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Research Faculty Summit 2012

ADVANCING THE STATE OF THE ART



Custom Devices for Research

Albrecht Schmidt
University of Stuttgart, Germany



Custom Devices ^{not only} for Research

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Overview

- **Hardware is opening opportunities**
- Challenges for creating a hardware platform
- Opportunities for research in...
- Homogeneity vs. heterogeneity
- Gadgeteer as “material” for physical apps
- Challenges

The Computer for the 21st Century

*Specialized elements of hardware and software,
connected by wires, radio waves and infrared, will be
so ubiquitous that no one will notice their presence*

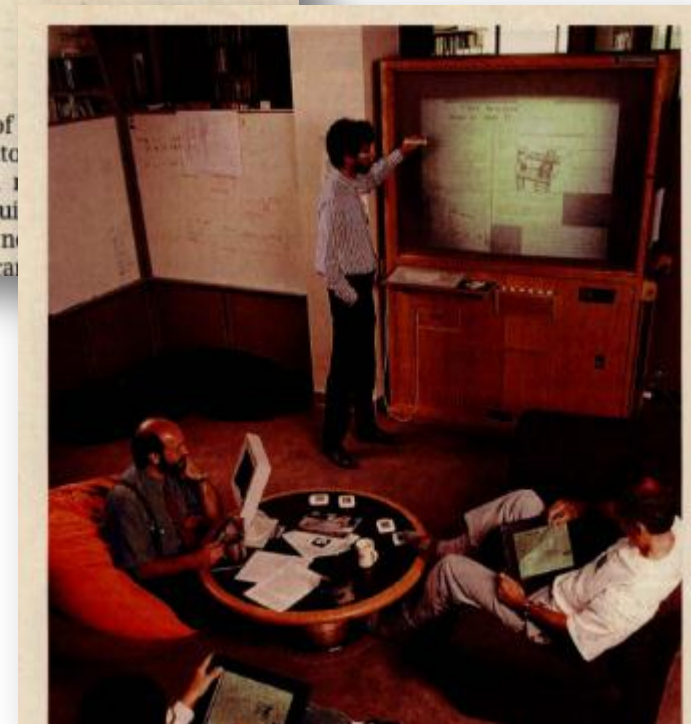
by Mark Weiser

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

Consider writing, perha

is approachable only through complex jargon that has nothing to do with the tasks for which people use computers. The state of the art is perhaps analogous to the period when scribes had to

The idea of seamlessly into counter to a trends. "Ubiqui context does not that can be ca



Photos from [1]

Albrecht Schmidt, July 2012, Microsoft
Faculty Summit

Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms

Hiroshi Ishii and Brygg Ullmer

DataTiles: A Modular Platform for Mixed Physical and Graphical Interactions

Jun Rekimoto Brygg Ullmer* Haruo Oba

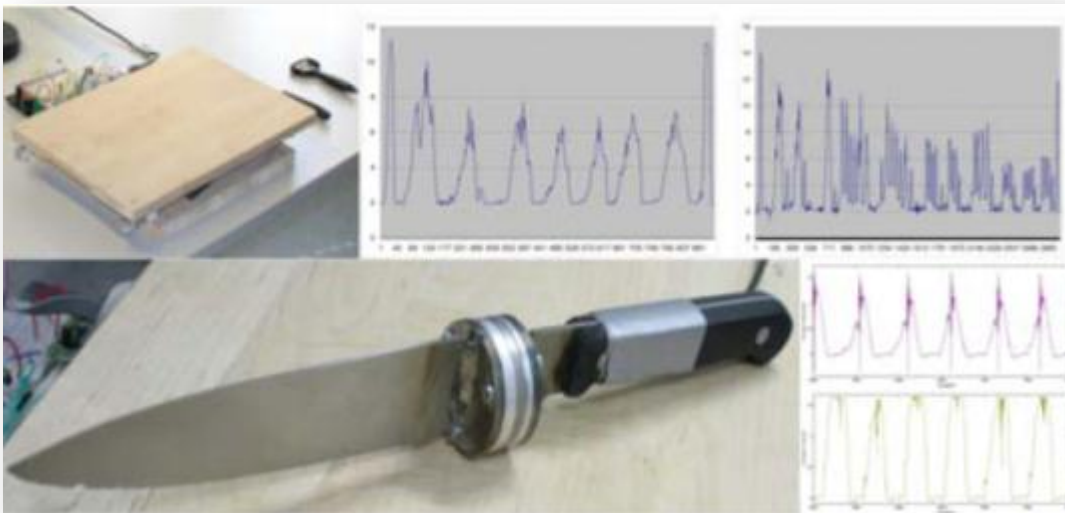
I/O Brush: Drawing with Everyday Objects as Ink

