The POSIX shell as a programming language

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Bash
HEAVY SIZE
Bash
CONCRETE
Detergent
Bash
FOR PEOPLE WITH
ROCKS IN THEIR HEAD
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i love shell

shell is everywhere

- vital for managing systems
  - maintenance
  - deployment
- universal tool for sysadmins
- extremely powerful

POSIX shell

- Open Group Spec/IEEE Standard 1003.1
    - Intimately connected to POSIX
- Many implementations!

```
# figure out the absolute path to the script being run a bit
# non-obvious, the ${0%/*} pulls the path out of $0, cd's into the
# specified directory, then uses $PWD to figure out where that
# directory lives - and all this in a subshell, so we don't affect
# $PWD
STEAMROOT="$(cd "${0%/*}" && echo $PWD)"

# Scary!
rm -rf "$STEAMROOT/"*
```

https://github.com/ValveSoftware/steam-for-linux/issues/3671

```
curl -k https://<master hostname>:8140/packages/current/install.bash | bash
```

https://puppetlabs.com/blog/simplified-agent-installation-puppet-enterprise-3.2

ba&sh

SOLDES

ba&sh

1 BIS

i love reasoning

hasn’t shell been ‘fixed’ already?

- scsh and shill?
  - not POSIX shells!
- tclsh
  - no formal attention, to my knowledge
  - and a bit out of date at this point

ShellCheck

- Linter for shell
- Catches bug in Steam script…
  - …but not a trivial refactoring

NoFAQ

- Machine learning to correct console commands
- No semantics insights
- No guarantees
- More about *commands* than about the *shell*

D’Antoni and Vaughn 2016

ABash

- Static analysis for number of arguments
- Semantic understanding
- Great start!

Mazurak and Zdancewic 2007

shell is unique

- unique evaluation model
  - expansion, not evaluation, of args by default
- deploy and manage concurrency
- uniquely interactive programming model
  - try before you buy

conventional evaluation

$$e_1 \textbf{ eval } v_1 \qquad e_2 \textbf{ eval } v_2 \qquad \delta(\otimes, v_1, v_2) = v_3$$

$$e_1 \otimes e_2 \textbf{ eval } v_3$$

expansion by default

$$\frac{e_1 \textbf{ expand } s_1 \qquad e_2 \textbf{ expand } s_2 \qquad \textbf{unparse}(\delta(\otimes, \textbf{parse}(s_1), \textbf{parse}(s_2))) = s_3}{e_1 \otimes e_2 \textbf{ eval } v_3}$$

$$\frac{e \textbf{ eval } v \qquad \textbf{unparse}(v) = s}{\text{`}e\text{`} \textbf{ expand } s}$$

```
c ::= v=a … a … | c r
    | c1|c2|c3|…|cn | c & | ( c )
    | c1 && c2 | c1 || c2
    | ! c | c1 ; c2 | if c1 c2 c3
    | switch a … { case a…) c } …
    | while c1 c2 | for x in a … c
    | defun v c
```

