"Digits" does not refer only to your 10 fingers…

Digitization & Processing

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Announcements

- After Image Survey, due by 5:00 today …
  thanks for telling the evaluators how its going

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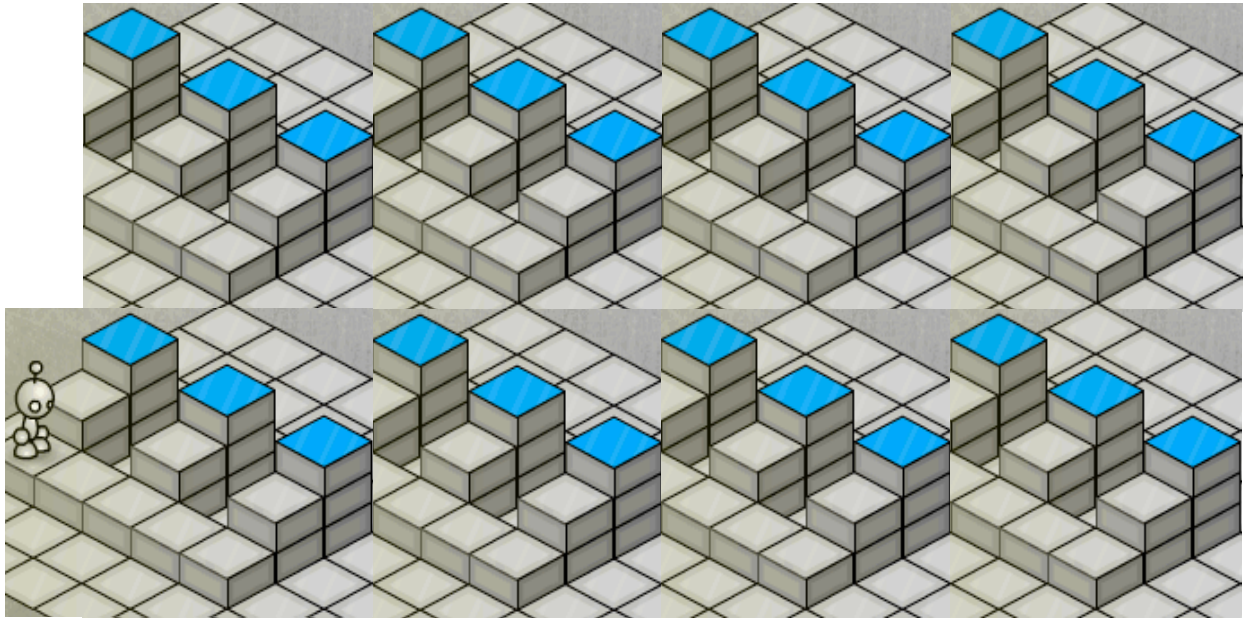
Review: Last Time, Abstraction

- An instruction (of the Lightbot or any other computer) is **abstracted** into the command name; functions **abstract** useful and meaningful operations, functions abstract functions built of functions, etc.



- Layer upon layer, we build software solutions

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A Short History of Digital Info

- One goal of CS Principles is to understand how computers and digital information are "game changers," how they *create* opportunities
- I will do that by highlighting progress of "data processing" over last 120 years or so (it's very incomplete)
  - Digitization, computers, ICs, transistors, PCs, Internet, and WWW are key
  - Focus on advances since …

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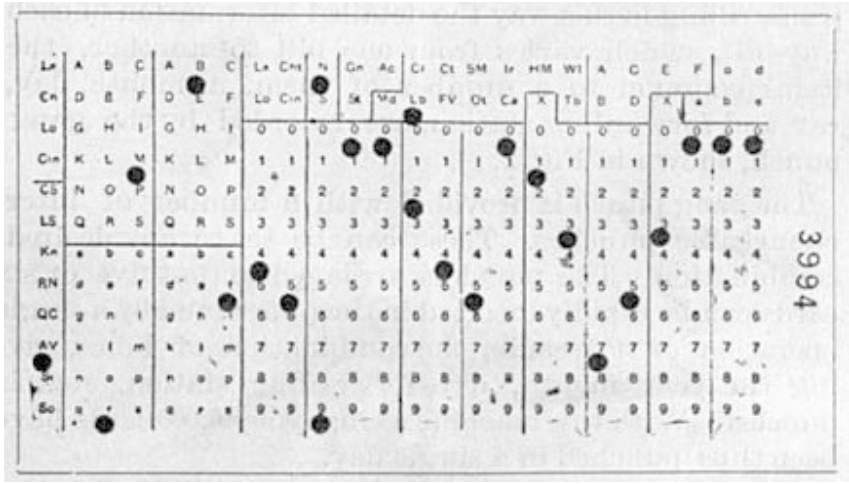
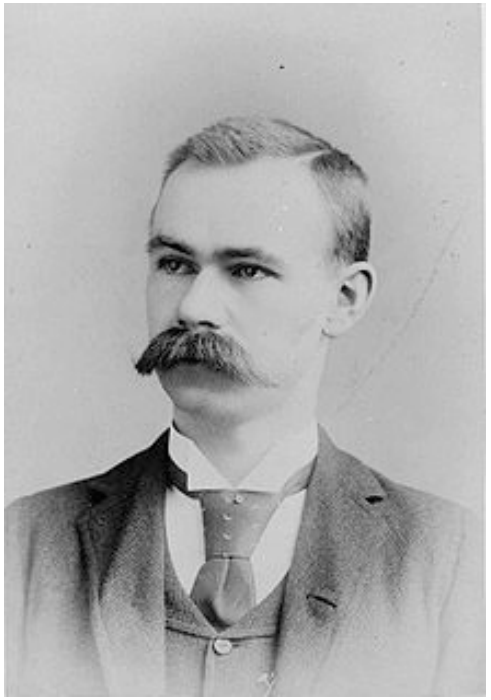
The Problem with Writing …

- Only **people** can read it … [Though recently, *some* progress in handwriting analysis has occurred; limited use.]
- First serious advance in digitization: punch cards
- Herman Hollerith develops idea for 1890 census



