A Formalisation of an Access Control Framework

joint work with Chunhan Wu and Xingyuan Zhang from the PLA University of Science and Technology in Nanjing

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Access Control

- perhaps most known are Unix-style access control systems (root super-user, setuid mechanism)

```
> ls -ld . * */*
drwxr-xr-x 1 alice staff    32768  Apr  2 2010 .
-rw----r-- 1 alice students 31359  Jul 24 2011 manual.txt
-rwsr--r-x 1 bob   students 141359 Jun  1 2013 microedit
dr--r-xr-x 1 bob   staff    32768  Jul 23 2011 src
-rw-r--r-- 1 bob   staff    81359  Feb 28 2012 src/code.c
```

Access Control

more fine-grained access control is provided by

- SELinux
  (security enhanced Linux devloped by the NSA;
  mandatory access control system)
- Role-Compatibility Model
  (developed by Amon Ott;
  main application in the Apache server)

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Operations in the OS

using Paulson's inductive method a **state of the system** is a **trace**, a list of events (system calls):

$$[e_1, \ldots, e_2]$$

$$
\begin{array}{lcl|l|l}
e & ::= & \textit{CreateFile}\ p\ f & \textit{ReadFile}\ p\ f & \textit{Send}\ p\ i \\
 & | & \textit{WriteFile}\ p\ f & \textit{Execute}\ p\ f & \textit{Recv}\ p\ i \\
 & | & \textit{DeleteFile}\ p\ f & \textit{Clone}\ p\ p' & \textit{CreateIPC}\ p\ i \\
 & | & \textit{ChangeOwner}\ p\ u & \textit{ChangeRole}\ p\ r & \textit{DeleteIPC}\ p\ i \\
 & | & \textit{Kill}\ p\ p' & &
\end{array}
$$

Valid Traces

we need to restrict the traces to **valid traces**:

$$\frac{}{\textit{valid}\ []} \qquad \frac{\textit{valid}\ s \quad \textit{admissible}\ s\ e \quad \textit{granted}\ s\ e}{\textit{valid}\ (e::s)}$$

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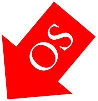

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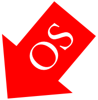

$$\frac{}{\textit{valid}\ [\,]} \qquad \frac{\textit{valid}\ s \quad \textit{admissible}\ s\ e \quad \textit{granted}\ s\ e}{\textit{valid}\ (e::s)}$$

$$\frac{p \in \textit{current\_procs}\ s \qquad p' \notin \textit{current\_procs}\ s}{\textit{admissible}\ s\ (\textit{Clone}\ p\ p')}$$

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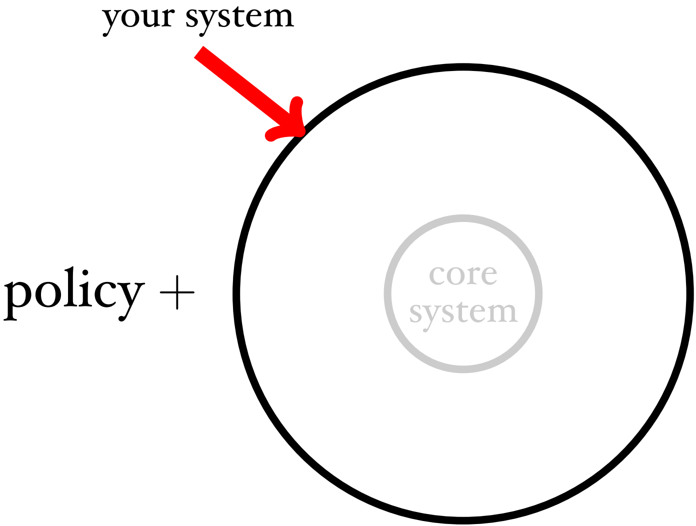
RC

$$\frac{\textit{is\_current\_role}\ s\ p\ r \quad \textit{is\_file\_type}\ s\ f\ t \quad (r,\ t, \textit{Execute}) \in \textit{permissions}}{\textit{granted}\ s\ (\textit{Execute}\ p\ f)}$$

Design of AC-Policies

"what you specify is what you get but not necessarily what you want..."

