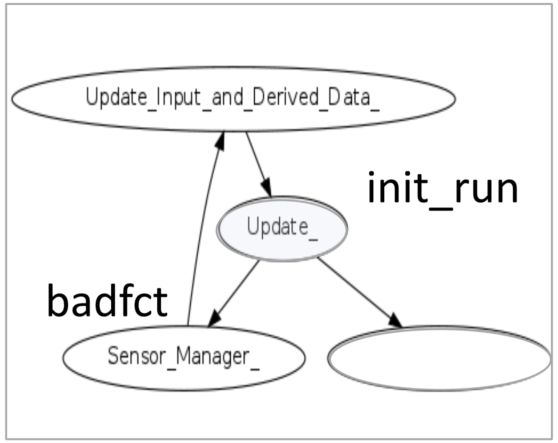
part 2: using sets

example: is there any dynamic memory allocation after initialization is completed?

```
$ cobra *.c
: fcts                  # mark all function names
: next {                # move to function body
: contains malloc       # restrict to those containing malloc calls
: back (                # back to the function parameter list
: back                  # back to the function name
: >1                    # store these names in set 1
: reset                 # clear all marks
: fcg init_run *        # mark all functions reachable from init_run
: <&1                   # check the intersection with set 1
: list                  # list them (e.g, it shows “badfct” as a match)
: fcg init_run badfct   # show call graph connecting init_run and badfct
```



the query language

operations on sets

```
>n     # save all current marks and ranges in set n

<n     # restore current marks and ranges from set n
<|n    # add marks from set n to current (set union)
<&n    # keep only marks also in set n(set intersection)
<^n    # keep only marks not in set n (set difference)
```

where n is 1..3

the query language

defining query *functions*

```
: def p10_rule4(rn, nr)
      fcts                        # mark function names
      n {                         # move to fct body
      m & (.range > nr)           # restrict to fcts longer than nr lines
      b (                         # back to start of parameter list
      b                           # back to function name
      = "=== rn: functions exceeding nr physical source lines:"
      d
end
: p10_rule4(R4, 75)
```

a simple textual replacement of parameters

```
.fnm      # source filename (a string)
.lnr      # source line-number
.curly    # level of {…} nesting
.round    # level of (…) nesting
.bracket  # level of […] nesting
.len      # length of token text
.typ      # token type (a string)
.txt      # token text (a string)
.seq      # token sequence number
.mark     # marked value
```

remember: .range is a predefined token attribute

the query language

pattern matches and .mark

by default all tokens in a matched pattern are marked with the value *1*

there are two exceptions:

- the first token in each pattern is marked with value *2*
- any bound variables in the pattern is marked with value *3*

that makes it possible to quickly simplify long pattern matches to just their start, or to just the effectively bound variables from the pattern

```
$ cobra *.c
: pat for ( x:@ident .* ) { .* :x = .* }
bound variables matched:
      1: cobra_te.c:1579: q_now
      2: cobra_te.c:1358: m
      3: cobra_te.c:881: b
      4: cobra_sym.c:105: r
      5: cobra_sym.c:51: r
      6: cobra_prep.c:339: c
      7: cobra_lib.c:2492: r
      8: cobra_lib.c:2122: z
      9: cobra_lib.c:1202: s
      10: cobra_lib.c:782: r
      11: cobra_fcg.c:156: r
      12: cobra_cfg.c:171: cur
      13: cobra_cfg.c:67: cur
13 patterns matched
3929 matches
: m & (.mark == 2)
12 matches
: undo
: m & (.mark == 3)
14 matches
```

the query language

reading commands from files

- to read a query function from the “play” library we can use the dot command **.** :

```
$ cobra *.c
: . play/declarations.cobra
```

- we can read query files also from the command line:

```
$ cobra –f play/declarations.cobra *.c
```

