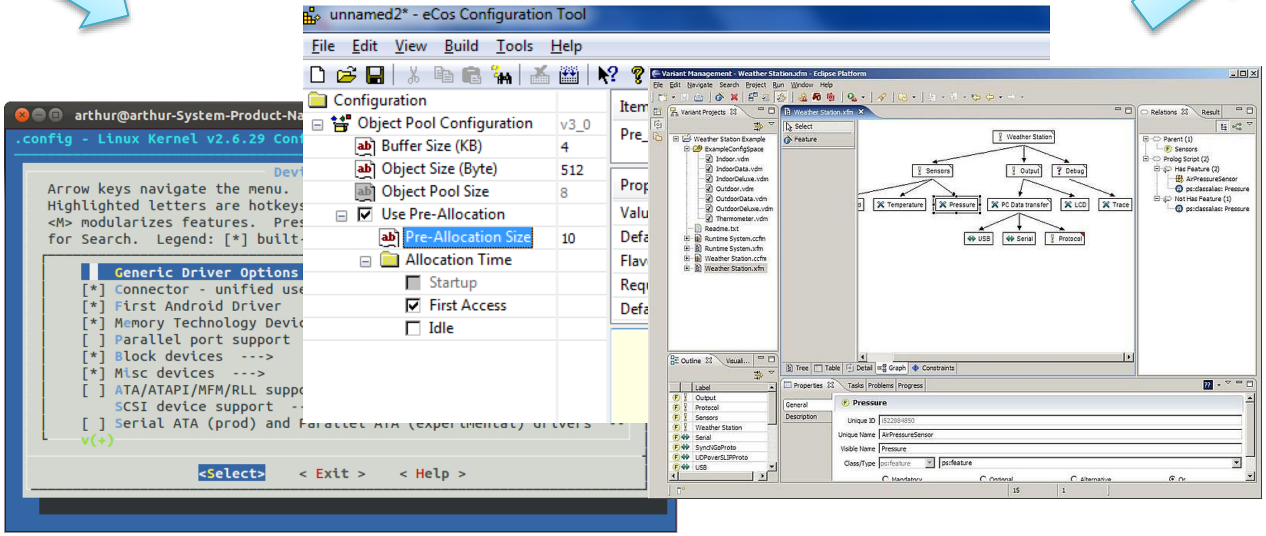
- 国内最早开展软件工程研究、规模最大、最有影响力的软件工程研究团队
- 院士三名（含双聘一名），博士生导师10名，硕士生导师13名
- 在软件工程顶级会议发表论文数占大陆总数约三分之二
- 获得ACM SIGSOFT杰出论文奖三次，大陆共获奖四次，香港共获奖一次

北京大学软件工程研究所

- 多名来自大连理工的优秀同学
  - 吴倩， 2008级博士
    - 从事软件数据挖掘领域研究
    - 已经在WWW等多个顶级会议上发表论文
  - 黎萱，2012级博士
    - 读研一年已经在缺陷解释上做出出色工作
    - 投稿到软件工程顶级会议ICSE上
- 带她们向母校老师同学问好！

Variability Models & Configurators

Configuration



arthur@arthur-System-Product-Na
unnamed2* - eCos Configuration Tool
File Edit View Build Tools Help
Variant Management - Weather Station.xfm - Eclipse Platform
File Edit Navigate Search Project Run Window Help
Variant Projects
Weather Station.xfm
Relations
Result
Select
Feature
Weather Station
Sensors
Output
Debug
Temperature
Pressure
PC Data transfer
LCD
Trace
USB
Serial
Protocol
Tree Table Detail Graph Constraints
Properties Tasks Problems Progress
General
Description
Outline
Visuali...
Item
Pre_
Prop
Valu
Defa
Flav
Requ
Defa

```
.config - Linux Kernel v2.6.29 Conf
                                                        Devi
  Arrow keys navigate the menu.
  Highlighted letters are hotkeys
  <M> modularizes features.  Pres
  for Search.  Legend: [*] built-

        Generic Driver Options
    [*] Connector - unified use
    [*] First Android Driver
    [*] Memory Technology Devic
    [ ] Parallel port support
    [*] Block devices  --->
    [*] Misc devices  --->
    [ ] ATA/ATAPI/MFM/RLL suppo
        SCSI device support  --
    [ ] Serial ATA (prod) and Parallel ATA (experimental) drivers  --
    v(+)

            <Select>    < Exit >    < Help >
```

Configuration
- ⊟ Object Pool Configuration v3_0
  - Buffer Size (KB) 4
  - Object Size (Byte) 512
  - Object Pool Size 8
  - ⊟ ☑ Use Pre-Allocation
    - Pre-Allocation Size 10
    - ⊟ Allocation Time
      - ▨ Startup
      - ☑ First Access
      - □ Idle

- ⊟ Weather Station Example
  - ⊟ ExampleConfigSpace
    - ☑ Indoor.vdm
    - ☑ IndoorData.vdm
    - ☑ IndoorDeluxe.vdm
    - ☑ Outdoor.vdm
    - ☑ OutdoorData.vdm
    - ☑ OutdoorDeluxe.vdm
    - ☑ Thermometer.vdm
  - Readme.txt
  - ⊞ Runtime System.ccfm
  - ⊞ Runtime System.xfm
  - ⊞ Weather Station.ccfm
  - ⊞ Weather Station.xfm

- ⊟ Parent (1)
  - Sensors
- ⊟ Prolog Script (2)
  - ⊟ Has Feature (2)
    - AirPressureSensor
    - ps:classalias: Pressure
  - ⊟ Not Has Feature (1)
    - ps:classalias: Pressure

Label
- Output
- Protocol
- Sensors
- Weather Station
- Serial
- SyncNGoProto
- UDPoverSLIPProto
- USB

Pressure

Unique ID i522984850

Unique Name AirPressureSensor

Visible Name Pressure

Class/Type ps:feature ps:feature

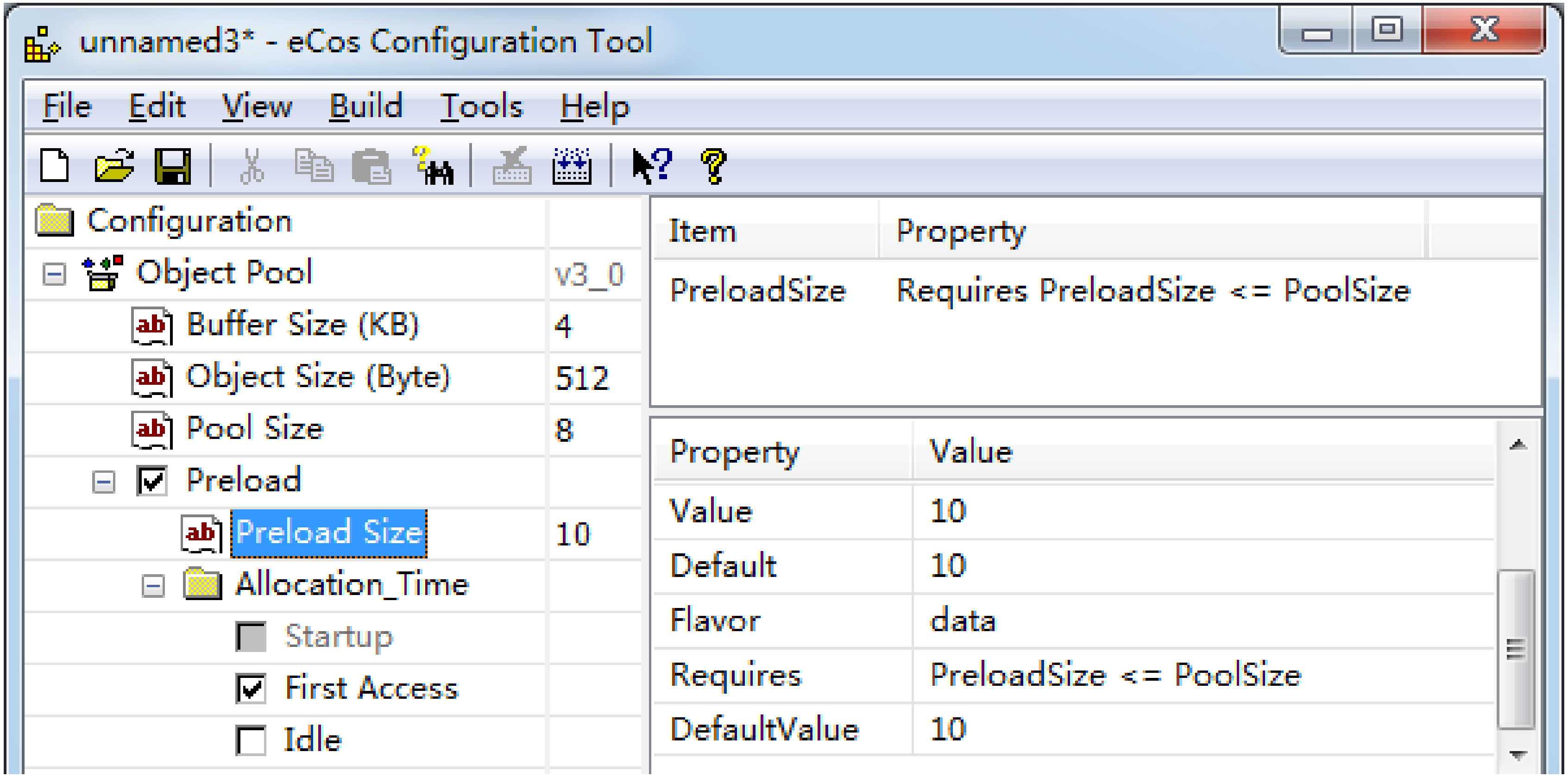
○ Mandatory ○ Optional ○ Alternative ● Or

15 1

Linux Kconfig,
eCos CDL,
pure::variants,
…

Variability Models

eCos Configurator - Errors

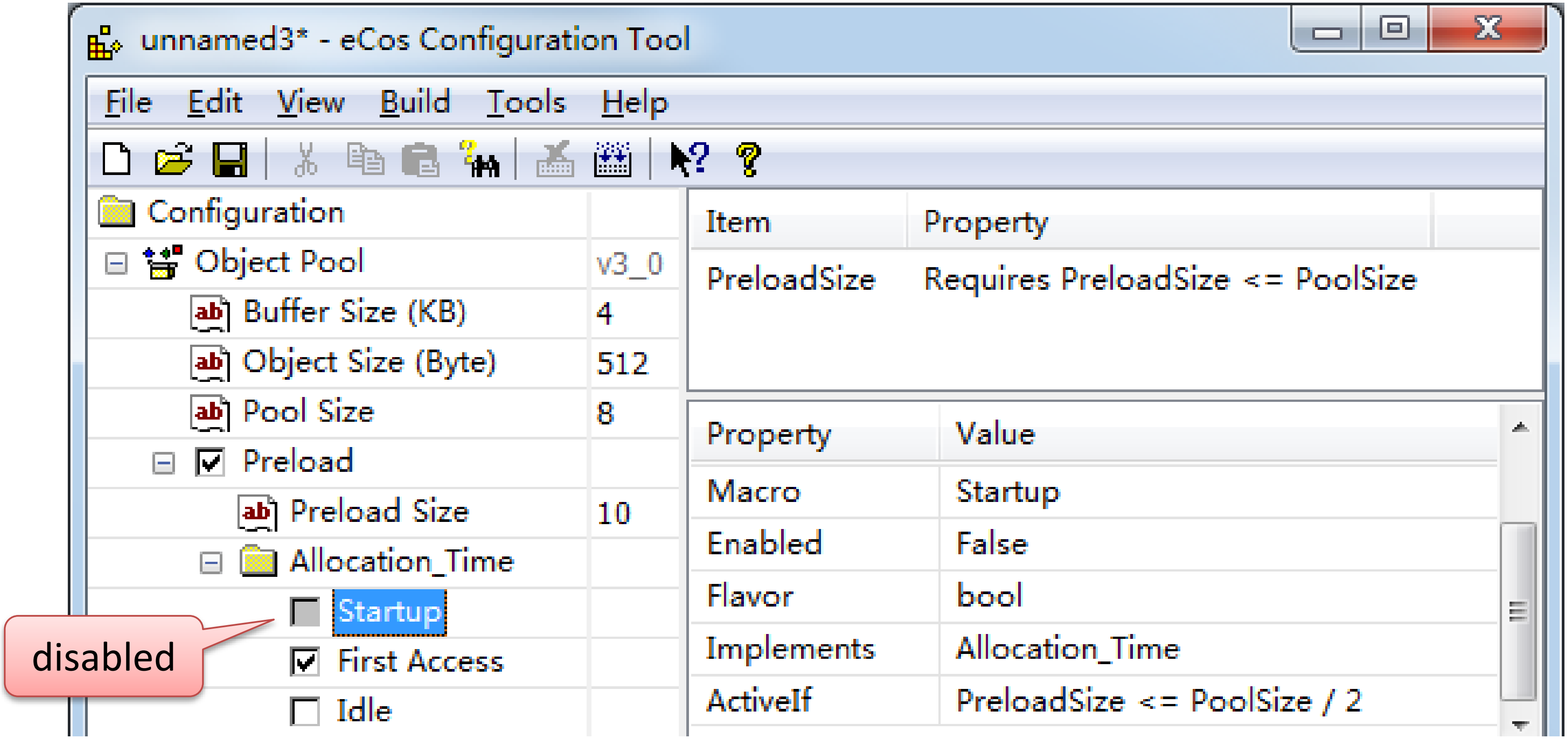


Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Property	Value
Value	10
Default	10
Flavor	data
Requires	PreloadSize <= PoolSize
DefaultValue	10

eCos Configurator - Inactive Options



unnamed3* - eCos Configuration Tool
File Edit View Build Tools Help

- Configuration
  - ⊟ Object Pool — v3_0
    - Buffer Size (KB) — 4
    - Object Size (Byte) — 512
    - Pool Size — 8
    - ⊟ ☑ Preload
      - Preload Size — 10
      - ⊟ Allocation_Time
        - □ Startup
        - ☑ First Access
        - □ Idle

