

# Ubiquitous Computing

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What is it, and why are we here?

# First, some concepts, terms and definitions

- Sometimes referred to as UbiComp, The Internet of Things, even Industry 4.0
    - Web 2.0 is something different
    - What about the Internet of Services?
  - It's all about the data
  - The idea has been around for some time
  - There was a (hacked together) Internet toaster in 1990
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# Internet Toaster!



# What it involves

- Networking
  - Security
  - Databases
  - Sensors
  - Big Data
  - The Cloud
  - 'Smart' things
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# Some major concerns

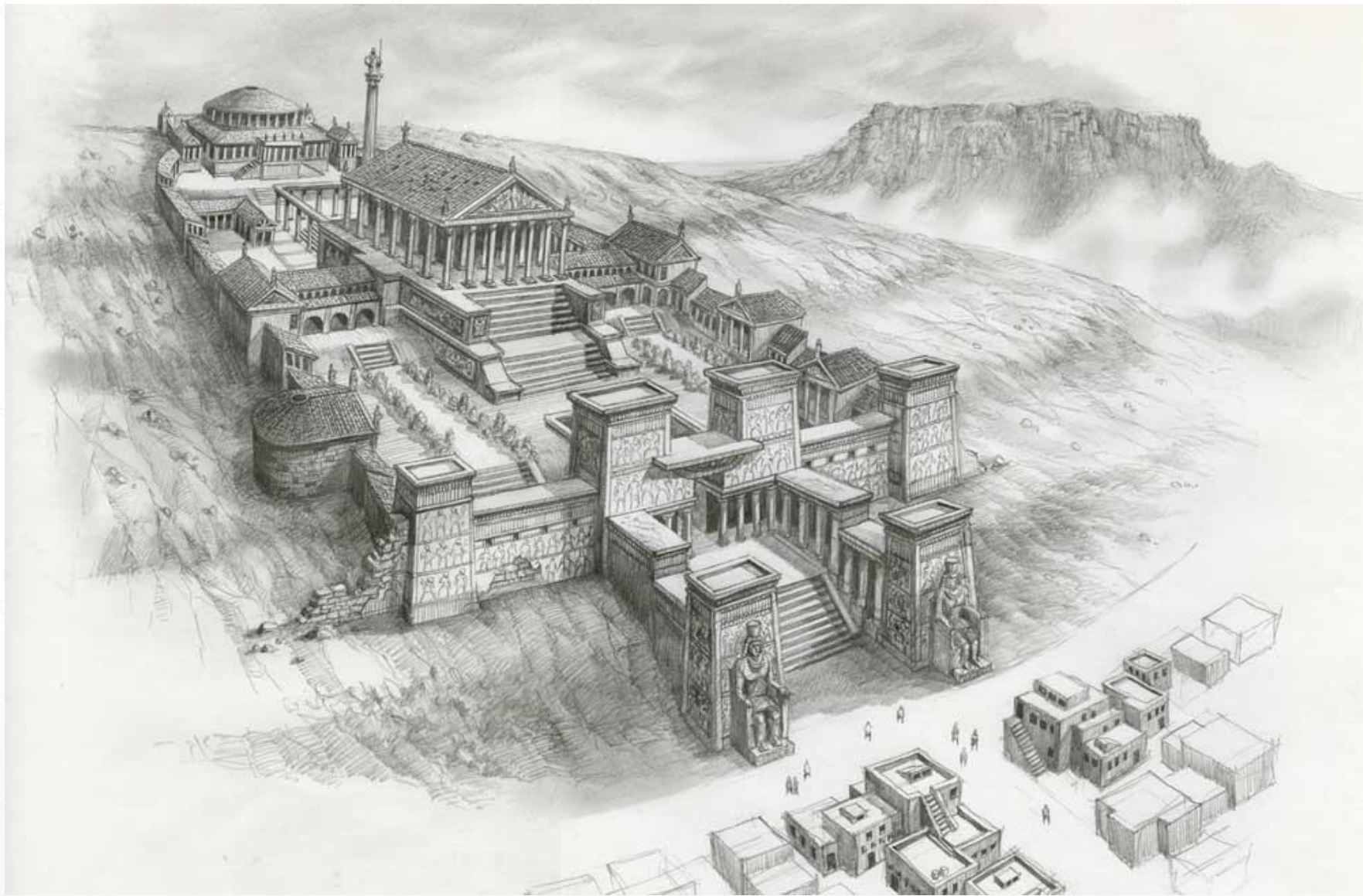
- Privacy
  - Security
  - Confidentiality
  - Storage
  - Unauthorized access
  - Bad actors
  - Domino effects
  - The human factor
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# History of data and information, and its use

