Lecture 1
Introduction
Pervasive Computing
MIT 6.883 & SMA 5508

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Course Structure Overview

- Two sets of students -- MIT and SMA
- Two parts to class
  - Individual technologies (PS & Quiz)
  - Group projects
- Materials
  - iPaq & backpaq, Cricket, Nokia Series 60 Phone
  - Slides, handouts, notes (raw)
  - Readings
  - TA's -- filter for your questions
    - Ning Song (nsong@mit.edu), ???@ SMA

Administration

- Official Web Site and Wiki
  - http://people.csail.mit.edu/rudolph/Teaching/home883.html
  - http://org.csail.mit.edu/mode

What is pervasive computing?

- Post PC -- PC not the center
- Digital devices all around us
- Ubiquitous Computing
  - Mark Weiser -- Calm Computing

The origin of the course: Project Oxygen

To bring an abundance of computation & communication within easy reach of humans
through natural perceptual interfaces of speech and vision
so computation blends into peoples' lives
enabling them to easily do tasks they want to do:

- ***collaborate,***
- ***access knowledge,***
- ***automate routine tasks***

MIT PROJECT OXYGEN
PERVASIVE, HUMAN-CENTERED COMPUTING

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Pervasive, Human-Centric Computing

What do these words mean?

- Computers are already pervasive
  - even in Boston and Singapore
- Computers are already human-centric
  - are they for the birds?
- It's not really about computing
  - we already know how to do that

So, what do we mean?

- Pervasive
  - Should be where we need them
    - not have to go to them or set them up
- Human-centric
  - Computers should adapt to humans
    - computation enters our world/environment
- Computing
  - Computer-mediated function
    - digital media

Look back to see ahead

- Monolithic Programs & Hardware
- Decompose into interactive pieces
  - Compose to build large thing
- Continue decomposing into autonomous, interacting components

Finding and naming stuff

- Few items
  - Use list
- Many items
  - Use heirarchy
- Very many items
  - Use multi-index

Organization of material

- Top-down
  - would be nice to start writing apps
  - but we are not there yet
- Bottom-up
  - Build on what is known
    - Keyboard, mouse, pen
    - Location, Speech, Multimodal
    - Integrative Technologies

H21 components

- Hardware
  - iPAQ
  - Backpaq
  - Wireless Communication

Software

– Linux
– Landcam
– Galaxy Audio Interface
– Cricket Location Reporting

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iPAQ 3870

3870 iPAQ

– 206 MHz Strong Arm
– 64 Mbytes SDRAM
– 32 Mbytes flash storage
– Bluetooth
– SD/MMC card slot
– 16 bit color display

5500 iPAQ

– 400 MHz Xscale
– 128 Mbytes SDRAM
–48 Mbytes flash storage
– Bluetooth & WiFi
– SD/MMC card slot
– 16 bit color display

Linux on H21

- Why Linux?
  - Linux allows full access to all software
  - Common development with desktop
  - Can use open source code from many sources
- Porting Linux to a handheld device
  - More difficult than standard PC or Laptop
    - Non-standard interfaces (screen, control FPGAs, touch screen, …)
    - Requires rewritable Flash ROMs
    - For iPaq, port done by HP's Cambridge Research Lab

H21 Backpaq

- Redesigned BackPaq (Version 3)
  - Philips imager (640x480 CMOS color imager UPA1022)
  - Larger FPGA (Xilinx Virtex 300E)
  - 256k x 16 SRAM
  - Lower power
  - 3-axis accelerometer in camera housing
  - 2-axis accelerometer in Backpaq
  - Dual PCMCIA slots
  - Audio input/output codec and headset jack
  - 32 MBytes Flash in Backpaq
  - LVDS Connector from FPGA pins
  - Lion Battery