Testing Policies



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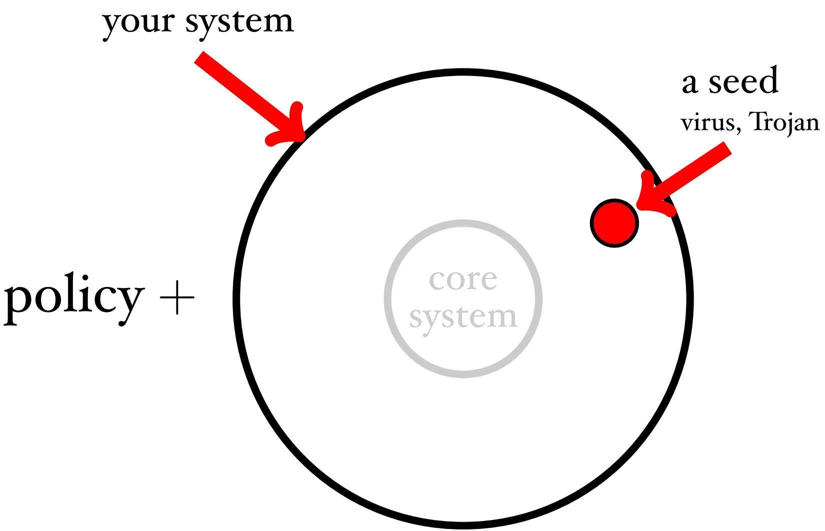

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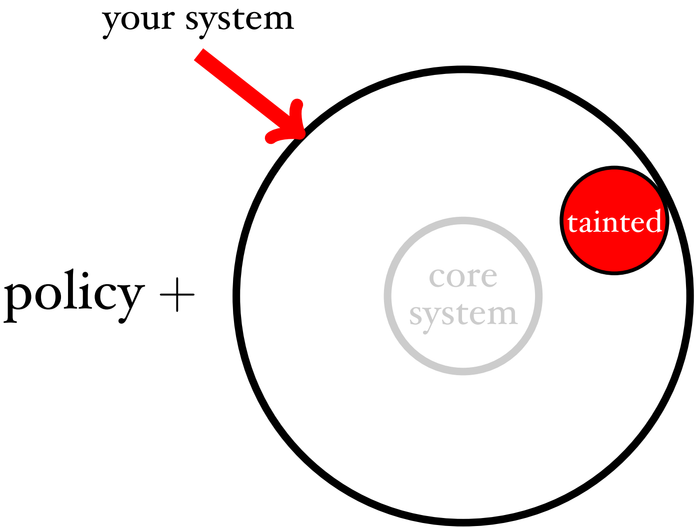

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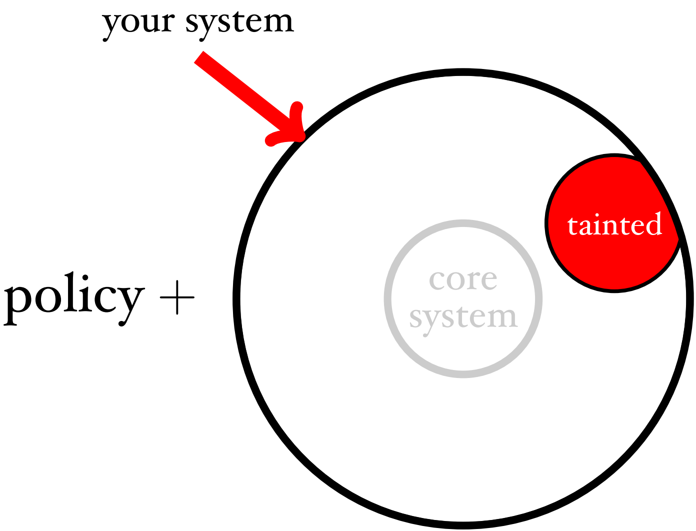
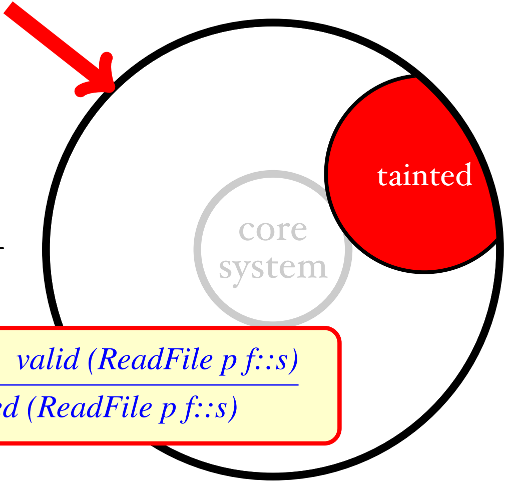


