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

Leonardo Passos

University of Waterloo

lpassos@gsd.uwaterloo.ca

Krzysztof Czarnecki

University of Waterloo

kczarnec@gsd.uwaterloo.ca

Andrzej Wasowski

IT University of Copenhagen

wasowski@itu.dk

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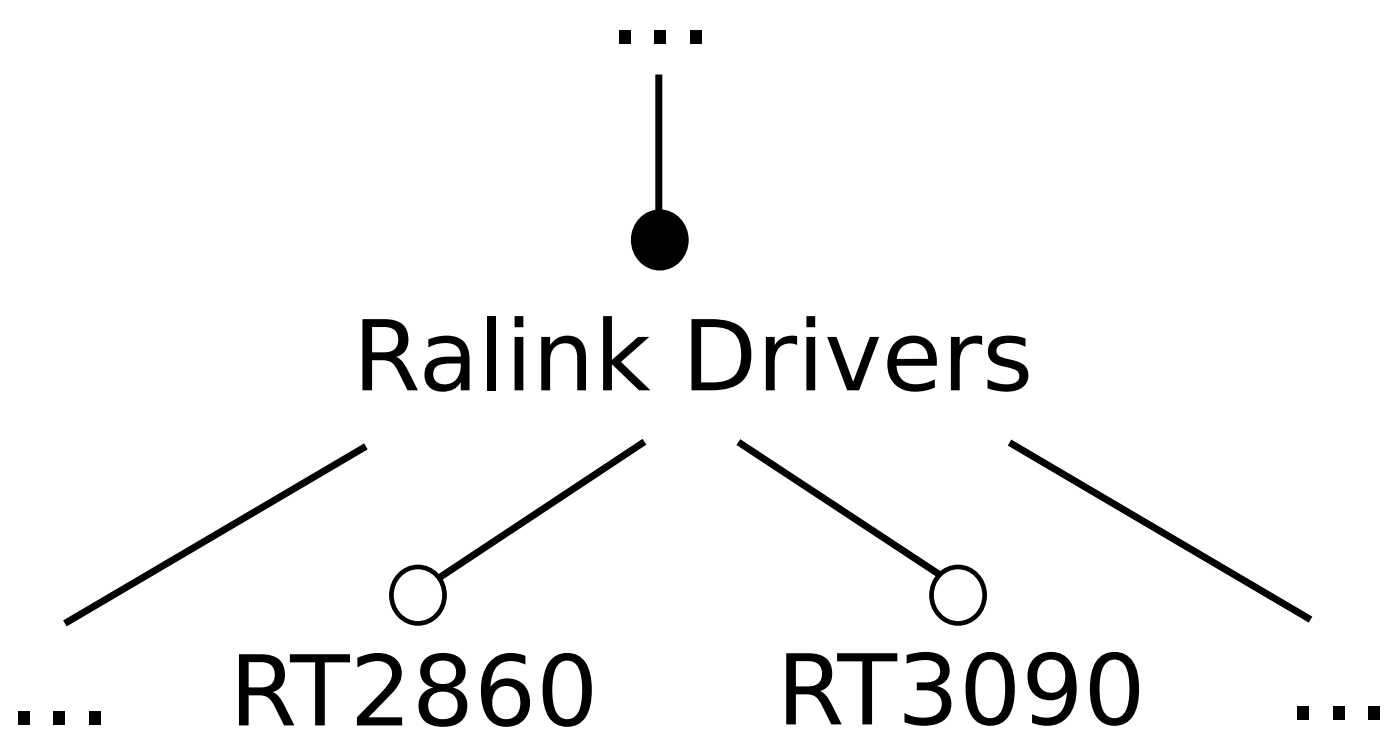
     Examples:

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

Example (from Linux)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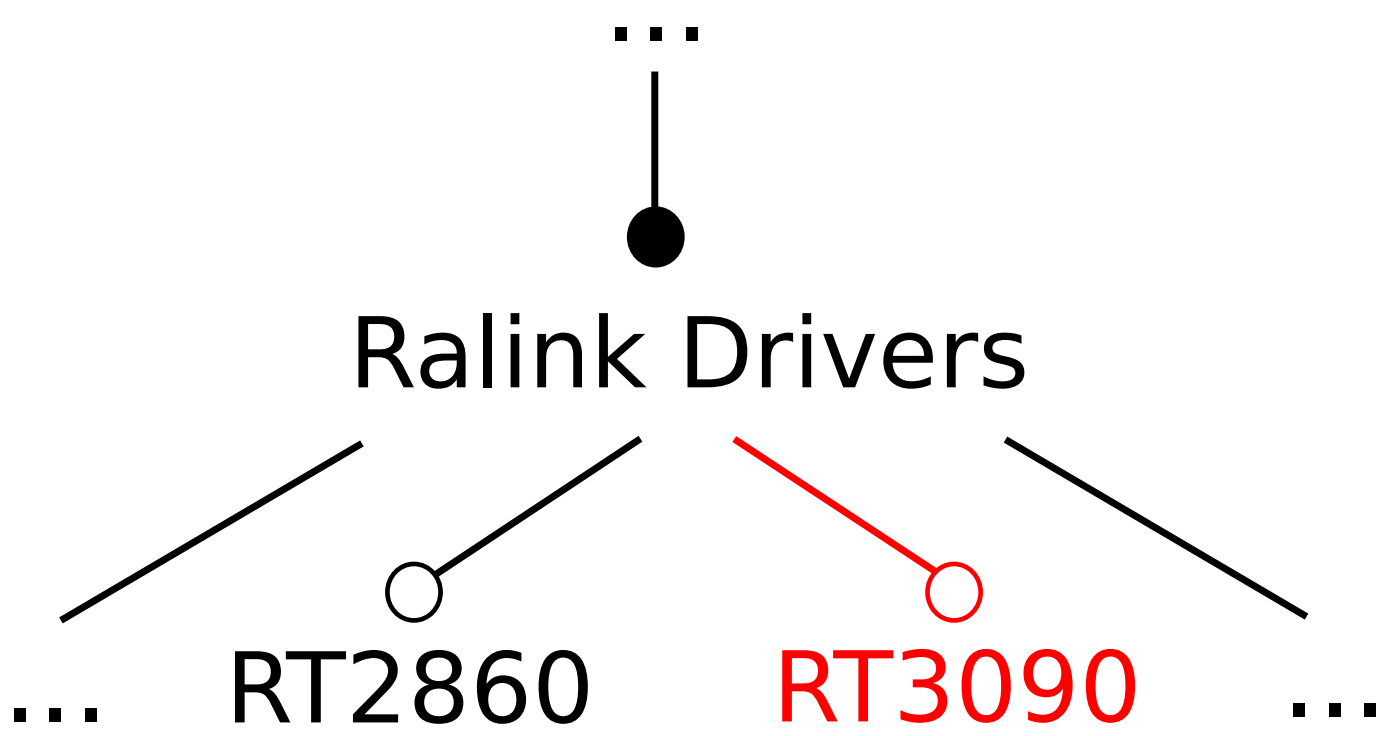
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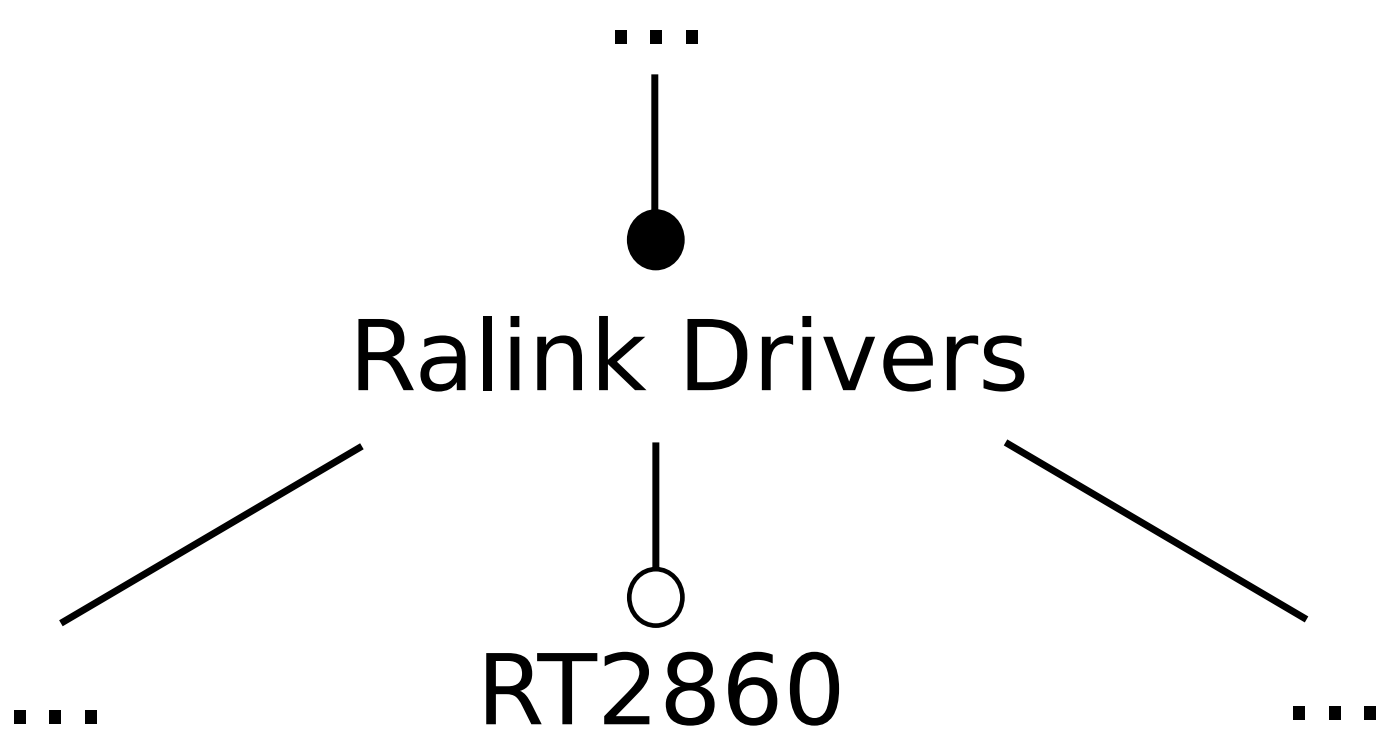
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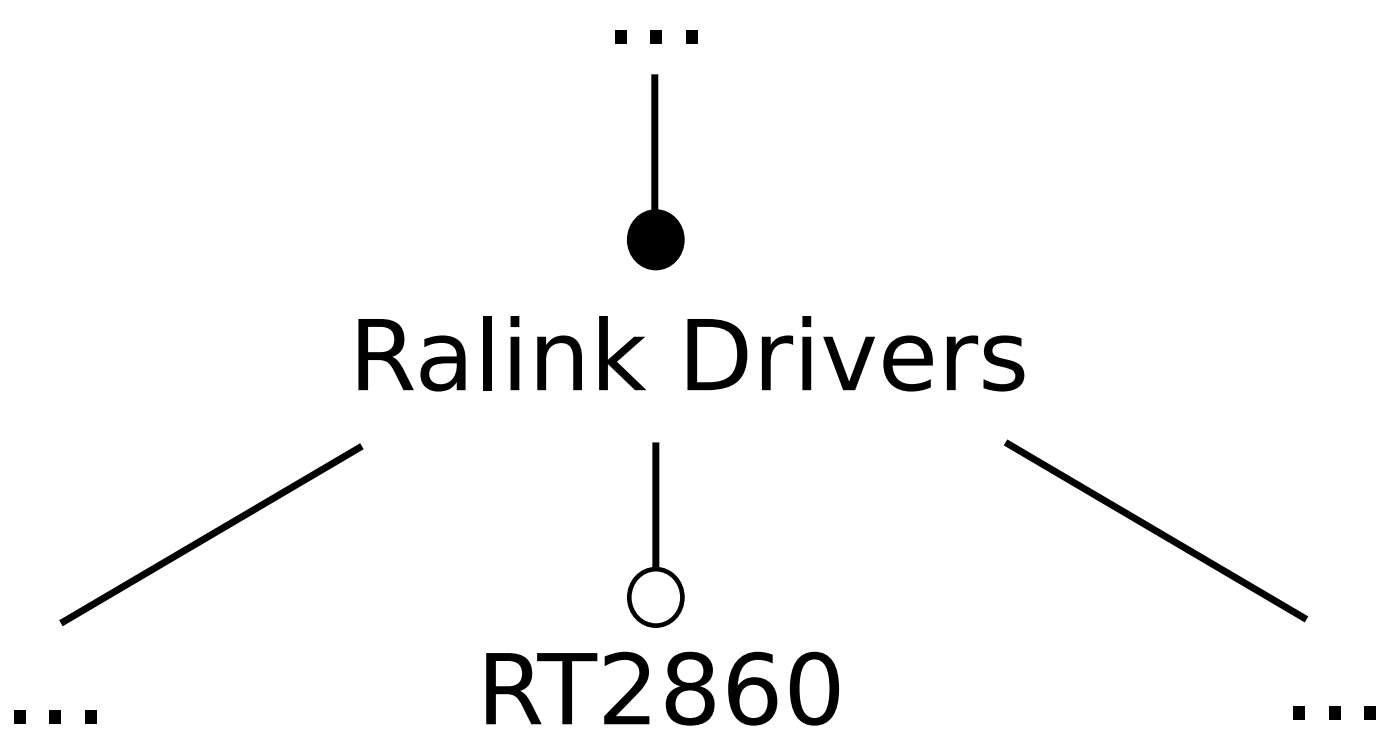
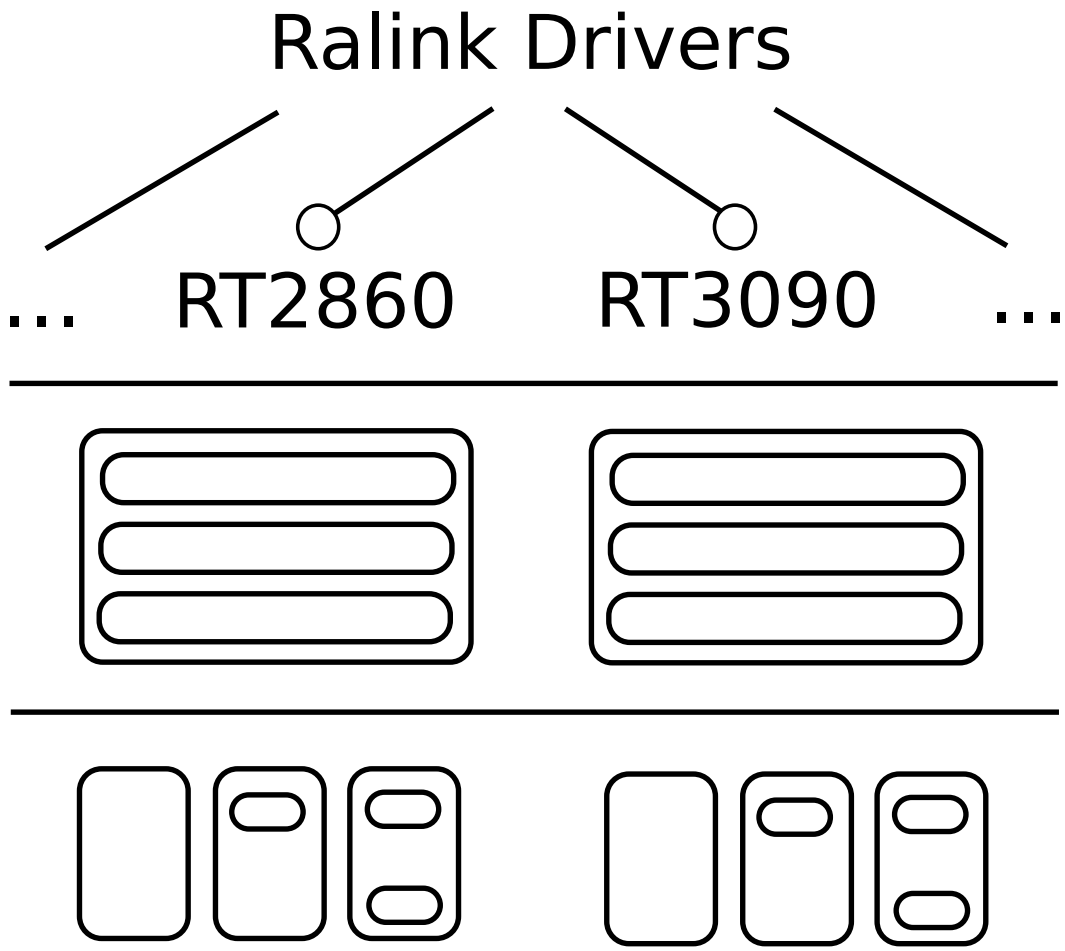


Complete removal?

