Energy-Aware Computing Systems (EASY)

Energy measurement

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Energy Measurement

Energy Measurement

- Physics: $E_{t_0}(t) = \int_{t_0}^{t} P(\tau)\mathrm{d}\tau = \int_{t_0}^{t} V(\tau)I(\tau)\mathrm{d}\tau$

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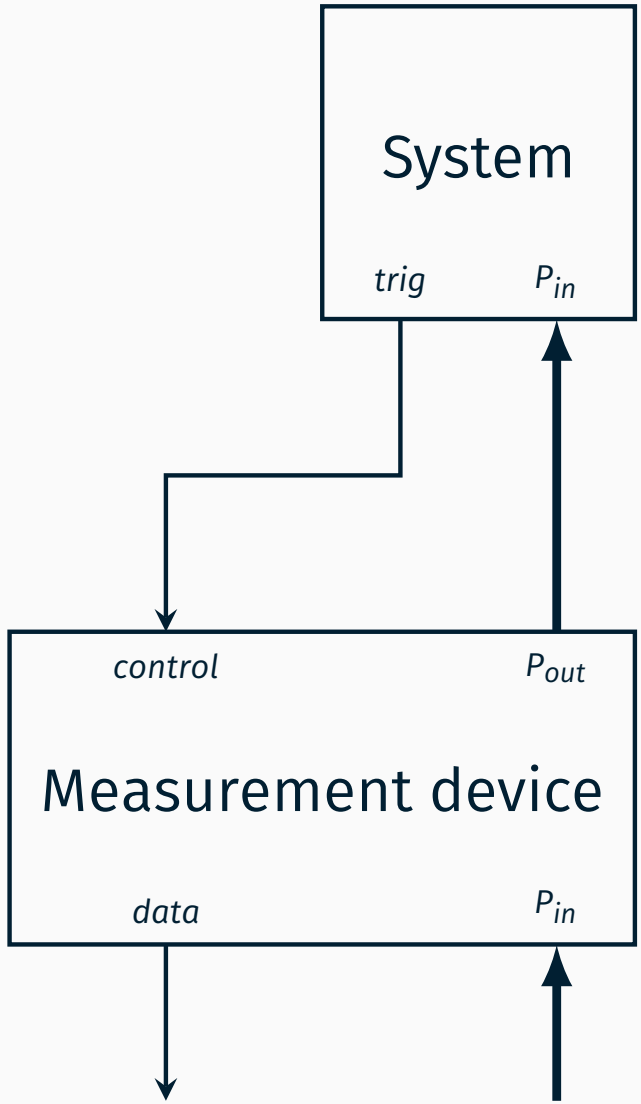
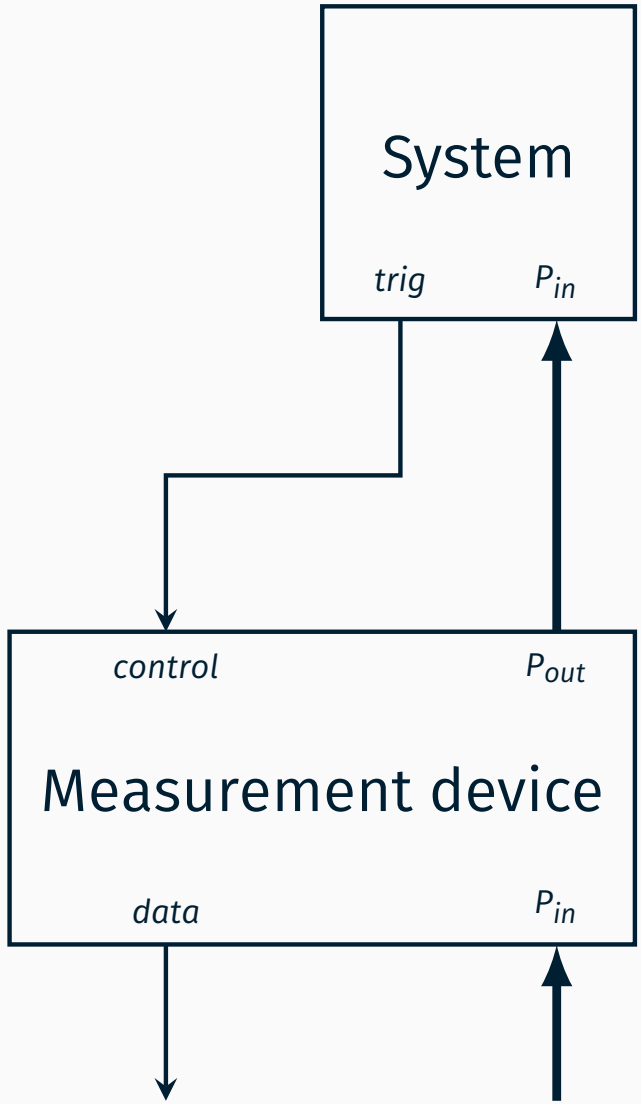
- CMOS power model: $P = \underbrace{\alpha C f V^2}_{P_{dynamic}} + \underbrace{V I_{leak}}_{P_{static}}$
- How to measure the energy demand?

