Getting to Massive Sensor Networks by Tenfold Steps

Orders of magnitude from mainframes to the IoT

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Books

Enterprise Android
Programming Android
The upcoming Deep Dive series for Addison Wesley, as series editor
The Mobile Sensing Enterprise for APress
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What is this story about?

Knowledge workers and their environment
Discontent and change
Orders of magnitude
How the established order is overturned
How that will play out in the coming age of sensor networks

Android Deep Dive

Embedded Programming with Android: Bringing Up an Android System from Scratch (Android Deep Dive)

Roger Ye

Knowledge workers

Knowledge workers have been around (unlike factory workers) forever
Tallying and reckoning has been around for about 50,000 years
Offices have been around for about 500 years

Knowledge workers drive information management progress

Mainframe computing
Report generation
Getting information to knowledge workers

The first industry dominance

IBM used to be 80%+ of the computing industry

The Information Management System (IMS), created for the Apollo space program dominated software

This was before computing got exposed to a mass-market

IBM mainframes, IMS, and knowledge workers

- Knowledge workers depend on information in IMS
- Information is delivered in the form of reports
- Knowledge workers specify the reports they need, IT personnel program them… someday

Knowledge workers are malcontents

Reports are hard to specify
Implementation backlogs threaten the relevance of reports
Iteration is difficult or impossible
IT is seen as a roadblock, not an enabler

Bob? You know how this story goes

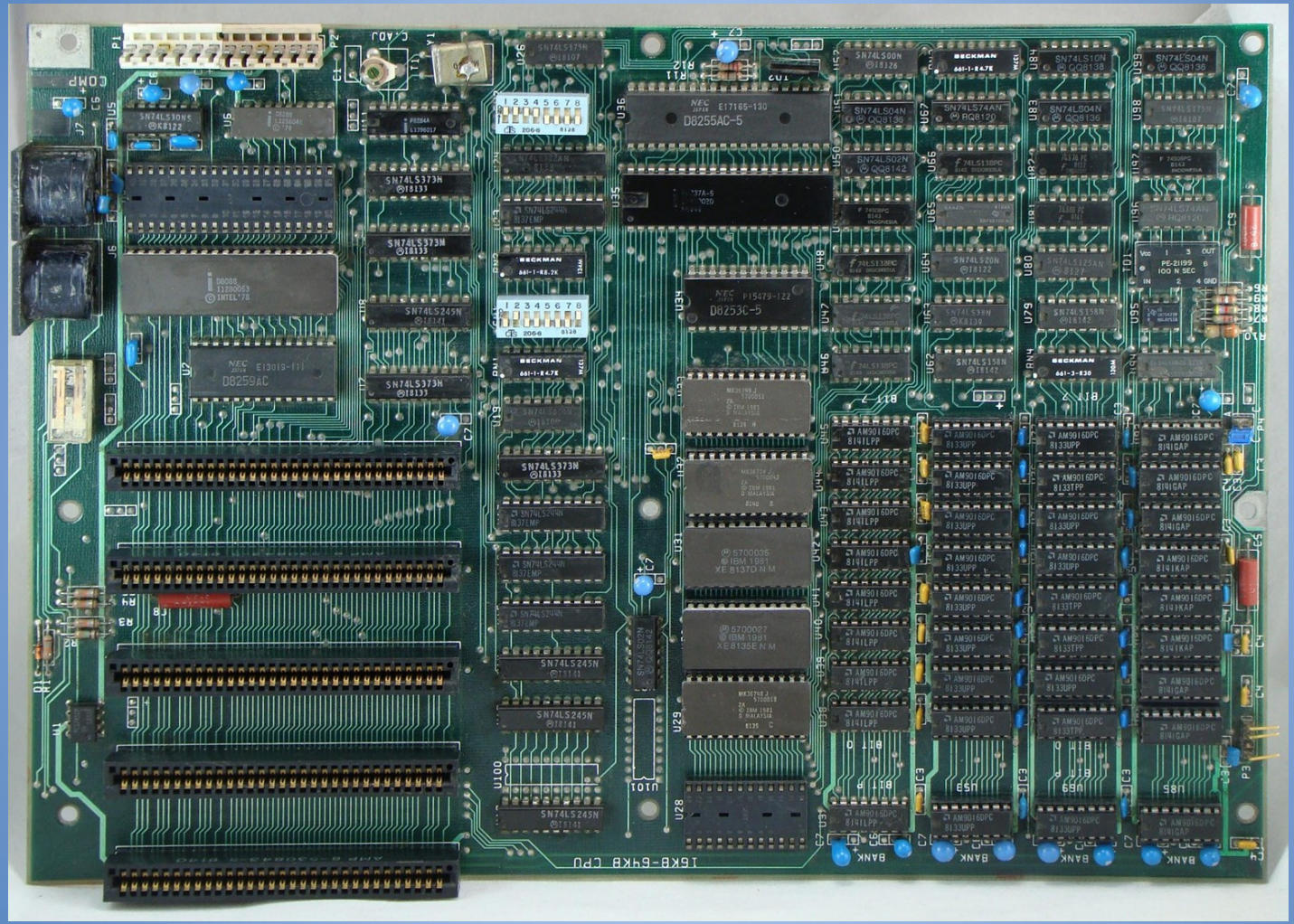
Steve and Steve made a usable “personal” computer

