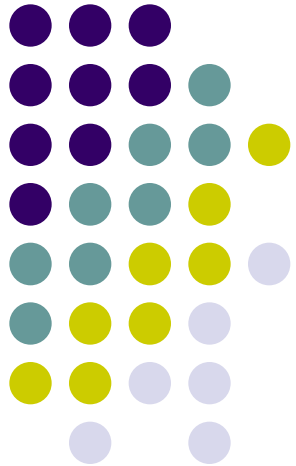
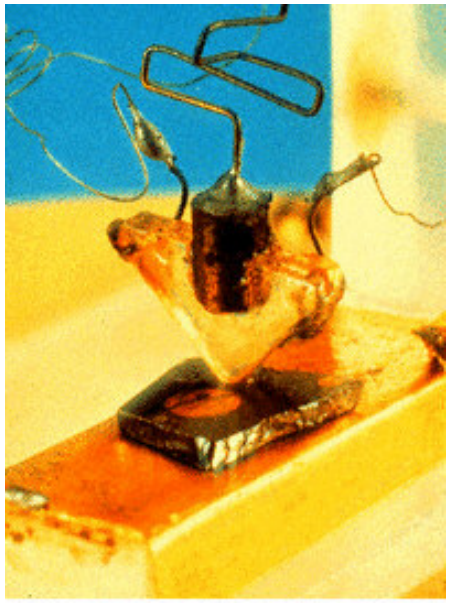
CSE 301
History of Computing

The integrated circuit
and other advances



Transistors

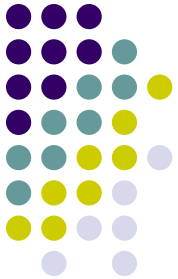


- First invented & tested in 1947 by William Shockley, Walter Brattain, and John Bardeen for AT&T Bell Labs in New Jersey
  - Awarded Nobel Prize in Physics in 1956
    - http://nobelprize.org/physics/laureates/1956/
- One of the most important inventions of the 20th Century
  - Certainly for modern computers
- Started the trend towards miniaturization

Jack St. Clair Kilby

- Born in 1923 in Jefferson City, MO
  - EE degree from University of Illinois in 1947
- He invented the integrated circuit in 1958 while working at Texas Instruments.
  - In 1970, in a White House ceremony, he received the National Medal of Science.
  - In 1982, he was inducted into the National Inventors Hall of Fame.
  - He was awarded the Nobel Prize in Physics in 2000 for his breakthrough discovery.

What's an Integrated Circuit?



- A microchip
- A small electronic device made out of semiconductor material with transistors, resistors, & capacitors on it
- Used to build CPUs (we'll see soon)
  - replaced simple transistors
- Used to build RAM
  - replaced core memory

