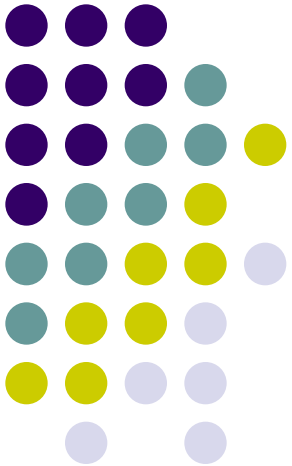
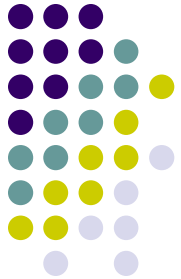
CSE 301
History of Computing

History of Programming Languages (through 1980)



Theoretical Foundations of Computation



- So far we've primarily talked about computer engineering
- Computer programming's foundations lie in theory
  - Kurt Gödel
  - Alan Turing

Kurt Gödel

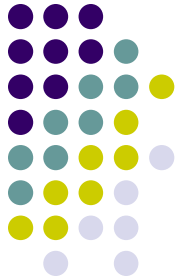
- Incompleteness Theorem
  - Provided arithmetic is consistent, mathematics is incomplete in that there exist propositions which cannot be proved.
  - Landmark in 20th century mathematics
  - implies that a computer can never be programmed to answer all mathematical questions
- Fled Nazi occupied Austria in 1940 to U.S. because:
  - He thought he might be conscripted to fight in German army
  - Though he was Christian, people thought he was Jewish
    - On one occasion he and his wife were attacked by a gang in the street
- Became a chair at Princeton University
- Close friend of Einstein

- http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Godel.html

Alan Mathison Turing

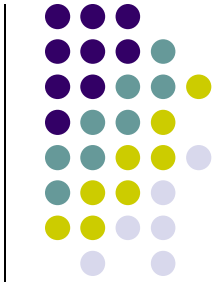
- Born in 1912 in London, England
- Began studying the work of John von Neumann in quantum mechanics in 1932
- Wrote *"On Computable Numbers, with an application to the Entscheidungsproblem"* in 1936
  - Defines the notion of an algorithm
  - Introduces the fundamental concept of a computing model commonly referred to as a "Turing machine"
  - Introduces the notion of a universal algorithmic automaton, more commonly referred to later as a universal Turing machine
  - Considered to be one of the major contributions to the *logical foundations* of Computer Science

Turing Machine



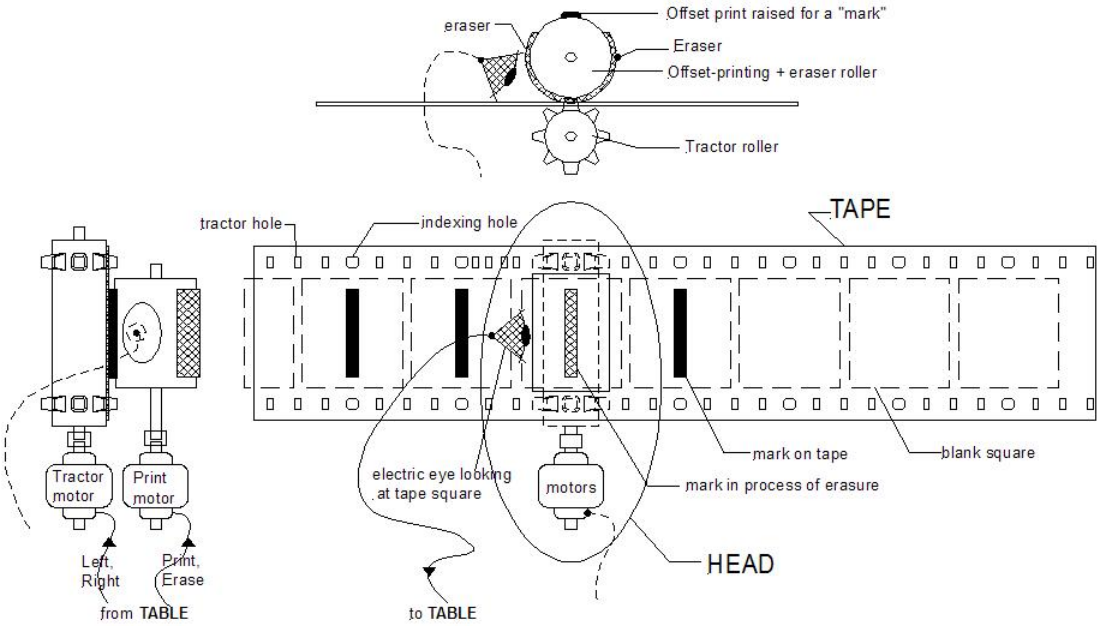
- An abstract mathematical device capable of reading and writing units of information on a tape that is partitioned into a succession of squares and potentially infinite in length.
  - A tape (of infinite length) divided into “cells” horizontally along its surface
  - A finite set of symbols that can be stored on the tape
  - A reading and writing device capable of reading data from a single cell, erasing data in a single cell, writing data to a single cell or moving left or right along the tape one cell at a time
  - A control unit that determines its operation

