

# Atoms vs. Bits

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“The universe is looking less and less like a great machine and more and more like a great thought.” — Ortega Y Gasset

“Genius is an African who dreams up snow.” — Vladimir Nabokov

## 1. 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.

Our "bit" problems are often currently solved with atoms -- e.g. newspaper, car keys. Using atoms for the solution is costly and constraining. Bits are potentially much cheaper.

We tend to think of a daily life of atoms (objects, location, form) with information being just a means to that end. In fact, just the reverse may be true.

## Information Problems — It's The Bits

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### Stupid

An "information problem" is a problem that can be solved by the proper flow of information. Solving the problem does not require rearranging atoms. All the parties want to cooperate; what's missing is **communication**.

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. See Nabokov quote above.)

## Selling Old Junk

I have the intake manifold to a '79 VW bug sitting in my garage. They sell for \$200 retail, but I would be delighted if someone would give me \$30 for it and take it away. There is someone nearby who wants the manifold, but we don't know about each other. And if we do know about each other there's the "trust" information problem to be solved to make the exchange (See the Information Opportunity Example below)

## 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 while you feel safer in a parking lot that's illuminated and has security cameras. The watch, the cameras -- these are pure bit technologies. This sort of social policy is called "transparency", and it's a separate topic; it happens to run 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, 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

(This exercise is based on a long-running joke between me and my friend Brian Skinner, for example when I lock us out of my car or when we are standing in line for dinner without reservations) 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. Whoever recognizes the situation first gets to say "You know what kind of problem this is?" to which the reply is "this is an information problem" with the possible addendum "when we describe to our grandkids that we used to spend time doing this, they are going to laugh their heads off."

## **2. "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 of 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. 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 information handling is so cheap, it's everywhere -- like air or water. 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.

In other words, you can take bit technology, shrink it by a factor of 1000 physically, and it can still work to manipulate bits. Obviously this doesn't work for atom technology like cars, food, housing.

## 3. 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 mischaracterize them as atom-based problems because that's how they are traditionally solved : a physical key for your 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 in college you had computers, but they weren't all "connected" all the time (at least when I was an undergraduate). 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.

## 4. The Internet

### The Internet Niche

Like the telephone system for computers— "enabling" in the extreme.

We used to think computers were for computing. Now we recognize that many information problems also depend on communication.

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 choose? 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.