INFORMATION IS A MATERIAL

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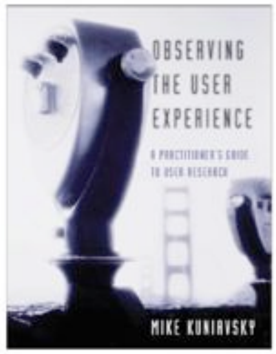
Mobile Monday
Amsterdam
November 8, 2010

Good afternoon! 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.

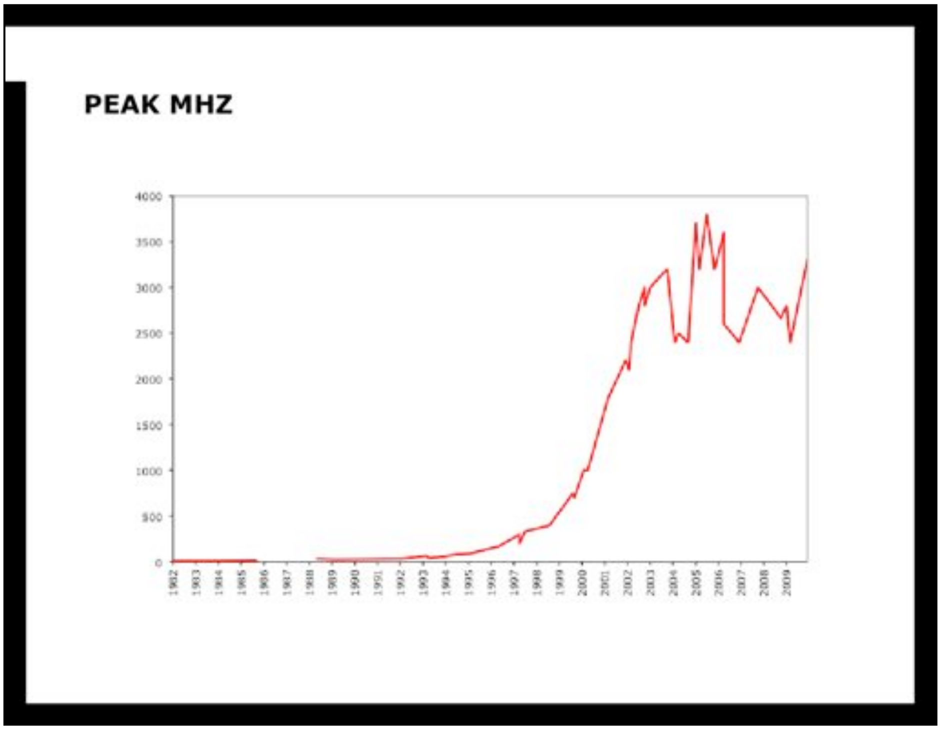
And 2001 I co-founded a design and consulting company called Adaptive Path.

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 in it I also try to articulate general ideas that define the design context in which this kind of work will happen. This talk is largely from the conceptual side of it.

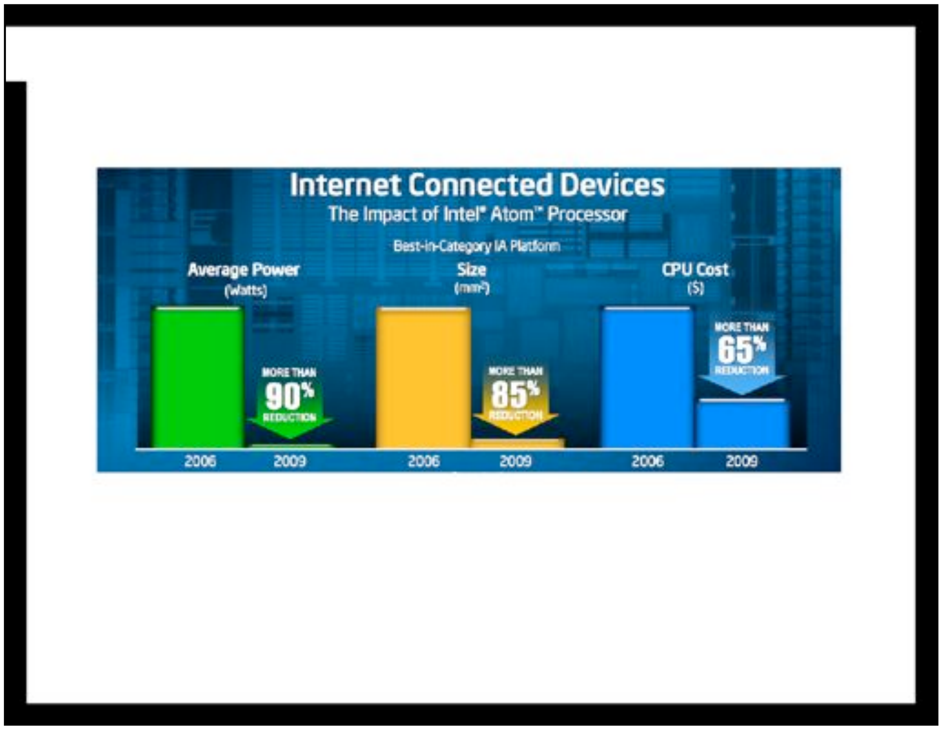


I want to start by mentioning a curious phenomenon. If you any of you follow developments in microprocessors, you'll notice that the clock speed of today's new CPUs is basically the same as that of CPUs from five years ago. For those of us who used computers in the 80s and 90s, this is very confusing. 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.

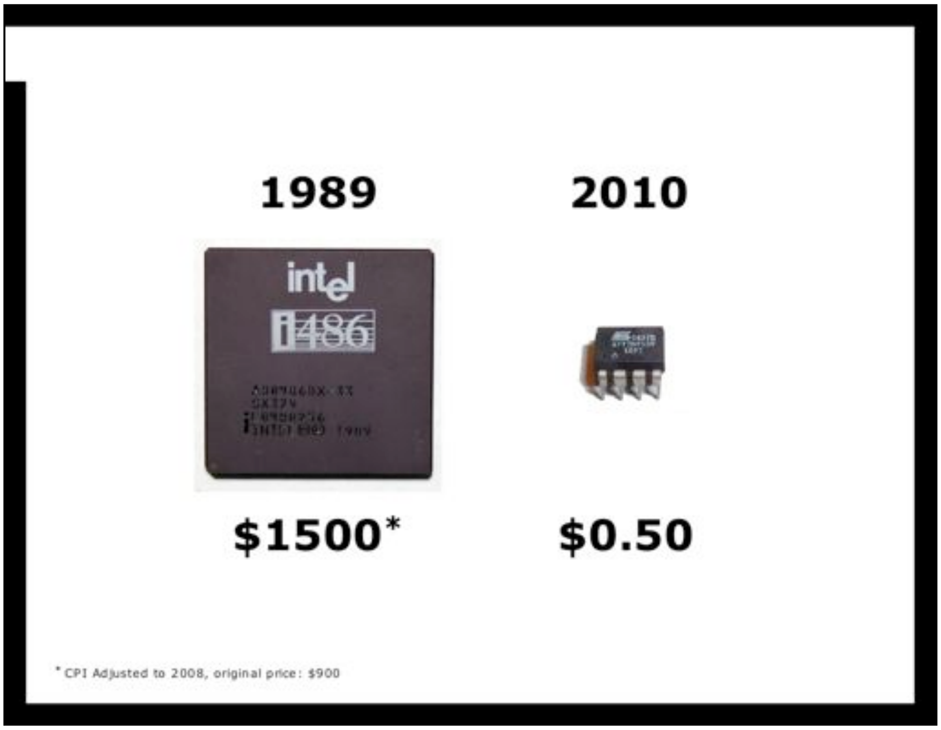
But after 20 years during of a logarithmic increase that spanned 3 orders of magnitude, suddenly clock speed abruptly stopped going up in 2004. The industry went from exponential growth in clock speed to no growth, zero growth, in one season. It's like someone slammed the emergency brake.