Bob wrote a tool that enables individuals to crunch numbers and make their own analyses and reports

But, then...

But, then...

IBM put their product development process aside
The IBM PC matched Apple for price, and was a little more capable
Jon and Mitch wrote a very similar tool for knowledge workers


16KB-64KB CPU
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D8253C-5
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SN74LS245N
SN74LS374N
SN74LS158N
AM9016DPC
BECKMAN

After that, everything looked like a PC

PC processors became the fastest processors
PC GPUs became the fastest GPUs
Large storage became arrays of PC-sized disks
Data centers are full of many PC-architecture servers

Does that make sense?

How likely is it that the optimal CPU is a Core i7 or Xeon?

...that the optimal storage unit is 3.5 inches?

...that the best graphics performance is from an array of PC GPU cores?

For example:

8086: 29,000 transistors

ARM1: 25,000 transistors

And yet, ARM could make no dent in the PC industry

IBM had their own RISC SPU

Wasn’t quite ready for the PC
Eventually became Power PC
Never caught up

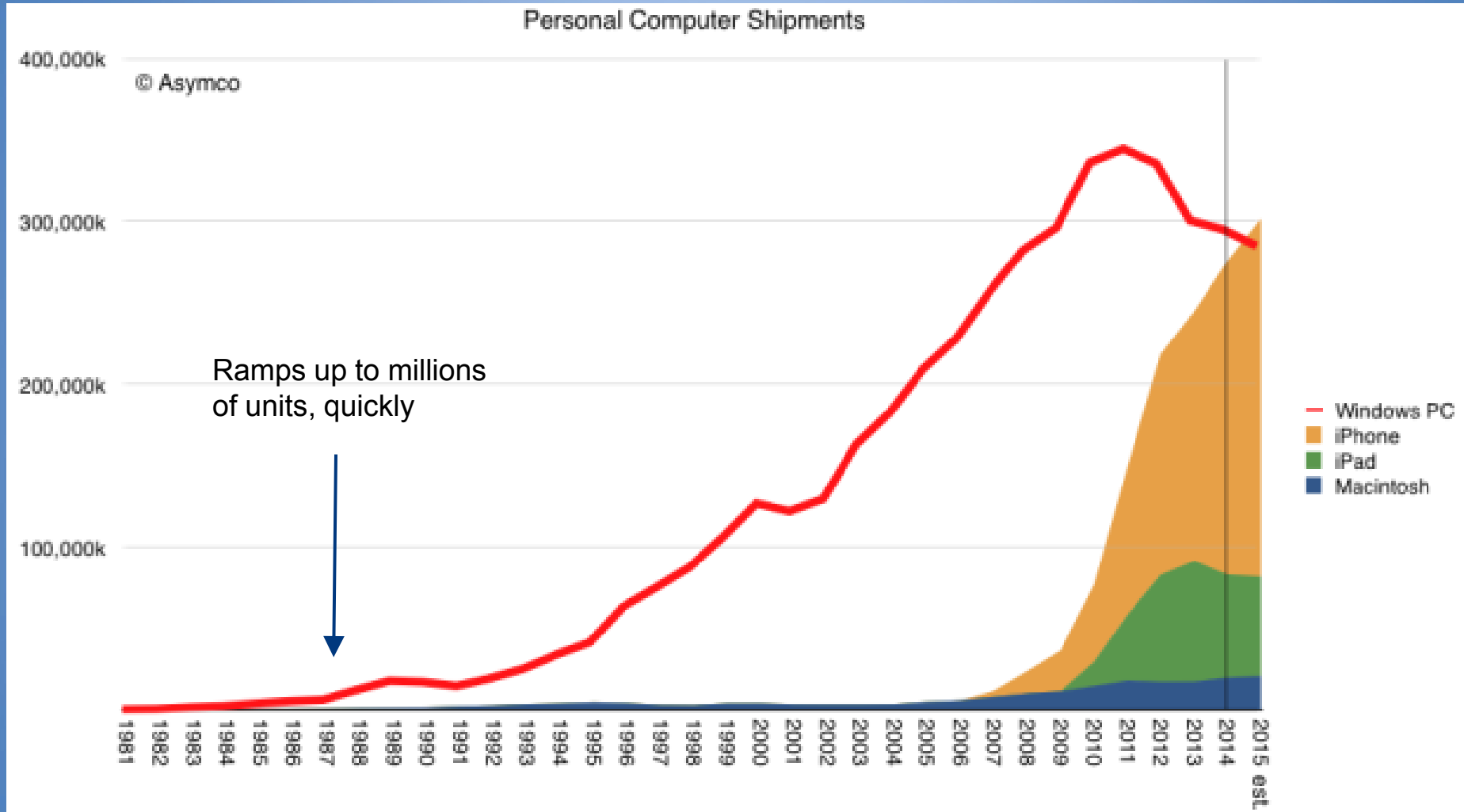
Orders of magnitude

Mainframes numbered in the tens of thousands, at their peak, and still number in the low to middle tens of thousands worldwide