Existing evolution studies tend to focus on the variability model alone

That doesn't tell the whole story. . .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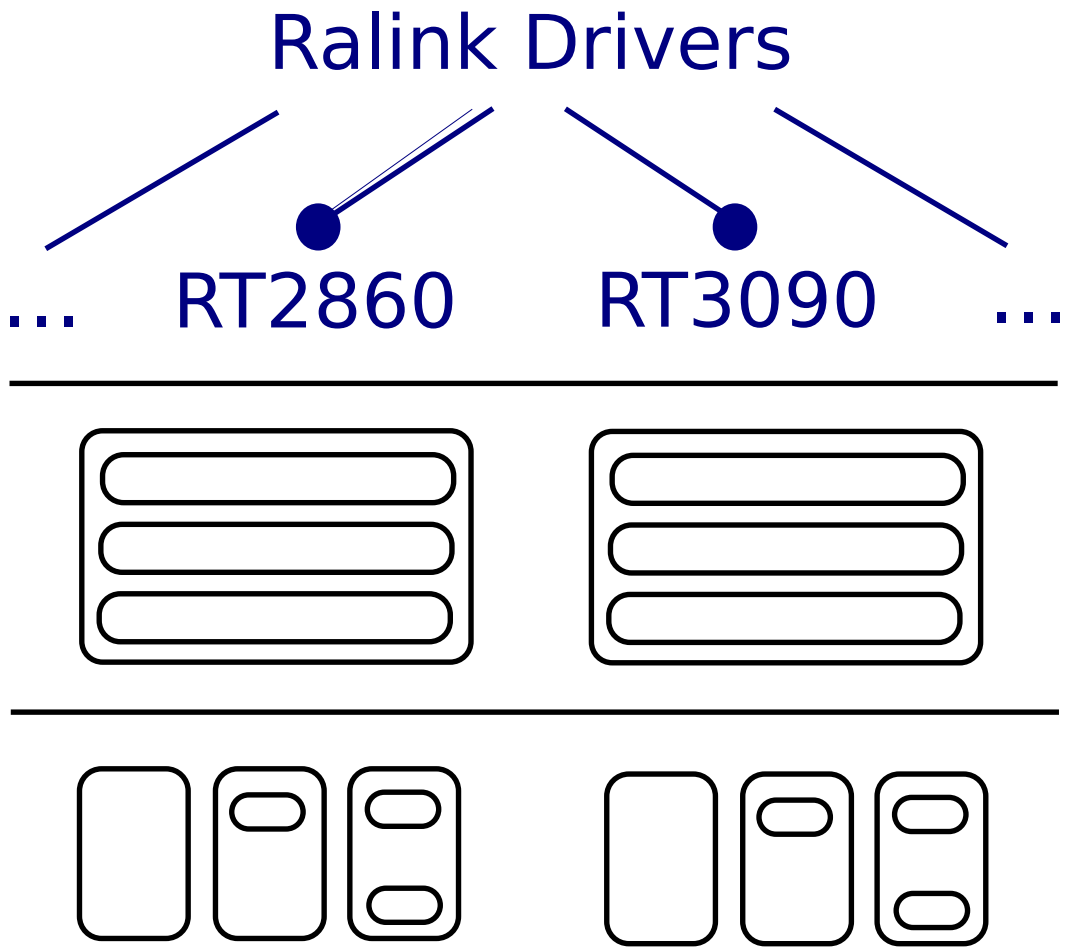
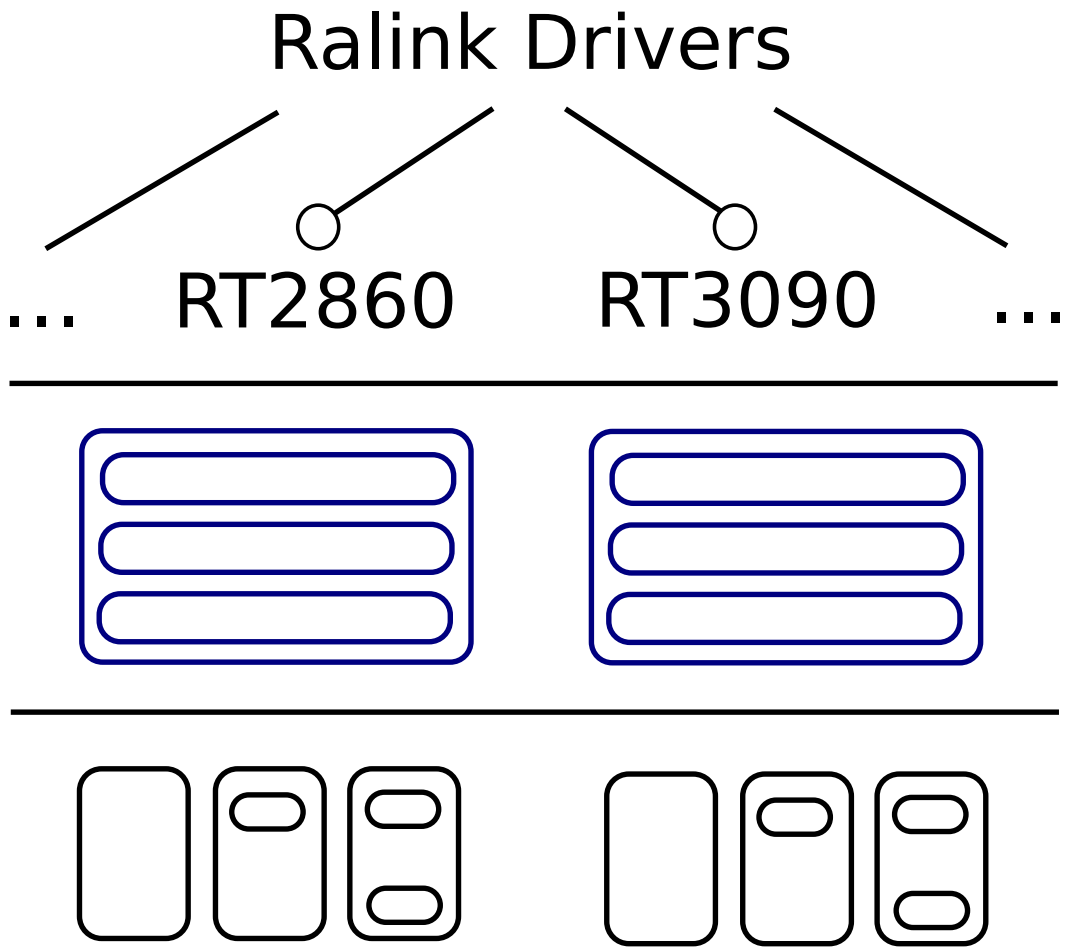
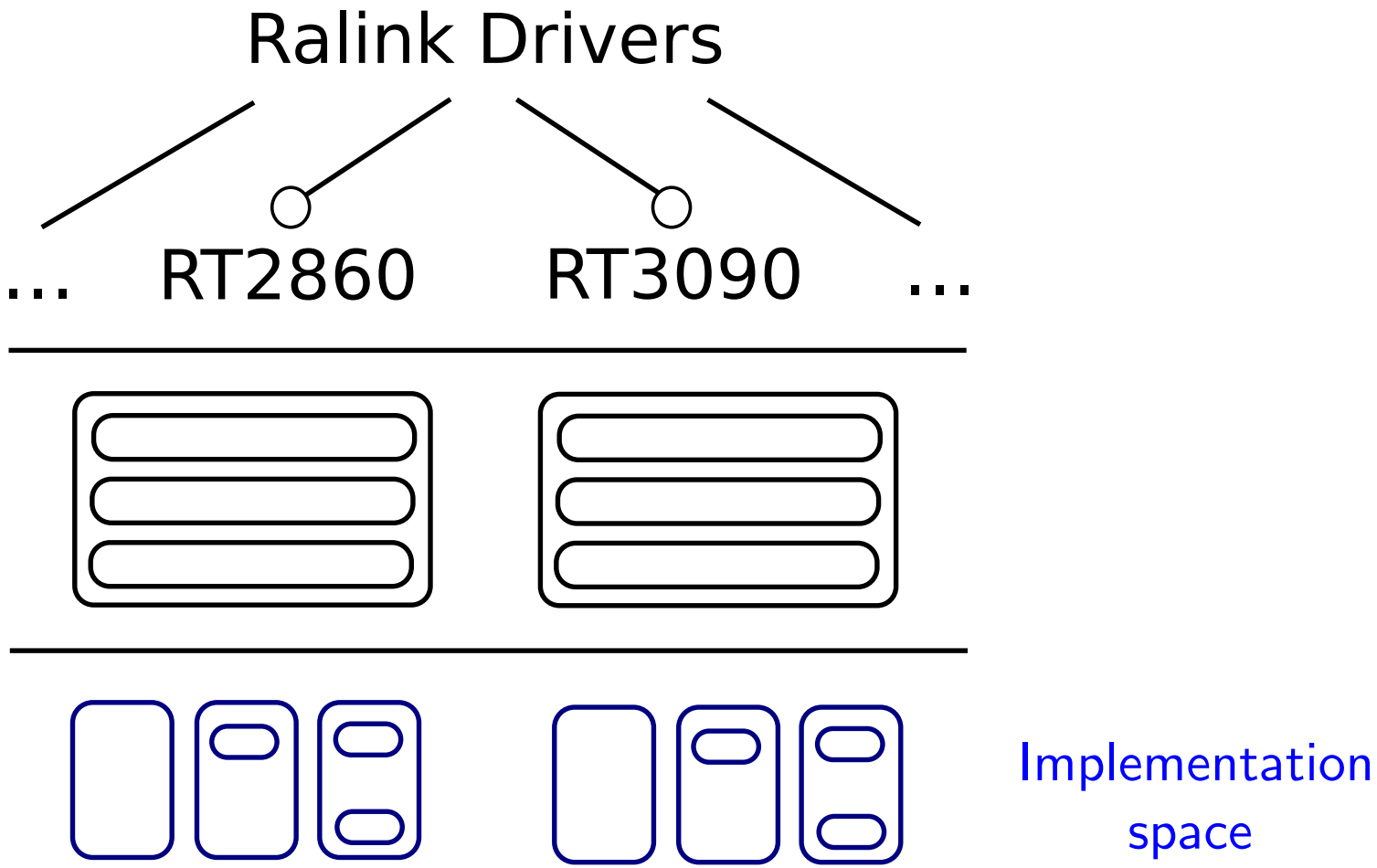