Practical Energy Measurement



Practical Energy Measurement

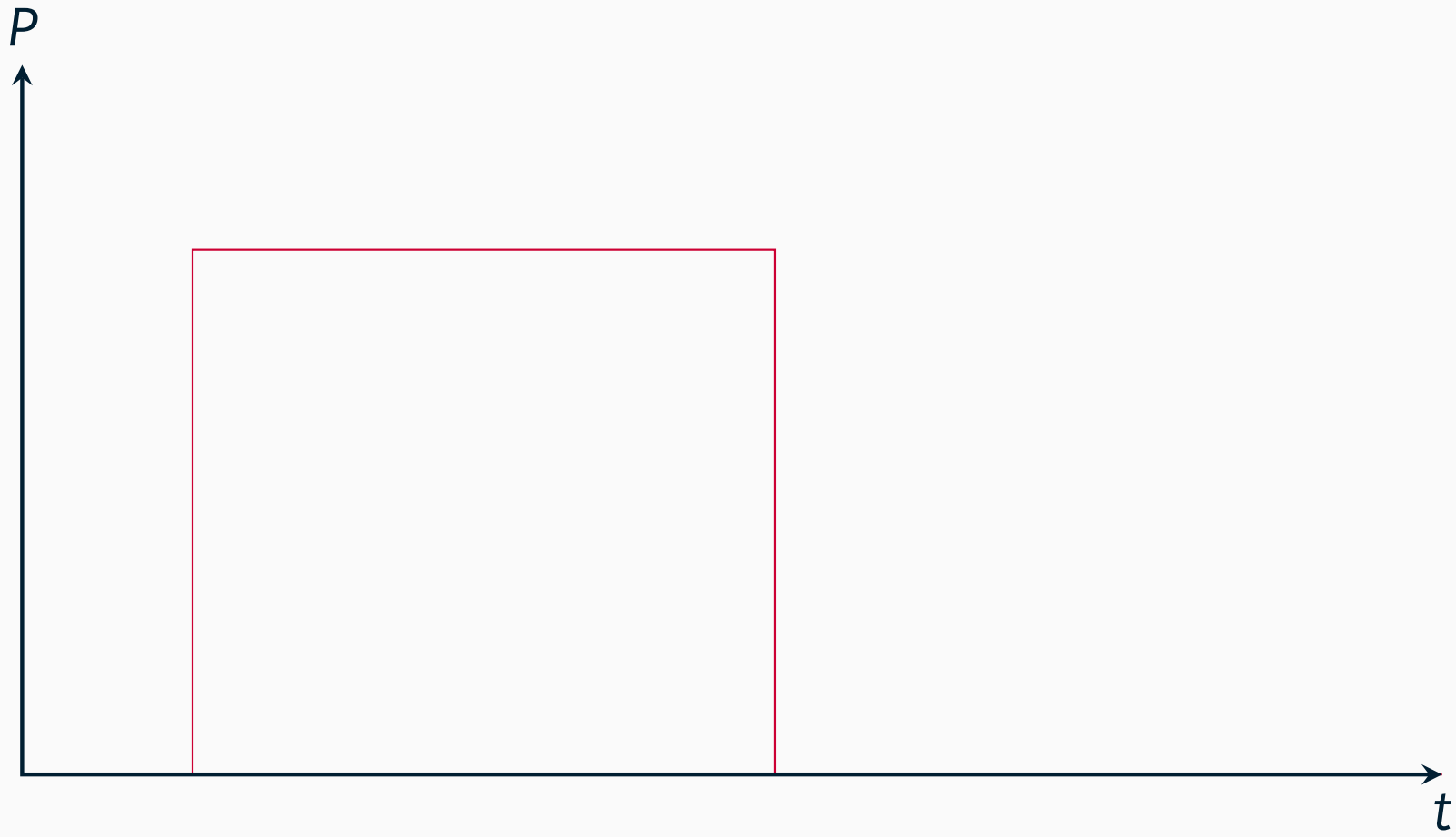
- Dedicated measurement device monitors power supply
- Discrete & periodic power sampling and aggregation



Typical usage

```
01 E1 = read();
02 foo();
03 E2 = read();
04 DE = E2 - E1;
```

