Taming of Pict

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The object-capability paradigm

Pict specific details

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Open Problems

Hypothesis: Advantages of the object-capability security paradigm

- POLA can be obeyed without discomfort
- expressivness
- elegance
- efficiency
- smaller TCB

Limitations

- source code of all parts of the system must be available

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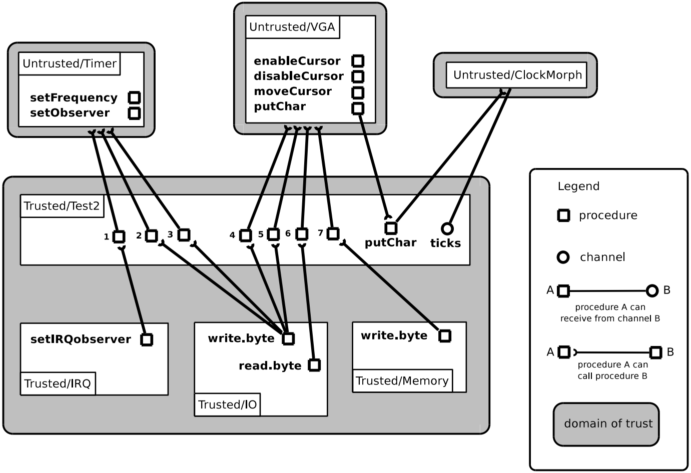
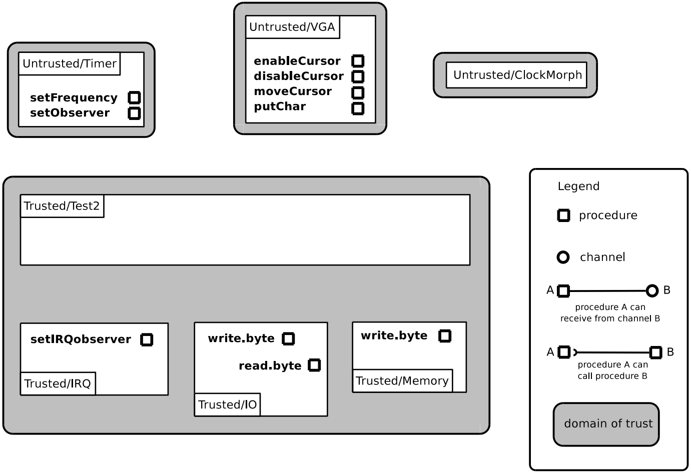
An example of “can call” relationship



An example of “can call” relationship



Untrusted/Timer

setFrequency ☐

setObserver ☐

Untrusted/VGA

enableCursor ☐

disableCursor ☐

moveCursor ☐

putChar ☐

Untrusted/ClockMorph

Trusted/Test2

setIRQobserver ☐

Trusted/IRQ

write.byte ☐

read.byte ☐

Trusted/IO

write.byte ☐

Trusted/Memory

Legend

☐ procedure

○ channel

A ☐—○ B

procedure A can receive from channel B

A ☐›—☐ B

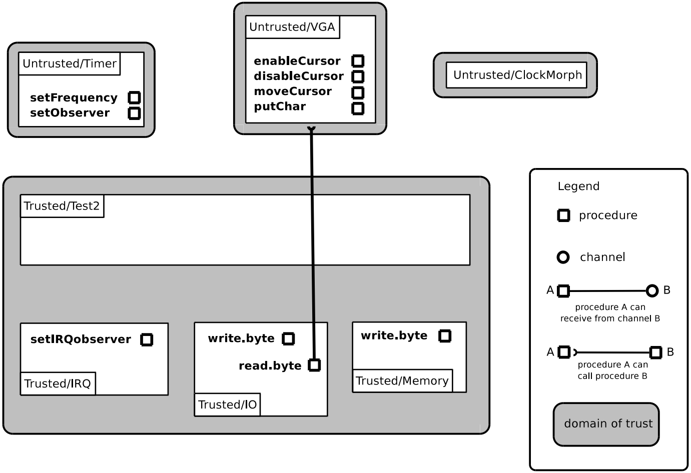
procedure A can call procedure B

domain of trust

The Problem: Required authority of the untrusted VGA driver

- to read from the `0x3D5` I/O register
- to read from the `0x3D4` I/O register
- to write to the `0x3D4` I/O register
- to write to the frame buffer