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, or even as entire subsystems, 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.



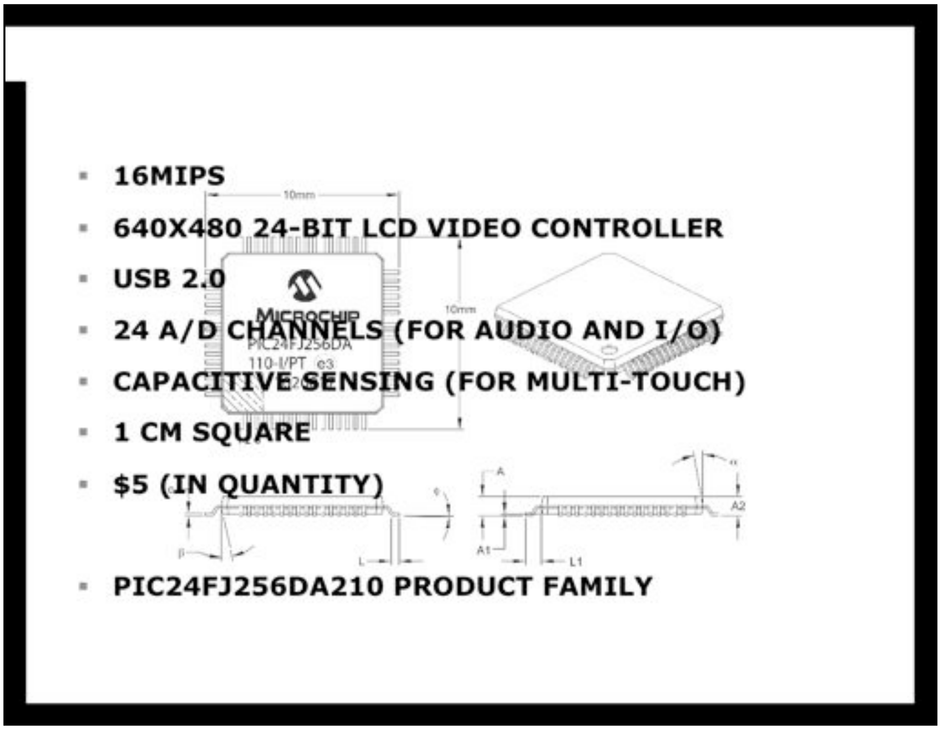
One of the main effects of this shift is that in addition to pushing the price, size and energy consumption of the latest CPUs down, it also pushes the price of all previous processing technologies down along with it. For example, at the beginning of the Internet era we had the 486 as the state of the 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.

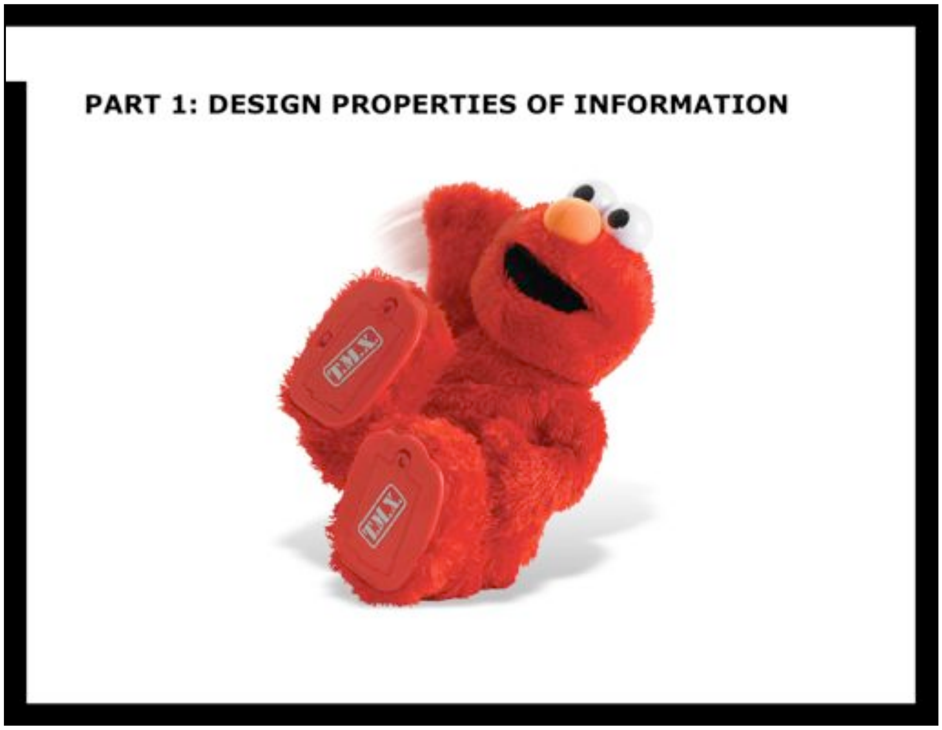
In the last five years cheap, small processors have drastically lowered the cost of taking information in, evaluating it, manipulating it, rearranging it, and acting on it. It is no longer unthinkable to have an everyday object use an embedded processor to take a small piece of information—say the temperature,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



This is a new System on a Chip from Microchip. It 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 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. Toymakers regularly compete by making a product with cheaper materials, but adding behavior to create a competitive advantage. Behavior and polyester are now nearly equivalent line items.

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, 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?

Let me run down a list I've made of properties that make information different than previous materials. You'll find many of the items on the list familiar, but I recommend that you take a step back and re-examine these properties anew. Each represents a new possibility space and a new way of thinking about what it means for the design of our lived world.

When you make something with information, 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.

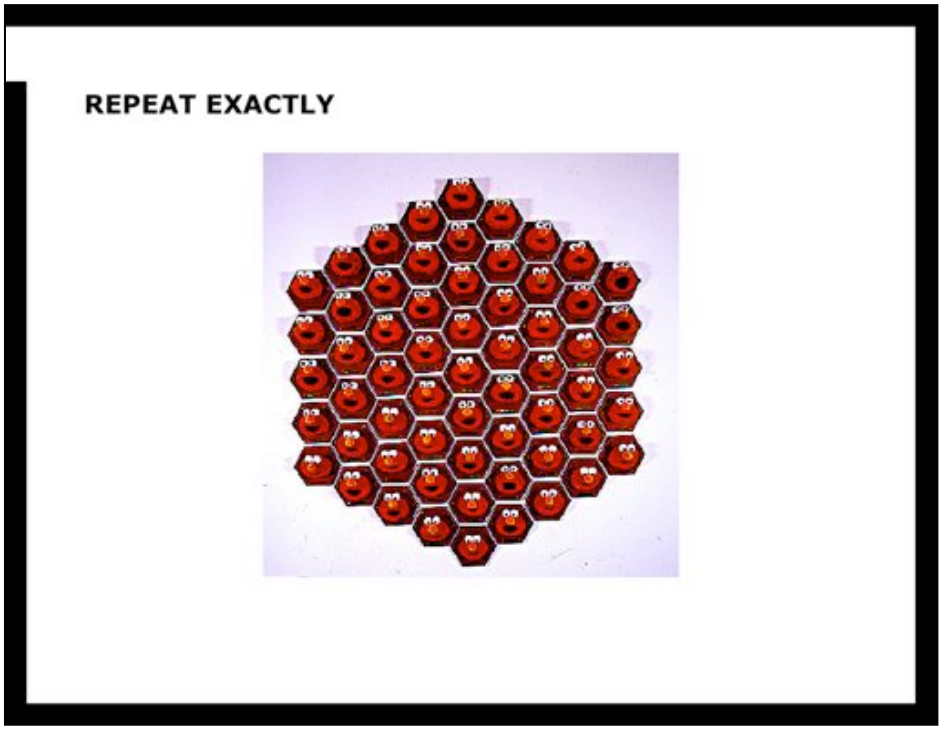
Actuators, which is the generic term for anything that can make a physical change based on input, can be triggered based on information. Thus, information can be used to autonomously affect the world in a way that no previous material was capable of.