Hollerith Card, Courtesy IBM



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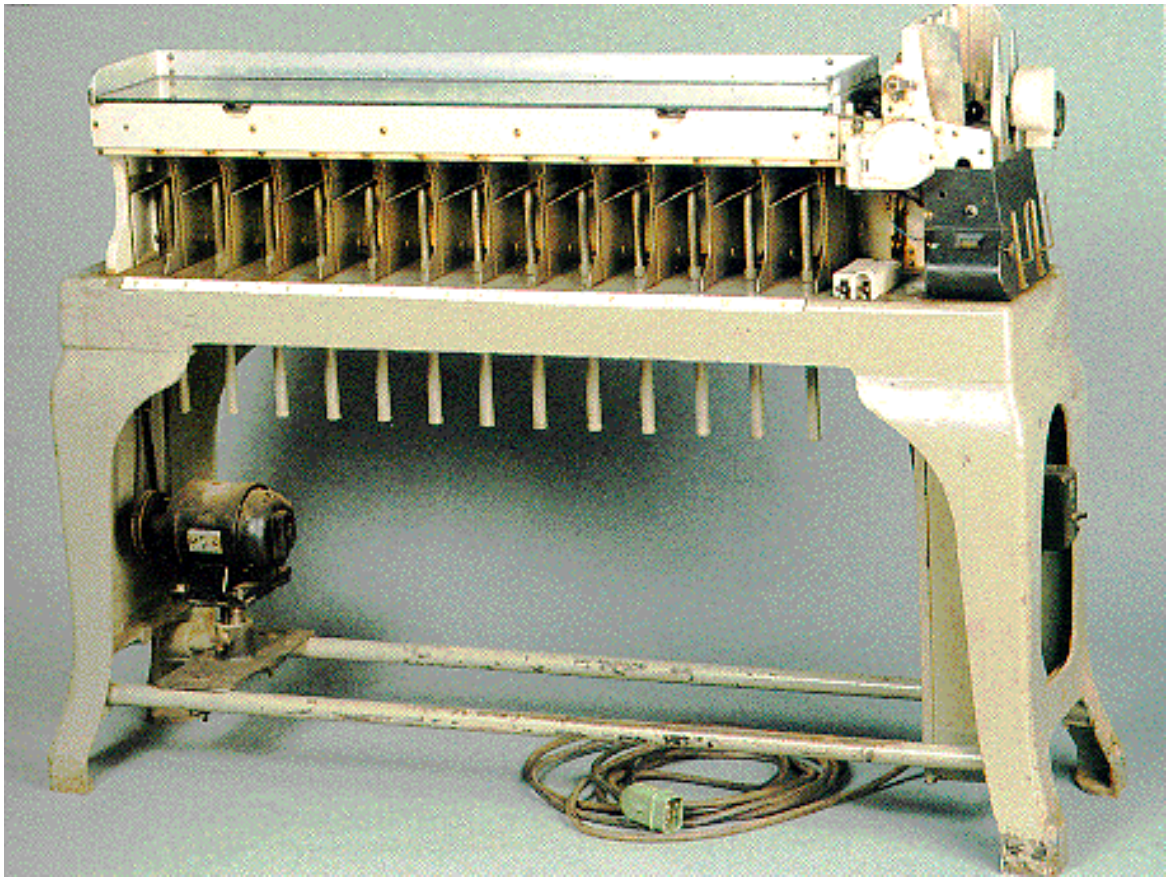
Machines Process Digital Data

- Mechanical methods – sensing a hole in a card or not – allows machines to help w/work



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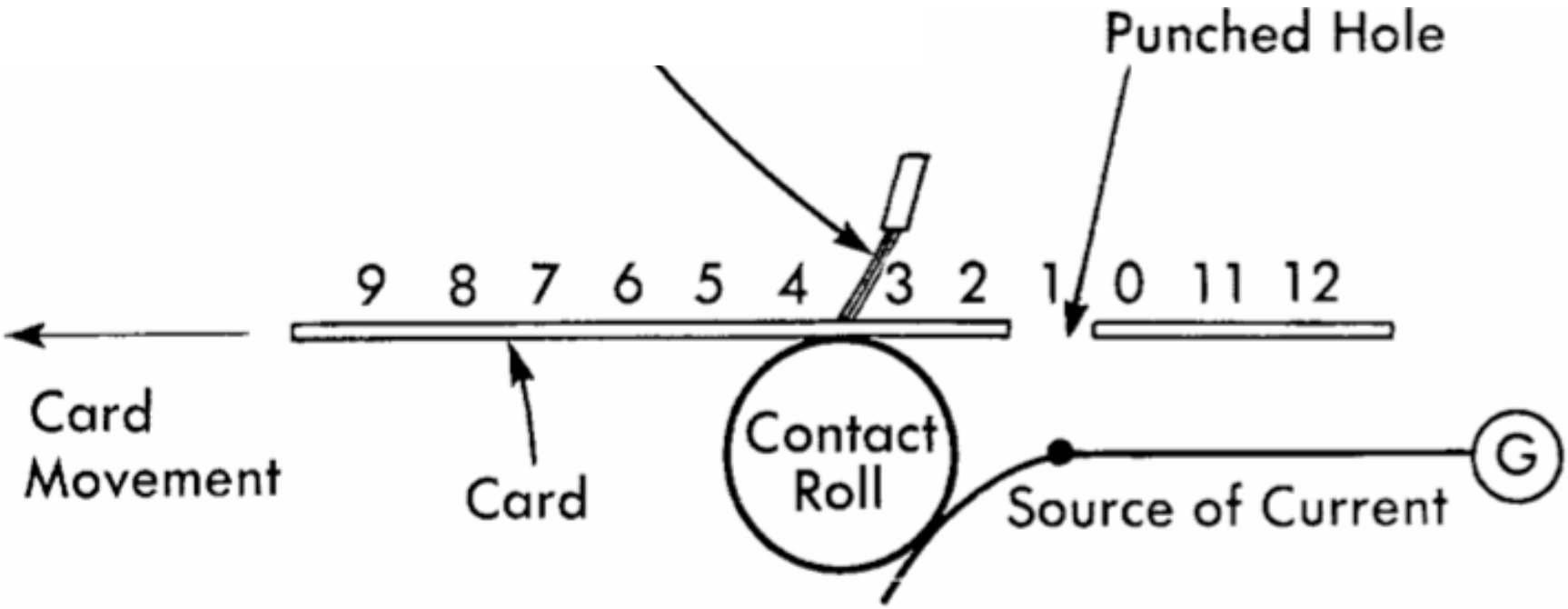
No Computer Needed To Process Data

- A mechanical machine can "read" a card with … a "metal brush"



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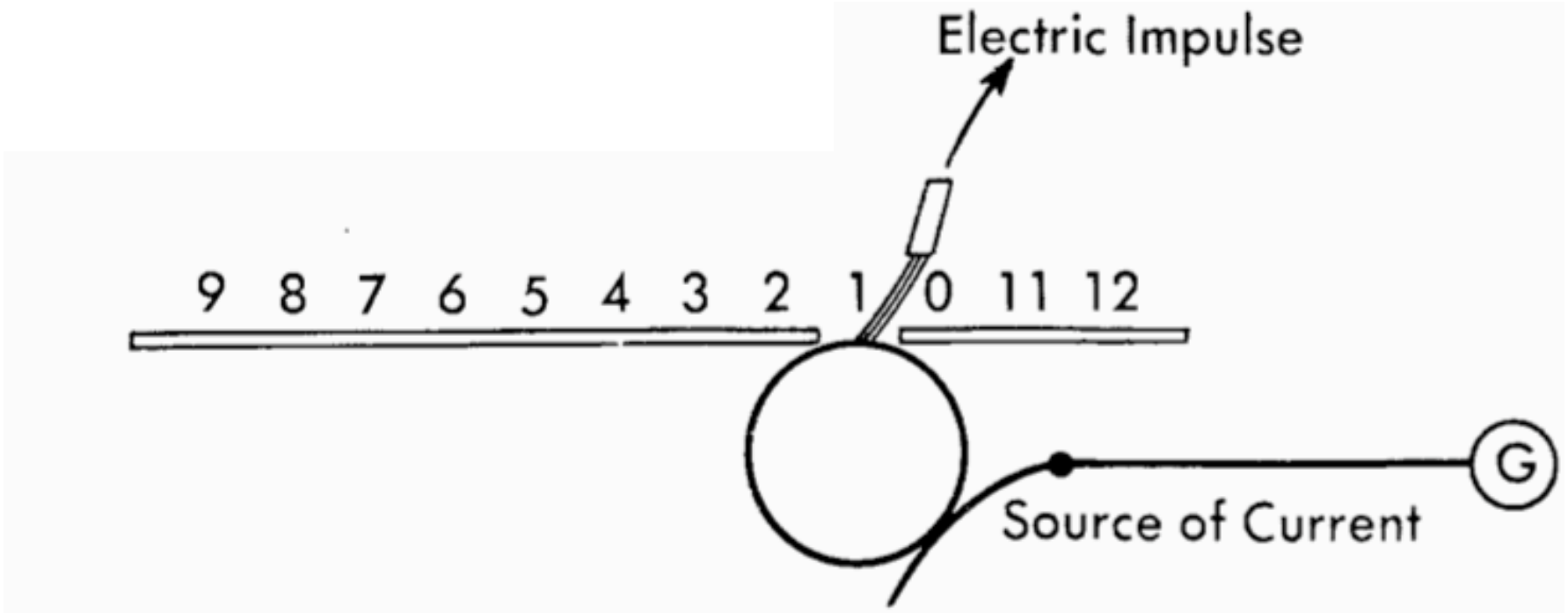
Sensing Punch Allows Some Action

