

Towards a Catalog of Variability Evolution Patterns – The Linux Kernel Case



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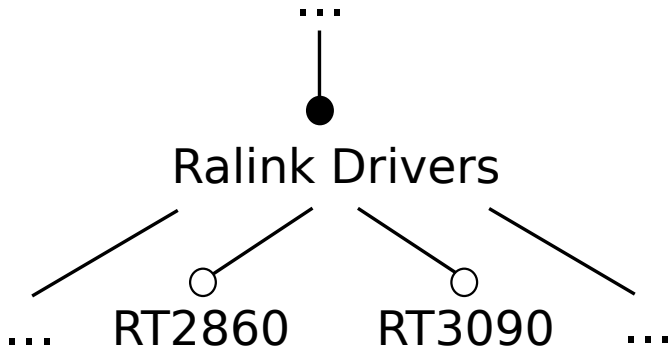
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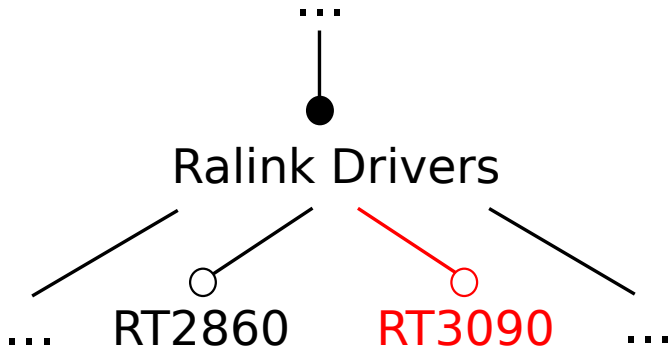
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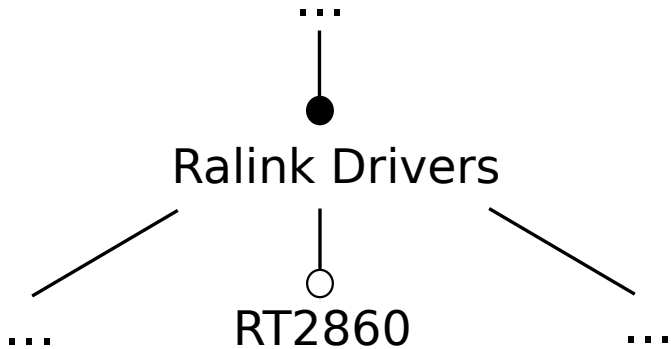
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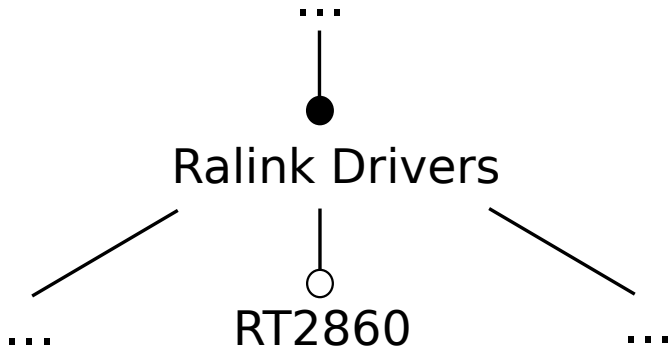
- merge
- split
- rename
- Constraints are changed, etc.

Example (from Linux)







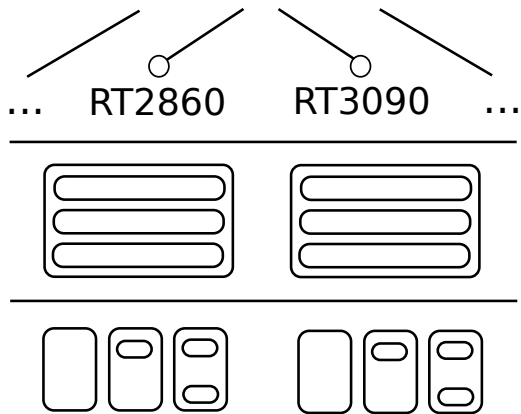


Complete removal?

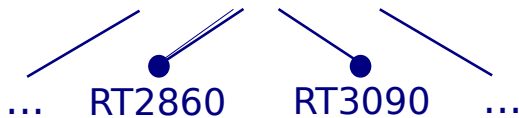
Existing evolution studies tend
to focus on the variability model
alone

That doesn't tell the whole
story...