Configuration space



Compilation space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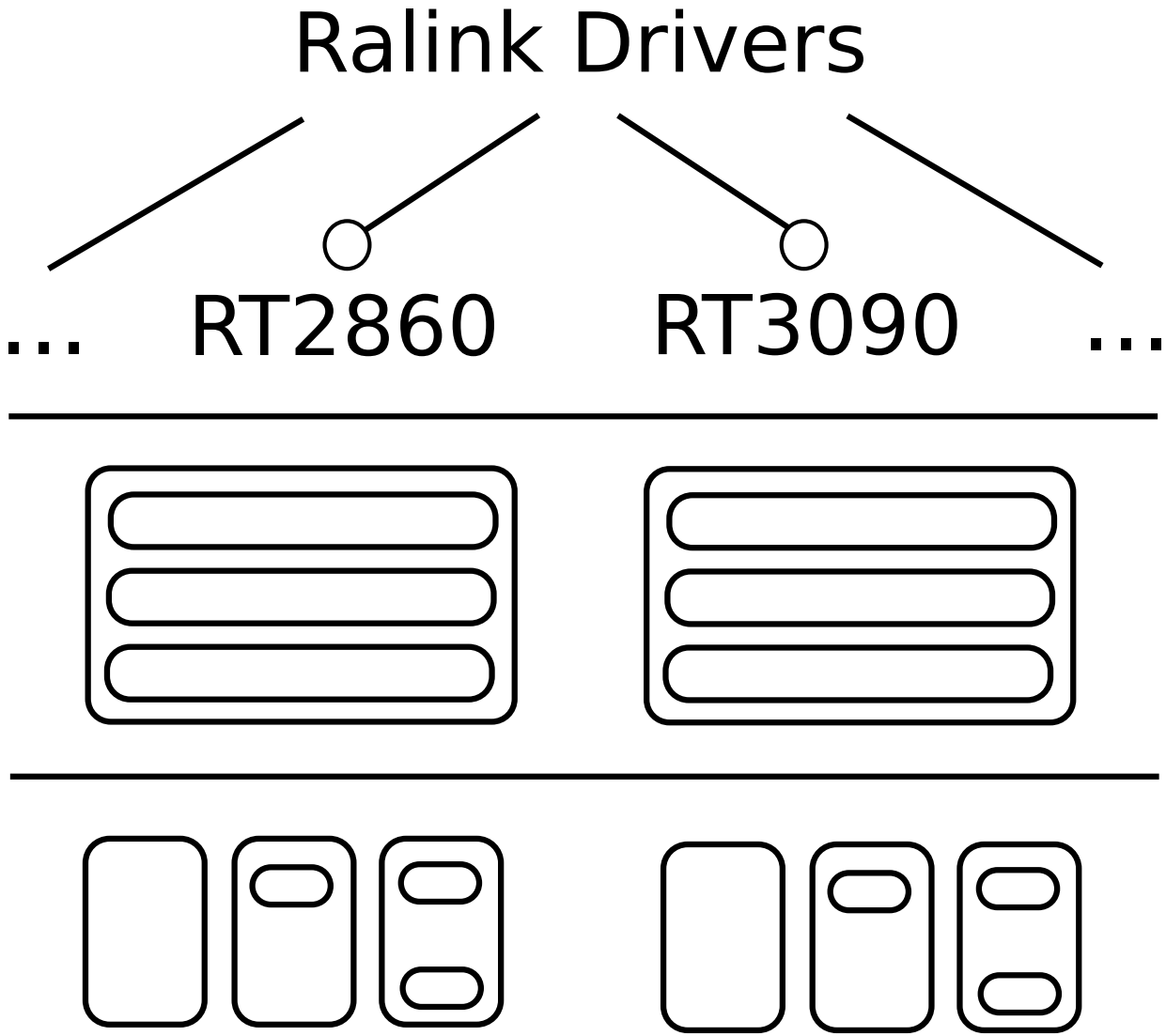
Implementation space