An example of "can call" relationship



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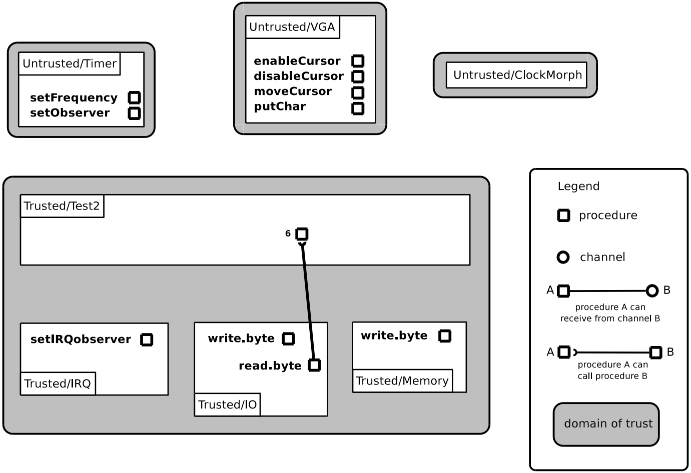

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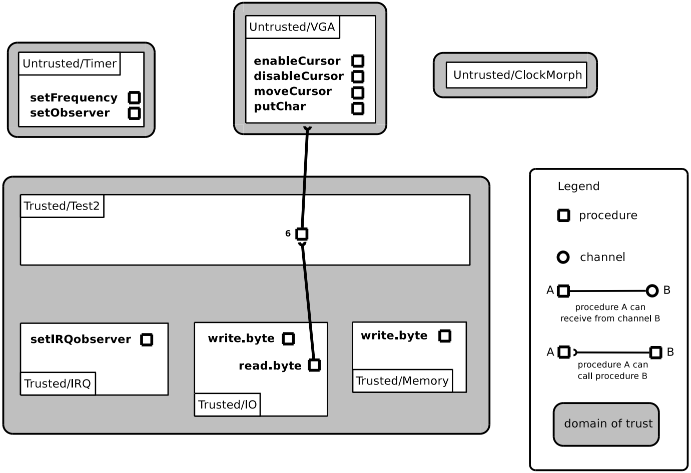

An example of “can call” relationship

```
io.read.byte
```

```
\() = (io.read.byte 981)
```

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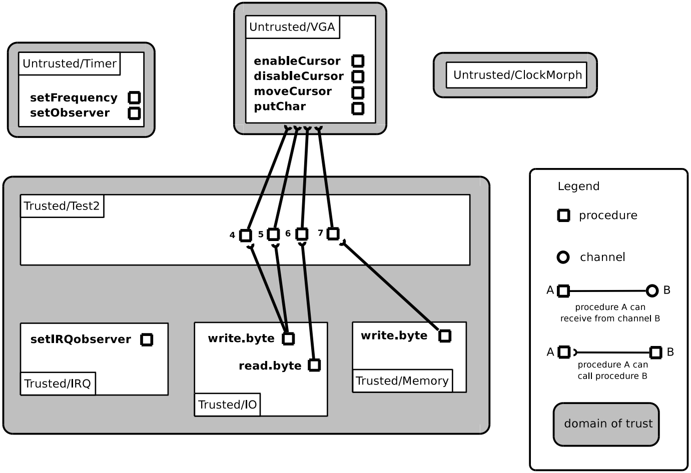

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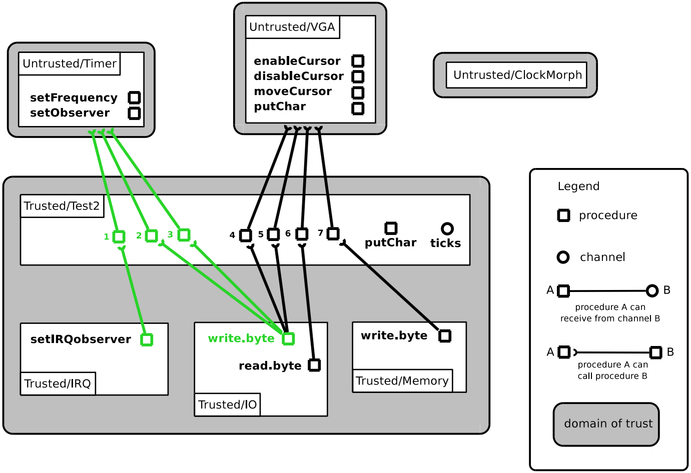

