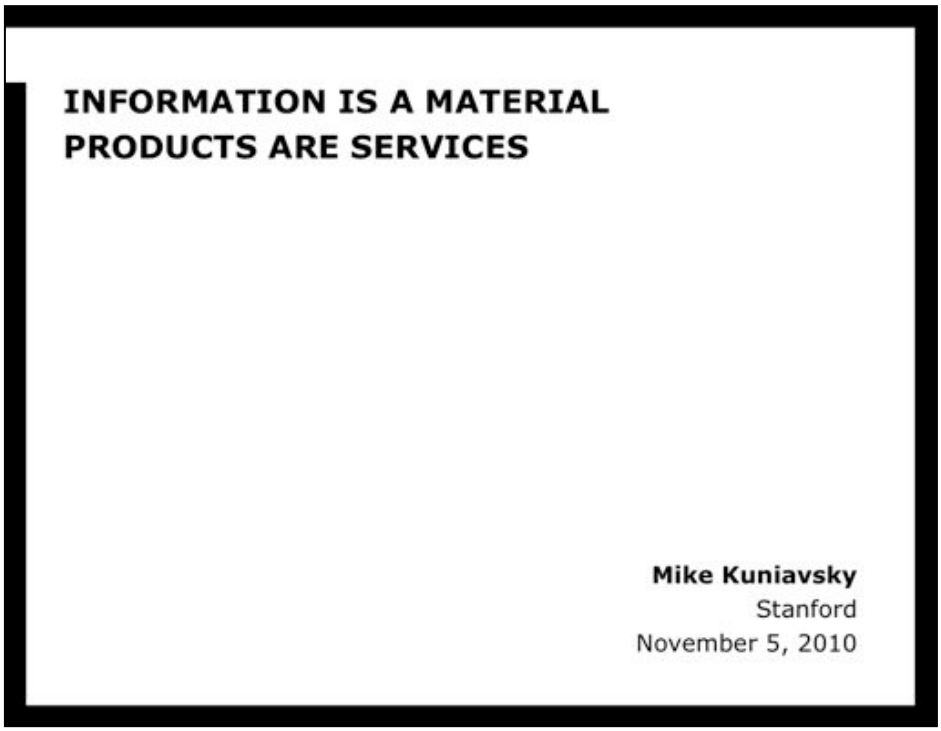
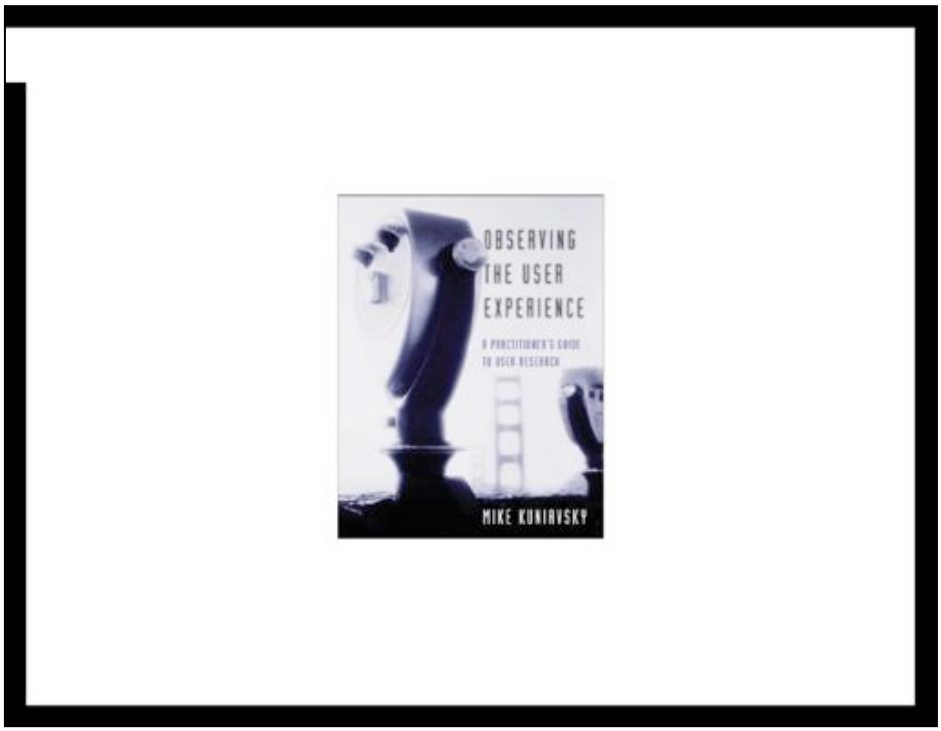


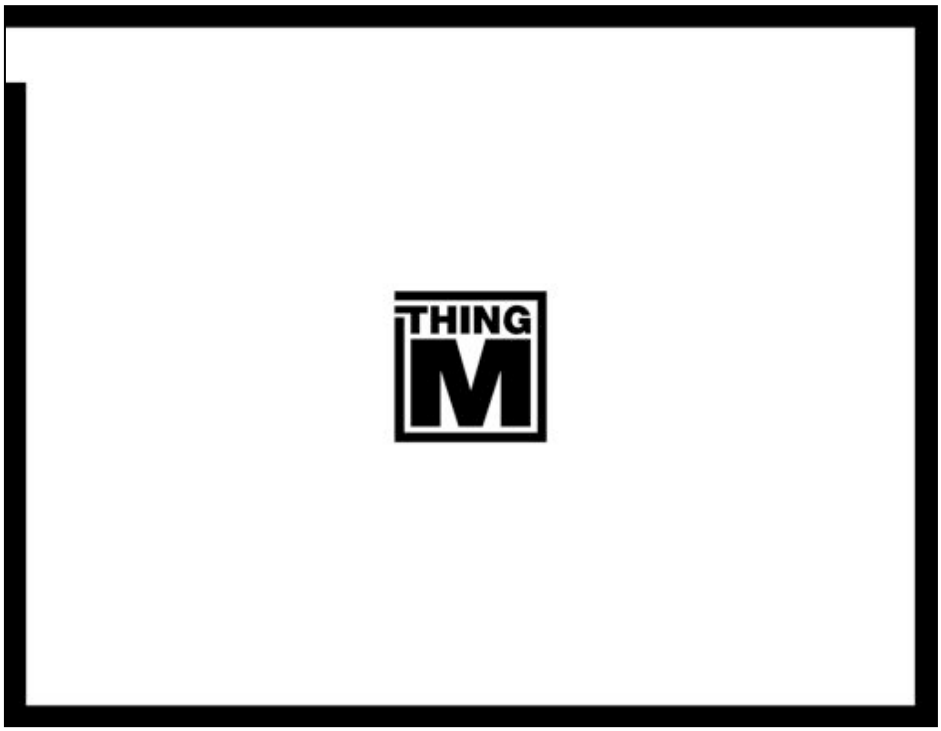
Good Morning! Thank you very much for inviting me. It's a pleasure to be here.

First, let me tell you a bit about myself. I'm a user experience designer and entrepreneur. I was one of the first professional Web designers in 1993. Since then I've worked on the user experience design of hundreds of web sites. I also consult on the design of digital consumer products, and I've helped a number of consumer electronics and appliance manufacturers create better user experiences and more user centered design cultures.



I sat out the first dotcom crash writing a book based on the work I had been doing. It's a cookbook of user research methods.

And 2001 I co-founded a design and consulting company called Adaptive Path.

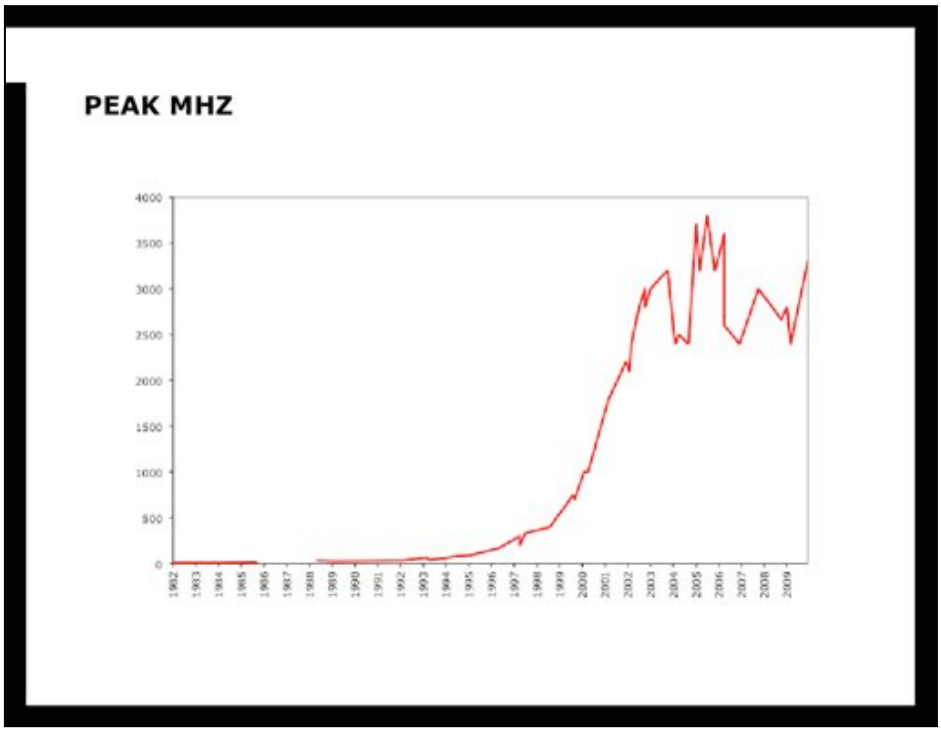


I left the Web behind in 2004 and founded a company with Tod E. Kurt called ThingM in 2006. We're a small ubiquitous computing company and we design, manufacture and sell ubicomp hardware.

