Fixing Software Configurations based on Self-Adaptive Priorities

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Modern Software Product Lines



Variability Models

eCos Configurator - Errors

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Configuration		Item	Property	
🖃 😫 Object Pool	v3_0	PreloadSize	Requires PreloadSize <= PoolSize	1
b Buffer Size (KB)	4			
(Byte)	512			
مع) Pool Size	8	Property	Value	1
🗆 🔽 Preload		roperty		
ab) Preload Size	10	Value	10	
Allocation_Time		Default	10	1
Startup		Flavor	data	
✓ First Access		Requires	PreloadSize <= PoolSize	
🗖 Idle		DefaultValue	10	

Fixing an error is hard! [Hubaux et al., VaMoS'11]

Existing Approaches Generate Fixes [Xiong et al., ICSE'12]

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Other fix generating approaches: [White et al., SPLC'08] [eCos Configurator]

Problem: Large Fixes

- The fixes are sometimes large in size and number
- Fixes for eCos [Xiong et al. ICSE'12]:
 - Fix lists contain up to nine fixes
 - Fixes change up to nine variables
 - In total, 17% of all fix lists contain changes over more than 10 variables

Users have to read through potentially large lists and decide the most desirable fix

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

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Our Approach



Provide feedback for each variable

- Accept the change
- Reject the change
 - Fix duration
 - I do not want to change the variable to the suggested value/range for now; perhaps later.
 - Error duration
 - I do not want to change this variable during this error resolution
 - *Permanent* duration
 - I do not want to change this variable in the whole configuration process

Our Approach



Our Approach



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

Our Contribution

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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 = 0
- Invoke the fix generator
 - Randomly pick one fix from the generated fix list
 - Threshold += 1 if no fix is generated, and invoke again

Threshold	0	1	2	3				
Priority	0			v1	V	2	v3	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

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 during the error resolution
- *Reject with Permanent* duration
 - priority = <max>

Handling No fixes

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

Users should cancel some of the durations
 The priorities of cancelled variables are reset to 0

Our Contribution

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Supporting Tool: Smart Fixer

		Item	Conflict Prope	rty	
Global build options		CYGPKG_HAL_POWERPC_VI.	. Unsatisfi Requir	es CYGHWR_HAL_POWERPC_PPC4XX	== "405"
Global command prefix	powerpc-eabi	CYGPKG_HAL_POWERPC_VI.	Unsatisfi Requir	es !CYGHWR_HAL_POWERPC_ENABLE	E_MMU
Global compiler flags	-I\$(HW DESIGN)	CYGSEM_VIRTEX4_GPIO_C	Unsatisfi Requir	es MNDHWR_VIRTEX4_CHARLCD	
Global linker flags	-msoft-float -mc	CYGPKG_IO_SERIAL_POWE	Unsatisfi Requir	es MNDHWR_VIRTEX4_UART	
Ruild GDB stub ROM image		CYGPKG_POSIX_CLOCKS	Unsatisfi Requir	es CYGBLD_ISO_STRUCTTIMEVAL_HE	ADER == " <cyg posix="" sys="" time.h="">"</cyg>
Build common GDB stub BOM	in	CYGBLD_BUILD_GDB_STUBS	Unsatisfi Requir	res_CYG_HAL_STARTUP == "ROM"	
Bedboot HAL options		CYGBLD_BUILD_GDB_STUBS	Unsatisfi Requir	res CYGSEM_HAL_ROM_MONITOR	
Ad Mause drives fer utrend	current	CYGBLD_BUILD_GDB_STUBS	Unsatisfi Requir	es CYGBLD_BUILD_COMMON_GDB_ST	UBS
Mouse driver for virtex4	current	CYGBLD BUILD GDB STUBS	Unsatisfi Requir	es CYGDBG_HAL_DEBUG_GDB_INCLUI	DE_STUBS
ter by: Al	4	Select		Fix Unit	Assignment (var = value) Durat
					Franger Here - Faracting - Cores
# Fix			HAL DEBUG GOB INCL	UDE_STUBS_bool:=true	NA
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Fix CYGDBG_HAL_DEBUG_GDB_INCLUDE_STUBS_bool CYGDBG_HAL_COMMON_INTERRUPTS_SAVE_MINIM	=true JM_CONTEXT_book=fa	alse	HAL DEBUG GOB INCL HAL_COMMON_INTERRU HAL_COMMON_CONTEX	UDE_STUBS_bool:=true PTS_SAVE_MNIMUM_CONTEXT_bool:=false T_SAVE_MNIMUM_bool:=false	NA NA Error
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Fix CYGDBG_HAL_DEBUG_GDB_INCLUDE_STUBS_bool CYGDBG_HAL_COMMON_INTERRUPTS_SAVE_MINIM CYGDBG_HAL_COMMON_CONTEXT_SAVE_MINIMUM CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool CYGSEM_HAL_UREP_DDM_MONTOR_bool_bool_ CYGSEM_HAL_UREP_DDM_MONTOR_bool_bool_bool_ CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool	=true UM_CONTEXT_bool:=fi _bool:=false ol:=true	alse	HAL DEBUG GDB INCL HAL COMMON INTERRI HAL COMMON CONTEX HAL VIRTUAL VECTOR O HAL USE ROM_MONITO	LDE_STUBS_bool:=true IPTS_SAVE_MNIMUM_CONTEXT_bool:=false T_SAVE_MNIMUM_bool:=false CLAIM_COMMS_bool:=true R_bool:=false	NA NA Error Error Error
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Fi