- When the circuit closes, some mechanical action can happen



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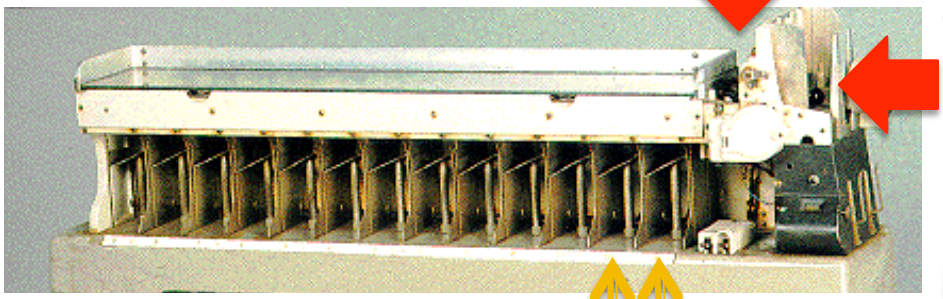
Computing w/o Computers

- Suppose Hollerith coded men as 0, women a 1

How many men and women in the population?

card counter



census data

Machine Reads Cards,
  Puts women in this slot
  Puts men in this slot
… producing 2 piles
Run each pile through again
  just to count them -- done

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Meanwhile, w/o Digital Data

- Poor Kermit must go through census sheets, counting (and probably making mistakes)

The message: "Digitizing" makes information discrete, it's either there (1) or not (0), and a machine can determine that fact using mechanical or electronic means. Once data is digital, it is just a matter for engineers to build more capable machines

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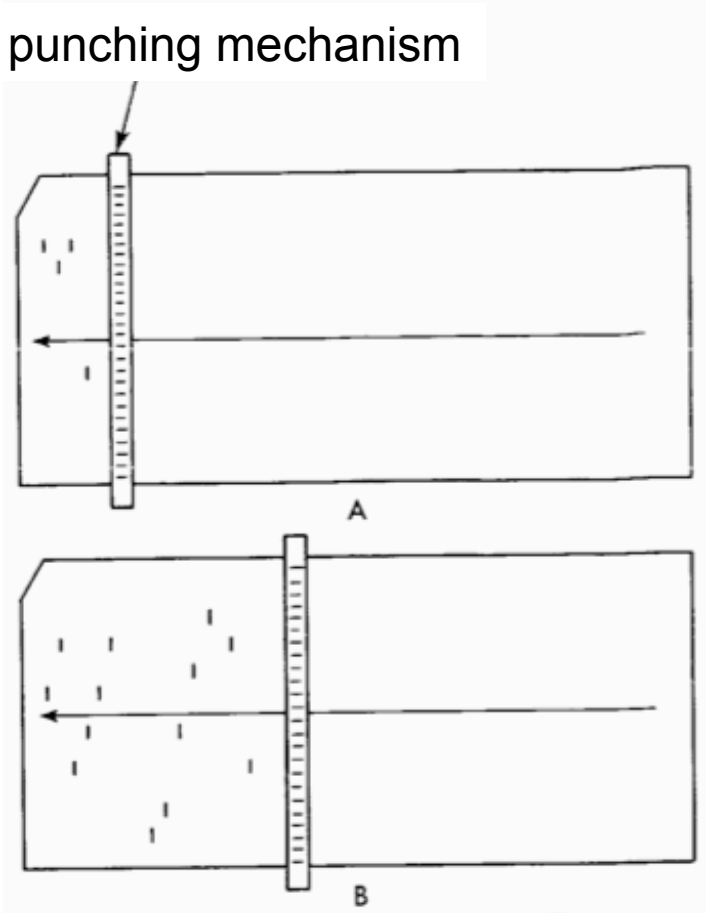
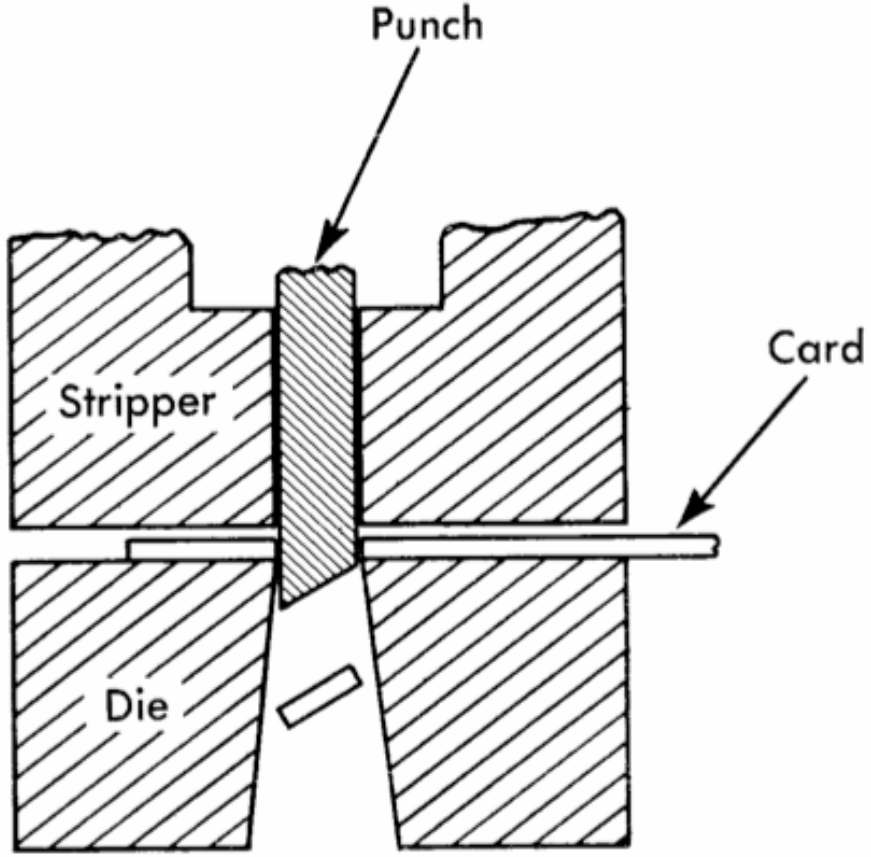
Writing As Important As Reading

- After processing based on reading cards, a machine can "save its work" by punching cards





Staying Digital

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Next Big Things … Very Big!