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.

REPEAT EXACTLY

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, as we know.

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



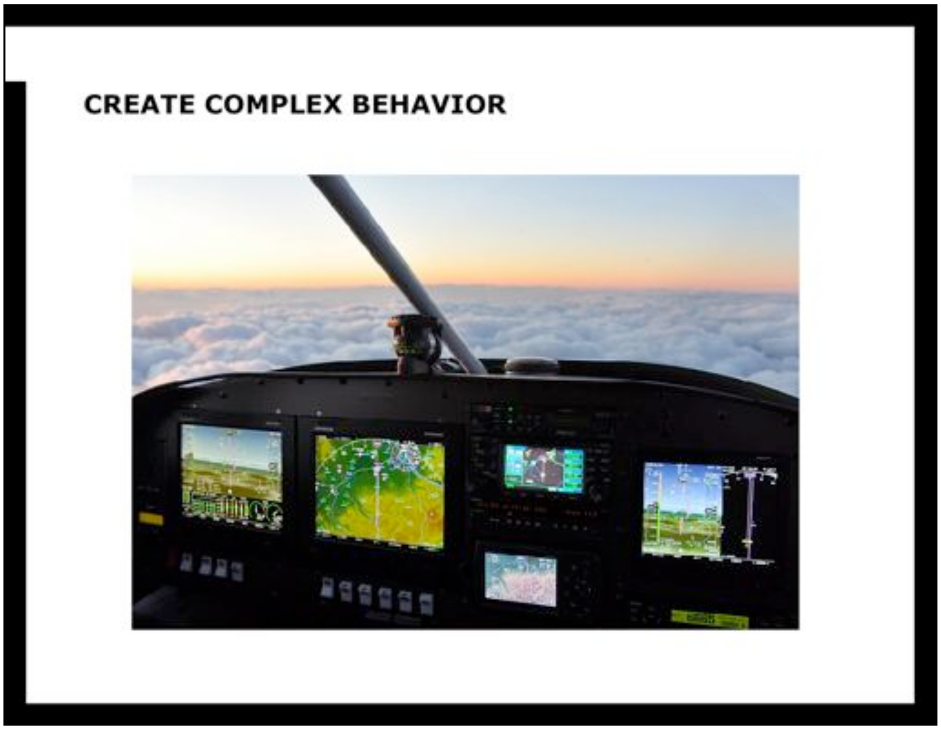
But it also means that device behavior can be replicated exactly. We've become acclimated to it, but--stepping back--the idea of near-exact replication in a world full of randomness and uncertainty is a pretty amazing thing, and is a core part of what makes working with information as a material so powerful.

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 right communicates with its immediate environment through chemical and biological means, through replication, respiration, sending out roots and, if you get too close, through direct physical contact. It’s a robust system, but its communication is distinctly local and limited in scope.

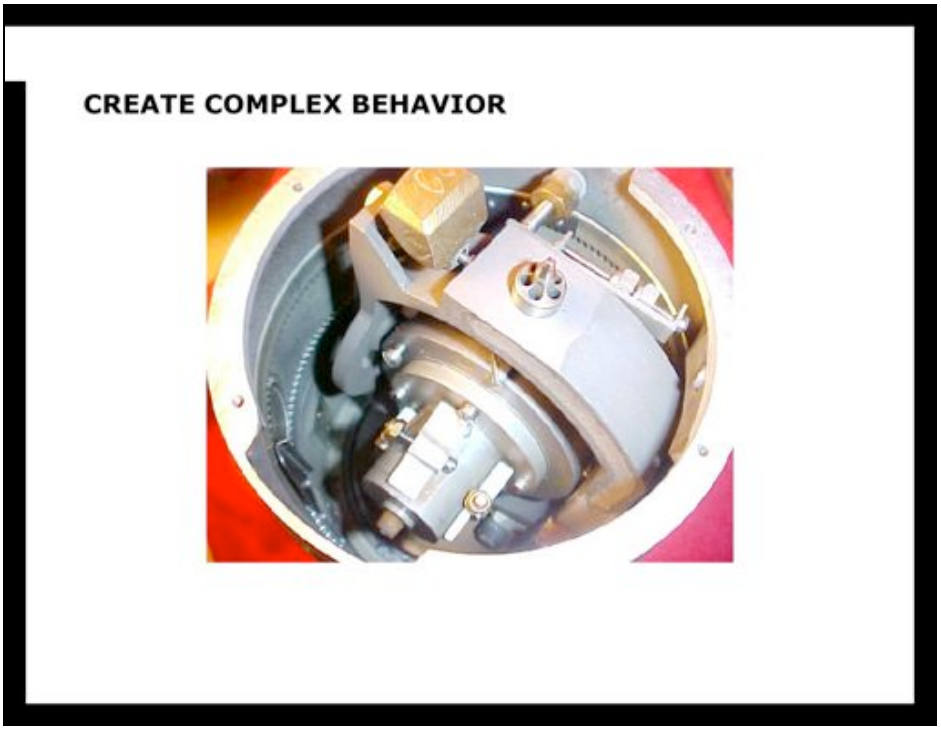
The cactus on the left is made with information. It is a camouflaged cell tower. It’s not as self-contained as the cactus on the right, and is missing the nice properties of a biological organism, but it can communicate autonomously with the whole world at the speed of light. Cars passing by it send machine to machine telemetry, Google Map tiles, pictures of friends, or new firmware. Making with information means making devices that are more interwoven with the whole world than anything before. The ecosystem of the cactus on the right is the SouthWestern US. The ecosystem of the one on the left is the whole world.

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. It's a bit like a flight simulator that actually flies.

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



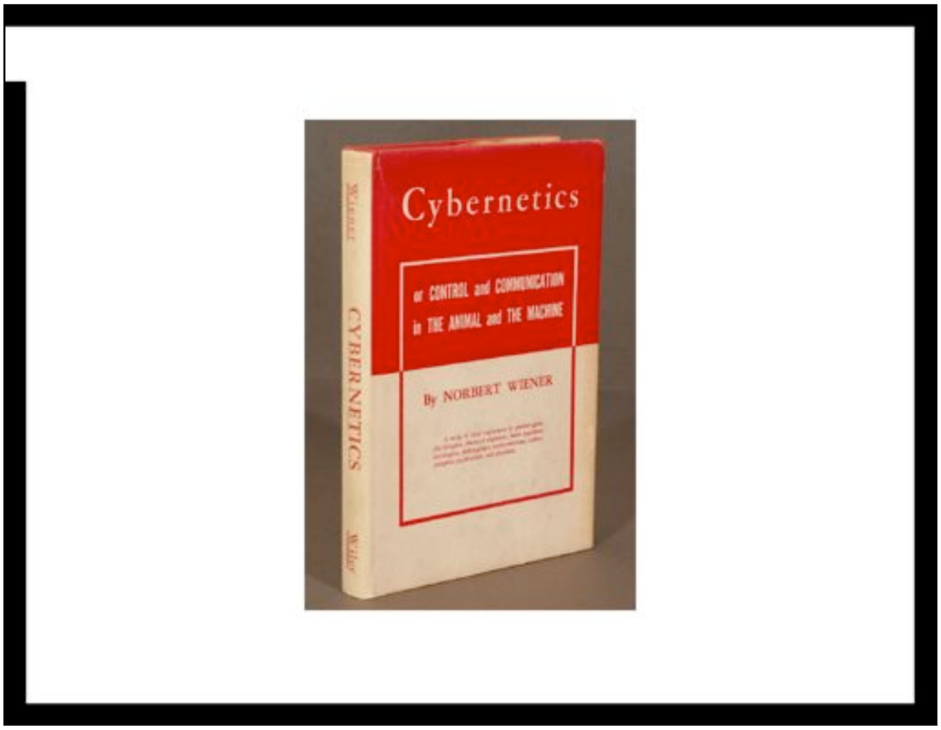
Compare that to a traditional gyroscopic autopilot where every single component is unique, it does very little, and to change its behavior you have to completely reengineer it.