This talk is based on a chapter from my new book on ubiquitous computing user experience design. It came out in September and it's called "Smart Things" and it's published by Morgan Kaufmann.

This book is my attempt to create a framework for the different kinds of activities, and the products of those activities, involved in the design of devices that use information processing, but which are not general purpose computers. As a designer, I find it useful to have interesting constraints, and this book is my way of trying to create some.

The book has lots of illustrations, techniques and in-depth case studies of a number of commercial products, but also what I consider to be important concepts. This talk is largely from the conceptual side of it.

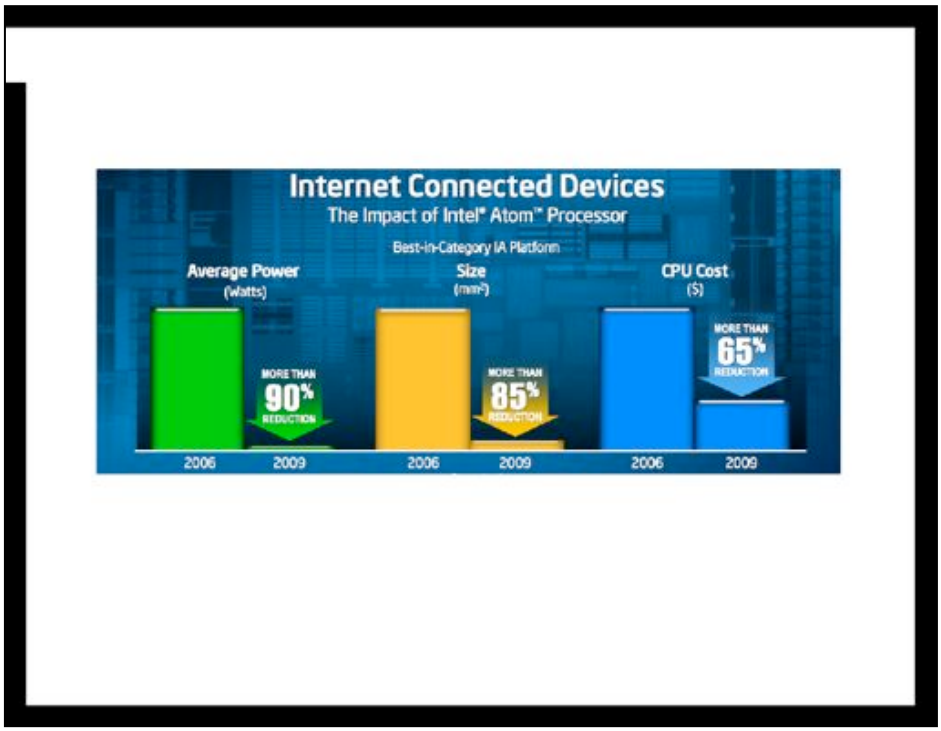


I want to start by mentioning a curious phenomenon. If you any of you follow developments in microprocessors, you'll notice that the clock speed of today's new CPUs is basically the same as that of CPUs from five years ago. For those of us who used computers in the 80s and 90s, this is very confusing. We watched clock speeds go from 6MHz in 1983 to 3GHz in 2003. During that time, we became used to clock speeds as the measure of power and value in information processing.

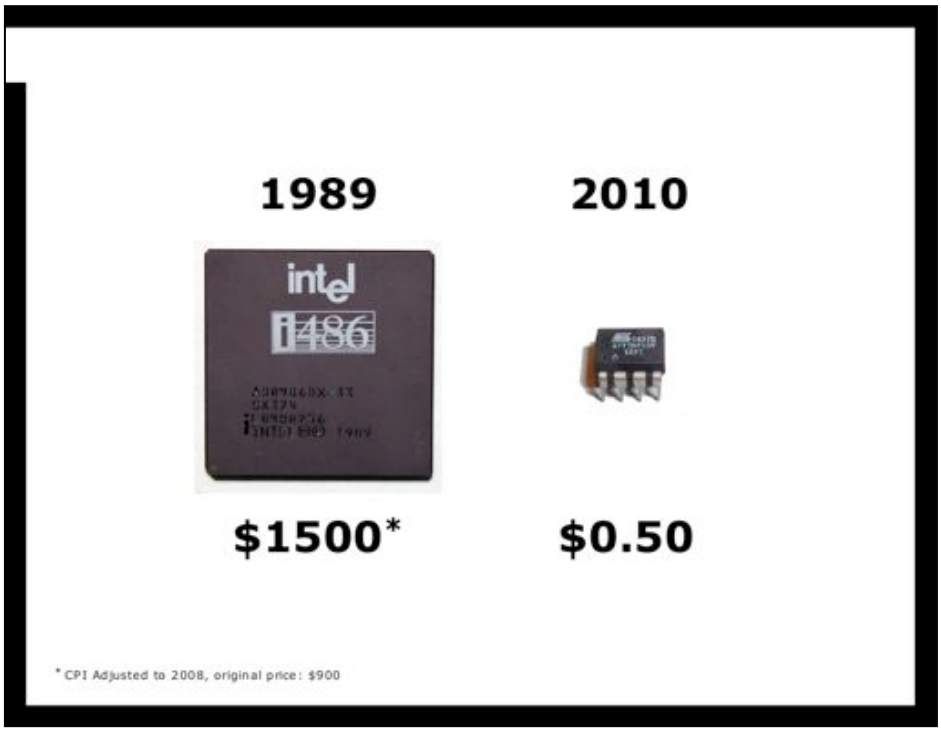
But after 20 years during of a logarithmic increase that spanned 3 orders of magnitude, suddenly clock speed abruptly stopped going up in 2004. The industry went from exponential growth in clock speed to no growth, zero growth, in one season. It's like someone slammed the emergency brake.

I call this phenomenon Peak MHz.

Unlike oil, we're not literally running out of CPU clock cycles, but we are seeing a reevaluation of how we understand the value that computers provide, and this has resulted in a shift in the strategy of microprocessor makers. What happened in 2004 was, broadly speaking, that chip manufacturers saw that we were running out of uses for big, energy-hungry, hot processors, and they shifted the game. Since 2004 the competition has shifted from raw CPU to making smaller, cooler, cheaper chips that can do as much work as older chips, while using fewer resources.



Here's a slide from a talk Paul Otellini, the CEO of Intel, gave last year. Notice that instead of talking about numbers going up, processor manufacturing has become all about pushing numbers down. Instead of competing on doing more with more, they are now competing on doing the same with less. Less power, smaller size, and lower cost.



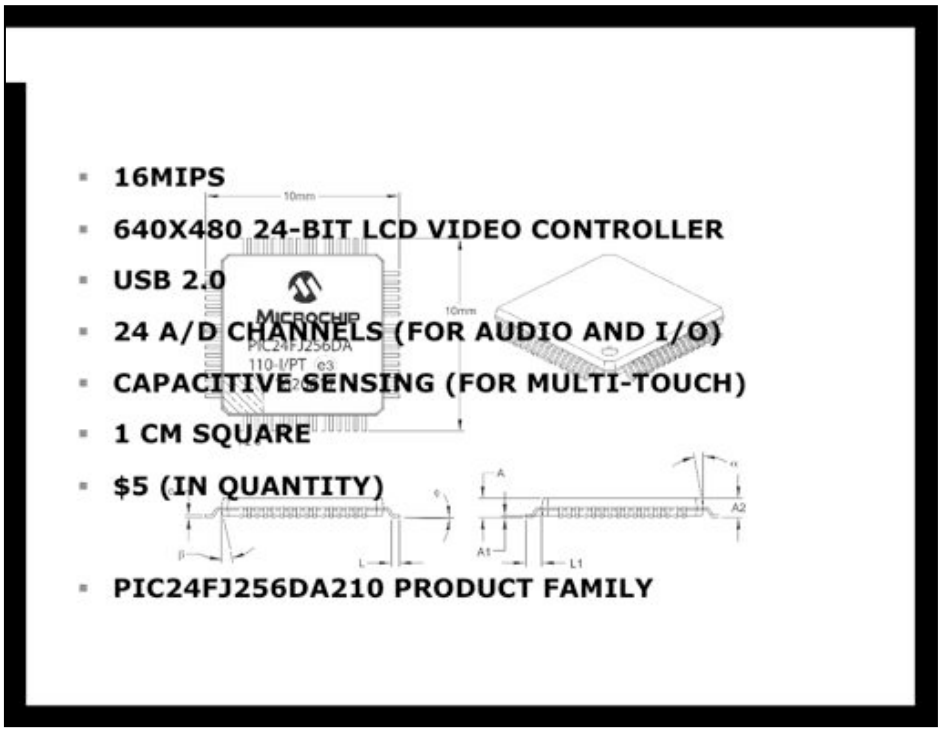
One of the main effects of this shift is that in addition to pushing the price, size and energy consumption of the latest CPUs down, it also pushes the price of all previous processing technologies down along with it. For example, at the beginning of the Internet era we had the 486 as the state of the art and it cost $1500 in today's dollars. It's the processor that the Web was built for and with. Today, you can buy that same amount of processing power for 50 cents, and it uses only a fraction of the energy. That decrease in price is the same 3 orders of magnitude drop as the increase in speed to 2004. This is not a coincidence, because both are the product of the same underlying technological changes.