What to expect



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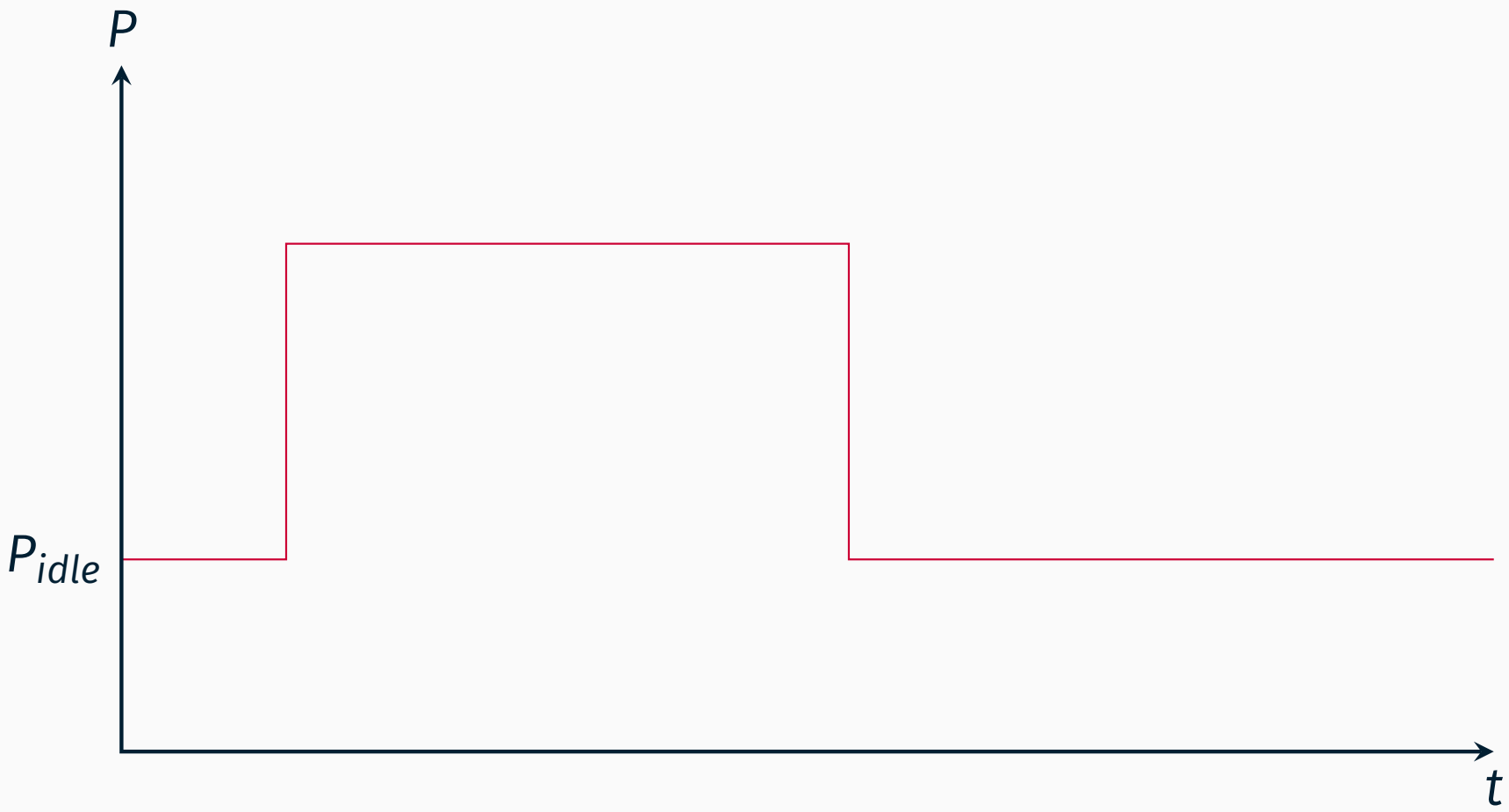
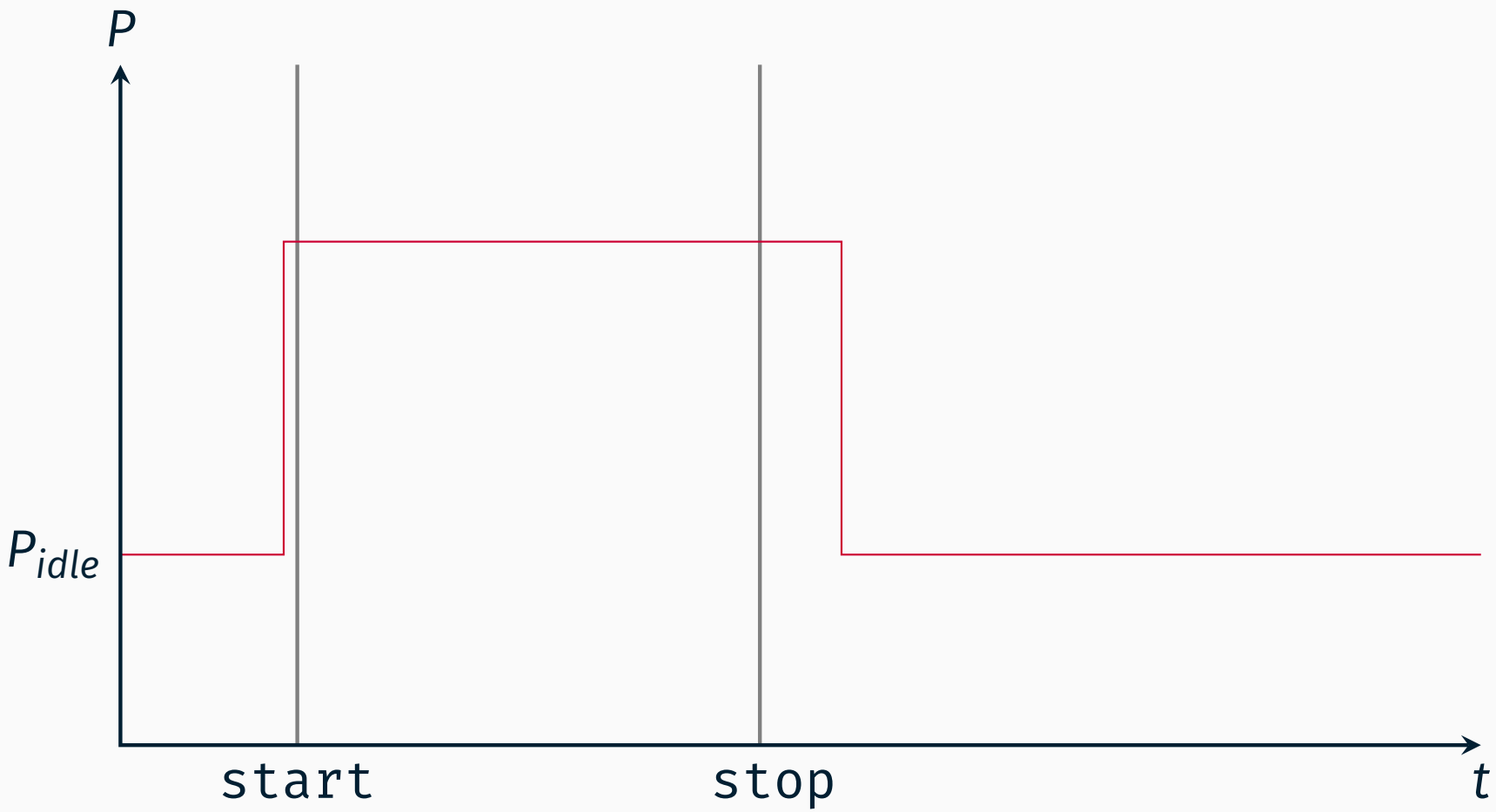
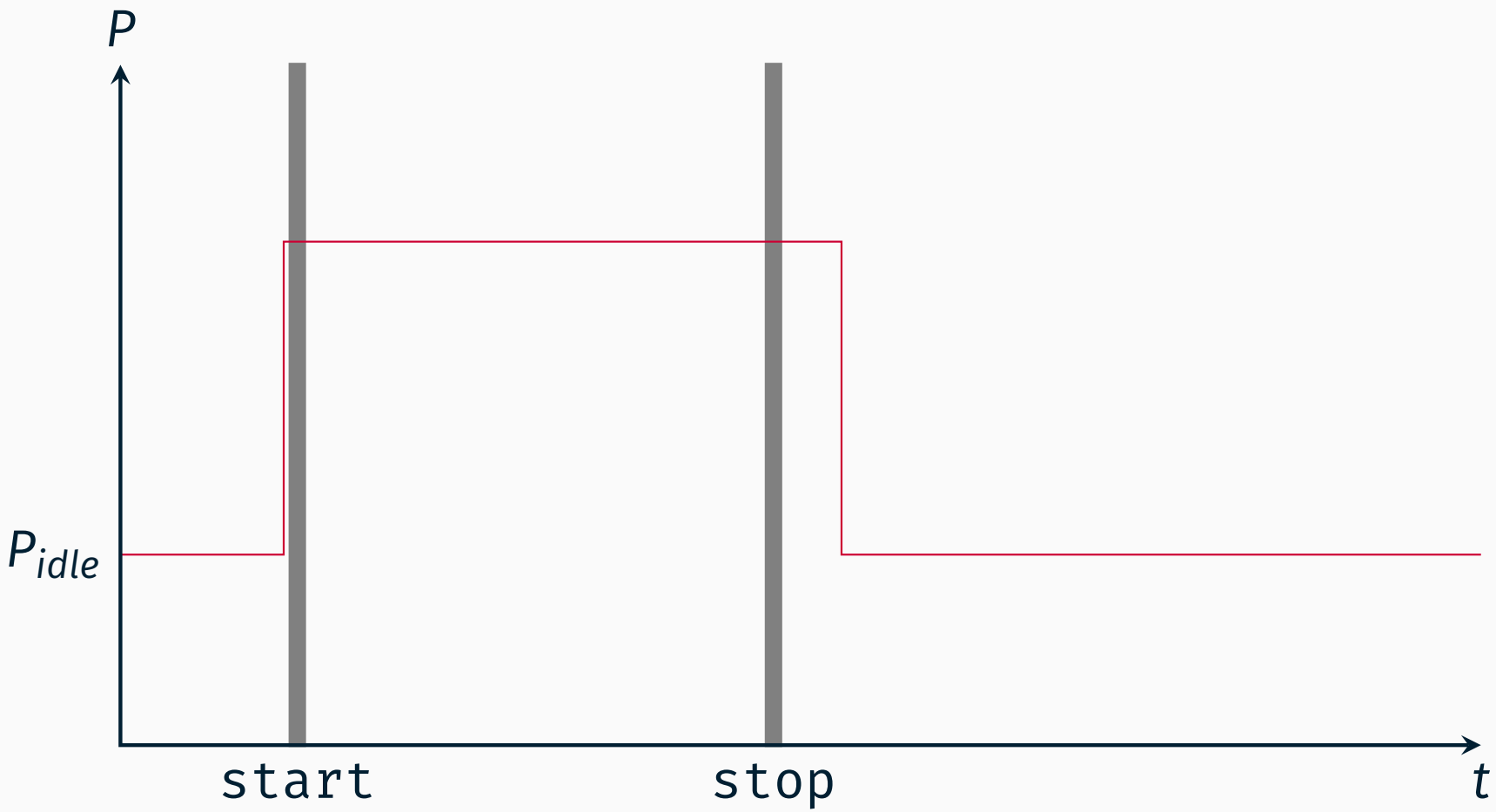