- Data (Information, really) has always been important
    - It was as important in ancient societies as it is now
    - Back then, there wasn't as much information to digest
    - Information was slow to move, slow to have impact
    - But the information itself was very, very valuable (runners)
  - As society advanced, so did the amount of data it produced
  - There needed to be a way to analyze and interact with that data, as well as store it
  - The first widely accepted, impactful issue of data analysis manifested in 1880
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# History of data and information, and its use

- Writing didn't come into its own until recently
  - The storing of data and information meant skilled people would write down information in books, that were then stored in libraries
  - Ancient libraries were great stores of knowledge, but inefficient in terms of accessing and utilizing that knowledge
  - The Library of Alexandria
    - Original Wonder of the Ancient World
    - One of the most well-known ancient data-stores in history
    - Not terribly well-organized, housed scrolls, originals taken from owners
    - Cause of destruction is not known
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# Printing Press

- Origins are complicated
  - Moveable type?
  - Automation?
  - Ownership?
- Originally flat press
- Then Cylinders, offset press
- Even that is becoming obsolete



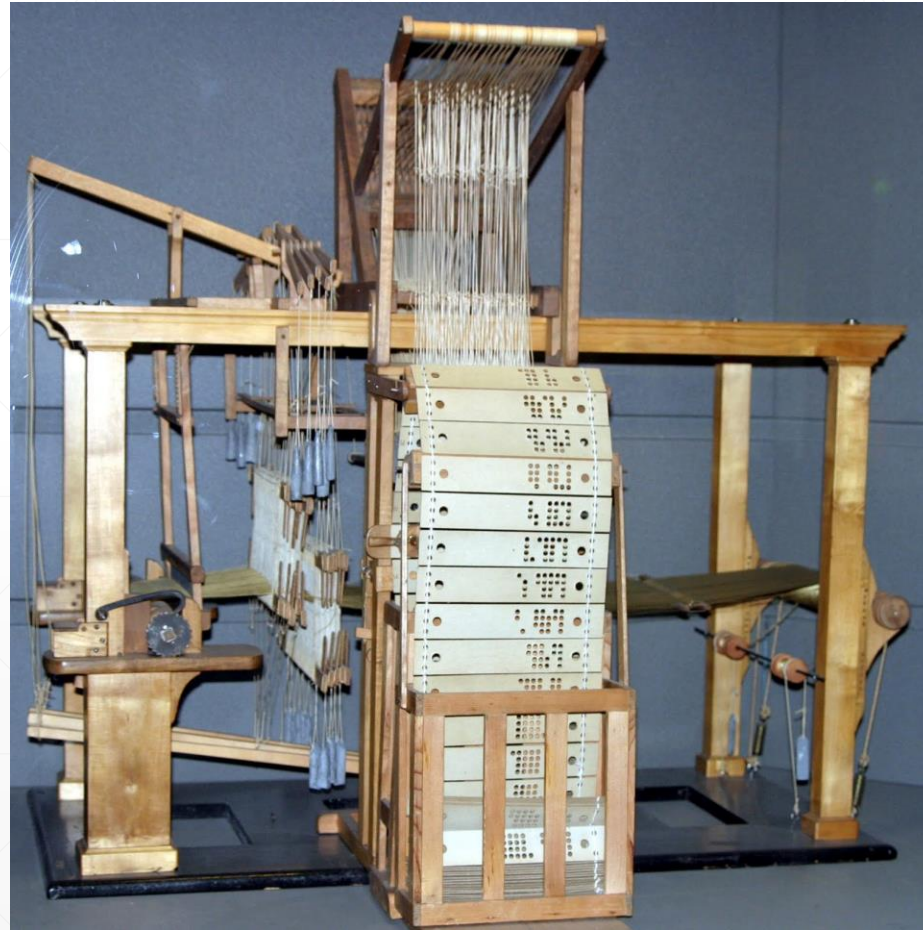