Kimiko Ryokai, Stefan Marti and Hiroshi Ishii



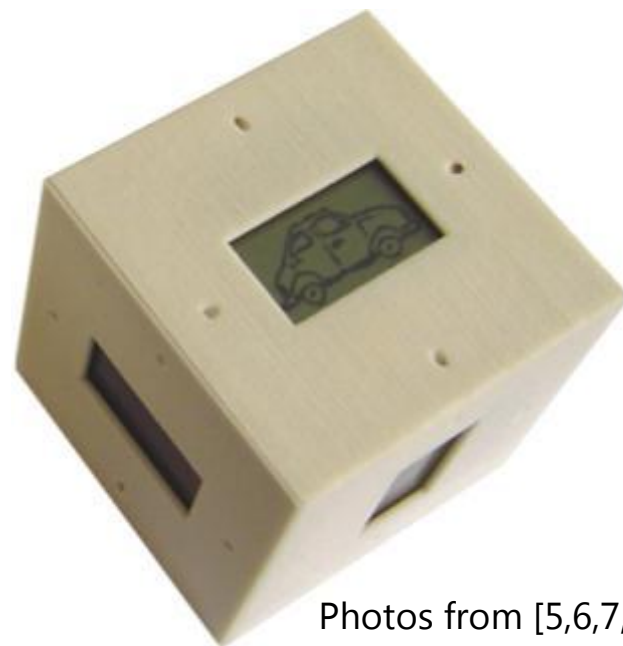
Photos from [2,3,4]





Multi-Sensor Context-Awareness in Mobile Devices and Smart Artefacts

Hans-W. Gellersen¹, Albrecht Schmidt¹ and Michael Beigl²



Albrecht Schmidt, July 2012, Microsoft Faculty Summit

Photos from [5,6,7,8]

New Hardware is creating opportunities for research

- New hardware makes people explore new research questions



Photo from [9]

- **Researchers who can build new hardware can open out new domains**

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Designing a hardware platform for ubiquitous computing research

- Trade-offs
 - Self-contained vs. extendable
 - Size and weight vs. DIY friendliness
- Requirements
 - Processing
 - Connectivity
 - Sensing
 - Actuation

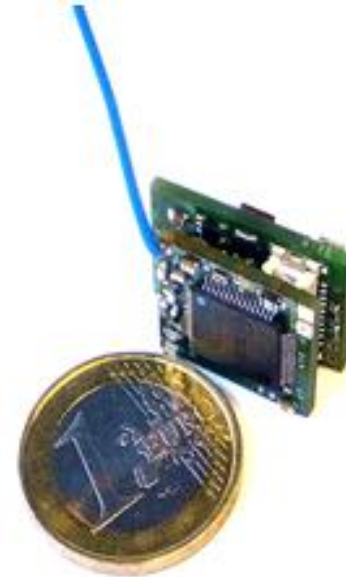
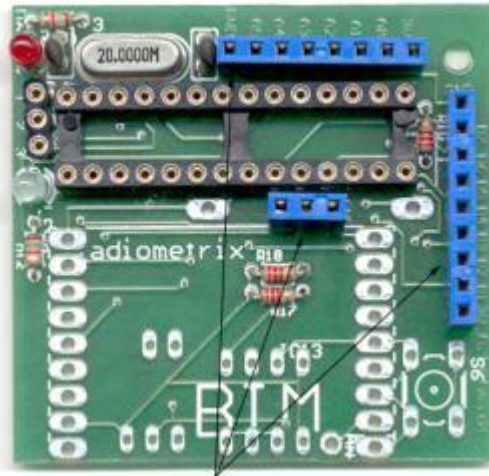
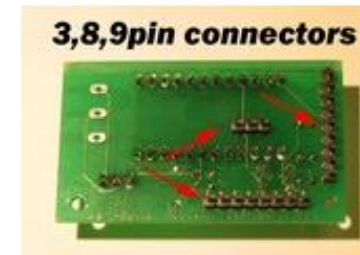