When you make something with information, you enable that thing to exhibit behaviors that are vastly more sophisticated than what was possible with any previous material.

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. They used to embody that knowledge in metal—a carburetor is essentially a set of algorithms encoded in metal—but making a car with information is so much more flexible and efficient cars with carburetors have largely disappeared.

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.

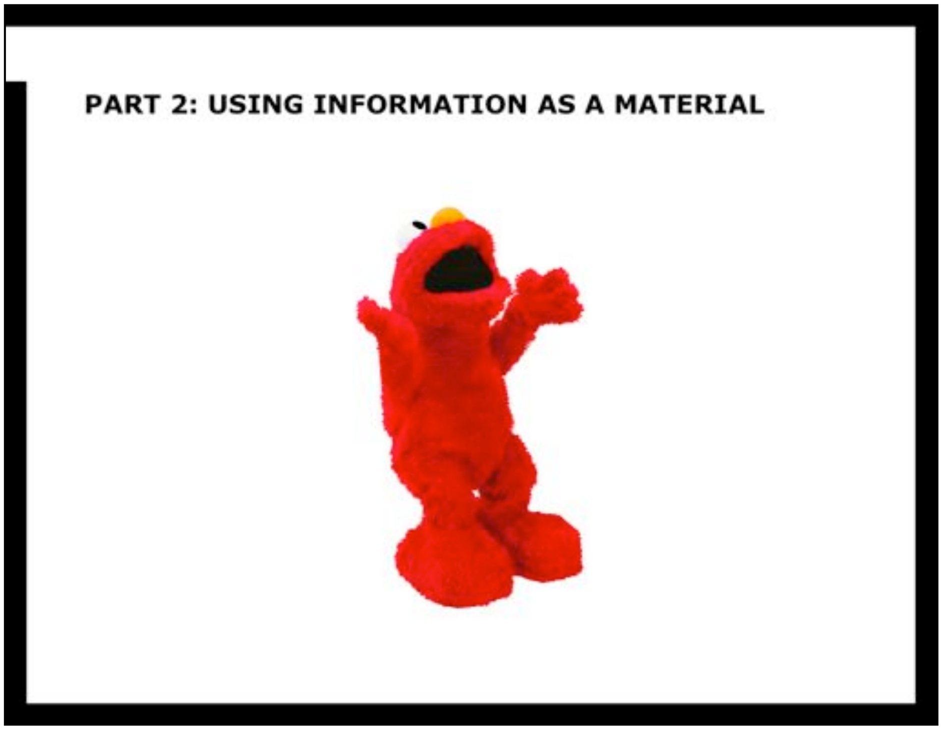
Why do this? Well, if you're Jamba Juice, which is a large US smoothie chain, your business depends on such programmable blenders so their staff don't have to be trained in the fine points of blending and their product is always consistent. Their profit margins depend on knowledge that's encoded into their blenders, knowledge that's accessed with a single button.



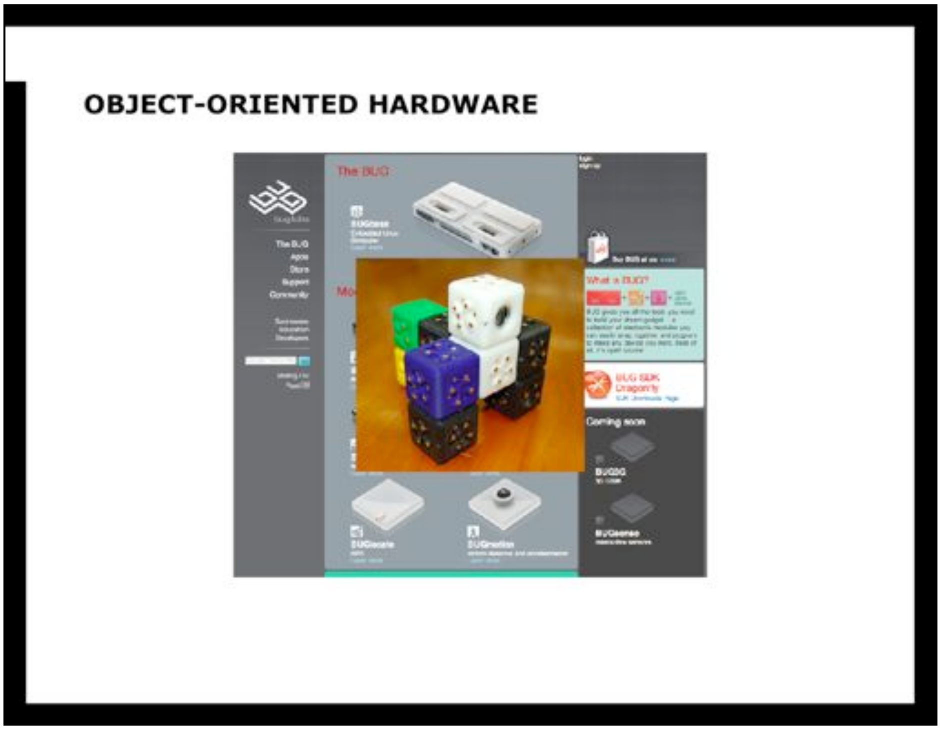
If you just thought, “Wait a minute. I know all this and, besides, Norbert Weiner covered this in Cybernetics in 1948.” you’re right. This is not new. We are intuitively familiar with these properties because we’ve been using computers for a long time. You can probably come up with many examples of products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



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

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

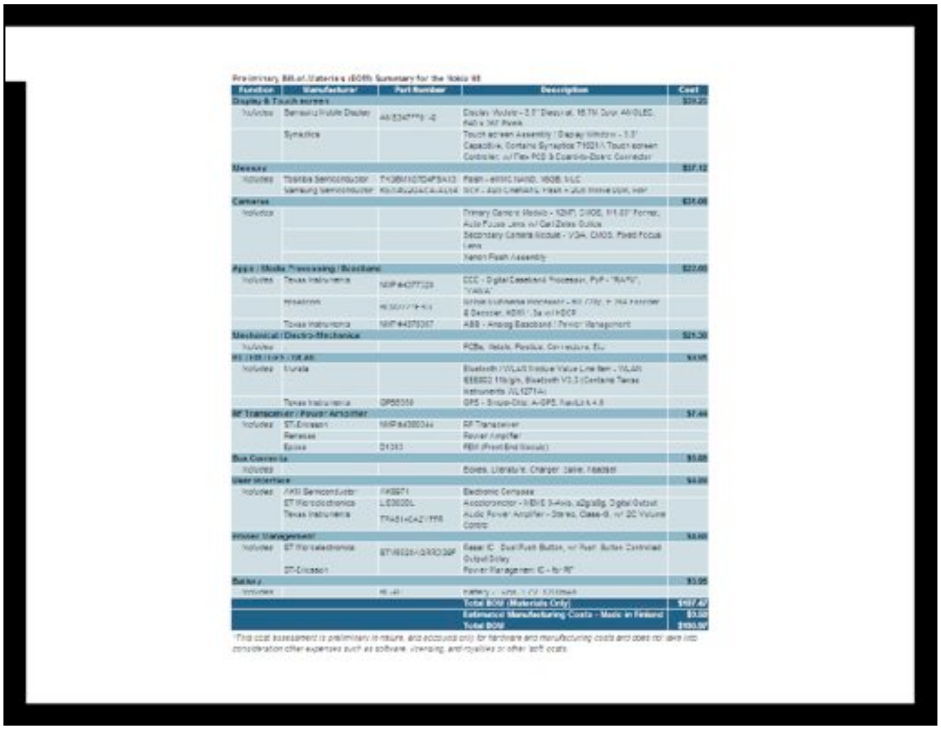
Embedded processors make it possible to create an abstraction layer around basic sensing, processing and actuation components to creates building blocks that are meaningful in human terms, rather than just electronic terms. Each block is an atom of functionality that has a CPU and communicates with other 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



