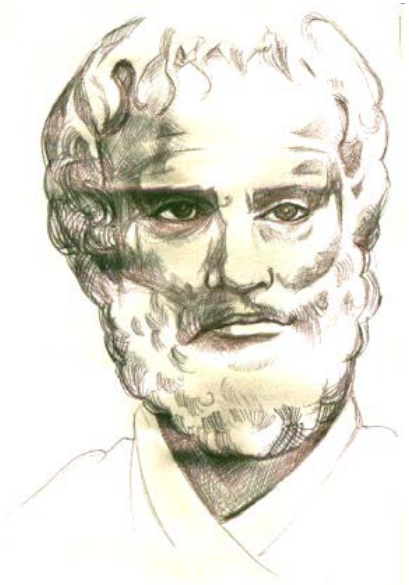
Geography 128 Winter Quarter 2017

Lecture 18: A Selective History of Computer Mapping

If you would understand anything, observe its beginning and its development.

Aristotle

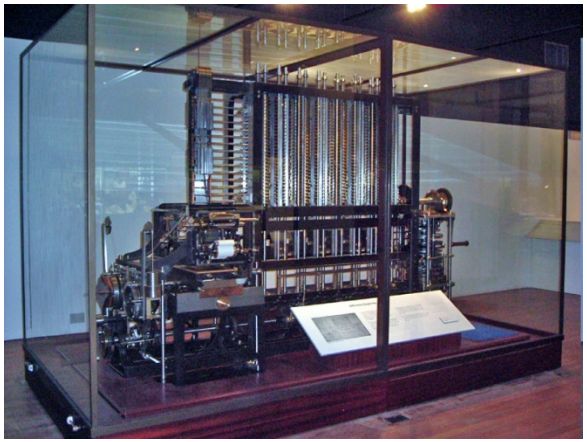


Cartography and Computer Science

- Do we know the history of computing?
- Do we know how cartography and computing are intrinsically linked?
- Can computer science offer insight into the future of analytical and computer cartography?

Origins of Computing

Jacquard's Loom (1805) in use in India (Assam, January 2011)

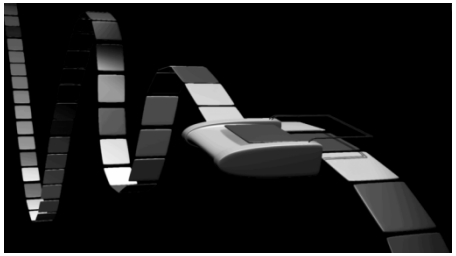


Charles Babbage: Difference Engine 1820s

Hollerith Tabulator 1890 Census

First theory

David Hilbert's Entscheidungsproblem, which asked if there was a mechanical procedure for separating mathematical truths from mathematical falsehoods



Turing machine

Alonzo Church: Lambda Calculus

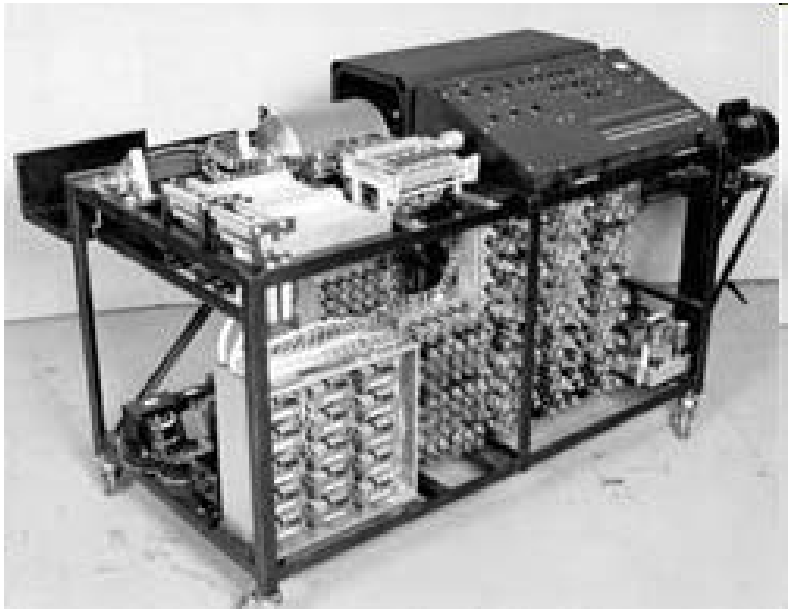
Church-Turing Thesis

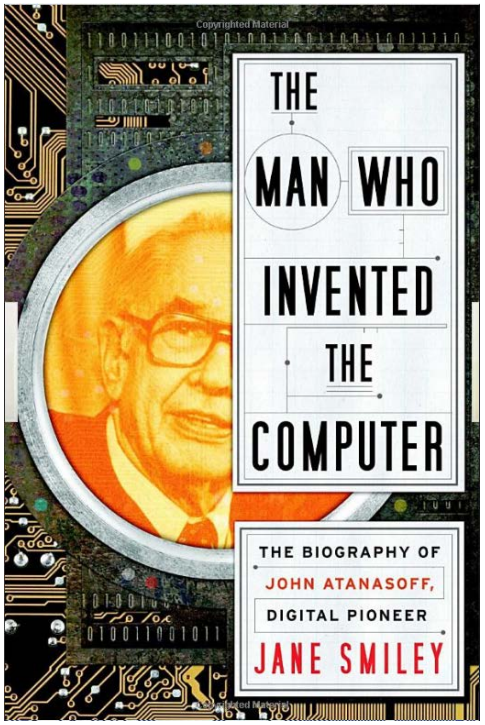
Church-Turing Thesis

- M is set out in terms of a finite number of exact instructions (each instruction being expressed by means of a finite number of symbols);
- M will, if carried out without error, produce the desired result in a finite number of steps;
- M can (in practice or in principle) be carried out by a human being unaided by any machinery save paper and pencil;
- M demands no insight or ingenuity on the part of the human being carrying it out.
- Today: Any task that can be reduced to a series of incremental steps can be automated