When a technology falls in price this much, it opens up enormous possibilities for new products, while creating fundamental changes in society as the new technologies displace established social systems and networks.

Steam engines, for example, lowered the price of harnessing energy by orders of magnitude…and the Industrial Revolution was born as people found all kinds of new uses for mechanical energy. Mechanization suddenly became an option for making and using things where it never existed, or was highly impractical.

You can see similarly transformative effects if you look at what happened when the price of extracting aluminum dropped by two orders of magnitude in the late 19the century, or when electric motors became significantly cheaper and smaller in the 1920s. When something becomes cheap, it quickly joins the toolkit of things we create our world with. It becomes a design material. Sometimes for better and other times for worse.

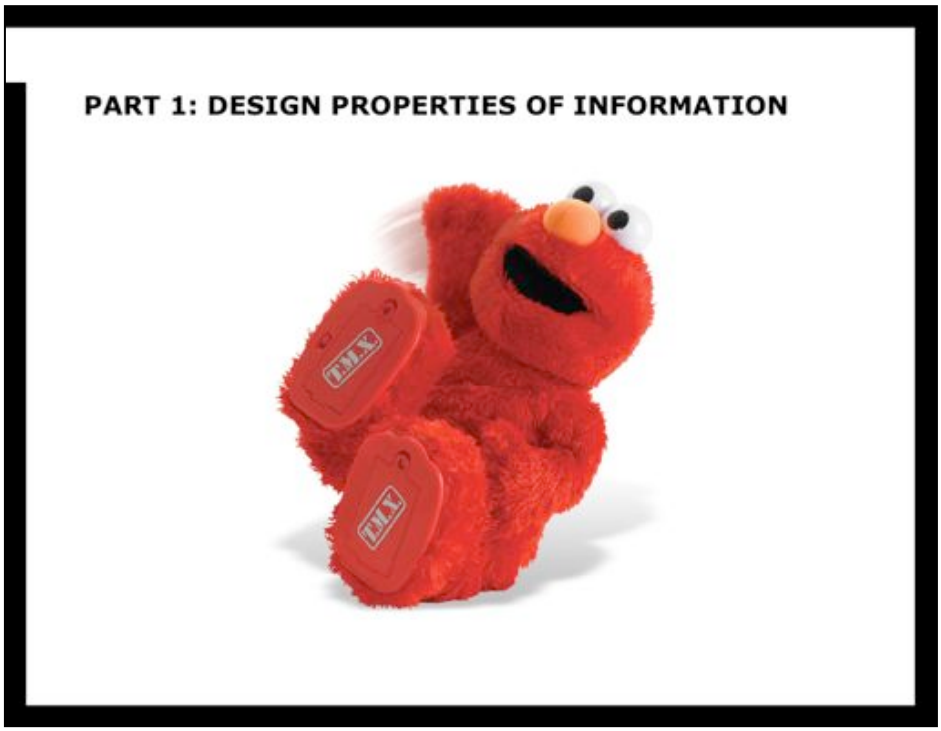
In the last five years cheap, small processors have drastically lowered the cost of taking information in, evaluating it, manipulating it, rearranging it, and acting on it. It is no longer unthinkable to have an everyday object use an embedded processor to take a small piece of information—say the temperature, or the orientation of a device, or your meeting schedule—and autonomously act on it to help the device do its job better



This new System on a Chip from Microchip has about as much processing power as that initial 486, but is also has an onboard video controller that can drive a VGA-class screen, a USB controller for peripherals, a 24-channel analog to digital converter for sensor, and a capacitive sensing driver that can drive a touch screen. It costs about $5, uses less power than a keyring LED flashlight, and fits on a chip the size of your fingernail. It's also not unusual. Almost every semiconductor maker makes similar products.

Products like this mean that information is quickly becoming a material to design with. Enabling objects to make autonomous decisions and act using arbitrary information has now joined the palette of options a product designer has to work with when trying to create a compelling, effective new product. Regardless of what that product is.

I believe that this is as deep an infrastructural change in our world as electrification, steam power, and mechanical printing. Maybe it's as big of a deal as bricks. Seriously, it's a huge change in how the world works, and we're just at the beginning of it.



If information is a design material, what are its material properties? Sure, at some level there are basic information theoretic properties such as bandwidth, noise and complexity, but those are the microscopic properties, the equivalent of basic nuclear forces in material science. They won't help us design a Tickle Me Elmo Extreme, which is a device that's only practical to make using cheap information as a material. What are the MACROSCOPIC properties of information that we can use to design with?

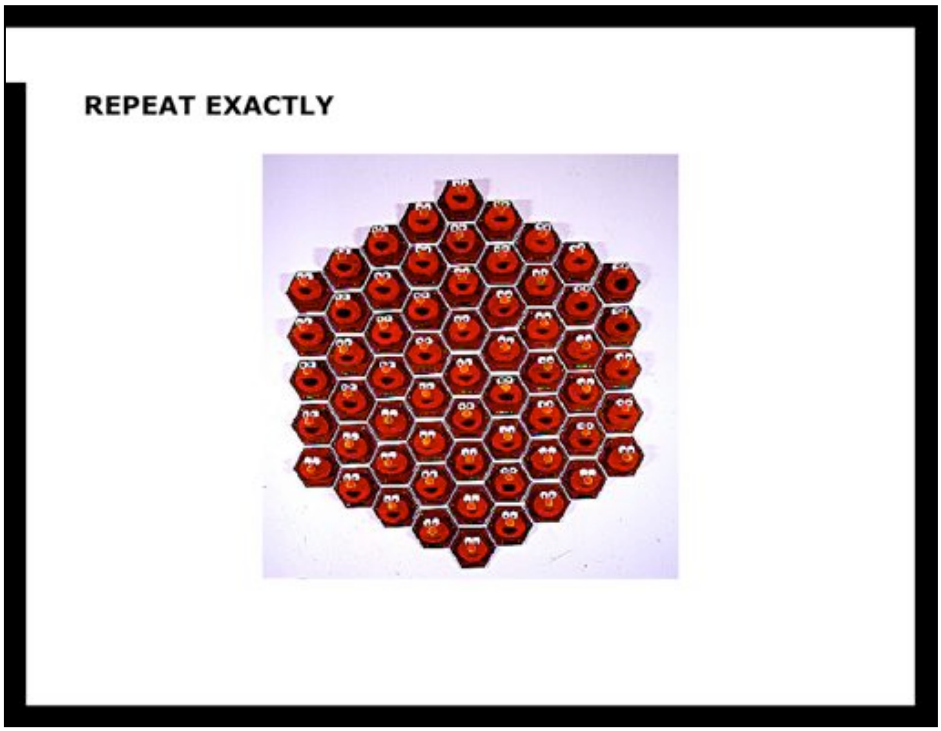
It can sense the world. There are thousands sensors that convert states of the world into electrical signals that can be manipulated as information. This also includes sensors that sense human intention. We call these “buttons”, ”levers”, “knobs” and so on.

Actuators, which is the generic term for anything that can make a physical change based on input, can be triggered based on information. Thus, information can be used to autonomously affect the world in a way that no previous material was capable of.

Information can be used to store knowledge about the state of the world and act on it later. This could be just a single piece of data, such as what a mechanical thermostat does when it stores the temperature you'd like to keep your house at, or something much more sophisticated, say, storing an image of everything you look at, which is what justin.tv was doing a couple of years ago.

One of the most transformative qualities of information is that it can be duplicated exactly and transmitted flawlessly. This has already changed the music and video industry forever.

Image: UPI: http://www.upi.com/enl-win/9b95da78f449e1a5dc28a05efc4d55a4/

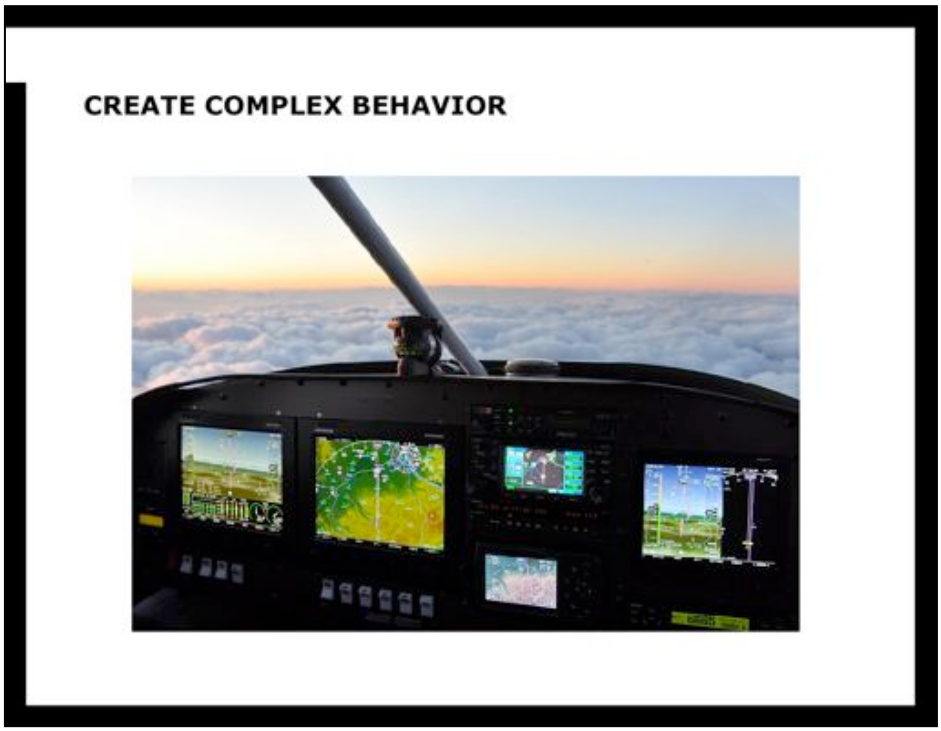


But it also means that device behavior can be replicated exactly. We've become acclimated to it, but--stepping back--the idea of near-exact replication in a world full of randomness and uncertainty is a pretty amazing thing, and is a core part of what makes working with information as a material so powerful.

