Computer Science
North University of China

CS101

Introduction to
Computer Science

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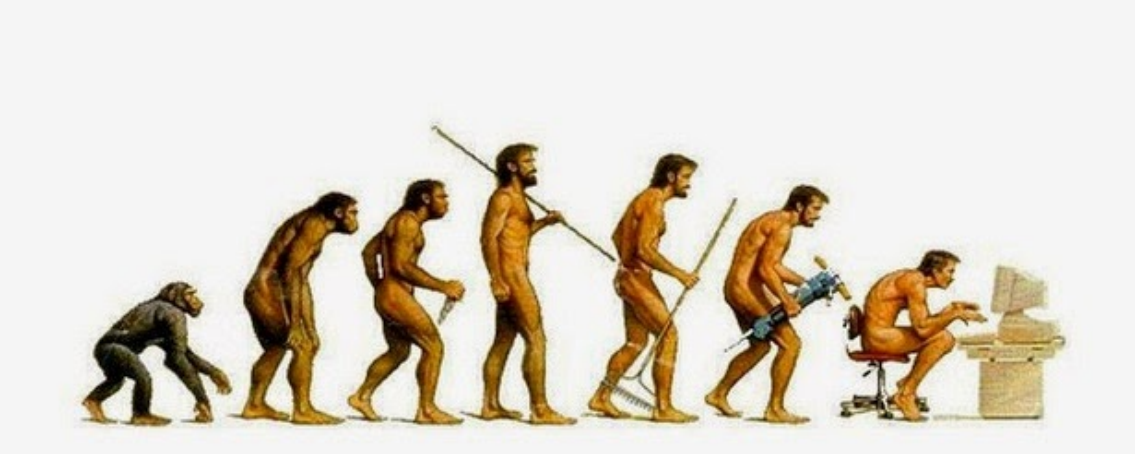
School of Computer Science & Technology

Fall 2017

The Origin of Computer



The origin of computers

1. Where did computers come from?
2. Why did computers emerge in the 1940s?
3. How did computers differ from previous technologies for computation?

Threads in the story

- Charles Babbage / Ada Lovelace: Difference Engine, Analytical Engine
- Tabulating machines, card-based calculators
- ENIAC to EDVAC to UNIVAC and the birth of the commercial computing industry

The Problem: Computation

Many important activities require computation

- **Money lending**: A key activity in capitalist economic systems, requires the computation of compound interest for multiple interest rates
- **Navigation**: Sailing over the open ocean requires the accurate calculation of current position
- **Artillery**: Each gun requires a different firing table to point artillery depends on the range of the target, weight of shell, etc.

Computation takes time, and is error-prone

- Humans are not well adapted to perform complex computations
- To reduce time and improve accuracy, we need books of numerical tables that is pre-computed

M.V. 820 m/s or 2690 ft/sec. Weight of shell 9.00 kg or 19.8 lb Weight of air at ground level = 1.22 kg/m³ or 533 grains/cu ft

Range		Quadrant Elevation	Drift	For 1/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate Distance	Maximum Ordinate Height	1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion Range	Means (50 percent) Dispersion Width	Means (50 percent) Dispersion Height	Angle of Impact	Velocity
yd	m	deg	mils	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
109	100	0 1	0	—	0.13	50	0	147	—	—	—	0 1	810
219	200	0 1	0	—	0.26	100	0	145	68	0.1	0.2	0 1	800
328	300	0 2	0	—	0.39	150	1	143	68	0.1	0.3	0 2	789
437	400	0 3	0	21	0.52	201	1	140	69	0.1	0.3	0 2	779
547	500	0 4	0	22	0.65	252	2	138	69	0.2	0.4	0 3	769
656	600	0 4	0	24	0.78	303	2	136	69	0.2	0.4	0 4	759
766	700	0 5	0	25	0.91	354	3	134	69	0.2	0.5	0 5	749
875	800	0 6	0	27	1.05	406	3	131	69	0.3	0.6	0 6	739
984	900	0 7	0	28	1.18	458	4	129	69	0.3	0.7	0 7	729
1094	1000	0 8	0	30	1.32	510	5	127	69	0.3	0.7	0 8	720
1203	1100	0 9	0	31	1.46	562	5	125	69	0.4	0.8	0 9	710
1312	1200	0 9	0	33	1.60	614	6	122	69	0.4	0.9	0 10	700
1422	1300	0 10	0	35	1.74	667	7	120	69	0.5	1.0	0 11	691
1531	1400	0 11	0	36	1.89	720	8	118	69	0.5	1.0	0 12	681
1640	1500	0 12	0	38	2.04	773	9	116	69	0.5	1.1	0 13	672

*Numbers in column 2 are in degrees, and in column 5 in 1/16 degrees.