The Man Who Invented the Computer: John Vincent Atanasoff

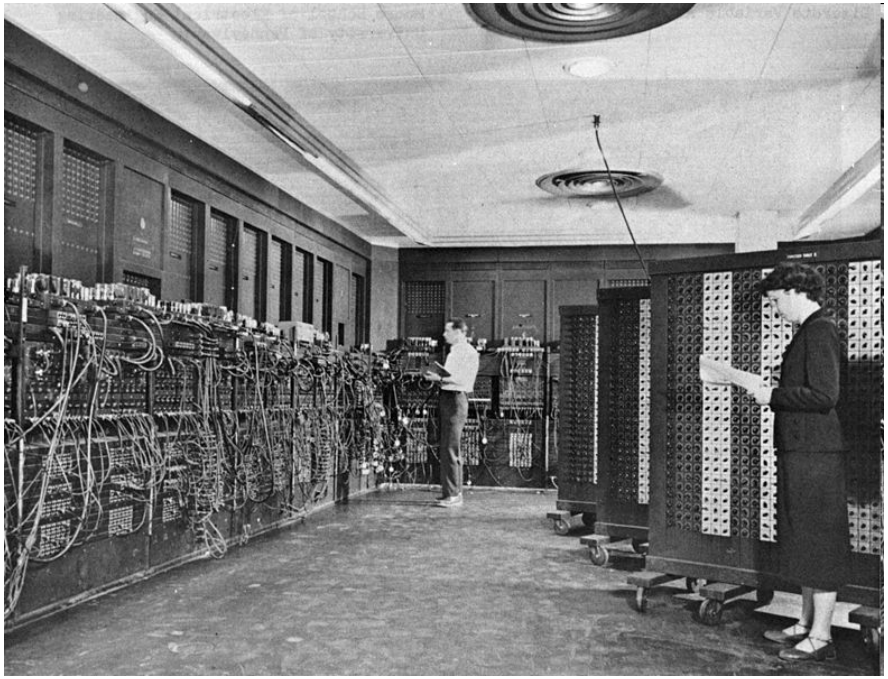
- Professor of physics at Iowa State University
- ABC: Atanasoff Berry computer developed 1934-1942 used Boolean logic
- Verified in 1973 when U.S Federal Judge Earl Larson voided the ENIAC patent of Mauchly and Eckert (Public domain-Turing)





ENIAC: Electronic Numerical Integrator And Computer

University of Pennsylvania's Moore School of Electrical Engineering

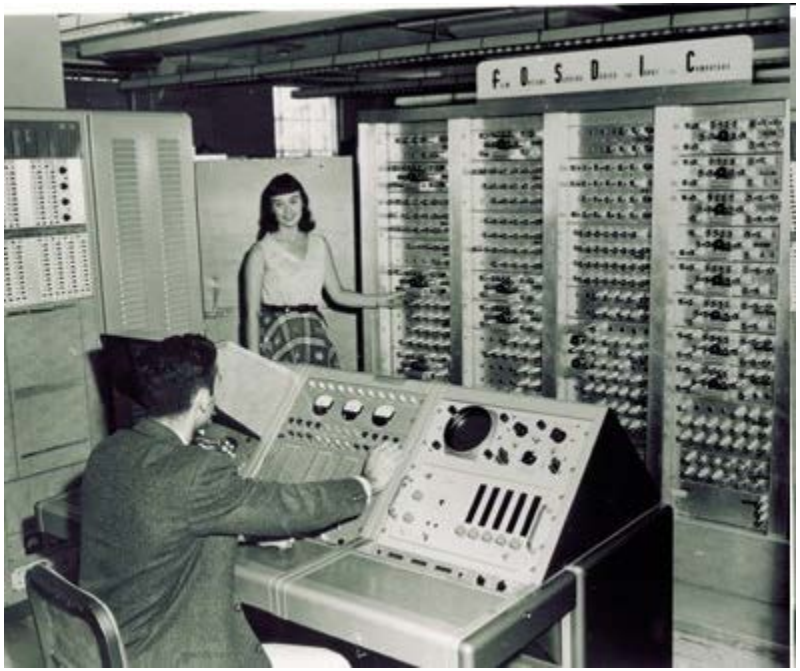


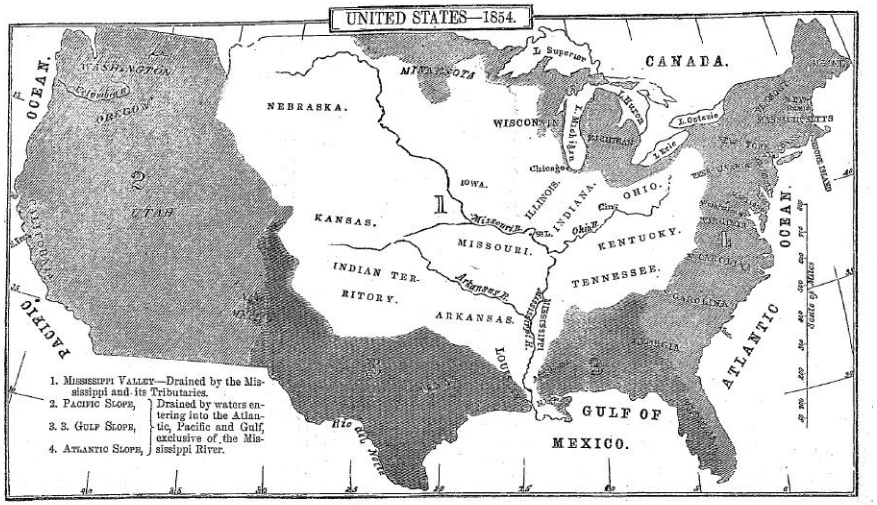
ENIAC contained
- 17,468 vacuum tubes
- 7,200 crystal diodes
- 1,500 relays
- 70,000 resistors
- 10,000 capacitors