Preliminary Bill-of-Materials (BOM) Summary for the Nokia N8

Function	Manufacturer	Part Number	Description	Cost
Display & Touch screen				[illegible]
Includes	[illegible] Mobile Display	[illegible]	Display Module - 3.5" Diagonal, 16.7M Color AMOLED, 640 x 360 Pixels	
	Synaptics		Touch screen Assembly / Display Window - 3.5" Capacitive, Contains Synaptics [illegible] Touch screen Controller, w/ Flex PCB & Board-to-Board Connector	
Memory				[illegible]
Includes	Toshiba Semiconductor	[illegible]	Flash - eMMC NAND, 16GB, MLC	
	Samsung Semiconductor	[illegible]	[illegible]	
Cameras				[illegible]
Includes			Primary Camera Module - 12MP, CMOS, [illegible] Format, Auto Focus Lens w/ Carl Zeiss Optics	
			Secondary Camera Module - VGA, CMOS, Fixed Focus Lens	
			Xenon Flash Assembly	
Apps / Media Processing / Baseband				$22.00
Includes	Texas Instruments	[illegible]	DBB - Digital Baseband Processor, PyP - "RAPU", "YAMA"	
	[illegible]	[illegible]	[illegible] & Decoder, HDMI 1.3a w/ HDCP	
	Texas Instruments	[illegible]	ABB - Analog Baseband / Power Management	
Mechanical / Electro-Mechanical				$21.30
Includes			PCBs, Metals, Plastics, Connectors, Etc.	
BT / FM / GPS / WLAN				[illegible]
Includes	Murata		Bluetooth / WLAN Module Value Line Item - WLAN IEEE802.11b/g/n, Bluetooth V3.0 (Contains Texas Instruments WL1271A)	
	Texas Instruments	[illegible]	GPS - Single-Chip, A-GPS, NaviLink 4.0	
RF Transceiver / Power Amplifier				$7.44
Includes	ST-Ericsson	[illegible]	RF Transceiver	
	Renesas		Power Amplifier	
	Epcos	[illegible]	FEM (Front End Module)	
Box Contents				[illegible]
Includes			Boxes, Literature, Charger, Cable, Headset	
User Interface				[illegible]
Includes	AKM Semiconductor	[illegible]	Electronic Compass	
	ST Microelectronics	[illegible]	Accelerometer - MEMS 3-Axis, ±2g/±8g, Digital Output	
	Texas Instruments	[illegible]	Audio Power Amplifier - Stereo, Class-D, w/ DC Volume Control	
Power Management				[illegible]
Includes	ST Microelectronics	[illegible]	Reset IC - Dual Push Button, w/ Push Button Controlled Output Delay	
	ST-Ericsson		Power Management IC - for RF	
Battery				[illegible]
Includes		[illegible]	Battery - [illegible]	
			Total BOM (Materials Only)	[illegible]
			Estimated Manufacturing Costs - Made in Finland	[illegible]
			Total BOM	[illegible]

*This cost assessment is preliminary in nature, and accounts only for hardware and manufacturing costs and does not take into consideration other expenses such as software, licensing, and royalties or other 'soft' costs.

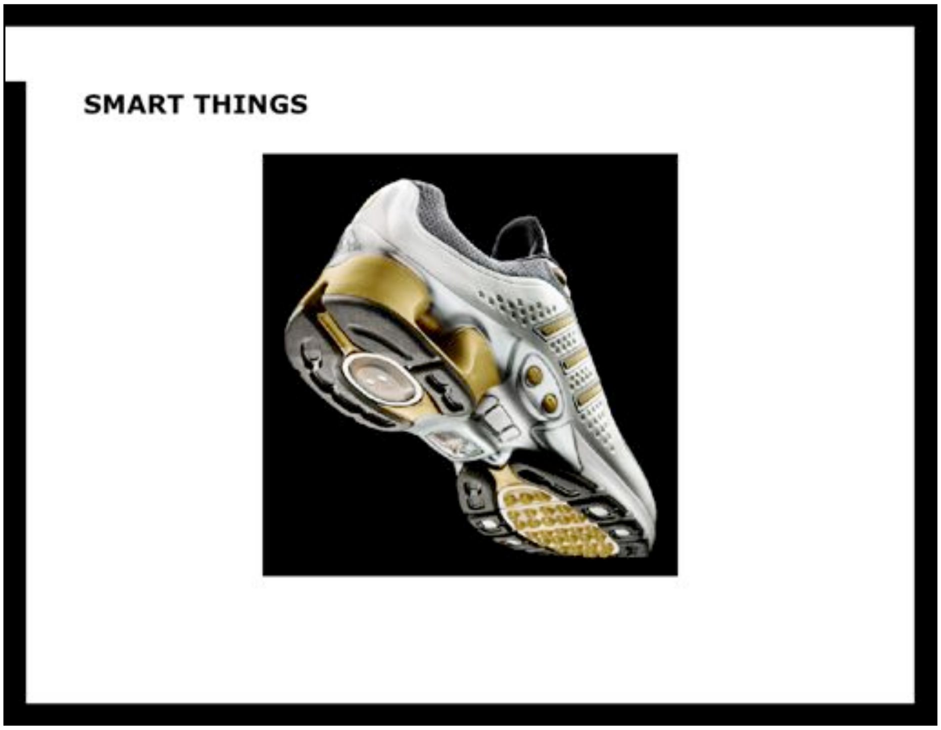
A modern digital device is already more like a small network of interacting components than a monolithic product of a single ground-up engineering process. Here's iSuppli's teardown analysis of the Nokia N8. Nokia itself makes almost none of the components. They buy them off the shelf like Lego bricks 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, or grow their own hardwood trees. 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 for designing with light. Our BlinkM line of smart LED products makes it very easy to put controllable RGB light into arbitrary locations with no knowledge of electronics or color theory. Pick some up today at fine electronics retailers worldwide.

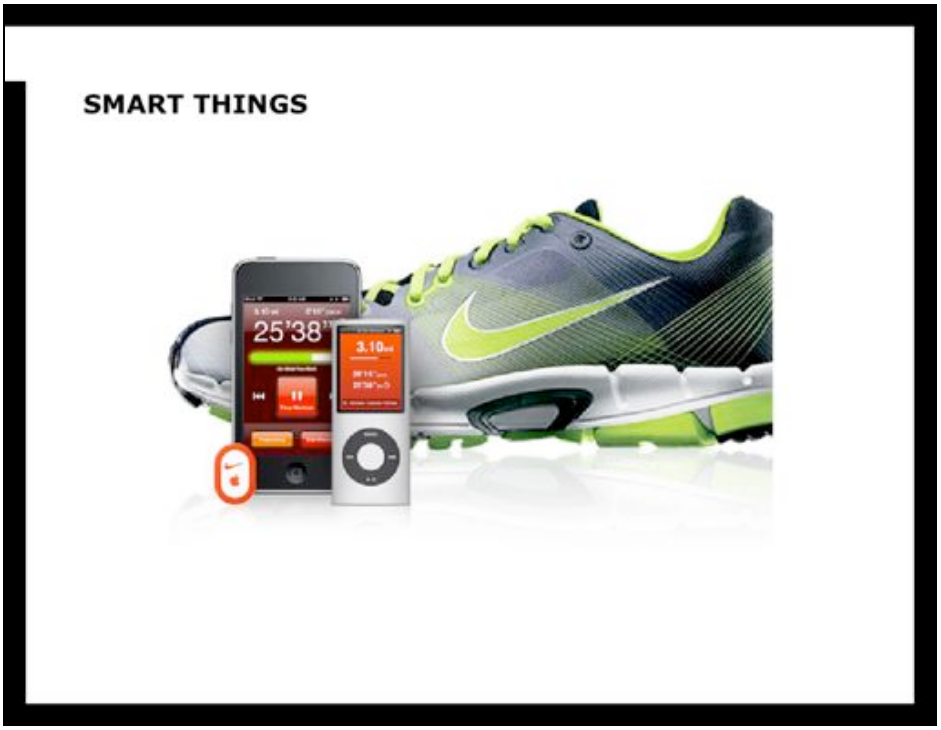
OK, end of sales pitch.