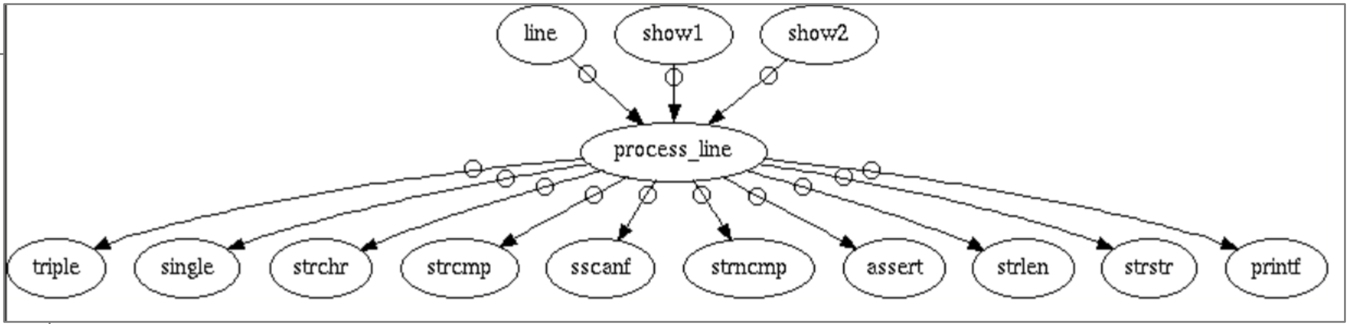
- cobra query files stored in rules/main can be read without the directory prefix, for instance, try:

```
$ cobra -terse –f basic *.c
$ cobra –terse –f stats *.c
$ cobra –terse –f metric *.c
$ cobra –terse –f cwe *.c
```

the query language

the context command

```
$ cobra *.c
1 core, 10 files, 56546 tokens
: context process_line
cobra_prim.c:626-673
calls:
        cobra_prim.c:671: triple()
        cobra_prim.c:669: single()
        cobra_prim.c:662: strchr()
        cobra_prim.c:649: strcmp()
        cobra_prim.c:647: sscanf()
        cobra_prim.c:646: strncmp()
        cobra_prim.c:644: assert()
        cobra_prim.c:640: strlen()
        cobra_prim.c:638: strstr()
        cobra_prim.c:631: printf()
is called by:
        cobra_lex.c:809: line()
        cobra_lex.c:279: show1()
        cobra_lex.c:288: show2()
:
```



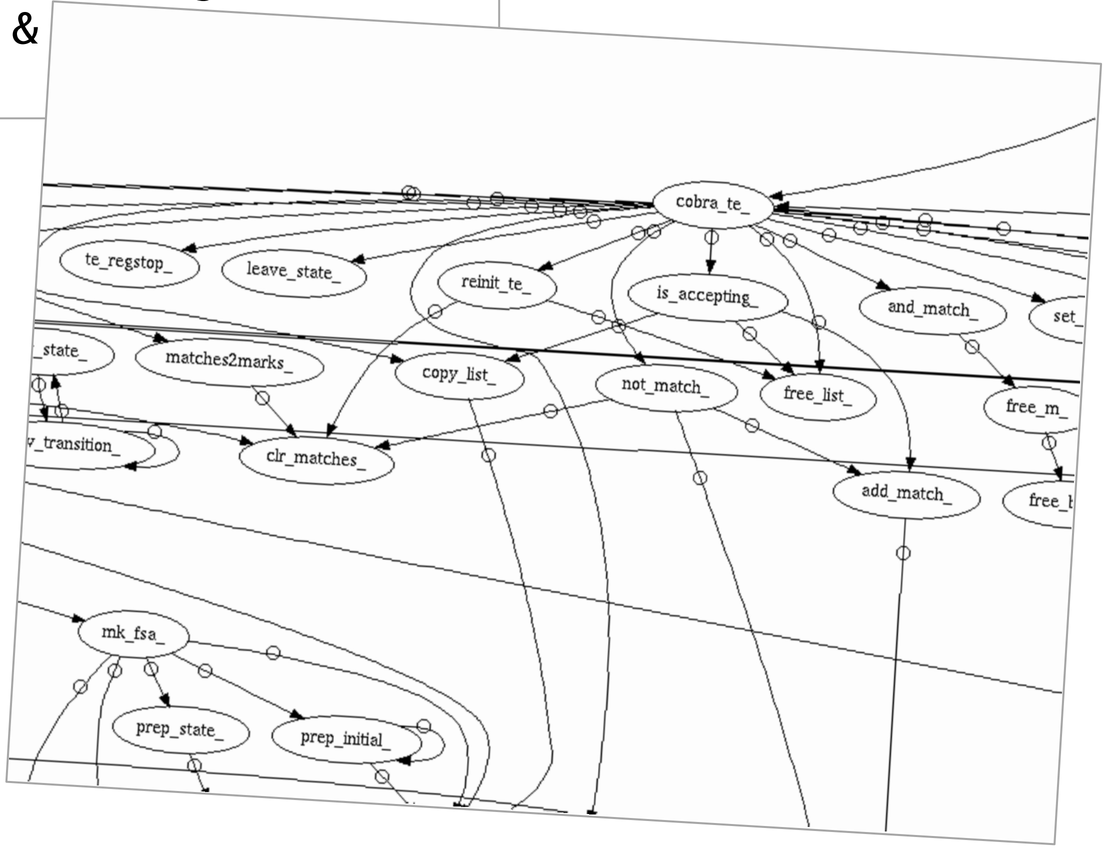
the text version on the left is the default,
the graph version requires the graphviz/dot
or dotty command to be installed on your system

