09/09/2015 Lecture

Announcements/Questions

- Able to locate course web page?
- Able to locate homework and lecture notes?
- Able to see messages on Piazza?

Announcements/Questions

- PDF of book chapters?
- Printed version?
- Solutions for exercises in book
- Open the Room early?

Programming

- Syntax error
- Logic error
- Runtime error

- Debugging

- Read: Soul of the New Machine, Tracy Kidder

Turing Machine

- A Turing machine is a general example of a CPU that controls all data manipulation done by a computer. More specifically, it is a machine (automaton) capable of enumerating some arbitrary subset of valid strings of an alphabet; these strings are part of a recursively enumerable set.
- Assuming a black box, the Turing machine cannot know whether it will eventually enumerate any one specific string of the subset with a given program. This is due to the fact that the halting problem is unsolvable, which has major implications for the theoretical limits of computing.
- The Turing machine is capable of processing an unrestricted grammar, which further implies that it is capable of robustly evaluating first-order logic in an infinite number of ways. This is famously demonstrated through lambda calculus.
- A Turing machine that is able to simulate any other Turing machine is called a universal Turing machine (**UTM**, or simply a **universal machine**). A more mathematically oriented definition with a similar "universal" nature was introduced by Alonzo Church, whose work on lambda calculus intertwined with Turing's in a formal theory of computation known as the Church–Turing thesis. The thesis states that Turing machines indeed capture the informal notion of effective methods in logic and mathematics, and provide a precise definition of an algorithm or "mechanical procedure". Studying their abstract properties yields many insights into computer science and complexity theory.

Turing Machine (simple definition and concept)

- Formalizes and defines concept of a universal computer!
- a tape consisting of slots in which numbers may be written,
- a read/write head that can move along the tape reading the numbers written there or writing numbers onto the tape (or possibly overwriting numbers already written on the tape),
- and a state machine by which it will decide what numbers to write and where on the tape to write them.

Cool thing about Turing Machines!

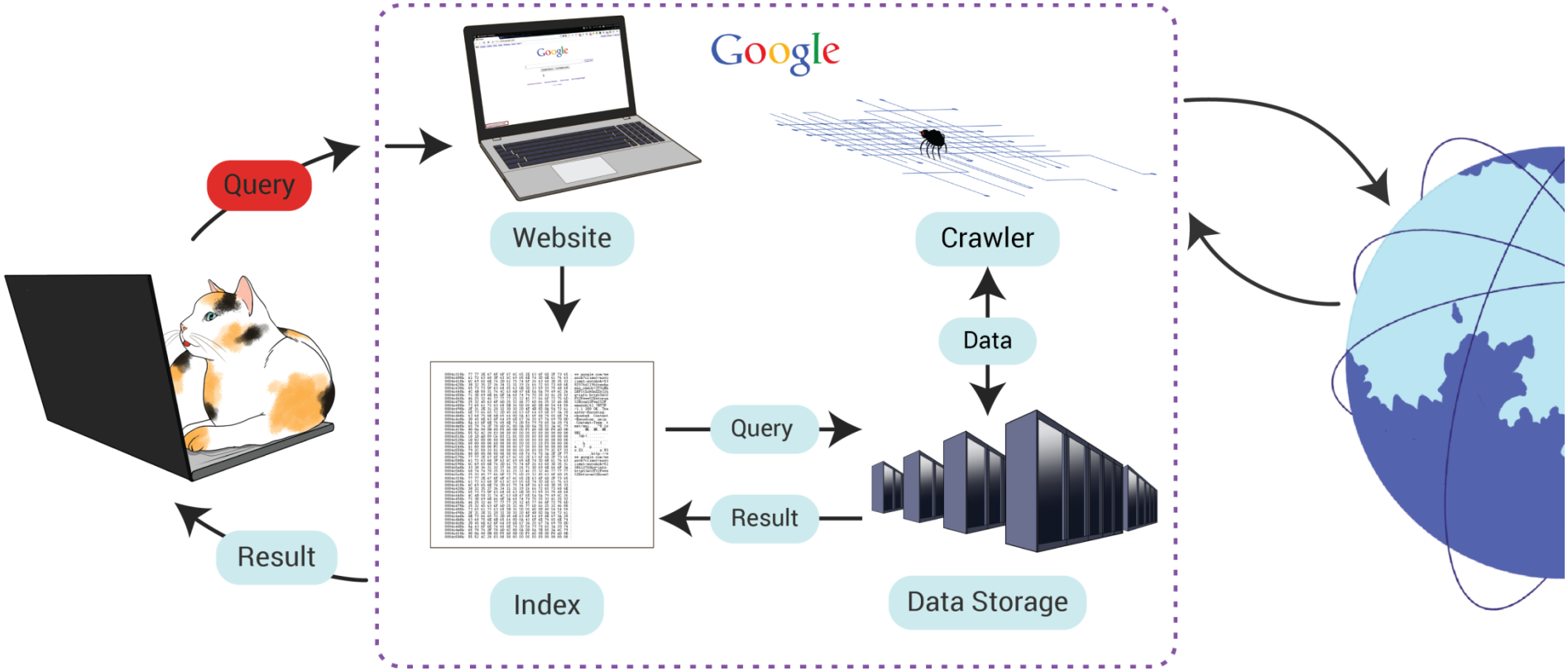
- It can solve all computable problems!