P
P_{idle}
start
stop
t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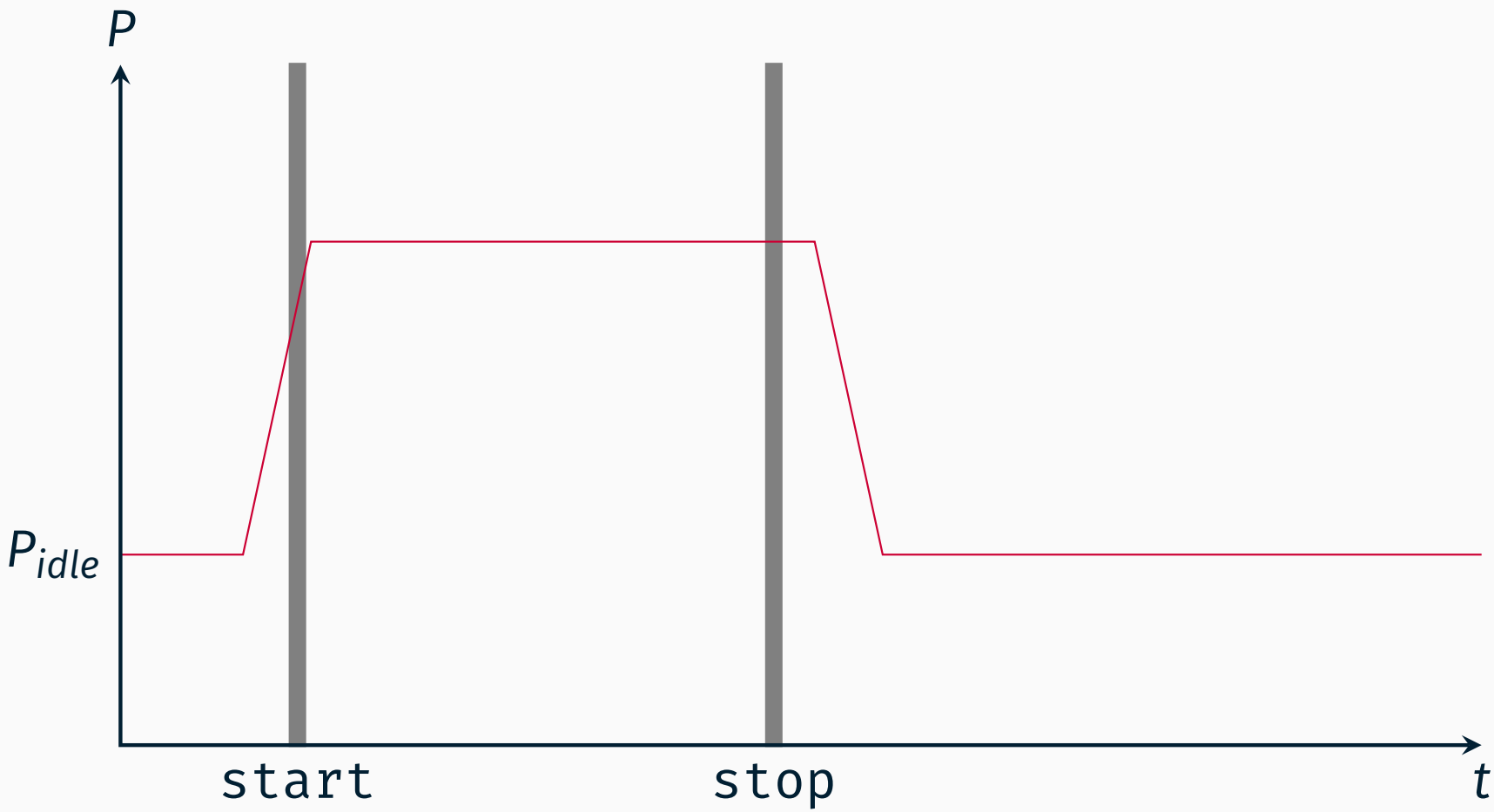
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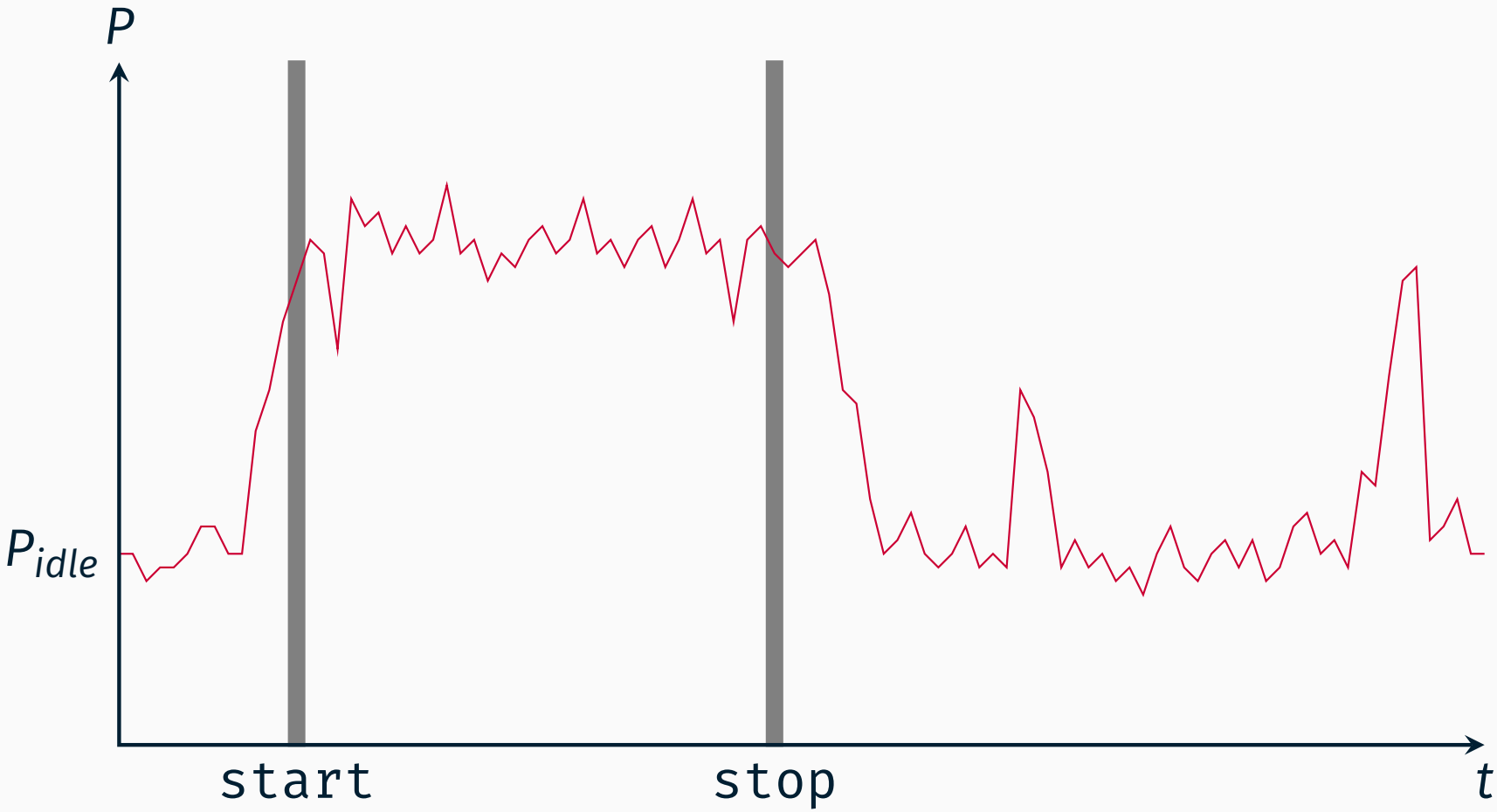