5 million hand-soldered joints
Weighed more than 27 t
2.6 m × 0.9 m × 24 m
consumed 150 kW of power

Developed 1943-46 Operational 1946-55
Also Z4, EDVAC, Colossus, Harvard Mark 1
EDVAC and ENIAC sold to AMS and Census

First users: Census Mapping



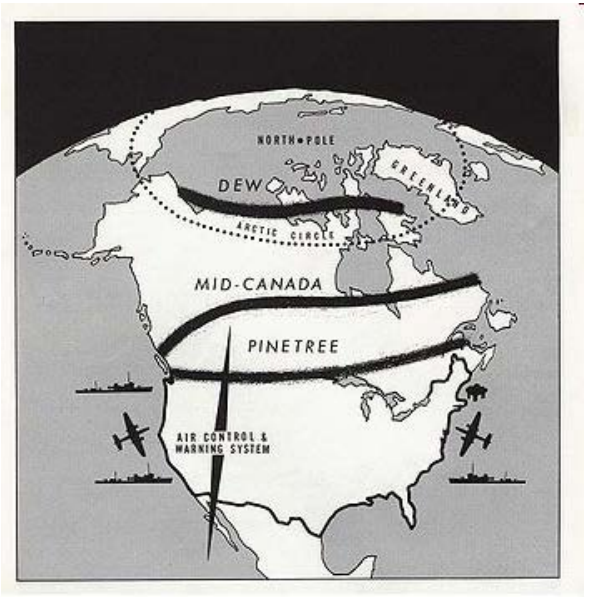


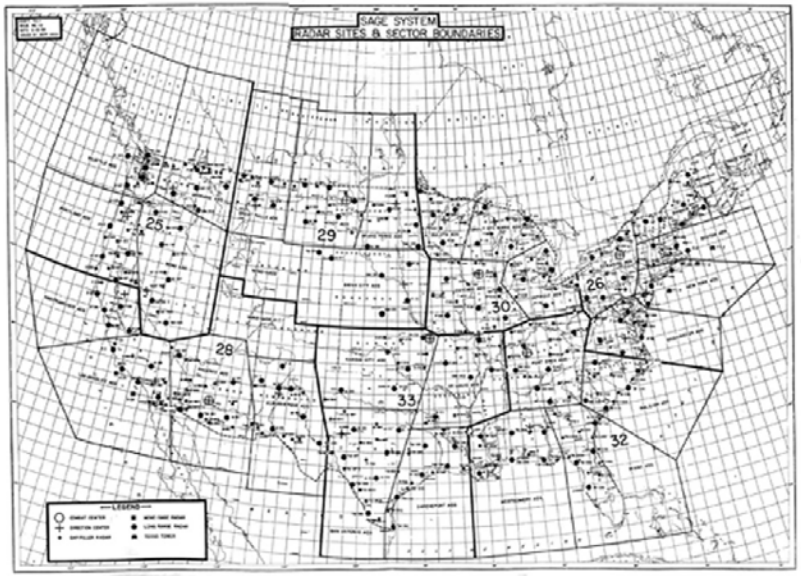
1950 UNIVAC

1980 GBF/DIME

1990 TIGER

- SAGE and the Cold War





Developed by MIT Lincoln Laboratory, IBM and others.

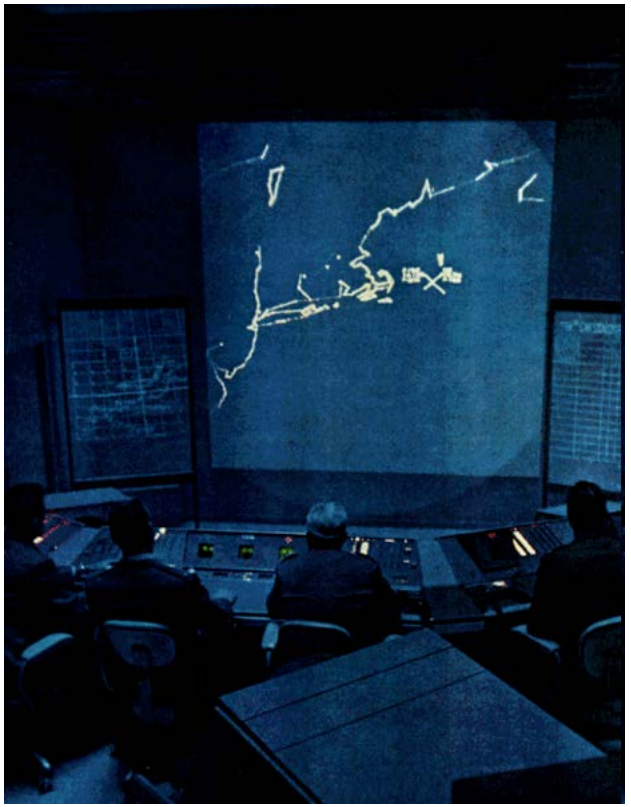
Operational in 1959

Part of North American Aerospace Defense Command (NORAD) until 1989

Servomechanisms Laboratory, under the direction of Jay Forrester (Systems dynamics)

SAGE: Semi Automatic Ground Environment

- Project cost between 8-12 billion dollars (1964)
- Pushed the limits of computing, networking, and control
- The AN/FSQ-7 computer contained 55,000 vacuum tubes, occupied about 2,000 m² of floor space, weighed 275 tons, and used up to three megawatts of power
- Telecommunications were radio and telephone based

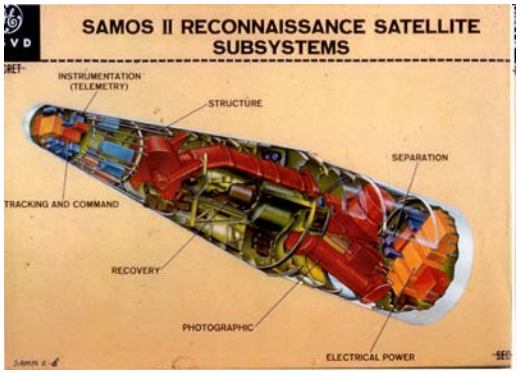


SAGE and Computer Cartography

- RAND in Santa Monica worked on Cathode Ray Tube Display & Workstation
- System included input and output
- Mylar map overlays become on-screen projected displays
- Tobler's classic "*Automation and Cartography*" 1959

CORONA’s Origins

- 1950/1 start of RAND Project FEEDBACK.
- December 1953 separated WS-117L at Wright Air Development Center. Languished.
- GENETRIX program 1953-4 640 “weather” balloons. C-119 capture designed, ITEK HYAC cameras used.