- Electronic computers came after WWII

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By Mid 20th Century ~ 1960

- Large and medium-size companies used card based digital data; mechanical processing
- Computers began to replace mechanical b/c a computer's "processing instructions" (program) could be easily changed, & they perform more complex operations – flexibility
- Computers, memory much more expensive – this sets conditions for the "**Y2K** Problem"

Message: Computers take the task specification (program) and digital data as inputs, making them very versatile machines; one machine does it all! Programming becomes critical technology.

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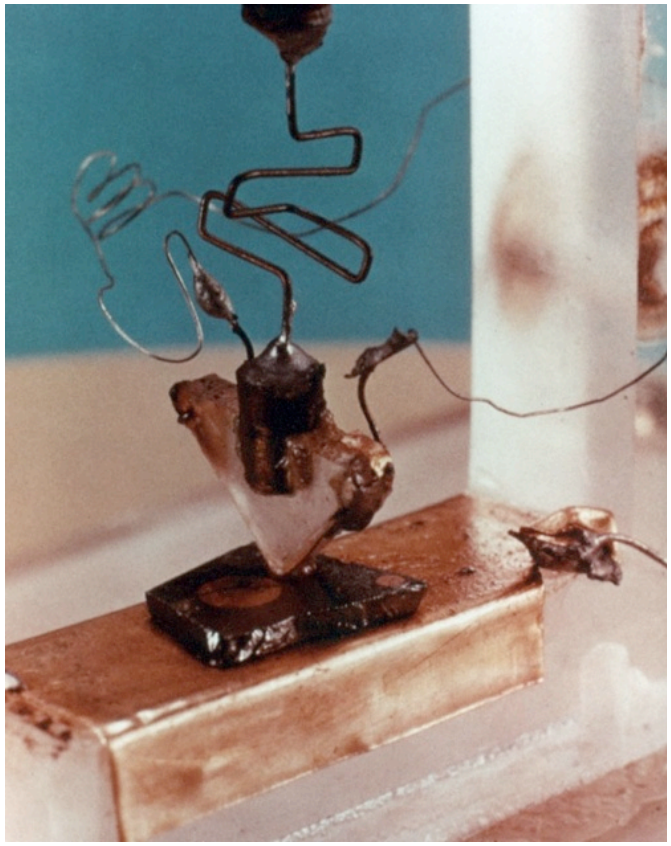
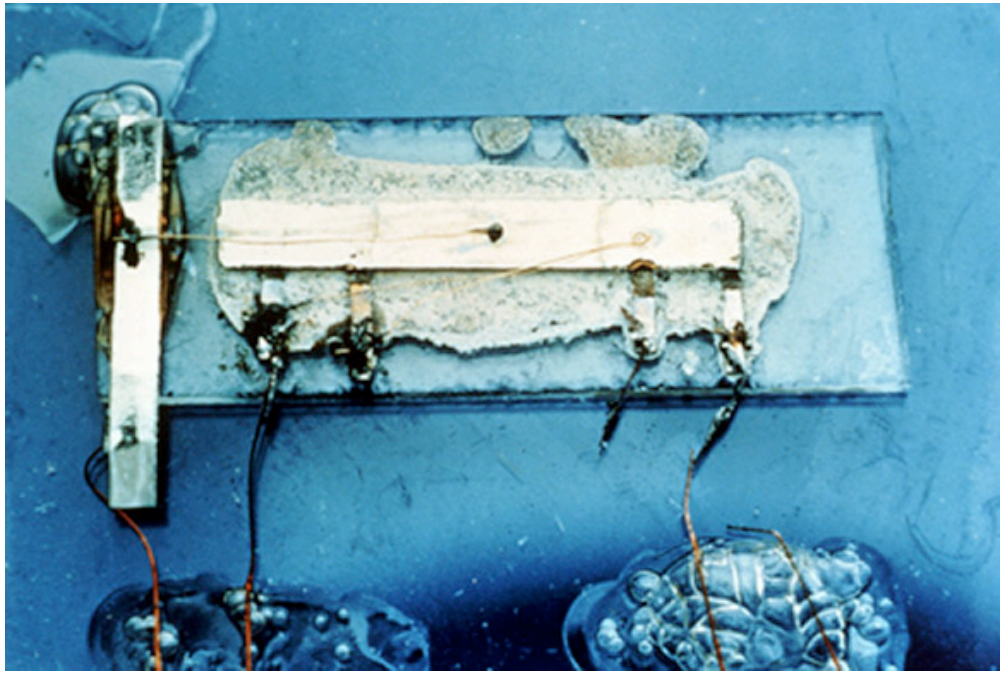
Next Big Things: Integrated Circuits

- Transistors – solid state switching
- Integrated Circuit – all circuit parts fabbed at once from similar materials



1st transistor



1st integrated circuit

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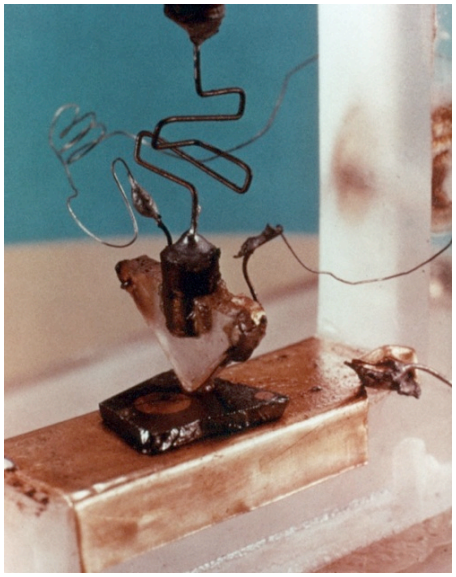
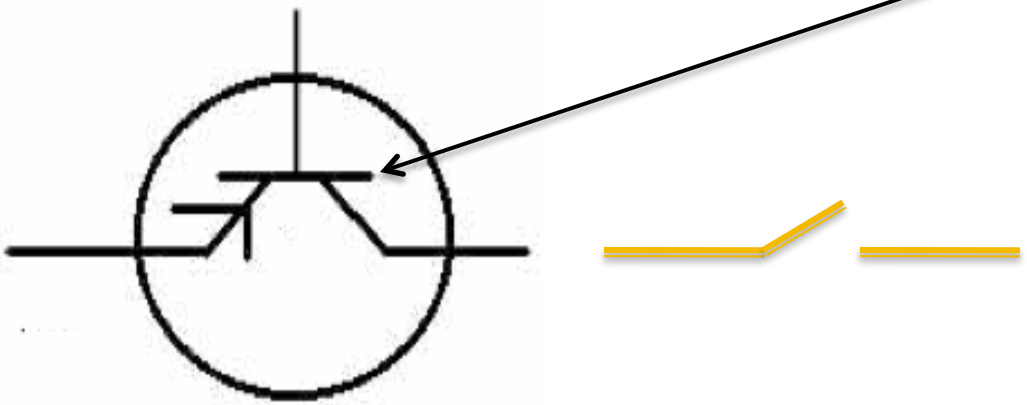
Solid State Electronics

- A transistor is a switch: If the gate (black bar) is neutral, charge cannot pass; if gate is charged, the wires are connected





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Solid State Electronics

- Transistors are smart, but "wiring them up" with other parts was labor intensive
- **Integrated circuits** – transistors + resistors + capacitors – are created together in one long recipe – small, cheap, reliable
- Key fabrication process is *photolithography* – the transistors are "printed" on the silicon!

