Program Verification as a Toolbox

A Brief, *Subjective* History

David Cock

January 23, 2015

Is Your System Correct?

Short answer — no.

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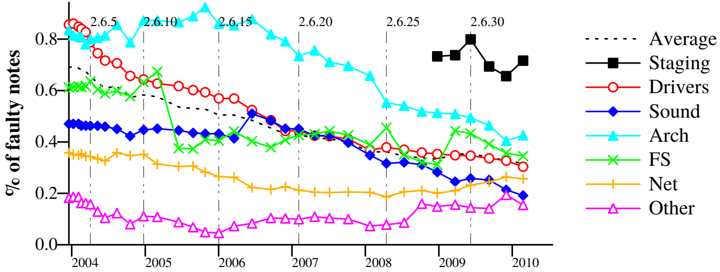
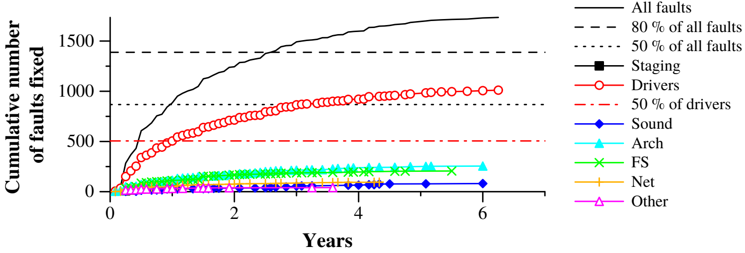
The Bug Rate in Linux [1]



It's dropping, but there's a long way to go.

[1] Source: Palix et. al., Faults in Linux: Ten Years Later, ASPLOS'11

Bug Lifetime in Linux [2]



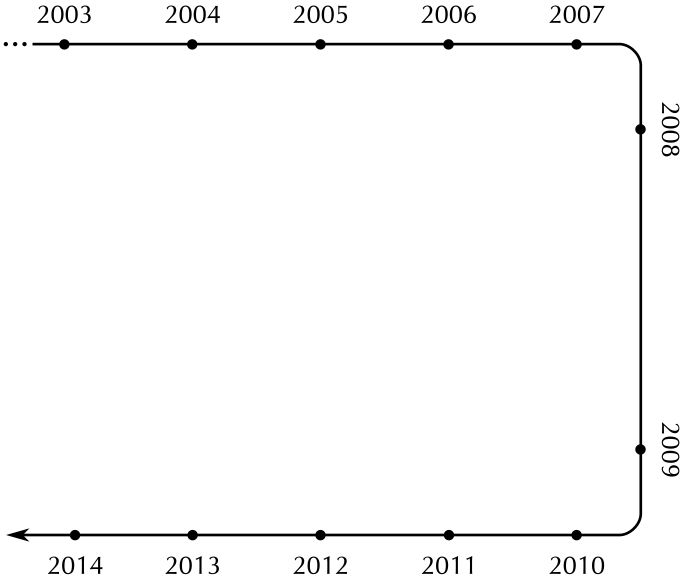
- Only 60% fixed within a year.
- Asymptotic — some bugs live 5 + years!

[2] Source: Palix et. al., Faults in Linux: Ten Years Later, ASPLOS'11

Why Now?

- Less expertise is required than 10 years ago.
- We’ve seen some real milestones:
  - seL4
  - CompCert
- *Tool support* has matured dramatically.