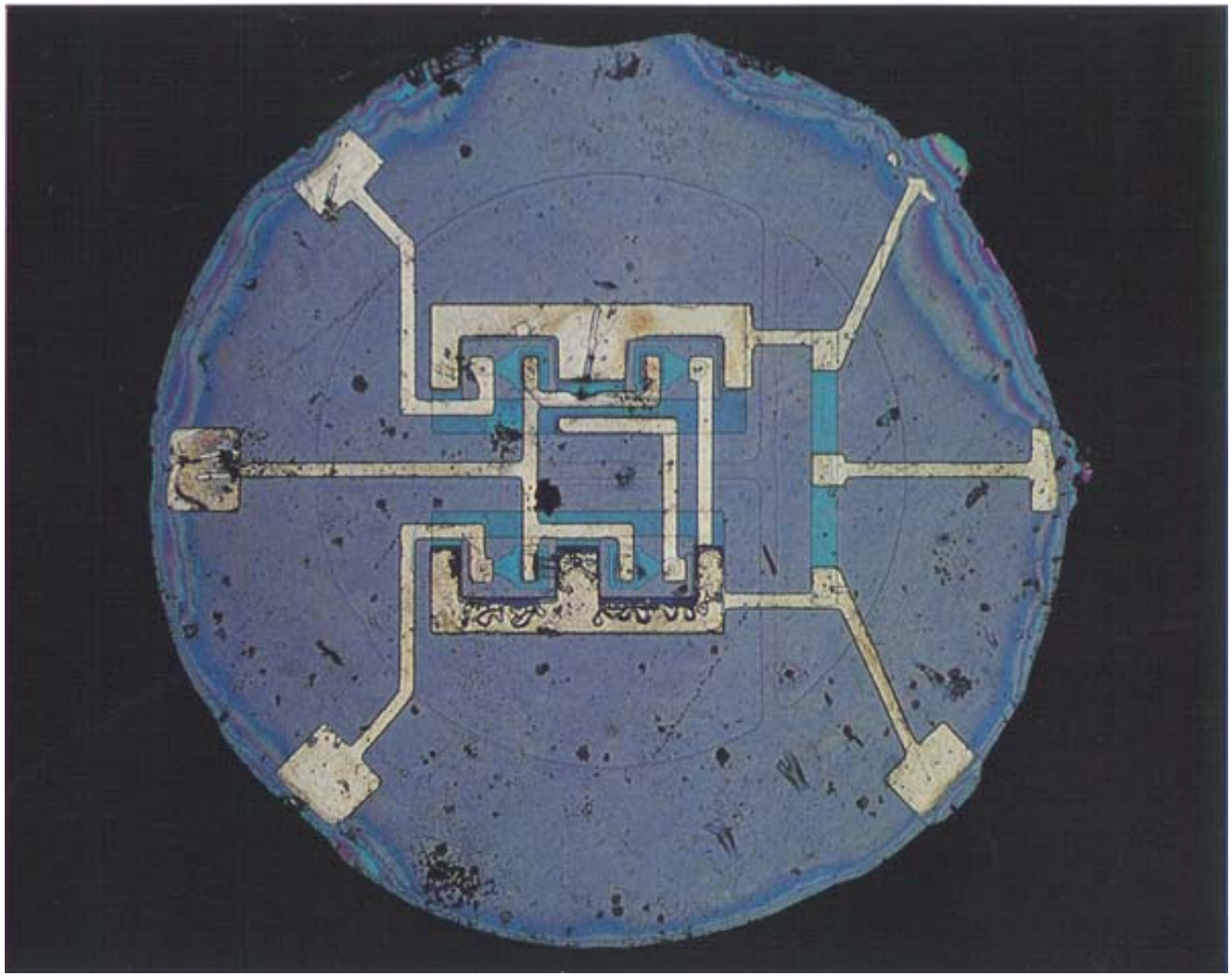
TI's First IC

Robert Noyce

- Born in 1927 in Grinnell, IA
  - Ph.D. from Massachusetts Institute of Technology in 1953.
- Worked for Shockley Semiconductor Labs in CA
- Co-founded Fairchild Semiconductor in 1957 and Intel in 1968.
  - Intel's headquarters building, the Robert Noyce Building, in Santa Clara, California is named in his honor.
- Nicknamed the “Mayor of Silicon Valley”
- Improved upon Jack Kilby’s IC (microchip)
  - Fabricated chip with entire components out of a single piece of silicon – almost like a sculpture
    - - the planar IC, which got help from Swiss Fairchild employee Jean Hoerni