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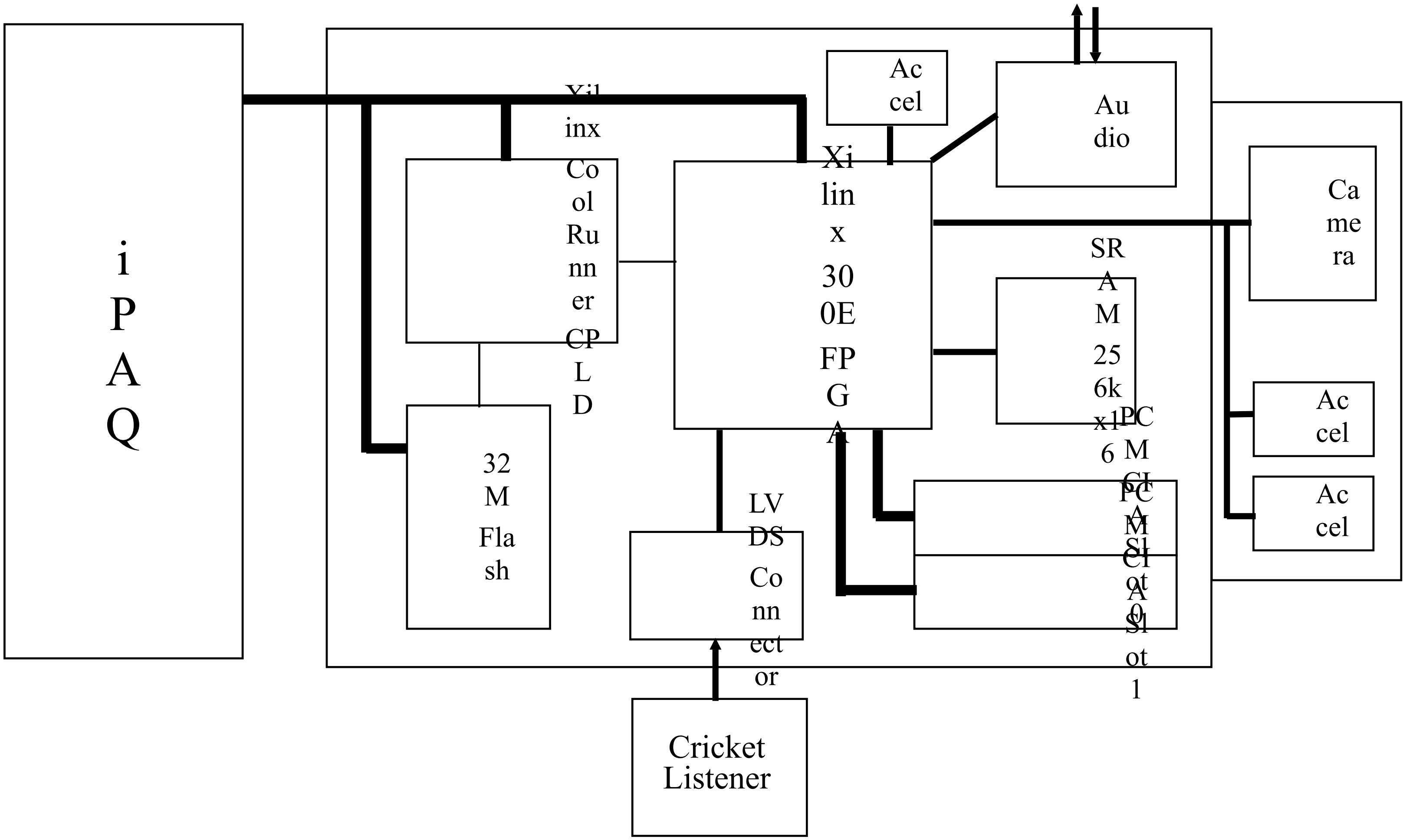

iPAQ
Xilinx CoolRunner CPLD
32M Flash
Xilinx 3000E FPGA
Accel
Audio
Camera
SRAM 256kx16
Accel
Accel
PCMCIA Slot 0
PCMCIA Slot 1
LVDS Connector
Cricket Listener