Photo from
<http://particle.teco.edu/devices/>

Lessons learned from Smart-Its



The 3 pin connector for the antenna.



The connectors to the Smart-Its board.



Modular open hardware is great.
Miniaturization is key to move beyond proof of
concept implementation
DIY is not enough...

Lessons learned from Arduino



```
Arduino - 0011 Alpha
File Edit Sketch Tools Help

Blink

/*
 * Blink
 * The basic Arduino example. Turns on an LED on for one second,
 * then off for one second, and so on... We use pin 13 because,
 * depending on your Arduino board, it has either a built-in LED
 * or a built-in resistor so that you need only an LED.
 * http://www.arduino.cc/en/Tutorial/Blink
 */

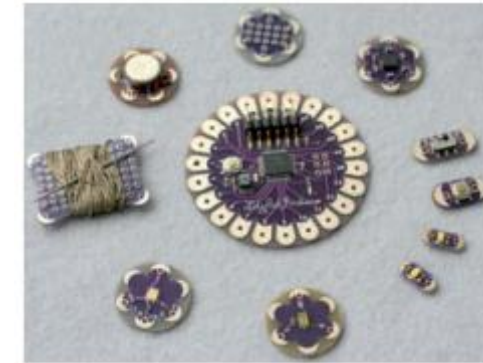
int ledPin = 13;           // LED connected to digital pin 13

void setup()               // run once, when the sketch starts
{
  pinMode(ledPin, OUTPUT); // sets the digital pin as output
}

void loop()                // run over and over again
{
  digitalWrite(ledPin, HIGH); // sets the LED on
  delay(1000);                // waits for a second
  digitalWrite(ledPin, LOW);  // sets the LED off
  delay(1000);                // waits for a second
}

Done compiling.

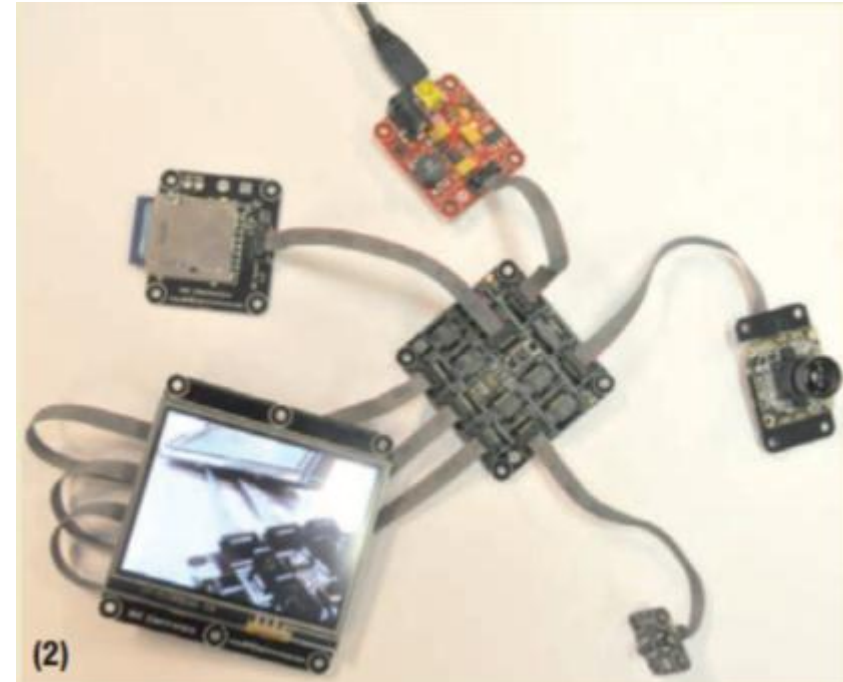
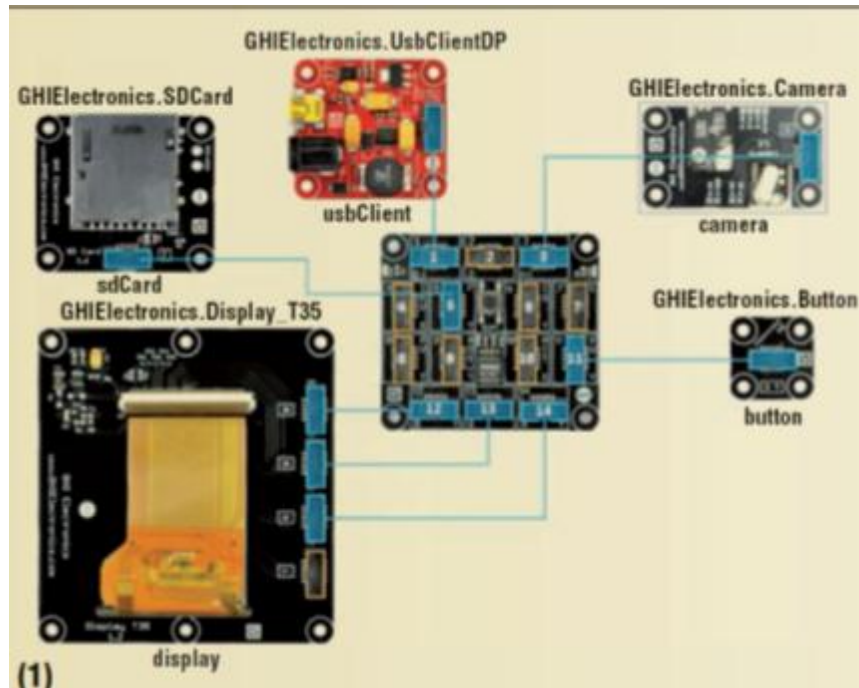
Binary sketch size: 1098 bytes (of a 14336 byte maximum)
22
```