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Property	Value
Macro	Startup
Enabled	False
Flavor	bool
Implements	Allocation_Time
ActiveIf	PreloadSize <= PoolSize / 2

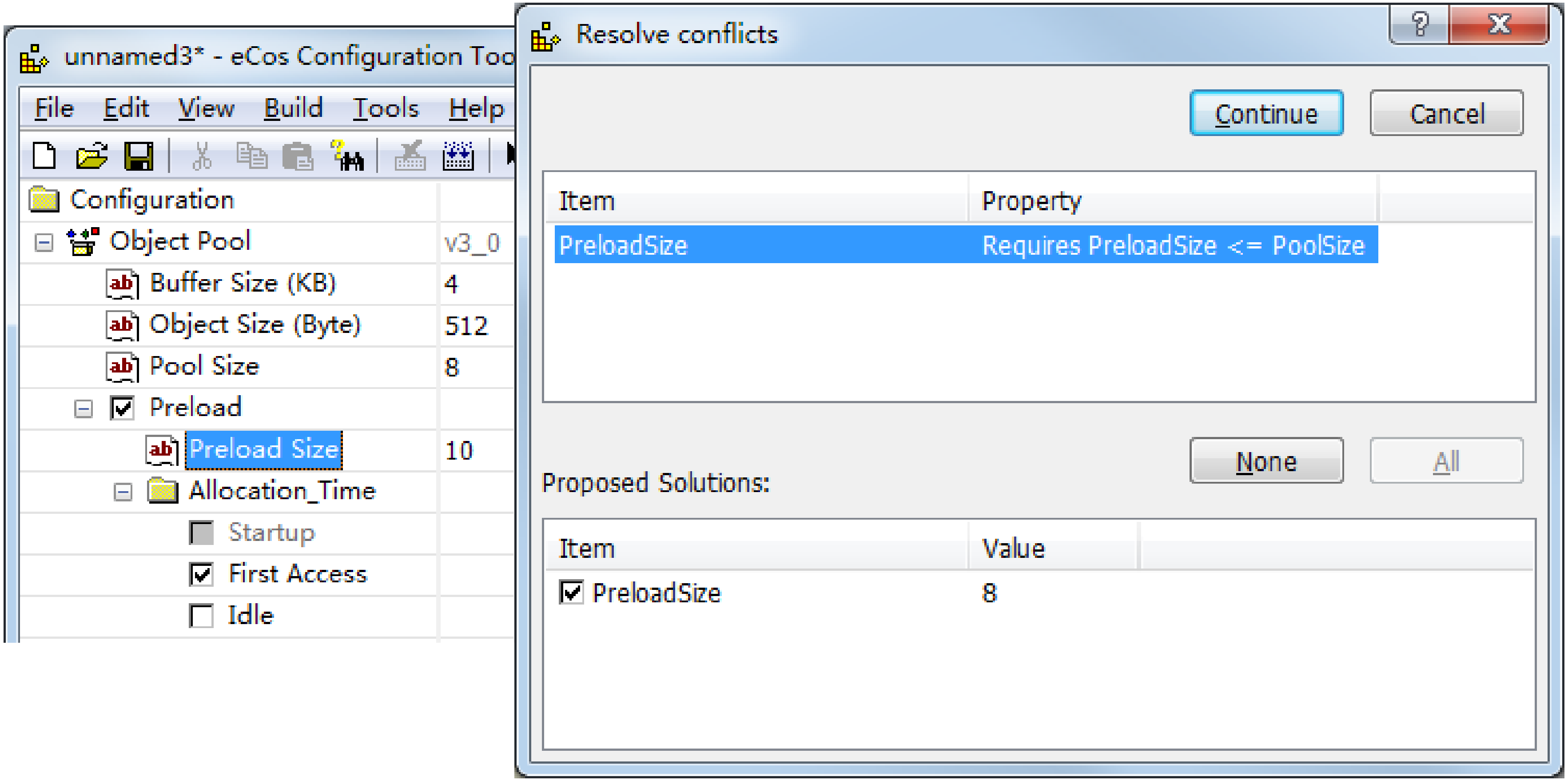
disabled

Error resolution and option activation both need to resolve violation of constraint.

Survey

- 97 Linux users and 9 eCos users
- Resolving a violation is hard
  - 20% Linux users need "a few dozen minutes" to activate an option in average
  - 56% eCos users consider activation to be a problem

eCos Configurator



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

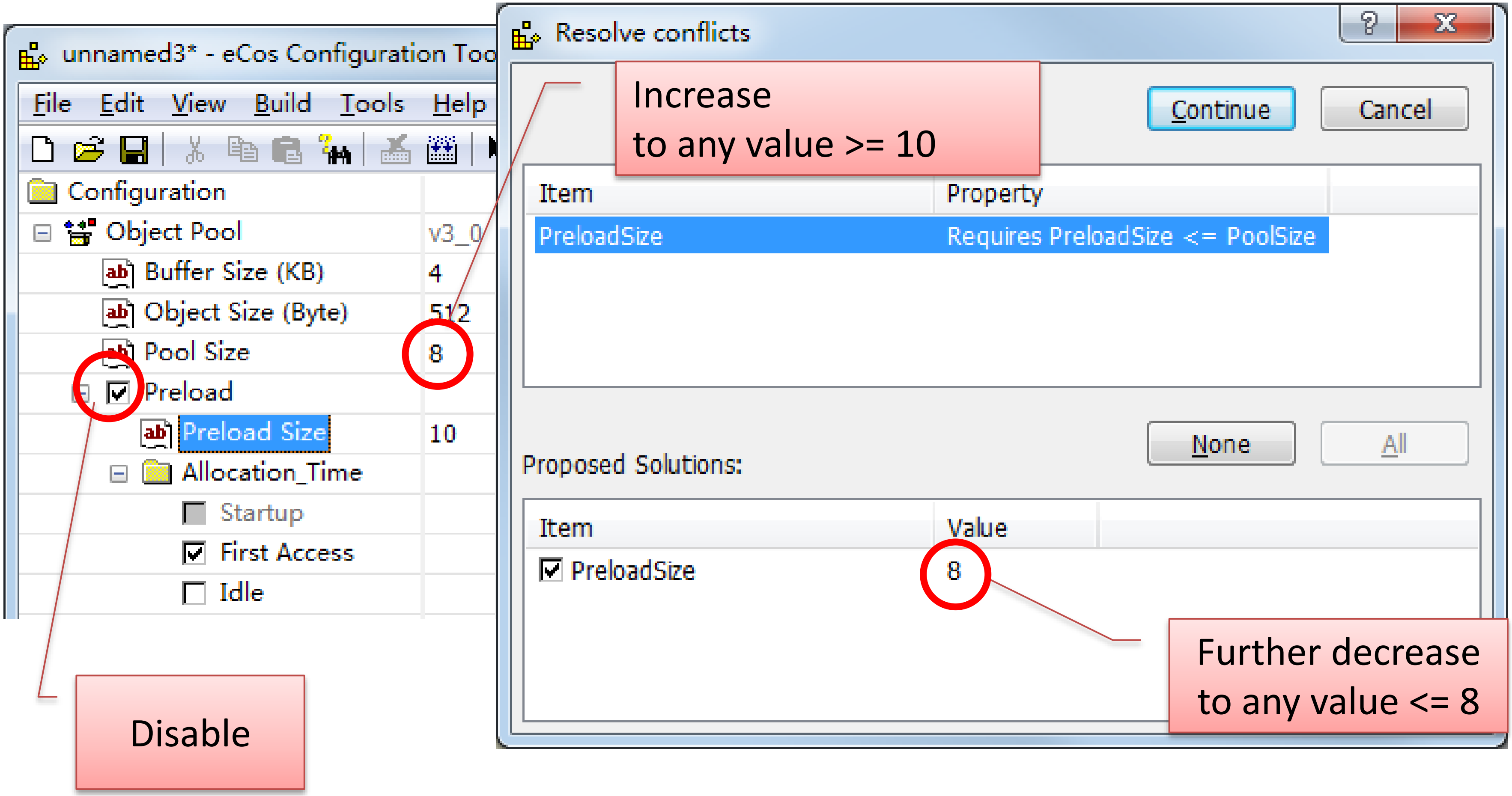
Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Proposed Solutions:

Item	Value
☑ PreloadSize	8

Essentially, fixes work for both resolving errors and activating options

Fix Incompleteness



unnamed3* - eCos Configuration Too
File Edit View Build Tools Help

- Configuration
- ⊟ Object Pool v3_0
  - Buffer Size (KB) 4
  - Object Size (Byte) 512
  - Pool Size 8
  - ☑ Preload
    - Preload Size 10
    - ⊟ Allocation_Time
      - □ Startup
      - ☑ First Access
      - □ Idle

Resolve conflicts

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Proposed Solutions:

Item	Value
☑ PreloadSize	8

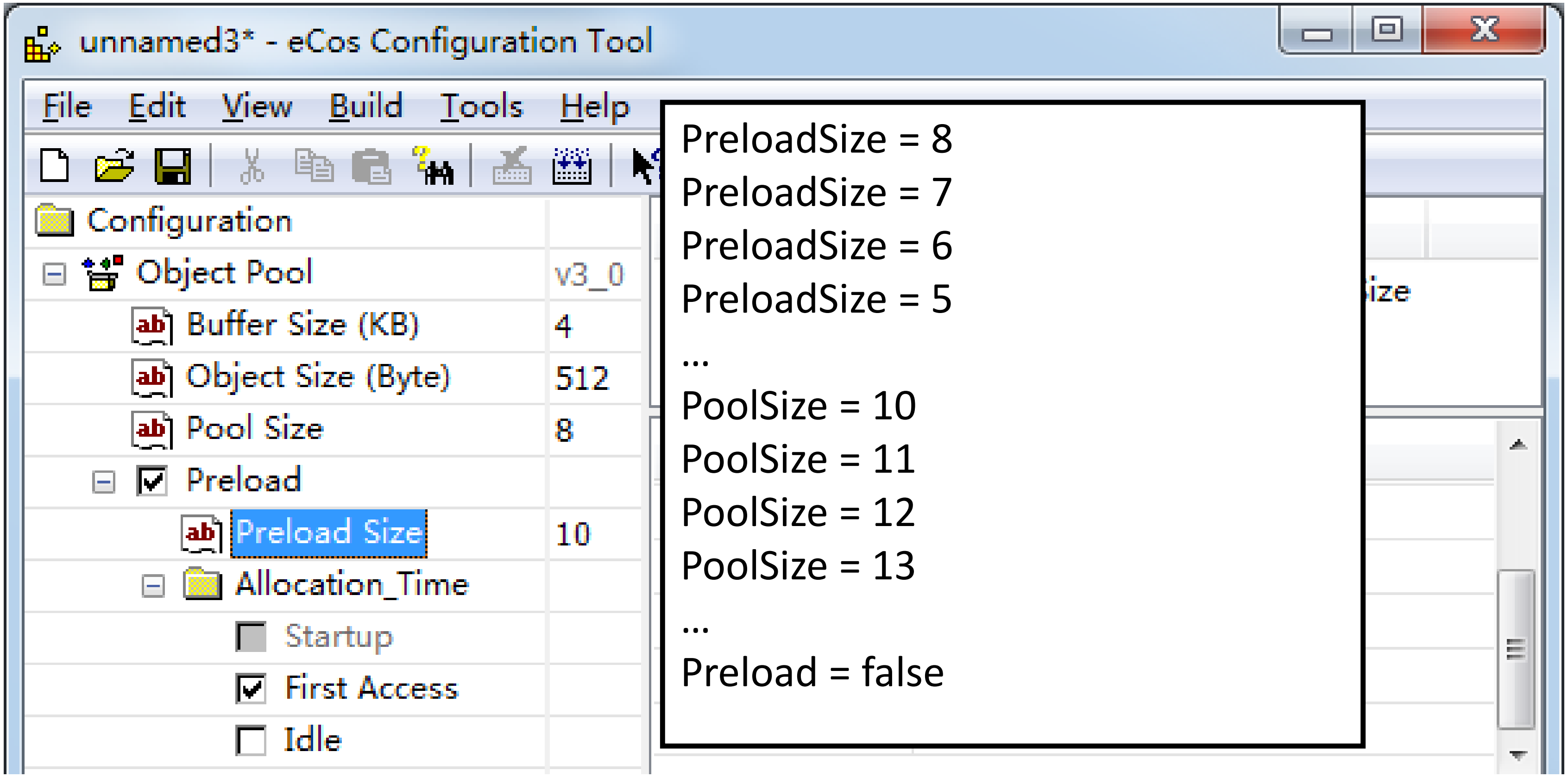
Increase
to any value >= 10

Disable

Further decrease
to any value <= 8

78% eCos users have ecountered situations where the proposed fix is not useful

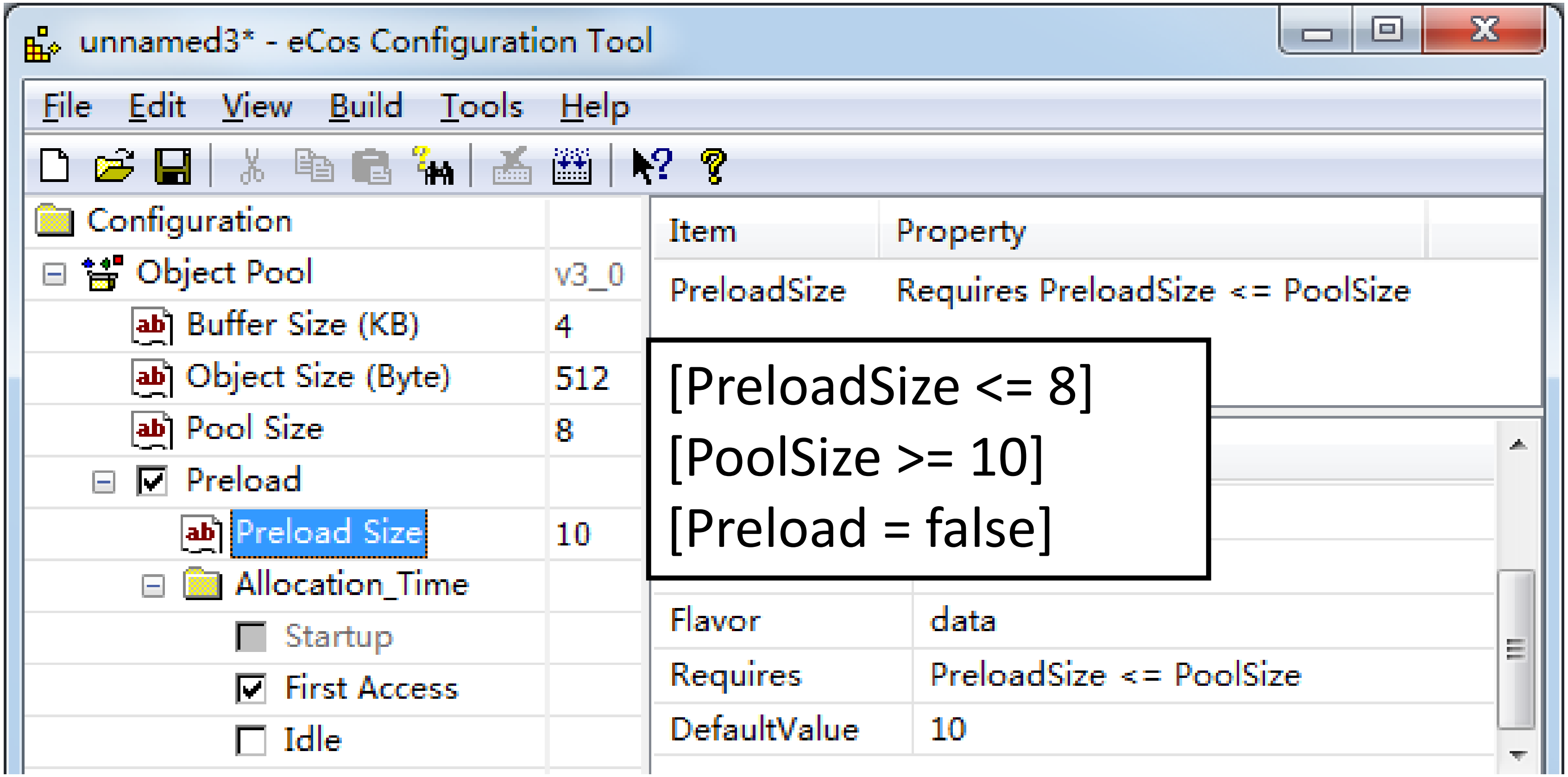
How to complete fixes



Configuration	
Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
☑ Preload	
Preload Size	10
Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

PreloadSize = 8
PreloadSize = 7
PreloadSize = 6
PreloadSize = 5
…
PoolSize = 10
PoolSize = 11
PoolSize = 12
PoolSize = 13
…
Preload = false

Our Solution – Range Fixes



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

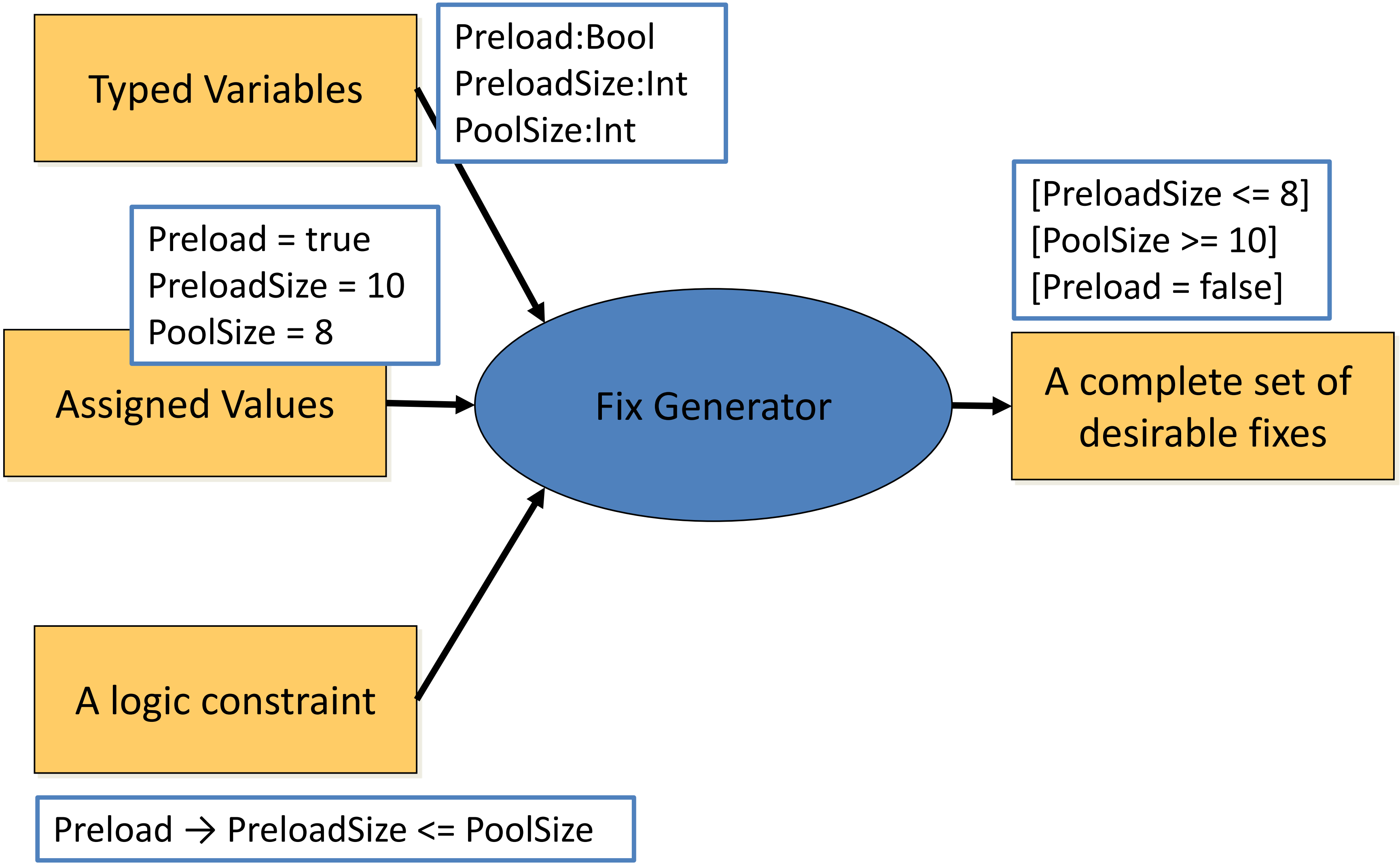
[PreloadSize <= 8]
[PoolSize >= 10]
[Preload = false]

Flavor	data
Requires	PreloadSize <= PoolSize
DefaultValue	10

Our Contributions

- Defining the range fix generation problem
  - Three desirable properties of range fixes
- Proposing a range fix generation algorithm
- Exploring the constraint interaction problem
  - Summarizing and adapting three strategies used in existing work
  - Comparing the strategies empirically

Fix Generation Problem – a General Definition



Typed Variables

Preload:Bool
PreloadSize:Int
PoolSize:Int

Assigned Values

Preload = true
PreloadSize = 10
PoolSize = 8

A logic constraint

Preload → PreloadSize <= PoolSize

Fix Generator

A complete set of desirable fixes

[PreloadSize <= 8]
[PoolSize >= 10]
[Preload = false]

Desired Properties of Fixes

Correctness	**Minimality of variables**	**Maximality of ranges**
Any change represented by a range fix will satisfy the constraint	There is no way to change a subset of variables to satisfy the constraint	A range fix represents the maximal ranges over the variables
A desirable one: [PreloadSize <=8]		
Undesirable ones		
[PreloadSize <= 9]	[PreloadSize <=8, Preload = false]	[PreloadSize <=7]

Algorithm Outline

- Step 1: find the variables to change
  - Basic idea: translating to an SMT problem
    - ① treat configurations also as soft constraints
      1. [soft] Preload = true
      2. [soft] PreloadSize = 10
      3. [soft] PoolSize = 8
      4. [hard] Preload → PreloadSize <= PoolSize
    - ② ask an SMT solver for unsatisfiable cores
      - (1, 2, 3)
    - ③ pick one variable from each core
      - {Preload}, {PreloadSize}, {PoolSize}

Algorithm Outline

- Step 2: find the range of the variables
  - Basic idea: simplify the constraint
    - Example: {PreloadSize}

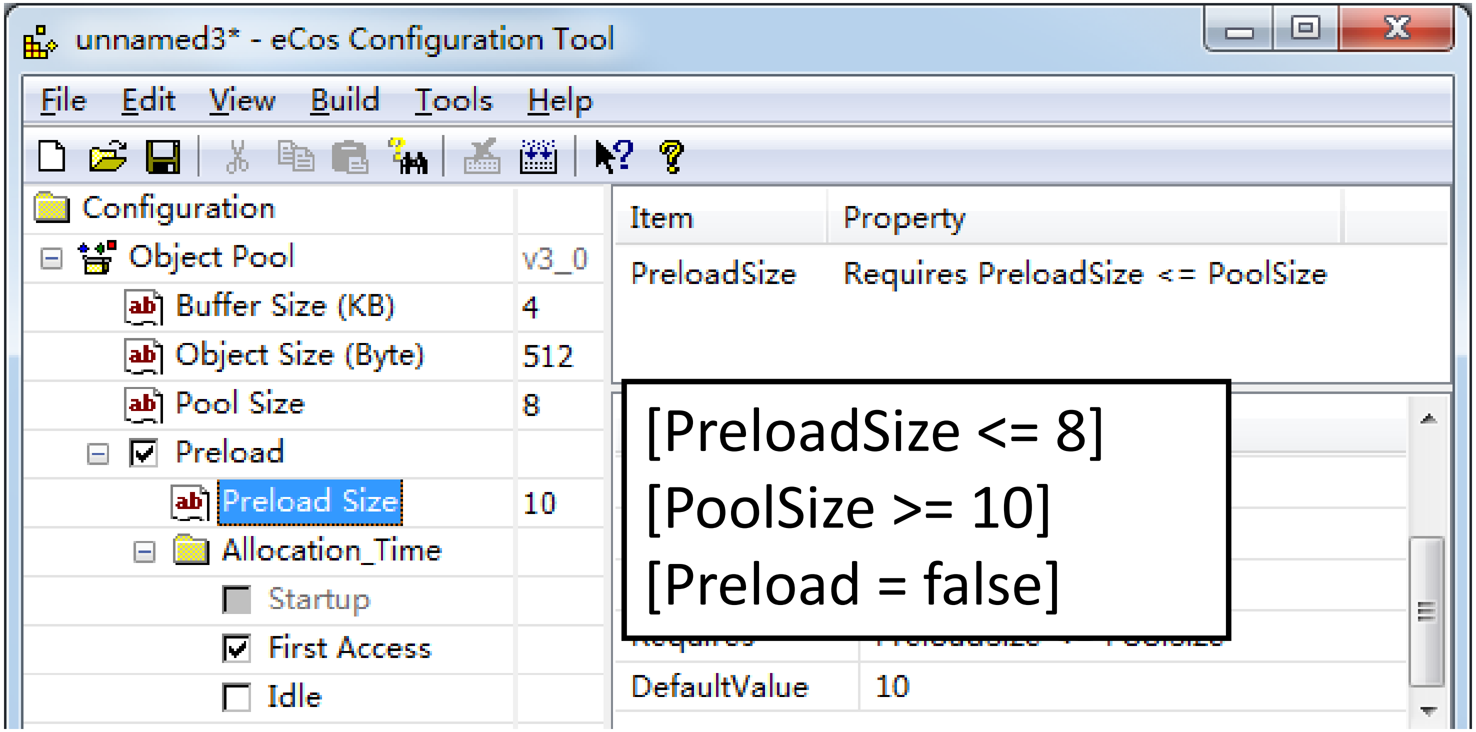
① replace unchangeable variables with their current values