Firing table for German 88mm anti-aircraft gun.

www.lonesentry.com/manuals/88mm-antiaircraft-gun/german-88-mm-firing-tables.html

N.	0	1	2	3	4	5	6	7	8	9	D.
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	40
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	37
12	0792	0828	0864	0899	0934	**0969**	1004	1038	1072	1106	33
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	31
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	29
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	27
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	25
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	24
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	23
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	21
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	21

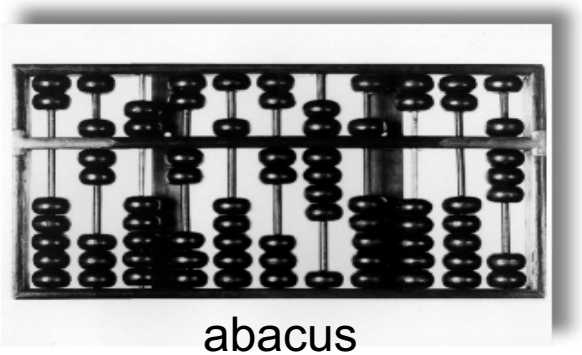
Portion of a table of logarithms.

kr.cs.ait.ac.th/~radok/math/mat1/mat147.htm

Early Calculating Devices

Abacus (算盘)

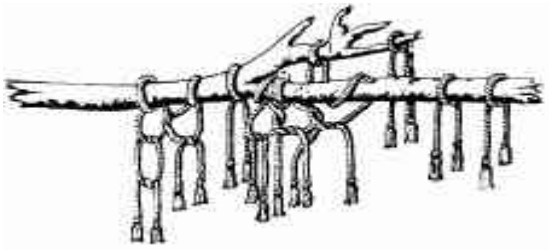
- Invented by Chinese
- Calculating device used for about 4000 years throughout the ancient world



abacus

Quipa (魁派尔)

- used by Incans to represent data (e.g. payments, memorable dates)



quipa

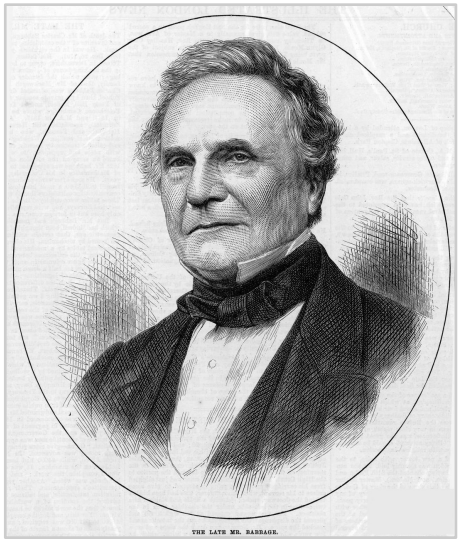
Charles Babbage

Charles Babbage (1791-1871), British

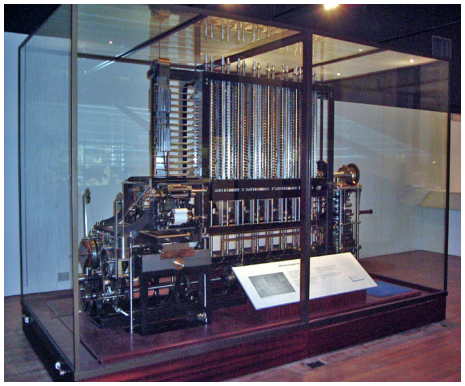
- Motivated by the desire to reduce drudgery of calculation, and to improve its accuracy
- "It is only by the *mechanical fabrication of tables* that (computation) errors can be rendered impossible."

