Bits and The Internet

Atoms vs. Bits

Atoms

What do you spend your time doing every day? Mostly we think of arranging and moving around physical objects — **atoms**. Food, shelter, cars, walking, eating, ...

Bits

Another class of activity has the goal of simply moving information around — **bits**. Television, newspaper, books, telephone, newspaper, checks, video, ATM cards, photos, college.

"Bit" problems can be solved with minute amounts of electricity, light, magnetism, etc. .... no atoms required. Ultimately, bit problems can be extremely cheap to solve.

Compare

Atoms are expensive and constrained compared to bits. Atoms are constrained by physical location and time. They require energy and more atoms to be arranged and duplicated.

Bit Technology

Bit Tech: Better and Cheaper

If you ever find yourself playing the role of talking head on TV as some sort of pundit, and you need to make some sort of vague prediction about the future, IMHO here is a safe trend to depend on...

> In the next 50 years, our ability to store, move, and manipulate atoms and energy will increase by a factor or 2 or so.
>
> Our ability to store, communicate, and manipulate information will increase by a factor of 1000. Manipulating bits is basically cheap.

The three fundamentally costly things in this world are: materials (atoms), energy, and labor (human attention). A highly developed digital information infrastructure does not depend too greatly on any these compared to traditional activities (all atoms or energy oriented) like food, travel, consumerism, warfare.

Imagine a world where bit handling is so cheap, it's everywhere – like air. We're just immersed in it.

Smaller = Cheaper

Bit technology can use electricity, optics, magnetism ....and in decreasing quantities each year as transistors get smaller and smaller. Feynman's "there's plenty of room at the bottom" talk.

In other words, you can take bit technology, shrink it by a factor of 1000 physically, and it can still work to manipulate bits.

Information Problems

An "information problem" is a problem that can be solved by the proper flow of information. Solving the problem does not require rearranging atoms.

The problems below are all pure information (aka "bit") problems, requiring only the movement of bits, and yet they are solved with atoms (bits of paper, queue's of people, ...)

Car Lock, Door Lock

Locked out of your car -- you want the car to let you and the people you authorize in, and not other people.

Grocery Store

Grocery store check out line -- the grocery store wants to know what you bought and cause the right amount of money to change hands. This is a four way information problem between you and the grocery store and your respective banks.

Restaurant

You and 200 other people all want to eat at the Hobee's roughly between 10:00 am and noon this Saturday morning. 50 of you can be eating there at any one time. Staggering everyone in is a pure information problem. I especially like this example, since your own physical body is used as the physical token to solve the bit problem. It helps emphasize the lameness of the atom based solution.

Meeting Friend

You and a friend arrive separately at a Stanford basketball game. You'd like to sit together, but you can't find each other. Or maybe the friend bailed, but you're not sure. Before the invention of the cellular phone, this problem would seem just as insoluble as the others. “Genius is an African who dreams up snow.” — Vladmir Nabokov

Mugging

I want to go for a walk at night, but I'm afraid of being mugged. The problem is that the mugger can conceal their identify. If my wristwatch or the park itself or whatever just knew and recorded who was around me, then I wouldn't be afraid of being mugged. The mugger knows about the watch, so they won't try anything. This is why you feel safer in a parking lot that's illuminated and has security cameras. The watch that knows who's around, the cameras -- these are pure bit technologies.

This sort of social policy is called "transparency", and it's a whole topic of its own; it runs counter to "privacy" so it's contentious.

DMV Registration

Register your car with the DMV -- just an exchange of bits between you, the DMV, the police, your insurance company, possibly the previous owner, your bank, and the DMV's bank. This is my reference problem for the "paperless world of the future". When you can register a car with the DMV using only bits ...we will have arrived.

Information Problems

We are positively surrounded by unsolved information problems. That's why I think information technology is so exciting -- so much potential.

The "It's an information problem" Game

Notice in your life when you are significantly blocked by an Information Problem. Its easy to notice when you are blocked since you typically get to stand around with nothing to do.

Information Problem Potential

Information Opportunity

Surrounded by information problems, most of them unsolved. It does not occur to us, say, that we should be able to walk up to our car and have it open for us, or walk around at night and feel safe.

We tend to think of them as unsolvable or we mischaractersize them as atom-based problems because that's how they are traditionally solved : a physical key for you car, forming a line at a restaurant.

Recognize the true underlying information problem.

The technology to solve information problems is basically cheap and getting cheaper, more portable, more available...

Conclusion: a trend of more and more solved information problems.

Exercise: Wait until the year 2030. Attempt to explain to a child that when you were young, you had computers, but they weren't all "connected" all the time. That to remember a quotation or a person's contact information, you had to write it down and then be able to find the paper later. To look something up, you had to go hunting through books.

Information Example

See the newspaper classified ad business. See the Internet. Opportunity...
Wrong: take the classified ads, and put them online
Right: found ebay.com
Point: classified ads were not ultimately what people wanted, really they wanted to many-to-many connections to exchange goods.

The Internet

In the pre-Internet world, we used computers for computation.
With the Internet, we learned that the most interesting information problems rely on communication.

Challenge

Need a way for computers to exchange bits with each other
Need vendor-neutral public standards, so various types of computers can talk to each other.
Individual vendors have a hard time talking to each other without a public standard to force it.

The Internet Niche

Like the telephone system for computers— "enabling" in the extreme.
Format: Digital
- Digital is the ultimate information format
- If you were on a desert island and could only get one sort of media, what would you chose? Digital! It can express all the others.

Device: Computers
- Computers are the ultimate information appliance
- More versatile than TV, telephone, fax, pager, etc.. all rolled into one

Connection: Internet
- The Internet — connecting all the computers. "The telephone system for computers."
- The final key step.

Standards
- (these happen to mirror the 193i syllabus basically)
- Standards for how the basic communication infrastructure works (TCP/IP)
- Standards for how the data is formatted (HTML, JPEG, XML)
- Standards for how the computers interact with each other (HTTP, CGI)

Standards -- Any-to-Any

With standards in place, any computer can talk to any other computer
This is perhaps the basic secret of the Internet -- that supporting any-any connections unleashes a lot more value than something that just works for 80% of the computers.

n^2 Network Effect

A "network effect" is a system where the total utility of the system is proportionate to n^2. (also known as Metcalfe's Law). The explosion of the Internet is an example of this virtuous cycle: public standards → any-any connections → n^2 network effect.
<http://www.mgt.smsu.edu/mgt487/mgtissue/newstrat/metcalfe.htm>

An example of Metcalfe's Law in the modern day Internet and WWW would be AOL instant messenger, or Friendster. Imagine if only 2 people were using Friendster. Only

one friendship can be formed. Not too useful. Four people allows 6 potential friendships. Ten people allows 9 + 8 + … 2 + 1 = 45 friendships. N people will allow for N (N-1) / 2 friendships. We thus can see that the utility of a networking application such as Friendster or AOL IM increases at the same rate as n-squared.