

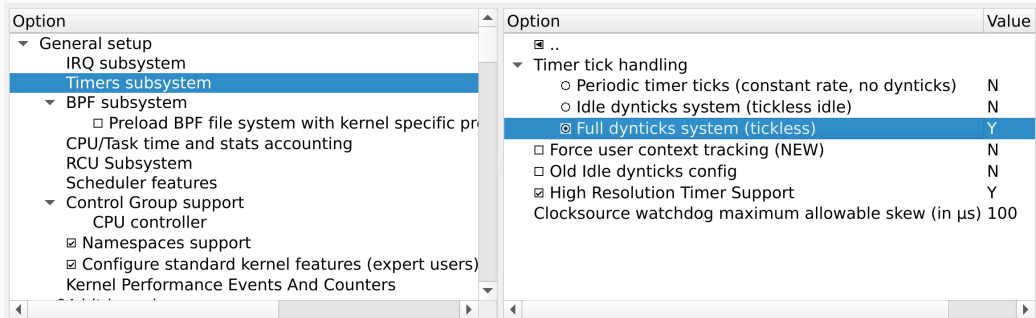
kconfig-webconf: Retrofitting Performance Models onto Kconfig-Based Software Product Lines

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Osnabrück University / Embedded Software Systems

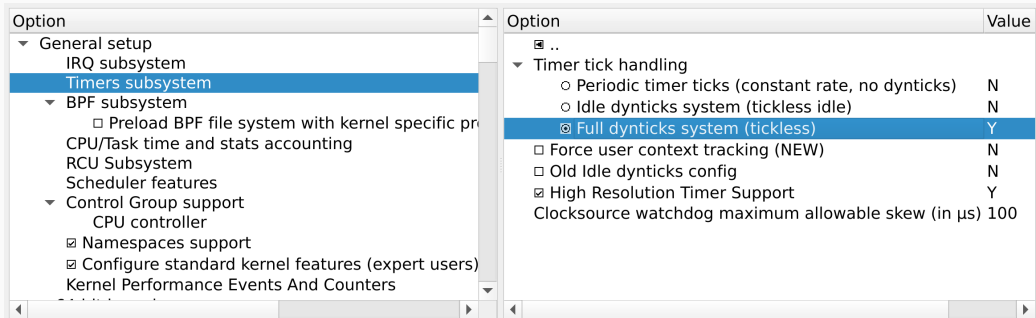
Kconfig-Based Software Product Lines



Linux: kconfig-qconf

- Kconfig: variability modeling language [Sin+07; EKS15]

Kconfig-Based Software Product Lines



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Kconfig-Based Software Product Lines

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.config - Configuration

System Logging Utilities

[*] klogd (5.7 kb)
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[*] Use the klogctl() interface
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[*] logread (4.8 kb)
[*] Double buffering
[*] syslogd (13 kb)
    [*] Rotate message files
    [*] Remote Log support
    [*] Support -D (drop dups) option
    [*] Support syslog.conf
    [ ] Include milliseconds in timestamps
    (255) Read buffer size in bytes
    [*] Circular Buffer support
        (16) Circular buffer size in Kbytes (minimum 4KB)

F1 Help F2 SymInfo F3 Help 2 F4 ShowAll F5 Back F6 Save F7 Load F8 SymSearch F9 Exit
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Busybox: kconfig-nconf

- Kconfig: variability modeling language [Sin+07; EKS15]
- Does not support performance models
- Integrated into build process → switching is costly

Kconfig + Performance Models

Configuration

data+bss size: 1999432 B

ELF size: 5684950 B

Settings

- What kind of applet links to install (NEW)
- Additional debugging library (NEW)
- Buffer allocation policy (NEW)