Church-Turing Thesis

- If you can write an algorithm for performing a computation, then a Turing machine can be built that performs that same computation

Turing Completeness

- A Turing machine is said to be **Turing complete** if it is capable of simulating any other Turing machine (and therefore of running any algorithm, if you believe Church's Thesis).


Google
Query
Website
Crawler
Data
Query
Result
Result
Index
Data Storage

- computer
- fixed program
- stored program
- program
- Turing completeness
- interface
- implementation
- abstraction
- ISA (basic)
- programming language (basic)
- compiler (basic)
- microarchitecture (basic)
- architecture (basic)
- registers (basic)
- instruction set (basic)
- syntax (basic)
- semantics (basic)
- library (basic)
- algorithm
- complexity
- trade-off
- low-level language
- high-level language
- syntax error
- logic error
- runtime error
- debugging
- state machine
- microarchitecture
- binary (basic)
- logic gate
- and gate
- truth table
- xnor gate
- Turing machine
- Church-Turing thesis
- Turing complete
- computational complexity
- binary (basic)

Computer

Which Capabilities are being used in each step?

i. Take a number from the user and call it *n1.*

ii. Take another number from the user and call it *n2.*

iii. Add *n1* and *n2*. Save the sum in a location. We will call this location *total*.

iv. Divide *total* by 2. If you get 0 as a remainder, go to step v, else go to step vi.

v. Display "*total* is even" on the monitor.

vi. Stop

1. *Arithmetic*
2. *Storage*
3. *Branching*
4. *Input/Output*

Algorithms and Programming

1. Start by storing x/2 in a storage slot called s.
2. Take the current value of s and add x/s to it.
3. Divide s by 2
4. If s*s - x is bigger than 0.001 or smaller than -0.001, return to step 2.

sqrt

```
x = 25

y = 1
max_possible = x /2
while (y < max_possible):
    if (y * y > x):
        print "Finished. Sqrt is close to: "
        print y
        break
    y = y + 1
```

Algorithms & Programming

- Write an algorithm to find the smallest of 3 numbers: n1,n2, and n3?

```
1.smallest = n1
2.If n2 < smallest
     smallest = n2
3.If n3 < smallest
     smallest = n3
```

Next Class & Announcements

- HW-1 is due
- Read up through 2.4.1

CS/ECE 252 Lecture 3: Programming 2015 September 9

Logistics

Not many people want a PDF version of the book
PDF will be available soon
Will distribute some solutions
3 people volunteer to open door earlier than 10:45