Testing Policies

your system

policy +



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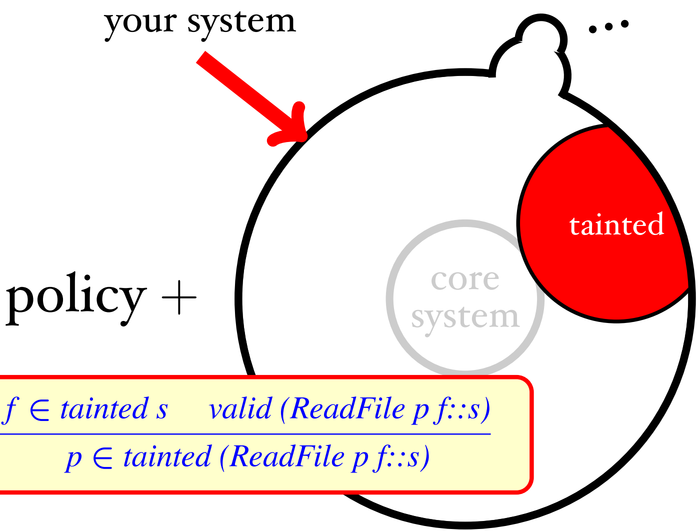

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A Sound and Complete Test

- working purely in the *dynamic world* does not work – infinite state space
- working purely on *static* policies also does not work – because of over approximation
  - suppose a tainted file has type *bin* and
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- our solution: take a middle ground and record precisely the information of the initial state, but be less precise about every newly created object.

Results about our Test

- we can show that the objects (files, processes, ...) we need to consider are only finite (at some point it does not matter if we create another *bin*-file)

Thm (Soundness)
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Thm (Completeness)
If an object is taintable in the OS and *undeletable*⋆, then our test will find out that it is taintable.

⋆ an object is *undeleteable* if it exists in the initial state, but there exists no valid state in which it could have been deleted

Why the Restriction?

- assume a process with *ID* is tainted but gets killed by another process
- after that a proces with the same *ID* gets *re-created* by cloning an untainted process
- clearly the new process should be considered *un*tainted

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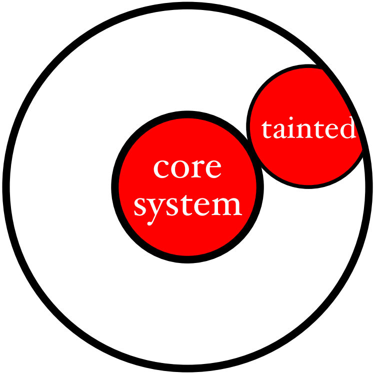
Is this a serious restriction? We think not ...

Core System

Admins usually ask whether their policy is strong enough to protect their core system?



core system files are typically undeletable

Conclusion

- we considered the Role-Compatibility Model used for securing the Apache Server

  13 events, 13 rules for OS admisibility, 14 rules for RC-granting, 10 rules for tainted

- we can scale this to SELinux

  more fine-graided OS events (inodes, hard-links, shared memory, ...)

22 events, 22 admisibility, 22 granting, 15 taintable

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- hard sell to Ott (who designed the RC-model)
- hard sell to the community working on access control (beyond *good science*)

Thanks!
Questions?