Archival Utilities

Coreutils

Console Utilities

Debian Utilities

klibc-utils

Editors

Finding Utilities

Init Utilities

Login/Password Management Utilities

Linux Ext2 FS Progs

Linux Module Utilities

Linux System Utilities

Filesystem/Volume identification

Miscellaneous Utilities

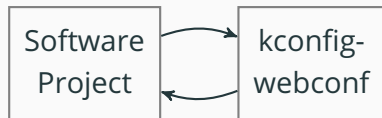
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- Rotate message files ☒ -1385690 B
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- Support -D (drop dups) option ☒ +425415 B
- Support syslog.conf ☒ -74323 B
- Include milliseconds in timestamps ☐ +687093 B
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⇒ kconfig-webconf: Performance-aware drop-in replacement for Kconfig

- kconfig-webconf: single-page React application
Rationale: Browsers are ubiquitous cross-platform GUI

Implementation



- kconfig-webconf: single-page React application
Rationale: Browsers are ubiquitous cross-platform GUI
- local usage (no internet connection required)

Implementation



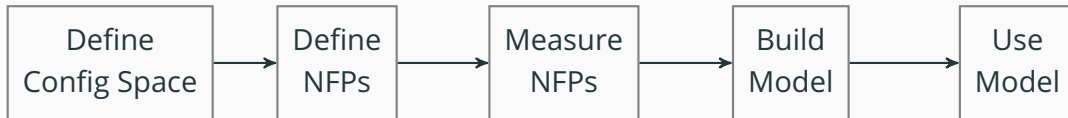
- kconfig-webconf: single-page React application
Rationale: Browsers are ubiquitous cross-platform GUI
- local usage (no internet connection required)
- web usage (e.g. combined with build server)

Implementation



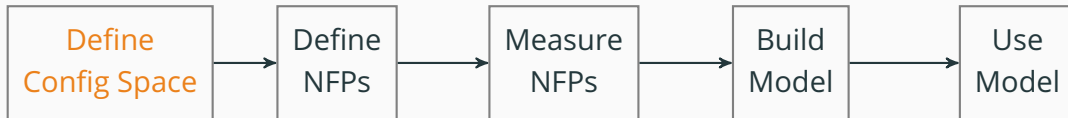
- kconfig-webconf: single-page React application
Rationale: Browsers are ubiquitous cross-platform GUI
- local usage (no internet connection required)
- web usage (e.g. combined with build server)
- dfatool: Python3 companion tool for NFP model generation

Workflow



Example: **busybox** multi-call binary

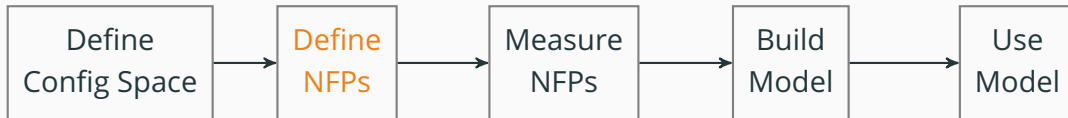
Workflow



Kconfig: machine-readable variability model → known configuration space

```
config MD5_SMALL
    int "MD5: Trade bytes for speed (0:fast, 3:slow)"
    default 1 # all "fast or small" options default to small
    range 0 3
    help
    Trade binary size versus speed for the md5sum algorithm.
    Approximate values running uClibc and hashing
    linux-2.4.4.tar.bz2 were:
    value          user times (sec)  text size (386)
    0 (fastest)    1.1                6144
    1              1.4                5392
    2              3.0                5088
    3 (smallest)   5.1                4912
```

Workflow



Define and measure performance attributes (non-functional properties)

```
df@ios /t/t/busybox-1.35.0 > make nfpkeys  
{"Image": {"ROM": {"unit": "B", "description": "ELF size", "minimize": true},  
  "RAM": {"unit": "B", "description": "data+bss size", "minimize": true}}}  
df@ios /t/t/busybox-1.35.0 > make nfpvalues  
{"Image": {"ROM": 566328, "RAM": 2344}}
```