Image: N-Trophy, 2000-2003, Kelly Heaton, Feldman Gallery: http://www.feldmangallery.com/pages/exhsolo/exhhea03.html

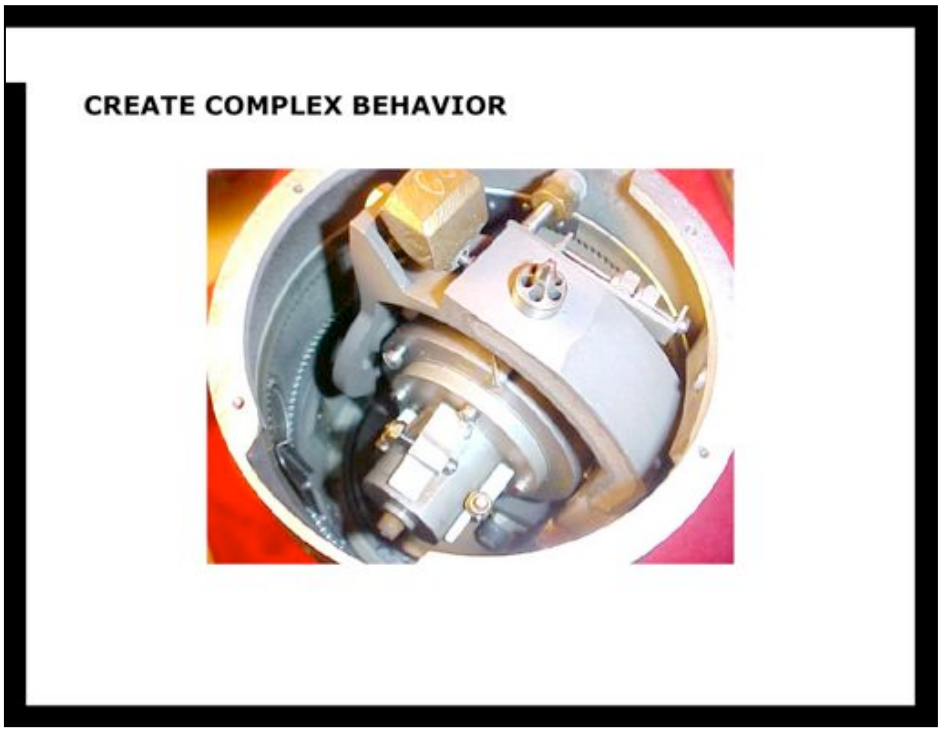
Networking technology enables devices made with information to communicate autonomously. The cactus on the left in this photo is a cell tower in the desert that enables mobile devices in cars passing by it to communicate to the world at large. That communication, as we know, can be machine to machine telemetry, Google Map tiles, pictures of your friends, or new firmware for the devices.

Source: http://www.utilitycamo.com/sites.html



Information enables behavior that's orders of magnitude more complex than possible with just mechanics, at a fraction of the cost. This is a modern small airplane avionics system. It consists of a bunch of small fairly standard computers running special software.

Found on: http://www.vansairforce.com/community/showthread.php?t=51435



Compare that to a traditional gyroscopic autopilot where every single component is unique, it does very little, and to change its behavior you have to completely reengineer it.

Finally, information lets you encode knowledge. Modern cars doesn't stall or need chokes because automotive engineers have installed specific sensors and actuators that embody their knowledge of internal combustion engine thermodynamics into a set of algorithms that adjust the car performance dynamically in response to data.

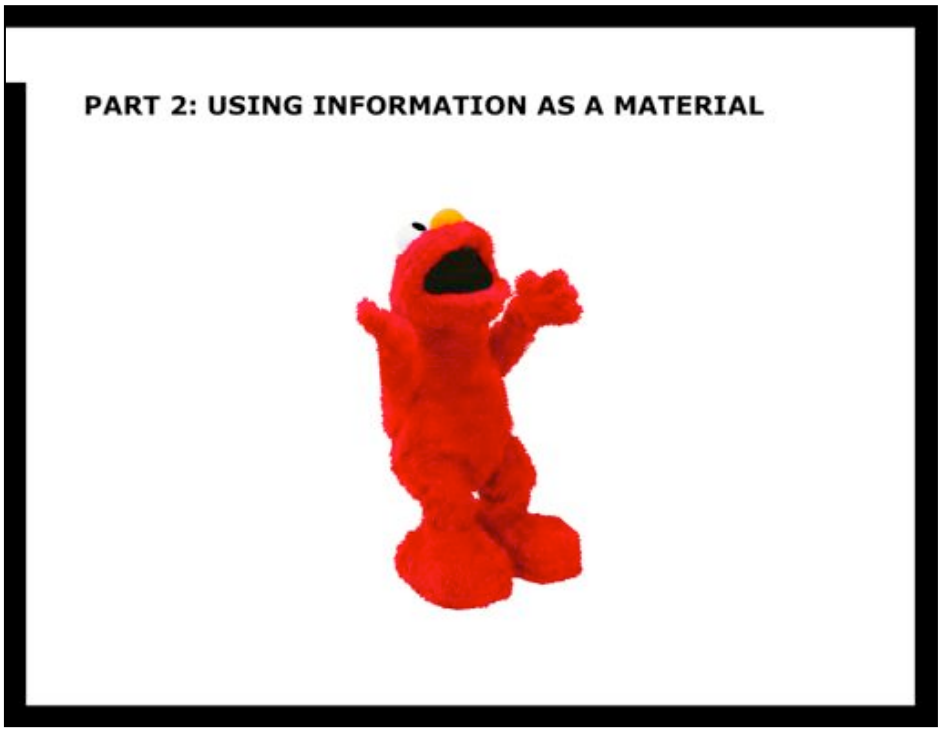
This is a Blendtech programmable kitchen blender. With it you can program a specific sequence of blender power, speed and duration and associate that sequence with a button on the blender. it allows you to embed experience and knowledge about food processing into the tool, which can then produce that as a behavior, rather than requiring the operator to have that knowledge and develop the experience.

Jamba Juice's business depends on such programmable blenders so their staff don't have to be trained in the fine points of blending. It may seem like a small thing, but consistent blending is the cornerstone of their company and this embedding of knowledge into the tool wouldn't have been possible if the blender wasn't made with information. The behavior is the value.

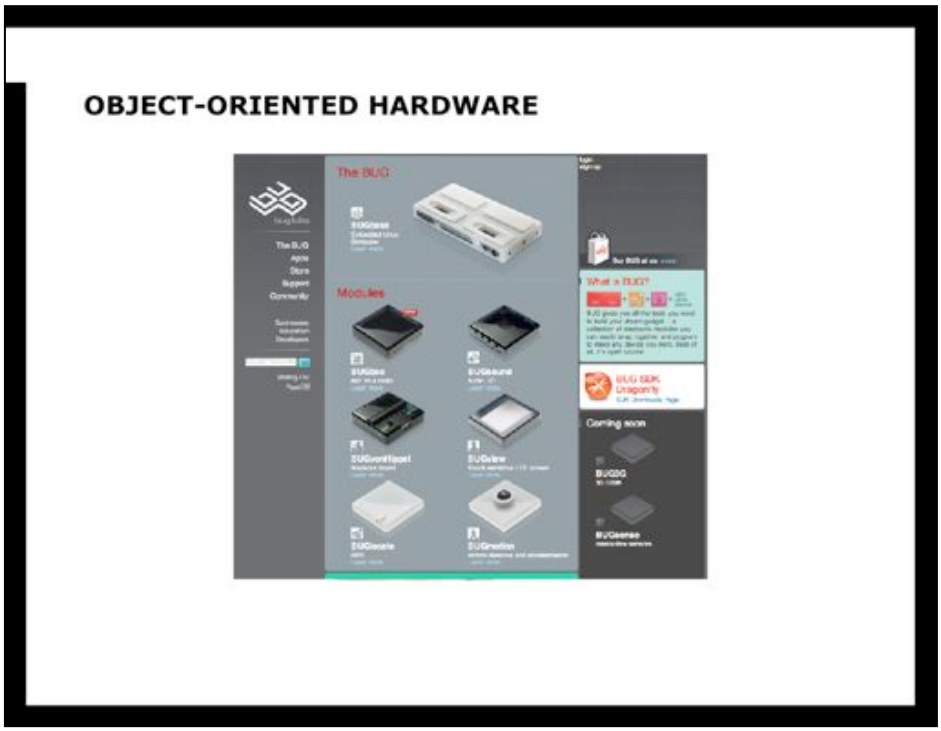
If you just thought, “Wait a minute. I know all this and, besides, Norbert Weiner covered this in Cybernetics in 1948.” you’re right. This is not new. We are intuitively familiar with these properties because we’ve been using computers for a long time. You can probably come up with many examples of products that exploit each of these properties.