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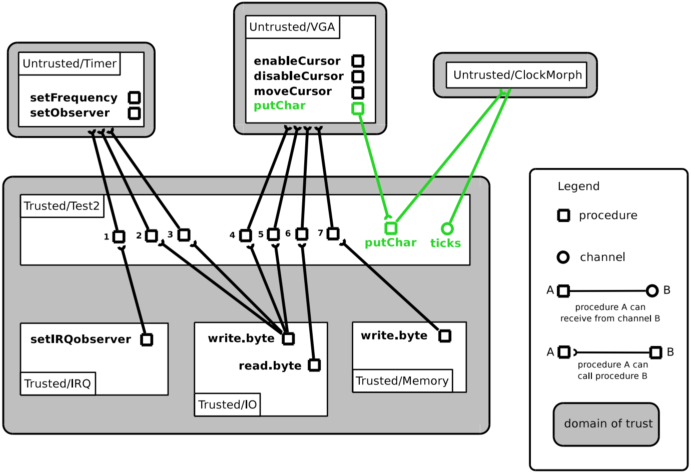
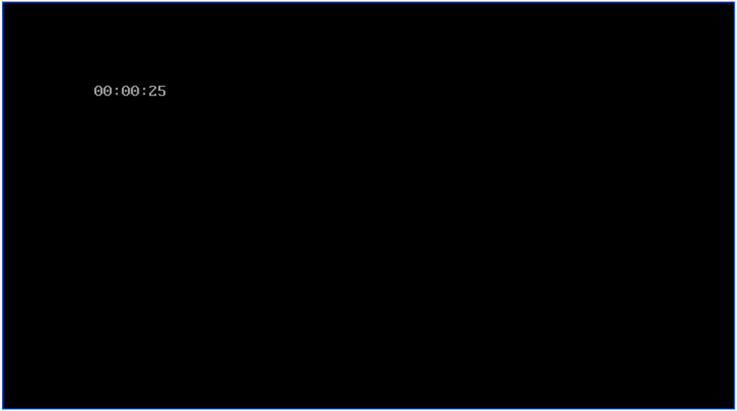
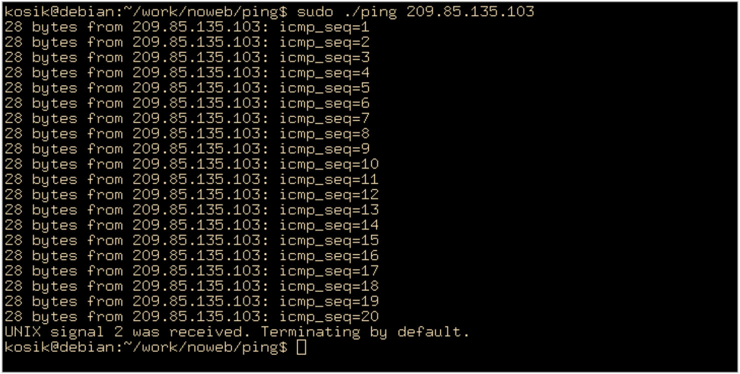


Powerboxed `ClockMorph`



Powerboxed ping



```
kosik@debian:~/work/noweb/ping$ sudo ./ping 209.85.135.103
28 bytes from 209.85.135.103: icmp_seq=1
28 bytes from 209.85.135.103: icmp_seq=2
28 bytes from 209.85.135.103: icmp_seq=3
28 bytes from 209.85.135.103: icmp_seq=4
28 bytes from 209.85.135.103: icmp_seq=5
28 bytes from 209.85.135.103: icmp_seq=6
28 bytes from 209.85.135.103: icmp_seq=7
28 bytes from 209.85.135.103: icmp_seq=8
28 bytes from 209.85.135.103: icmp_seq=9
28 bytes from 209.85.135.103: icmp_seq=10
28 bytes from 209.85.135.103: icmp_seq=11
28 bytes from 209.85.135.103: icmp_seq=12
28 bytes from 209.85.135.103: icmp_seq=13
28 bytes from 209.85.135.103: icmp_seq=14
28 bytes from 209.85.135.103: icmp_seq=15
28 bytes from 209.85.135.103: icmp_seq=16
28 bytes from 209.85.135.103: icmp_seq=17
28 bytes from 209.85.135.103: icmp_seq=18
28 bytes from 209.85.135.103: icmp_seq=19
28 bytes from 209.85.135.103: icmp_seq=20
UNIX signal 2 was received. Terminating by default.
kosik@debian:~/work/noweb/ping$ 
```