Turing Machine



- The machine has a number of states that it can be in.
- The behavior of the machine is determined by the current state of the machine and the symbol at the cell on the tape where the read/write device is situated.
- Given this information, the machine may
  - change to another state or remain in the same state
  - move left or right on the tape
  - write data to the tape or erase data on the tape

Turing Machine Visualization



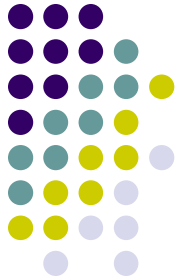
Above: a fanciful mechanical Turing machine's TAPE and HEAD (TABLE not shown).

Below: Usually Turing machines are drawn in a much simpler way -- as just a row of squares with symbols in them, the "head" drawn over the "square being scanned" (drawing after Kleene (1952) p. 375).

q_4

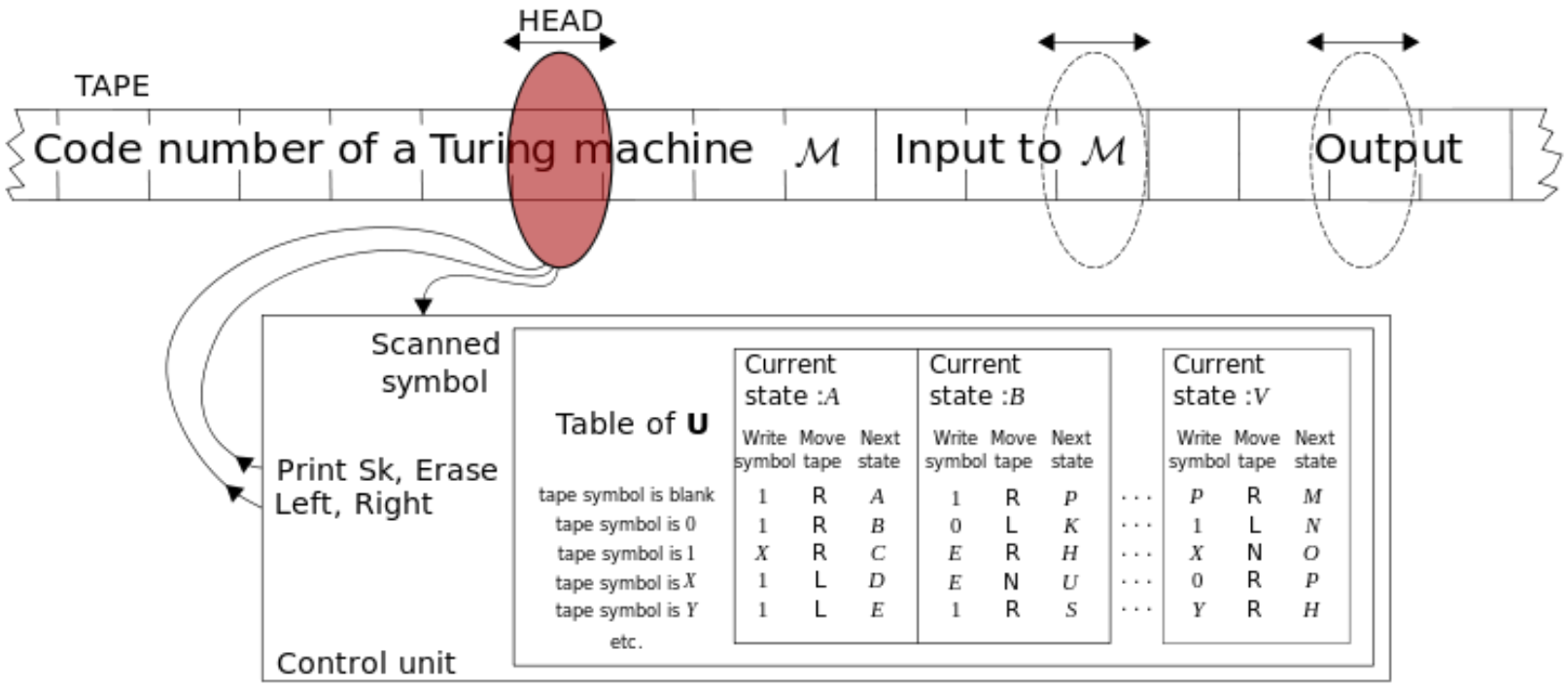
	S_1	S_1	S_3	S_1	S_0	S_1	

Universal Turing Machine

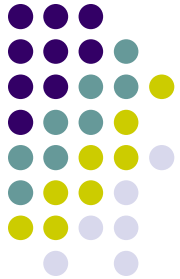


- A Turing machine that is capable of simulating any other Turing machine.
  - One tape holds the "program“ (machine to be simulated).
  - A second tape holds the current "state" of the Turing machine that we are emulating.
  - A third tape holds the "input" and will, upon completion, hold the "output."
- Turing was describing a modern computer in 1936 before it was realistically possible to construct one.
- No one has come up with a more general model for computation to this day.

Universal Turing Machine



The Halting Problem



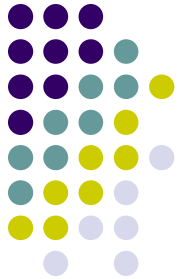
- Turing's work gave rise to the notion that computers could not solve every theoretically possible problem