P
P_{idle}
start
stop
t

Energy measurement “devices”

Model-based energy measurement (1)

- Running average power Limit (RAPL):
  - Built-in interface for power/energy measurement and configuration
  - x86-specific

- Domains:

package	processor package
pp0	processor core(s)
pp1	processor uncore
dram	memory (potentially unsupported)
psys	platform

Model-based energy measurement (2)

- Internal calculation of power-over-time integral:

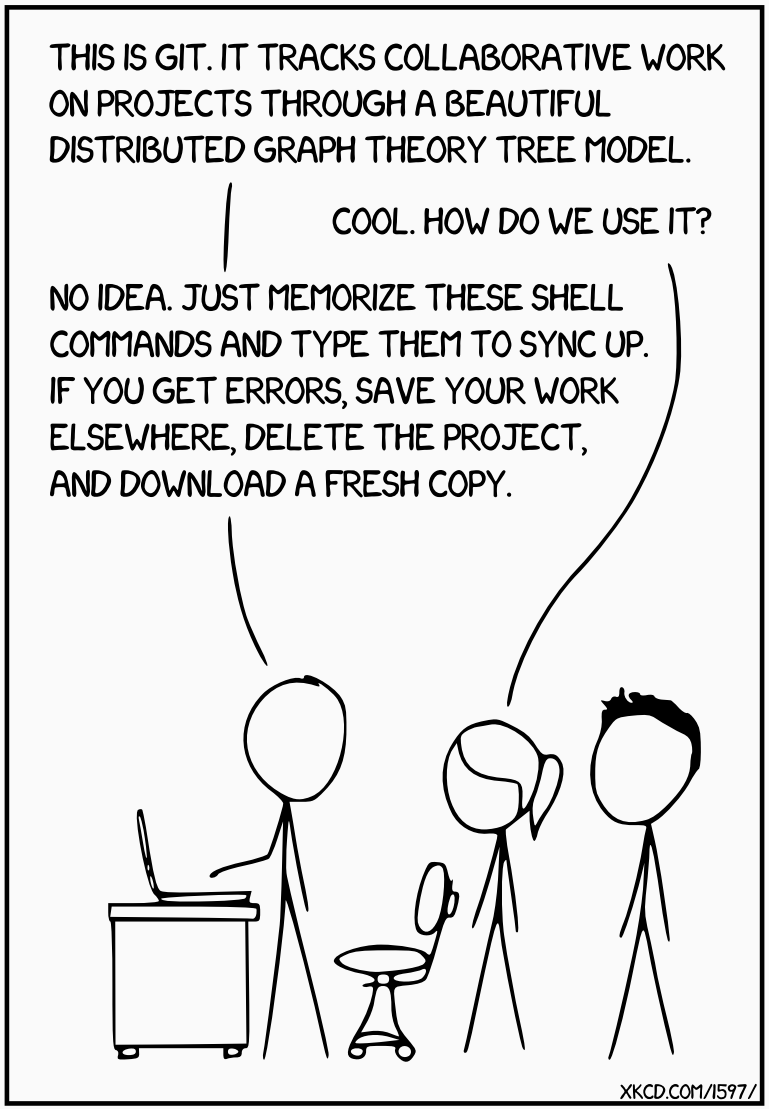
```
01 e1 = rapl_read();
02 foo();
03 e2 = rapl_read();
04 return e2 - e1;
```