A Timeline



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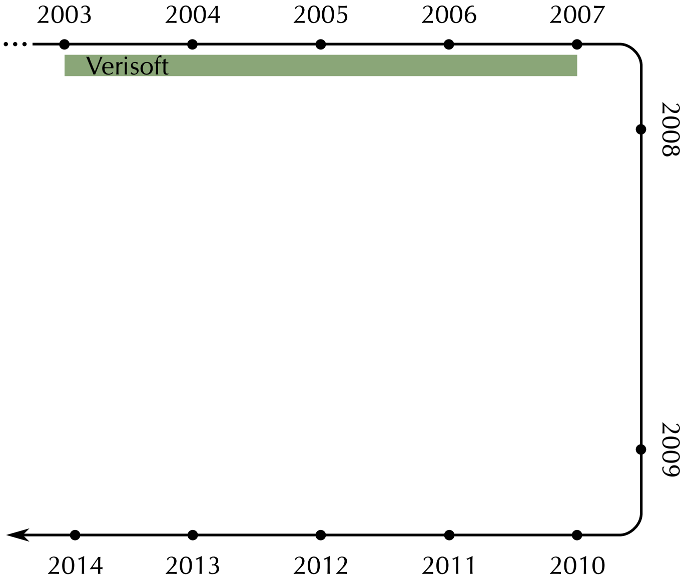

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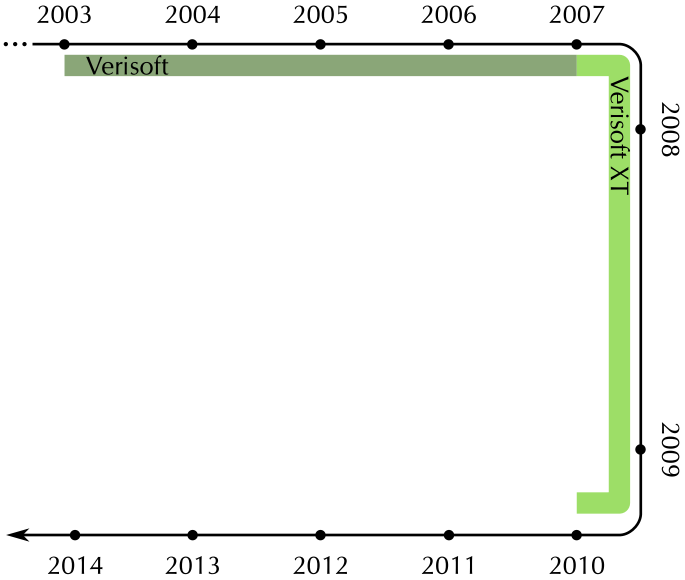
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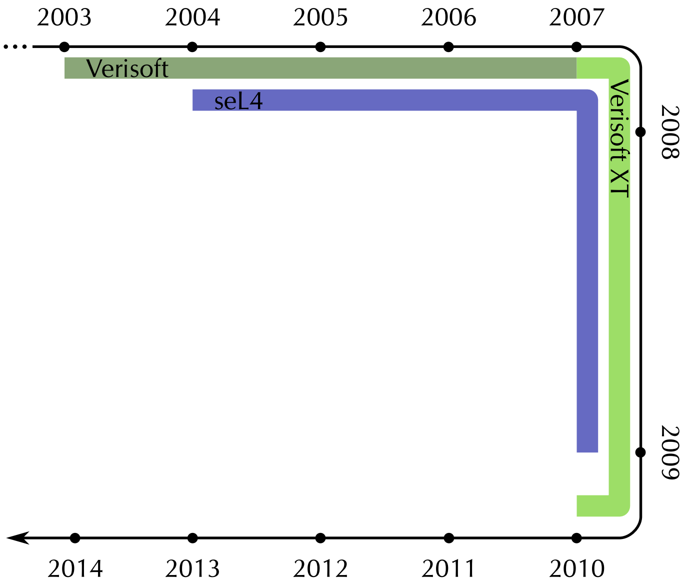