Was born in the steam age, when electronics was in its infancy

- As a consequence, thought to create a mechanical, steam-powered computing machine
- First machine was the **Difference Engine**, a mechanical calculator (partially realized)
- Second machine was the **Analytical Engine**, a programmable calculation device



Charles Babbage



Difference Engine

Analytical Engine

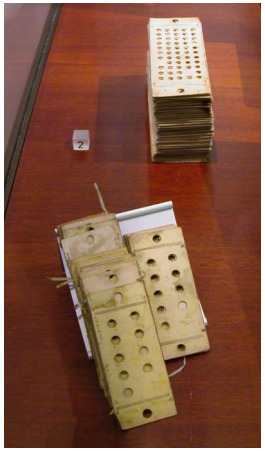
Jacquard loom (1801) 织布机

- Fabric patterns are encoded on punched cards
- Each row corresponds to one row of the fabric design

Babbage was inspired by this idea of *abstracting the instructions away from the physical device that realizes them*

- The goal of the analytical engine was to abstract apart the instructions for performing a computation
- Hence, one machine could perform a wide range of computations
- That is, it could be programmed

Jacquard loom



Punched cards used to program analytical engine

Ada Lovelace

Born 1816, daughter of Lord Byron (famous romantic poet)

A mathematical genius, worked with Babbage on Analytical Engine

- Documented the Analytical Engine, but more importantly…

Programmed Analytical Engine

- Though never realized, Ada developed a strong mental model of how it works, and then developed programs, also in her head, that ran on the machine.
- More impressively, these programs were recursive (re-running the same computation, using the results from the previous run-through)

She died age 36, and is generally credited as being the **world's first computer programmer**

Ada Lovelace

Watch:

- http://topdocumentaryfilms.com/creation-computer/
- "Computing by Steam" starts at 4:04

Tabulating the US Census: The crisis of 1890

US Constitution stipulates that the census is conducted every 10 years

- Results are used to create congressional districts, assign electoral votes to states, and are broadly useful in understanding the nation

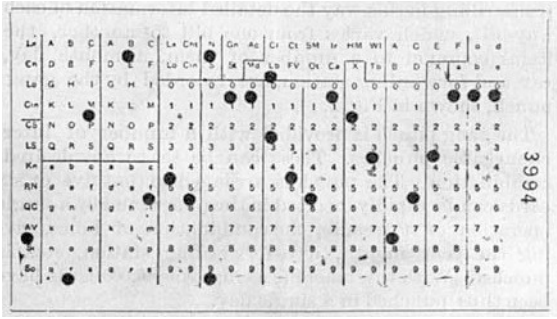
1880 census took seven years to tabulate

- In 1880s, estimate was that 1890 census would take 13 years to tabulate!

Herman Hollerith

- Inspired by train conductors punching holes in tickets who recorded traveler details using holes punched in tickets
- Realized that census data could be recorded on punched cards
- Cards were coded for age, state of residence, gender, and other information
- Using relays and solenoids (electrical equipment) it was possible to increment mechanical counters
- Cards sat over pools of mercury. Spring loaded wires would come down – if there was a hole, wire would go down into the mercury, completing a circuit.

- Watch:
- http://topdocumentaryfilms.com/creation-computer/
- Saving the Census starts at 11:58



Hollerith Punched Card
en.wikipedia.org/wiki/Tabulating_machine

Tabulating machine and sorter
en.wikipedia.org/wiki/Tabulating_machine

Aftermath of 1890 Census

Benefits of tabulating technology were immediately apparent for tracking inventory and accounting

Hollerith founded Tabulating Machine Company in 1896

- Hollerith Integrating Tabulator could add numbers coded on cards
- Shift to arithmetic, not just counting

In 1911, four similar firms merged to form Computing Tabulating Record Corporation (CTR)

In 1924, CTR was renamed **International Business Machines (IBM)**

Integrating Tabulator

Hollerith Integrating Tabulator

www.officemuseum.com/data_processing_machines.htm

Punched Card Computation (穿孔卡计算)