The Birth of CORONA

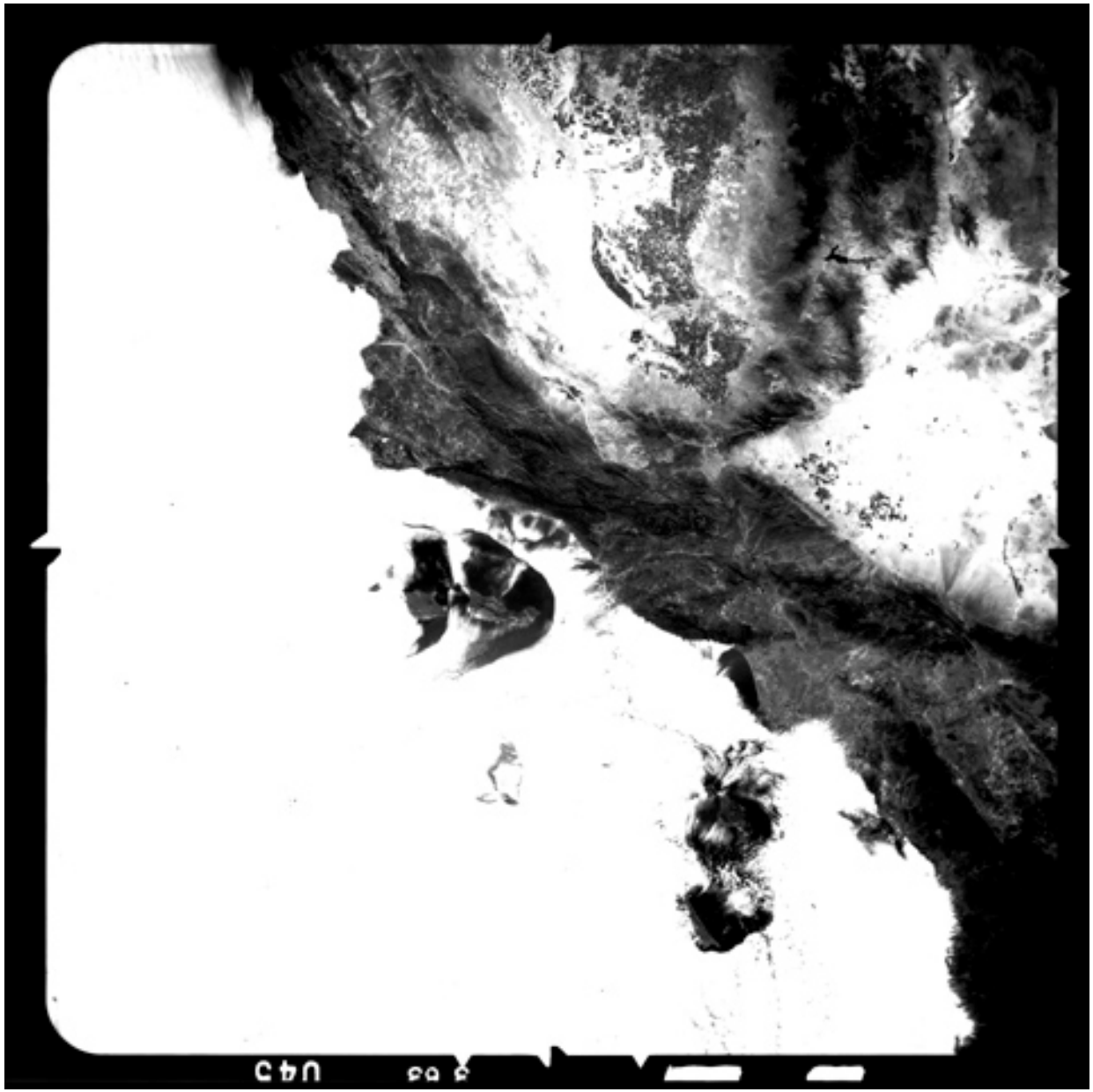
- “Denied territory”
- U-2 AQUATONE first flew 1955.
- By 1958 WS-117L went deep black and became CORONA
- Project Feedback became SAMOS
- Francis Gary Powers shot down in May 1st 1960
- Replacement SR-71 OXCART came in 1965
- But, in August 1960 CORONA achieved its first success

Discoverer at Vandenberg

CORONA by the numbers

- Length of program in years: 12
- Number of successful missions: 103
- Number of images taken: 800,000
- Mapped image coverage in sq. nm: 750 million
- Number of film canisters in the archive:39,000
- Length of film strips in feet: 2.1 million