- true → PreloadSize <= 8

② simplify the constraint and convert to CNF

- [PreloadSize <= 8]

Constraint Interaction



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
☐ Startup	
☑ First Access	
☐ Idle	

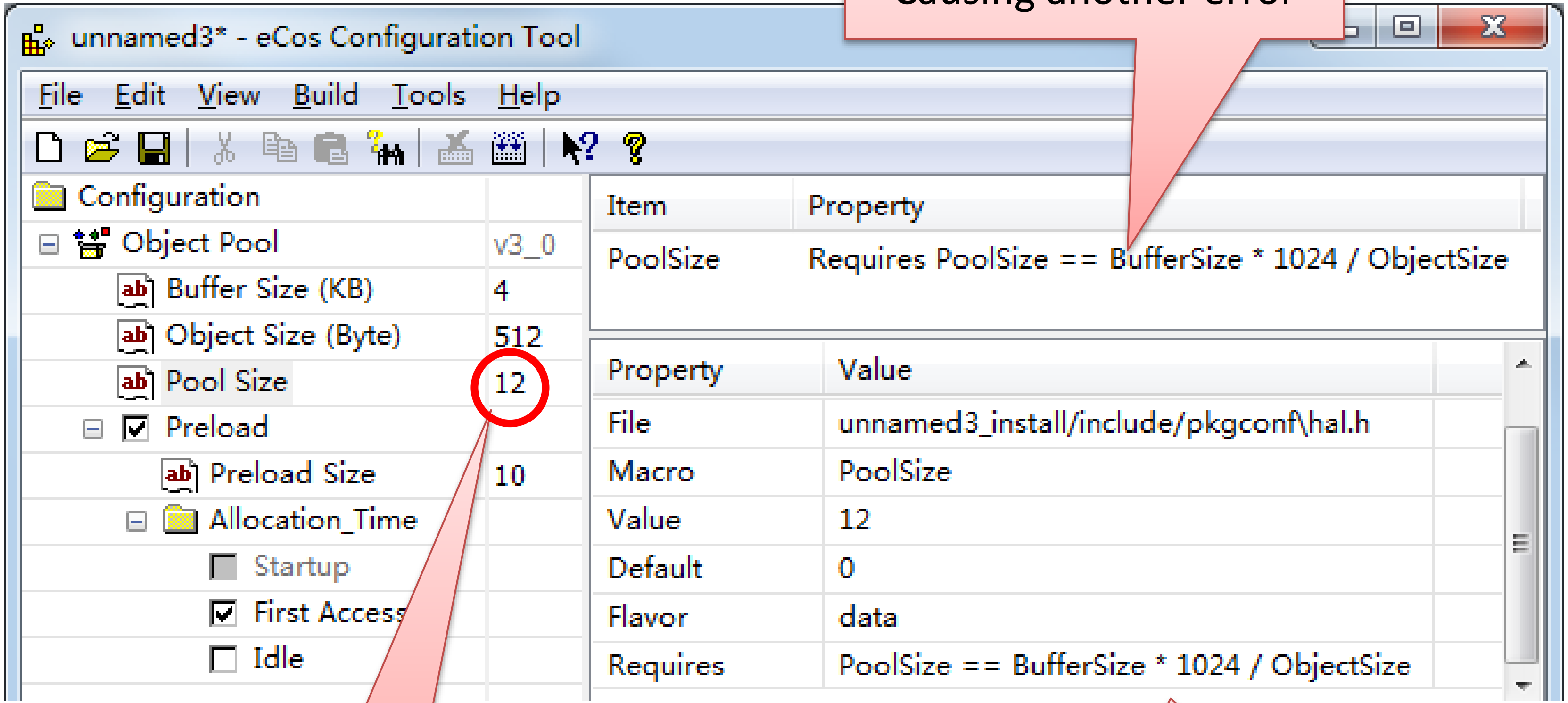
Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

DefaultValue	10

[PreloadSize <= 8]
[PoolSize >= 10]
[Preload = false]

Constraint Interaction

Causing another error


unnamed3* - eCos Configuration Tool
File Edit View Build Tools Help

Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	12
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PoolSize	Requires PoolSize == BufferSize * 1024 / ObjectSize

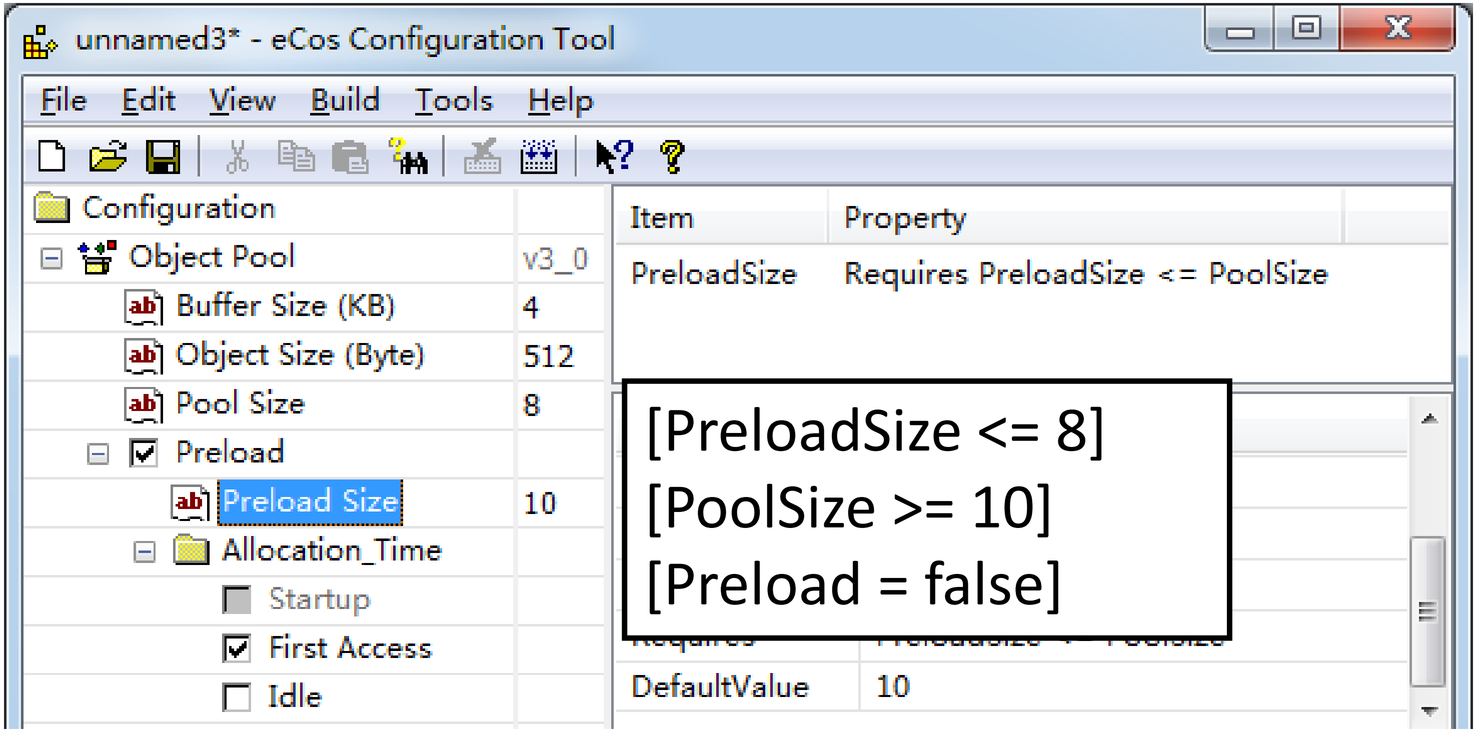
Property	Value
File	unnamed3_install/include/pkgconf\hal.h
Macro	PoolSize
Value	12
Default	0
Flavor	data
Requires	PoolSize == BufferSize * 1024 / ObjectSize

Increase PoolSize

Interacting constraint

Ignorance

Ignore the interaction


unnamed3* - eCos Configuration Tool
File Edit View Build Tools Help

Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
▨ Startup	
☑ First Access	
☐ Idle	

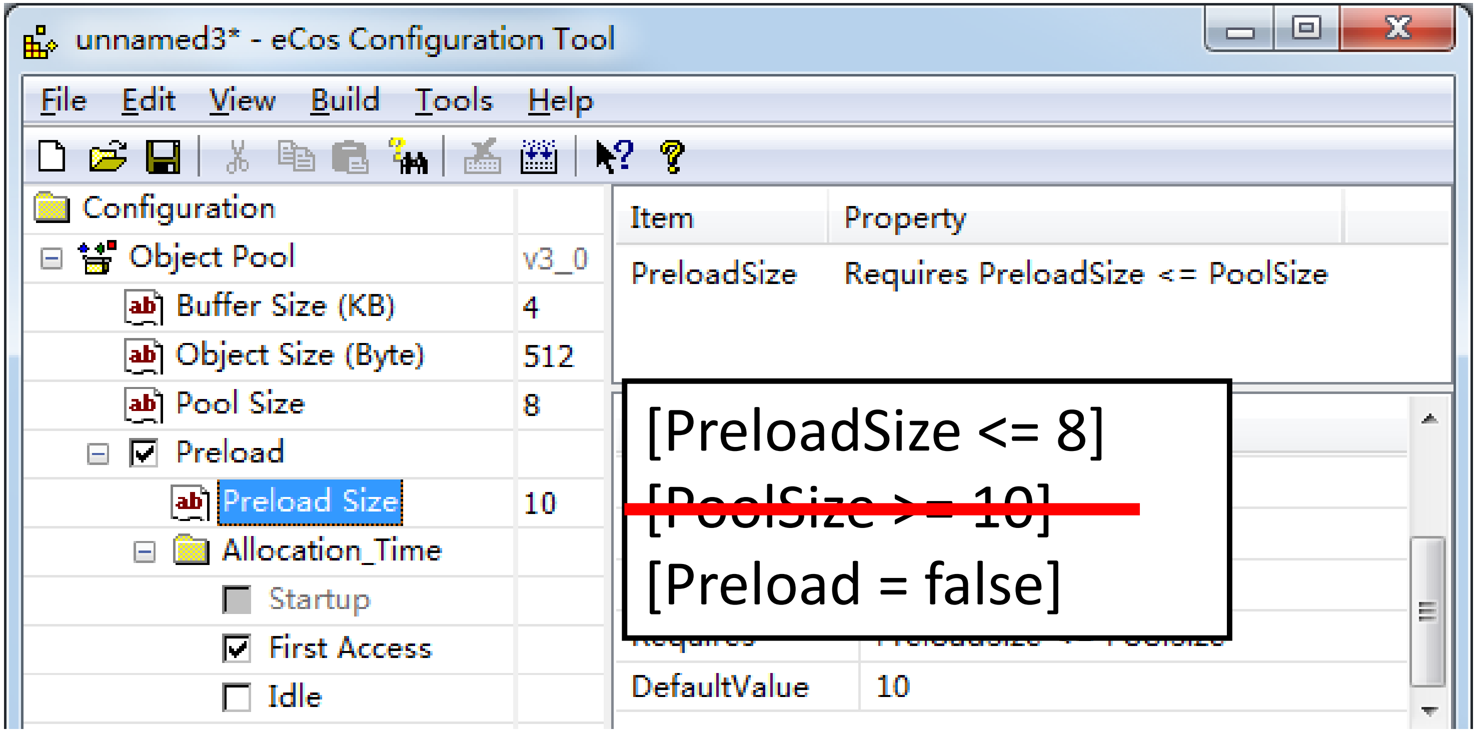
Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Requires	PreloadSize <= PoolSize
DefaultValue	10