Typical punched card computation

- Stack of cards holds numbers
- The same operation (e.g., addition, multiplication) is performed on all cards as they are read through the device
- This works well for most business uses (accounting, inventory control)

Engineering and scientific computing

- Increasing use of mathematical analysis in engineering and science led to increased need for computation in these fields
- In engineering, especially complex systems of first and second derivatives, that were difficult or impossible to solve analytically
- Many times, these computations required **multiple operations** to be performed on each number (card), not just one
- Worse, sometimes the next number to be operated on depended on the output of a calculation on the prior number

Punched Card Computation (cont'd)

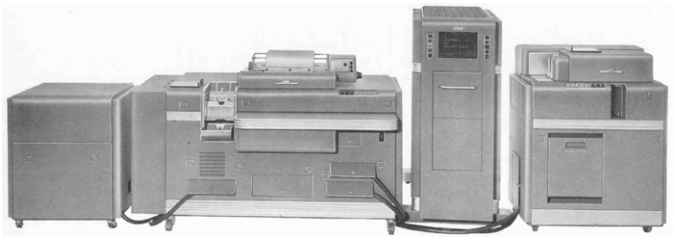
Needs of scientific and engineering computing led to creation of what are essentially lightly programmable card computers

Aberdeen Relay Calculator

- Allowed up to 12 predefined computational steps (later up to 48) to be performed on each card
- Why Aberdeen? This is the location of the US Army Ballistic Research Laboratory (Aberdeen, Maryland)
- IBM had a similar machine (IBM 604)

IBM Card-Programmed Calculator (CPC), 1949

- Allowed a sequence of calculations to be encoded on punched cards
- Permitted the programming of a calculator using punched cards
- Holes on a card would refer to the operations performed by specific circuit board, hence the same program would behave differently on different CPCs, depending on their circuits



IBM Card Programmed Calculator (Model A1)
Left to right: Type 941 Storage Unit, Type 412-418 Accounting Machine, Type 605 Electronic Calculator, Type 527 High-Speed Punch
www.columbia.edu/acis/history/cpc.html

ENIAC

Electronic Numerical Integrator and Calculator

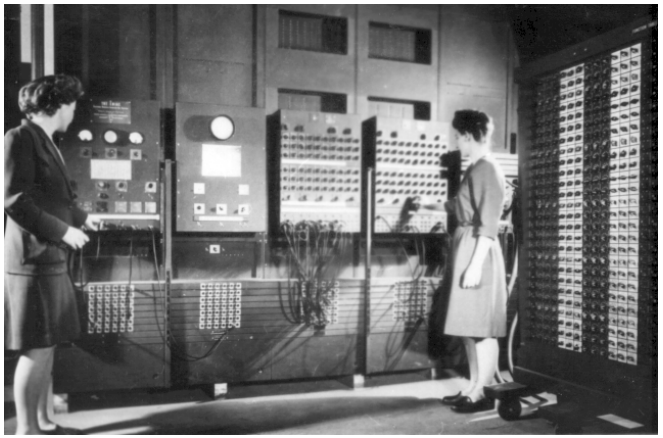
- Designed to compute artillery tables for US Army Ballistic Research Laboratory
- Development began during WWII, but was completed in 1946
- Conceived and designed by John Mauchly and J. Presper Eckert at Univ. of Pennsylvania

ENIAC could be programmed (可编程)

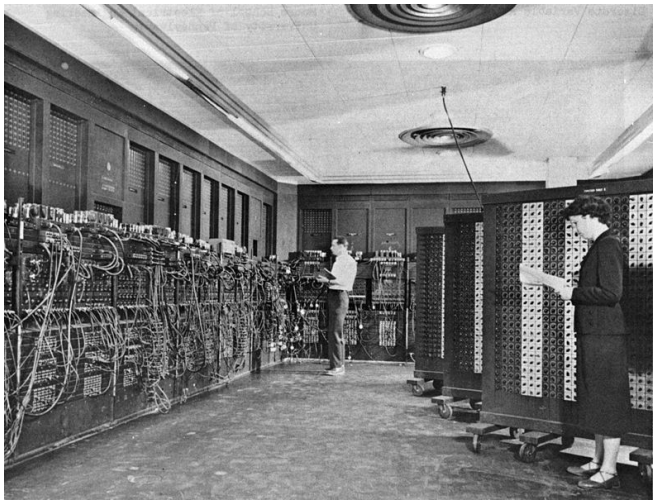
- Complex sequences of instructions, could include loops, branches, and subroutines
- Taking a problem and mapping it onto the machine was complex, often took **weeks**
- Once a potential mapping was put onto paper, the process of getting the program into the ENIAC took days of manipulating cables and switches
- **Not a stored program computer**