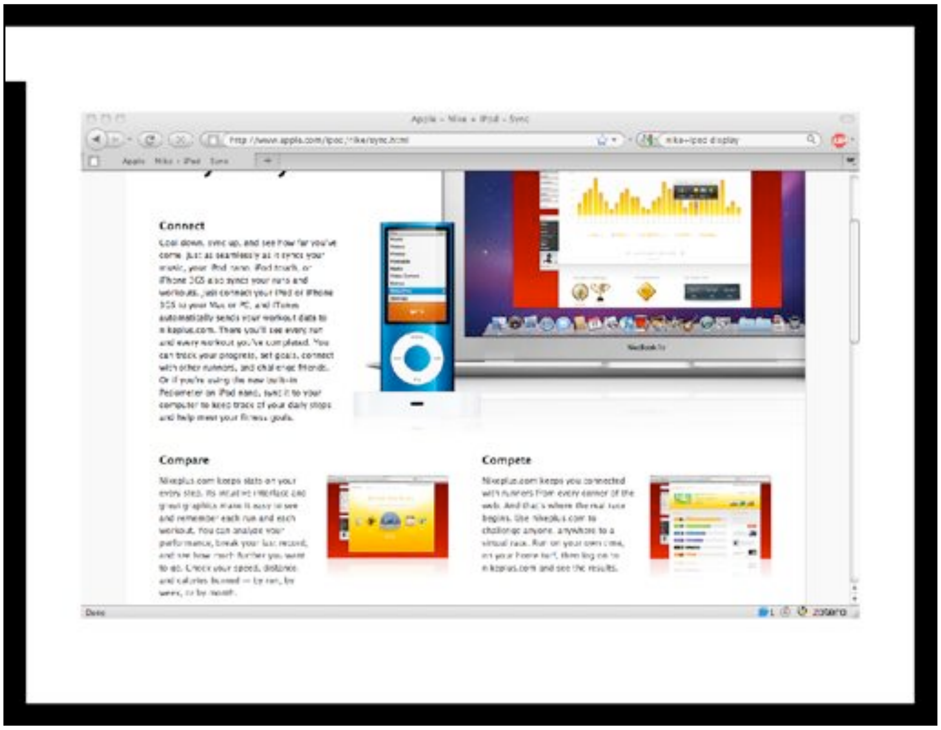
So what’s made with these atoms?

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.

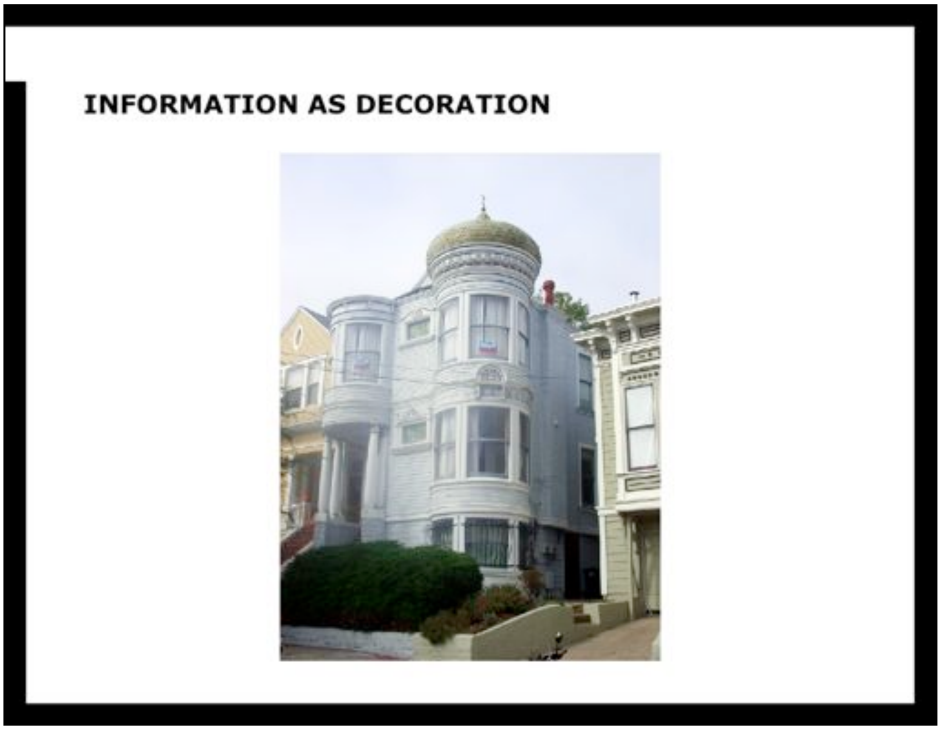
For me it represents how a small amount of information, carefully deployed can profoundly change an object.



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

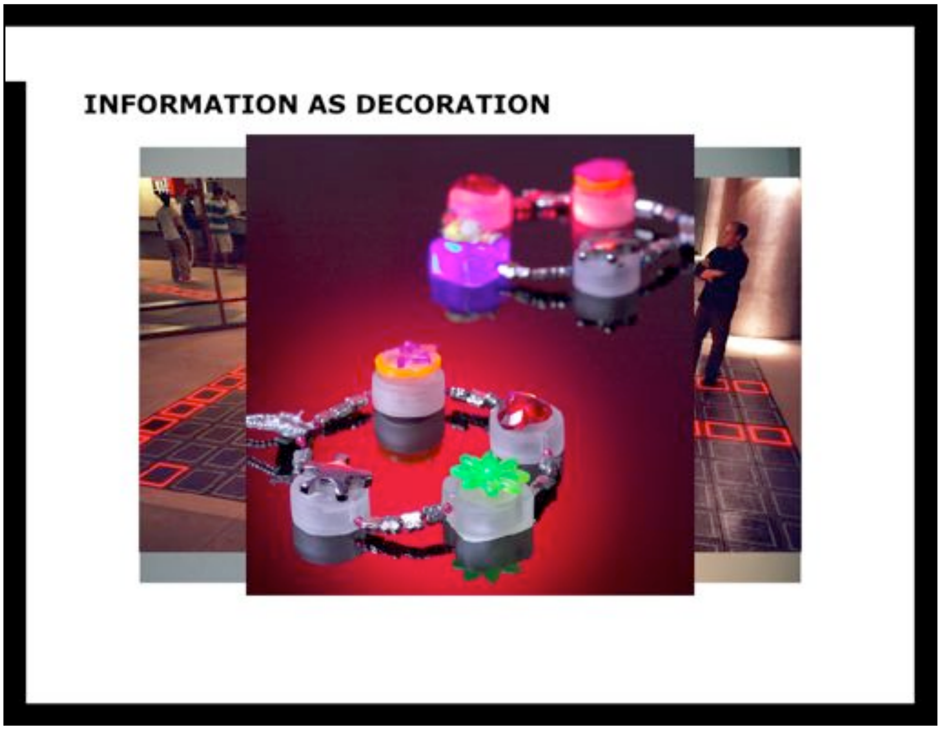


Now that tiny bit of information transforms your shoe from something you run with to the entry point to a new way of experiencing the world. You get analytics, a social network, games, and all of the other things that the Web does well. The boundary of what value the object creates and where that value lies has profoundly changed.