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# The Jacquard Loom



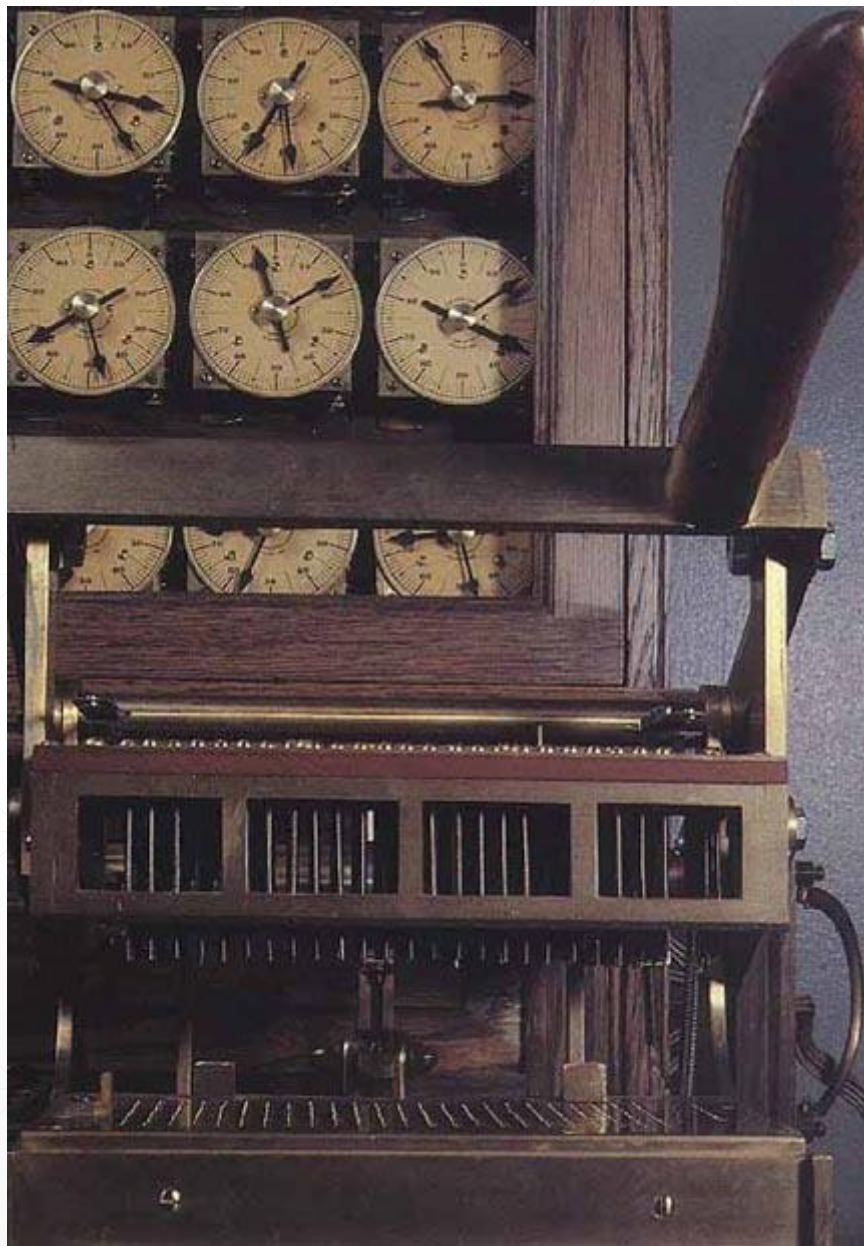
# The 1880 census

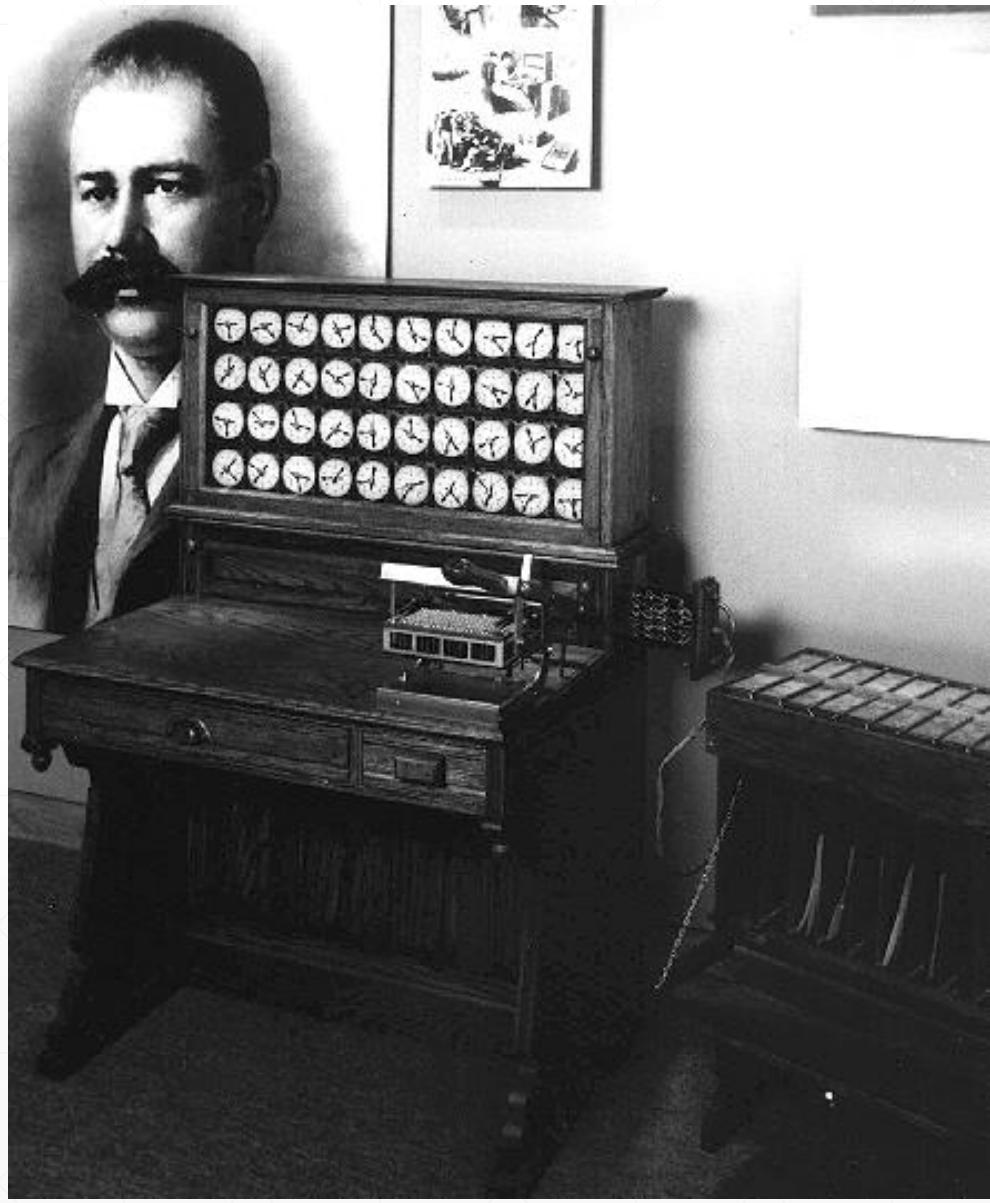
- One month to complete
  - Oklahoma was not yet founded, many western states were still territories, including Arizona, New Mexico, Utah, and Washington.
  - Estimated population: 50 million
  - Ended up taking eight years to analyze, rife with errors
  - The census is taken every ten years
  - If something wasn't done to improve the process, the 1890 census would be incomplete by 1900
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# The 1880 census

- Enter Herman Hollerith
  - Developed the Hollerith Tabulating Machine, which won a census contest
  - Information from questionnaires was punched into punch cards by operators
  - Those were then fed into the machine, which incremented a dial
  - The dial position was noted, and the card placed into a specific drawer
  - Reduced the time it took to tabulate the census from eight years to two
  - Saved approximately \$5 million
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The following questions were those included on the Population Schedule for the 1880 Census.

In Cities (Name of Street, House Number)

1. Dwelling houses numbered in order of visitation
  2. Families numbered in order of visitation
  3. The Name of each Person whose place of abode, on 1st day of June, 1880, was in this family.