[PreloadSize <= 8]
[PoolSize >= 10]
[Preload = false]

Elimination

Eliminate all changes that will violate other constraints



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Requires	PreloadSize <= PoolSize
DefaultValue	10

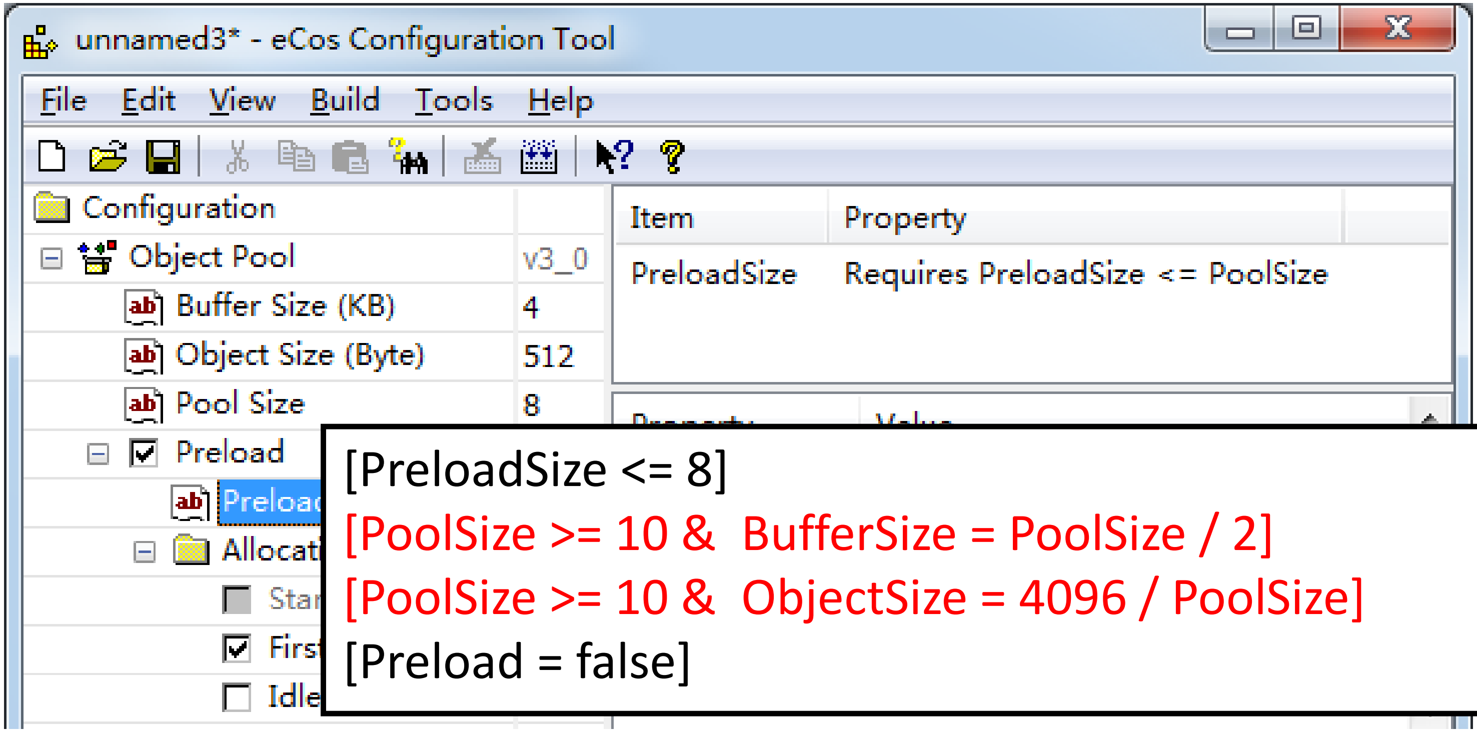
[PreloadSize <= 8]

~~[PoolSize >= 10]~~

[Preload = false]

Propagation

Propagate the change along other constraints



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preloac	
⊟ Allocati	
□ Star	
☑ Firs	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

[PreloadSize <= 8]

[PoolSize >= 10 & BufferSize = PoolSize / 2]

[PoolSize >= 10 & ObjectSize = 4096 / PoolSize]

[Preload = false]

Translating to the basic case

- Assignments: Preload = true, PreloadSize = 10, PoolSize = 8, BufferSize = 4, ObjectSize = 512
- Constraints:
  - **Preload → PreloadSize <= PoolSize**
  - PoolSize == BufferSize * 1024 / ObjectSize
- Ignorance:
  - Preload → PreloadSize <= PoolSize
- Elimination:
  - Preload -> PreloadSize <= PoolSize /\ PoolSize == 4 * 1024 / 512
- Propagation:
  - Preload → PreloadSize <= PoolSize /\ PoolSize == BufferSize * 1024 / ObjectSize

Comparison of Strategies

	Ignorance	Elimination	Propagtion
Execution time	Shortest	Short	Possbily long
Complexity of fix lists	Simple	Simplest	Possibly complex
Introduction of new errors	Possible	Never	Never
Fix completeness	Complete (for one constraint)	Incomplete	Complete (for all constraints)

Experiments

- Source
  - – Version histories from 5 open source projects
- Steps
  - – Compare each pair of consecutive versions
  - – Replay the user changes in different orders
  - – Generate fixes for the violations and compare with user changes

Execution Time

	Ignorance	Elimination	Propagtion
Execution time	Average: 17ms Maximum: 20ms	Average: 20ms Maximum: 30ms	Average: 50ms Maximum: 250ms
Complexity of fix lists	Simple	Simplest	Possibly complex
Introduction of new errors	Possible	Never	Never
Fix completeness	Complete (for one constraint)	Incomplete	Complete (for all constraints)

Our algorithm is sufficiently fast for each strategy

Complexity of fix lists

	Ignorance	Elimination	Propagtion
Execution time	Average: 17ms Maximum: 20ms	Average: 20ms Maximum: 30ms	Average: 50ms Maximum: 250ms
Complexity of fix lists (Number of variables in a list)	Max: 4 Median: 2 Average: 2.2	Max: 4 Median: 2 Average: 1.64	Max: 58 Median: 2 Average: 8.0
Introduction of new errors	Possible	Never	Never
Fix completeness	Complete (for one constraint)	Incomplete	Complete (for all constraints)

In propagation, 83% of the fix lists contain less than 10 variables

Introduction of new errors

	Ignorance	Elimination	Propagtion
Execution time	Average: 17ms Maximum: 20ms	Average: 20ms Maximum: 30ms	Average: 50ms Maximum: 250ms
Complexity of fix lists (Number of variables in a list)	Max: 4 Median: 2 Average: 2.2	Max: 4 Median: 2 Average: 1.64	Max: 58 Median: 2 Average: 8.0
Introduction of new errors	44% of all violations	Never	Never
Fix completeness	Complete (for one constraint)	Incomplete	Complete (for all constraints)

Fix completeness

	Ignorance	Elimination	Propagtion
Execution time	Average: 17ms Maximum: 20ms	Average: 20ms Maximum: 30ms	Average: 50ms Maximum: 250ms
Complexity of fix lists (Number of variables in a list)	Max: 4 Median: 2 Average: 2.2	Max: 4 Median: 2 Average: 1.64	Max: 58 Median: 2 Average: 8.0
Introduction of new errors	44% of all violations	Never	Never
Fix completeness (coverage of user changes)	100%	57%	100%

eCos configurator: 73%

Problem: Large Fixes

	Ignorance	Elimination	Propagtion
Execution time	Average: 17ms Maximum: 20ms	Average: 20ms Maximum: 30ms	Average: 50ms Maximum: 250ms
Complexity of fix lists (Number of variables in a list)	Max: 4 Median: 2 Average: 2.2	Max: 4 Median: 2 Average: 1.64	Max: 58 Median: 2 Average: 8.0
Introduction of new errors	Possible	Never	Never
Fix completeness	Complete (for one constraint)	Incomplete	Complete (for all constraints)

In propagation, 83% of the fix lists contain less than 10 variables

How to guide the users to identify their desirable fixes?

Our Solution

- Use the idea of priority
  - The priority of a variable represents the likelihood of its current value being desirable to the user.

- Two Basic ideas:
  - Generate fixes that only change variables with lower priorities
  - Dynamically adjust the priority of variables through implicit translation of user feedback

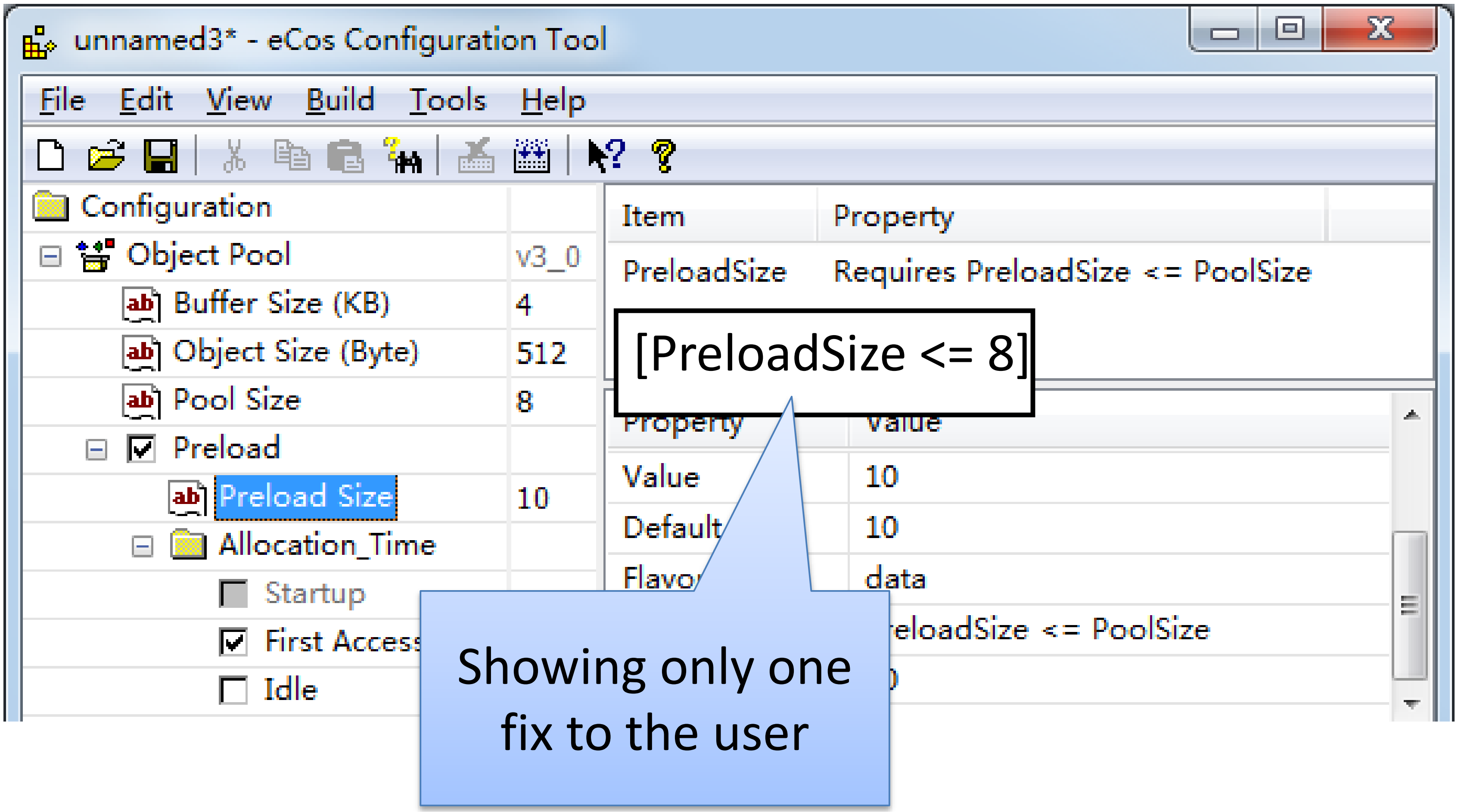
Our Contribution

- A priority-based approach to locating a desirable fix through user feedbacks
- An algorithm to implement the approach using any fix generation algorithm
- An empirical evaluation that shows the overall reduction of choices exposed to the user

Our Contribution

- A priority-based approach to locating a desirable fix through user feedbacks
- An algorithm to implement the approach using any fix generation algorithm
- An empirical evaluation that shows the overall reduction of choices exposed to the user

Our Approach



unnamed3* - eCos Configuration Tool
File Edit View Build Tools Help

Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Property	Value
Value	10
Default	10
Flavo	data
	reloadSize <= PoolSize