However, now it is more relevant than ever, because now these qualities can be distributed throughout the environment in a way that's never been economically feasible before. It's like the difference between Leonardo Da Vinci writing about mechanized flight and Douglas using new manufacturing techniques, and materials such as aluminum, to made widespread commercial flight practical.

We're now at a point where theory can become reality, and we're now in the position where we actually have to make it happen.



Now I would like to speculate about treating information as a material that affects design.



First, it changes the way that we think about hardware.

Because information can encode knowledge, it makes it easier to reduce complexity, including the complexity of information technology itself.

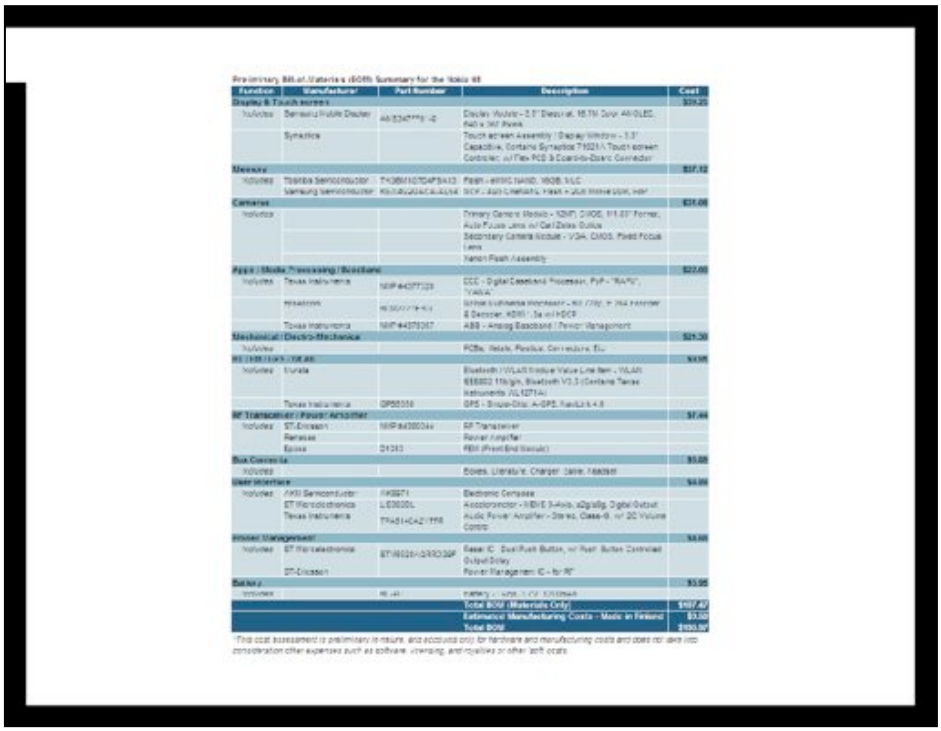
Embedded processors make it possible to create an abstraction layer around basic sensing, processing and actuation components to creates building blocks that are meaningful in human terms, rather than just electronic terms. Each block is an atom of functionality that has a CPU and communicates with other blocks over a network. This is the start of object-oriented hardware. What you see here are mostly all prototypes that make it easier to demonstrate this idea, but this is already how many modern devices are constructed.

Most images from Jacob Nielsen's PhD, "User-Configurable Modular Robotics"

Also LittleBits from Bdeir, Hoefs, et al.

Tinkerkit from Tinker.it

Bug Labs



A modern digital device is already more like a small network of interacting components than a monolithic product of a single ground-up engineering process. Here's iSuppli's teardown analysis of the Nokia N8. Nokia itself makes almost none of the components. They buy them off the shelf like Lego bricks and combine them to create a final product.

From an interaction design standpoint, object oriented hardware means that rather than starting from basic principles of electronics, you get to focus more on what experience you're trying to create, rather than which capacitor to use. Most designers don't smelt their own iron to make things out of steel, or grow their own hardwood trees to make things out of wood. Similarly, object-oriented hardware turns information from a raw material into a design material.

http://www.isuppli.com/Teardowns-Manufacturing-and-Pricing/News/Pages/Nokia-N8-Smart-Phone-Matches-iPhone-4-Costs-iSuppli-Teardown-Reveals.aspx

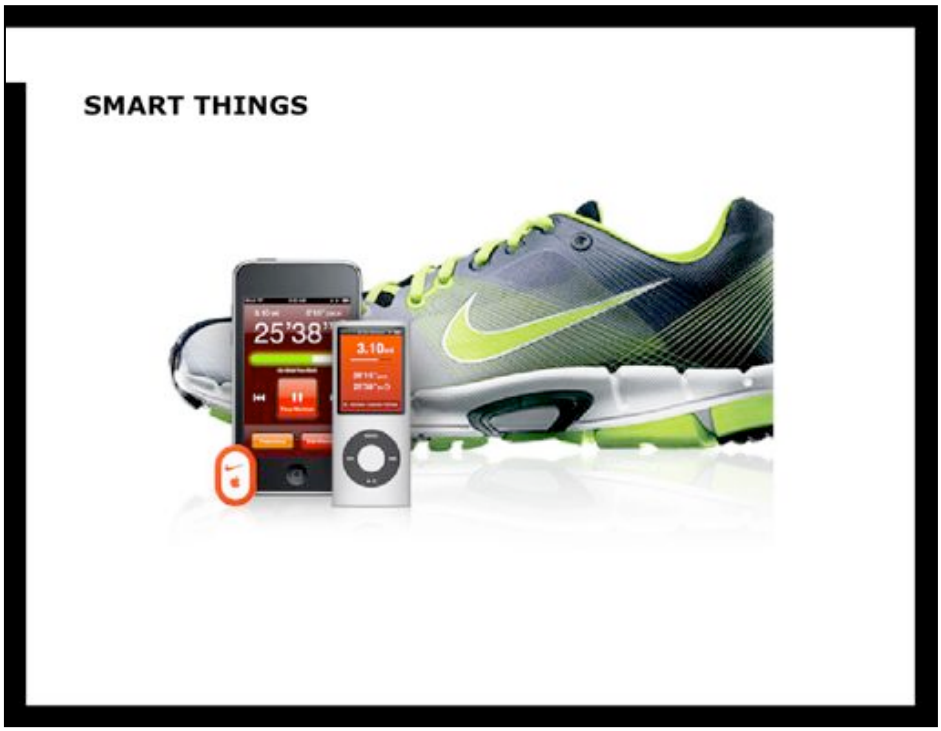
ThingM, my company, makes a set of such atoms of information processing that emit light. Our BlinkM line of smart LED products makes it very easy to put controllable RGB light into arbitrary locations with no electronics knowledge or color theory. Pick some up today at fine electronics retailers worldwide.

OK, end of sales pitch.

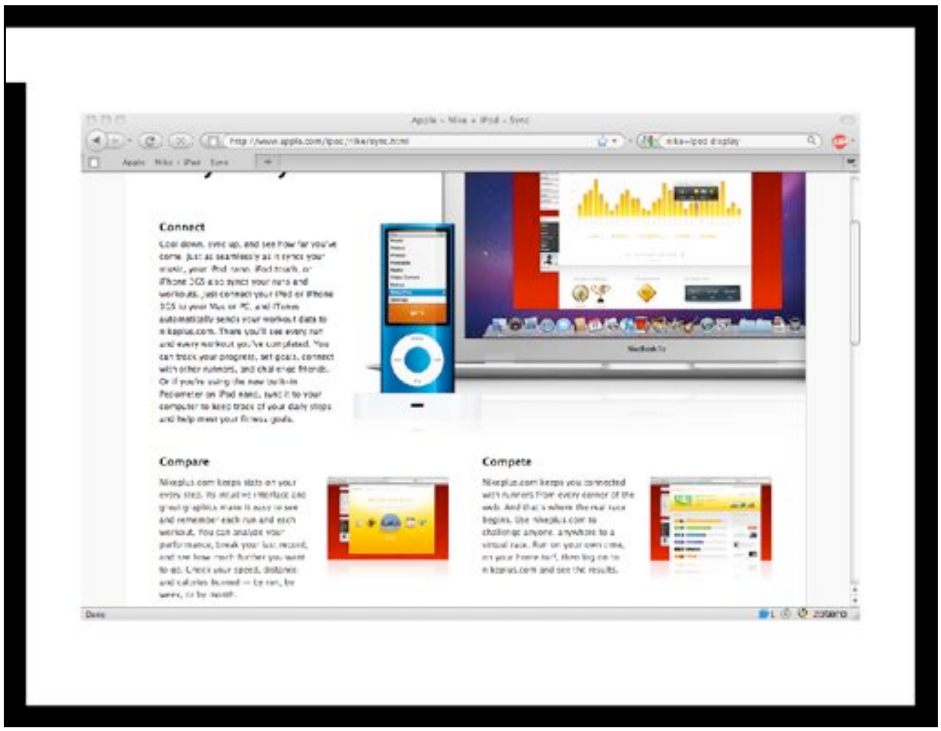
So what's made with these atoms?