- Source code is available online:
  → http://web.eece.maine.edu/~vweaver/projects/rapl/rapl-read.c

Physical energy measurement (1)

- Microchip MCP39F511N
  - Monitoring of 230V power supply
  - Output: (timestamp, power) tuples
  - Driver in `/proj/i4easy/pub/`

git


THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.
COOL. HOW DO WE USE IT?
NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP. IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.
XKCD.COM/1597/

Create a repository

```
01 user:~$ mkdir example
02 user:~$ cd example
03 user:~/example git init
04 Initialized empty Git repository in  /example/.git/
```

Add files

```
01 user:~/example$ touch README.md
02 user:~/example$ git add README.md
03 user:~/example$ git commit -m "initialer commit"
04 [master (root-commit) 16e1b9b] initial commit
05  1 file changed, 0 insertions(+), 0 deletions(-)
06  create mode 100644 README.md
```

16e1b9b

Track changes

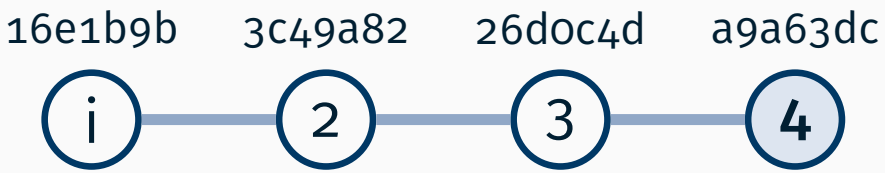
```
01 user:~/example$ echo "23" > foo
02 user:~/example$ git add foo
03 user:~/example$ git commit -m "set foo to 23"
04 [master 3c49a82] set foo to 23
05  1 file changed, 1 insertion(+)
06  create mode 100644 foo
```

Track changes (2)

```
01 user:~/example$ echo "42" > foo
02 user:~/example$ git add foo
03 user:~/example$ git commit -m "another commit"
04 [master 26d0c4d] another commit
05  1 file changed, 1 insertion(+), 1 deletion(-)
```

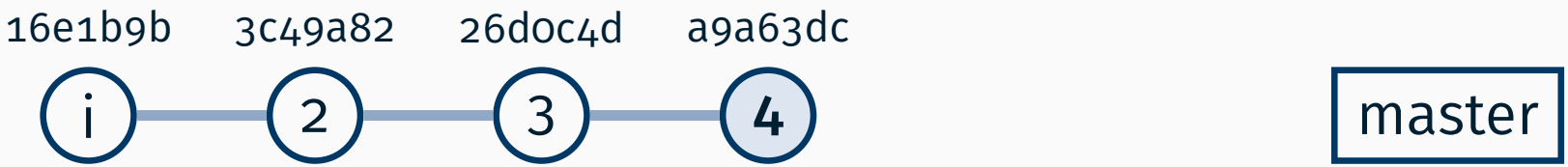
Track changes (3)

```
01 user:~/example$ echo "1337" > bar
02 user:~/example$ echo "zero" > foo
03 user:~/example$ git add bar foo
04 user:~/example$ git commit -m "another change"
05 [master a9a63dc] another change
06  2 files changed, 2 insertions(+), 1 deletion(-)
07  create mode 100644 bar
```



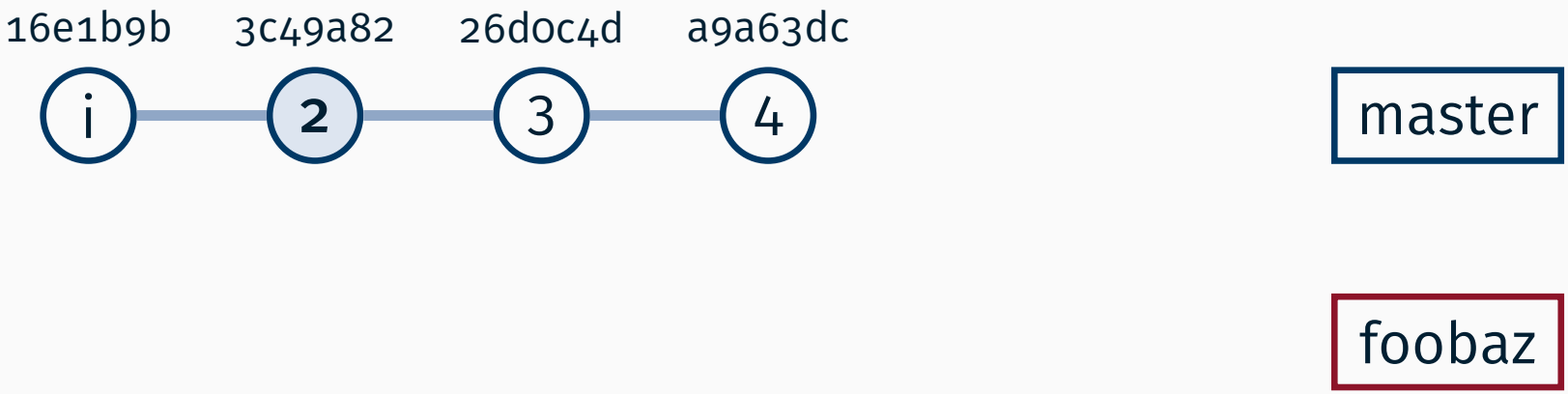
Show status

```
01 user:~/example$ git status
02 On branch master
03 nothing to commit, working tree clean
```



