A quick look into verification in OS kernels

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BPF syntax

```
; load syscall number
ld [0]
; deny open() with errno = EACCES
jeq #SYS_open, L1, L2
L1: ret #RET_ERRNO|#EACCES
; allow getpid()
L2: jeq #SYS_getpid, L3, L4
L3: ret #RET_ALLOW
; allow gettimeofday()
L4: jeq #SYS_gettimeofday, L5, L6
L5: ret #RET_ALLOW
L6: ...
; default: kill current process
ret #RET_KILL
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As seen above, each system call gets an entry in the list of rules, along with the expected behavior regarding this particular sytem call. A default behavior is also defined, should any system call be absent from the previous list.

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Example of SCPL

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As seen above, SCPL is really close to the natural thought process of defining the rules of sytem call behavior, and this intuitive ease of use guarantees minimal errors within policies definition.

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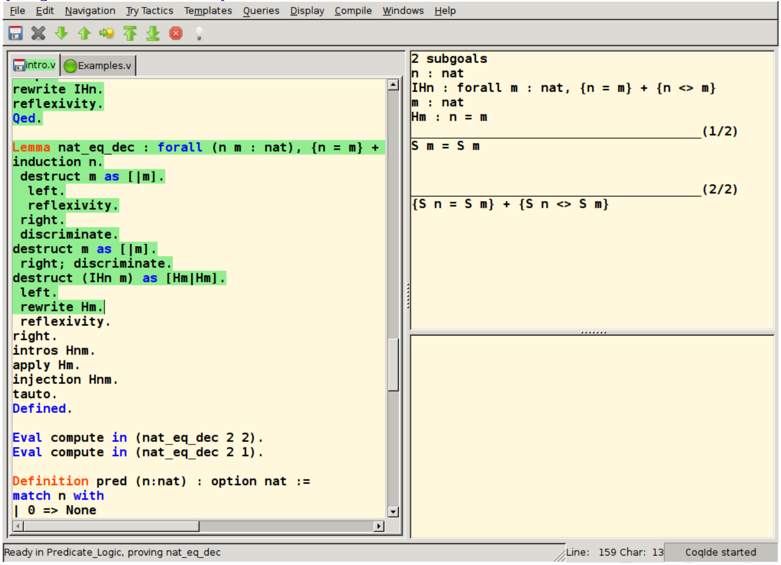
Coq syntax example


File Edit Navigation Try Tactics Templates Queries Display Compile Windows Help
intro.v
Examples.v

```
rewrite IHn.
reflexivity.
Qed.

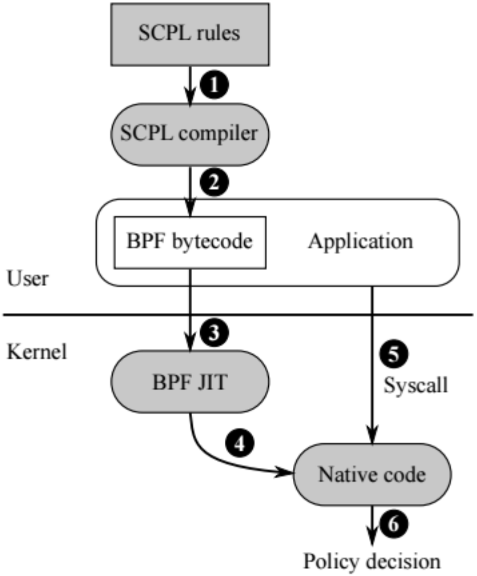
Lemma nat_eq_dec : forall (n m : nat), {n = m} +
induction n.
 destruct m as [|m].
  left.
  reflexivity.
 right.
 discriminate.
destruct m as [|m].
 right; discriminate.
destruct (IHn m) as [Hm|Hm].
 left.
 rewrite Hm.
 reflexivity.
right.
intros Hnm.
apply Hm.
injection Hnm.
tauto.
Defined.

Eval compute in (nat_eq_dec 2 2).
Eval compute in (nat_eq_dec 2 1).

Definition pred (n:nat) : option nat :=
match n with
| 0 => None
```

```
2 subgoals
n : nat
IHn : forall m : nat, {n = m} + {n <> m}
m : nat
Hm : n = m
______________________________________(1/2)
S m = S m
______________________________________(2/2)
{S n = S m} + {S n <> S m}
```

```
Ready in Predicate_Logic, proving nat_eq_dec    Line:  159 Char:  13    CoqIde started
```


SCPL rules
1
SCPL compiler
2
BPF bytecode
Application
User
3
Kernel
BPF JIT
5
Syscall
4
Native code
6
Policy decision

JITK operation steps

JITK operation is divided in several steps:

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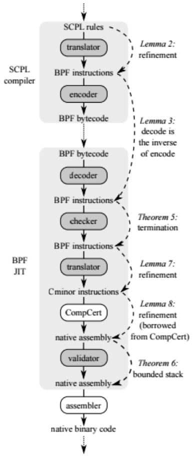
SCPL rules
translator
BPF instructions
encoder
BPF bytecode
SCPL compiler
Lemma 2: refinement
Lemma 3: decode is the inverse of encode
BPF bytecode
decoder
BPF instructions
checker
BPF instructions
translator
Cminor instructions
CompCert
native assembly
validator
native assembly
assembler
native binary code
BPF JIT
Theorem 5: termination
Lemma 7: refinement
Lemma 8: refinement (borrowed from CompCert)
Theorem 6: bounded stack

Thank you for your attention ! Any questions ?

Further Reading I

Xi Wang, David Lazar, Nickolai Zeldovich, Adam Chlipala, Zachary Tatlock
Jitk: A Trustworthy In-Kernel Interpreter Infrastructure.
11th USENIX Symposium on Operating Systems Design and Implementation, 2014.

Grigore Rosu, Traian Florin Serbanuta
An Overview of the K Semantic Framework
J.LAP, 2010.