Orders of magnitude

PCs very quickly went from 100s of thousands of unit to millions

The mature PC market is measured in the hundreds of millions of units


Personal Computer Shipments
© Asymco
400,000k
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Ramps up to millions
of units, quickly
Windows PC
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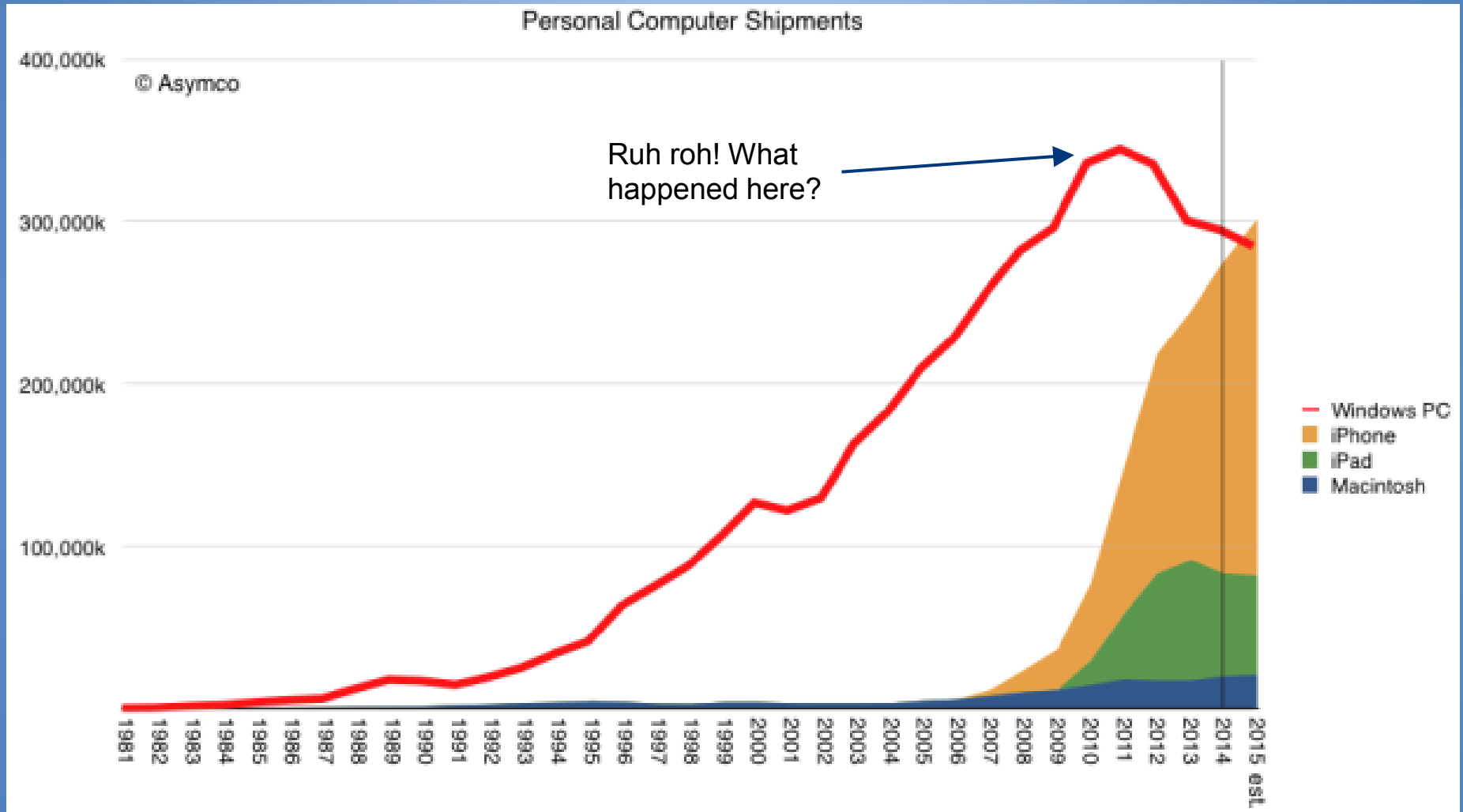
Personal Computer Shipments
© Asymco
Ruh roh! What happened here?
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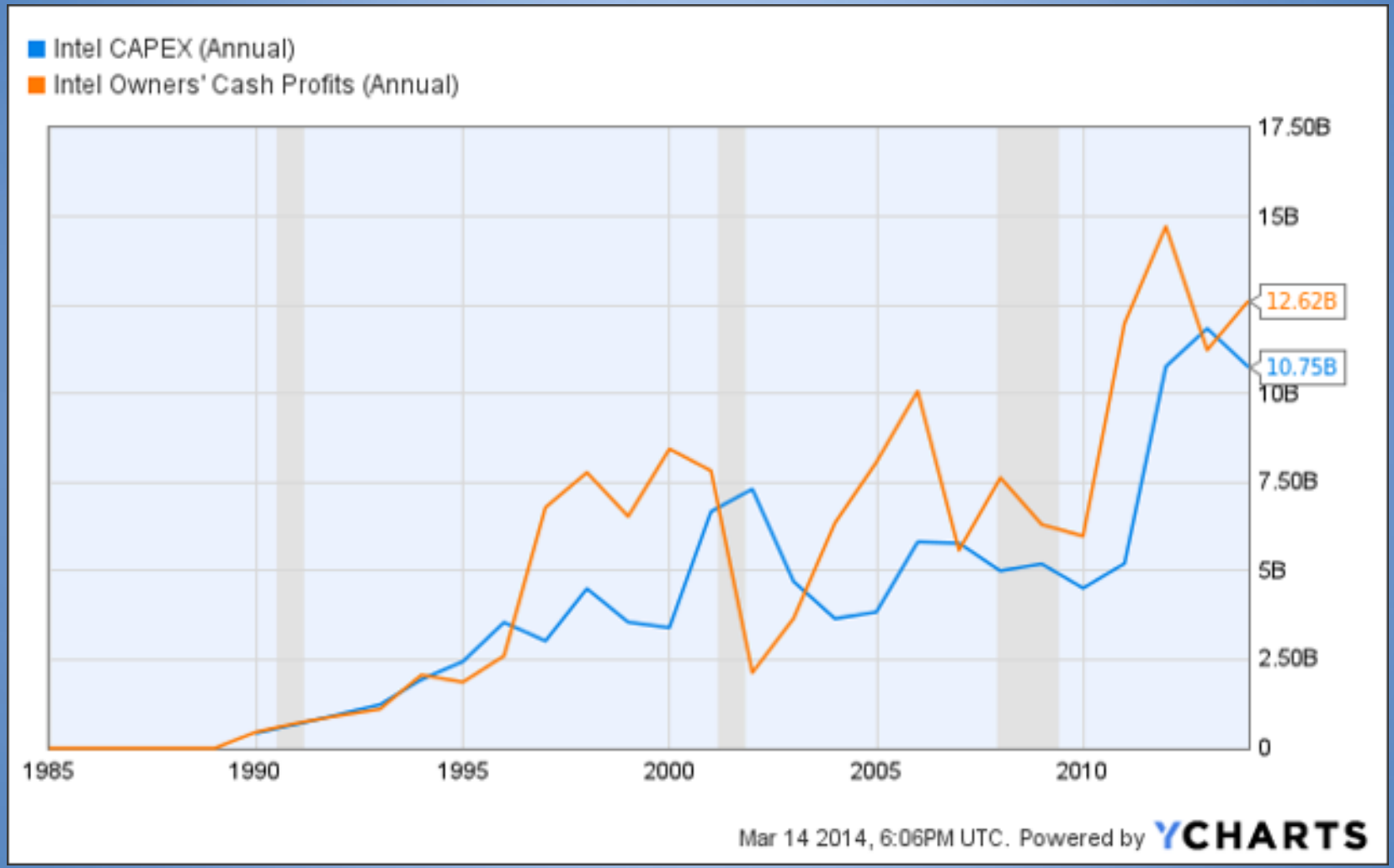
2015 est.
Windows PC
iPhone
iPad
Macintosh