Changing gears a bit. When a material becomes inexpensive, it can be used for nonessential purposes.

You can use wood to hold up a house or as decoration. I live in San Francisco, which is famous for its 19th century Victorians that use as much wood for decoration as they do to hold up the roof. Those Victorians are a product of cheap wood—California was covered in forests in the 19th century and had earthquakes, so bricks were both a luxury and dangerous--and cheap mechanical energy.

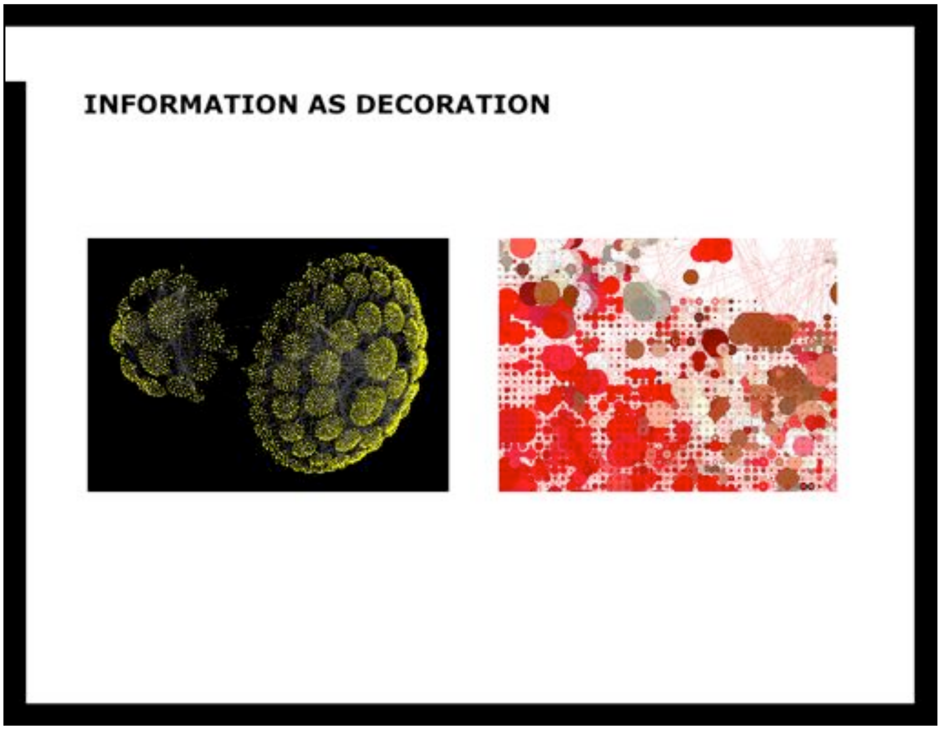


Information will follow the same route and it will be used to create incredibly beautiful, profound esthetic experiences. It has already revolutionized music and cinema, but treating it as a permanent material, rather than a medium, creates fantastic new opportunities. Information is increasingly decoupled from its primarily functional properties and its esthetic potential starts to come out.

Shelf by Jean-Louis Frechin

Floor by Enteractive

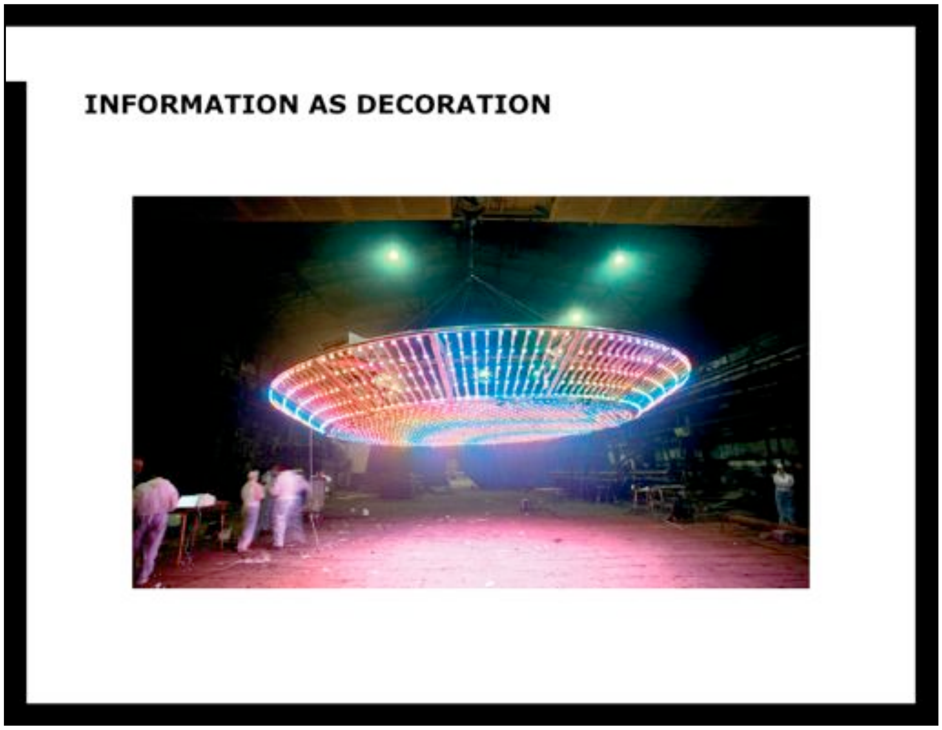
Buddy Beads by Ruth Kikin-Gil



A lot of data visualization today is as much about decoration as it is about information analysis or communication, and that trend is only going to continue.

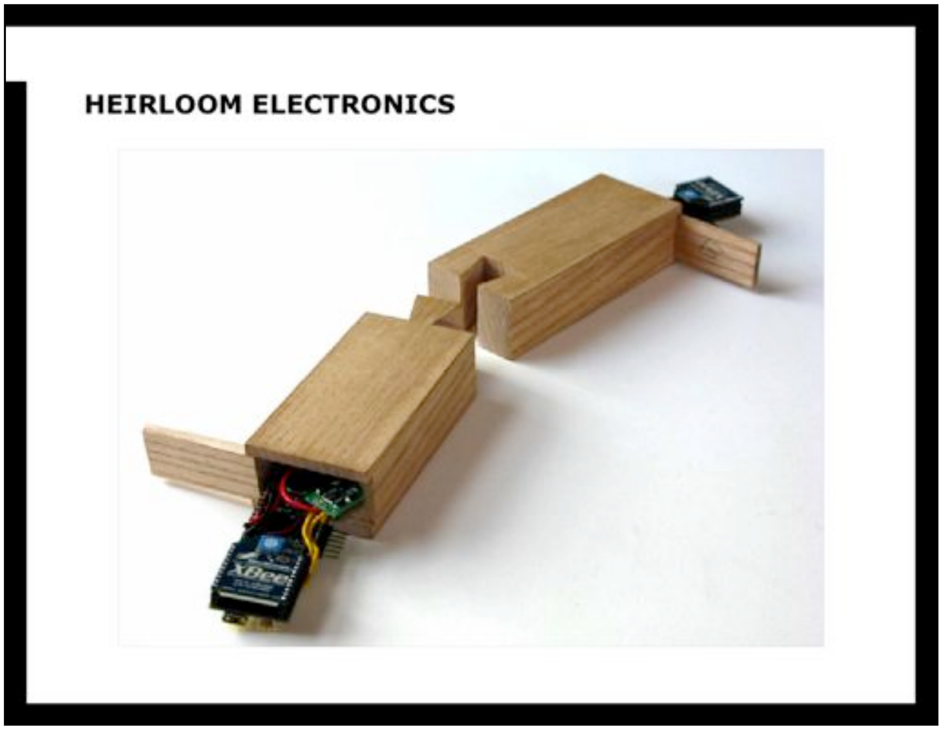
Left visualization by einer von denen: http://www.flickr.com/photos/78875000@N00/364592356/ and http://www.soa-world.de/echelon/2007/01/visulization-of-social-network.html

Right visualization by Nicholas Hardeman: http://www.flickr.com/photos/95943853@N00/3983164252/



The surfaces of our world will begin shimmer and react just to be beautiful. Why not?