  - A universal program U cannot exist that is capable of answering, within a finite number of steps, the following question relative to any program P:
    - *Will P terminate after a finite number of steps?*
  - If such a program U existed, it would generate a logical contradiction simply by being applied to itself.
- Many scientists claimed that a Turing machine could compute any intellectual process, and Turing proves them wrong.

Turing's Work Continues

- Worked on the Enigma problem during WWII at Bletchley Park
- Developed the Bombe in 1940 to help decode encrypted Enigma messages by the Germans
  - Based on a earlier work by Polish mathematicians Rejewski, Rozycki, Zygalski
- Worked in 1941 to help break more difficult Enigma codes using statistical analysis
- Joins the National Physical Laboratory in 1946 and works on ACE (Automatic Computing Engine)
- Works on MADAM (Manchester Automatic Digital Machine) project in 1948 at Manchester University

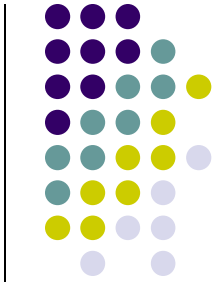
ACE

Final contribution to computing



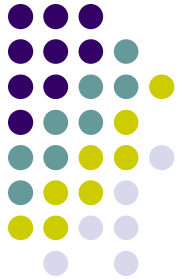
- Writes *Computing Machinery and Intelligence* in 1950 and describes his famous Turing Test:
  - If a computer and a person are placed behind a wall and answer questions such that we cannot tell which is answering, the computer exhibits artificial intelligence.
- Arrested in 1952 for violating British homosexuality statutes
  - Found guilty and sentenced to injections of estrogen for a year rather than prison
  - Loses his security clearance and is deemed a security risk
- Dies of potassium cyanide poisoning in 1954 at the age of 41. Officials rule this a suicide.

