CS 4160

Formal Verification

Prof. Clarkson

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Approaches to validation

- Social
  - Code reviews
  - Extreme/Pair programming
- Methodological
  - Design patterns
  - Test-driven development
  - Version control
  - Bug tracking
- Technological
  - Static analysis ("lint" tools, FindBugs, …)
  - Fuzzers
- Mathematical
  - Sound type systems
  - "Formal" verification

Less formal: Techniques may miss problems in programs

All of these methods should be used!

Even the most formal can still have holes:

- did you prove the right thing?
- do your assumptions match reality?

More formal: eliminate *with certainty* as many problems as possible.

Slide credit: Benjamin C. Pierce (UPenn)

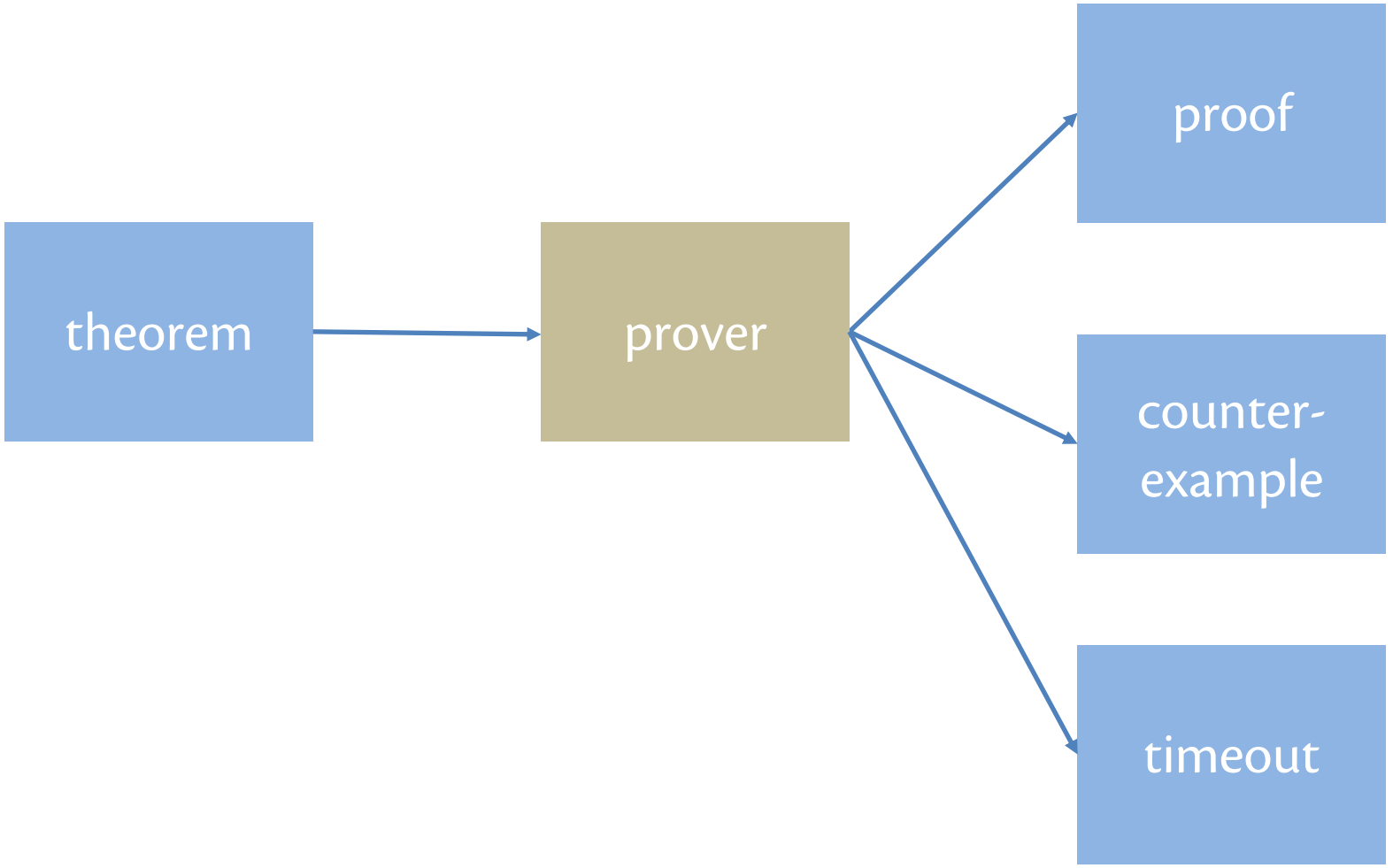
Verification

- In the 1970s, scaled to about tens of LOC

- Now, research projects scale to real software:
  - CompCert: verified C compiler
  - seL4: verified microkernel OS
  - Ynot: verified DBMS, web services
  - Four color theorem
  - Project Everest: verified HTTPS stack [in progress]
  - Etc.

- In another 40 years?

Automated theorem provers

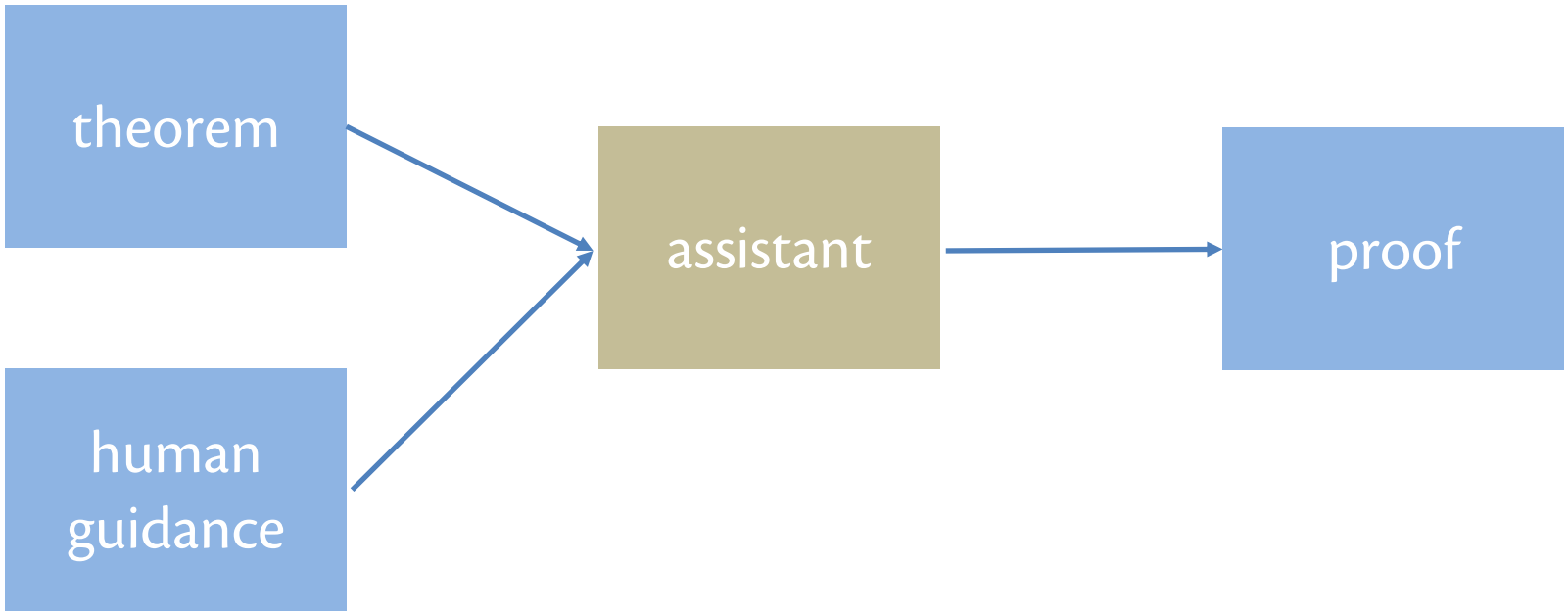


Automated theorem provers

- Z3: Microsoft started shipping with device driver developer's kit in Windows 7

- ACL2: used to verify AMD chip compliance with IEEE floating-point specification, as well as parts of the Java virtual machine

