Basics of Verification

https://wikimpri.dptinfo.ens-cachan.fr/doku.php?id=cours:c-1-22

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MPRI – M1
2016 – 2017

Disastrous software bugs

Ariane 5 flight 501, 1996

http://en.wikipedia.org/wiki/Ariane_5_Flight_501

- Destroyed 37 seconds after launch (cost: 370 millions dollars).
- data conversion from a 64-bit floating point to 16-bit signed integer value caused a hardware exception (arithmetic overflow).
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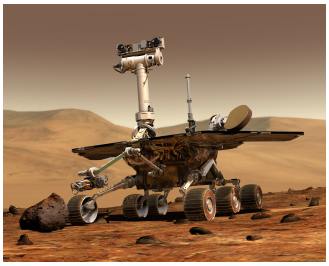

Disastrous software bugs

Other well-known bugs

- Therac-25, at least 3 death by massive overdoses of radiation.
  Race condition in accessing shared resources.
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Need for formal verification methods

Critical systems

- Transportation
- Energy
- Medicine
- Communication
- Embedded systems
- Security
- ...

A few things one can check automatically

- Result of an arithmetic operation
  - $36443 \times 28376 + 29385 = 1034135953$?
- Check that a finite graph is (strongly) connected
- Correctness of a proof
  - Proof checker
- Static analysis of programs
  - Typing
  - Undeclared, unused variables

Exercise: complexity of these problems?

Many things one can *not* check automatically a.k.a. Undecidable problems

Halting problem for Turing machines [Turing, 1936]

- Assume $P : (Q, x) \mapsto \{\text{true}, \text{false}\}$
  such that $P(Q, x)$ iff $Q(x)$ halts
- Build R such that $R(Q)$ halts iff $Q(Q)$ does not halt (exercise)
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Rice, 1953

All non trivial problems about Turing machines are undecidable

...and even most problems about most (even very simple) extensions of automata!

Formal verification methods

Based on

- a formal model of the system
  - written in a not too expressive formalism
- a formal semantics
- a formal specification

Complementary approaches

- Theorem prover
- Model checking
- Static analysis
- Test
- ...

Model Checking

- Purpose 1: automatically finding software or hardware bugs.
- Purpose 2: prove correctness of abstract models.
- Should be applied during design.
- Real systems can be analysed with abstractions.


E.M. Clarke


E.A. Emerson


J. Sifakis

Turing Award 2007.

Model Checking

3 steps

- Constructing the model M (transition systems)
- Formalizing the specification φ (temporal logics)
- Checking whether $M \models \varphi$ (algorithmics)

Main difficulties

- Size of models (combinatorial explosion)
- Expressivity of models or logics
- Decidability and complexity of the model-checking problem
- Efficiency of tools

References

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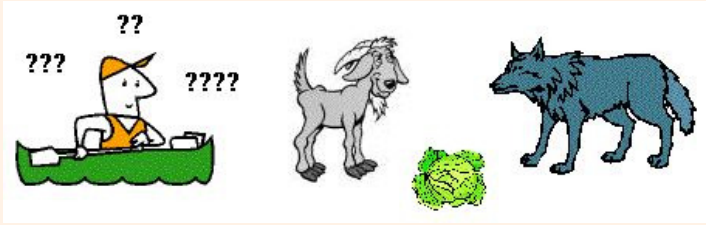
Model and Specification

Example: Man, Wolf, Goat, Cabbage



Model = Transition system

- State = who is on which side of the river
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  Safety: Never leave WG or GC alone
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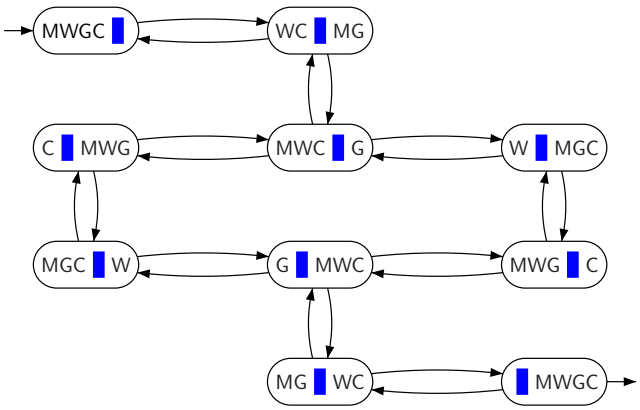
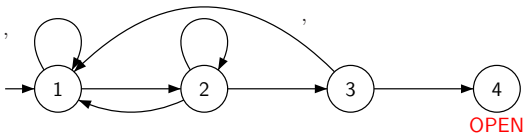
Transition system



Example: Timed Digicode with UPPAAL



Construct a timed version and check it with UPPAAL.

Exercise

Describe a thechnique to automatically detect a bug in the following function:

```
function GCD(x:  int, y:  int) {
 while x ≠ 0 do
   if x > y then {tmp := y; y := x; x := tmp}
   x := y - x
 return y
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```

Exercise

```
function f91(x:  int) {
 if (x > 100)
   then return x - 10;
   else return f91(f91(x + 11));
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Describe a transition system and a property that expresses correctness.

Outline of the course

September 15 to October 20

- Lectures by Thomas Chatain and Philippe Schnoebelen
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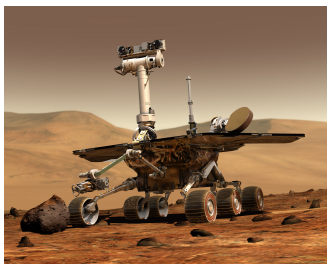

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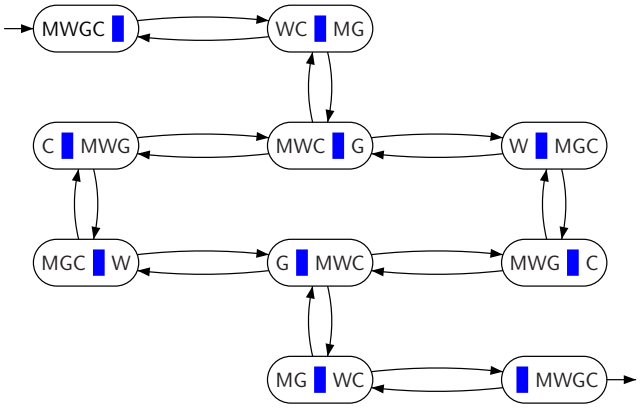

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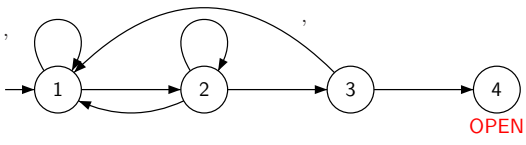

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