Hardware vs. Software



- Computer Hardware
  - the physical components of a computer
  - ex: CPU, RAM, Hard Drive, etc …
- Computer Software
  - programs that run on a computer
  - ex: Operating System, Word Processor, Internet Browser, etc …
  - makes use of *algorithms* to solve problems
    - algorithms are step-by-step procedures for solving a problem in a finite number of steps
    - based on mathematical principles
  - software is defined using programming languages
- In the old days, money was spent primarily on hardware
  - By 1953, half the cost of running a computer was already spent on programming
- These days, it's not even close, software is more than 90% of computer costs
  - many more CS jobs than CE
  - more research in CS than CE
- One thing is always for sure, software is beholden to hardware
  - software can only use real hardware technologies that exist

The first assembler

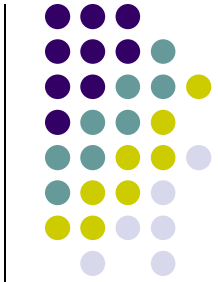


- Assembler - a computer program for translating assembly language into executable machine code
  - Example: ADD R1, R2, R3 0110000100100011
- The EDSAC programming system was based on a subroutine library
  - commonly used functions that could be used to build all sorts of more complex programs
  - the first version, Initial Orders 1, was devised by David Wheeler, then a research student, in 1949
- Team published “The Preparation of Programs for an Electronic Digital Computer”
  - the only programming textbook then available
  - computers today still use Cambridge model for subroutines library

The first compiler

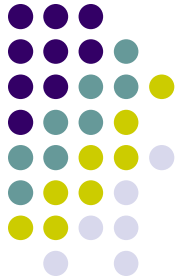
- A compiler is a computer program that translates a computer program written in one computer language (the *source* language) into a program written in another computer language (the *target* language).
  - Typically, the target language is assembly language
  - Assembler may then translate assembly language into machine code
    - Machine code are directions a computer can understand on the lowest hardware level (1s & 0s)
- A-0 is a programming language for the UNIVAC I or II, using three-address code instructions for solving mathematical problems.
- A-0 was the first language for which a compiler was developed.
  - It was produced by Grace Hopper's team at Remington Rand in 1952
  - Grace Hopper had previously been a programmer for the Harvard Mark machines
    - One of U.S.'s first programmers
    - She found a moth in the Mark I, which was causing errors, and called it a computer "bug"

FORTRAN (1957)



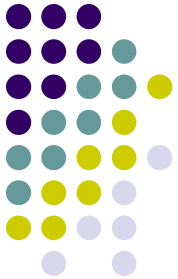
- First successful high-level programming language
  - Code more readable and understandable by humans
- Developed by John Bachus at IBM
  - Stands for: FORmula TRANslation
  - Started development in 1954
  - Released in 1957, is still in use today (how many technologies can say that?)
- A key goal of FORTRAN was efficiency, although portability was also a key issue
  - automatic programming that would be as good as human programming of assembly code
  - resulted in making programs 90% as good as humans
- Programs that took weeks to write could now take hours
- 1961 – First FORTRAN programming textbook
  - Universities began teaching it in undergrad programs
- Provided standard exchange of programs despite different computers
- Became the standard for scientific applications