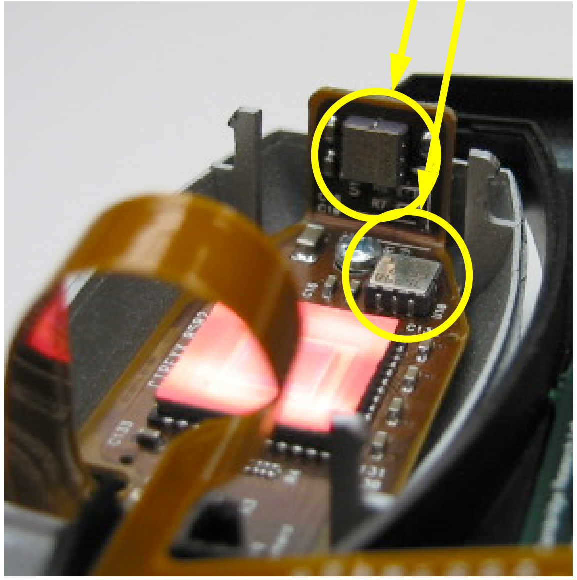
- Philips UPA1022 Imager
  - 640x480 CMOS
  - [illegible]

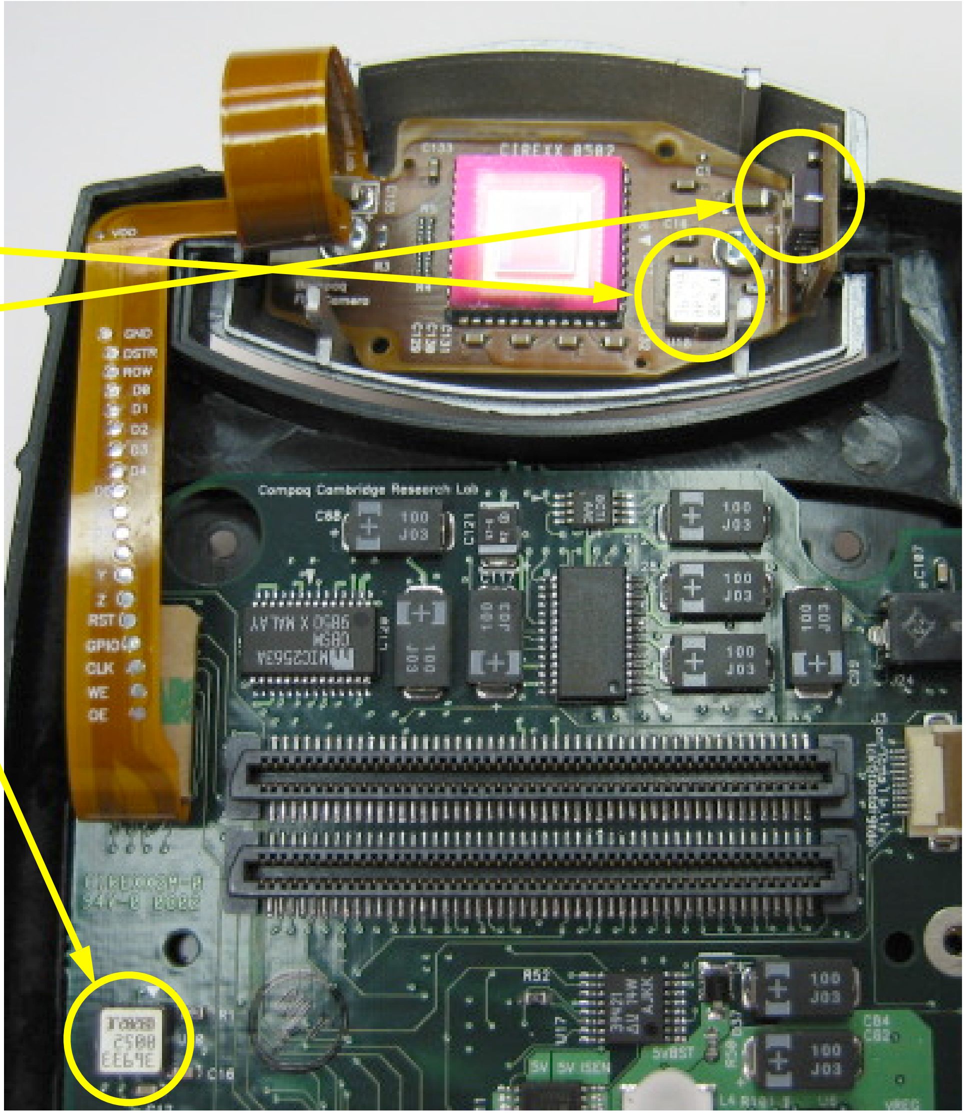
Three Accelerometers:

One in camera plane

One perpendicular

One on Backpaq PCB





Accelerometer Linux Devices

- 2-Axis accelerometer (on main PCB)
  - `/dev/backpaq/accel`
  - Each read returns X and Y acceleration values
- 2-Axis accelerometer (on camera PCB)
  - `/dev/backpaq/cam_accel`
  - Each read returns X and Y acceleration values
- 3-Axis accelerometer (in camera housing)
  - `/dev/backpaq/cam_accel_xyz`
  - Created from 2 perpendicular 2-axis accelerometers
  - Each read returns X, Y and Z acceleration values

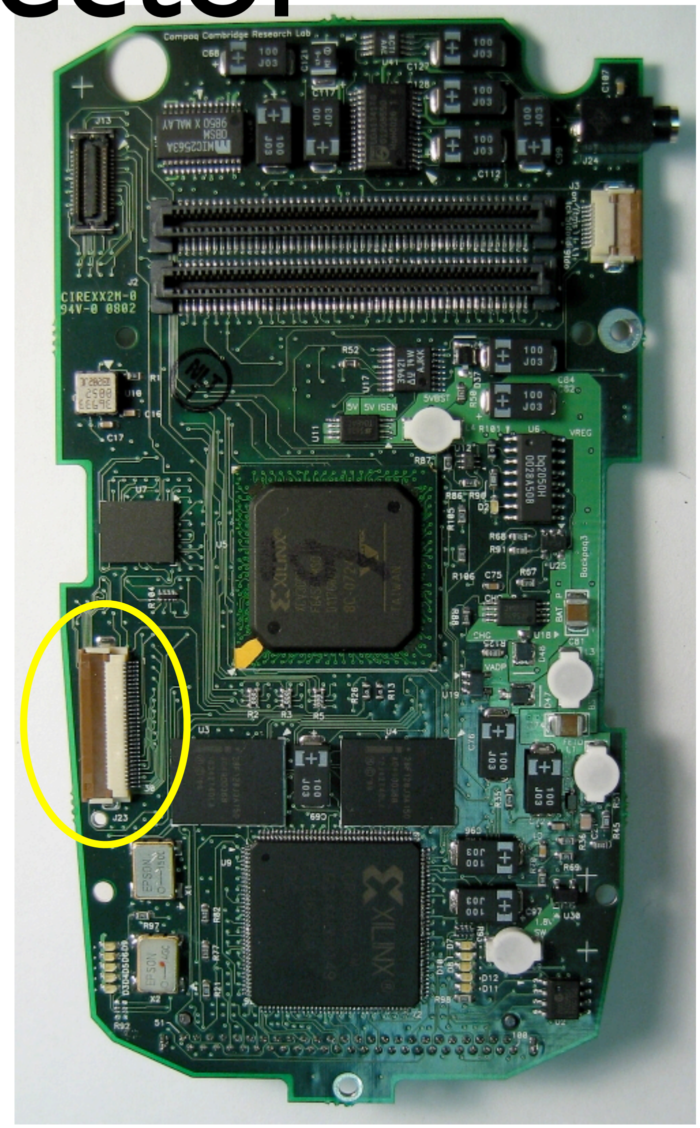
Reading Accelerometers

- Linux character device
- Open the device:
  - `fd = open("/dev/backpaq/accel",O_RDONLY | O_NOCTTY);`
- Read from the device
  - `struct h3600_backpaq_accel_data accel_buffer;`
  - `read(fd,&accel_buffer,sizeof(accel_buffer));`
- The structure returned:
  - `struct h3600_backpaq_accel_data {`
    - `short x_acceleration;`
    - `short y_acceleration;`
- From:
  - http://cvs.handhelds.org/cgi-bin/viewcvs.cgi/apps/backpaq/oneko/

PCMCIA Slots

- Dual PCMCIA Slots
- 16-bit cards (Not CardBus) supported
- Pins driven directly from the FPGA
  - Hardware supports CardBus cards
  - Could implement CardBus controller in FPGA

LVDS Connector



- Low Voltage Differential Signaling
  - 10 differential signal pairs
    - **or 20 single signals**
  - Driven from Xilinx 300E FPGA
  - 5 Power and 5 ground pins
- 30 pin flex cable ZIF connector

Mobile Phones What's the big deal







- < 200 Million PC's sold last year
- > 200 Million Phones sold last quarter
- .5 Billion PC's in 2003
- 1.5 Billion consumers own mobile phones worldwide -- Economist, Jan 2006
- 3 Billion subscribers by 2008





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- September 18, 2005 -- 2 Billion connections.