Spaces are connected. . .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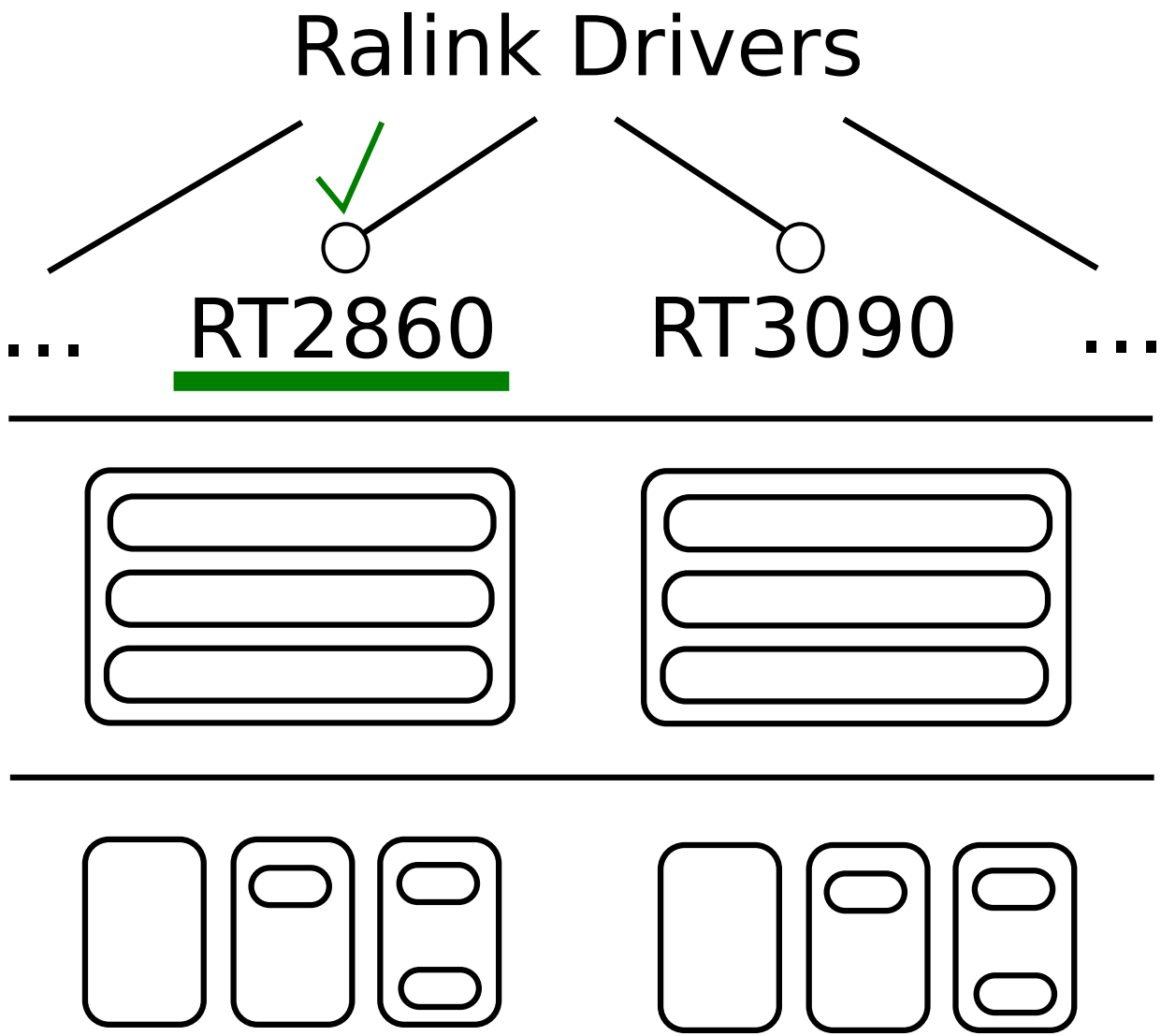
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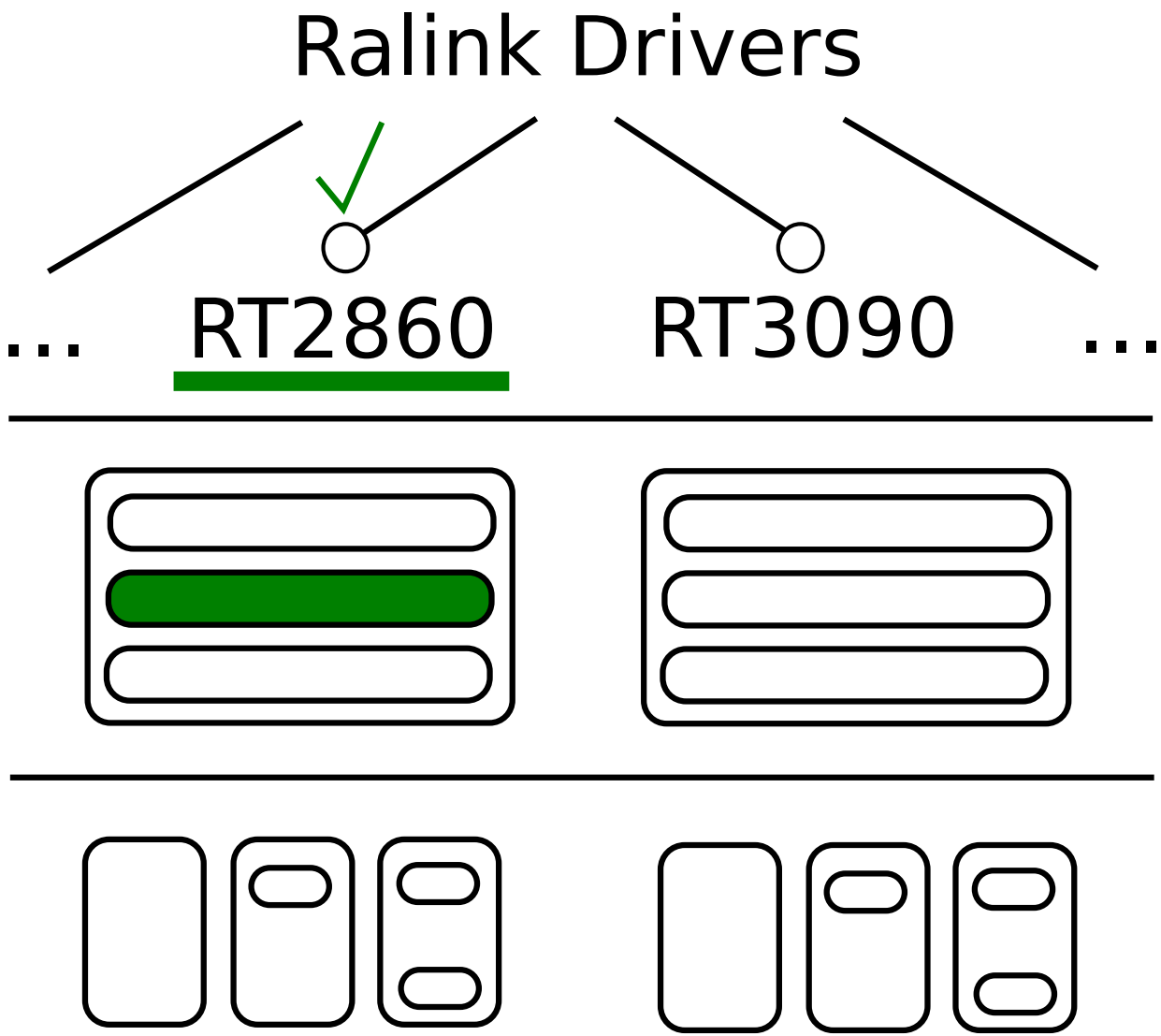
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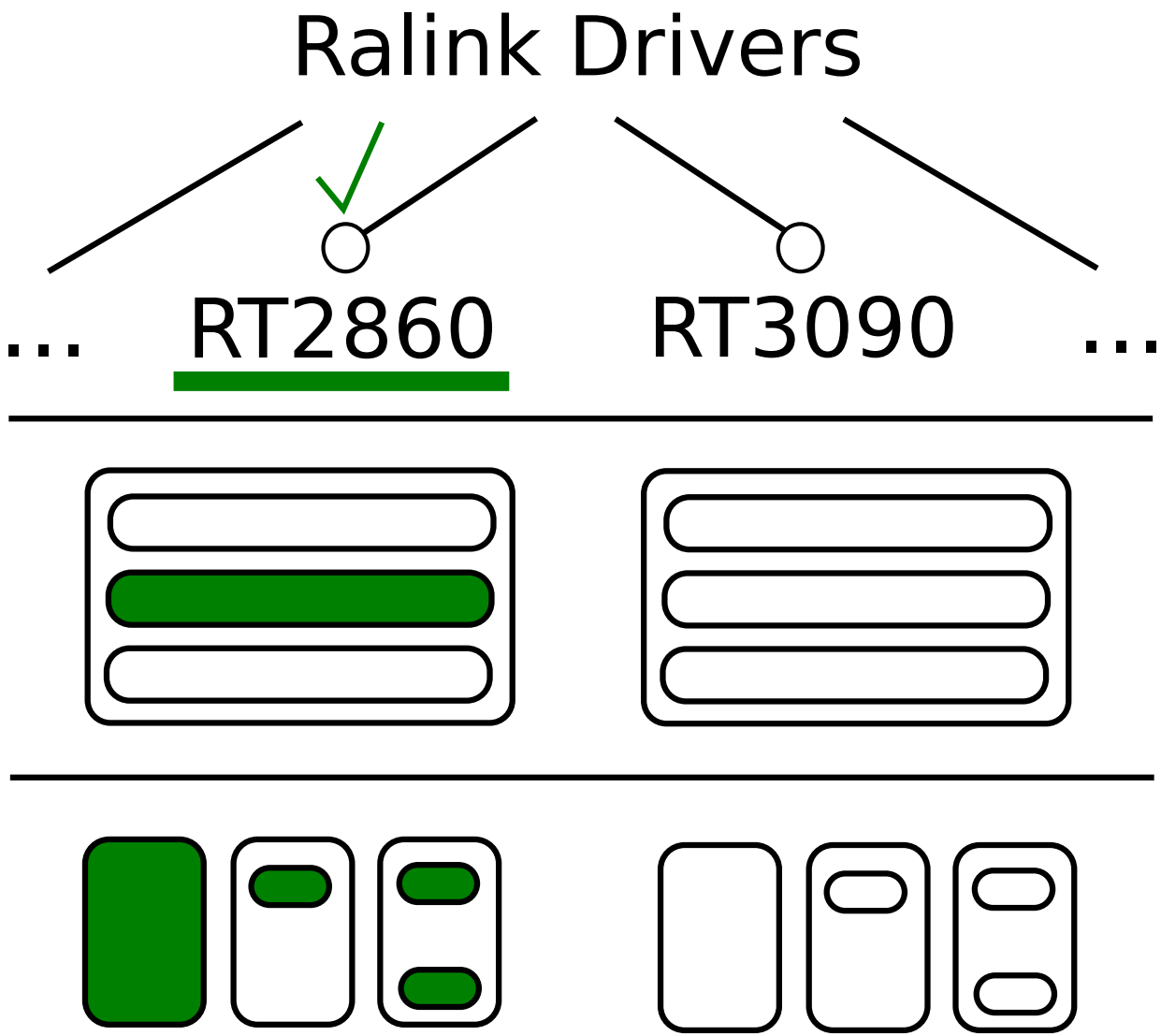
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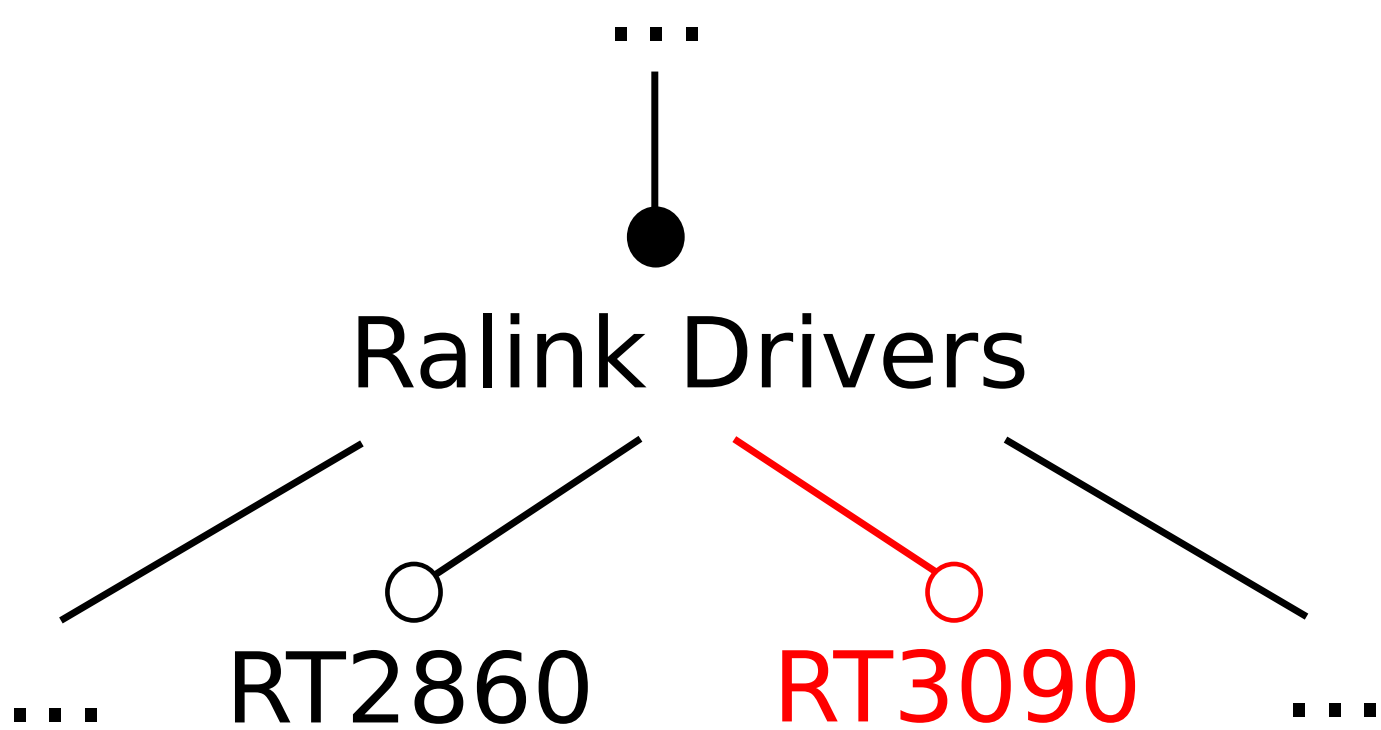
With the three spaces in mind,
the real picture of . . .