FORTRAN



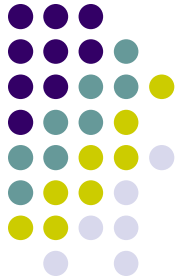
```
REAL SUM6,SUM7,SUM8,DIF6,DIF7,DIF8,SUMINF
OPEN(6,FILE='PRN')
SUM6=.9*(1.-0.1**6)/0.9
SUM7=.9*(1.-0.1**7)/0.9
SUM8=.9*(1.-0.1**8)/0.9
******COMPUTER SUM OF INFINITE TERMS
SUMINF=0.9/(1.0-0.1)
******COMPUTE DIFFERENCES BETWEEN FINITE & INFINITE SUMS
DIF6 = SUMINF - SUM6
DIF7 = SUMINF - SUM7
DIF8 = SUMINF - SUM8
WRITE(6,*) 'INFINITE SUM = ', SUMINF
WRITE(6,*) 'SUM6 = ', SUM6, '    INFINITE SUM - SUM6 = ', DIF6
WRITE(6,*) 'SUM7 = ', SUM7, '    INFINITE SUM - SUM7 = ', DIF7
WRITE(6,*) 'SUM8 = ', SUM8, '    INFINITE SUM - SUM8 = ', DIF8
STOP
END
```

COBOL (1960)



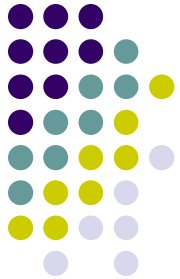
- Stands for: COmmon Business-Oriented Language
- COBOL was initially created in 1959 (and released in 1960 as Cobol 60) by a group of computer manufacturers and government agencies
  - US Government wanted a standard for its computers
- One goal of COBOL's design was for it to be readable by managers, so the syntax had very much of an English-like flavor.
  - The specifications were to a great extent inspired by the FLOW-MATIC language invented by Grace Hopper
    - She then promoted COBOL's use
- Became the standard for business applications
  - Still used in business applications today.
- 90% of applications over next 20 years were written in either COBOL or FORTRAN
  - Old programmers came out of hiding for Y2K

COBOL



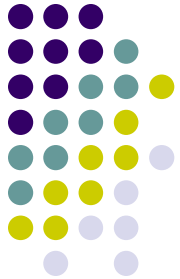
```
000100 ID DIVISION.
000200 PROGRAM-ID.  ACCEPT1.
000300 DATA DIVISION.
000400 WORKING-STORAGE  SECTION.
000500 01  WS-FIRST-NUMBER      PIC 9(3).
000600 01  WS-SECOND-NUMBER     PIC 9(3).
000700 01  WS-TOTAL             PIC ZZZ9.
000800*
000900 PROCEDURE DIVISION.
001000 0000-MAINLINE.
001100     DISPLAY 'ENTER A NUMBER: '.
001200     ACCEPT WS-FIRST-NUMBER.
001300*
001400     DISPLAY 'ANOTHER NUMBER: '.
001500     ACCEPT WS-SECOND-NUMBER.
001600*
001700     COMPUTE WS-TOTAL = WS-FIRST-NUMBER + WS-SECOND-NUMBER.
001800     DISPLAY 'THE TOTAL IS: ', WS-TOTAL.
001900     STOP RUN.
```

Living & Dead Languages



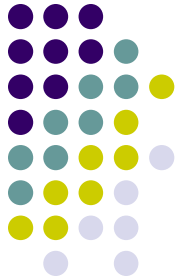
- Hundreds of programming languages popped up in the 1960s, most quickly disappeared
- Some dead:
  - JOVIAL, SNOBOL, Simula-67, RPG, ALGOL, PL/1, and many, many more
- Some still kicking:
  - LISP (1957)
  - BASIC (1964)
  - Pascal (1970)
  - Prolog (1972)
  - And of course, C (1973)

ALGOL-60 (1960)