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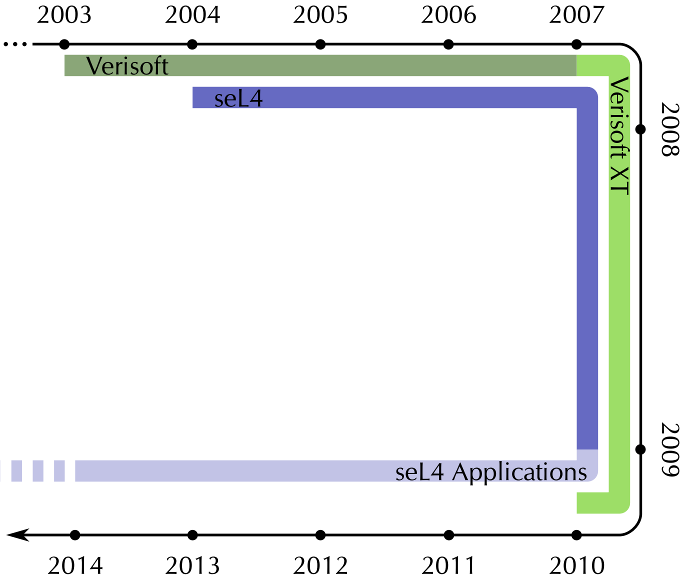
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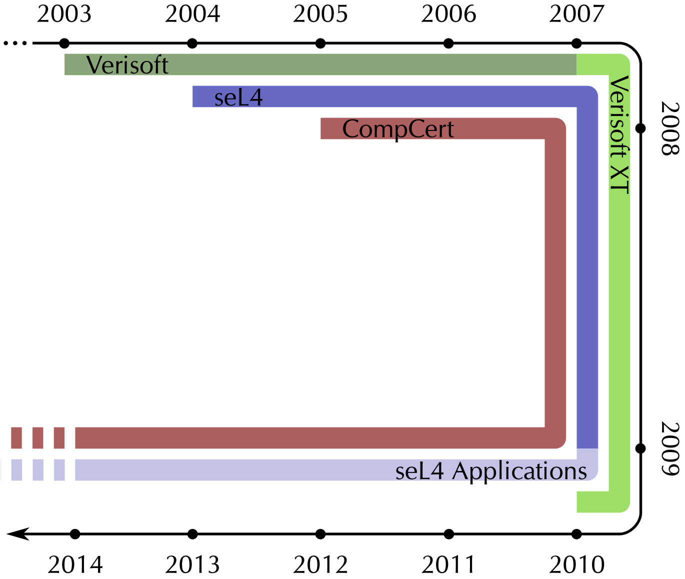

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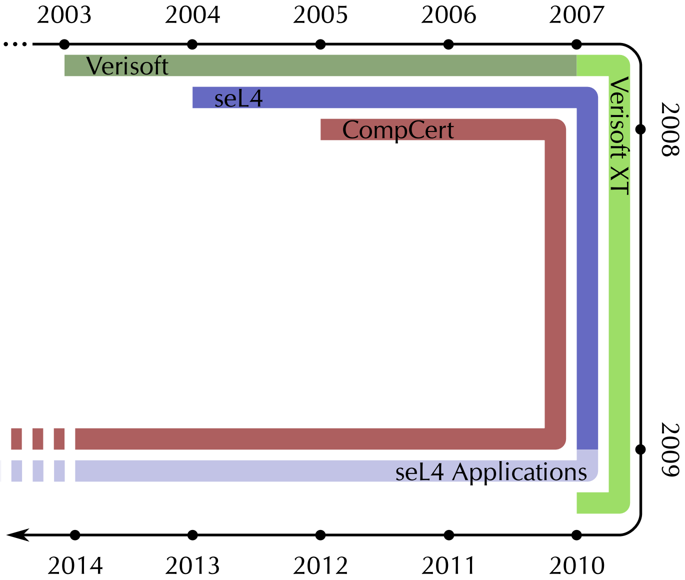
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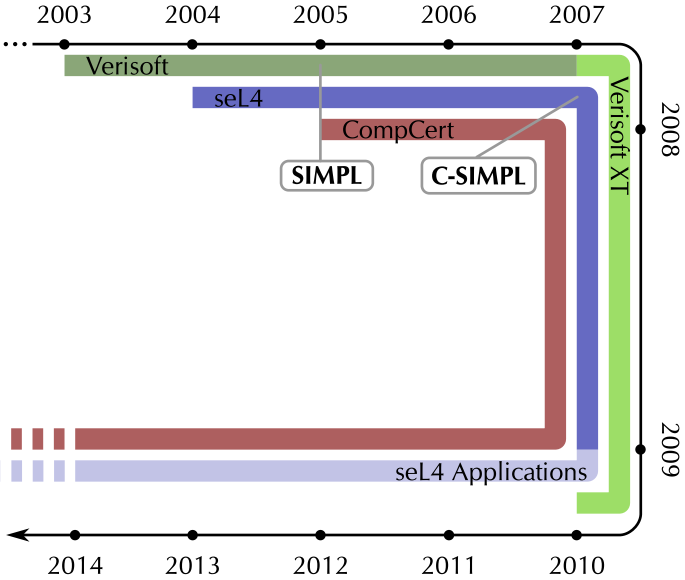