On the next larger scale, we see new personal tools. Today we have digital pedometers, Internet connected bathroom scales, networked parking meters, and cars that don't stall, but there will be many more. Pick nearly any object, add information to it, and you get a new object. My favorite example of this the adidas_1 shoe, which was put out 5 years ago and then almost immediately discontinued. It has a pressure sensor that a small embedded processor uses to estimate the qualities of the surface being run on and adjusts the heel in between strides to optimize the resiliency regardless of what surface you're running on. The buttons adjusts how it responds. Sensing, processing, acting on the world.

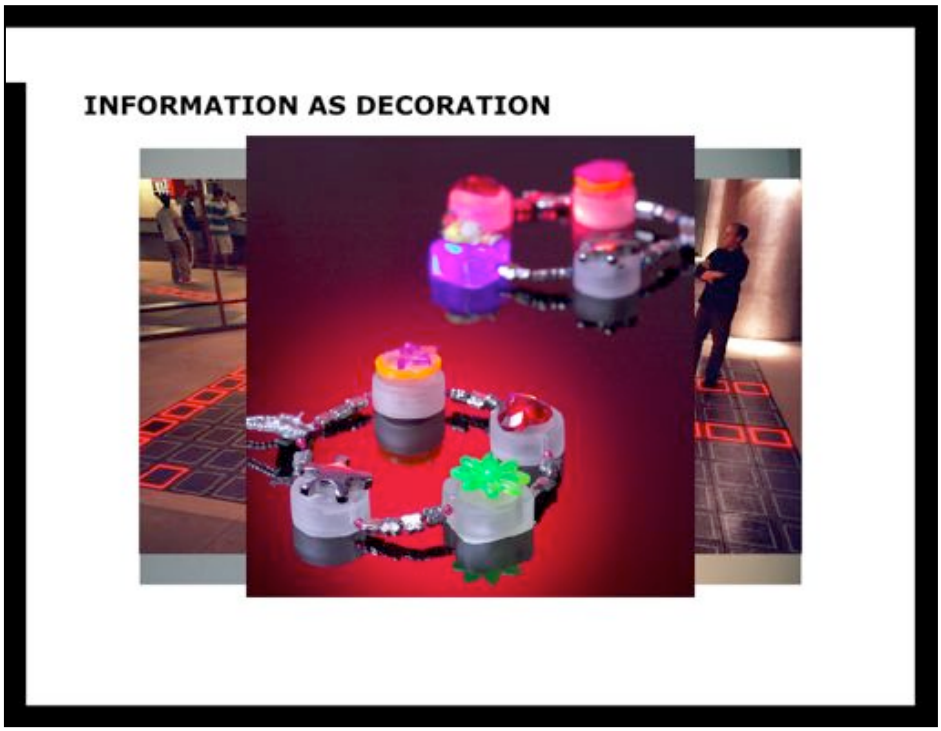
For me it represents how a small amount of information, carefully deployed can profoundly change an object.



Nike and Apple took this same basic concept and shifted the emphasis on actuation to an emphasis on communication.



Now that tiny bit of information enables your shoe to becomes the key ingredient in transforming your shoe from something you run with, to the entry point to a new way of experiencing the world. You get analytics, a social network, and all of the other things that the Web does well.

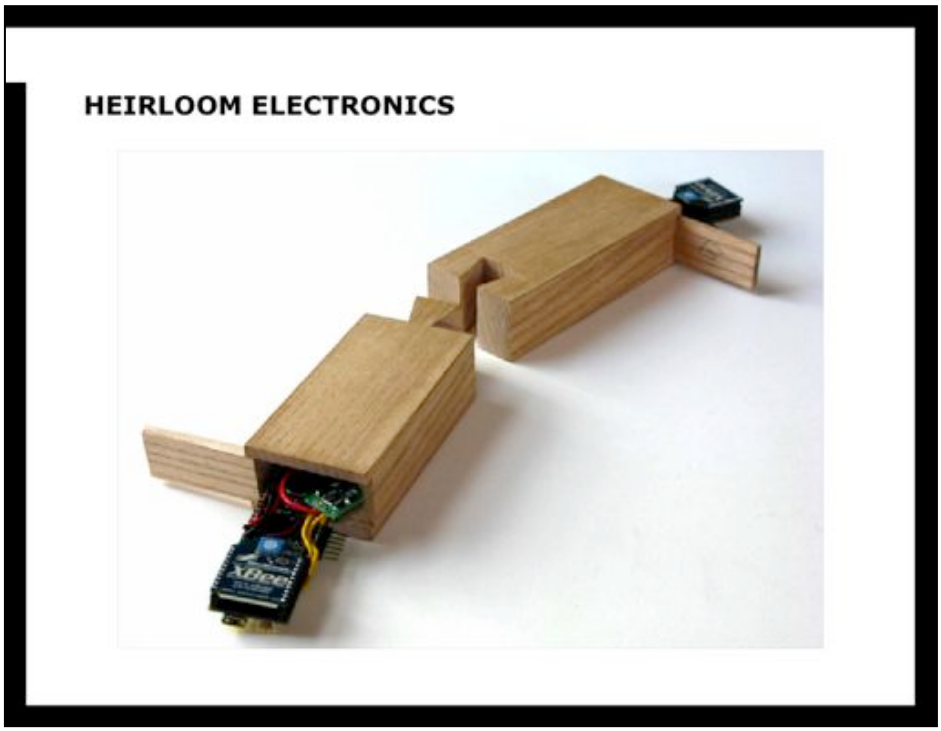


At a still larger level, we see information used as a decorative material. Just as you can use wood to hold up a house or make a sculpture with it, so information can be used to create incredibly beautiful, profound esthetic experiences. It has already revolutionized music and cinema, but treating it as a permanent material, rather than a medium, creates fantastic new opportunities.

Shelf by Jean-Louis Frechin

Floor by Enteractive

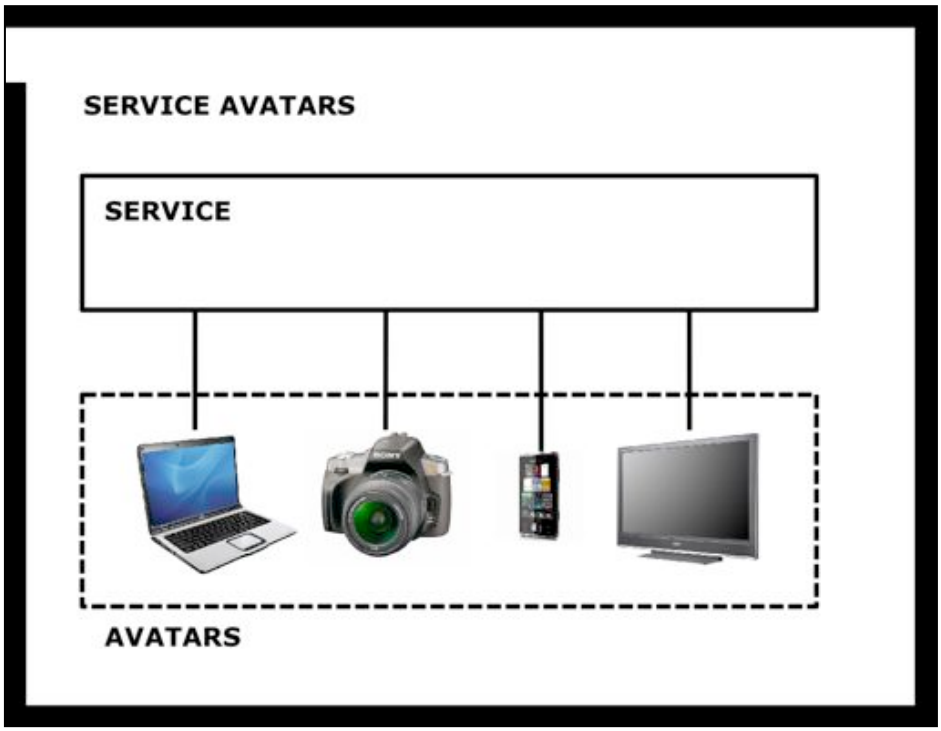
Buddy Beads by Ruth Kikin-Gil



This in turn is causing our relationship with electronics to change, as we start to see objects made with information more than just disposable consumer electronics, but as something that becomes an inherent part of our lives.

