9. Radar, Electronics, and Computers

Electricity to electronics

Early History

- 19th C, discover relationship between electricity and magnetism
    * Michael Faraday and Clark Maxwell
    * light is an electromagnetic wave
    * develop the electronic oscillator
- electromagnetic or radiowaves produced
    * predicted by Maxwell
    * demonstrated to exist by Henrich Hertz (1857-1894)
    * put to use in the radio by Marconi (1874-1937)
- to help control currents, the vacuum tube is invented in the early 20th C.
    * diode vacuum tube, has two plates, used to rectify current
    * triode vacuum tube, has three plates, used to amplify signals.

Development of electromagnetics early 20th C.

- radio developed into AM, FM, and short wave
- also developed for medical uses
    * radiowaves heat tissue
    * developed medical treatment known as diathermy
- late 1930s, British succeeded in producing oscillators that produced very short wave length radiowaves, called microwaves
    * RADAR = "radio direction and range determination"

Development of radar during WWII and after

- became a classified project, even before the War started
- major laboratory set up at MIT, at Lincoln laboratory
    * will constitute most of the MIT war effort
    * a crash program similar to Manhattan project
- crucial part of the War effort
    * submarine and airplane spotting
    * night bombing runs
    * Germans do not keep abreast
- after the war, will become indispensable civilian and military technology

TV, start to become popular after WW II, although developed before

- technology, electron scanning tube
- spreads in major cities because of need of broadcasting towers
- CATV, community access TV

Computer

Early History

- devises to aid calculation (computers) are ancient
- first mechanical calculators also appear in 17th C.
- to make computers more flexible, faced two problems:
    1. how can you give them instructions, so that they can do operations without your having to tell them to do these operations every time
    2. how can you give them a memory, so they can:
        > remember instructions
        > remember the result of one calculation to pass it on to the next

    * example:
        > 4x4 is add 4 to 4, 4 times
        > is there some way to tell a machine to add 4 to 4, 4 times (instructions)
        > how does the machine remember that 4+4=8, so next step is 8+4 and so on

- Charles Babbage (1791-1871) began to solve these problems in theory
    * still used strictly mechanical devices - one part pushes another
    * adopts some interesting industrial technology, such as the Jacquard Loom (explain)

- 1890, punch cards adopted in US Census, explain punch cards

20th Century, misc. developments

- one approach is to use analogue, rather than digital machines
    * wheels rub on each other, one ten times to other, will yield same results
    * is easier to use for some difficult mathematical problems
    * has design problems (wheels slip)
    *Vannevar Bush designed the best analogue differential analyzers of the 1920s and 1930s
- more commonly, tried to build more complex mechanical machines
    * Konrad Zuse, in Germany, used mechanical pins and rolls of tape
    * George Stibitz, Bell Labs, use electrical relays used in telephone systems
    * Just before the War, Harvard Mark IV, a combination of all technologies is designed
    * IBM helping on all these projects and developing their own punched card machines
- all of the machines now go to a binary system

- machines now also start to become very large, e.g Mark IV
    * 51 feet long, 8 feet high
    * 750,000 parts - binary switches, relays, decade (ten-position) switches, rotating wheels, cams, etc.
    * 1400 ten-position switches
    * 500 miles of wire
    * finished in 1944, put to immediate use for the war effort

Electronic Computing

- in the late 1930s, John Atanasoff and Clifford Berry, at Iowa State University, developed idea of the electronic computer
    * breakthrough, was to use vacuum tubes and capacitors to store binary numbers
- early 1940s, these ideas come together at Moore School in Philadelphia, PA
    * Arthur Burks, J. Presper Eckert, and John Machly
    * design, and eventually are given the go ahead to build ENIAC (electronic numerical integrator and calculator)
- ENIAC specifications
    * 100' x 8' x 3', weighed 30 tons
    * 18,000 vacuum tubes, 16 basic types
    * 1500 relays
    * 70,000 resistors
    * 10,000 capacitors
    * cost, $486,804.22 (1/2 billion = 4.5 billion today)
- operation
    * became operational in Spring 1945
    * was used primarily to compute ballistics tables
    * took 2 days to set a problem, about 20 second to run, of which about 4 seconds was actual calculations
    * calculated the trajectory of a shell faster than the shell reached its target
    * estimated that in its ten years, did more calculations that had been done in all of human history before 1945
    * was equivalent to a hand-held calculator today

Post War Development: The fight over memory and stored programs

- during war, emphasis was on getting machines that could do needed calculations
- after war, new problems emerged
    * who would pay the bills
    * who held the patents for what had been developed
    * what would be the course of future development
- the key problem was programming--the way in which you told a computer what to do; give it instructions
    * early machines programmed via instructions on a tape or cards or by wiring

* needed something that could hold instructions, be changed, and accessed quickly

- Moore School Developments
  * January 1944, Eckert and Mauchly had completed design, began to look to future
  * John von Neumann
    > June, 1945, wrote a paper: First Draft on a Report on the EDVAC
    >EDVAC is next generation being planned, computer with a memory (Electronic Discrete Variable Arithmetic Computer)
    >Mauchley and Eckert, who were restricted by classification, became concerned that von Neumann was taking more credit than he deserved
  * 1945-46, crucial years
    > Summer, 1946, seminar held at Moore School; attended by 28, spread technology around the world
  * several different systems for memory are tried
    > thermal devices, does not work out
    > mechanical devices, too slow
    > mercury delay devices, most useful during early years
    > rotating and stationary magnetic memories (will eventually be adopted
    > electrostatic storage, not too efficient
  * by end of 1946, the rush to build new generations of computers is under way
    > Sperry Rand and IBM emerge as giants, but there are many other players
- by 1950s, computers are becoming available for commercial purposes
  * 1952 elections
    > CBS was going to have UNIVAC predict result of an election
    > 8:30, UNIVAC predicted landslide for Eisenhower (just after poles closed); decided to check
    > finally, 9:15 predicted Eisenhower by a slight edge
    > final results showed that early election prediction by computer were correct