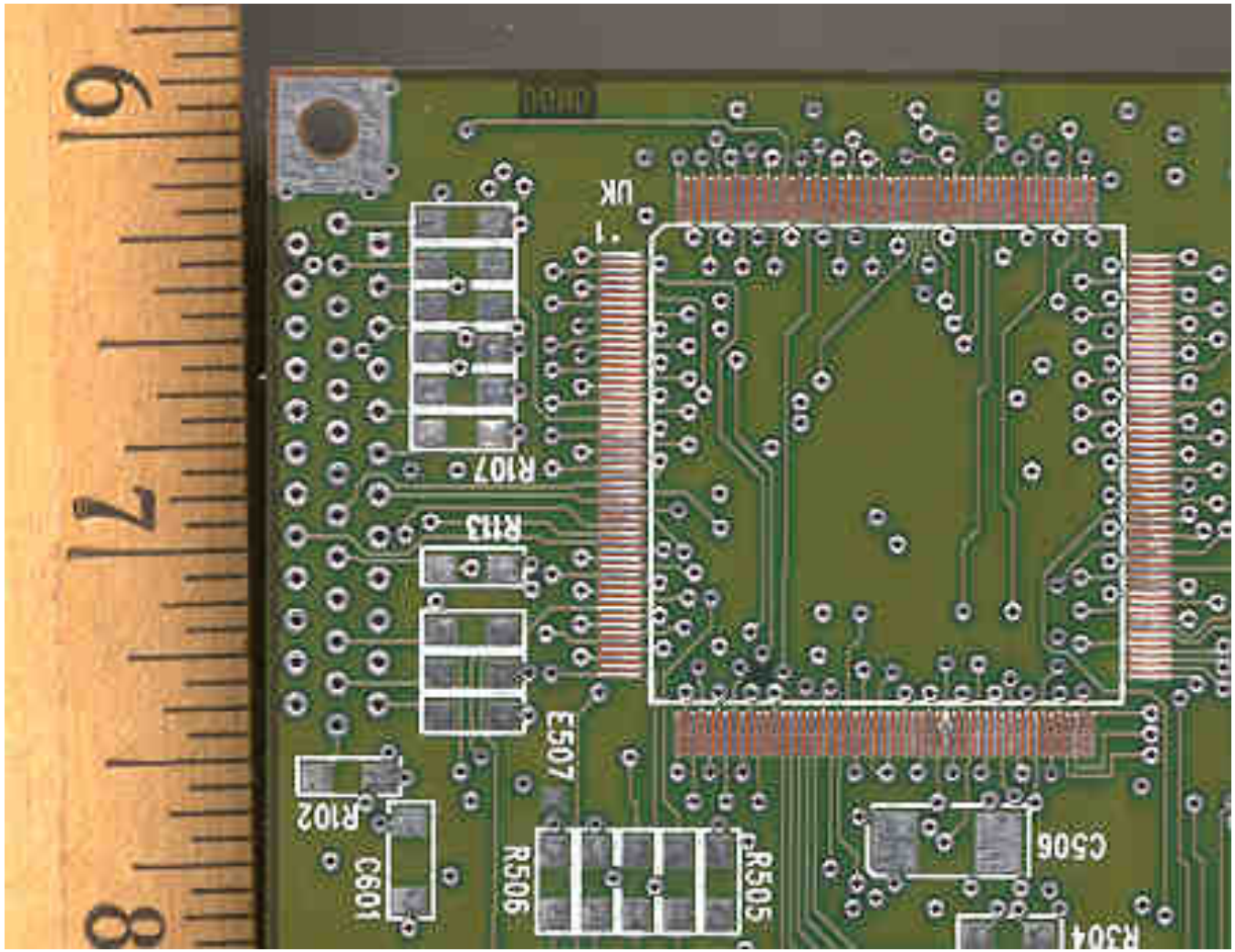
The first Planar IC – Fairchild

http://smithsonianchips.si.edu/augarten/i10.htm

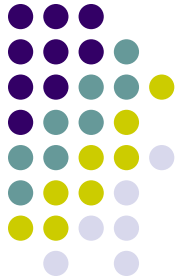


A typical IC

http://klabs.org/richcontent/old_news/old_news_9/

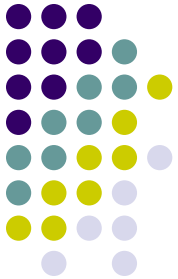


How do you make an IC?

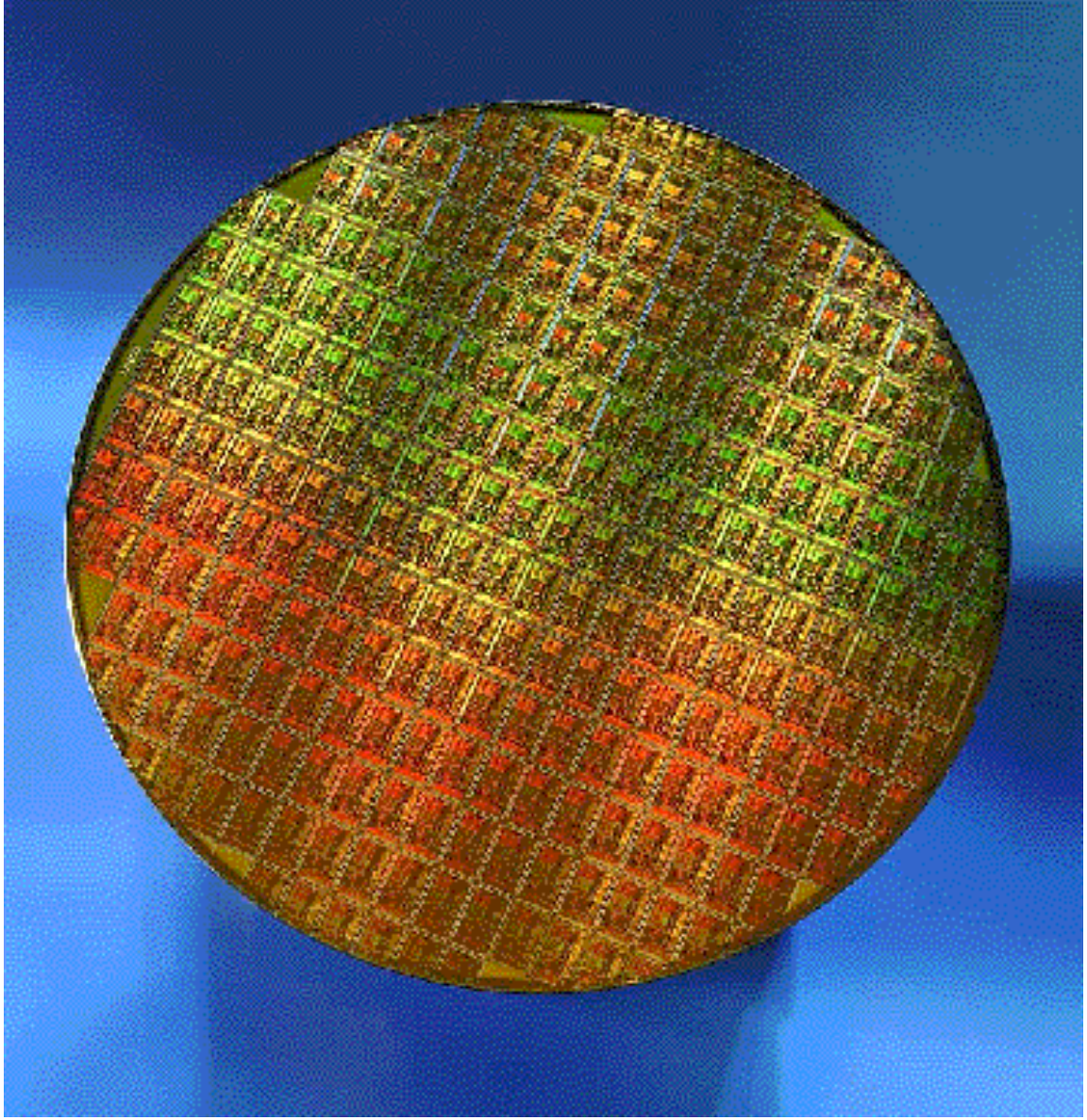


- Take a round silicon wafer (the larger, the more chips you can make)
- Oxidize the surface – converts surface to silicon oxide
- Carve a pattern using a mask onto the surface using light – called photolithography
- Etch the surface, removing excess material
- Sputtering adds metal to fill what has been etched
- Additional chemical treatment is then performed, as is packaging
- Now you have chips of silicon with a pattern
- This process requires extremely clean environments
  - Clean rooms