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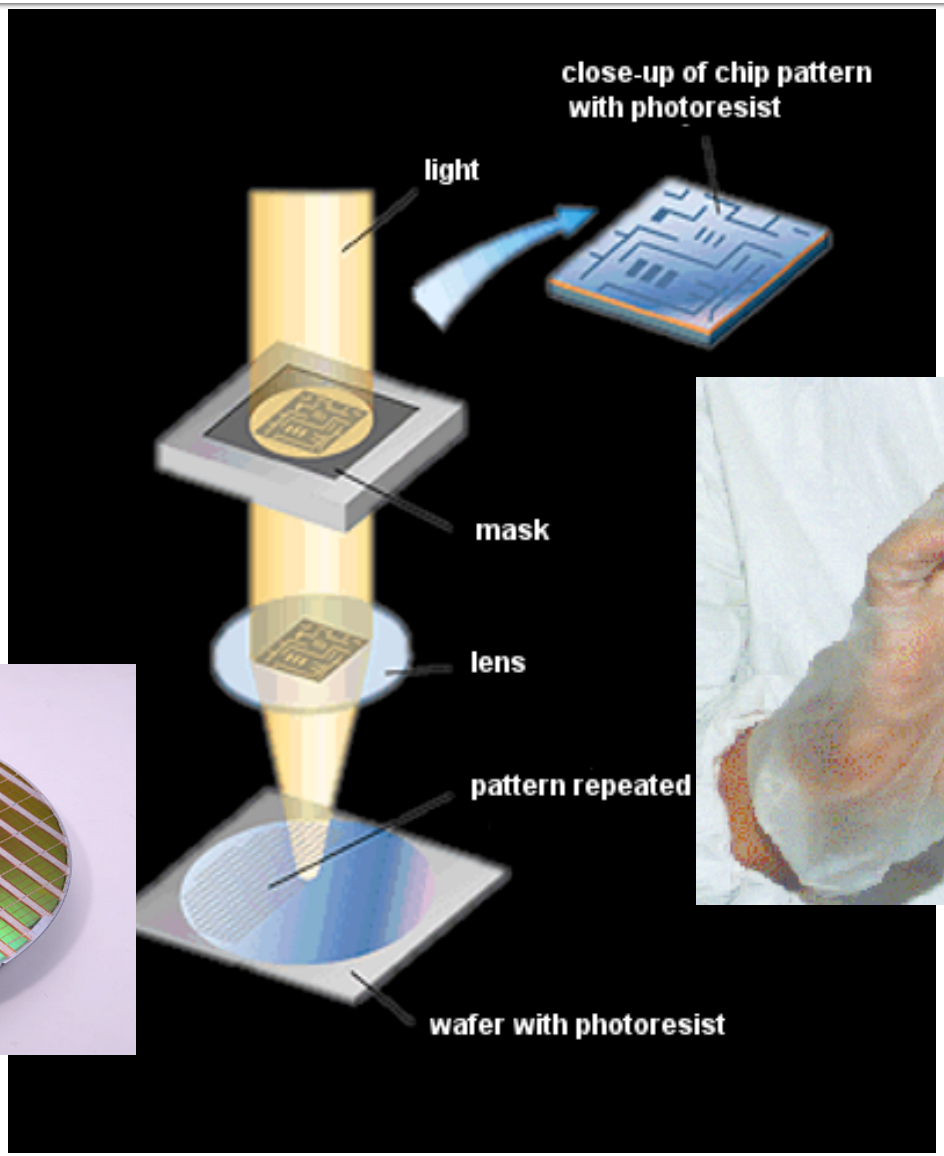
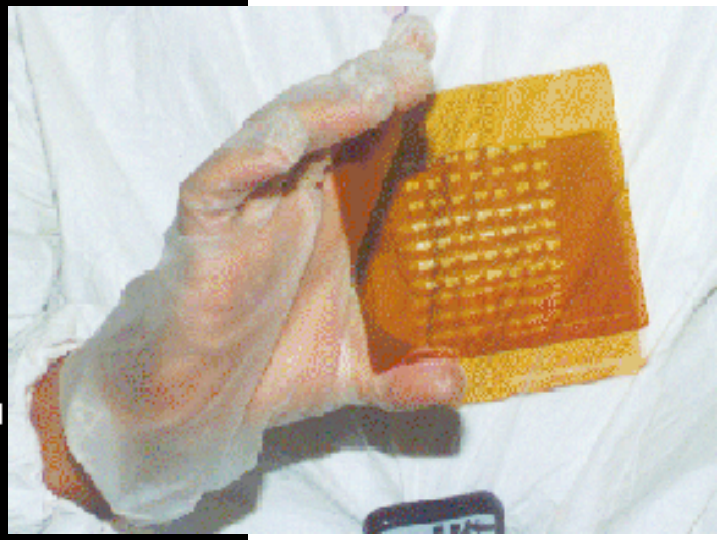
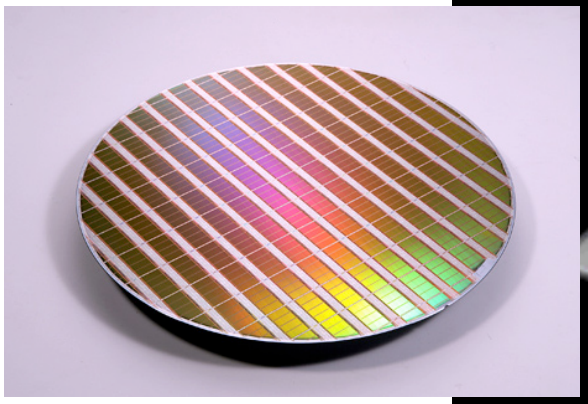
Photolithography