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SIMPL/C

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- We’ve now got a formal semantics for C[3].

[3] Winwood et. al., Mind the gap: A verification framework for low-level C, TPHOLS’09

SIMPL/C

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*(a++) = ++*a-- + (*(a++))++ * *--a;
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- We've now got a formal semantics for C[3].
- As long as you don't write nonsense like this.

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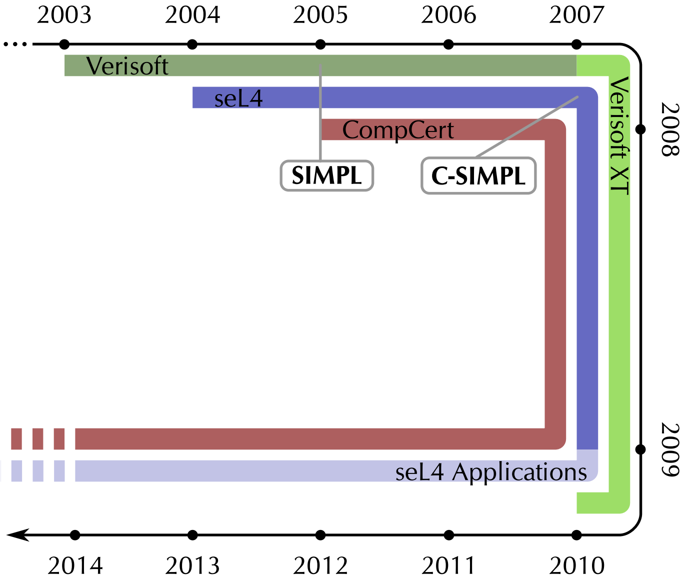
A Timeline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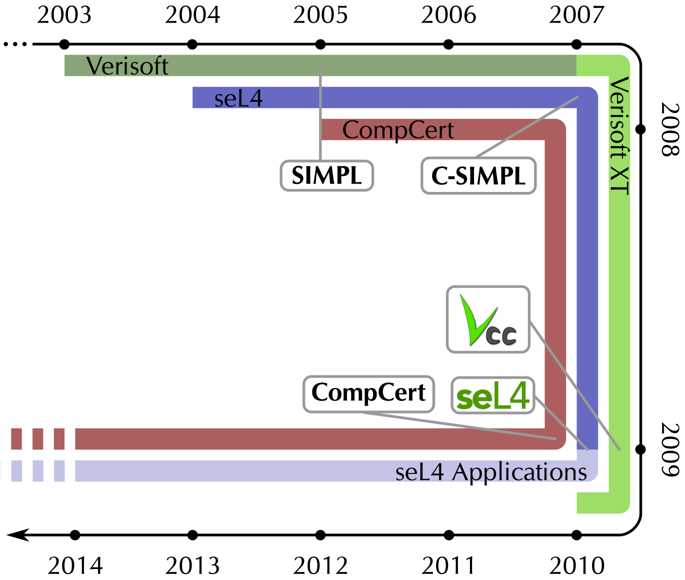
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seL4, VCC & CompCert

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seL4, VCC & CompCert

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seL4, VCC & CompCert

Vcc seL4

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seL4, VCC & CompCert

As of 2009, we've got:

- A verified kernel: seL4.
- A *verifying* compiler: CompCert.
- An automatic verifier for concurrent C: VCC.
- seL4 compiles with CompCert. . .
  but VCC can't (yet) verify seL4.