Clean Rooms



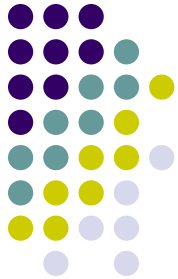
- The measure of the air quality of a clean room is described in Federal Standard 209. Clean rooms are rated as "Class 10,000," where there exists no more than 10,000 particles larger than 0.5 microns in any given cubic foot of air; "Class 1000," where there exists no more than 1000 particles; and "Class 100," where there exists no more than 100 particles. Hard disk drive fabrication requires a Class 100 clean room.



A Silicon Wafer with many Chips on it

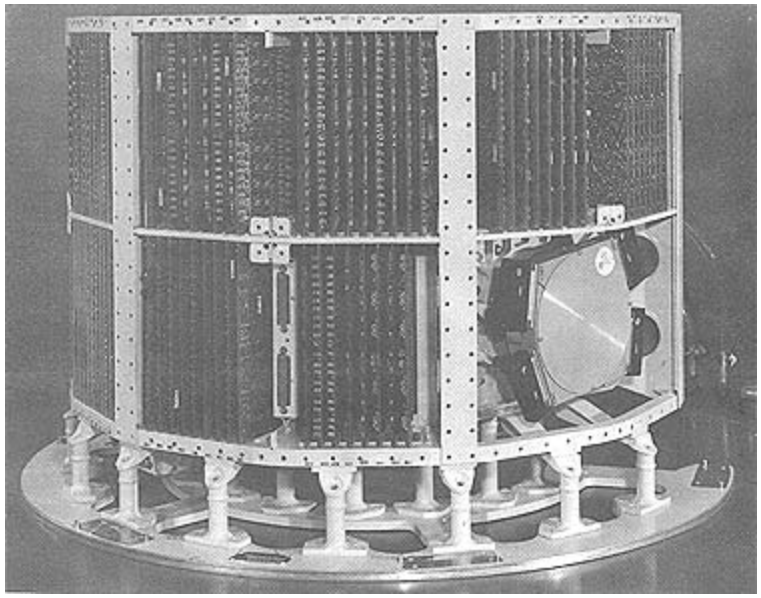
http://www.cstl.nist.gov/div837/Division/programs/microelect/microelect1.htm

Integrated Circuits: SSI



- SSI = Small Scale Integration
- Early to mid 1960s
- Contained transistors numbering in the tens.
- Crucial to early aerospace projects that needed lightweight digital computers
  - U.S. Air Force Minuteman missile - forced IC technology into mass-production
  - NASA Apollo flight computer - led and motivated the IC technology
- Germanium & then Silicon used as semi-conductor for ICs

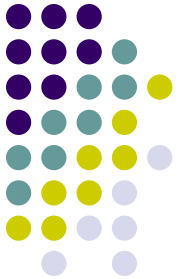
Integrated Circuits: SSI



Minuteman I Guidance Computer D-17 (Ballistics Research Laboratory, Aberdeen, MD)

Apollo Guidance and Navigation System (Smithsonian National Air and Space Museum)

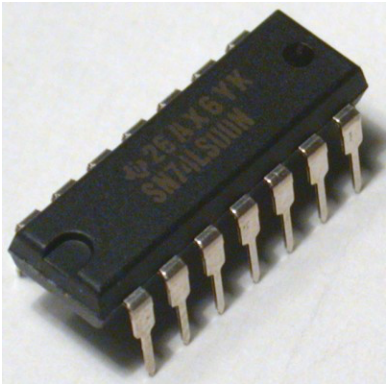
Integrated Circuits: MSI



- MSI = Medium Scale Integration
- Late 1960s
- Contained transistors numbering in the hundreds.
- These ICs were attractive economically
  - They cost little more to produce than SSI devices
  - They allowed more complex systems to be produced using smaller circuit boards,
  - They required less assembly work (because of fewer separate components)

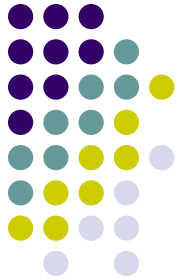
Transistor-transistor logic (TTL)

- Notable for being the base for the first widespread semiconductor integrated circuit (IC) technology.
- Gained almost universal acceptance after Texas Instruments had greatly facilitated the construction of digital systems with their 1962 introduction of the 74xx series of ICs.
  - TTL devices are also limited to a set voltage, typically 5V.
  - Contains many hundreds of devices that provide everything from basic logic gates to special purpose bus transceivers and Arithmetic Logic Units (ALU).