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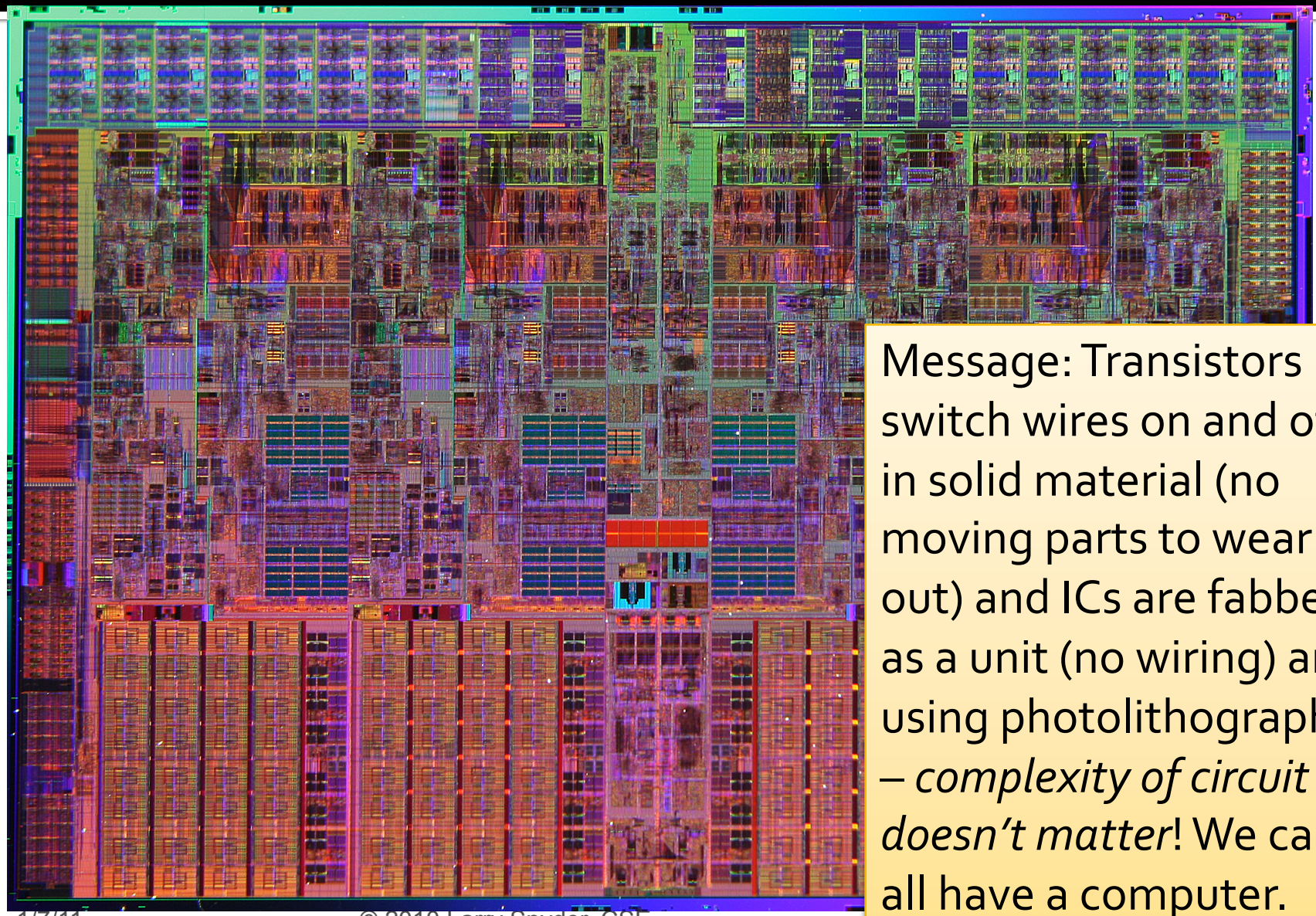
Integrated Circuits



Message: Transistors switch wires on and off in solid material (no moving parts to wear out) and ICs are fabbed as a unit (no wiring) and using photolithography – *complexity of circuit doesn't matter*! We can all have a computer.

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Next Big Thing: Personal Computers

- Ken Olsen, Founder of Digital Equipment, "There is no reason for any individual to have a computer in their home [1977]"

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Computing Comes To Everyone

- Regular folks – not just government, military, scientists, banks and companies – could now apply computers to their interests
- Created a demand for digital data: news, pics, audio, video, books, etc., causing old technologies to digitize rapidly. Now it matters to everyone if a machine can "read" it
- From about 1985 most "new" information has been digital
- Quickly, people acquired enormous amounts of information

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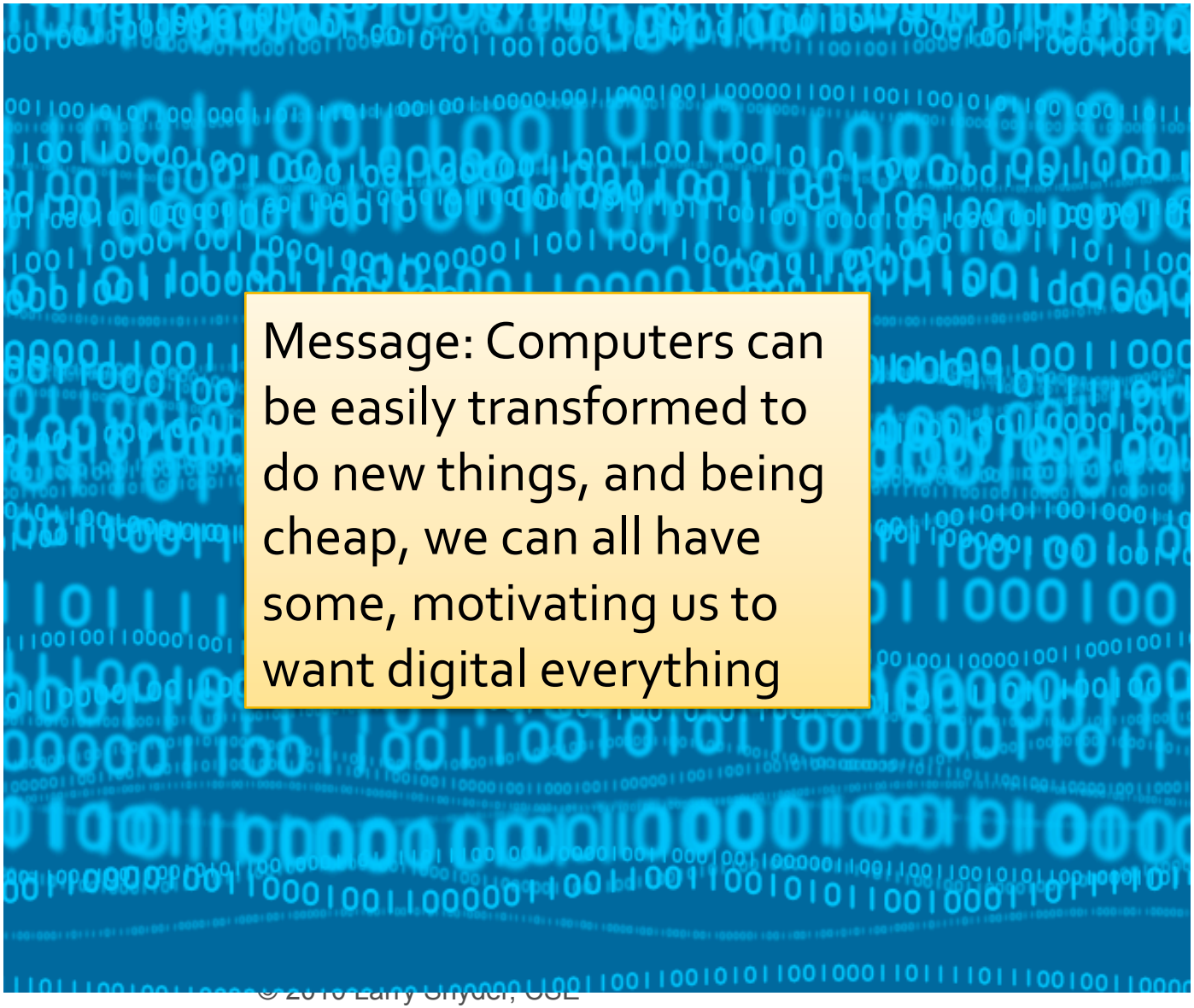
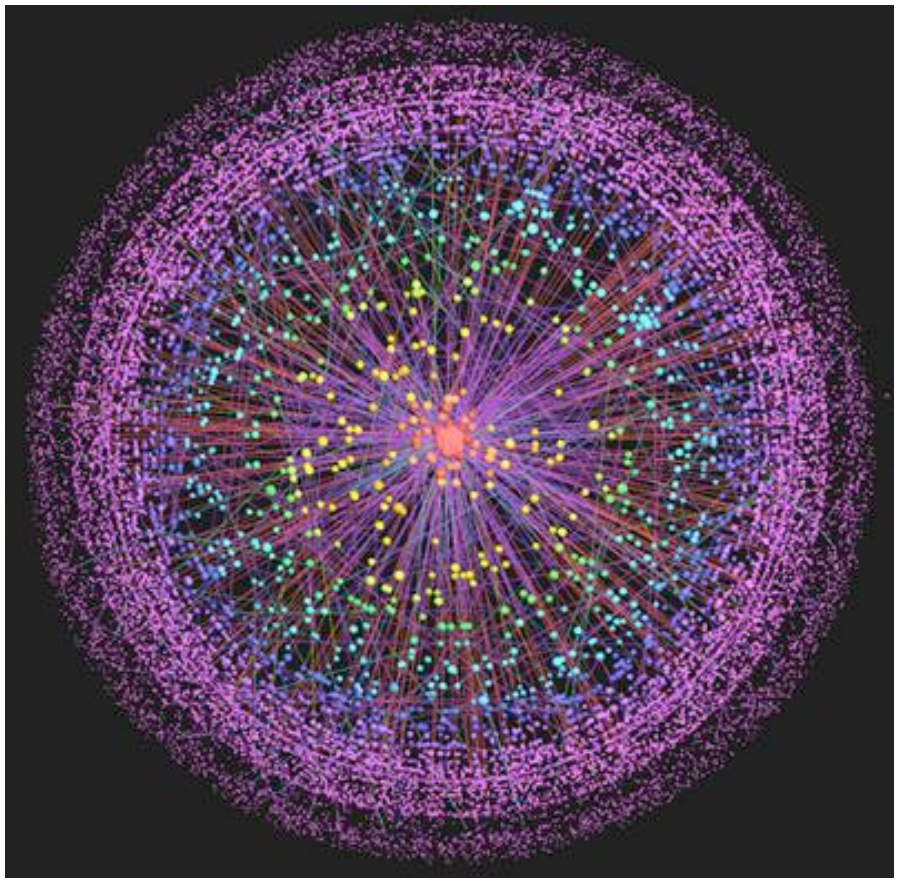
Digital Rocks



