Semantics of Programming Languages

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The search for meaning

Examples

- $f()\{\texttt{prt}\ a;\ \texttt{ret}\ 1\};\ g()\{\texttt{prt}\ b;\ \texttt{ret}\ 0\};\ x := f() \vee g()$
- $x := 2\ ;(x := x + 1 \parallel x := 0)$
- $(a := 1\,;\texttt{prt}\ b) \parallel (b := 1\,;\texttt{prt}\ a)$

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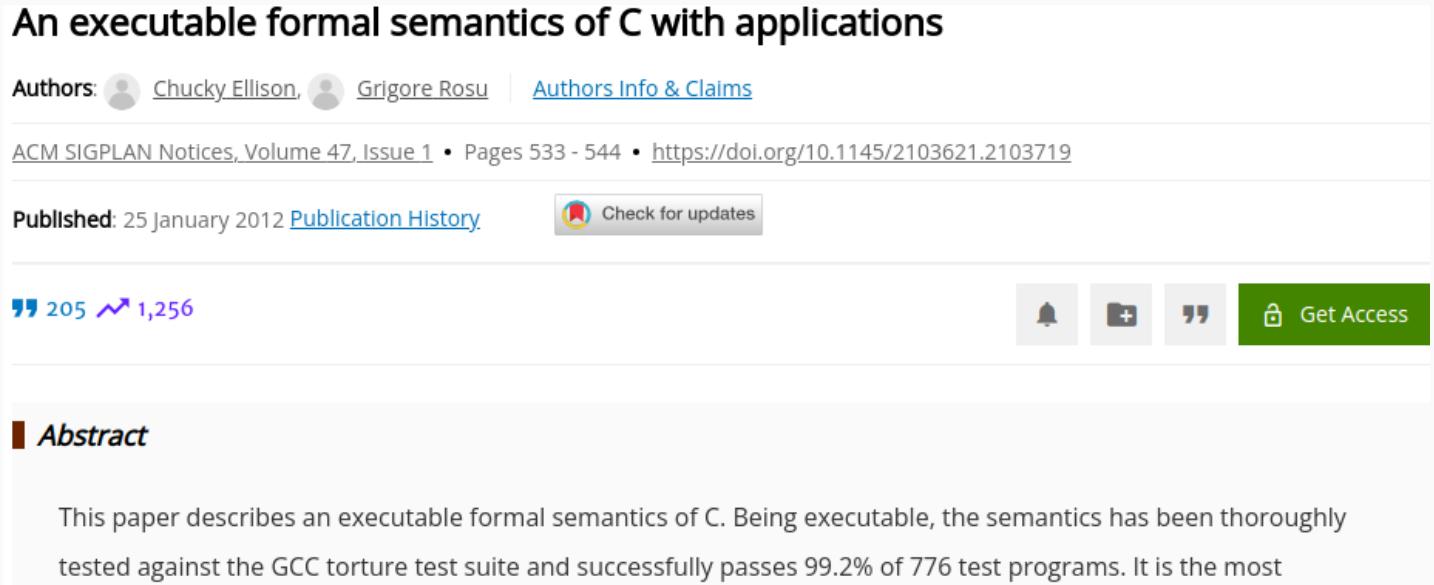

An executable formal semantics of C with applications

Authors: Chucky Ellison, Grigore Rosu | Authors Info & Claims

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205 1,256 | Get Access

Abstract

This paper describes an executable formal semantics of C. Being executable, the semantics has been thoroughly tested against the GCC torture test suite and successfully passes 99.2% of 776 test programs. It is the most

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- $\mathtt{p}; (\mathtt{q}; \mathtt{r}) \stackrel{?}{=} (\mathtt{p}; \mathtt{q}); \mathtt{r}$
- $\mathtt{p} \parallel \mathtt{q} \stackrel{?}{=} \mathtt{q} \parallel \mathtt{p}$
- $\left(\mathtt{p} +_{\frac{1}{2}} \mathtt{q}\right); \mathtt{r} \stackrel{?}{=} \mathtt{p}; \mathtt{r} +_{\frac{1}{2}} \mathtt{q}; \mathtt{r}$
- $\mathtt{entangle}(\mathtt{x}, \mathtt{y}) \stackrel{?}{=}$ spooky action

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Will my program behave correctly ?