Programming

Errors

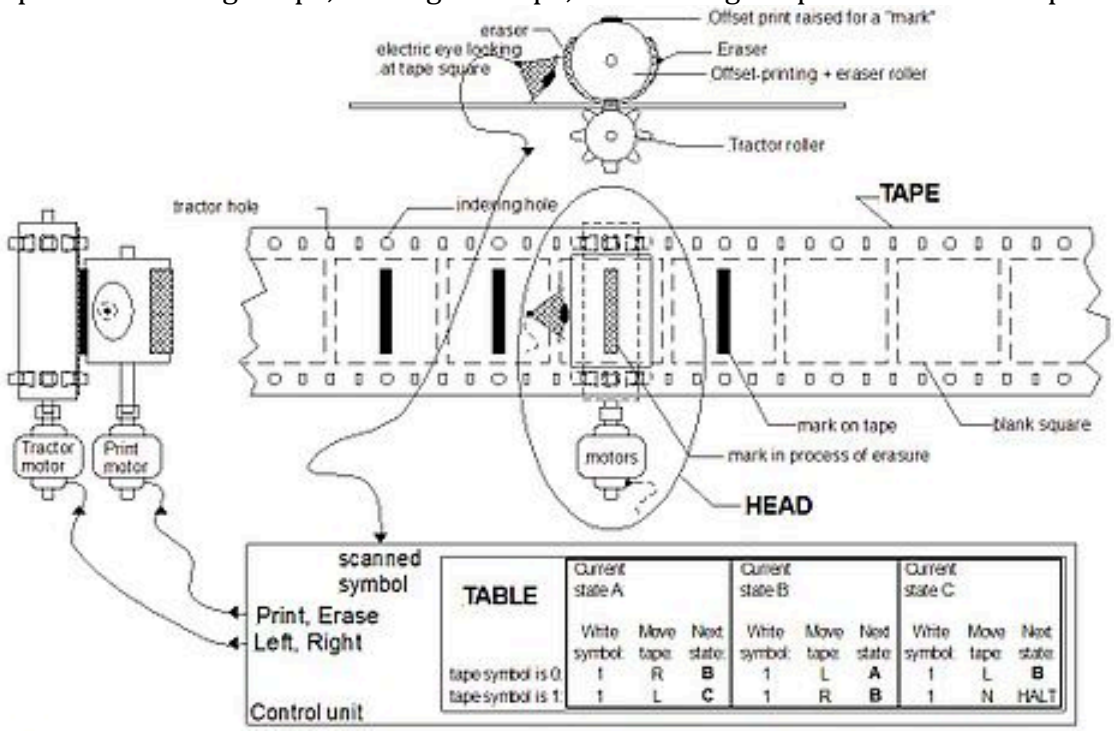
Syntax Errors – error that causes the problem to be unable to compile
Logic Errors – something logically wrong, like mistyping values
Runtime Errors – some error occur. E.g. something (disk, network, memory) not available

Debugging – find and fix the problem with the program

Soul of the machine – a book about a team racing to design the next microcomputer starting from the ISA.

Turing Machine

Formalize/defines the concept of a universal computer
Capable of reading a tape, writing to a tape, and moving a tape to solve all computable problems



A fanciful mechanical Turing machine's TAPE and HEAD. The TABLE instructions might be on another "read only" tape, or perhaps on punch-cards. Usually a "finite state machine" is the model for the TABLE.

Image above taken form Wikipedia.
Church-Turing thesis: If you can write an algorithm, then a Turing machine can solve it.
A Turing machine is Turning complete if it is capable of simulation any other Turing machine.

Search Engine

For every web page

Google will visit that webpage at some frequency

Figure out all the words on that web page

Store page data in database

Your search terms (keywords) are compared against the database by index

Those webpages that matches the keywords are returned

Google search is divided into the web crawling team, indexing team, networking team, database team, and etc.

Google wants the change the hardware in the data storage

Terminology Review

Visit http://discovering.cs.wisc.edu/text/ch1.xml and click on the "Definitions" link on the left sidebar.

In Class Exercise: what capability is each step using

Capabilities:

Arithmetic

Storage

Branching

Input/Output

Steps:

take number and store it: input and storage

add and save the sum: arithmetic and storage

divide by 2: arithmetic

if 0 then go here, else go there: branching

display text: input/output

Algorithms Review

Square Root Algorithms

Start with x/2 and store as s, add s to x/s, divide by 2, and repeat

Take any random number, square it, adjust number, and repeat

Start with counter = 1, square it, increment counter, and repeat until the square is greater

Find the smallest of 3 numbers

Scan each number and set as the smallest as you go

Announcements

HW 1 is due Friday, September 11th

Read up to Chapter 2.4.1