Next Big Thing: Internet

- Invented in 1969, it took almost 20 years to get out of the lab and into public consciousness



"On the Internet, nobody knows you're a dog."

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Connecting Up

- Computers are useful; connected computers are awesome
- If *n* computers are connected, adding one more gives *n* new connections!
- Communication with friends or businesses all over the world became easy and casual – some people even found out about time zones
- Digital media allows people to share each other's information at no cost

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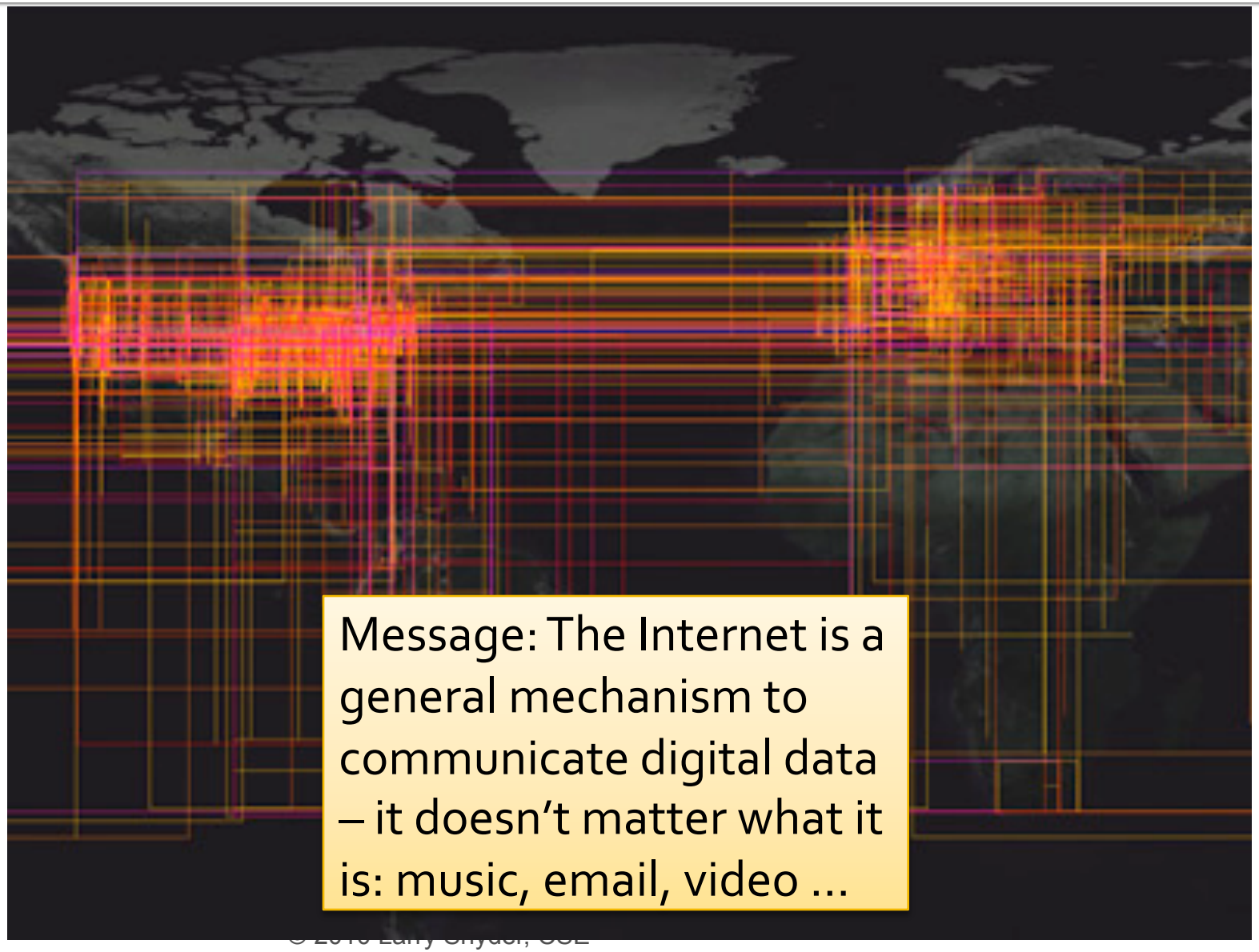
Connectivity to Change the World



Next Big Thing: WWW + http

- Today, all computers "speak" a common language: hyper-text transfer protocol

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WWW Is The Servers + The Data

- Two phenomena make the WWW brilliant
  - All computers use one standard protocol (http) meaning for once all of the world's people – who don't speak one language – have a surrogate that does
  - Publishing and accessing information is completely decentralized – generally, no one limits what you put out or go after