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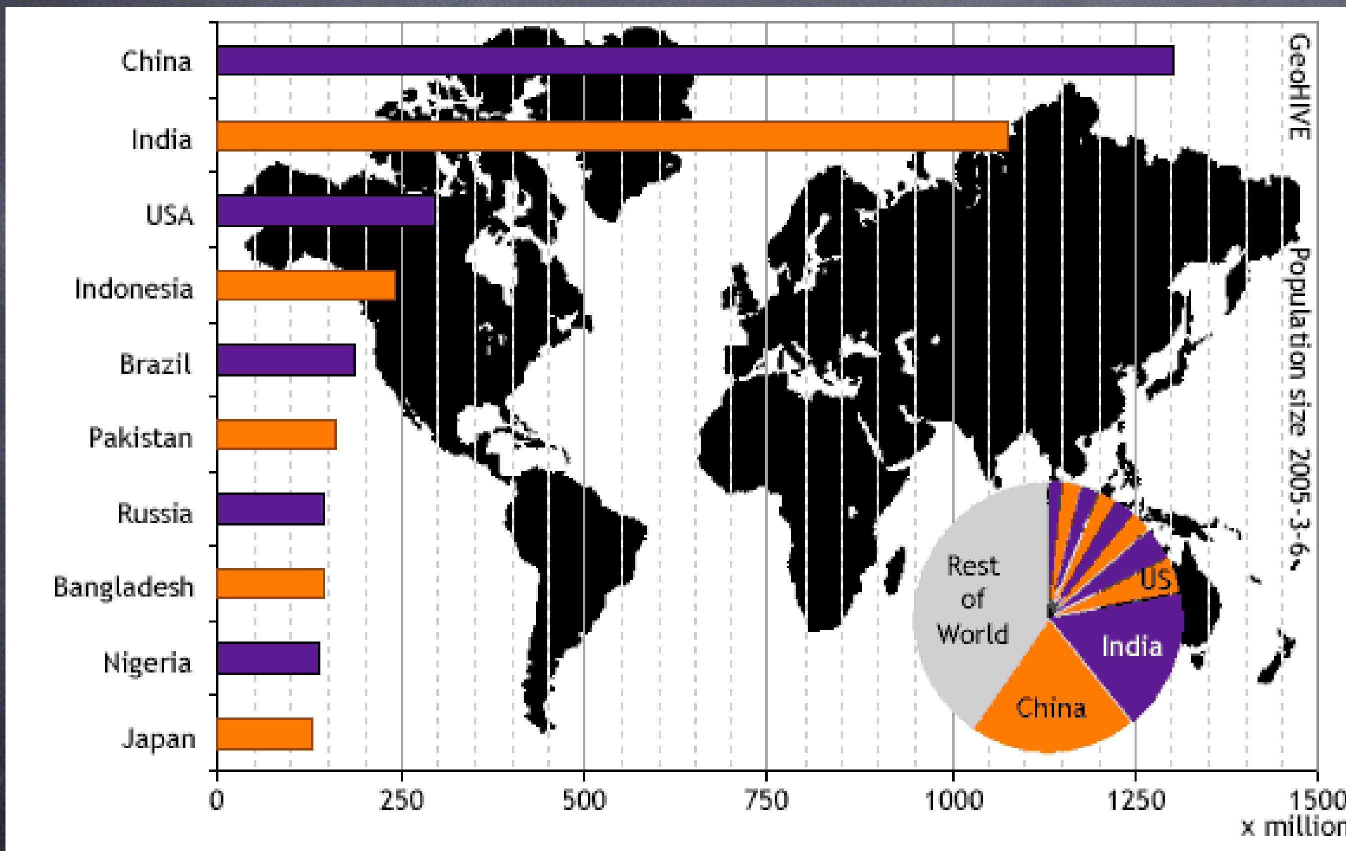
Perspective



- 6.4 Billion people
- 2 Billion mobile phones sold

OK, so lots of phones ....