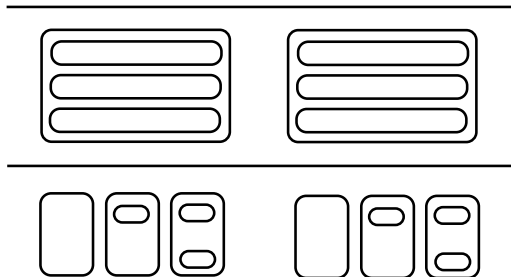
Ralink Drivers



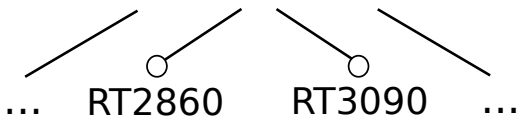
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Configuration space



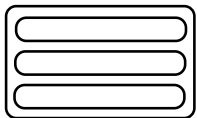
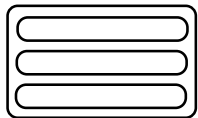
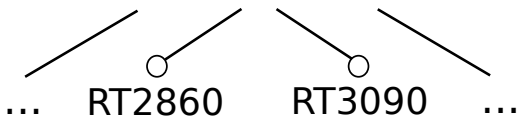
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Compilation space



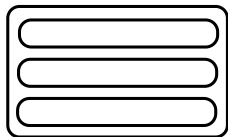
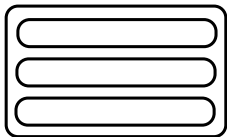
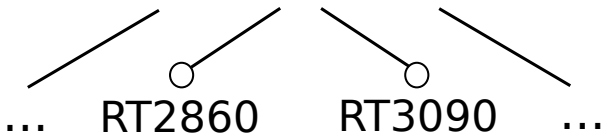
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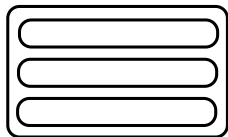
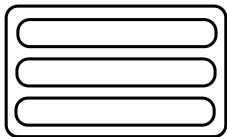
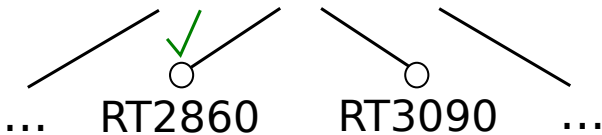
Implementation space

Spaces are connected...

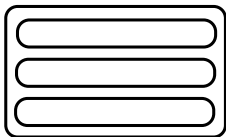
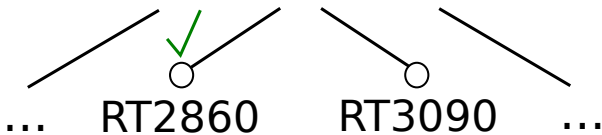
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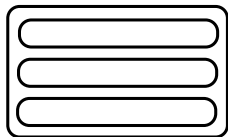
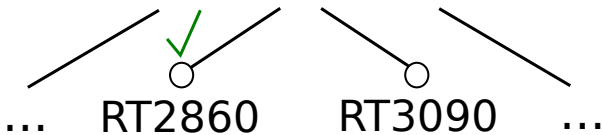
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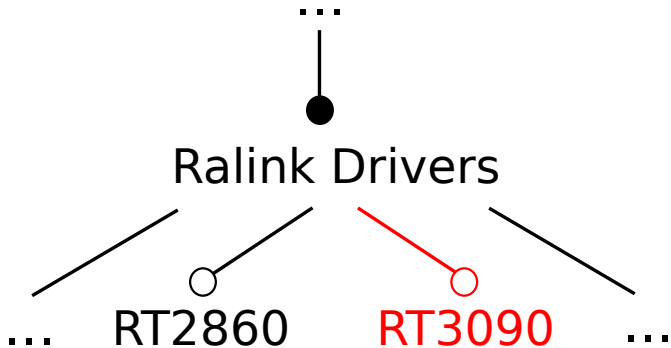
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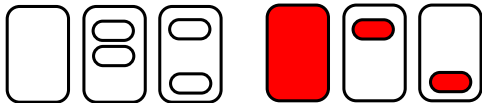
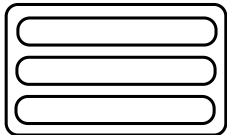
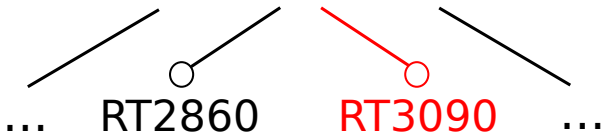


With the three spaces in mind,
the real picture of . . .