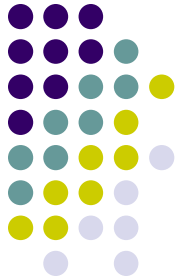
- Created mainly in Europe by a committee of computer scientists
  - John Backus and Peter Naur both served on the committee which created it
  - Desired an IBM-independent standard
- Stands for: ALGOrithmic Language
- Primarily intended to provide a mechanism for expressing algorithms uniformly regardless of hardware
- The first report on Algol was issued in 1958,
  - Specifications revised in 1959 and 1960 (and later in 1968)
- The language itself was not a success, but it was an influence on other successful languages
  - A primary ancestor of Pascal and C.
- It introduced block structure, compound statements, recursive procedure calls, nested if statements, loops, and arbitrary length identifiers

LISP (1958)



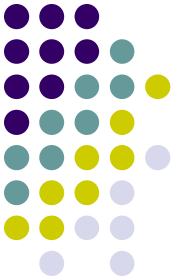
- Developed by John McCarthy at MIT
- Stands for: LISt Processing
  - Designed for symbolic processing
  - Introduced symbolic computation and automatic memory management
- Used extensively for Artificial Intelligence applications

BASIC (1964)



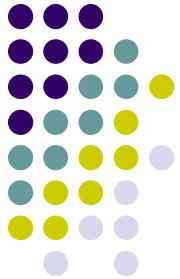
- Created by John Kemeny and Thomas Kurtz at Dartmouth College
- Stands for: Beginner's All-purpose Symbolic Instruction Code
  - one of the first languages designed for use on a time-sharing system
  - one of the first languages designed for beginners
- Variants like Visual BASIC still used today by Microsoft.

Pascal (1970)



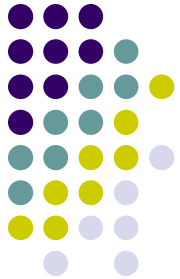
- Developed by Niklaus Wirth in an effort to make structured programming easier for a compiler to process.
- Based on Algol
  - Named in honor of mathematician and philosopher Blaise Pascal
- Wirth also developed Modula-2 and Oberon, languages similar to Pascal which also support object-oriented programming.
- Pascal was the most popular programming language for teaching computer programming in the 1970s and 1980s (now it's very, very ill)

Prolog (1972)



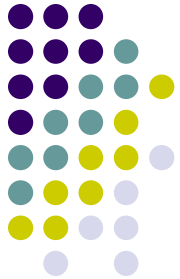
- Created by Alain Colmerauer and Phillipe Roussel of the University of Aix-Marseille and Robert Kowalski of the University of Edinburgh
- Stands for: PROgramming in LOGic.
- Prolog is the leading *logical* programming language.
  - used in artificial intelligence programs, computer linguistics, and theorem proving.

Prolog



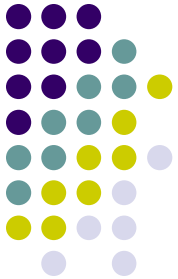
```
parents(william, diana, charles).
parents(henry, diana, charles).
parents(charles, elizabeth, philip).
parents(diana, frances, edward).
parents(anne, elizabeth, philip).
parents(andrew, elizabeth, philip).
parents(edwardW, elizabeth, philip).
married(diana, charles).
married(elizabeth, philip).
married(frances, edward).
married(anne, mark).
parent(C,M) <= parents(C,M,D).
parent(C,D) <= parents(C,M,D).
sibling(X,Y) <= parents(X,M,D) and parents(Y,M,D).
```

C (1973)



- Developed by Ken Thompson and Dennis Ritchie at AT&T Bell Labs for use on the UNIX operating system.
  - now used on practically every operating system
  - popular language for writing system software
- Features:
  - An extremely simple core language, with non-essential functionality provided by a standardized set of library routines.
  - Low-level access to computer memory via the use of pointers.
- C descendants: C++, C#, Java
- We'll see more when we talk more about the PC & Internet

Simula 67



- First Object Oriented Programming languages
- Developed in Norway in 1960s by Kristen Nygaard and Ole-Johan Dahl
  - got idea making ship simulations
  - they won Turing Award in 2001
- Later Object Oriented Programming languages?
  - Smalltalk, C++, Visual Basic, Java, C#