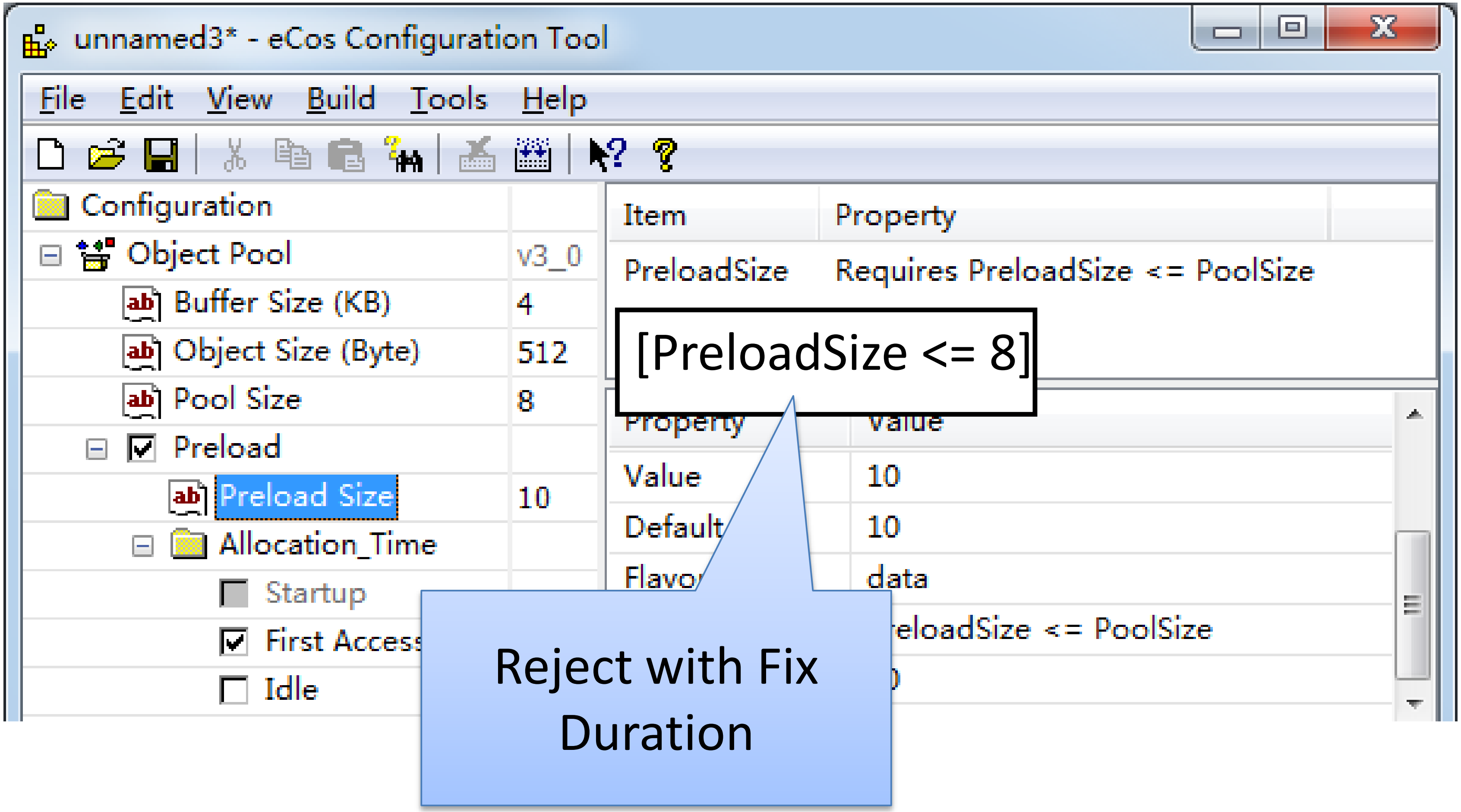
[PreloadSize <= 8]

Showing only one fix to the user

Provide feedback for each variable

- Accept the change (and pick a value)
- Reject the change
  - *Fix* duration
    - Current range is incorrect, future fixes can propose changes for this variable
  - *Error* duration
    - Current value is correct when fixing this error
  - *Permanent* duration
    - Current value is correct in the whole configuration process

Our Approach


unnamed3* - eCos Configuration Tool
File Edit View Build Tools Help

Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
☐ Startup	
☑ First Access	
☐ Idle	

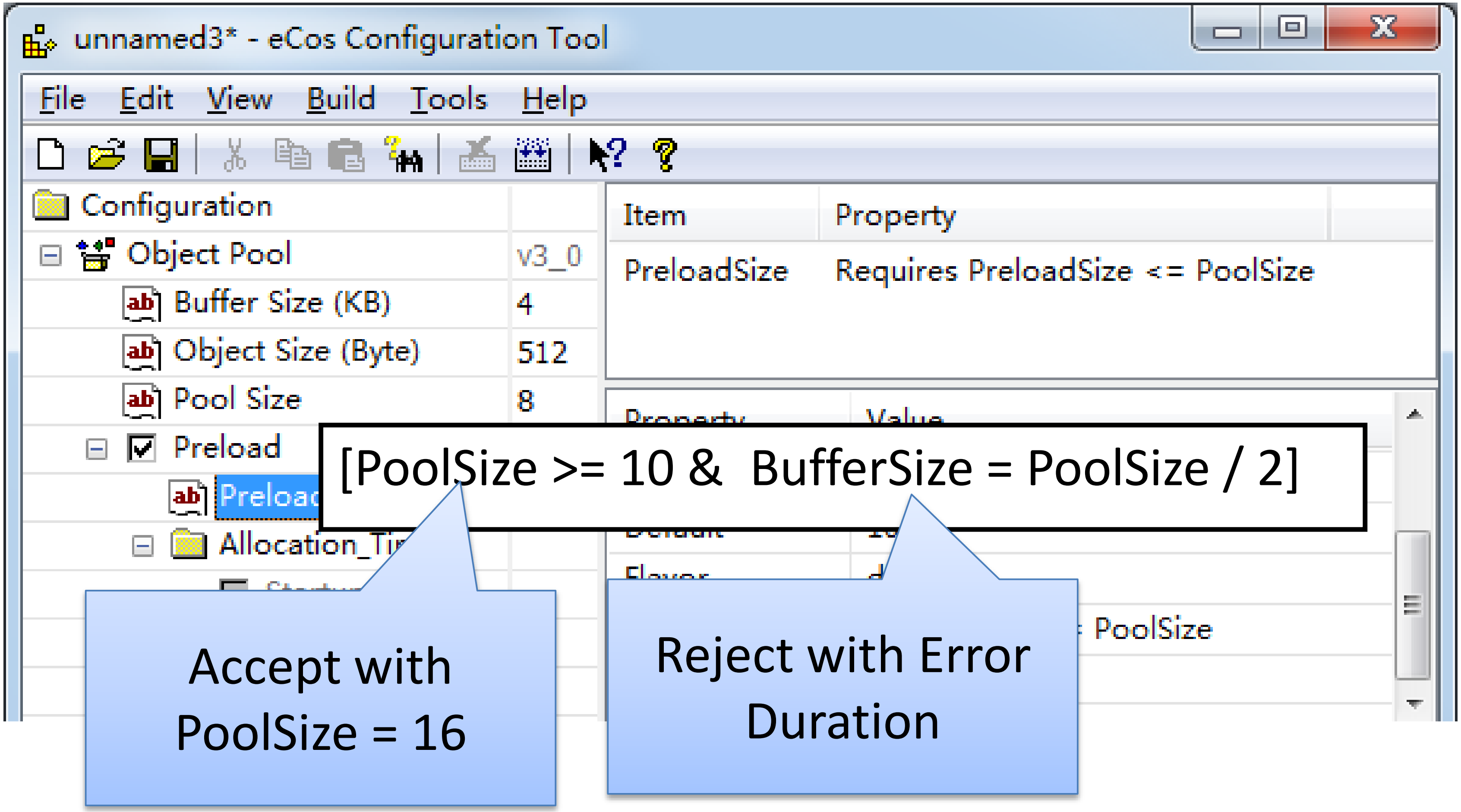
Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Property	Value
Value	10
Default	10
Flavo	data
	reloadSize <= PoolSize
	0

[PreloadSize <= 8]

Reject with Fix Duration

Our Approach



Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preloac	
⊟ Allocation_Ti	

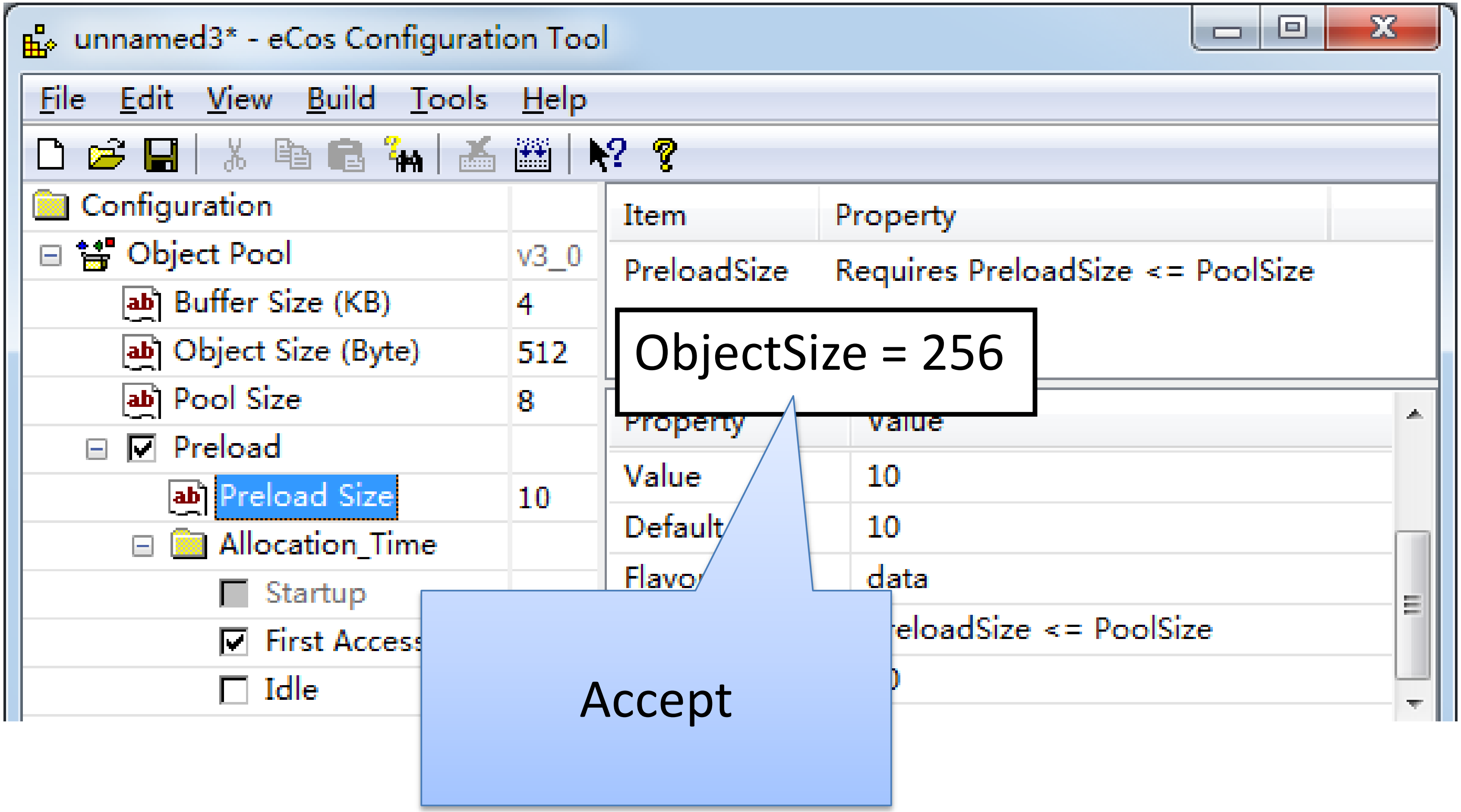
Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

[PoolSize >= 10 & BufferSize = PoolSize / 2]

Accept with PoolSize = 16

Reject with Error Duration

Our Approach



unnamed3* - eCos Configuration Tool

Configuration	
⊟ Object Pool	v3_0
Buffer Size (KB)	4
Object Size (Byte)	512
Pool Size	8
⊟ ☑ Preload	
Preload Size	10
⊟ Allocation_Time	
□ Startup	
☑ First Access	
□ Idle	

Item	Property
PreloadSize	Requires PreloadSize <= PoolSize

Property	Value
Value	10
Default	10
Flavo	data
	eloadSize <= PoolSize

ObjectSize = 256

Accept

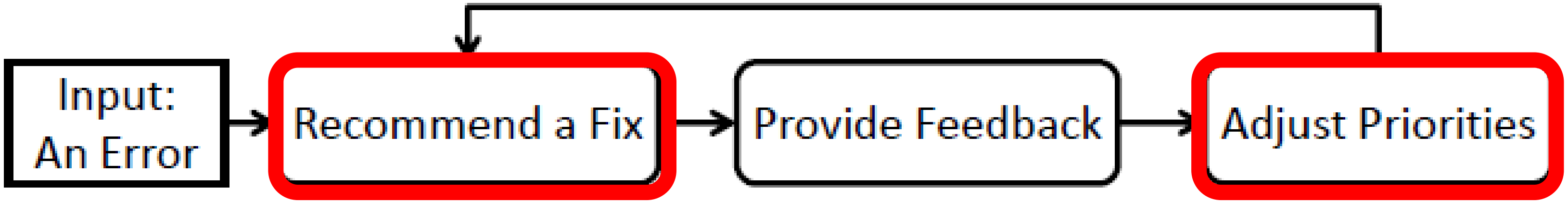
The user feedbacks are stored so that later fixes will be smarter.