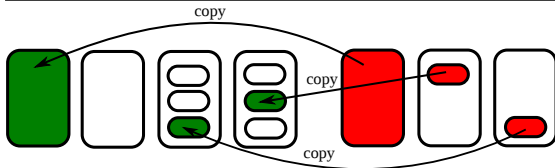
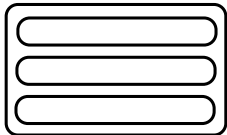
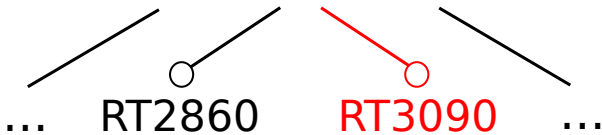


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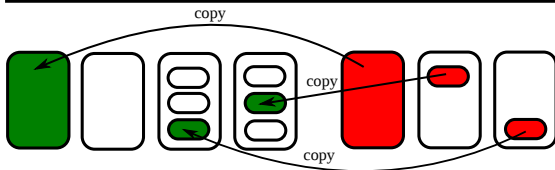
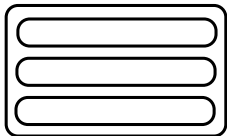
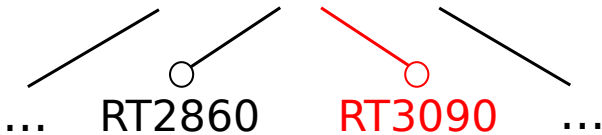
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Ralink Drivers



Ralink Drivers



RT3090 is merged into RT2860

We want to know...

How do the three spaces evolve
together in real world variant
rich software?

How do the three spaces evolve together in real world variant rich software?

Focus: features that disappear from the configuration space

Two goals

Understand the evolution of the three spaces in a
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Understand the evolution of the three spaces in a real-world variant rich software

Document our understanding in the form of evolution patterns (preliminary).

Our subject of analysis



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 - compilation space: Makefile

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- Contains multiple spaces:
 - configuration space: Kconfig
 - compilation space: Makefile
 - implementation space: C code

Variability evolution patterns from Linux

Data collection & Analysis

- Data collection is limited to three pairs of stable kernel releases in x86_64
- For each pair, we considered only the features that disappeared from the configuration space
- Manual analysis of 140 removals from a total of 220 (63%)

Infrastructure

- Extraction and reuse of Kconfig parsing infrastructure from Linux itself
 - allow us to compute disappearing features among each release kernel
- Conversion of Linux patches from git into a relational database
 - allow us to quickly identify which commit erases a feature from the configuration space
- `git log + gitk, grep`: visualize and search logs

Extracting patterns is hard!

Difficulties in analyzing patches when collecting patterns:

- unrelated changes (noise)
- technical comments (too much jargon)
- extensive set of changes
- everything is recorded in the SCM as addition/removal of lines (too low level)

Four identified patterns

- Optional feature to implicit mandatory
- Computed attributed feature to code
- Merge features by module aliasing
- Optional feature to kernel parameter

Template: structure, instance and discussion

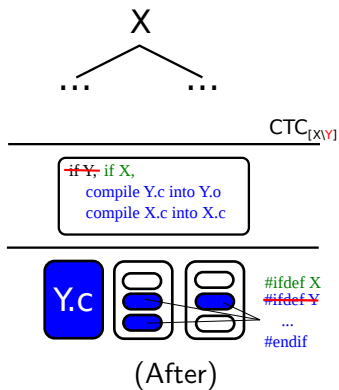
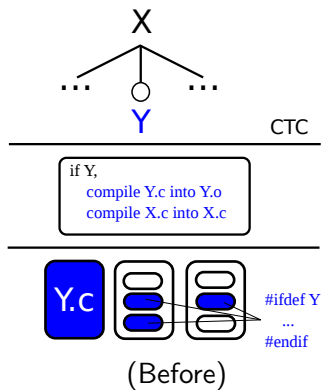
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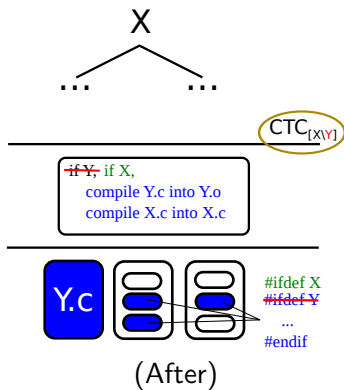
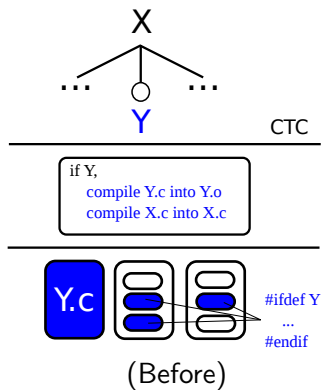
Template: structure, instance and discussion

