Power of software

1

What's going on

- User report are being graded
- 1.0 release due Tue Dec 10, 11:59 PM
- Presentations Tue Dec 10
- Final team assessment due Dec 13

2

Power of Computing

Can you write any program I describe to you?

3

Can you write:

A program HALTS? whose input is the body of a method, and that outputs 0 if the method enters an infinite loop, and 1 if it does not.

4

What's HALTS?(method)?

```
method() {
  print "hello world";
}
```

5

What's HALTS?(method)?

```
method() {
  for (int x=0; x<5; x++)
    print "hello world";
}
```

6

What's HALTS?(method)?

```
method() {
  for (int x=0; x<-1; x++)
    print "hello world";
}
```

7

What's HALTS?(method)?

```
method() {
  while (true);
}
```

8

What's HALTS?(method)?

```
method() {
  int x = 785th digit of π;
  if (x == 7)
    while(true);
}
```

9

What's HALTS?(method)?

```
method() {
  int x = 785th digit of π;
  int y = x^x^x^x^x+1;
  int z = yth digit of π;
  if (z == 0)
    while(true);
}
```

10

What's HALTS?(method)?

```
method() {
  int x = 785th digit of π;
  int y = x^x^x^x^x+1;
  int[] z[] = the yth through (x+y)th
              digits of π;
  if (z ever repeats in π again)
    while(true);
}
```

11

How about the general case?

- Let's count programs. How many programs are there?
- And how many problems are there?
  - let's limit ourselves to simple problems:
    - given a set of numbers, e.g., {2, 4, 6}
    - on input i, return 1 if i is in the set, and 0 otherwise

12

First 64 programs

- How many of our problems can I solve with 64 programs?
  (a) 64
  (b) 32
  (c) 8
  (d) 6
  (e) 2

13

First 64 programs

- With 64 programs, how large can my sets get (if I am being compact)
  (a) 64
  (b) 32
  (c) 8
  (d) 6
  (e) 2
- Example: with 4 programs, I could cover: {}, {1}, {2}, {1,2}

14

Scalability Problem

- To cover subsets of a set of n numbers, I need 2^n programs.
- But I only have as many programs are there are natural numbers.
- That's exponentially smaller than the number of problems there are.

Can't do it for all subsets!

15

Can HALTS? exist?

- Imagine that you wrote HALTS?
- I will write a new program NALTS?:

```
NALTS?(Method p) {
  if (HALTS?(p)==0) return 1;
  else while (true);
}
```

Key, run the program on (almost) itself
What is the value of
NALTS?(NALTS?)

16

What is the value of NALTS?(NALTS?)

- Two cases:

1. If NALTS?(NALTS?) goes into an infinite loop, then HALTS?(NALTS?)==1, which means that NALTS? terminates.
   So case 1 is impossible.
2. If NALTS?(NALTS?) does not go into an infinite loop, then HALTS?(NALTS?)==0, which means that NALTS? does not terminate.
   So case 2 is impossible.

17

Conclusion

- The program HALTS cannot exist!
- Many programs cannot exist!

- Learn more in CS 401 or CS 601

18