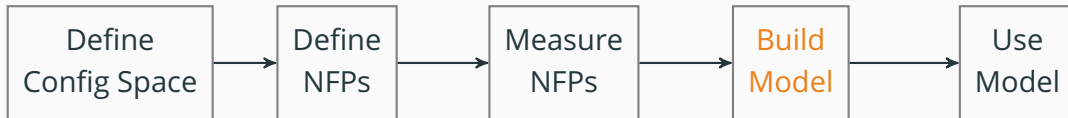
Workflow



Automatic measurements in configuration space

```
df@ios /t/t/busybox_data > explore-kconfig.py --log-level debug --random 2000 --with-neighbourhood ../busybox-1.35.0
INFO:root:Running randconfig 1 of 2000
INFO:dfatool.kconfig:build error
INFO:root:Running randconfig 2 of 2000
INFO:root:Exploring neighbourhood of /tmp/tmpfs/busybox_data/RandomConfig-b43a6b027123600c80b85d064e20053b/.config
DEBUG:dfatool.kconfig:Set DESKTOP to y
warning: FEATURE_MOUNT_FAKE (defined at /tmp/tmpfs/busybox-1.35.0/Kconfig:4746) has direct dependencies MOUNT with value y
g symbols:
- FEATURE_MTAB_SUPPORT (defined at /tmp/tmpfs/busybox-1.35.0/Kconfig:5119), with value y, direct dependencies MOUNT |
NT (value: y)
DEBUG:dfatool.kconfig:Set EXTRA_COMPAT to y
DEBUG:dfatool.kconfig:Set FEDORA_COMPAT to n
DEBUG:dfatool.kconfig:Set INCLUDE_SUSv2 to n
```

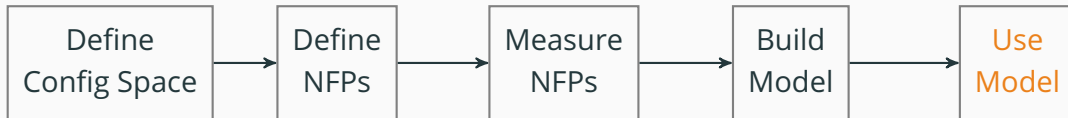

Workflow



Automatic performance model generation

```
df@ios /t/t/busybox-data > analyze-kconfig.py --force-tree --export-webconf busybox.json ../busybox-1.35.0/Kconfig .
Model error after cross validation (kfold, 10):
```

key	attribute		static		parameterized		LUT
Image	RAM		157.08% / 2033715		9.40% / 196390		157.08% / 2033715
Image	ROM		106.35% / 4837516		9.27% / 538199		106.35% / 4837516



Performance-aware system configuration

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data+bss size: 1999432 B ELF size: 5684950 B

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Further Resources

- Live Demo
 - `ess.cs.uos.de/git-build/kconfig-webconf/splc22`
 - `ess.cs.uos.de/git-build/kconfig-webconf/splc22/embeddedml`
- Source Code
 - `ess.cs.uos.de/git/software/kconfig-webconf` (Frontend)
 - `ess.cs.uos.de/git/software/dfatool` (Model Generation)

Details $\Rightarrow$ Demo session during coffee break

- [EKS15] Sascha El-Sharkawy, Adam Krafczyk, and Klaus Schmid. **“Analysing the Kconfig Semantics and Its Analysis Tools”**. In: Proceedings of the 2015 ACM SIGPLAN International Conference on Generative Programming: Concepts and Experiences. GPCE 2015. Pittsburgh, PA, USA: Association for Computing Machinery, 2015, pp. 45–54. ISBN: 9781450336871. DOI: 10.1145/2814204.2814222. URL: <https://doi.org/10.1145/2814204.2814222>.
- [Sin+07] Julio Sincero et al. **“Is The Linux Kernel a Software Product Line?”** In: Open Source Software and Product Lines (SPLC-OSSPL 2007). Ed. by Frank van der Linden and Björn Lundell. Kyoto, Japan, Sept. 2007.