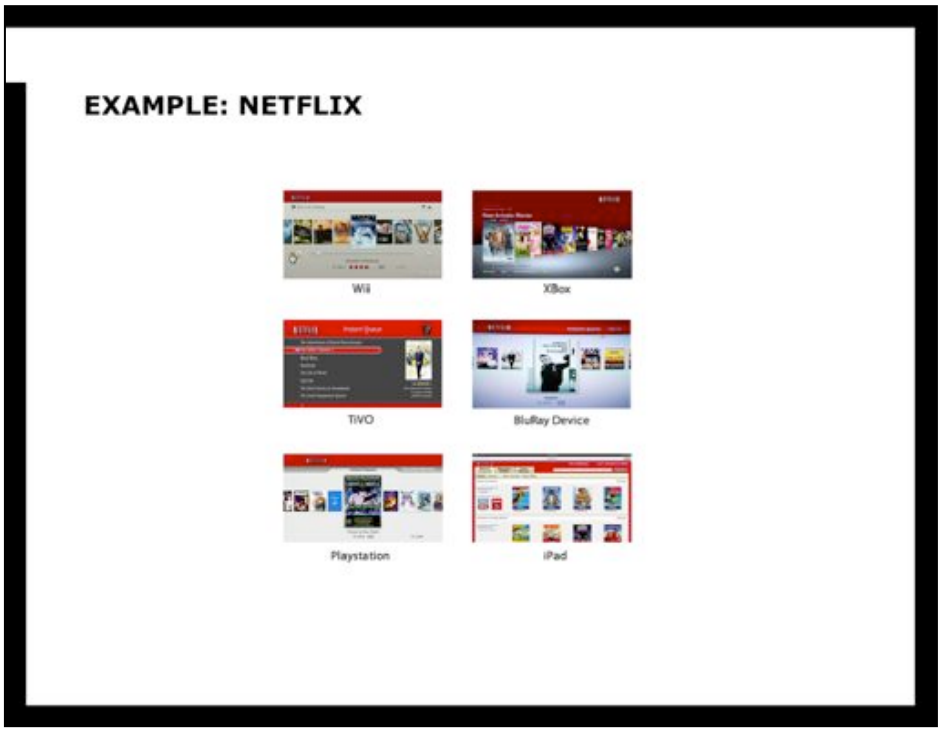
Matt Cottam, an industrial designer, has started exploring the concept of heirloom electronics. What does it take to create devices made with information that have both the operational longevity and long-term utility of traditional heirlooms? How can we integrate the functional and esthetic properties of electronics such that our digital devices do not less interesting and useful with time? These are all questions we're going to have to think about.

Next, our understanding of what a device does, and where its value lies, is changing when devices are made with information. We already have some experience with connected devices that are so tightly coupled to digital services in the cloud that they're useless without them. An ATM is a computer that's useless without the network it's connected to, and mobile phones are nearly useless.



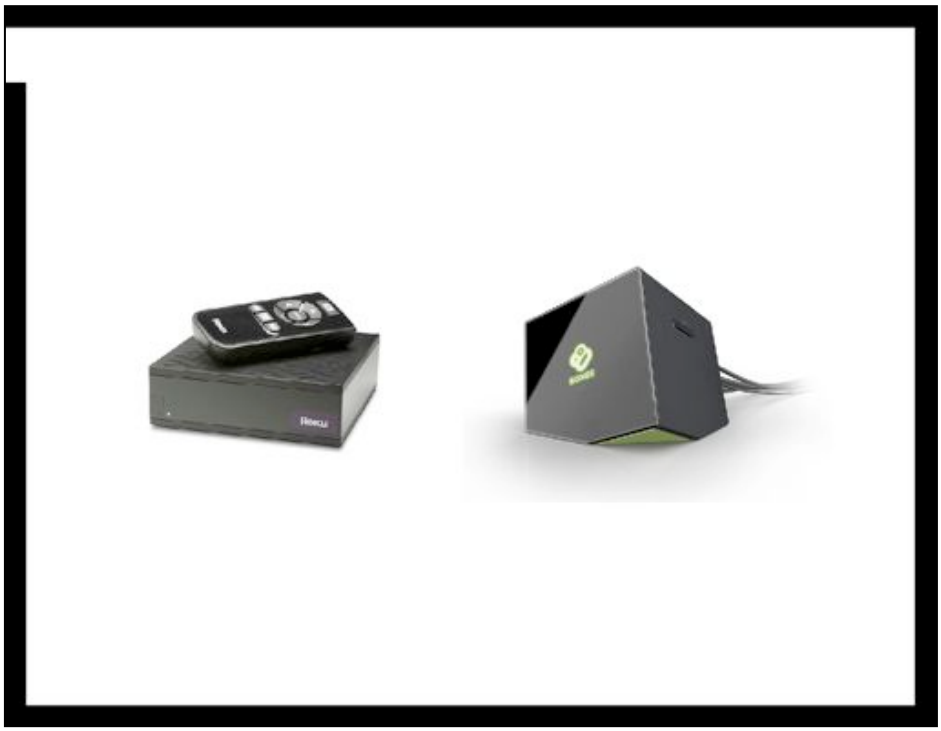
We will see many more such devices. I call them service avatars. They are the physical representatives of a services that's in the cloud, rather than being useful as standalone devices. The value of the device dissolves in favor of the service itself.

A camera becomes a really good appliance for taking photos for Flickr, while a TV becomes a nice Flickr display that you don't have to log into every time, and a phone becomes a convenient way to take your Flickr pictures on the road.



Let me give you an example. You can now get Netflix on virtually any terminal that has a screen and a network connection. You can pause a Netflix movie on one terminal and then upause it on another. This may feel a bit novel, but it also seems natural. Why?

Because to the Netflix customer, any device used to watch a movie on Netflix is just a hole in space to the Netflix service. It's a short-term manifestation of a single service. The value, the brand loyalty, and the focus is on the service, not the frame around it. The avatar exists to enable the service, not as an end to itself.



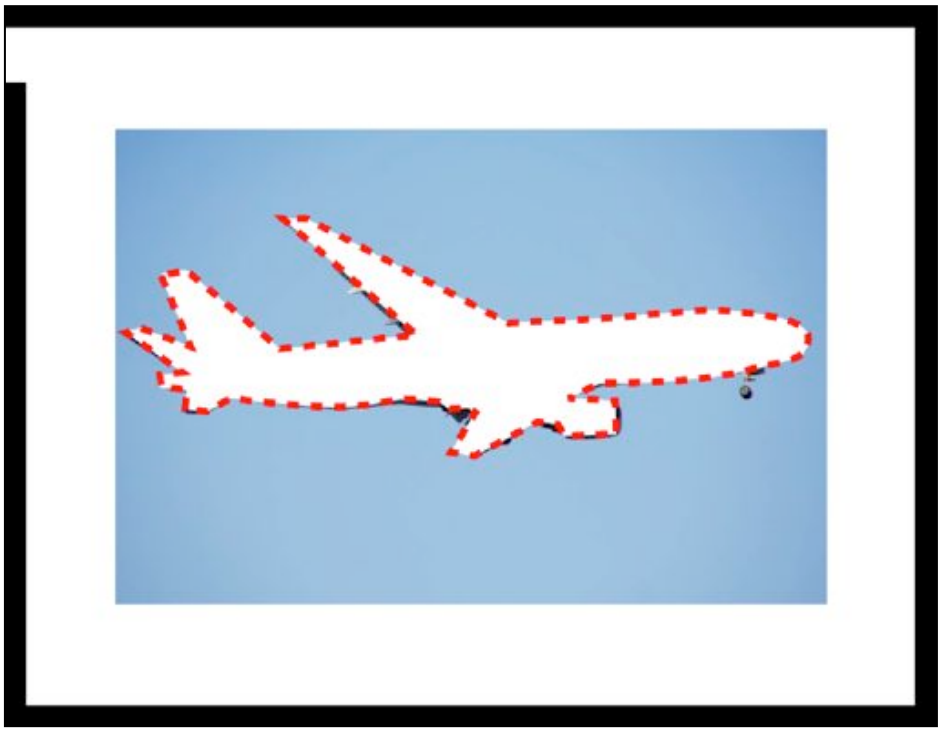
Netflix appliances are created for a single reason: to make it easier to access Netflix. That's what Roku does. It turns every terminal that's not already Netflix enabled into a Netflix terminal. The Boxee box does that for the Boxee service. The new Apple TV does it for iTunes.

This is a fundamental shift in our relationship with everyday devices.

One final example of how our relationship to everyday objects changes once they're made with information.

Once you start making things with networked trackable information, those things develop information shadows. Once you can digitally identify an object, first you can get all kinds of information about it. You can know where it was made, what it is made of, what your friends think of it, how much it sells for on Ebay, how to cook it, how to fix it, how to recycle it, whatever.

Image source: Yottamark



More importantly, however, you can turn that object into service avatar.