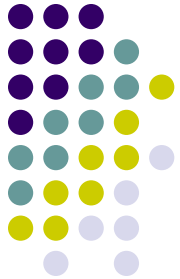
7400 NAND

Integrated Circuits: LSI



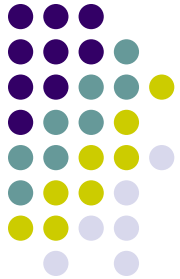
- LSI = Large Scale Integration
- mid 1970s
- Contained tens of thousands of transistors per chip.
- LSI circuits began to be produced in large quantities for computer main memories and pocket calculators.
  - In 1970, Intel created the 1103--the first generally available DRAM chip. By 1972, it was the best-selling semiconductor memory chip in the world.
  - Today, you would need more than 65,000 of them to put 8 MB of memory into a PC.

Integrated Circuits: VLSI



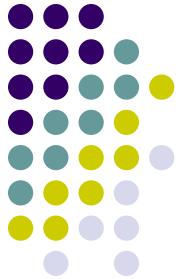
- VLSI = Very Large Scale Integration
- Starting in the 1980s and onward
- Contained hundreds of thousands of transistors, and beyond (well past several million in the latest stages).
  - The largest chips are sometimes called "Ultra Large-Scale Integration" (ULSI).
- For the first time it became possible to fabricate a CPU or even an entire microprocessor on a single integrated circuit.
  - In 1986 the first one megabyte RAM was introduced, which contained more than one million transistors.
  - Microprocessor chips produced in 1994 contained more than three million transistors.

What SI?

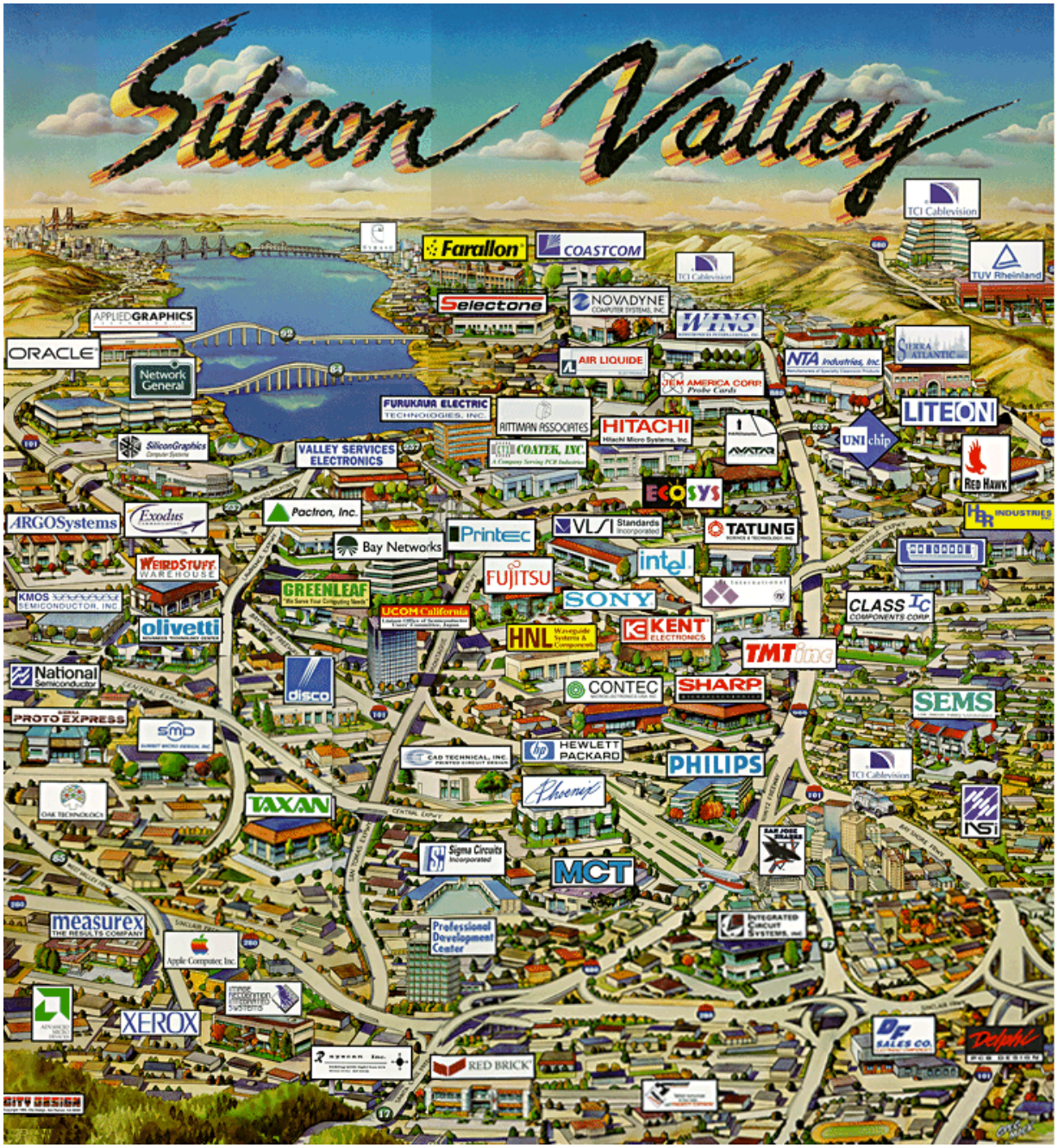


- SSI **(small-scale integration):** Up to 100 electronic components per chip
- MSI **(medium-scale integration):** From 100 to 3,000 electronic components per chip
- LSI **(large-scale integration):** From 3,000 to 100,000 electronic components per chip
- VLSI **(very large-scale integration):** From 100,000 to 1,000,000 electronic components per chip
- ULSI **(ultra large-scale integration):** More than 1 million electronic components per chip