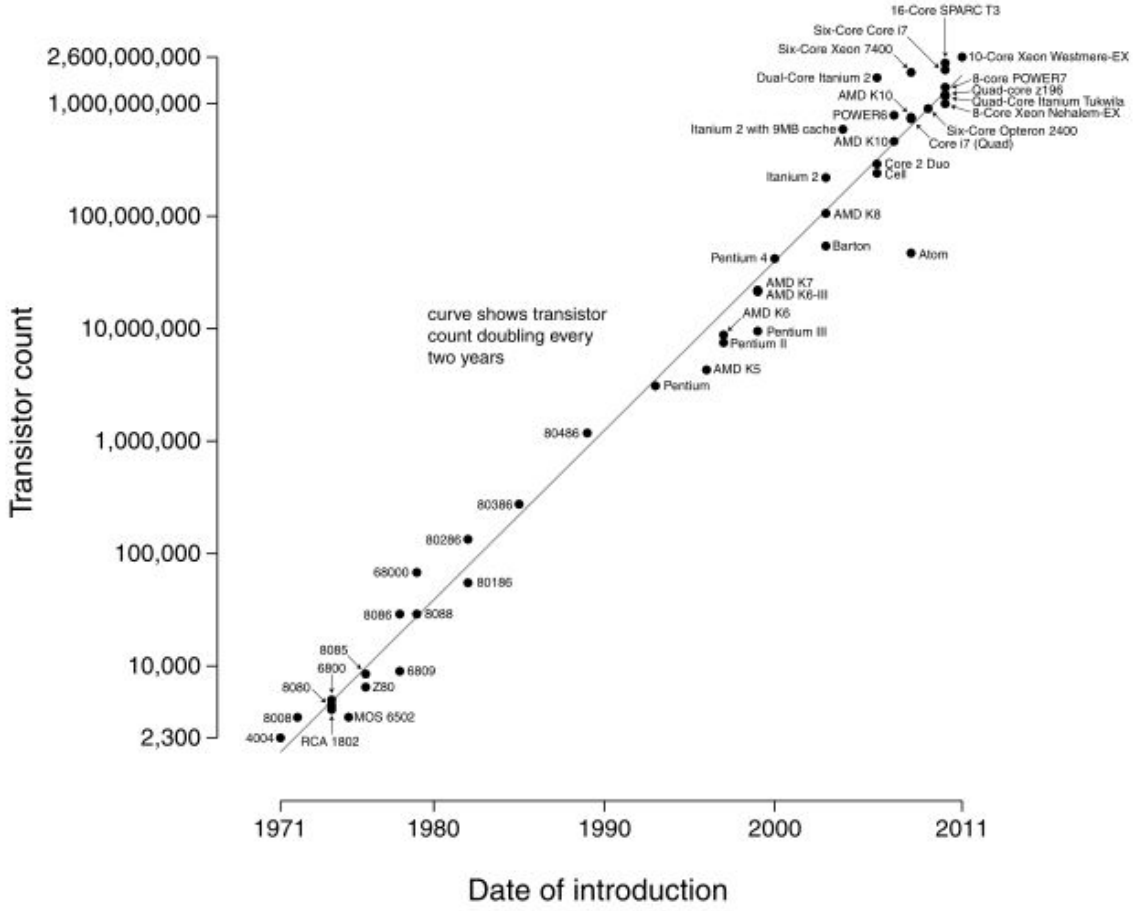
Outspending the rest of the industry, by an order of magnitude

