computer science
college of engineering

Engineering Software Correctness

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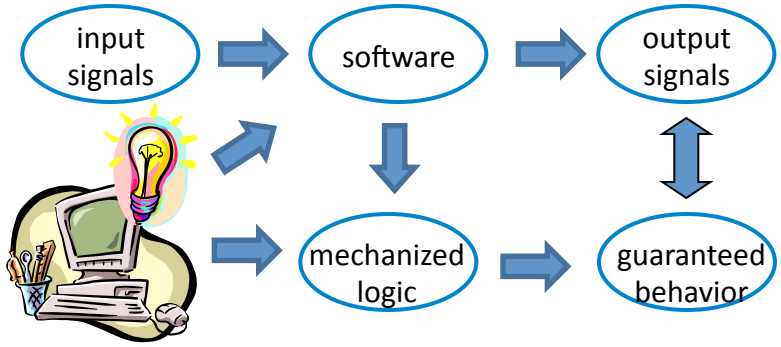
Objectives

- Software components with guaranteed properties
- Education in practices that can lead to software guarantees



Background

- Some software needs to be free of certain defects
  - You don't want your car to speed up when you press brake
  - You don't want your ailerons stuck in "roll"
  - You don't want your word processor to lose your edits
- Conventional software cannot have certified properties
  - Why? Because classical logic fails on conventional software
  - No machine-checked verification beyond driver-level SW
- What is needed?
  - Software expressed as equations, so classical logic works
  - Mechanized logic, for checking details down to the bit level
- **Tools exist … We want to put them into practice**

How to Design a Reliable Software Component

- Imagine that you already have the component
- Express basic properties as equations ("axioms")
- Make sure axioms cover all possible cases
- Make sure circular axioms move toward non-circular ones

It's as simple as that!

- All other properties derive from the basic axioms
- Computation based on substituting equals for equals
- Verification relies only on classical logic
- Machines check all details

Engineers can know behavior of designs

Example and References

- Simple properties of a multiplexor, expressed as equations

$x_1 : [x_2 , x_3 , \ldots x_n] = [x_1, x_2 \ldots x_n]$
$mux\ [\ ]\ [\ ] = [\ ]$
$mux\ (x : xs)\ (y : ys) = x : y : (mux\ xs\ ys)$

software

- Derived property

$mux\ [x_1 , x_2 , \ldots x_n]\ [y_1 , y_2 , \ldots y_n] = [x_1 , y_1 , x_2 , y_2 \ldots x_n , y_n]$

- Derivation: proof by mathematical induction
  - Fully verified by machine
- Methods scale to large components
- References

Engineering Software Correctness, Page, *Journal Functional Programming* (2007)
Discrete Math with a Computer 2nd Ed, O'Donnell/Hall/Page (Springer 2006)
DoubleCheck Your Theorems, Carl Eastlund, *ACL2 2009* (Boston)