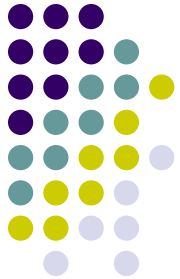
Silicon Valley



- Silicon Valley is a nickname for the southern part of the San Francisco Bay Area centered roughly on Sunnyvale.
  - coined by journalist Don C. Hoefler in 1971,
- It was named "Silicon" for the high concentration of semiconductor and computer related industry in the area, and "Valley" for the Santa Clara Valley.
- Fairchild Semiconductor really started and then fuelled it all


Silicon Valley
Farallon
COASTCOM
TCI Cablevision
TUV Rheinland
Selectone
NOVADYNE
WINS
APPLIED GRAPHICS
ORACLE
Network General
AIR LIQUIDE
NTA Industries, Inc.
FURUKAWA ELECTRIC TECHNOLOGIES, INC.
RITTIWAN ASSOCIATES
HITACHI
Hitachi Micro Systems, Inc.
LITEON
SiliconGraphics
VALLEY SERVICES ELECTRONICS
COATEK, INC.
AVATAR
UNIchip
RED HAWK
ECOSYS
ARGOSystems
Exodus
Pactron, Inc.
Printec
VLSI Standards Incorporated
TATUNG
Bay Networks
FUJITSU
intel
WEIRDSTUFF WAREHOUSE
GREENLEAF
SONY
KMOS SEMICONDUCTOR, INC.
UCOM California
CLASS IC COMPONENTS CORP.
olivetti
HNL
KENT ELECTRONICS
TMTinc
National Semiconductor
disco
CONTEC
SHARP
SEMS
PROTO EXPRESS
smd
HEWLETT PACKARD
PHILIPS
CAD TECHNICAL, INC.
TAXAN
Sigma Circuits Incorporated
MCT
measurex THE RESULTS COMPANY
Professional Development Center
Apple Computer, Inc.
INTEGRATED CIRCUIT SYSTEMS, INC.
XEROX
DF SALES CO.
Delphi
RED BRICK
CITY DESIGN

Silicon Valley “wannabes”



Brazilian Silicon Valley - Campinas, Brazil

Mexican Silicon Valley - Jalisco, Mexico

Multimedia Super Corridor - Kuala Lumpur, Malaysia

Research Triangle - North Carolina

Route 128 - Massachusetts (known as the "Silicon Valley of the East Coast")

Silicon Alley - New York, New York, Broadway from the Flatiron District to TriBeCa, and parts of Brooklyn

Silicon Forest - Portland, Oregon

Silicon Prairie - the region around Schaumburg, Illinois, Dallas, Texas, and Ames, Iowa

Silicon Sentier - France

Silicon Glen - Scotland

Silicon Hills - Texas, United States

Silicon Valley North - Kanata, Ontario, Canada and Ottawa, Canada

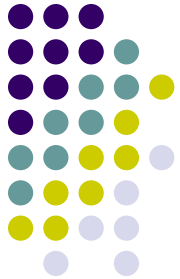
Silicon Valley of India - Bangalore, India

Wireless Valley - Stockholm, Sweden

J.C.R. Licklider

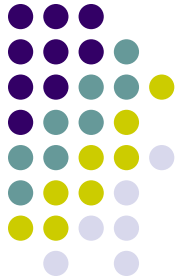
- 1915-1990
- In 1950, Licklider moved from Harvard to MIT
  - Wrote his famous paper *Man-Computer Symbiosis* in 1960, which outlined the need for simpler interaction between computers and computer users.
    - **`http://memex.org/licklider.pdf`**
  - The earliest ideas of a global computer network were formulated by Licklider at MIT in August 1962
    - *The Computer as a Communications Device* (w/ R.W. Taylor)
- In October 1962 Licklider was appointed head of the DARPA information processing office
  - set up initial funding that led to the Internet years later
- In 1968, he became director of Project MAC at MIT

Project MAC



- A research laboratory, started at MIT in 1963 with initial funding from a two-million-dollar DARPA grant.
- Project MAC's major founders – Robert Fano, Fernando J. Corbató, John McCarthy, and Marvin Minsky The acronym "MAC" is glossed variously as
  - **M**ultiple **A**ccess **C**omputer
  - **M**achine **A**ided **C**ognition
  - **M**insky **A**gainst **C**orby (in later years)
- Project MAC envisioned the creation of a "computer utility“
  - computer utility - as reliable as source of computational power as the electric utility was a source of electrical power.