  4. PERSONAL DESCRIPTION: Color — White, W. Black, B. Mulatto, Mu. Chinese, C. Indian, I.
  5. PERSONAL DESCRIPTION: Sex — Male, M. Female, F.
  6. PERSONAL DESCRIPTION: Age at last birthday prior to June 1, 1880. If under 1 year, give months in fraction
  7. If born within the Census year, give the month
  8. Relationship of each person to the head of the family -- whether wife, son, daughter, servant, border, or other.
  9. Civil Condition: Single
  10. Civil Condition: Married
  11. Civil Condition: Widowed / Divorced, D.
  12. Married during Census year
  13. Occupation: Profession, Occupation or Trade of each person, male or female
  14. Occupation: Number of months this person has been unemployed during the Census year
  15. Health: Blind
  16. Health: Deaf and Dumb
  17. Health: Idiotic
  18. Health: Insane
  19. Health: Maimed, Chrippled, Bedridden, or otherwise disabled
  20. Education: Attended school within the Census year
  21. Education: Cannot read
  22. Education: Cannot write
  23. Nativity: Place of Birth of this person, naming State or Territory of United States, or the Country, if of foreign birth
  24. Nativity: Place of Birth of the Father of this person, naming the State or Territory of United States, or the Country, if of foreign birth.
  25. Nativity: Place of Birth of the Mother of this person, naming the State or Territory of United States, or the Country, if of foreign birth.
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# The 20<sup>th</sup> century