- But there are lots of digital watches as well
  - they have chips inside, but who cares?
- Today, there are
  - Basic phones (modem chip)
  - Regular phones (modem + microprocessor)
  - Smart phones (modem + micro + ...)
- Tomorrow, will all be smart, difference in
  - extra features
  - extra fashion

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Smartphones == 1996 PC?

- Smartphones (and PDA's) are like old PC's
- If they are the same, then
  "been there, done that"
- If they are different, then in what ways?

1996 Pentinum

- 200 MHz CPU; 60 MHz memory bus
- Floating point; expansion bus for
  - graphics, sound, other accelerators
- 3 million transistors; Voltage 3.3
- Primary Cache: 8 KB; Level 2: 512 KB
- Memory: usual ??? MB; Max 4 GB
- Disk capacity: ??? find out 160 MB ???

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Phone's two major cores

- DSP Core
  - 220 MHz
  - 64 KB on-chip Ram; 24 KB Instr. Cache
  - 1/2 instructions per cycle
- ARM Core
  - 229 MHz
  - 32 KB Data Cache; 16 KB Instr. Cache

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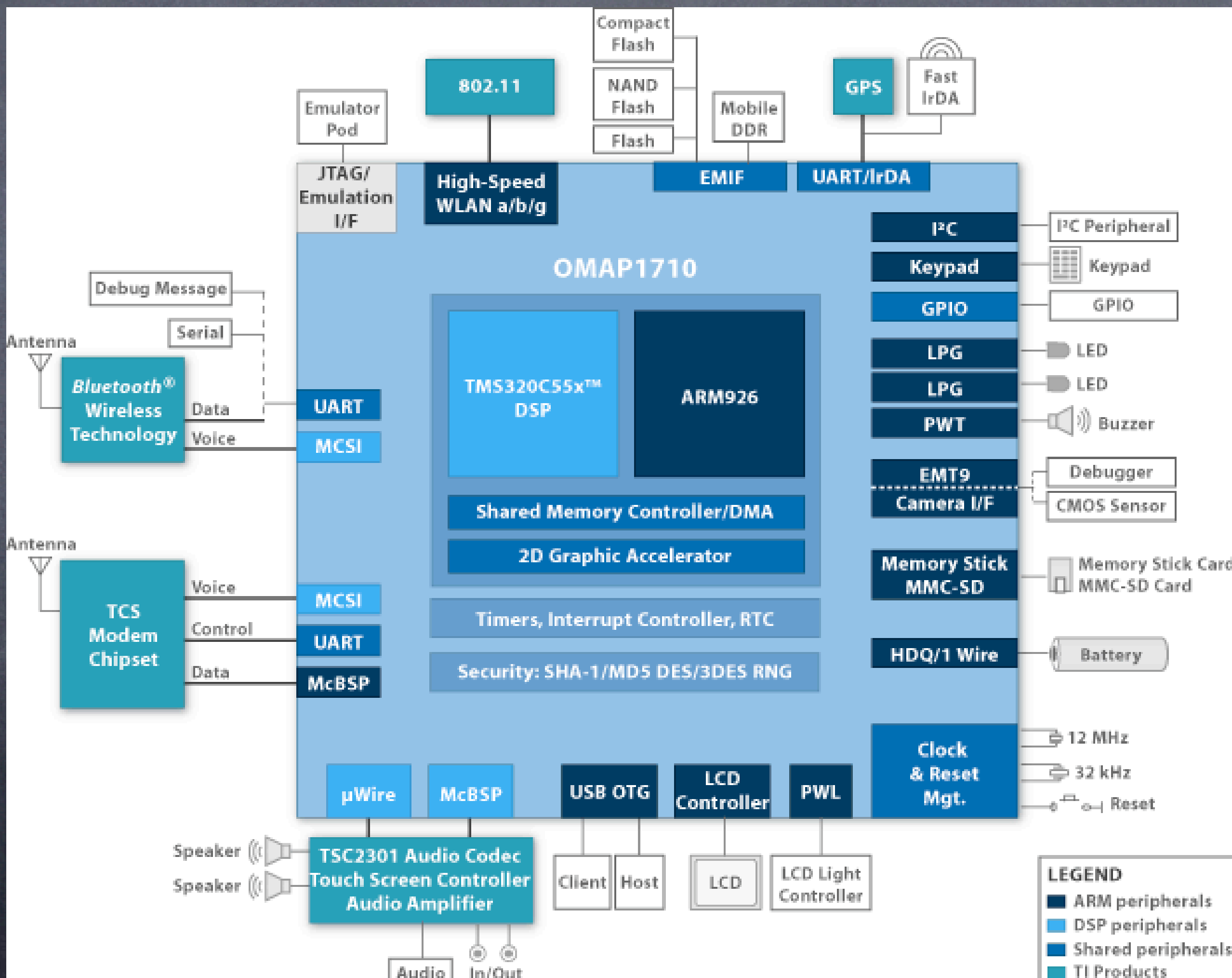
Phone == Lots of Integration