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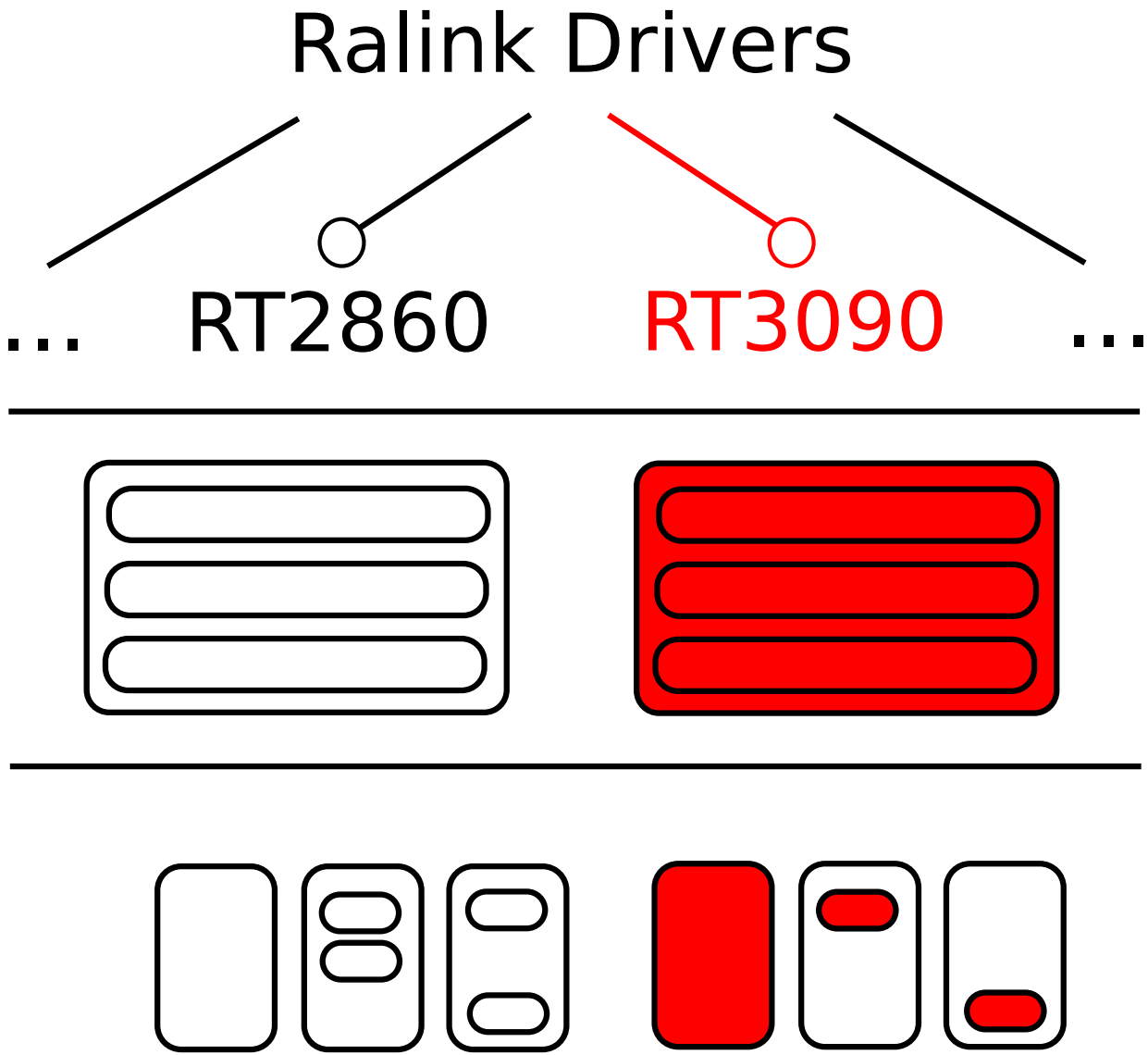
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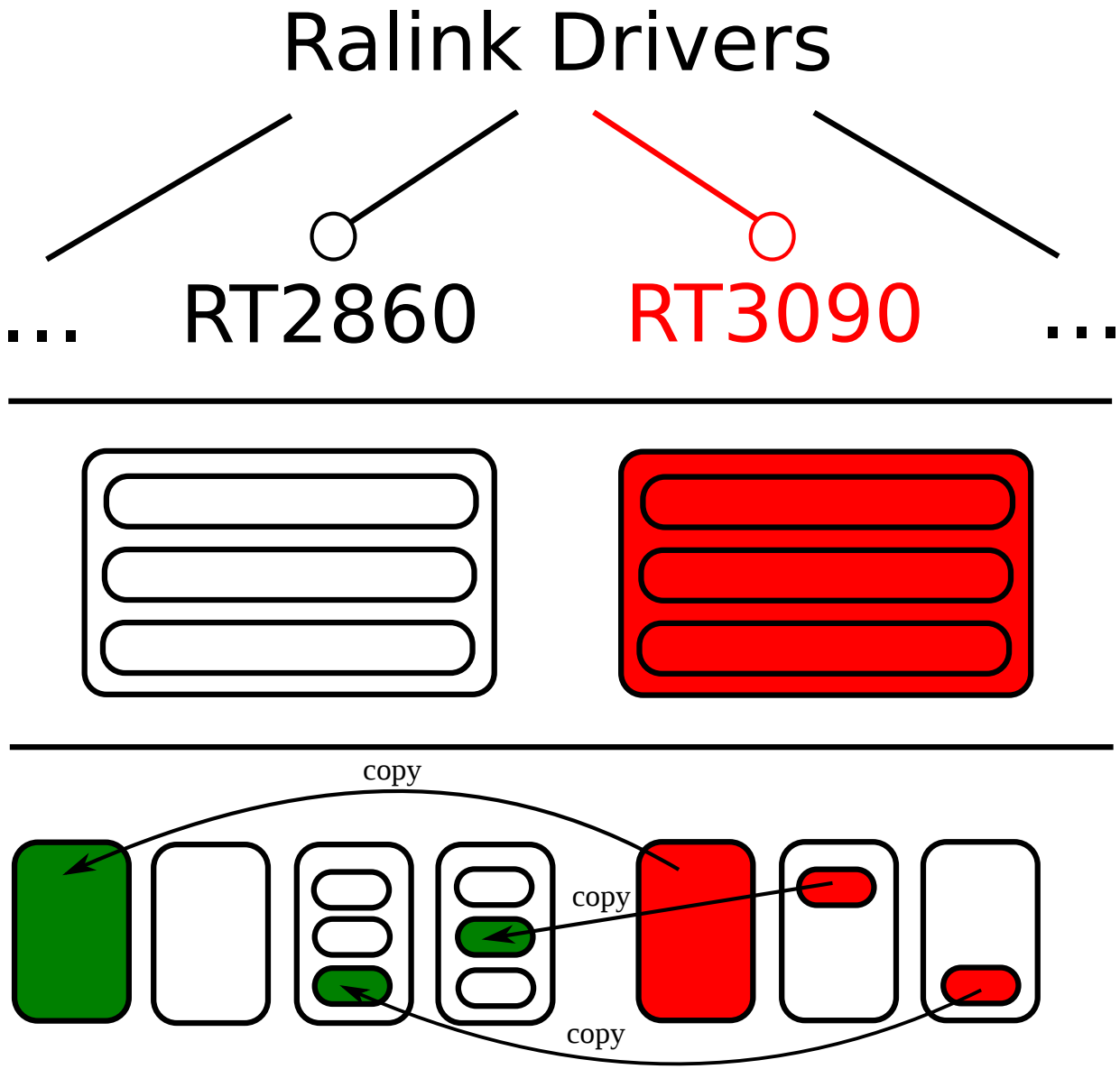
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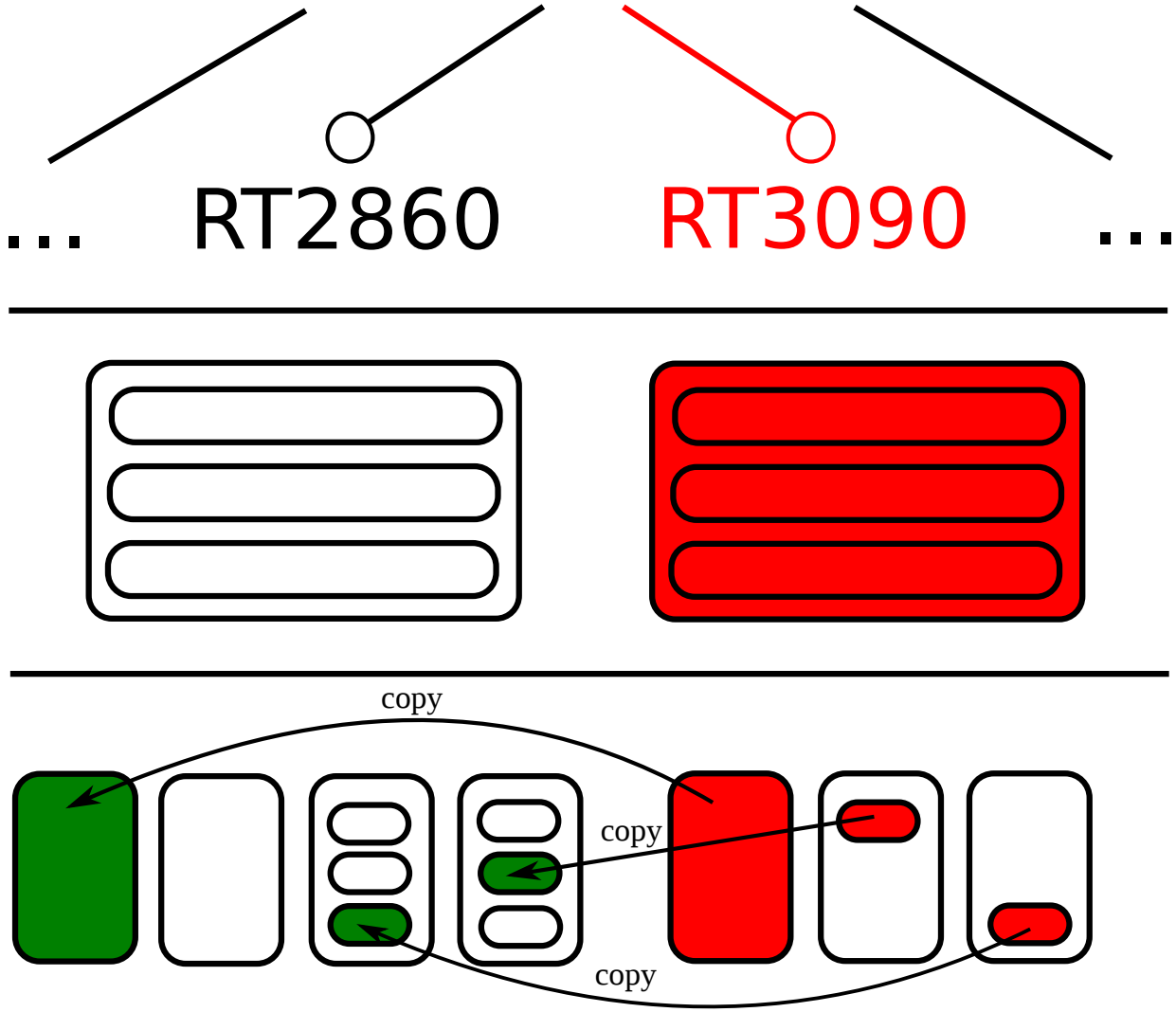

RT3090 is merged into RT2860

We want to know. . .