KH-5 Argon Santa Barbara Channel



Santa Rosa Island in 1967: KH-4

Civil Applications Committee

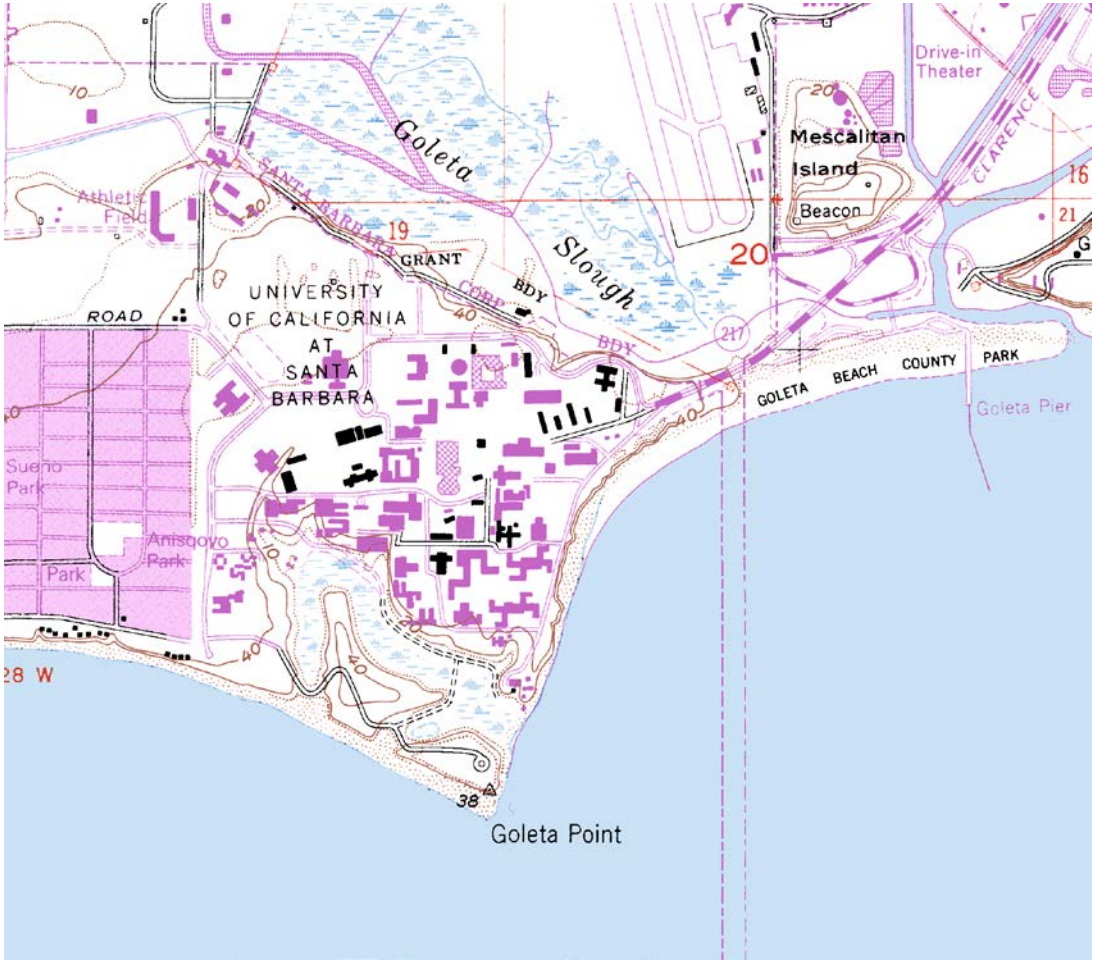
1965 **Department of Defense/Bureau of Budget study**
- Recommendation for Department of the Interior classified facility

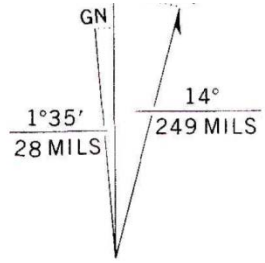
1967 **Steering Committee in Office of the President**
- Formal study on civil uses (Departments of the Interior, Commerce, and Agriculture; and NASA)

1969 **First USGS classified facility opens**
- Supports domestic mapping, charting, geodetic programs

1973 **Office of Management and Budget (OMB) study**
- Federal Mapping Task Force (Departments of the Interior, Commerce, Agriculture, and Defense; and OMB)