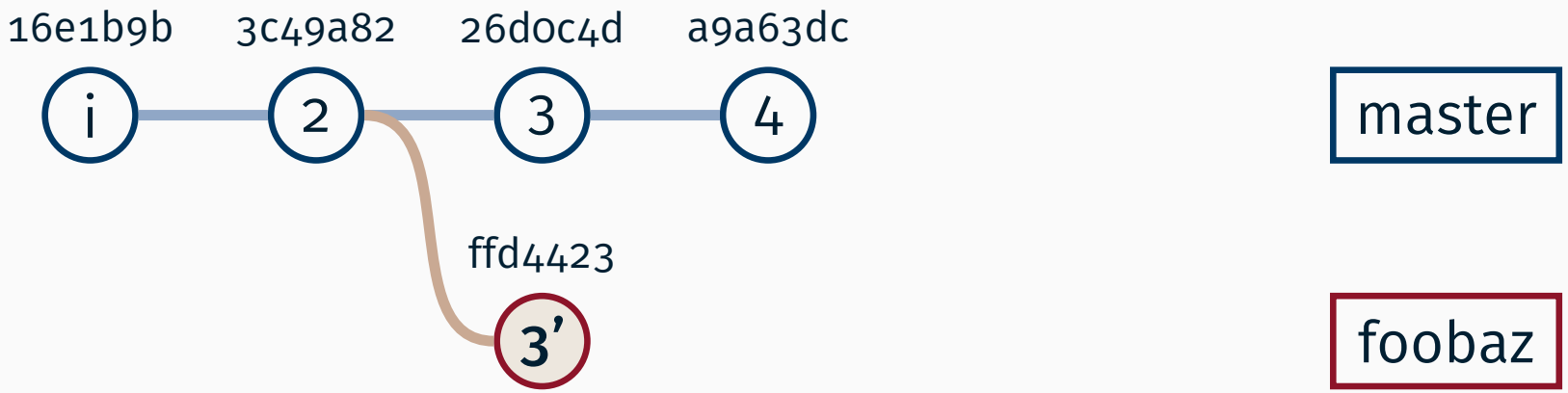
Create a new branch

```
01 user:~/example$ git checkout -b foobaz 3c49a82
02 Switched to a new branch 'foobaz'
03 user:~/example$ git shortlog
04 Demo User (2):
05  initial commit
06  set foo to 23
```



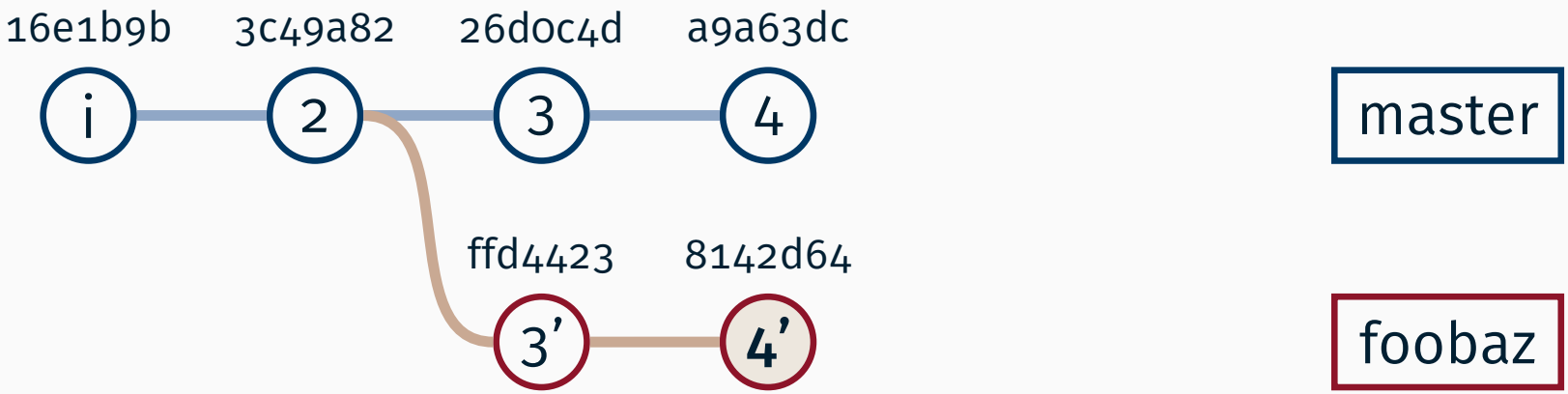
Make changes on new branch

```
01 user:~/example$ echo "3.141" > baz
02 user:~/example$ git add .
03 user:~/example$ git commit -m "new file"
04 [foobaz ffd4423] new file
05  1 file changed, 1 insertion(+)
06  create mode 100644 baz
```



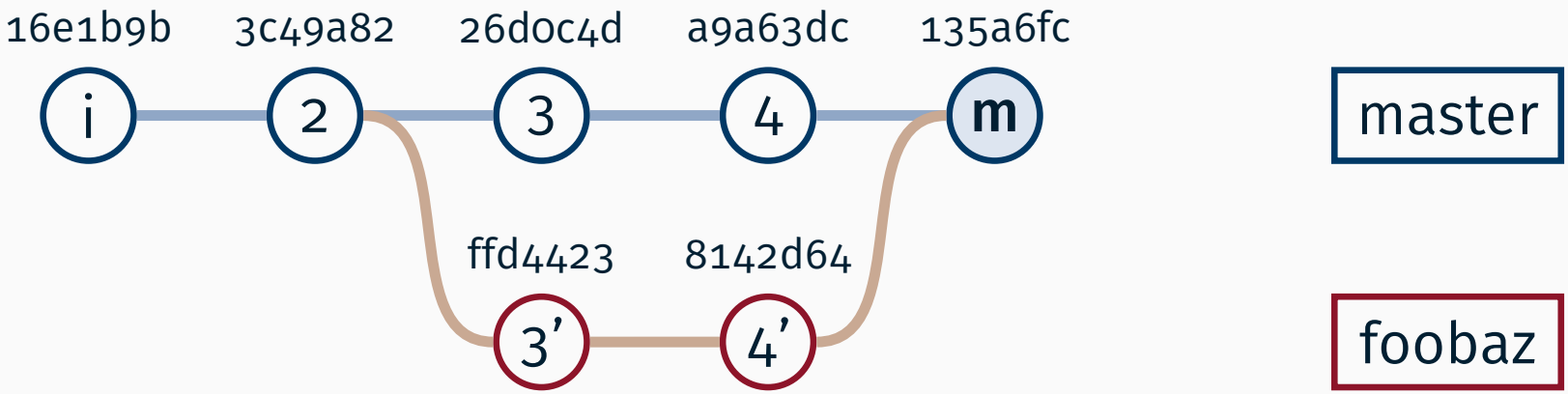
Make changes on new branch (2)

```
01 user:~/example$ echo "pi" > baz
02 user:~/example$ git commit -am "message"
03 [foobaz 8142d64] message
04  1 file changed, 1 insertion(+), 1 deletion(-)
```