Reference Graph Dynamics [1, §9.2]

- connectivity by initial conditions
- connectivity by parenthood
- connectivity by introduction
- connectivity by endowment

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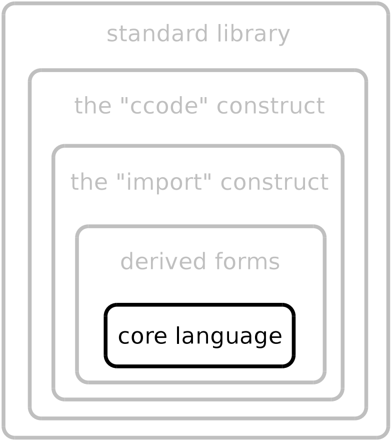


standard library

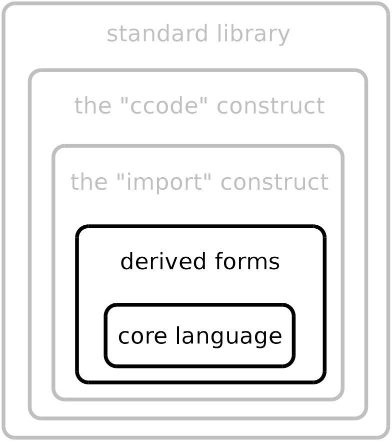
the "ccode" construct

the "import" construct

derived forms

core language

Layers of the Pict programming language



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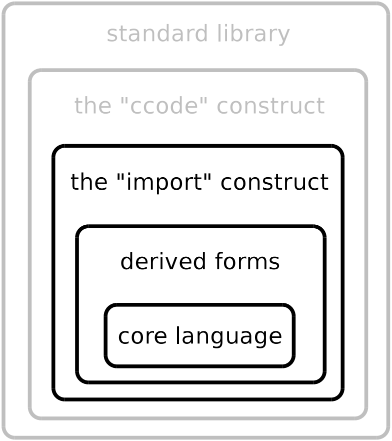

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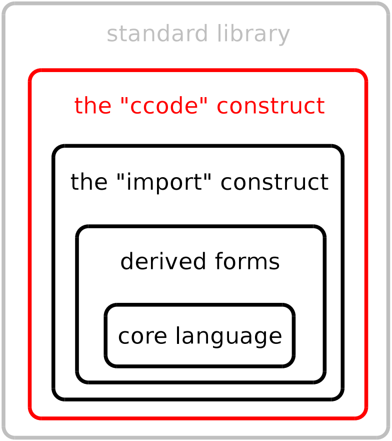
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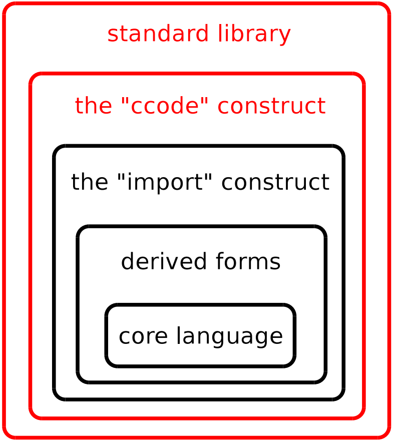

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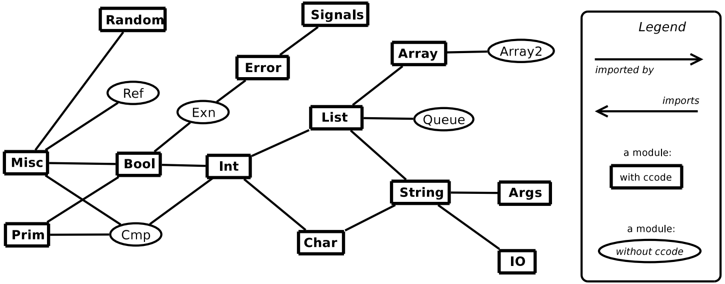
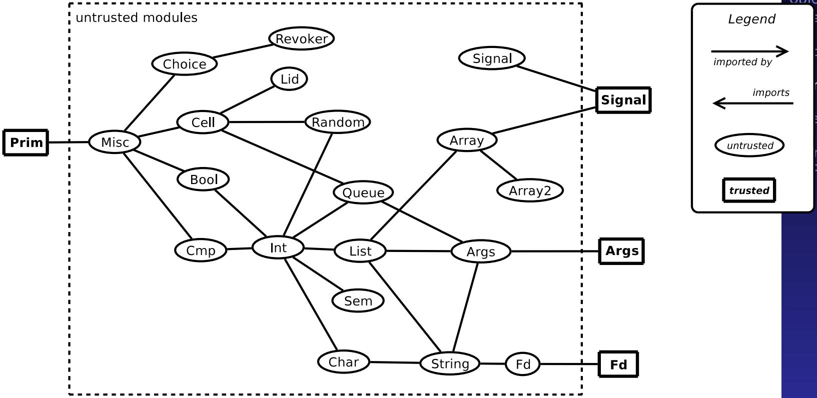
The original standard library