(a) SmartFixer: Interactive process GUI for fix resolution

Smart Fixer: providing feedbacks

Review of values/duration		_		_
Variable		Value	Duratio	n
CYGSEM_HAL_VIRTUAL_VECTOR_CLAIM_COMMS_bool	\bigcap	true	NA	
CYGSEM_HAL_USE_ROM_MONITOR_bool		true	Fix	
CYGDBG_HAL_COMMON_CONTEXT_SAVE_MINIMUM_bool		true	Error	
			Apply ch	anges

Evaluation

- Sources
 - Version history from 2 open source projects that cause large fix lists.

Project	Architecture	Variables	Constraints	Errors
ReconOS	virtex4	933	330	56
	xilinx	765	272	48

- Initial configuration already contains error.
- The final configuration has all error resolved.

Evaluations

• Steps:

 Resolve each error by simulating 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
3	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)



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 & Future Work

- Adopt self-adaptive priorities to guide users to the desirable fixes
 - Five assignment and adjustment rules
- Can be built on any fix generators
- Produce a good result in eCos configuration
- Future work: Need user-involved evaluation

Thank you for your attention!

Variability Modeling Languages

- Linux KConfig
- eCos CDL
- Feature models

- Usually come with a configurator
 - Can detect errors

eCos Configurator - Errors

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🛨 🚞 Netwi	CYGPKG_LIBC_TIME	Unsatisfi Requires CYGBLD_ISO_C_CLOCK_FUNCS_HEADER == " <cyg libc="" time="" time.h="">"</cyg>
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<u>لها</u> Ma. 16	Parent CYGPKG_NET	
ساع Nur8	Requires CYGPKG_IO	۷
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🛨 🧰 Fas	Basic networking support, inc	cluding TCP/IP.

• A error is a violation of a constraint.

Fix Errors

- How to fix errors?
 - Understand the constraints
 - Navigate the variables
- Fixing errors is hard.
 - Constraints are complex
 - Linux (56 variables in one constraint)
 - Real world variability models contain thousands of variables.

Survey

- 97 Linux users and 9 eCos users
- 20% Linux users need "a few dozen minutes" to fixing an error in average
- 56% eCos users consider fixing to be a problem

Existing Approaches Generate Fixes for Errors

Fixes

• Fixes is a set of changes for the variables

• A change is an assignment for a variable

• Executing the fixes will satisfy all the constraints in the variability model

eCos Configurator - Fixes

		CYGPKG_HAL_POWER	RPC_VI Unsat	tisfi Red	uires !C	GHWR_HAL	_POWERPC_	ENABLE_MI
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Filter l	by: All	▼						== _HE
#			Fix					
 1	CYGBLD_ISO_E CYGBLD_ISO_E	3SDTYPES_HEADER_bool: 3SDTYPES_HEADER_data:	=true =" <sys bsdtype<="" th=""><th>es.h>"</th><th></th><th></th><th></th><th></th></sys>	es.h>"				
								s-vi
 J							Expa	ind fix
		The VIRTEX4 HAL pac	kage provides t	he suppor	t needed	to run eCos o	on a XILINX	PowerPC 40

Evaluation Results (1/4)



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 (2/4)



(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 (3/4)



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 (4/4)



(b) Number of variables

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