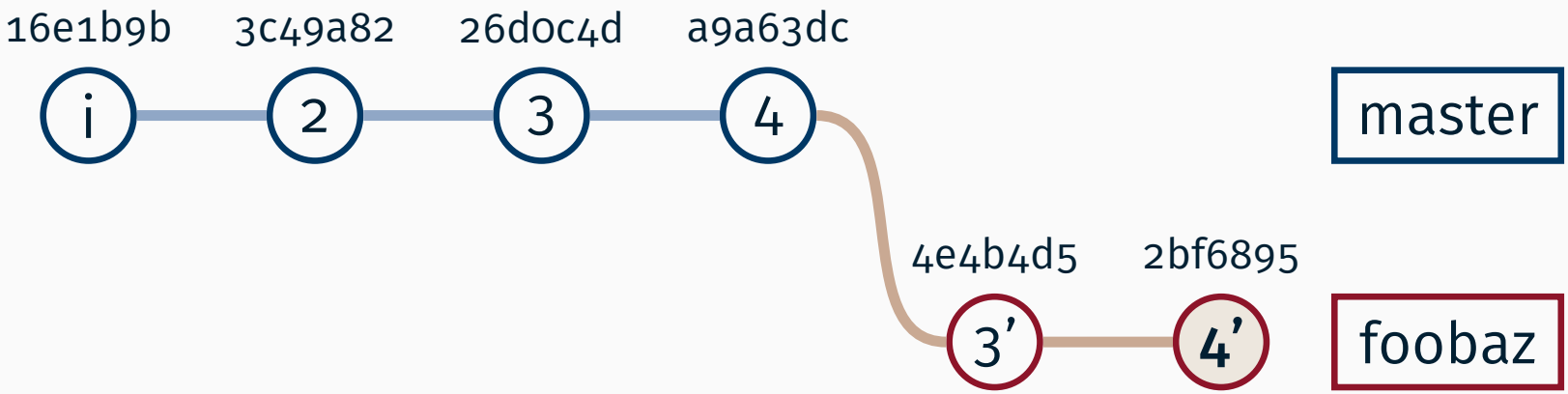
Merge branches

```
01 user:~/example$ git checkout master
02 user:~/example$ git merge foobaz -m "merge commit"
03 Merge made by the 'recursive' strategy.
04  baz | 1 +
05  1 file changed, 1 insertion(+)
06  create mode 100644 baz
```



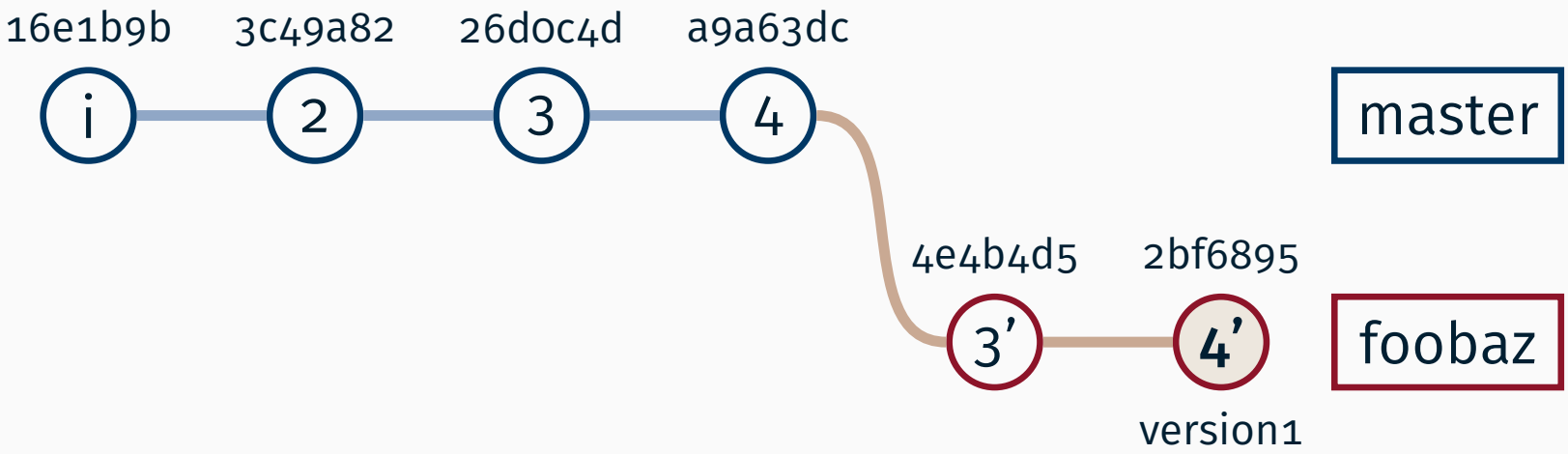
Alternatively: rewrite history

```
01 user:~/example$ git rebase master
02 First, rewinding head to replay your work on top of
   it...
03 Applying: new file
04 Applying: message
```



Create tags

```
01 user:~/example$ git tag version1
```



Cheatsheet

git init	Create new repository in the current directory
git add *file*	Mark file as candidate for next *commit*
git commit	Record changes
git diff	Show changes
git show	Show most recent change
git status	Show unrecorded changes
git branch	Show available branches
git log	Show history
man git-*command*	Show help, e.g. `man git-add`

Cheatsheet (remote repositories)

git clone *URL* Initial copy from a remote repository

git fetch *name* Download changes from remote repository

git pull *name* Shortcut for `fetch` and `merge`

git checkout *branch* Change current branch

git remote add *URL* Add remote repositories

git push *name* Upload changes to remote repository