Multics

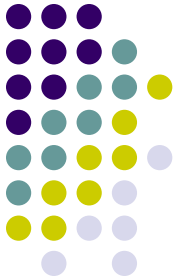


- Initial planning and development for Multics started in 1964.
- Corbató brought the first computer time-sharing system, CTSS, with him from the MIT Computation Center
- One of the early focuses of Project MAC would be the development of Multics, a successor to CTSS.
- Multics was to be the first high availability computer system
  - Developed as a part of an industry consortium including General Electric and Bell Laboratories.
  - In 1970 GE's computer business, including Multics, was taken over by Honeywell.

UNIX

- Bell Labs dropped out of Multics in 1969
- The UNIX operating system is produced in 1970 by Ken Thompson & Dennis Richie of Bell Labs who had worked on Multics
  - This project was called UNICS, short for Uniplexed Information and Computing System
  - The name has been attributed to Brian Kernighan, as a pun on Multics.
  - The name was later changed to UNIX.

UNIX (cont'd)



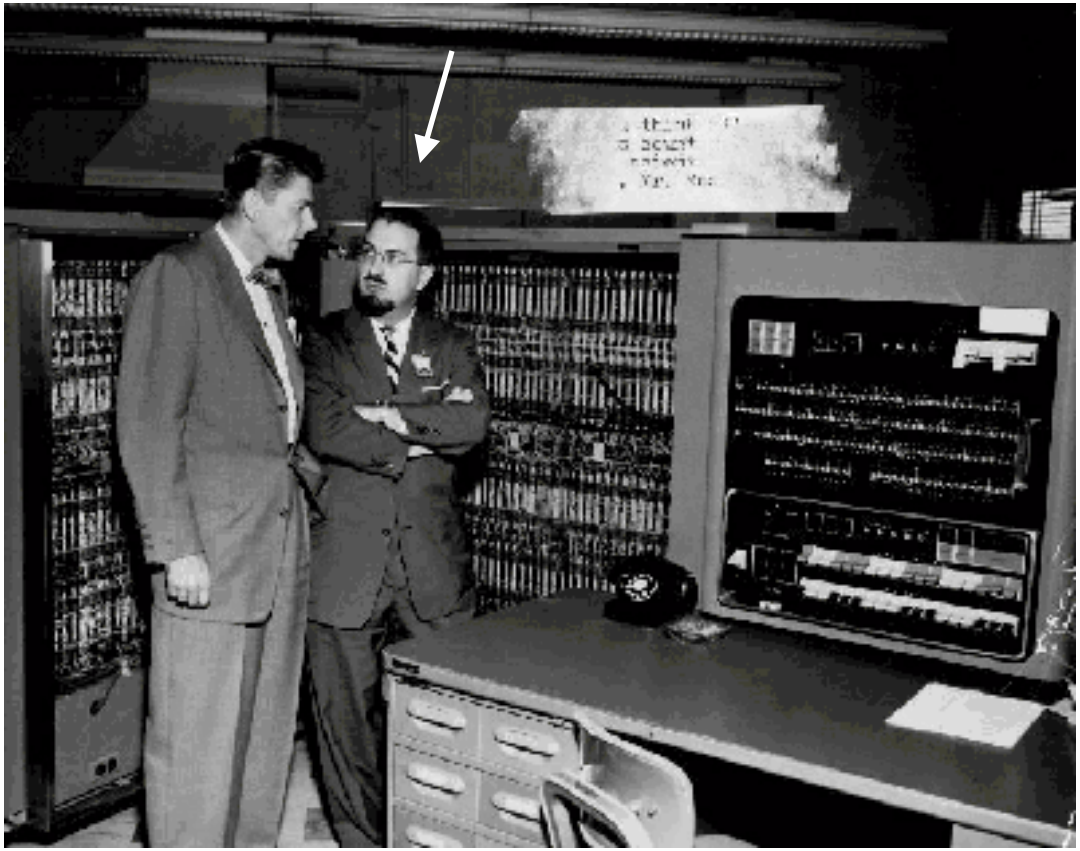
- Rewritten in C in 1973 to be more portable
- UNIX Variants:
  - BSD – University of California at Berkeley
  - SunOS – Sun Microsystems
  - Xenix – Microsoft Corporation
  - LINUX - written as a hobby by Finnish university student Linus Torvalds, who was attending the University of Helsinki in 1991
    - free software
    - open-source software
- UNIX was the one of the most popular operating systems of the 1970s and 1980s
  - Still used by Stony Brook & many companies

Herbert Grosch

Portrait of Herb Grosch, 1951.
AC Scan-image #01070301.tif

- In 1945, he was drafted into the new IBM Watson Lab at Columbia by Los Alamos to provide backup for bomb calculations.
- Grosch's Law (1965): Computer performance increases as the square of the cost.
  - You have a computer that costs $100,000
  - Another computer that costs $500,000 will be 25X as powerful.
  - It is cheaper to buy one $500K computer for 25 people than 25 $100K computers.
- His law didn't apply in the 1970s as the cost of computer power shrank by a factor of 100 due to integrated circuits.