Map Revision

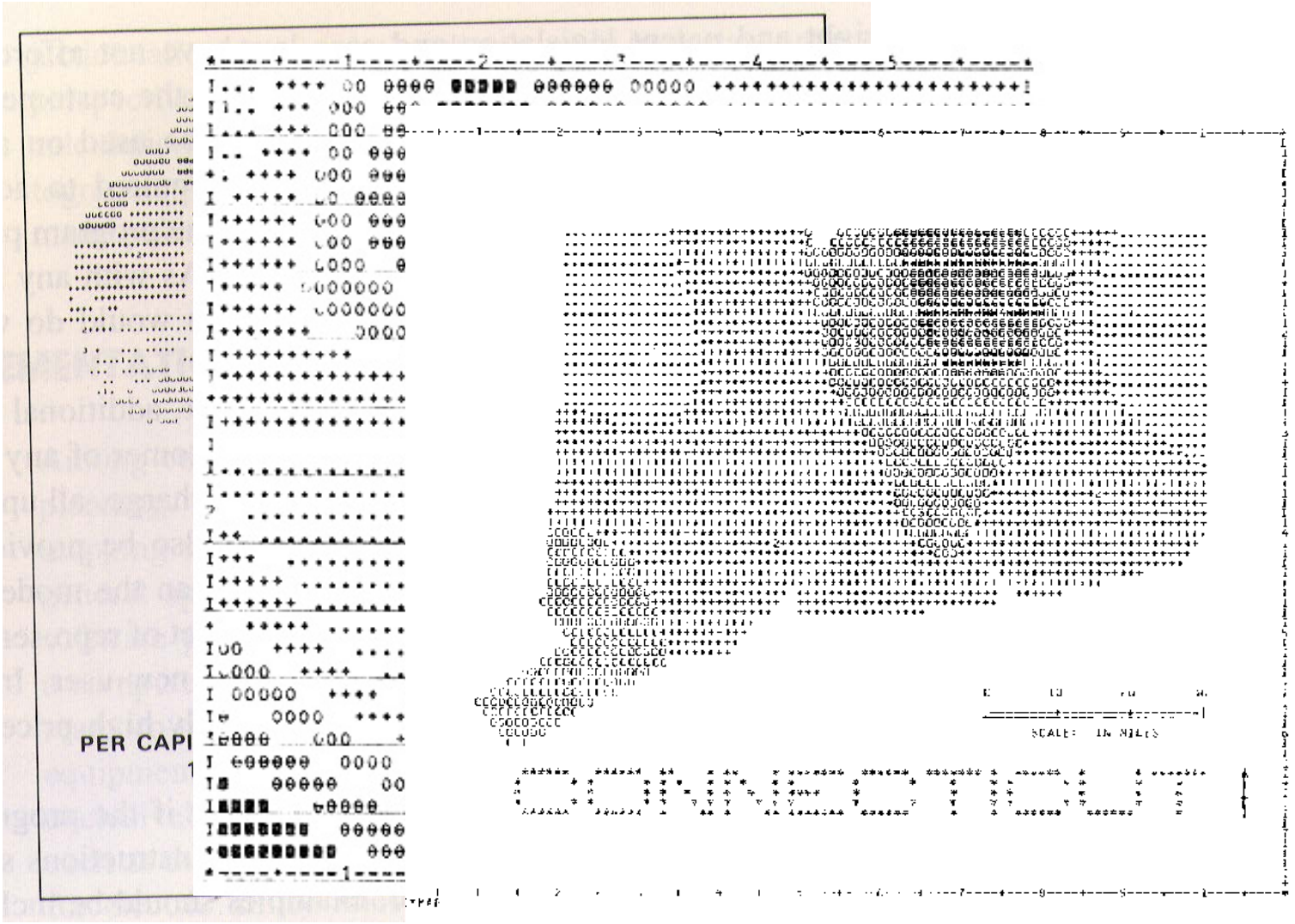




UTM GRID AND 1988 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

Revisions shown in purple and woodland compiled from aerial photographs taken 1984 and other source data. Partial field check by U.S. Forest Service. Map edited 1988

Early Computer-made Maps



Evolution of Computer Cartography

Some observations on computer mapping history

- Technology has a broader context
- National efforts spearheaded science
- Larger federal agencies fully integrated cartography and computer science e.g. Census, EPA, USGS, IC
- Computing history and cartography/graphics closer than might appear
- Computation theory for large scale problems (e.g. very large data bases) has implications for geodata
- Integration finally happening academically, e.g. IEEE, ACM

So what about the future? Say, 2061

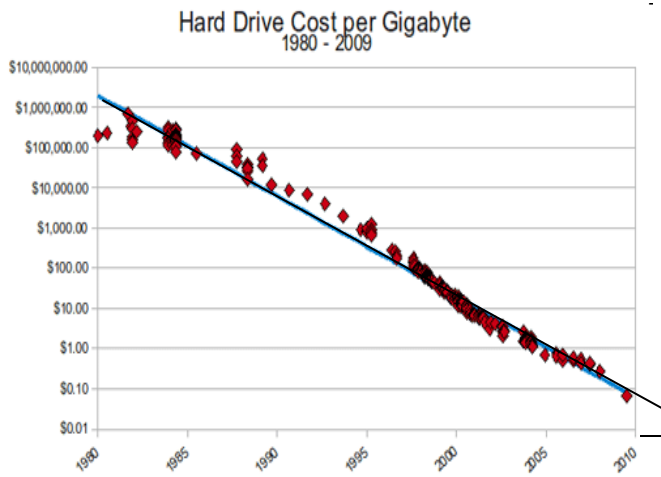
Six Trends

- Integration and interoperability Fusion
- Mobile
- Ubiquitous
- Web enabled
- Interactive Multimedia
- Biocomputing

Fusion and GeoData: today

- Proprietary vs. Open Source
- Accessible (i.e. Discoverable) vs. Isolated
- Protected, e.g. Private, Sensitive, Classified, Denied, Watermarked, Steganography
- Web-accessible, web-enabled, clearing house
- NSDI, GSDI, Digital Earth, OSM
- Imagery galore, high spatial/spectral resolution!
- Many imaging systems, including web cams and sensor webs
- Nascent grid, or cyberinfrastructure

Future Memory: Efficiency vs. Access



205MB: 1982

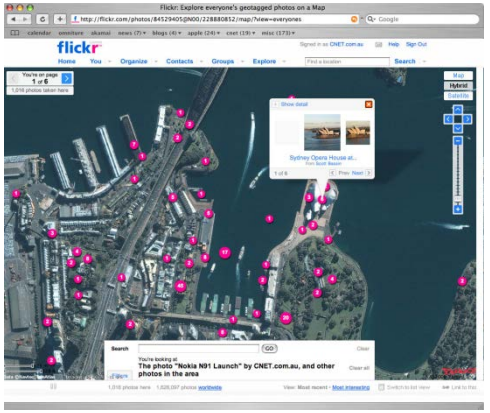
2061

Cost = 0

YouTube

Geo2061

- Smart images
- Feature level coding and metadata, Complete lineage
- Support for time-space-motion
- Real time wide area coverage
- Complete source integration with non-technical query e.g. speech, browsers
- Geographical intelligence:
  - Everything about here
  - What happened here?
  - What will happen here?