read

tokenize

parse

expand

redirect

execute

wait

fixed behavior at
compile time

semantics

read

tokenize

parse

expand

redirect

execute

wait

expansion

echo ~ → /Users/mgree

echo ${PWD} → /Users/mgree/talks/obt

basename `pwd` → obt

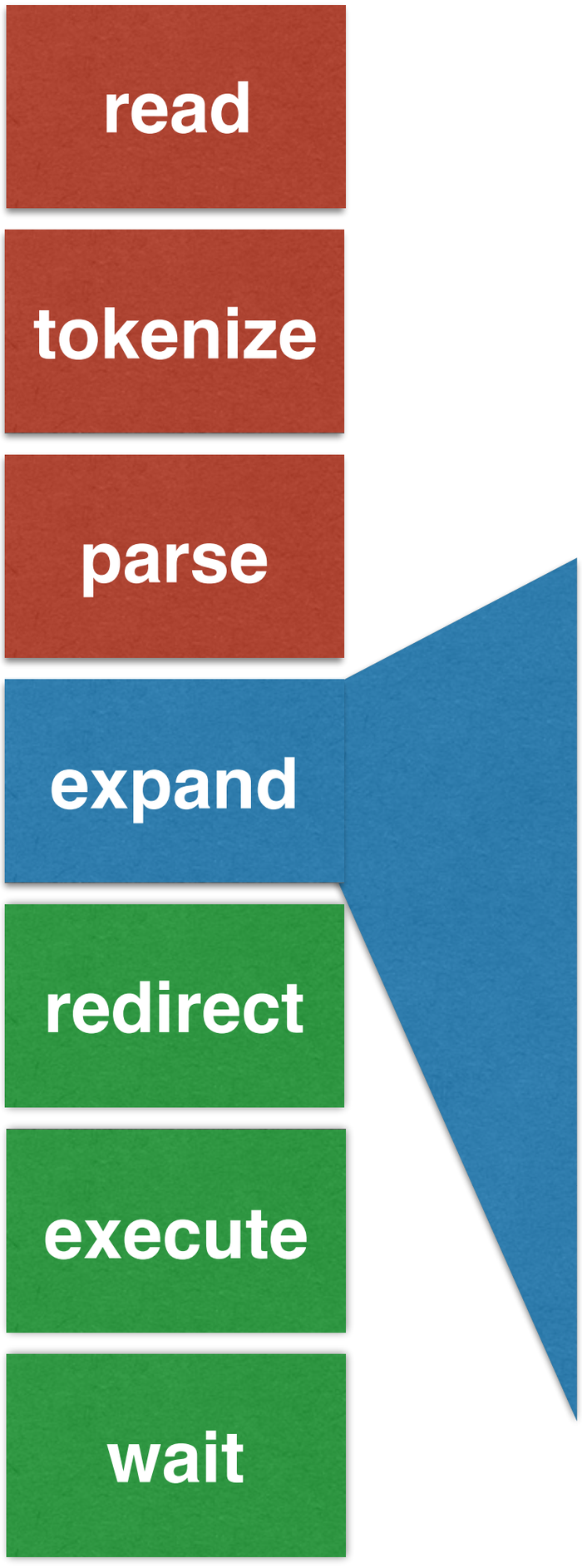
echo $((1+1)) → 2

IFS=“”
cat `echo some file` → [shows contents of ‘some file’]