For details and photos see
<http://en.wikipedia.org/wiki/Arduino>

More than one form factor required
Development support / programming language is key
Powerful computing and multimedia are tough

Gadeteer



- Powerful modular platform supporting multimedia
- Modern integrated development environment (Visual Studio)
- Catering for hardware, software, and industrial design

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Handheld Devices and Wearable Computing



Figure 1: a) RFIDs, b) Different Coils, c) The Wearable Tag Reader.



Smart Environments and interactive Furniture



Albrecht Schmidt, July 2012, Microsoft
Faculty Summit

Novel input and output devices



Figure 3. The Peppermill is an interaction-powered user interface device that used to control a TV. Rotating the Peppermill clockwise with the red button p turns up the volume, and with the green button pressed increments the chan

For details see [15]



For details see [14]

Robots



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Sensor networks deployments



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Who of you did bring a pen to Redmond?

Products and Services a means for Self-Expression



Photos from Wikipedia



Future of Simple Products

- There are many companies that make simple electronic products (e.g. alarm clock, radio)
- There are many companies and individuals that create software, apps, web-apps
- There are very few companies that make Phones, Computers, Tablets
- In the future: simple electronic products will be computers
- What will happen?



“Long lasting constants” Maslow’s Hierarchy of Human Needs

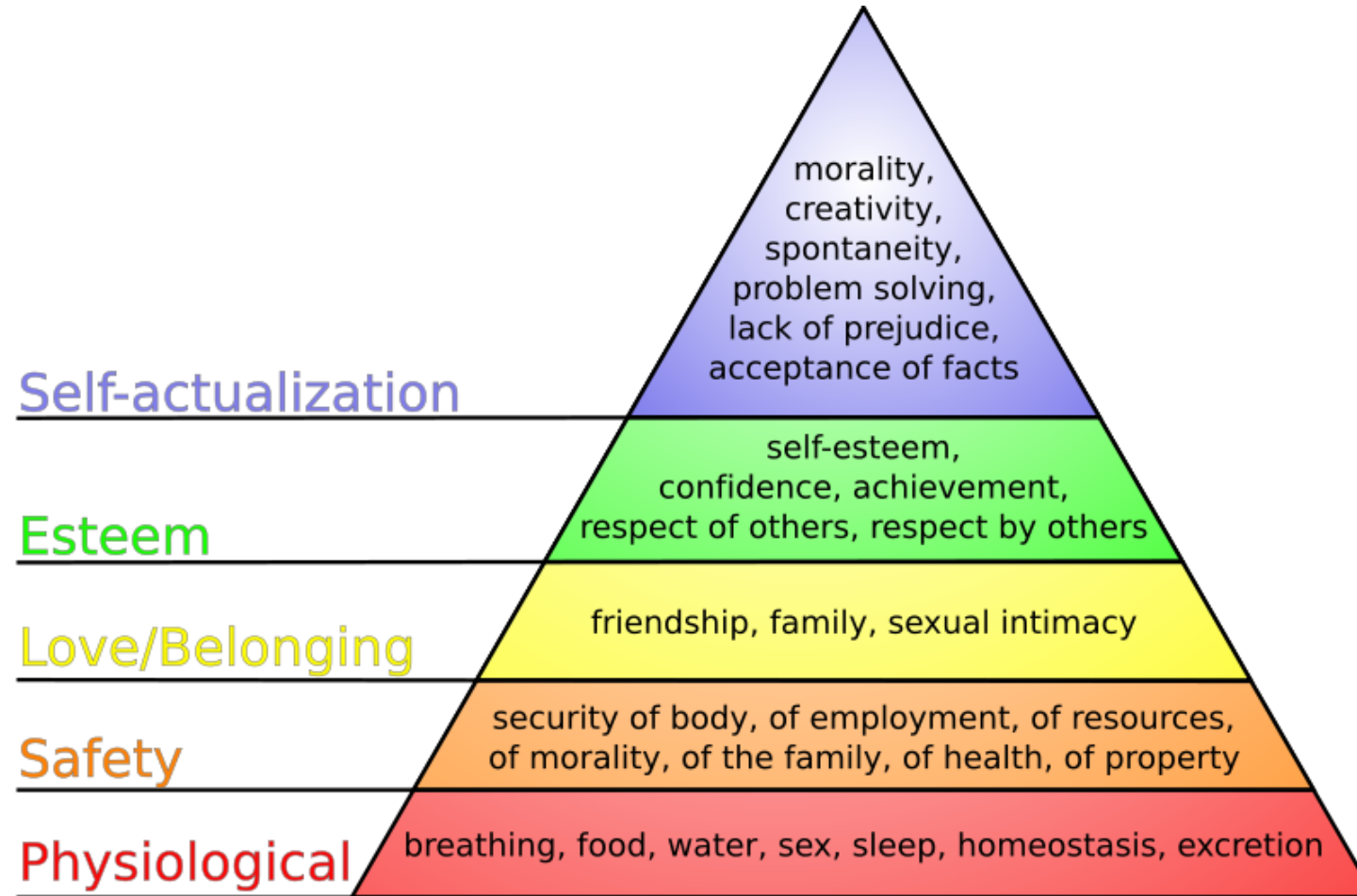


Image from Wikipedia

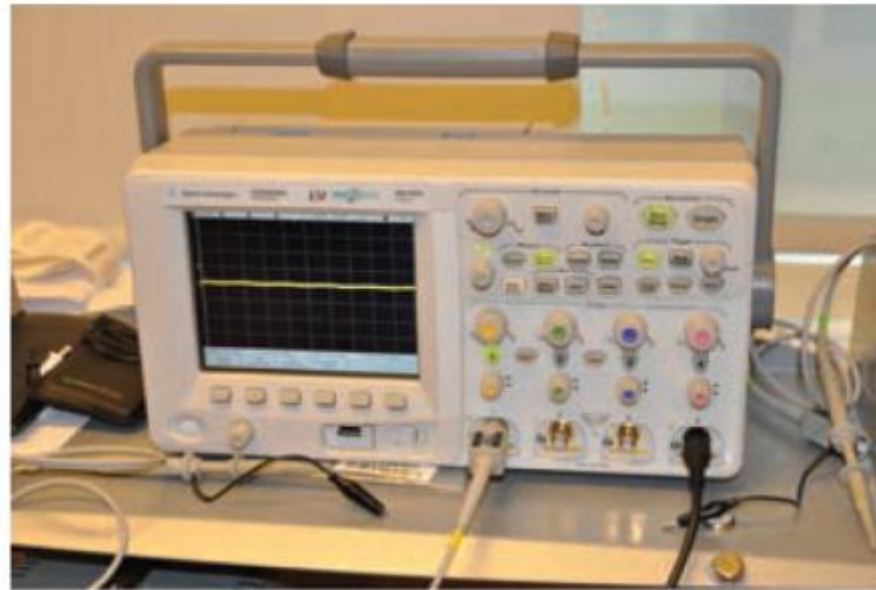
Killer Apps

- What is the killer app on a Windows Phone?
- What is the killer app on an iPhone?
- What is the killer app on a Android Phone?



Core and additional functionality for devices

- Will these devices have internet connectivity?
- Will they offer cloud connectivity?
- Will there be extensions and applications for download?
- What will be the key functionality?



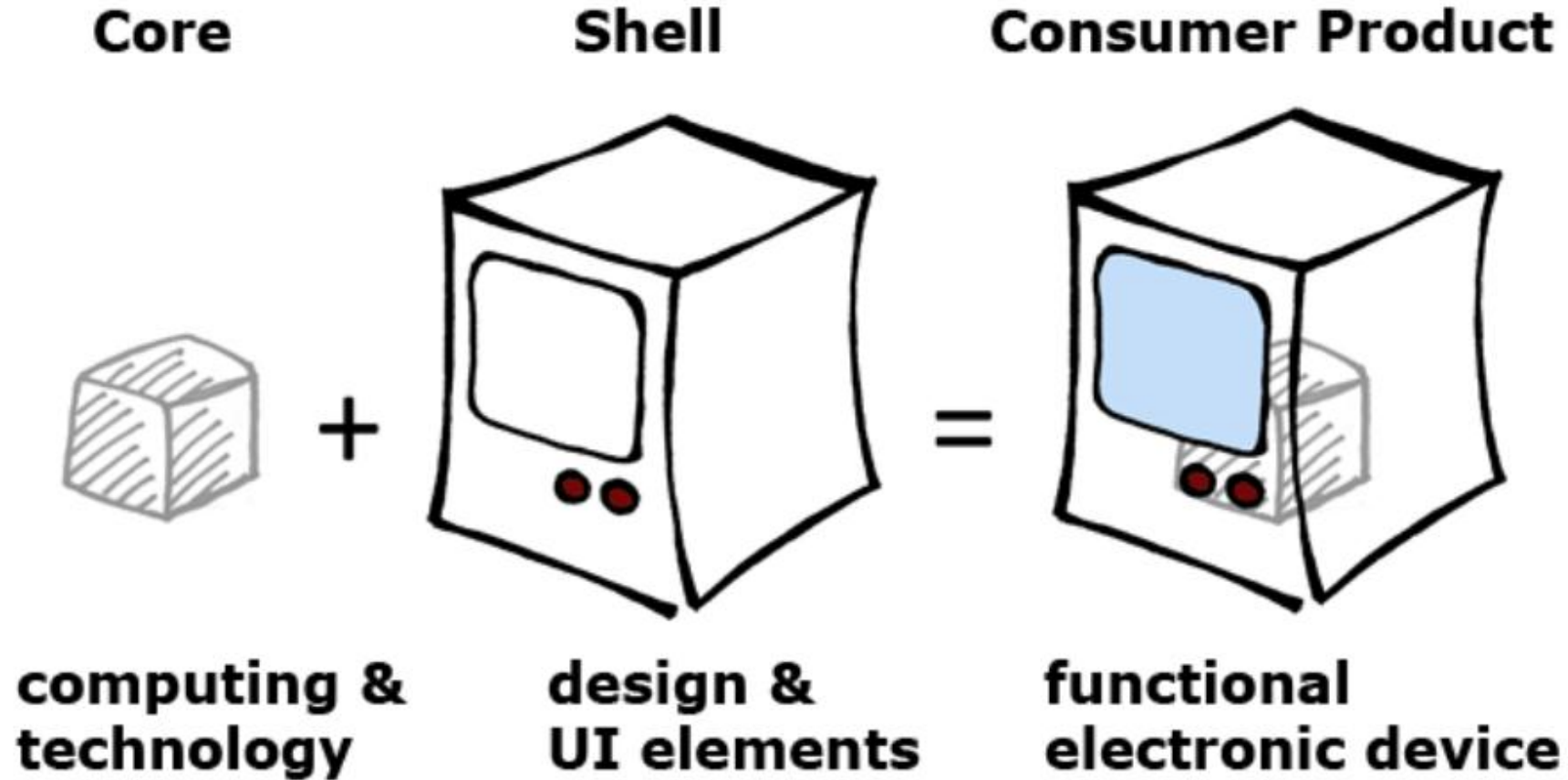
Lot size for consumer products? Will there be the long tail?