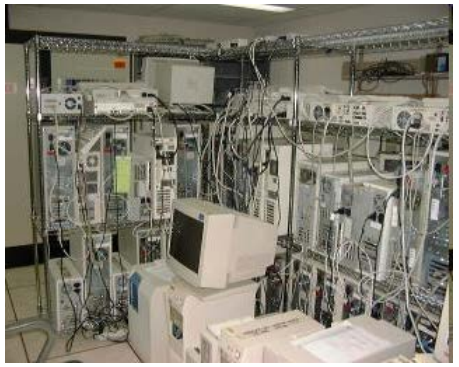


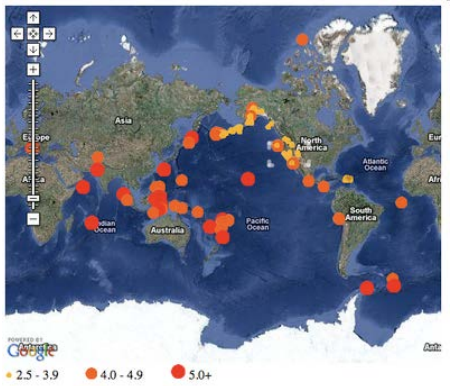
Mobile

- GPS/GNSS redundancy
- mm in seconds
- Works indoors, underground, underwater
- Integration with sensor webs
- Surgically implanted chips
  - (2006 Ben Thompson of ADC)
- GeoTime (Oculus)

Ubiquitous: Now

- Cyberinfrastructure
- Grid computing
- Mashups
- HPC: Massively parallel to Stone Supercomputer
- Geotools, server architecture, standards
- GeoWeb-enabled
- Cloud computing
- Crowd sourcing



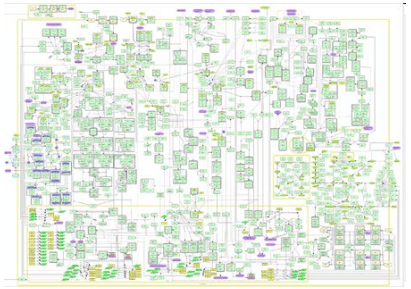


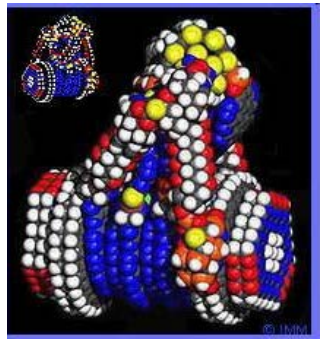
Ubiquitous 2061

- Reached limits of silicon-transistor based technology and Moore's law
- Shift to Quantum Computing and Nano-technology
- Theory already there: Q-Turing machine, Qubits, spin-state, spin-space
- A 300-qubit quantum computer has a state described by 2^{300} (approximately 10^{90}) complex numbers, more than the number of atoms in the observable universe
- Unimaginable computing capacity and storage
- The untractable will crumble, NP-hard

Q-GeoComputing

- A network of all things (“Internet of Things”) “A self-configuring wireless network of sensors whose purpose would be to interconnect all things.”
- Size will be miniscule, atomic, nano-machine integration (actuators, motes)
- Positioning within mm, microsecs
- Molecules can have memory, networks, processors
- A map can be its own analog!
- Positioning within a body, house, crowd, nation….





A biochemical "wiring diagram" of Budding Yeast
(extracted from K. Oda, H. Moriya, Y. Matsuoka, and H. Kitano,
A comprehensive molecular map of budding yeast, ver 0.5, Aug 2005

Web Enabled: Now

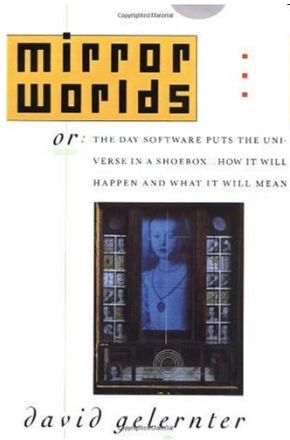
- Internet: ftp, e-mail
- Web: Search engines, http
- Web II: Social networks, twitter
- Spatial Web: 4Square, etc.
- Gaming
- Virtual organizations
- Government: eInitiatives

Web Mapping Now

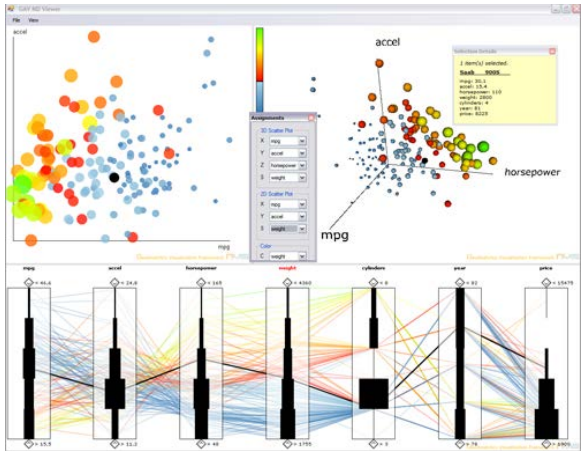
- Digital globes—interaction and visualization
- Immersion, e.g. stereo in GE
- 3D exploration emerging e.g. https://www.eegeo.com/about/
- Public contributions
- Position sharing
- Location Based services