echo * → abstract.txt posix.key some file

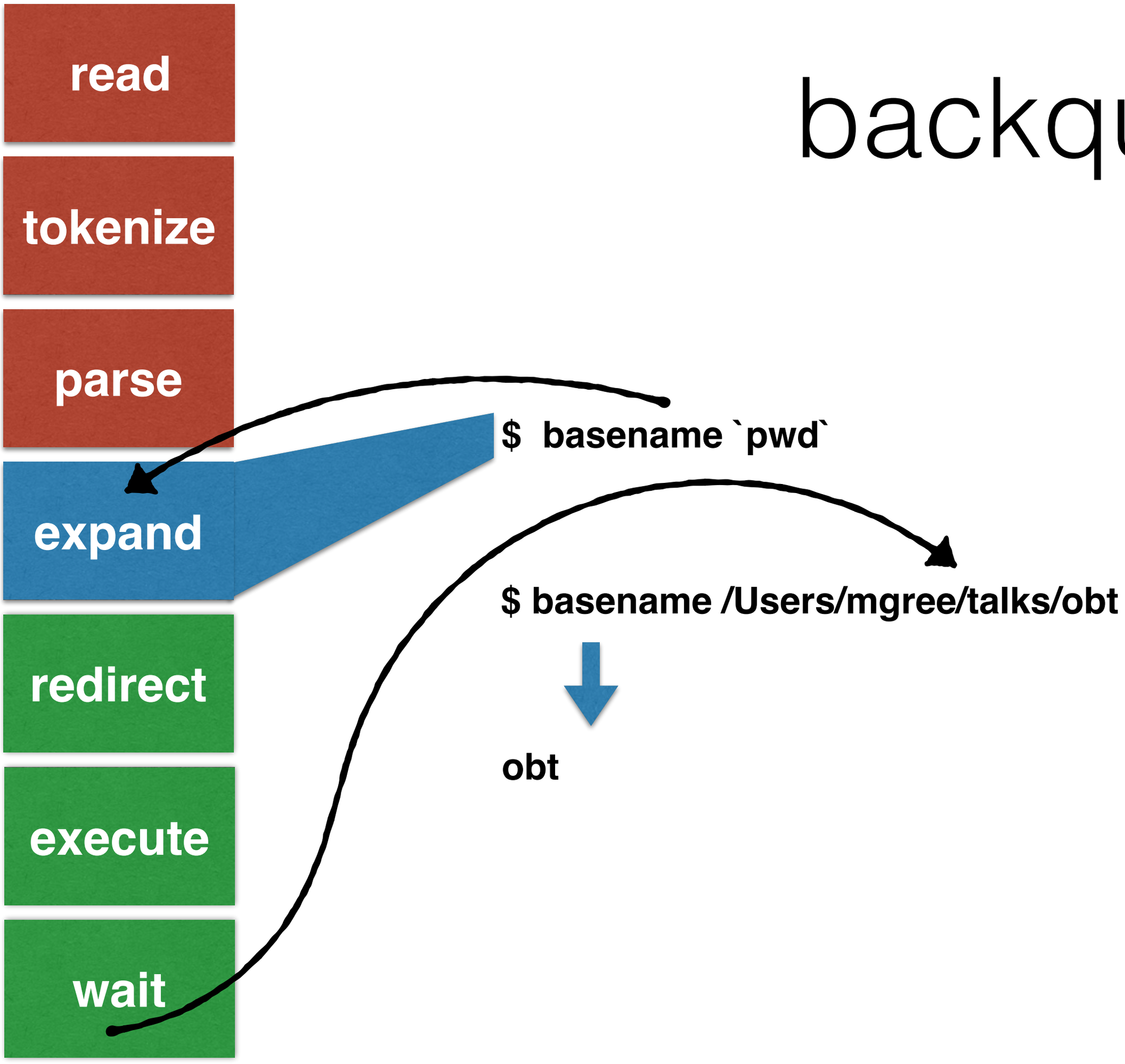
echo you can “” me → you can me

backquoting

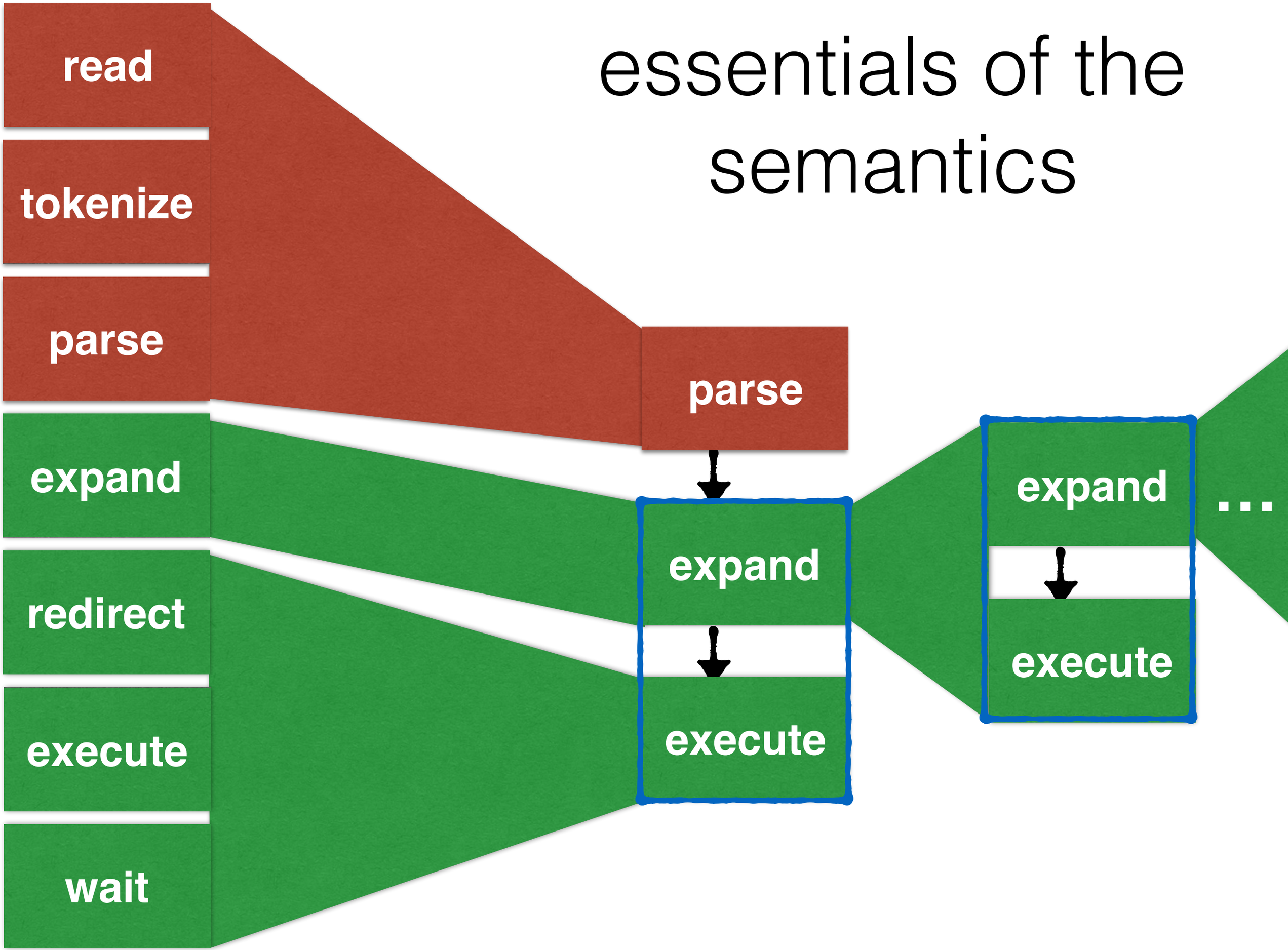


echo ~	→	/Users/mgree
echo ${PWD}	→	/Users/mgree/talks/obt
basename `pwd`	→	**obt**
echo $((1+1))	→	2
IFS=“” cat `echo some file`	→	[shows contents of ‘some file’]
echo *	→	abstract.txt posix.key some file
echo you can “” me	→	you can me

backquoting



essentials of the semantics



essentials of the semantics

```
$ x=${y:=1} ; echo $((x+=`echo 2`)) ⟶
$ x=${1}    ; echo $((x+=`echo 2`)) ⟶
$           echo $((x+=`echo 2`)) ⟶
$           echo $((x+=2))        ⟶
$           echo 3                ⟶
3
```

env

PATH	/usr/bin:…
x	3

legend: expansion evaluation

what do I want to do?

Shambaugh et al. PLDI'16

analyses

tools

Rehearsal

semantics for shell

SibyIFS

Ridge et al.
SOSP'15

program logic

Gardner Ntzik
OOPSLA 2015

Forest

Fisher et al.
ICFP'11

ptrace

support the programming model

- have script echo commands until script is just right
  - maybe running *some* commands

- set -x prints commands run…
  but it still runs the commands!

- can we do better?

other tools

- compile to other languages as a form of “gradual scripting”
- “cruft” inserter
  - hardens a shell script against, e.g., signals
  - uses weakest preconditions to guarantee good exit status of all commands

types!

- commands take a regular expression over args as input, produces certain patterns of system calls
- summarize sets of commands/system calls/ outputs
    - e.g., this script will delete all files in ~/.foo/ except for ~/.foo/cache
- analyze curl-based installers!

design

```
$ ls
filename
spaces
filename with spaces
$ x=“filename with spaces”
$ rm $x
rm: with: No such file or directory
$ ls
filename with spaces
$ rm “$x”
$ ls
$
```

what else?

- theoretical ideas/angles i'm missing?
- suppose we've got a great model…
  what else should we do with it?

  thanks to:
  Arjun Guha for early chats
  Calvin Aylward and Austin Blatt