Proof assistant



Proof assistants

- NuPRL [Prof. Constable]: Formalization of mathematics, distributed protocols, security

- Coq: CompCert, Ynot [Dean Morrisett]

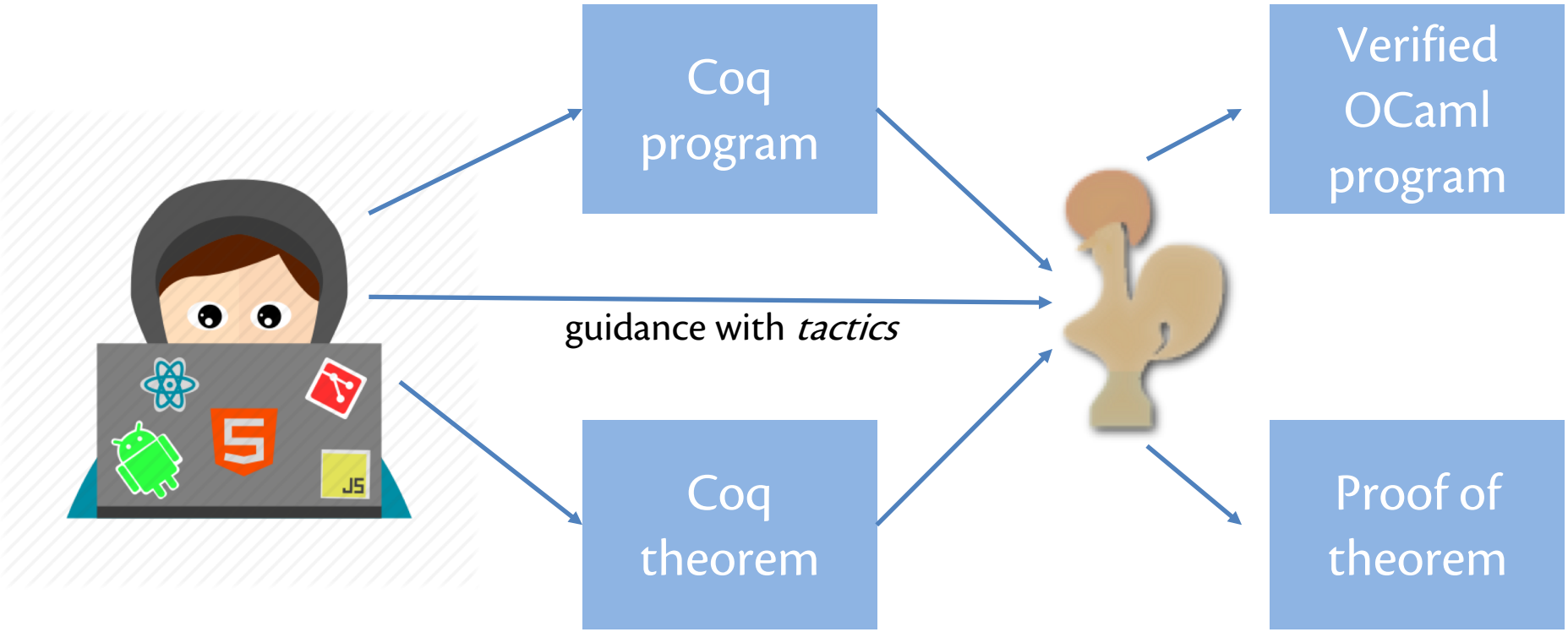
COQ

Coq

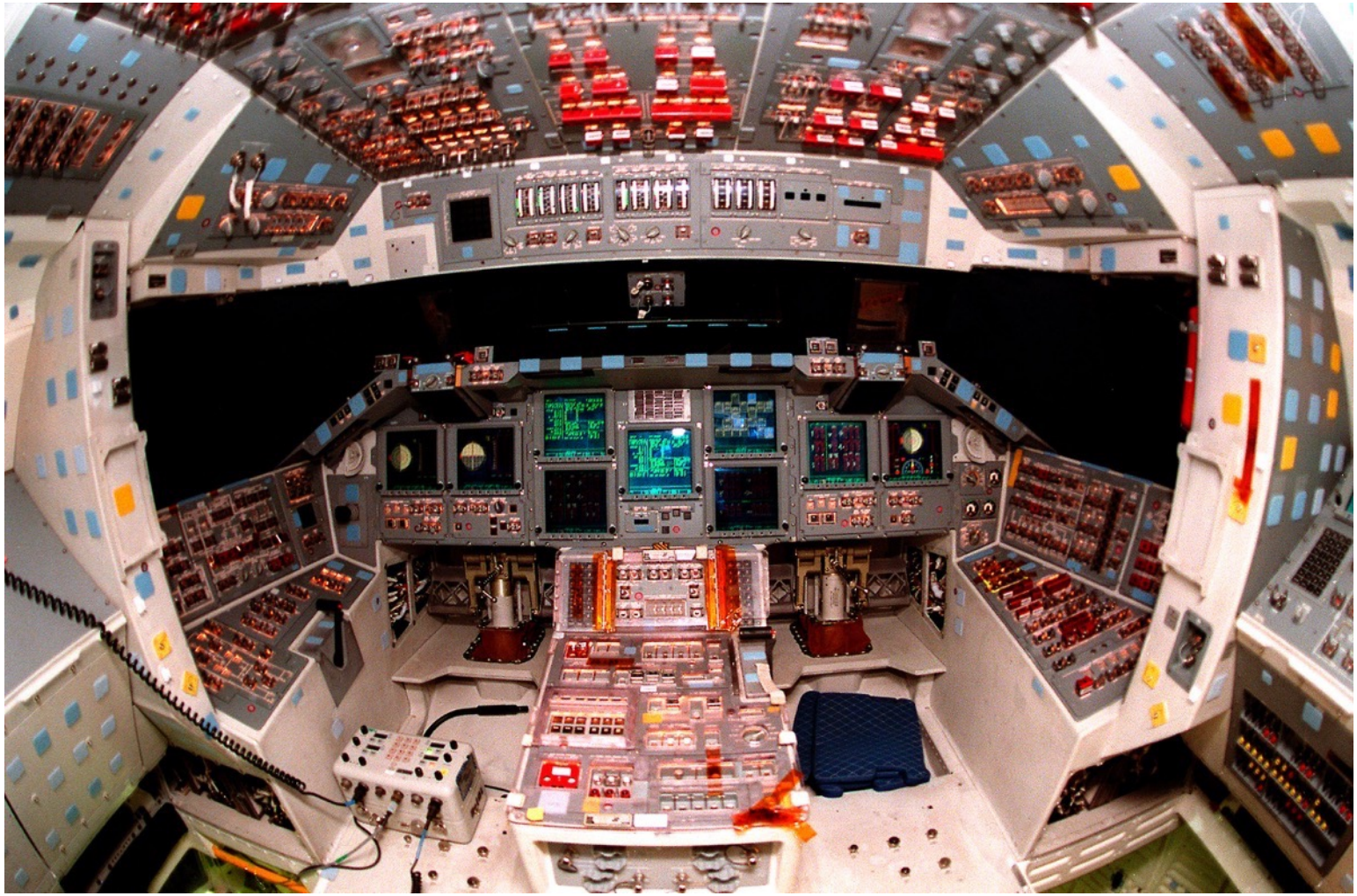
- **1984:** Coquand and Huet implement Coq based on *calculus of inductive constructions*
- **1992:** Coq ported to Caml
- Now implemented in OCaml

Thierry Coquand
1961 –

Coq for program verification



Coq's full system



Subset of Coq we'll use


CAUTION: HIGHLY ADDICTIVE

LOGISTICS

Prof. Michael Clarkson

- PhD 2010 Cornell University
- BS (CS) & BM (piano) 1999 Miami University
- Regularly teach: CS 2110, CS 3110

- Ugrad senior project: verification of some Space Shuttle specs with NASA/JPL
- PhD dissertation: verified in Isabelle/HOL
- [Hirsch and Clarkson, CCS 2013]: verified in Coq

Course website

https://www.cs.cornell.edu/courses/cs4160/2020sp/

Acknowledgment

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