Not really the same

- More connectivity
- More parallelism
- More advanced in
  - Hardware features
  - Software features & necessities
- More sophisticated expectations
  - cannot turn back time; people have evolved

Phones are different

- They are mobile
- They will always be bounded by power
- They will follow a different Mores' law
- The economics are different
  - different producer-consumer relationship
  - hw --> operators --> end users
  - ISP, independent software vendors, role?

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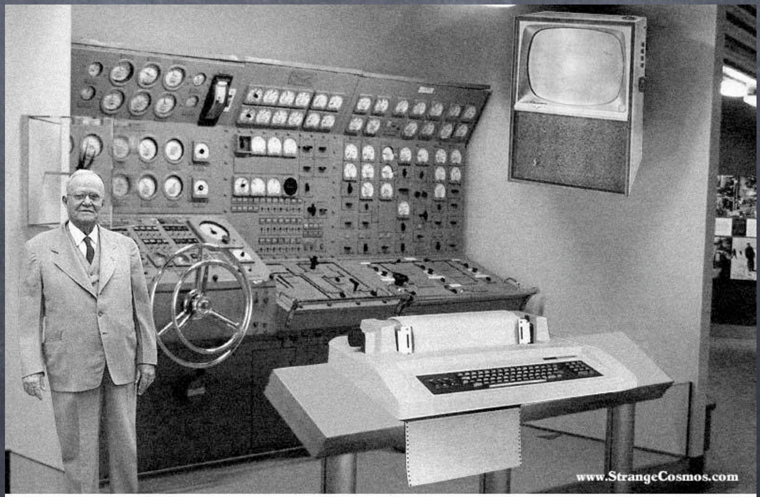
The Point?

- Phones are different from PC's
  - Claim: people want PC functionality
  - They do not want the PC's overhead
- There will be billions of smart phones
- Time to start taking up the challenge!



Scientists from the RAND Corporation have created this model to illustrate how a "home computer" could look like in the year 2004. However the needed technology will not be economically feasible for the average home. Also the scientists readily admit that the computer will require not yet invented technology to actually work, but 50 years from now scientific progress is expected to solve these problems. With teletype interface and the Fortran language, the computer will be easy to use and only

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Research Areas I

- User Interface (Huge)
  - Configuration
  - Syntax-free
  - Accessibility: physical & mental disabilities
- Security, Reliability, Fault Tolerance
  - Naive users; harsh physical world
- Synchronization & Sharing
  - Interoperability (no platform)

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Research Areas II

- Architecture:
  - Phone chips as building blocks
    - wireless expansion bus (no other board)
  - Power & heat management
    - e.g. streaming video via DSP or ARM
    - local vs remote compute & store
  - No H/W upgrades

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Research Areas III

- Applications
  - Services not applications; easier on user
  - Finding features (e.g. 287 menu items)
  - Platform independence (?)
    - same app for server; pc; phone
    - too many models (binary rewrite?)
- (location, user, env)-aware computing
- Phone as Sensor+Actuator Server
- Phone as (out-of-band) debugger

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Conclusion

- Whatever your expertise, phones offer
  - different set of constraints
  - different levels of abstractions

If you think technology is frustrating today, just wait...

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