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

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Focus: features that disappear from the configuration space

Two goals

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

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

Our subject of analysis

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  - 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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Optional feature to implicit mandatory

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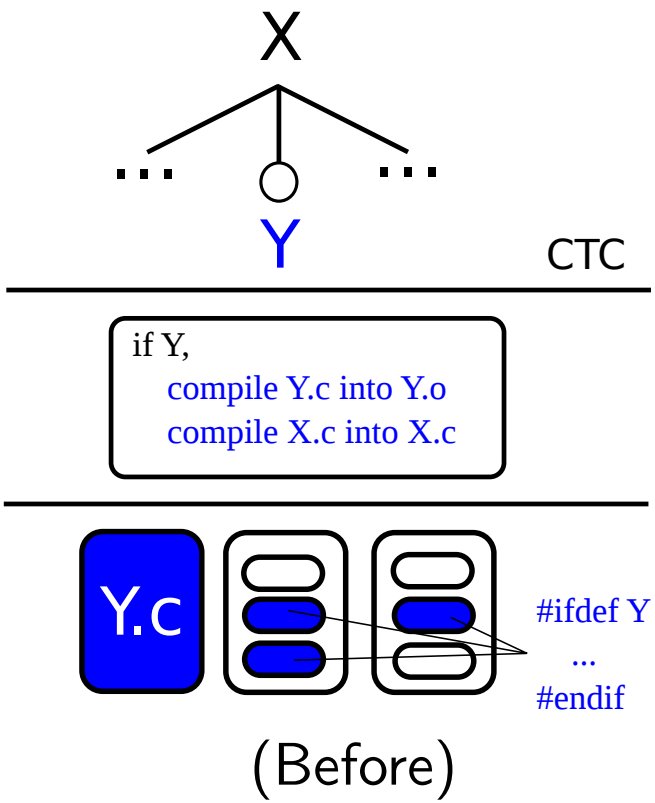

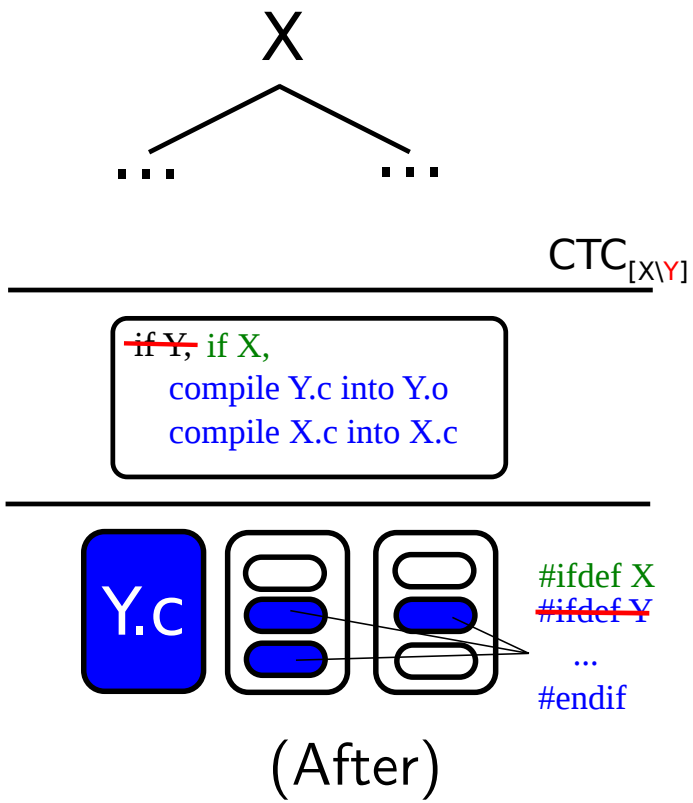

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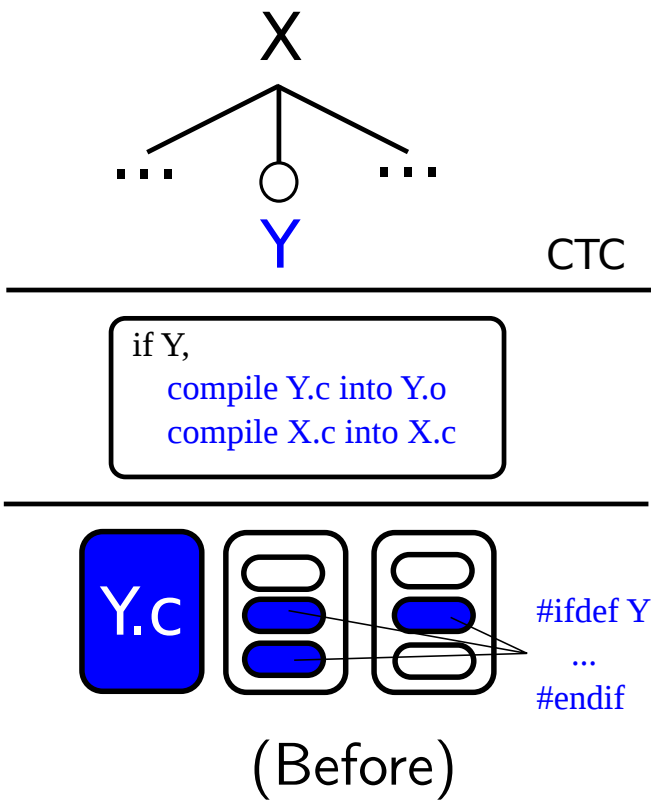

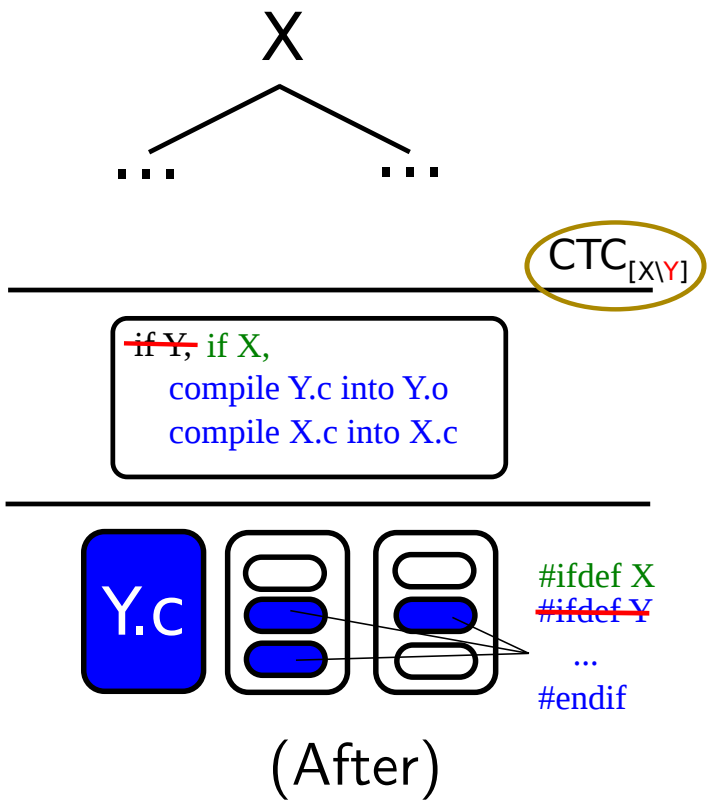

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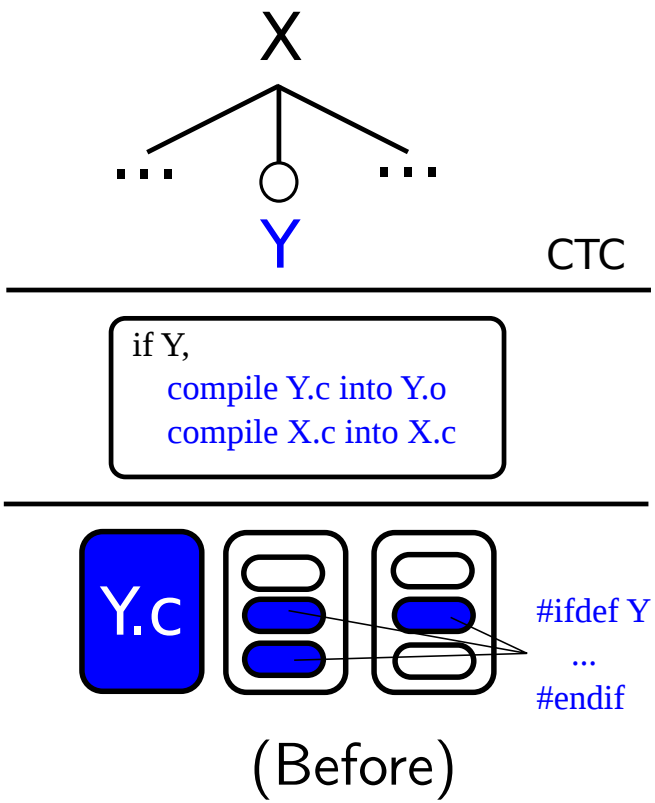