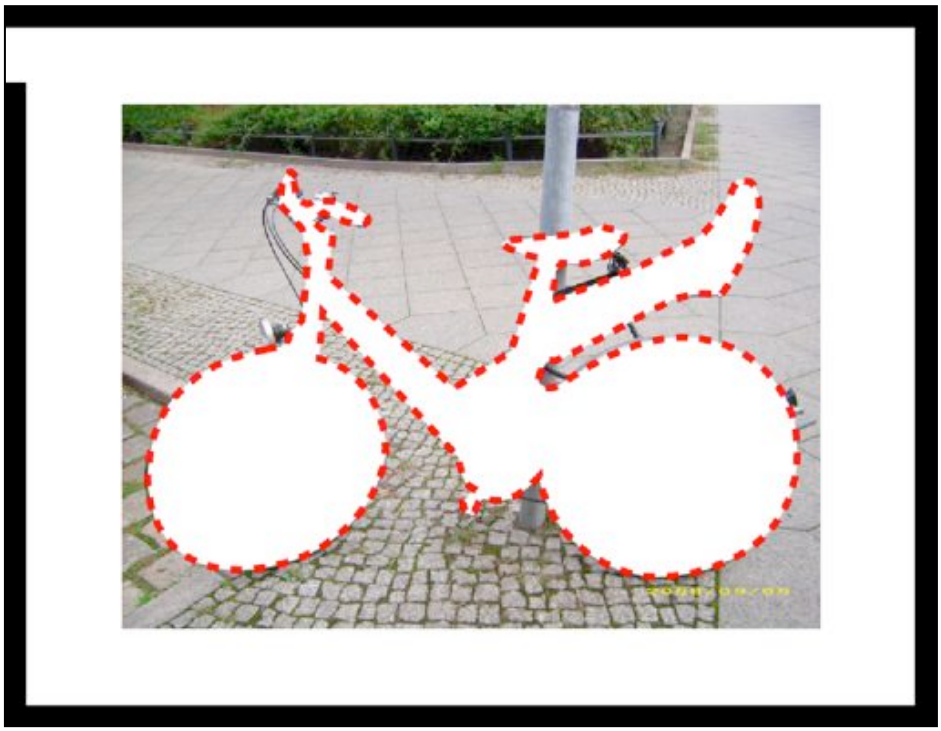
Most airlines, for example, don't own their own planes and haven't since 1965. They lease them from General Electric, sometimes complete with flight crew and ground crew. GE actually owns them and, as I understand it, in turn leases the engines from another division of itself. When an airline needs more capacity, it leases some more. What an airline owns is a promise from GE that it will provide the service of flight to the airline for a specific period. GE's engine division, in turn provides the plane division with the service of thrust.

When you make thing with information, you make this kind of affordable and profitable at ever smaller scales.

When you buy into a car sharing service such as City Carshare or Zip car you subscribe to a service.

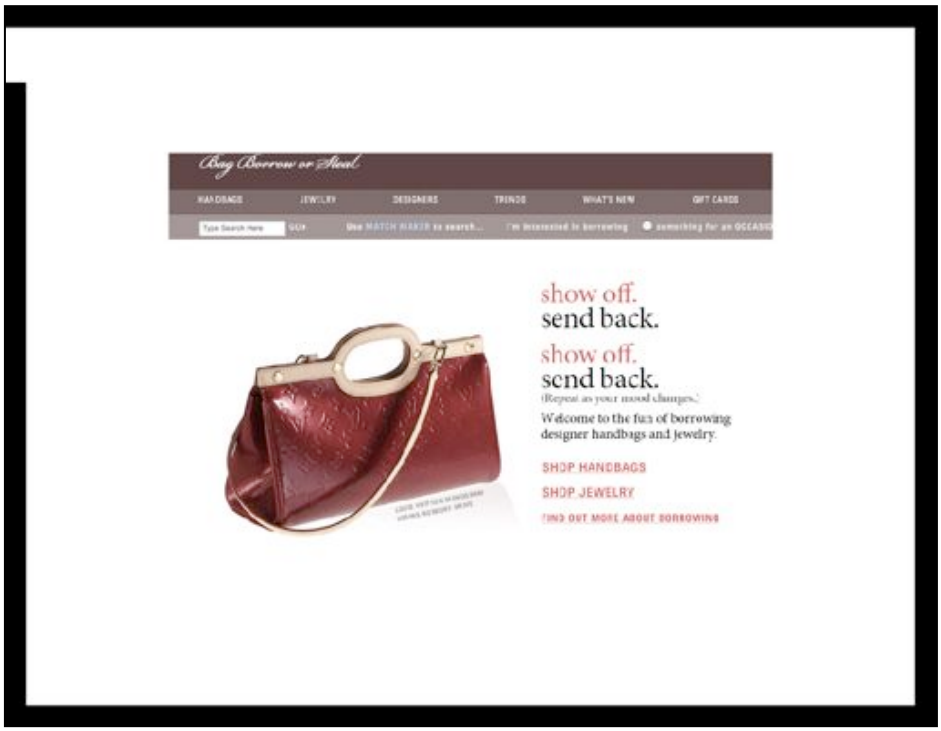
Each car is connected to a central network. You can only open the car and start the engine when your specific keyfob RFID is scheduled to open and start it. It uses a GPS to track where the car is, whether it's been dropped off at the right location, and how far it's been driven. All of that is transparent to you, the subscriber. The relationship you have with these cars is different than with a rental. It’s much more like having your own car because you have access to it 24 hours a day, 7 days a week, with very little advance notice.

However, unlike an owned car, it's a car possibility space. This is an ad from Zipcar that shows the implicit power of this kind of system, from the consumer perspective. From the social perspective, it means that resources are used more efficiently: the economies of scale for buying and repairing a fleet of vehicles is significantly lower than individual ownership. From the corporate perspective, it represents an ongoing source of revenue.



This is the German Call-a-Bike program, run by the rail service. You need a bike, you find one of these bikes, which are usually at major street corners. You use your mobile phone to call the number on the bike. It gives you a code that you punch in to unlock the bike lock. You ride the bike around and when you've arrived, you lock it. The amount of time you rode it automatically gets billed to your phone, by the minute. The program would not be possible without item-level identification and wireless networking technology and is much more successful than all of the free bike programs because it has built in financial incentives for everyone involved, and yet provides significant social goods.

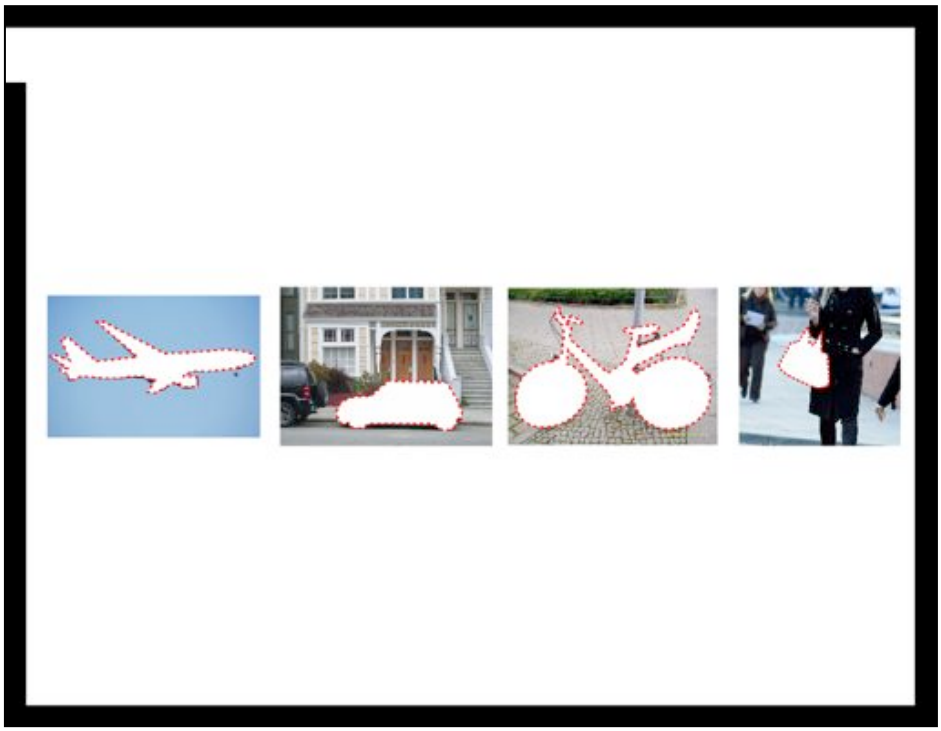
Photo CC by probek, found on Flickr.



Here's another example that points to some exciting possibilities. Bag, Borrow or Steal is a designer purse subscription site. It works like Netflix, but for really expensive handbags.

It's fashion by subscription and it again points to a new way of thinking about everyday objects. It changes the meaning of ownership and it changes the incentives in the design of everyday objects in a profound way.

Photo CC by bs70, Flickr



Notice a trend? It's getting cheaper all the time, roughly tracking the price of tracking individual objects and communicating their status.

Information is fundamentally changing out relationship to the physical objects around us.

When taken all together, all of these changes mean that at a large scale, our environment is growing increasingly information-based on a fractal level. Small information devices make large information devices that combine to form environment-sized devices made with information as a core material.

There's great opportunity here to create an ecology of services embodied as robust, valuable, exciting new tools with focused, limited functionality, tied together with item-level identitification and wireless networks. Whole classes of things that can enrich our lives and bank accounts are now possible thanks to the way ubiquitous computing interweaves services and devices at an intimate, everyday level.

From Herman-Miller's "Always Building"

TU Delft's Interactive Environment project

Usman Haque's Sky Ear

Hello.Wall

Any new material creates both possibilities and problems. We didn't get flying cars, but nor did we didn't have to fight atomic hydroplaning Soviet battleships.

It is our responsibility as creators of information technology to understand the properties of information, explore its capabilities, and build tools that make it easier to do the right thing with information than to do the wrong thing.

It is more our responsibility than it is Intel's, or LG's or the government's. They're just mining the raw ore. We're the ones who decide what to make with it.


SMART THINGS
Ubiquitous Computing User Experience Design
MIKE KUNIAVSKY
THING M
Mike Kuniavsky
mikek@thingm.com
ISBN: 978-0-12-374899-7

Thank you.