Our Contribution

- A priority-based approach to locating a desirable fix through user feedbacks
- An algorithm to implement the approach using any fix generation algorithm
- An empirical evaluation that shows the overall reduction of choices exposed to the user

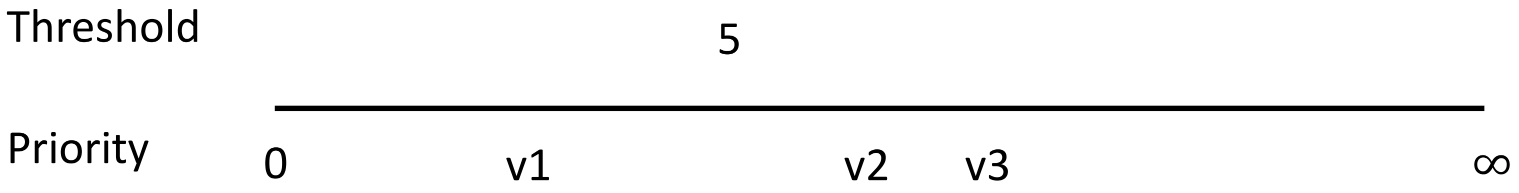
Algorithm Overview

Each variable is assigned a priority, initially zero.



Recommend a fix

- Use a threshold to confine the fix generation scope
  - Variables are changeable only when priority <= threshold.
  - Constraint [variable = current_value] is added for variables whose priority > threshold

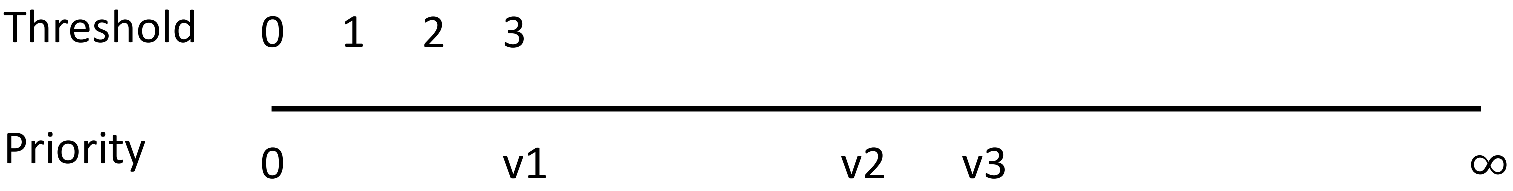


Threshold 5

Priority 0 v1 v2 v3 ∞

Recommend a fix

- Initial threshold for an error = 1
- Invoke the fix generator
  - – Randomly pick one fix from the generated fix list
  - – Threshold += 1 if no fix is generated



Adjust Priorities

- New value is assigned
  - priority = 0
- Reject with *Fix* duration
  - priority +=1
- *Reject with Error* duration
  - priority binds to <threshold> +1
  - will be updated when threshold increases
- *Reject with Permanent* duration
  - priority = <max>

Handling No fixes

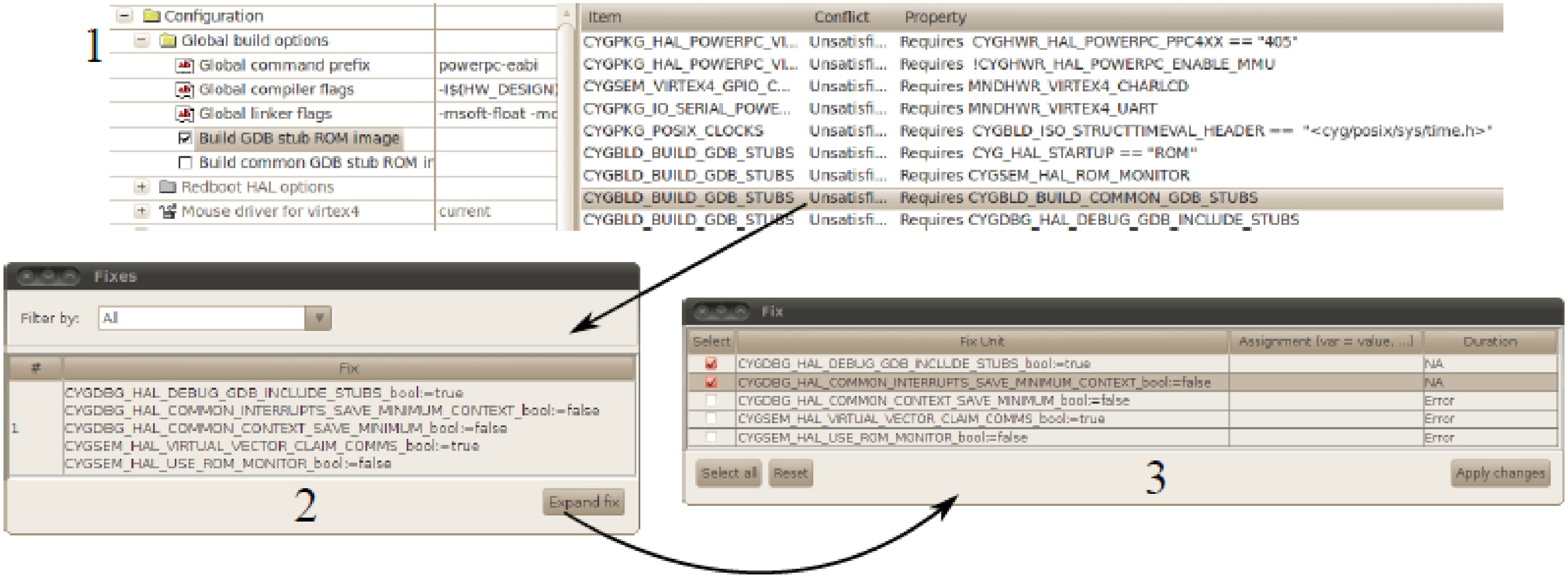
- Provide users with the variables with *error* and *permanent* durations

- Users should change the durations

Our Contribution

- A priority-based approach to locating a desirable fix through user feedbacks
- An algorithm to implement the approach using any fix generation algorithm
- An empirical evaluation that shows the overall reduction of choices exposed to the user

Supporting Tool: Smart Fixer



Configuration	
Global build options	
Global command prefix	powerpc-eabi
Global compiler flags	-I$(HW_DESIGN)
Global linker flags	-msoft-float -mc
☑ Build GDB stub ROM image	
□ Build common GDB stub ROM ir	
Redboot HAL options	
Mouse driver for virtex4	current

Item	Conflict	Property
CYGPKG_HAL_POWERPC_VI...	Unsatisfi...	Requires CYGHWR_HAL_POWERPC_PPC4XX == "405"
CYGPKG_HAL_POWERPC_VI...	Unsatisfi...	Requires !CYGHWR_HAL_POWERPC_ENABLE_MMU
CYGSEM_VIRTEX4_GPIO_C...	Unsatisfi...	Requires MNDHWR_VIRTEX4_CHARLCD
CYGPKG_IO_SERIAL_POWE...	Unsatisfi...	Requires MNDHWR_VIRTEX4_UART
CYGPKG_POSIX_CLOCKS	Unsatisfi...	Requires CYGBLD_ISO_STRUCTTIMEVAL_HEADER == "<cyg/posix/sys/time.h>"
CYGBLD_BUILD_GDB_STUBS	Unsatisfi...	Requires CYG_HAL_STARTUP == "ROM"
CYGBLD_BUILD_GDB_STUBS	Unsatisfi...	Requires CYGSEM_HAL_ROM_MONITOR
CYGBLD_BUILD_GDB_STUBS	Unsatisfi...	Requires CYGBLD_BUILD_COMMON_GDB_STUBS
CYGBLD_BUILD_GDB_STUBS	Unsatisfi...	Requires CYGDBG_HAL_DEBUG_GDB_INCLUDE_STUBS

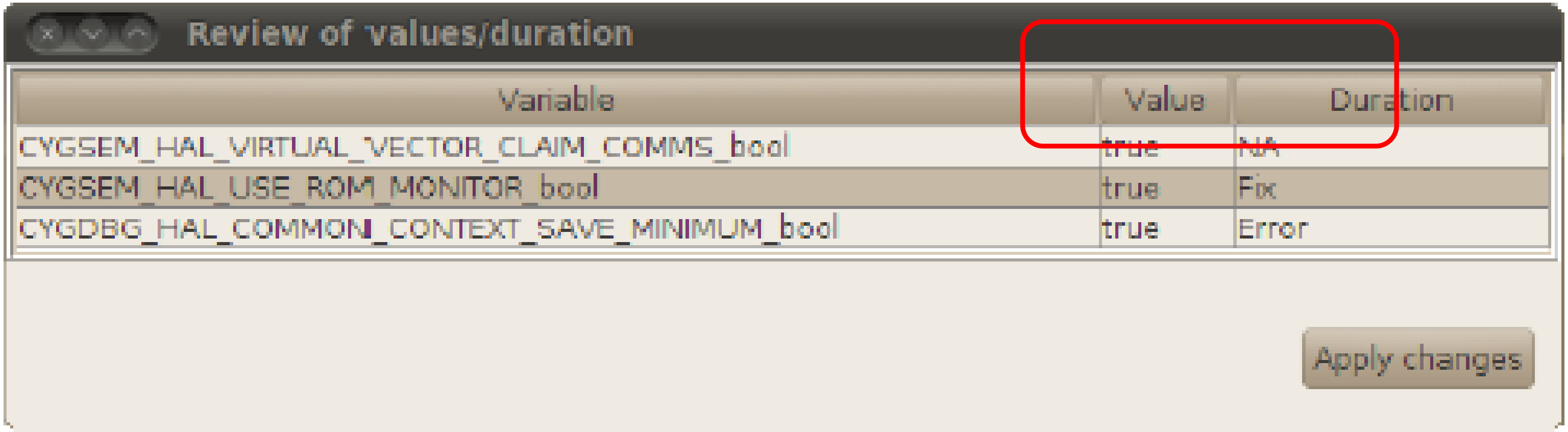
#	Fix

1	CYGDBG_HAL_DEBUG_GDB_INCLUDE_STUBS_bool:=true
	CYGDBG_HAL_COMMON_INTERRUPTS_SAVE_MINIMUM_CONTEXT_bool:=false
	CYGDBG_HAL_COMMON_CONTEXT_SAVE_MINIMUM_bool:=false
	CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool:=true
	CYGSEM_HAL_USE_ROM_MONITOR_bool:=false

Select	Fix Unit	Assignment (var = value, ...)	Duration
☑	CYGDBG_HAL_DEBUG_GDB_INCLUDE_STUBS_bool:=true		NA
☑	CYGDBG_HAL_COMMON_INTERRUPTS_SAVE_MINIMUM_CONTEXT_bool:=false		NA
□	CYGDBG_HAL_COMMON_CONTEXT_SAVE_MINIMUM_bool:=false		Error
□	CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool:=true		Error
□	CYGSEM_HAL_USE_ROM_MONITOR_bool:=false		Error

(a) SmartFixer: Interactive process GUI for fix resolution

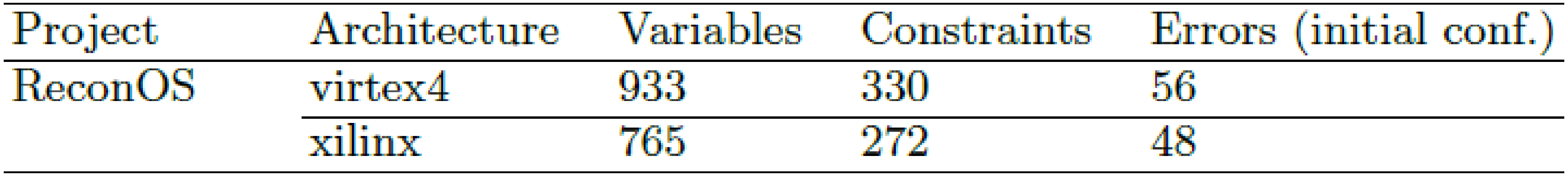
Smart Fixer: providing feedbacks



Variable	Value	Duration
CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool	true	NA
CYGSEM_HAL_USE_ROM_MONITOR_bool	true	Fix
CYGDBG_HAL_COMMON_CONTEXT_SAVE_MINIMUM_bool	true	Error