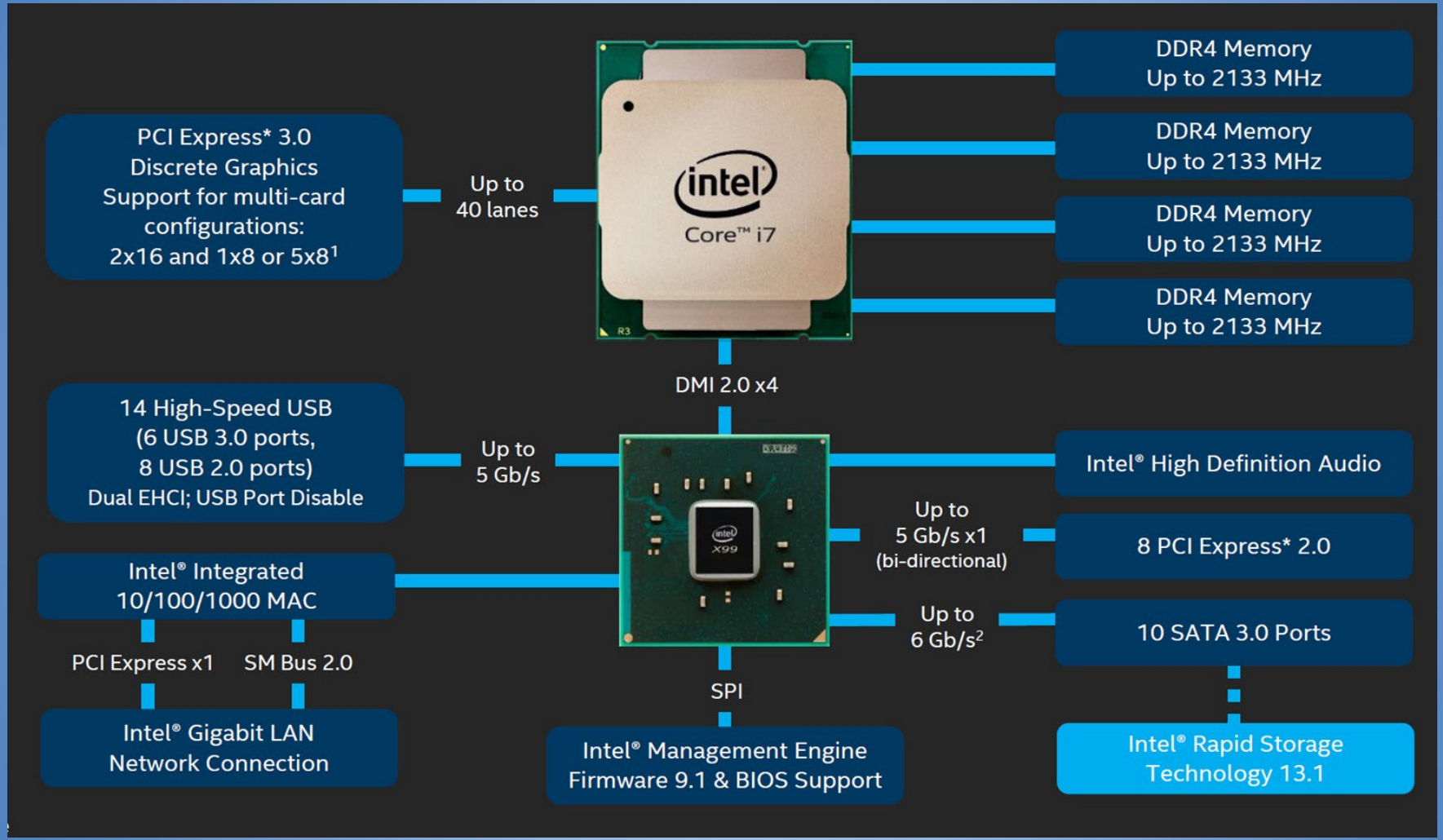
A mass market supports unprecedented R&D spending levels

