L1: Intro to Computer Systems: Controlling Complexity

Frans Kaashoek

6.033 Spring 2007
http://web.mit.edu/6.033

Logistics: http://web.mit.edu/6.033

- Schedule has all assignments
  - Every class meeting has preparation/assignment
  - First deliverable is due Tuesday 2/13.
  - To help you: read the Therac paper before Friday's writing recitation.
- Fill out sign up sheet and return at the end of lecture ▪ (if you didn't do so yesterday)
  - We will post sections assignment tonight

Monday	Tuesday	Wednesday	Thursday	Friday
5.feb *Registration Day*	6.feb *REC 1* WORSE IS BETTER *First day of classes*	7.feb *LEC 1* INTRO TO SYSTEMS Preparation: Read Ch. 1.A, 1.B, 1.C (click on link)	8.feb *REC 2* THE ARCHITECTURE OF COMPLEXITY Preparation: click here	9.feb WRITING PROGRAM RECITATION Preparation: click here

Emergent Property Example

- Experimental Ethernet design: 3Mbit/s
  - All senders share single cable
  - Send successful when there is no collision
  - Must send for 2*5 μseconds = 30 bits
  - Header is: 5 bytes = 40 bits
- First Ethernet standard: 10 Mbit/s
  - Must send for 2*20 μseconds = 400 bits
  - Header is: 14 bytes
    Need to pad packets to at least 50 bytes

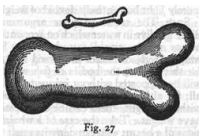
  Minimum packet size!

Propagation of Effects Example (C. Cole 1969)

- WHO attempted to control malaria in North Borneo
- Sprayed villages with DDT
- Wiped mosquitos, but ….
  - Roaches collected DDT in tissue
  - Lizards ate roaches and became slower
  - Easy target for cats
  - Cats didn't deal with DDT well and died
  - Forest rats moved into villages
  - Rats carried the bacillus for the plague

  WHO replaced malaria with the plague

Galileo in 1638

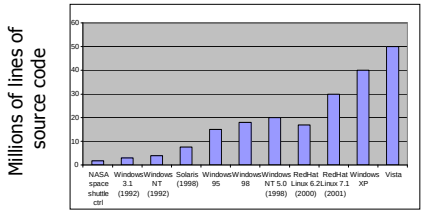


"To illustrate briefly, I have sketched a bone whose natural length has been increased three times and whose thickness has been multiplied until, for a correspondingly large animal, it would perform the same function which the small bone performs for its small animal. From the figures here shown you can see how out of proportion the enlarged bone appears. Clearly then if one wishes to maintain in a great giant the same proportion of limb as that found in an ordinary man he must either find a harder and stronger material for making the bones, or he must admit a diminution of strength in comparison with men of medium stature; for if his height be increased inordinately he will fall and be crushed under his own weight. Whereas, if the size of a body be diminished, the strength of that body is not diminished in the same proportion; indeed the smaller the body the greater its relative strength. Thus a small dog could probably carry on his back two or three dogs of his own size; but I believe that a horse could not carry even one of his own size."

Incommensurate scaling

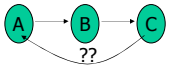
- Scaling mouse to size of an elephant (Haldane 1928)
  - Volume ~ $O(n^3)$
  - Bone strength ~ cross section ~ $O(n^2)$
- Scaling the Internet
  - IPv4 has 32 bit addresses; limited networks (2^{16})
  - Network Address Translators and IPv6
- Scaling Ethernet from 10Mbit/s to 1Gbit/s
  - Minimum packet size: 40x100Mbit/s = 4,000 bits
  - 100 Mbit/s: shorten the maximum cable length to 250m
  - 1 Gbit/s: increase minimum packet size to 512 bytes
  - Switched architecture: don't share cable

Example: more goals, more complexity operating systems



Example: interacting features, more complexity

- Call forwarding
- Call Number Deliver blocking
- Automatic callback
- Itemised billing



- A calls B, B is busy
- Once B is done, B calls A
- A's number on appears on B's bill

Principles

- Principle escalating complexity
- Avoid excessive generality
- Law of diminishing returns
- ….. Many more to come ….

Class plan

- Next lecture: computer systems are different
- Naming: glueing modules together
- Client/server: enforced modularity
- Networks: hard boundaries between modules
- Reliability and transactions: handing failures
- Security: handling malicious failures