the query language

or full or partial function call graphs (also requires graphviz/dot)

```
$ cobra *.c
1 core, 10 files, 56546 tokens
: fcg
wrote: /tmp/cobra_dot_Sf8RAv (269 nodes, 499 edges)
view with: !dotty /tmp/cobra_dot_Sf8RAv &
: !dotty /tmp/cobra_dot_Sf8RAv &
```

be warned: dot/dotty can be very slow on large graphs, and may even crash. cobra, though, can generate the input file very quickly



the query language

browsing code

```
: B cobra_te.c 100   # show file starting at line 100
: B                  # browse forward in same file
: B 90               # browse same file from line 90
```

other sometimes useful short-hands:

```
: ff par_scan        # find function definition
: cpp on             # processes the header files
: ft Prim            # find a type definition
```

or with tcl/tk installed:

```
: V cobra_te.c 100       # like B, but in a popup window
: window                 # enable automatic window popups
: m while                # mark something
: d 1                    # now pops up a tcl/tk window with the source text
: : nowindow             # disable window popups
```

similarly, with graphviz (dotty) installed, you can see how patterns are translated:

```
$ cobra –view –pat "…." *.c    # pop up graph showing FSA for the pattern
```

the query language

defining new token categories with the map command

```
$ cat prepositions.map          # map token text to new user-defined token types
of          preposition
to          preposition
in          preposition
for         preposition
on          preposition
with        preposition
by          preposition
but         preposition
at          preposition
from        preposition
about       preposition
like        preposition
into        preposition
...
```

```
$ cobra *.txt          # some random English prose
: map prepositions.map
: m @preposition .
: = "a sentence should not end with a preposition:"
: d
```

the query language

now we’re getting into the woods:
track_start, track_stop, and shell escapes

```
$ cobra *.[ch]
1 core, 15 files, 90063 tokens
: m while
127 matches
: track start file1   # redirect output to file1
: list
: track stop          # end redirection
: !wc file1           # shell escape to check the size of the file
: !sort file1         # or to display it after sorting
: q
$
```

the query language

scaling behavior

18,633,817 Lines of Code of the Linux 4.3 distribution, with 39,144 .c and .h files

checking 2 types of queries:

- find empty else stmnts
- find all switch stmnts without default clause

using 1..32 CPU cores

with 4 or more cores we obtain truly interactive query processing times < 1 sec per query