Evaluation

- Sources
  - Version history from 2 open source projects that cause large fix lists
  - Simulate the user change from the default configurations to the final configurations



Project	Architecture	Variables	Constraints	Errors (initial conf.)
ReconOS	virtex4	933	330	56
	xilinx	765	272	48

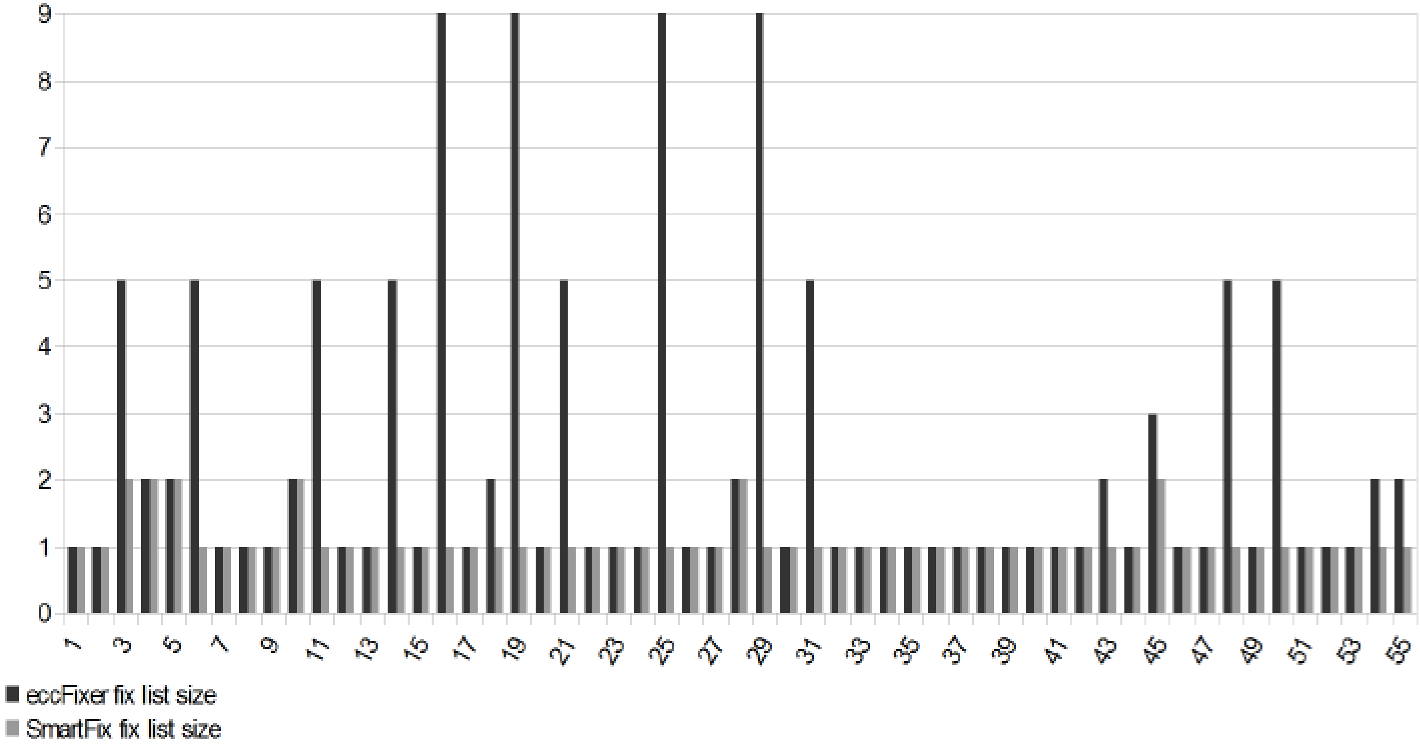
Evaluations

- Steps:
  - Generate a fix for each error, simulate the user feedback

Situation #	Current Value	Fix Changes	Final Value	Operation
1	a = 1	a < 1	a = 2	Reject Fix duration
2	a = 1	a >1	a = 2	Accept Assign new value
2s	a = 2	a > 2	a = 2	Reject Error duration

  - Count the number of fixes and variables

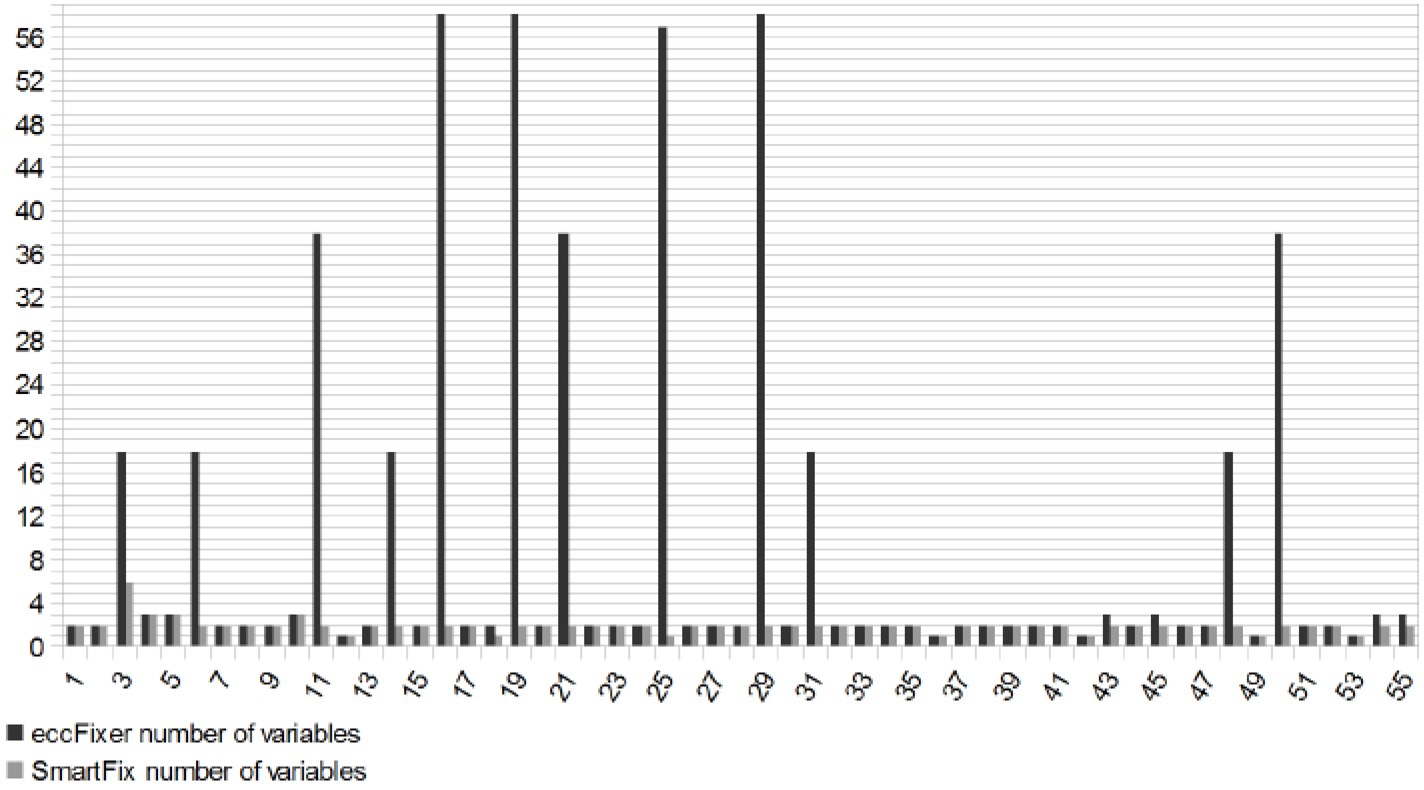
Evaluation Results – virtex4 (1/2)



(a) Fix list size

The number of fixes is decreased in 31% of the errors.
In average, there is a reduction of 22%, with a maximum reduction of 89% in the number of fixes

Evaluation Results – virtex4 (2/2)

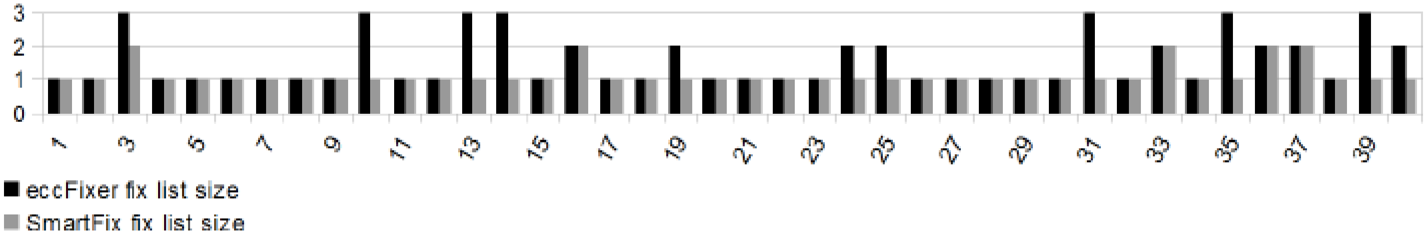


(b) Number of variables

Fig. 6: Experimental results for virtex4

The number of variables is decreased by 23% in average, with a maximum reduction of 98%

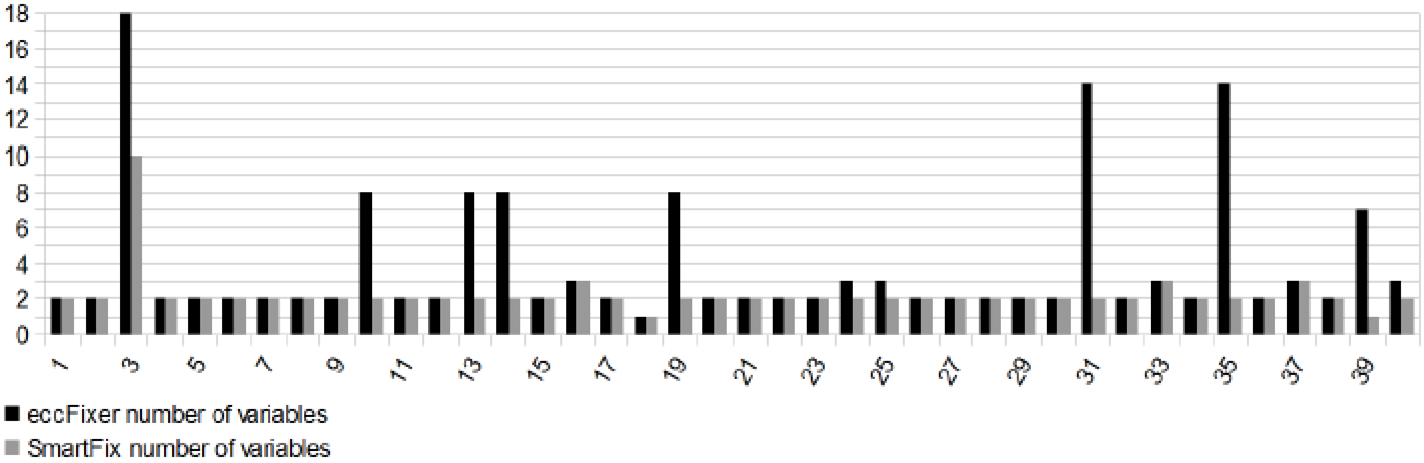
Evaluation Results – xilinx (1/2)



(a) Fix list size

The number of fixes is decreased in 28% of the errors.
In average, there is a reduction of 16%, with a maximum reduction of 2/3 in the number of fixes

Evaluation Results - xilinx (2/2)



(b) Number of variables

The number of variables is decreased by 18% in average, with a maximum reduction of 86%

Summary

- Error Resolution is difficult in configuring large systems
- Range fixes can be generated efficiently
- Large fix list could be controlled by priorities

Thank you for your attention!

- **References**:
- Yingfei Xiong, Arnaud Hubaux, Steven She, Krzysztof Czarnecki. Generating Range Fixes for Software Configuration. In ICSE'12: Proceedings of 34th International Conference on Software Engineering, pages 89-99, June 2012.
- Bo Wang, Leonardo Passos, Yingfei Xiong, Krzysztof Czarnecki, Haiyan Zhao, Wei Zhang. SmartFixer: Fixing Software Configurations based on Self-adaptive Priorities. In SPLC'13: Proceedings of 17th International Software Product Line Conference, August 2013.
- Arnaud Hubaux, Yingfei Xiong, Krzysztof Czarnecki. A User Survey of Configuration Challenges in Linux and eCos. VaMoS'12: Sixth International Workshop on Variability Modelling of Software-intensive Systems, January 2012.
- Leonardo Passos, Marko Novakovic, Yingfei Xiong, Thorsten Berger, Krzysztof Czarnecki, Andrzej Wasowski. A Study of Non-Boolean Constraints in Variability Models of an Embedded Operating System. FOSD'11: 3rd International Workshop on Feature-Oriented Software Development, June 2011.