Refactored library



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Open Problems

- any untrusted component can consume as much memory as it wishes
- any untrusted component can consume as much CPU ticks as it wishes
- formal methods can significantly refine assessments of upperbound of threat we face

References

Mark Samuel Miller.
Robust Composition: Towards a Unified Approach to Access Control and Concurrency Control.
PhD thesis, Johns Hopkins University, Baltimore, Maryland, USA, May 2006.

Robin Milner.
Communicating and Mobile Systems: The π-calculus.
Cambridge University Press, 1999.

The original π-calculus (the syntax) [2]

$$\begin{array}{rcl}
\pi & ::= & \overline{x}y \mid x(z) \mid \tau \mid [x = y]\pi \\
P & ::= & (P \mid P) \mid \nu z P \mid !P \mid M \\
M & ::= & 0 \mid \pi.P \mid M + M
\end{array}$$

Matching action was omitted

$$\begin{aligned}
\pi &::= \bar{x}y \mid x(z) \mid \tau \\
P &::= (P \mid P) \mid \nu z P \mid !P \mid M \\
M &::= 0 \mid \pi.P \mid M + M
\end{aligned}$$

Silent action was omitted

$$
\begin{aligned}
\pi &::= \overline{x}y \mid x(z) \\
P &::= (P \mid P) \mid \nu z P \mid\ !P \mid M \\
M &::= 0 \mid \pi.P \mid M + M
\end{aligned}
$$

The Choice operator was omitted

$$\pi \quad ::= \quad \overline{x}y \;\mid\; x(z)$$

$$P \quad ::= \quad (P \mid P) \;\mid\; \nu z P \;\mid\; !P \;\mid\; M$$

$$M \quad ::= \quad 0 \;\mid\; \pi.P$$

Only asynchronous sends are allowed

$$P \;::=\; (P \mid P) \;\mid\; \nu z P \;\mid\; !P \;\mid\; M$$

$$M \;::=\; 0 \;\mid\; \overline{x}y.0 \;\mid\; x(z).P$$

It does not make sense to replicate $\mathbf{\overline{x}y.0}$ particles

$$\mathsf{P} \quad ::= \quad (\mathsf{P} \mid \mathsf{P}) \;\mid\; \nu \mathsf{z} \mathsf{P} \;\mid\; \nu \mathsf{x}\,(!\mathsf{x}(\mathsf{z}).\mathsf{P} \mid \mathsf{P}) \;\mid\; \mathsf{M}$$

$$\mathsf{M} \quad ::= \quad 0 \;\mid\; \overline{\mathsf{x}}\mathsf{y}.0 \;\mid\; \mathsf{x}(\mathsf{z}).\mathsf{P}$$

Cleaned up grammar of this subcalculus

$$
\begin{array}{lll}
\mathsf{P} & ::= & \mathsf{0} \\
 & \mid & \overline{\mathsf{x}}\mathsf{y.0} \\
 & \mid & \mathsf{x(z).P} \\
 & \mid & \nu\mathsf{zP} \\
 & \mid & (\mathsf{P} \mid \mathsf{P}) \\
 & \mid & \nu\mathsf{x}\,(\,!\mathsf{x(z).P} \;\mid\; \mathsf{P}\,)
\end{array}
$$

. . . in ASCII

```
P  ::=  ()
     |  xy
     |  x?z = Proc
     |  (new z:^Type Proc)
     |  (Proc | Proc)
     |  (def x = Proc Proc)
```