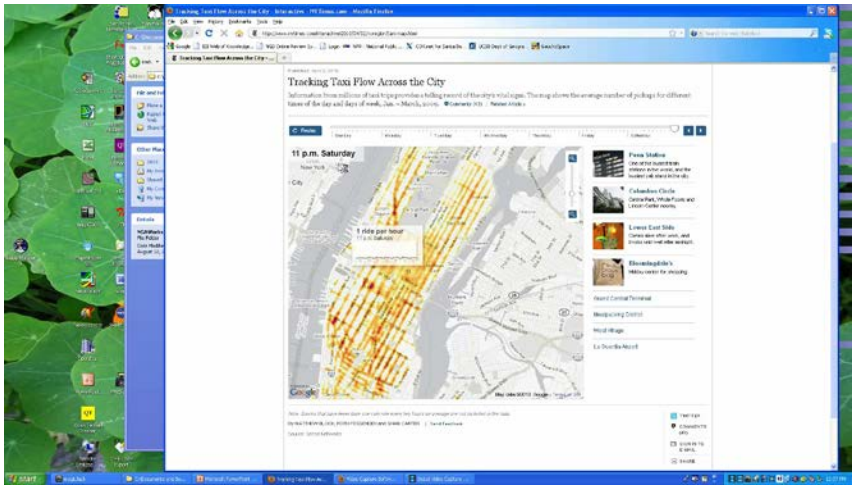
Web 2061

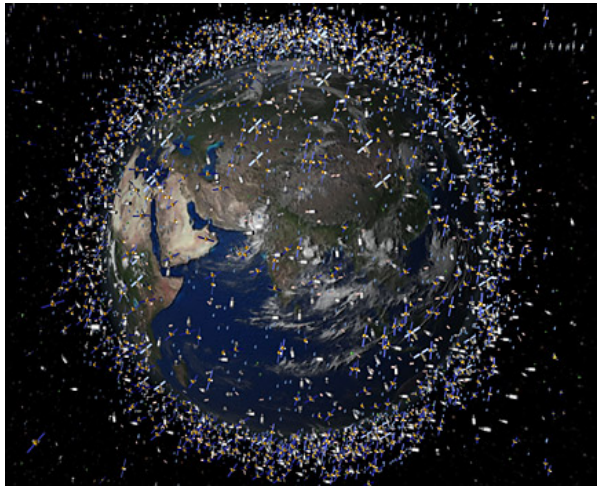
- Web as collective memory (GE, Flickr)
- Virtualization complete (Digital Earth, Mirror world)
- Reality slider, reality test
- Virtual travel to virtual experience, memory
- Could reinvent education!
- Expands role of sight: First glimpse is InfoViz and Visual Analytics

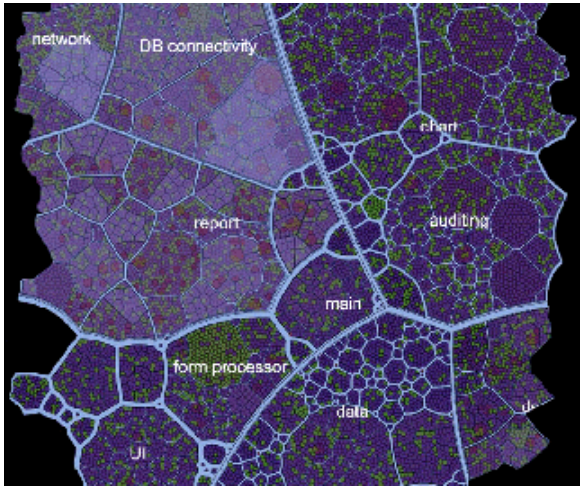


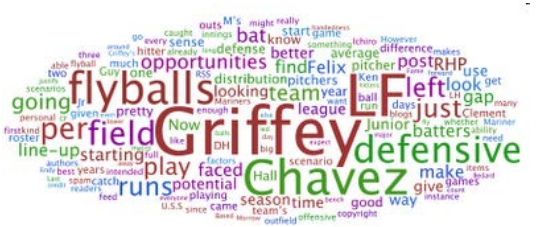
Visual analytics:
the science of analytic reasoning, facilitated by interactive visual interfaces.

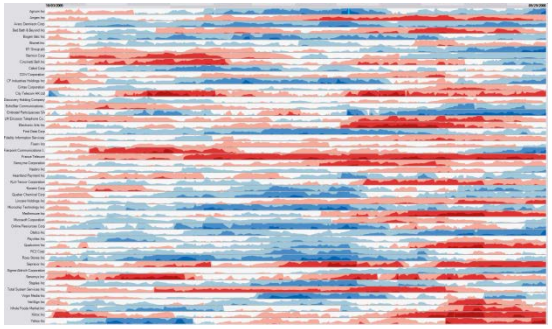












- http://vita.itn.liu.se/gav/gav/1.174303/GAV-Demo.png
- http://www.natural-environment.com/images/blog/space_junk_2.jpg
- http://kottkegae.appspot.com/images/taxi-flow-nyc.jpg
- http://ajperez.net/Images/InfoViz_small2.gif
- http://2.bp.blogspot.com/_InzW19CnouI/SaMDNpGClZI/AAAAAAAAAA8/3DGaPvuW7-Q/s1600-h/GriffeyWordle.png
- http://www.perceptualedge.com/blog/wp-content/uploads/2009/01/horizon-graph-large.jpg

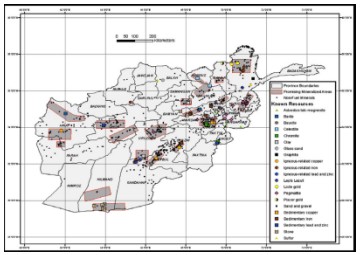
Interactive Multimedia 2061

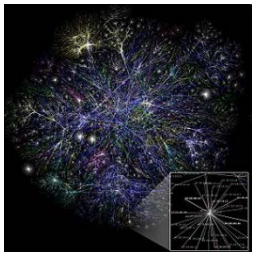
- Context sensitive computing
  - Environment
  - Location
  - Emotional context
  - Body language/gesture
  - Haptics
- Group interaction
- Rich documentation and help
- “Lost” Senses

Biocomputing
The “who” of computing

- Cyborgs (computer controlled mechanical systems enabling humans)

- Biomimicry
- Genetic engineering: Biocomputation
  - Custom creation of DNA, gates and switches
  - Breeding/growing an organic computer
- Where will innovation and resources reside in 2061?





In summary: 2061
(UCSB Geography still only 87 years old!)

- Integration and interoperability: Fusion
- Mobile
- Ubiquitous
- Web enabled
- Interactive Multimedia
- Biocomputing

- Who studies these in our discipline?
- Do we know our cartographic history (and future!)

A parting note

- *After growing wildly for years, the field of computing appears to be reaching its infancy (John Pierce 1910-2002)*

Summary

- Rich history in which CS and AC are intertwined
- Examples: CORONA, SAGE, Google Earth
- Examined six trends now and in 2061
- Much more to come!