Image: UFO by Cinimod Studio and Peter Coffin, 2009



This in turn will cause 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. If it's beautiful, why replace it every year? It's still going to be beautiful next year. Or will it?

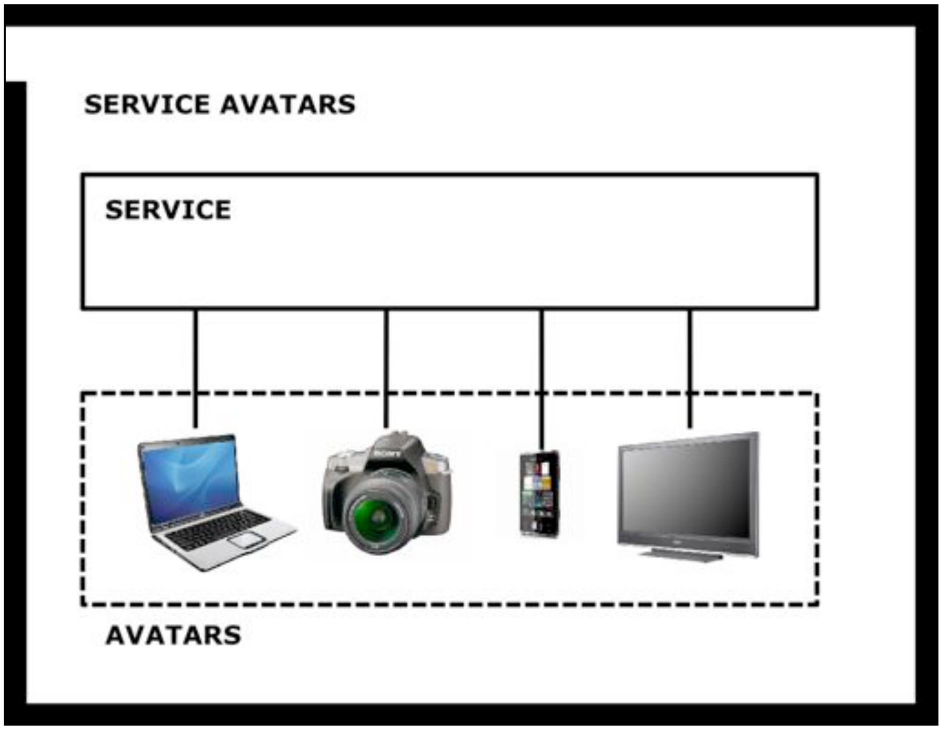
Matt Cottam, an industrial designer who lives here in Amsterdam, has started exploring the concept of heirloom electronics. What does it take to create devices made with information that have both the operational longevity and long-term utility of traditional heirlooms? How can we integrate the functional and esthetic properties of electronics such that our digital devices do not become less interesting and useful with time?

The general trend, however, is for digital devices to become less permanent, to become increasingly ephemeral as we redefine where the value lies in a given device. And this is not just about the disposability of consumer electronics. Making objects with information makes many physical objects increasingly less valuable.

An ATM, for example, is a computer that's useless without the network it's connected to. Similarly mobile phones are nearly useless without their networks. The devices primarily exist not to provide value, but to provide access to a more abstract system, a service, which is the primary source of value. Such services existed before we could make devices with information, but it's now much easier.

We will see many more such devices. I call them service avatars. They are the physical representatives of a service 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, a phone becomes a convenient way to take your Flickr pictures on the road, while a TV becomes a high resolution Flickr display.



Hardware becomes simultaneously more specialized and devalued as users see "through" each device to the service it represents.

Let me give you an example. You can now get Netflix on virtually any device that has a screen and a network connection. You can pause a Netflix movie on one device and then unpause it on another.

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.

When objects are made with information we begin to see the world in terms of the services they give us, not what they are.

INFORMATION SHADOWS

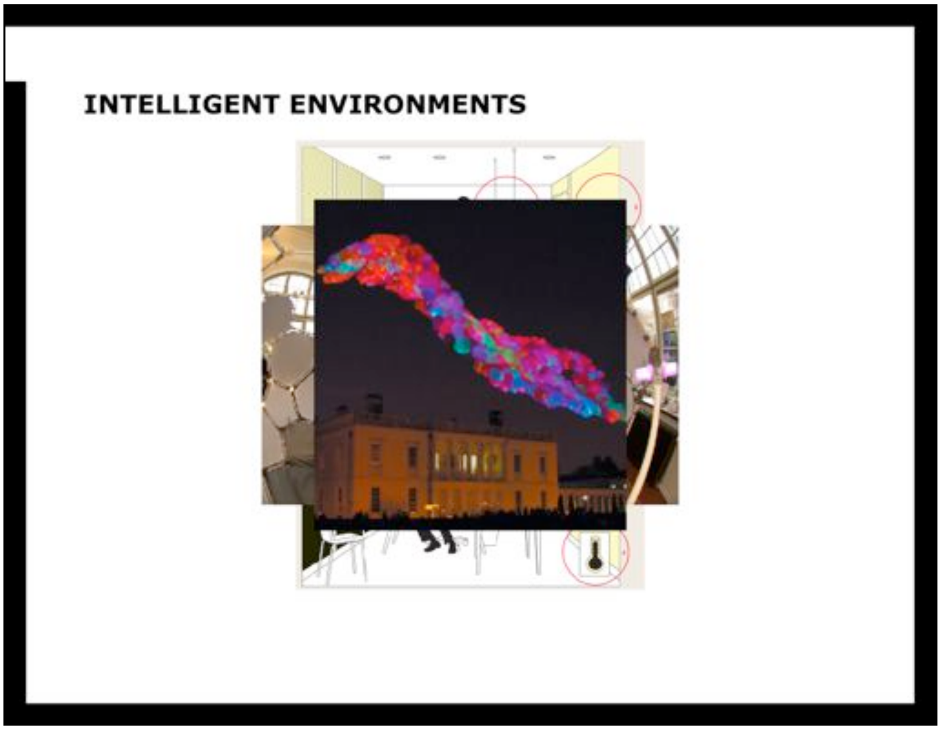
Even nondigital objects augmented with information begin to similarly dematerialize. As they cast information shadows into cloud-based services, our experience of them changes from being primarily about the object, to its role in terms of all the other digital and nondigital objects in our lives. Where was this cantaloupe yesterday? Which of my friends has bought one like this? How do I compost the rind? Has that ever mattered to me? Well, now it may.

Physical experiences become simultaneous data experiences, just as 200 years ago they became mechanized experiences.

Image source: Yottamark

Our notions of ownership changes when physical objects become avatars of services. Everything becomes a possibility space, rather than an object, a sign post, rather than an end point. I now look a book shelf and see searchable data. I look at my clothes and see product service systems. I look at a plate of food and see a temporary node in a system that goes from the farm and back to the farm, through me.

Adding information to the makeup of any object doesn’t just dematerialize it into a service, it profoundly changes it on all levels.



Our environment is 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, and we will have to renegotiate our understanding of every object we come in contact with, much as we did with every previous technology.

There's great opportunity here to create an ecology of services embodied as robust, valuable, exciting new tools 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

And yet there will always be negotiation, which will be done by designers.

Every 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, both of which were equally legitimate possibilities for the technological progress of the 1950s.

We are at the beginning of an enormous structural change in the objects that surround us, just as we experienced in the chemical revolution of the mid-20th century, the energy revolution of the late 19th and the Industrial Revolution of 200 years ago. Some products of those revolutions are undeniably good, and some are undeniably bad, but it's hard to predict which will be which until you're deep in it.

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.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Thank you.