Optional feature to implicit
mandatory

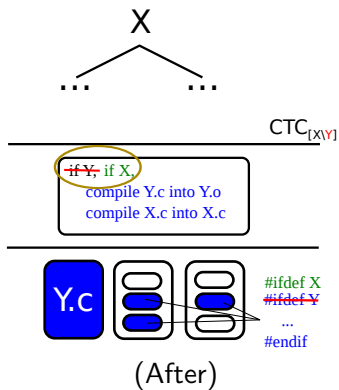
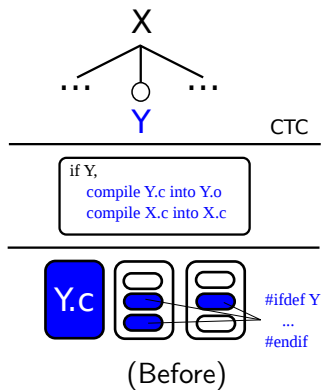
Structure & Instance



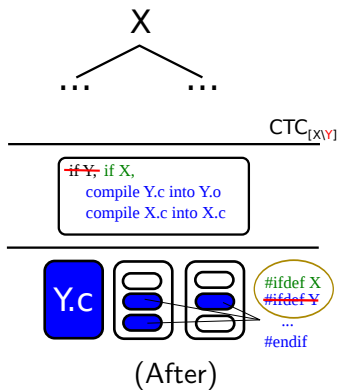
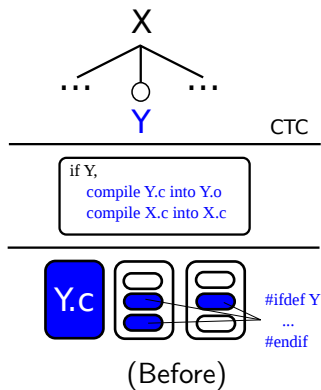
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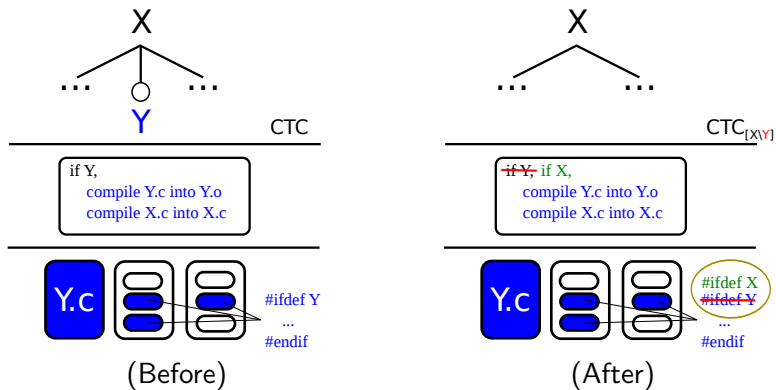
Structure & Instance



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Structure & Instance



Instance: X = OCFS, Y= OCFS Access Control List

Discussion

Pattern should be used when:

- users should not be given the freedom to configure Y
 - e.g.: they may inadvertently forget to select it, as in *Access Control List* (Y)
- Y is a critical feature that makes sense to exist in the software, given the presence of its parent X

Our patterns have direct
implications. . .

Direct implications

- Existing evolution studies (She et al. at Vamos'10, Lotufo et. al. at SPLC'10) focus on the variability model alone: our patterns show that features can be erased from the configuration space, while still present in the implementation space
- Our patterns capture situations not covered by the existing SPL evolution theory (Borba et al. at ITAC'10)
 - compatibility of product is not guaranteed (evolution is not safe)

Conclusions

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- Evolution must focus on all spaces
- We presented 4 patterns extracted from Linux
- Our patterns explain the evolution of features removed from the configuration space
- They show evolution steps not captured in previous studies (both theoretical and empirical).

Future work

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- Collect patterns not restricted to removals
- Measure frequency
- Study other systems

Thanks for listening!