- Long tail for apps and web pages
- In the app-model even 1000 paying users may make a business case for an individual developer
- Can we envision such a model for physical goods?

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Vision



For details see [12,16]

Scenario

- Designer produces a new alarm clock and allows design options for the user to select
- User goes to webpage, customizes the product, makes it unique, and orders it
- Manufacturing means:
 - Devices body is printed
 - Hardware is assembled from Gadgeteer core and I/O
 - software downloaded into the assembled hardware
 - Physical device is assembled
 - ... and ship (or instead of manufacturing it may also be done by the customer themselves)

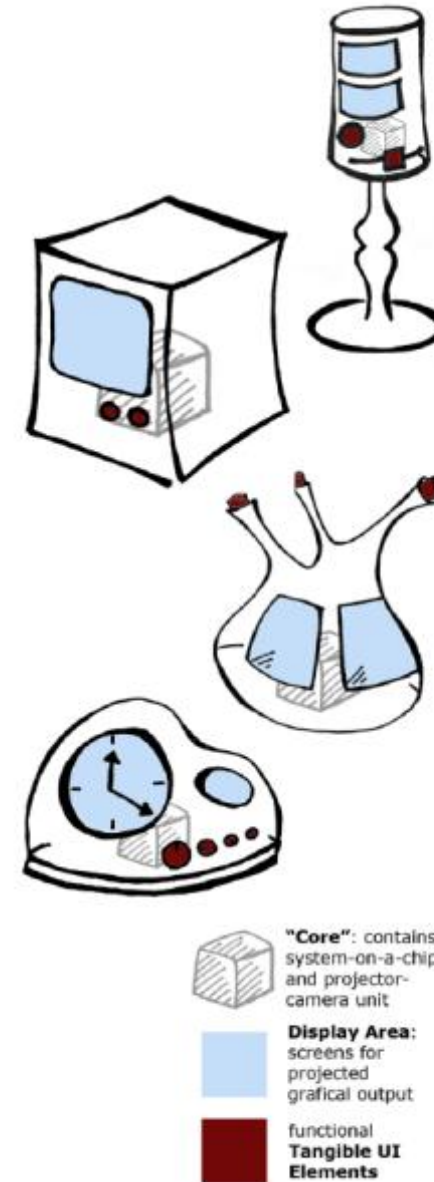
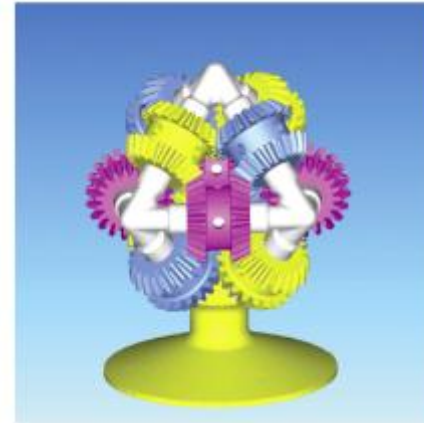