Herbert Grosch revisited

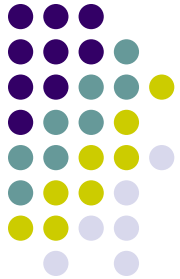


Ronald Reagan and Watson Laboratory's Herb Grosch at an IBM 701 in 1954.

Gordon Moore

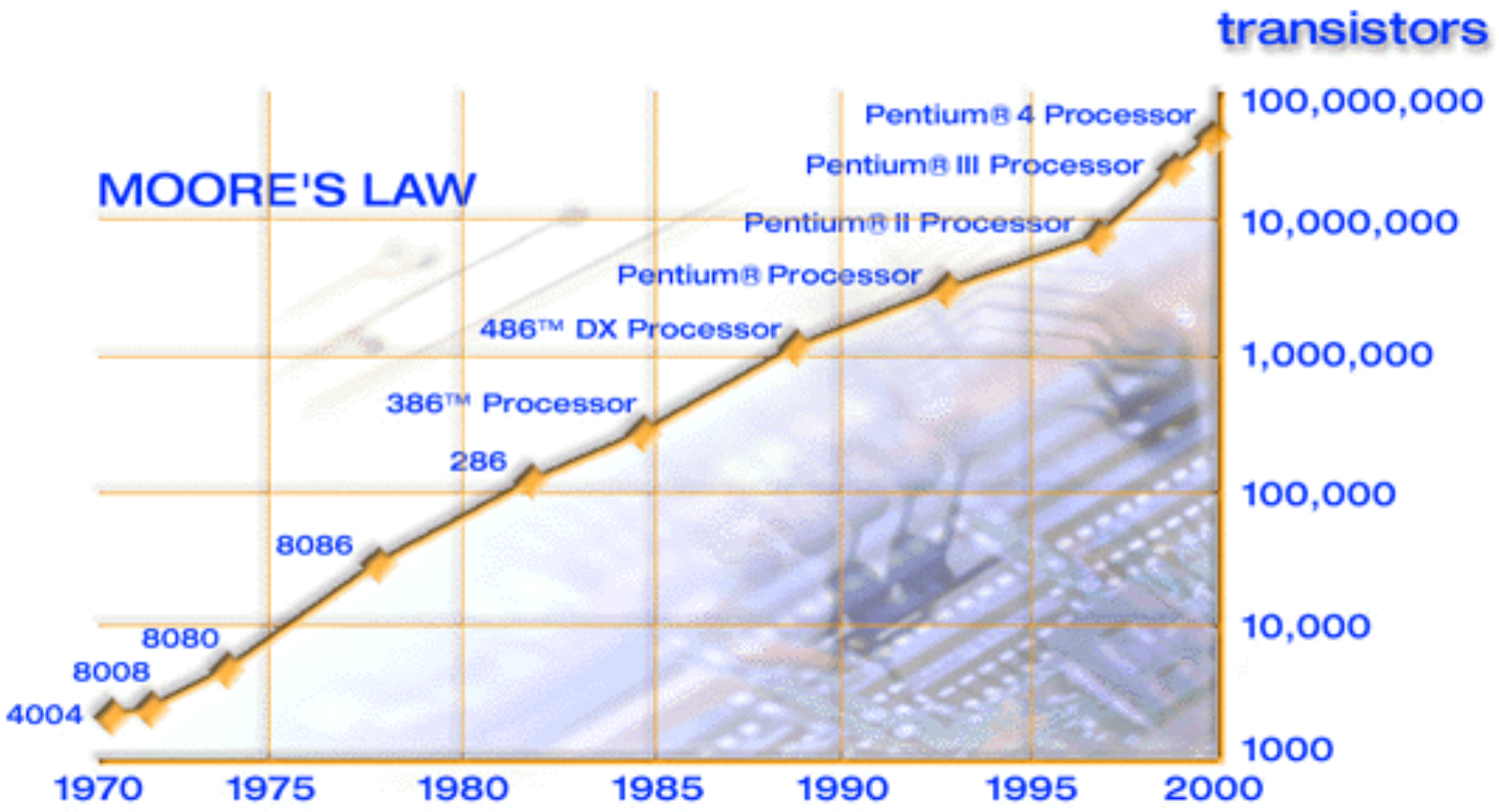
- Born in San Francisco, CA, in 1929.
  - He received a B.S. degree in Chemistry from the University of California, Berkeley in 1950 and a Ph.D. in Chemistry and Physics from the California Institute of Technology in 1954.
- He co-founded Intel Corporation in 1968.
- Famous for his prediction on the growth of the semiconductor industry: Moore's Law
  - **`ftp://download.intel.com/research/silicon/moorespaper.pdf`**

Moore's Law (1965)



- An empirical observation stating in effect that the complexity of integrated circuits doubles every 18 months.
  - "complexity" generally means number of transistors on a chip
- Amazingly, Moore's Law held for over 35 years!
- Current PC processors work at the 130 nm level, and a 90 nm chip has recently been announced.
  - Companies are working on using nanotechnology to solve the complex engineering problems involved in producing chips at the 45 nm, 30 nm, and even smaller levels -- a process that will postpone the industry meeting the limits of Moore's Law.

Moore's Law (1965)



source: Intel