Watch:

- First computer ENIAC (footage of setting up an ENIAC) http://www.youtube.com/watch?v=VAnhFNJgNYY
- The Philadelphia Brain http://topdocumentaryfilms.com/creation-computer/



Programmers Betty Jean Jennings (left) and Fran Bilas (right) operating ENIAC
en.wikipedia.org/wiki/ENIAC



Programmers Betty Snyder (foreground) and Glen Beck (background) program ENIAC
en.wikipedia.org/wiki/ENIAC

EDVAC

A follow-on to ENIAC

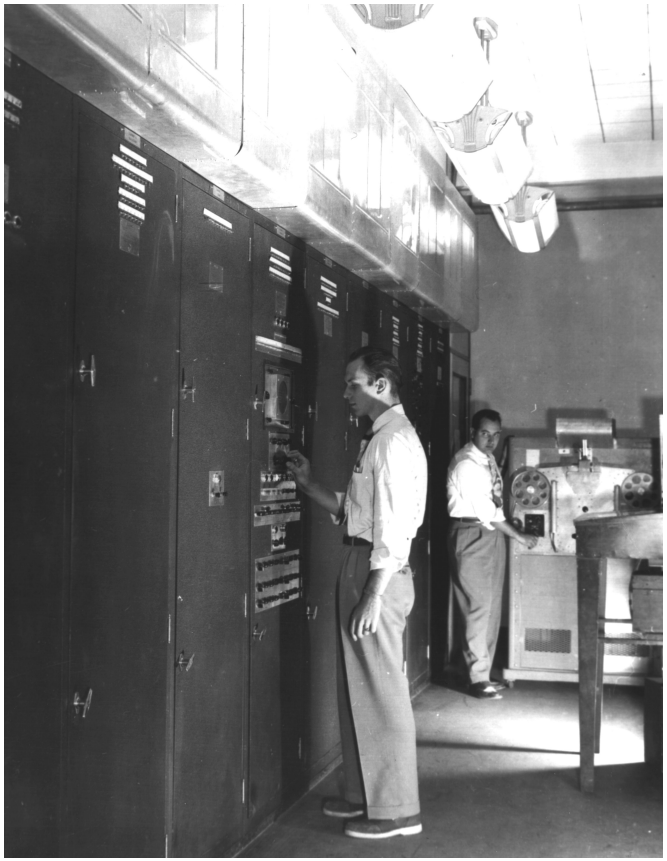
- Electronic Discrete Variable Automatic Computer
- Project initiated by John Mauchly and Presper Eckert

Key idea: stored program computing

- To avoid problem of long setup times, make this kind of setup controllable by the instructions themselves
- "An important feature of this device was that operating instructions and function tables would be stored in exactly the same sort of memory device as that used for numbers."
- This notion of stored-program computing has been central to every computer that has come since

Stored program computing in modern terms:

- The same memory is used for storing data and for storing programs.
- A program is just an interpretation applied to certain kinds of data.
- Builds on the Turing Machine (图灵机)