A particle and its orbital trajectory – what can go wrong?

```
x := -1; v := 0; a := 1;
while true do {
      if x <= 0 then a := 1 else a :=-1;
      x' = v, v' = a for 0.5;
}
```

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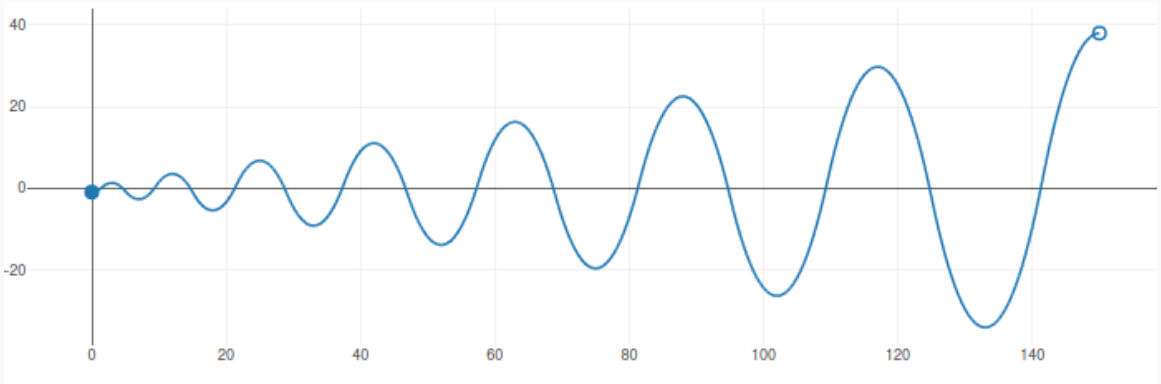
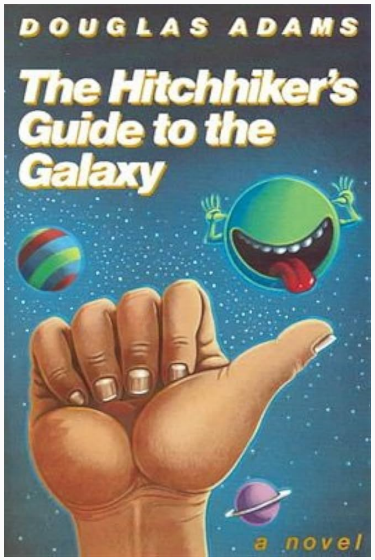


The search for meaning

But. . . what is a programming language really ?

And what is computation ?



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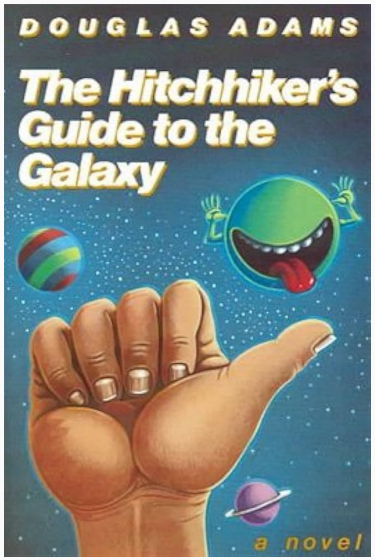

To answer these questions we will turn programming into mathematics . . .

in the same way that (other?) natural phenomena are turned into mathematics (electromagnetism, quantum physics . . .)

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A sprinkle of linguistics

We will face two linguistic concepts that every programmer ought to know

- syntax - determines whether a sentence is valid or not
- semantics - the meaning of valid sentences

Example (syntax)

The sentence (program) $\mathtt{x} := \mathtt{p}\,;\mathtt{q}$ is forbidden by the syntactic rules of most programming languages

Example (semantics)

The sentence (program) $\mathtt{x} := 1$ has the meaning "writes 1 in the memory address corresponding to $\mathtt{x}$"

Semantics for every season

Operational semantics	How a program operates
Denotational semantics	What a program is
Axiomatic semantics	Which logical properties a program satisfies

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Denotational semantics	What a program is
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Some truly surprising properties arise from their interaction . . .

An apparently impossible program

Take a concurrent program `p`

It relies on an external scheduler to interleave its actions

There are infinitely many schedulers even uncountably many

Yet one can write down a program that checks whether `p` satisfies a given property for all schedulers ... in finite time !!

How deep will we go into the rabbit hole ?

Our learning path will intersect theory and practice, from the very basics to the state-of-the-art — we will face current limitations and see what challenges lie ahead

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Assessment

Two written tests (24 Mar and 26 May)

Materials and Contacts

Relevant class material and announcements posted on the website

`http://lmf.di.uminho.pt/SLP-2425/`

e-mail: nevrenato@di.uminho.pt

office hours: wednesday afternoon (please send an email the day before if you wish to meet)


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Hanne Riis Nielson and Flemming Nielson, *Semantics with applications: An appetizer*, Springer London, 2007.


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