Lecture 2

CS625: Advanced Computer Networks
Fall 2004

Wednesday, 30 July 2003
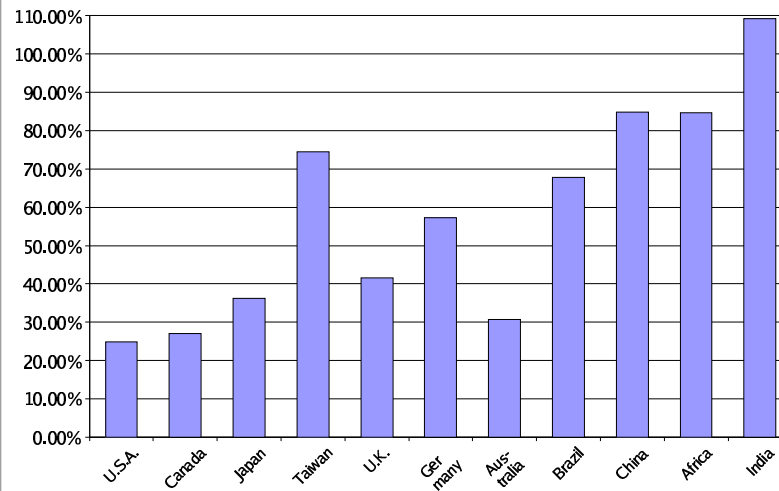
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http://www.cse.iitk.ac.in/users/braman/courses/cs625-fall2004/outline.html
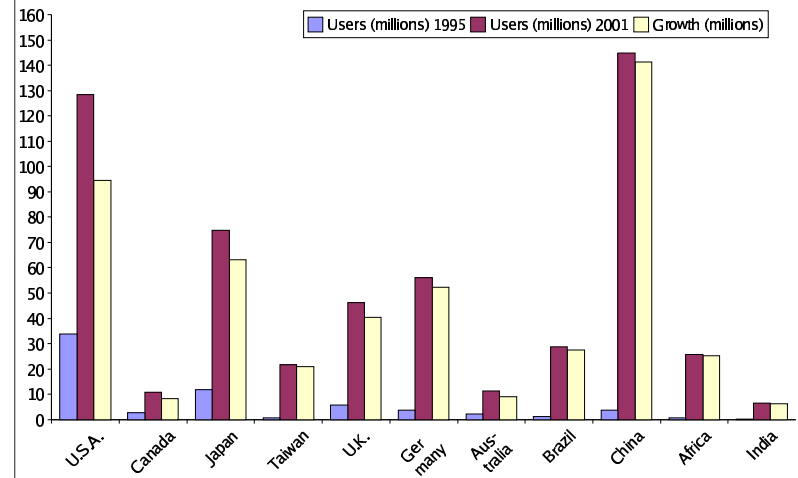
Outline for Today

- A little digression into some Internet statistics
- The end-to-end design principle
- *Scribe for today?*
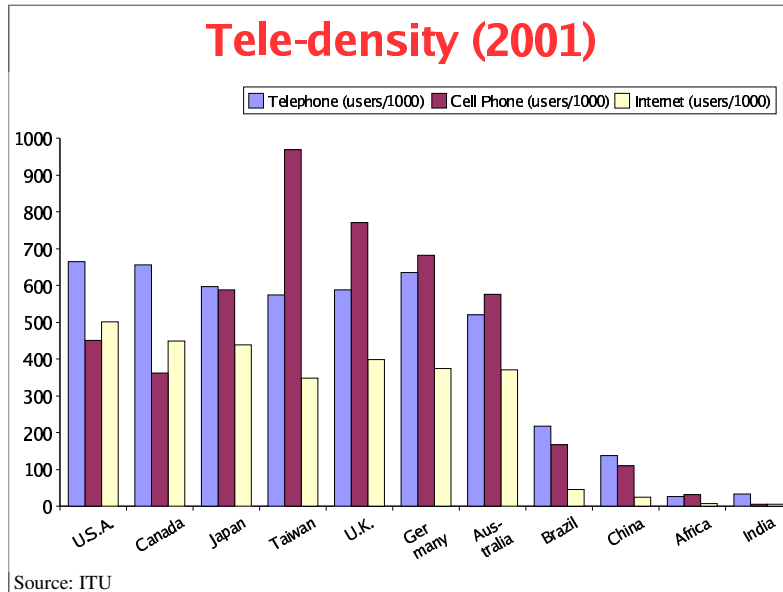
Cell Phones: CAGR 1995-2001

Source: ITU

Cell Phones: Absolute Growth

Source: ITU

Tele-density (2001)

Legend: ■ Telephone (users/1000) ■ Cell Phone (users/1000) □ Internet (users/1000)

Bar chart with y-axis 0 to 1000 (increments of 100), x-axis categories: U.S.A., Canada, Japan, Taiwan, U.K., Germany, Australia, Brazil, China, Africa, India

Source: ITU

What functions in what layers?

- The *end-to-end design principle* is a guide to determine what functionality should go in what layer/module in a system
- Can apply to
  - Networking systems
  - Operating system kernel modules
  - Processor architectures
  - Security systems
  - Other general systems too...

The End-to-End Principle

- Implement a function in a layer *only if it can be fully and correctly implemented at that layer*
- The function may be *partially implemented* as a performance enhancement

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Some Terminology

- *Upper/Higher* layer, *Lower* layer
- *Service, Function/Functionality:* A desirable property, implemented by a lower layer, used by upper layers
  - Examples: Reliable packet delivery, Secure delivery

Illustrating the e2e Principle

- File transfer application [SRC84]:
  - Read from file system
  - Transfer through communication network
  - Write to file system
- Sources of error:
  - Hardware faults while reading file
  - Communication system may be unreliable
- *Correctness* of file transfer can be checked/guaranteed *only* by the application

Another Example

- File transfer via three networks:
  - Ethernet, Optical, and Wireless
  - At which layer to implement *reliability* for the file transfer?

When to (partially) implement a function at a lower layer?

- When it is:
  - Possible to implement it without much perturbation
  - Performance improves
  - Many higher layer implementations (applications) find use for it
- Caveats in lower layer implementation:
  - All apps may have to use it, even if not required
  - Lower layer may not have enough information for efficient implementation

Other Examples for Discussion

- HTTP proxy
- Delivery guarantees:
  - Reliability, In-order delivery, Duplicate suppression
- Security, authenticity
- Real life banking system
- RISC
- Caching by the Operating System

The Lectures Ahead

- This week:
  - Medium-Access mechanisms
  - Adaptive LLC for wireless links
- Next week:
  - Internet routing
  - Border Gateway Protocol (BGP)
  - OSPF: Open Shortest Path First