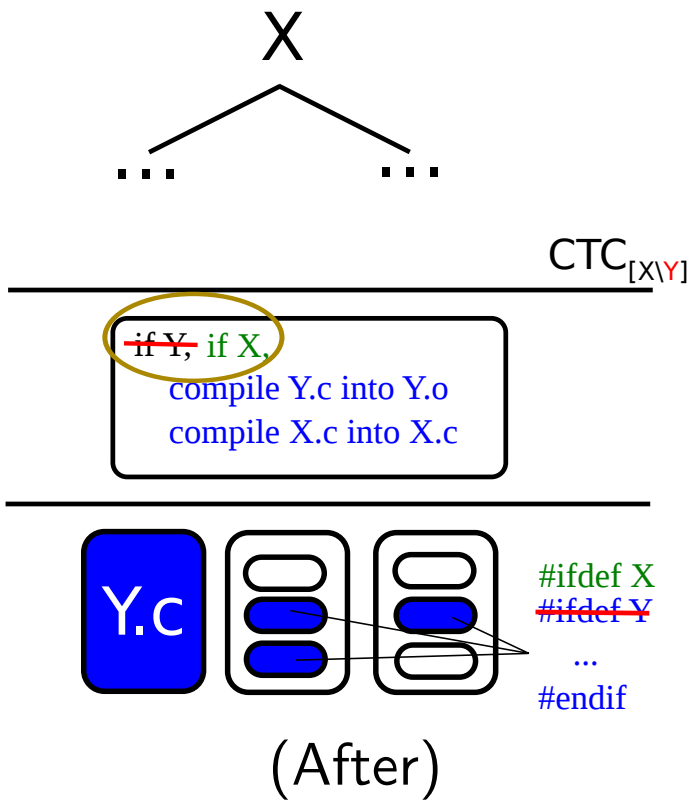

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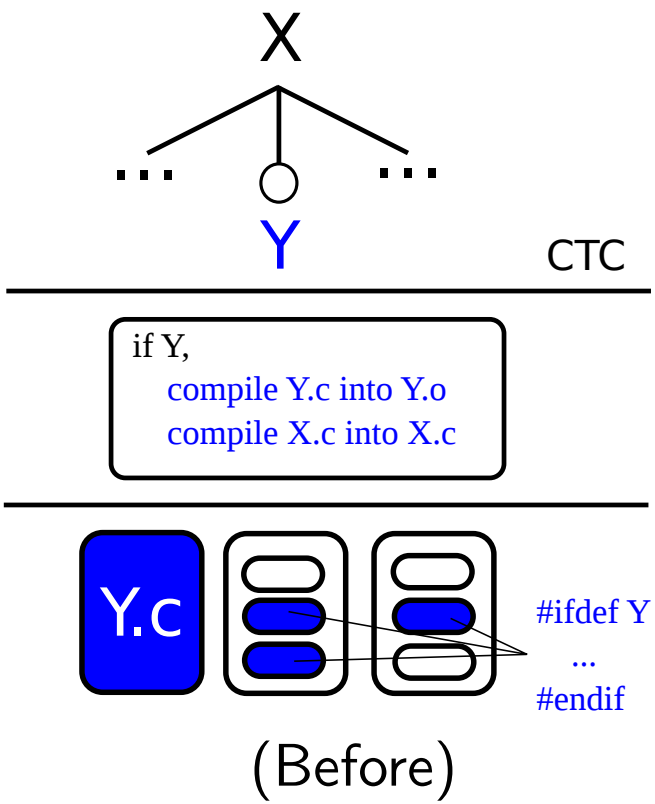

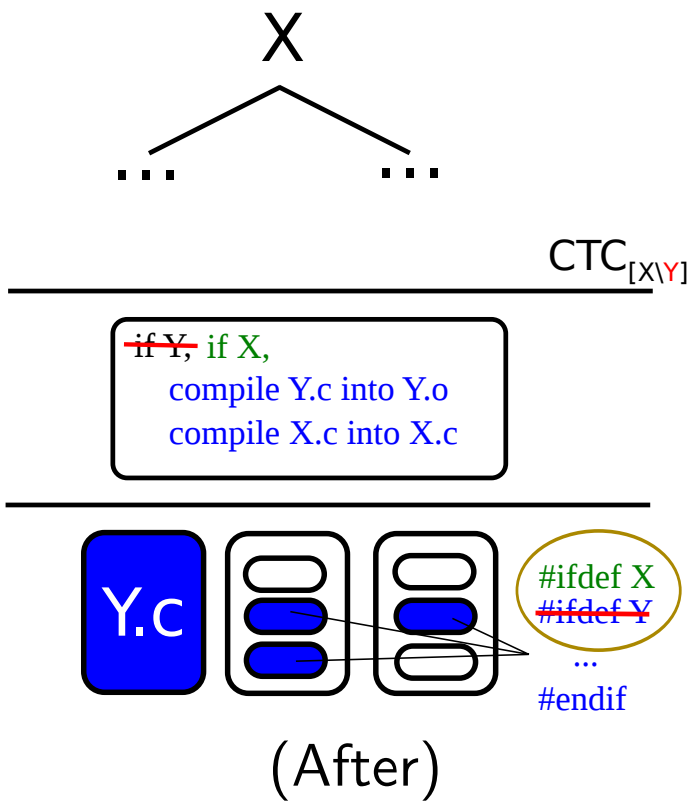

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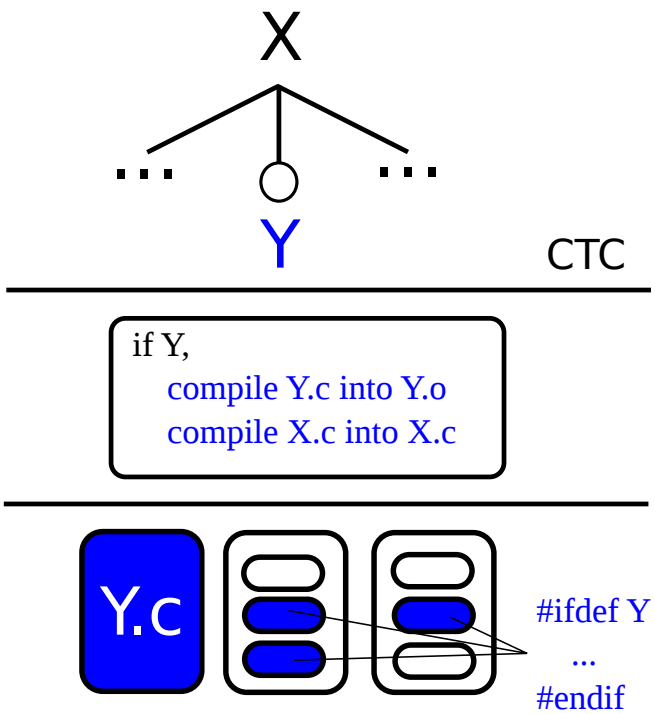
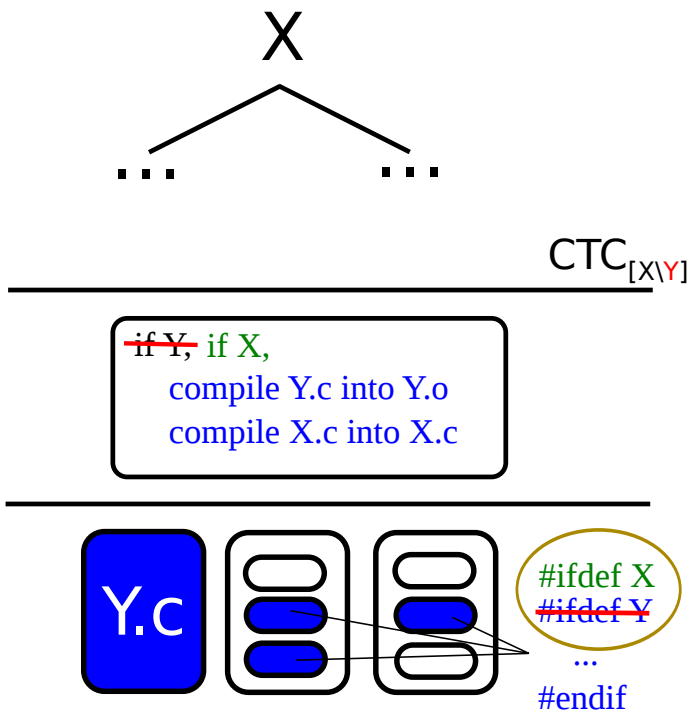


(Before)



(After)

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 inadvertly 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!