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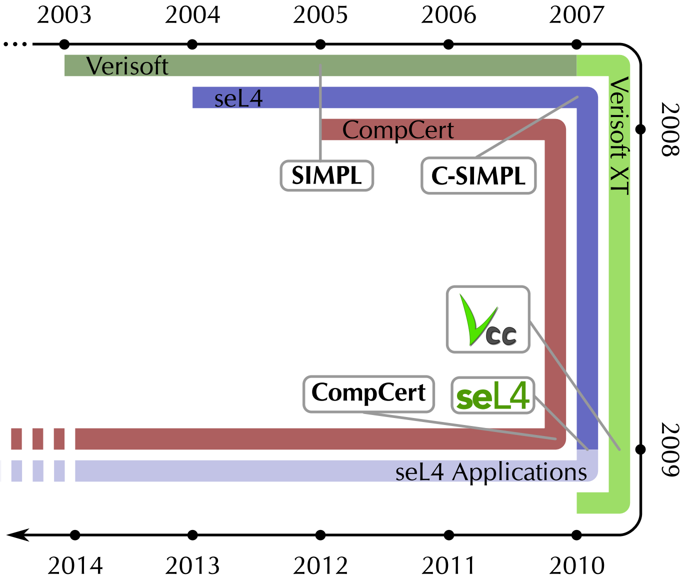
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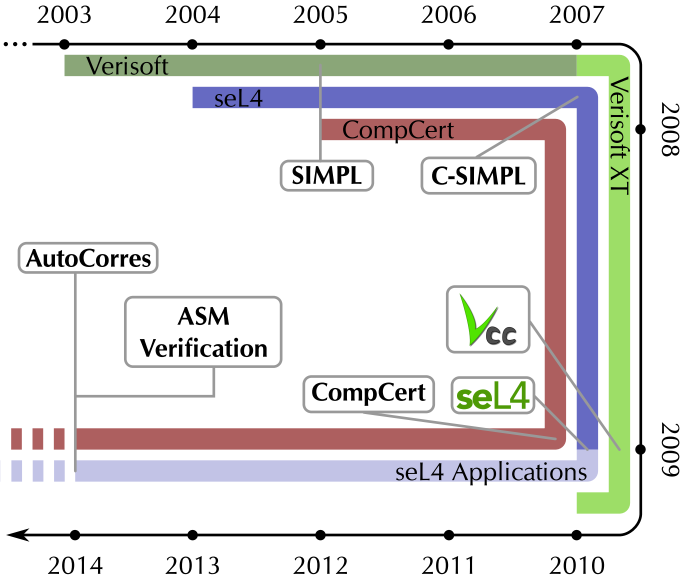

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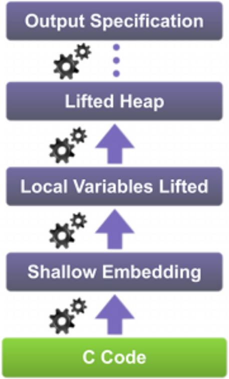
AutoCorres[4] & Assembly Verification[5]



- Brand new tools.
- Highly automated.
- Autocorres
  - Abstract from pointers and fixed-length words.
  - Lift to a verification-friendly model.
- ASM Verification
  - Alternative approach to CompCert.
  - Verify the *output* of `gcc -O1` (`-O2` coming).

[4] Greenaway et. al., Don't Sweat the Small Stuff: Formal Verification of C Code Without the Pain, PLDI'14

[5] Sewell et. al., Translation validation for a verified OS kernel, PLDI'13

Putting It Into Practice

- **Tools**
  - Still not seamless.
  - Interoperability and re-use.
  - Formal concerns (different logics).
- **Education**
  - Introduce programmers to the formal mindset.
- **Applications**
  - Trusted partitioning (Virtualisation, SDN, . . .).
  - Trusted computing.
  - Safety-critical systems.

Questions?