- Population increases
  - Expanding body of general and scientific knowledge
  - First SSNs issued
  - Card catalogs in libraries widely adopted after 1911
    - A librarian first raised the concern over the abundance of information
  - Manufacturing was streamlined and began to be automated
    - This required extensive record-keeping of many aspects of a business
  - Publication and scientific advancement
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# The 20<sup>th</sup> century

- Shannon's Information Theory (1948)
    - Technical in nature
    - Information theory studies how we interact with information, cognitively
    - Shannon's paper refined and codified these principles for automation
    - Invaluable for many, many aspects of technology, from networking to speech recognition
    - Dealing with so much information is still a problem on the human front
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# The 20<sup>th</sup> century

- Centralized computing systems, mainly for business (mid-60s)
  - Relational databases (early 70s)
    - Data structure and skill becomes less relevant
  - Taking seriously the re-application of Parkinson's Law
    - I. A. Tjomsland, *Where Do We Go From Here?*, 1980
    - Work expands to fill the time available
      - True for many things (traffic, plates)
      - Here it's addressing storage
    - Do we keep obsolete data, or discard potentially useful data?
    - The issue of data creation v. storage impacts us even today
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# The 20<sup>th</sup> century

- Business Intelligence
    - Really comes into its own in 1990s
    - Relies on massive data collection
    - Impossible without databases (Excel spreadsheets don't count!)
    - Requires data mining
    - First database reports developed in mid-90's
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# The 20<sup>th</sup> century

- The Web
  - Not to be confused with the Internet
  - A revolution in information, sharing, access, and data creation
  - Had a relatively slow start, then exploded exponentially, as did devices (later)
    - December 1995: 16 million users
    - December 1996: 36 million users
    - December 1997: 70 million users
    - December 1998: 147 million users
    - December 1999: 248 million users
    - March 2001: 458 million users
    - March 2005: 888 million users
    - June 2010: 2 billion



# The 20<sup>th</sup> century

- Enormous increases in computing power
    - Moore's Law
    - Early on, advances were slow but still adhered
    - As computing use increased, computing power had to keep up
    - Not just computing power, but everything that went along with it (Networking, storage, memory, etc.)
    - The big bottleneck was the network
      - Creating data was getting easier
      - Sharing it not so much
      - Major improvements happened circa 1997 without which we wouldn't be here
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# The late 20<sup>th</sup> century

- Many issues popped up during the last few years
    - High-speed networking
    - A collision between the data being created and the infrastructure / expertise to handle it
    - Michael Lesk, *How Much Information Is There in the World?* (1997)
      - Abstract: This paper makes various estimates and compares the answers with the estimates of disk and tape sales, and size of all human memory. There may be a few thousand petabytes [\*] of information all told; and the production of tape and disk will reach that level by the year 2000. So in only a few years, (a) we will be able save *everything* - no information will have to be thrown out, and (b) the typical piece of information will *never* be looked at by a human being.
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# The late 20<sup>th</sup> century

- Many issues popped up during the last few years
  - “In 2008, Americans consumed information for about 1.3 trillion hours, an average of almost 12 hours per day. Consumption totaled 3.6 Zettabytes and 10,845 trillion words, corresponding to 100,500 words and 34 gigabytes for an average person on an average day.”<sup>1</sup>
  - “In 2008, the world’s servers processed 9.57 Zettabytes of information, almost 10 to the 22nd power, or ten million million gigabytes. This was 12 gigabytes of information daily for the average worker, or about 3 terabytes of information per worker per year. The world’s companies on average processed 63 terabytes of information annually.”<sup>2</sup>

<sup>1</sup>Source: *How Much Information? 2009 Report on American Consumers*, Bohn & Short, 2009

<sup>2</sup>Source: *How Much Information? 2010 Report on Server Information*, Bohn, Short & Baru, 2011

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# The 21<sup>st</sup> century (minus one)

- 1999 – The Internet of Things
  - ~2000 – Cloud computing
    - Storage, processing, tech outsourcing, VMs,
    - Software as a Service
    - Social Networking, and web 2.0
    - Smart devices
      - Appliances, machines, consumer devices, systems, people, everything
      - Farming, agriculture, aviation, medicine, law enforcement, retail, manufacturing, utility
      - Smart everything, to control, or be controlled
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