Image from [16]

Creating Custom Shapes

- 3D Printing

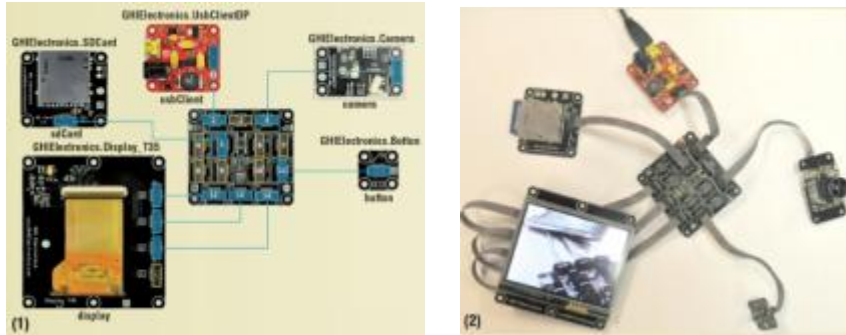


- Laser cutting



For details see [12]

Easy means for the creation of custom made multi-media computers



- Hello World Program „Digital Camera“

```
void ProgramStarted()
{
    // Associate events with event-handling methods
    button.ButtonPressed += new Button.ButtonEventHandler(button_ButtonPressed);
    camera.PictureCaptured += new Camera.PictureCapturedEventHandler(camera_PictureCaptured);
}

void button_ButtonPressed(Button sender, Button.ButtonState state)
{
    camera.TakePicture();
}

void camera_PictureCaptured(Camera sender, GT.Picture picture)
{
    // Show the picture on the display
    display.SimpleGraphics.DisplayImage(picture, 0, 0);

    // Save the picture to the SD card
    sdCard.GetStorageDevice().WriteFile("picture.bmp", picture.PictureData);
}
```

Microsoft
Gadgeteer

For details see [13]

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What is missing to make the work?

- System development IDE
 - Hardware
 - Software
 - Design
 - Low barrier to create systems
- Business model for physical apps
 - Distribution channels
 - Reputation and payment models
- Reusability
 - Components of devices that can be reused
 - Libraries of components for interactive devices
- Power options besides batteries

It is unlikely that “one size fits all” will work

Domain specific IDEs, e.g. for curators in museums, for children, creating cameras, ...

Discussion

Series of Articles about this in IEEE Pervasive Magazine

- A. Schmidt and D. Bial. “Phones and MP3 Players as the Core Component in Future Appliances.” IEEE Pervasive Computing, vol. 10, no. 2, 2011, pp. 8–11.
- A. Schmidt, T. Doring, and A. Sylvester, “Changing How We Make and Deliver Smart Devices: When Can I Print Out My New Phone?” IEEE Pervasive Computing, vol. 10, no. 4, 2011, pp. 6–9.
- S. Hodges, N. Villar, J. Scott, and A. Schmidt, “A New Era for Ubicomp Development” IEEE Pervasive Computing, vol. 11, no. 1, 2012, pp. 5–9.



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11. A. Schmidt and D. Bial. "Phones and MP3 Players as the Core Component in Future Appliances." *IEEE Pervasive Computing*, vol. 10, no. 2, 2011, pp. 8–11.
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13. S. Hodges, N. Villar, J. Scott, and A. Schmidt, "A New Era for Ubicomp Development" *IEEE Pervasive Computing*, vol. 11, no. 1, 2012, pp. 5–9.
14. Daniela Petrelli, Nicolas Villar, Vaiva Kalnikaite, Lina Dib, and Steve Whittaker. 2010. FM radio: family interplay with sonic mementos. In *Proceedings of the 28th international conference on Human factors in computing systems* (CHI '10). ACM, New York, NY, USA, 2371-2380. DOI=10.1145/1753326.1753683
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16. Tanja Doering, Bastian Pfleging, Christian Kray, and Albrecht Schmidt. 2010. Design by physical composition for complex tangible user interfaces. In *Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems* (CHI EA '10). ACM, New York, NY, USA, 3541-3546. DOI=10.1145/1753846.1754015

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