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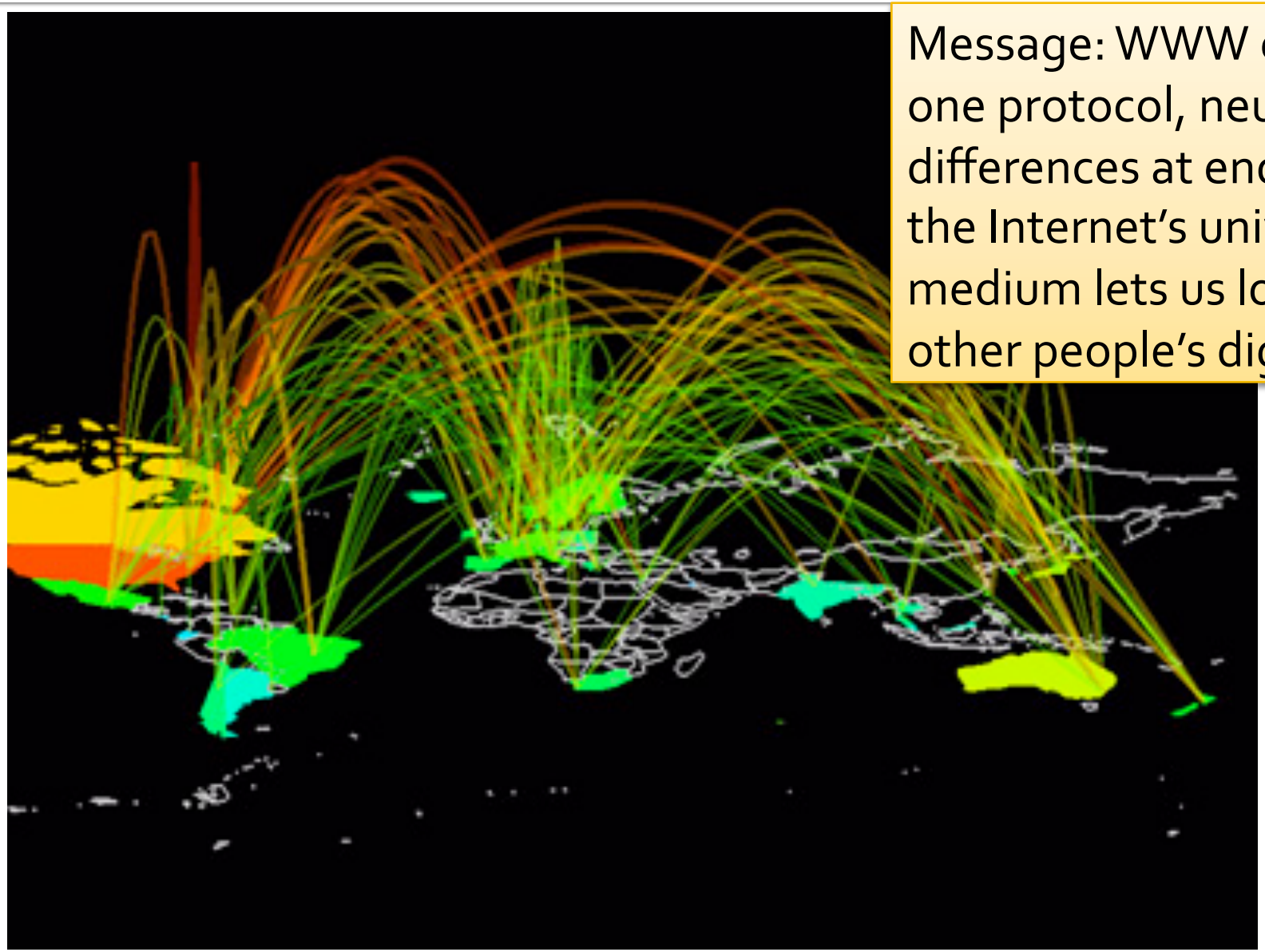
Seeing Other People's Digital Info



Message: WWW exploits one protocol, neutralizing differences at endpoints; the Internet's universal medium lets us look at other people's digital info

So, It All Works Because of Digital

- Key principle of digital encoding: Physically, information is the presence or absence of a phenomenon at a given place and time!
- Card example:
  - Phenomenon – hole in the card
  - Present – detected by brush making elec contact
  - Absent – brush insulated from electrical source
  - Place – there are several on the card; devices can know the positions
  - Time – hole is permanent representation of info

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A General Idea

- Digital Information: Detecting the presence or absence of a phenomenon at a specific place and time: PandA
- Phenomena: light, magnetism, charge, mass, color, current, …
- Detecting depends on phenomenon – but the result must be discrete: it was detected or not; there is no option for "sorta there"
- Place and time apply, but usually default to "obvious" values; not so important to us

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Digital Discussion

- Alternatives to detecting the hole in a card

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Digital Discussion

- Alternatives to detecting the hole in a card
- Sidewalk Memory – squares and rocks

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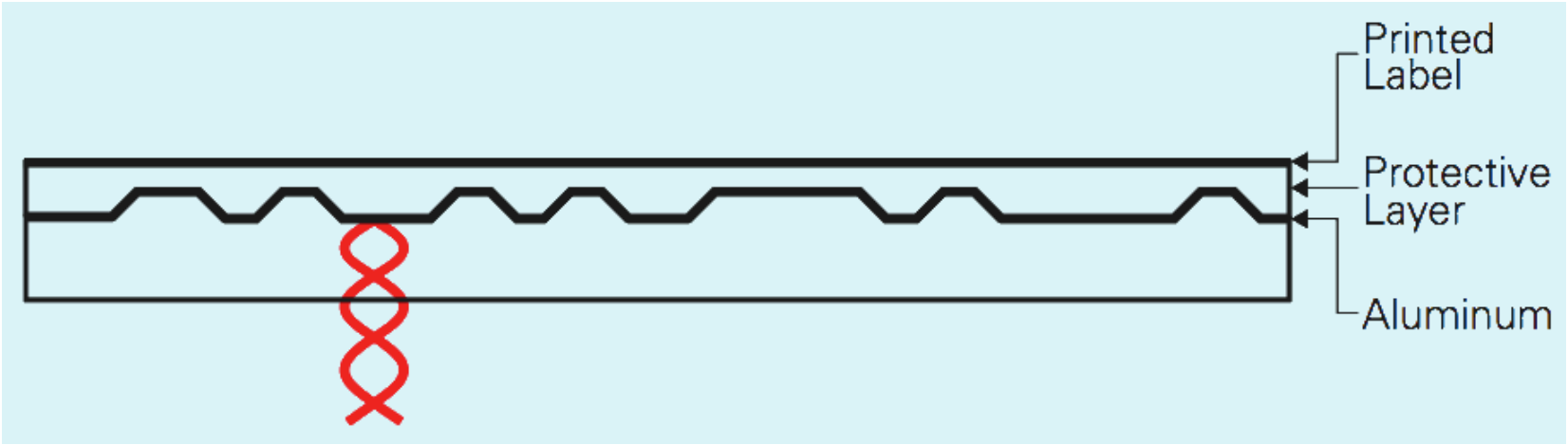
Digital Discussion

- Alternatives to detecting the hole in a card
- Sidewalk Memory – squares and rocks

- Other phenomena … CD ROM how it works:



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