EDVAC
en.wikipedia.org/wiki/EDVAC

Von Neumann Architecture

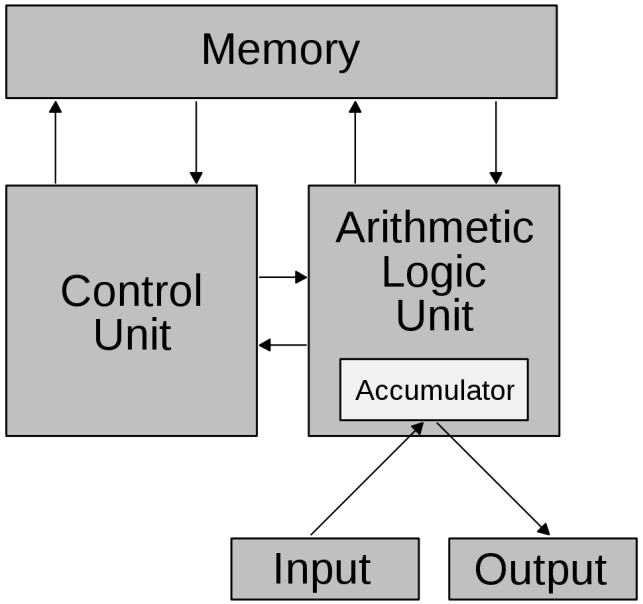
John von Neumann distilled out the key ideas behind EDVAC in a report titled "First Draft of a Report on the EDVAC"

- Clarified ideas by Eckert, Mauchly, & Turing

Describes the key notion of a stored program computer

- Computer includes an instruction set
- Computer memory can include either data or program instructions
- Computer fetches an instruction from memory, decodes & executes it, then fetches the instruction in the next memory location, etc.
- *"Sometimes I think the only universal in the computing field is the fetch-execute cycle" – Alan Perlis*

- Watch:
- http://topdocumentaryfilms.com/creation-computer/
- The Pathfinders begins at 26:16



Von Neumann Architecture

en.wikipedia.org/wiki/Von_Neumann_architecture

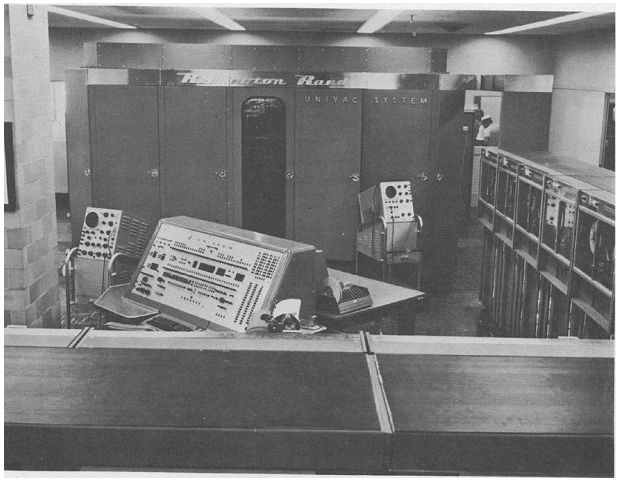
UNIVAC

In 1946, Irwin Travis, an administrator at the Univ. of Pennsylvania:

- Asked members of the staff to sign a release form
- Would prevent them from receiving royalties on their inventions
- Eckert and Mauchly refused to sign, and resigned.

Formed a company, the Eckert-Mauchly Computer Corporation

- Built BINAC, a one-off computer for Northrup Grumman (not successful)
- Then focused on UNIVAC (Universal Automatic Computer) the first commercial computer
- Launched the commercial computer industry
- Had difficulty raising capital, achieving initial sales
- Sold to Remington-Rand corporation in 1950
- In 1951, first UNIVAC was completed for US Census Bureau



UNIVAC I
en.wikipedia.org/wiki/UNIVAC

Review: Key Ideas

1. Abstracting the calculation away from the computing device
   - Babbage's punched cards
2. Putting data into machine-readable form
   - Use of punched cards for data (Babbage and Holerith)
3. A program as a series of instructions
   - Babbage Analytical Engine, card programmable calculators, ENIAC
4. Stored program computer
   - Using electronic memory for both instructions and data
   - John Von Neumann, John Mauchly, J. Presper Eckert: EDVAC, UNIVAC

Computer History Museum

Perhaps the best computer history museum in the world

Located in Mountain View (about 1 hour away)

Current exhibit:

- Revolution: First 2000 Years of Computing
- www.computerhistory.org

Homework

Reading Assignment

- **[Brookshear17]** chapter 0 Introduction
- [Dyson12] Chapter 01 - The Origins of The Digital Universe

Preparation for Next Lecture:

- **[Brookshear17]** Chapter 1 Section 1.1- 1.7 Data Storage

THANKS!

Q&A