Not just processor R&D, but production process spending: More than $10 billion in *annual* capex


Intel CAPEX (Annual)
Intel Owners' Cash Profits (Annual)
17.50B
15B
12.62B
10.75B
10B
7.50B
5B
2.50B
0
1985
1990
1995
2000
2005
2010
Mar 14 2014, 6:06PM UTC. Powered by YCHARTS

Microprocessor Transistor Counts 1971-2011 & Moore's Law



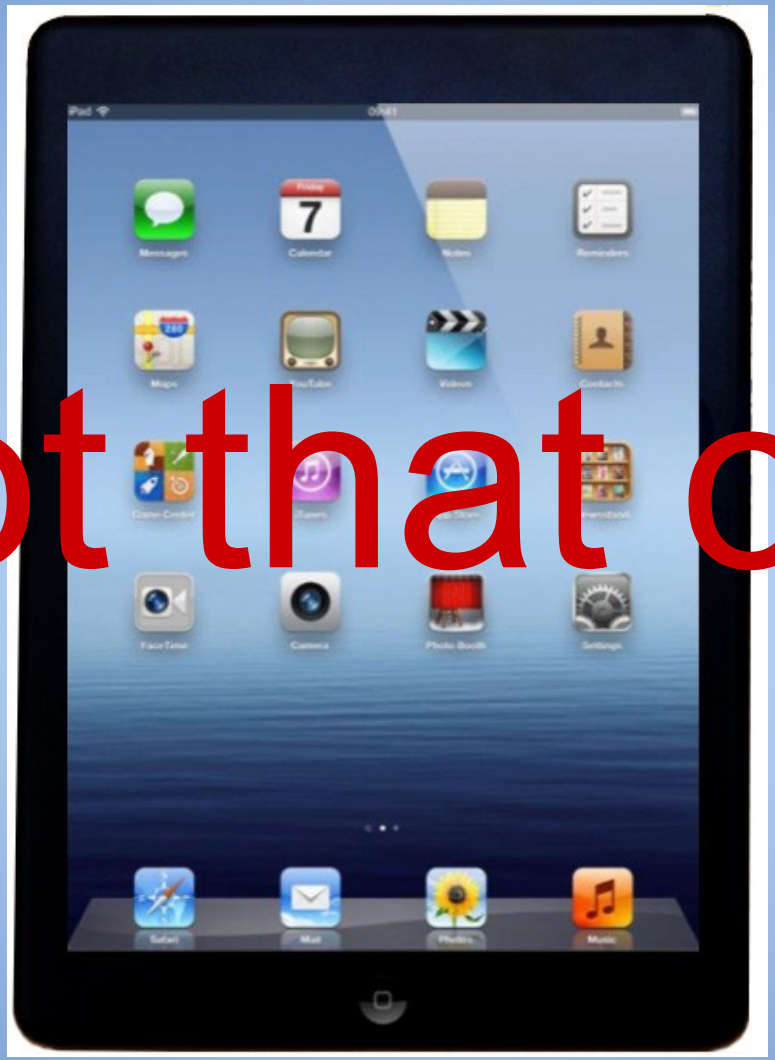

PCI Express* 3.0
Discrete Graphics
Support for multi-card
configurations:
2x16 and 1x8 or 5x8[1]
Up to
40 lanes
intel
Core™ i7
DDR4 Memory
Up to 2133 MHz
DDR4 Memory
Up to 2133 MHz
DDR4 Memory
Up to 2133 MHz
DDR4 Memory
Up to 2133 MHz
DMI 2.0 x4
14 High-Speed USB
(6 USB 3.0 ports,
8 USB 2.0 ports)
Dual EHCI; USB Port Disable
Up to
5 Gb/s
Intel® High Definition Audio
Up to
5 Gb/s x1
(bi-directional)
8 PCI Express* 2.0
Intel® Integrated
10/100/1000 MAC
Up to
6 Gb/s[2]
10 SATA 3.0 Ports
PCI Express x1
SM Bus 2.0
SPI
Intel® Gigabit LAN
Network Connection
Intel® Management Engine
Firmware 9.1 & BIOS Support
Intel® Rapid Storage
Technology 13.1

What do you get for all that money?

Billions of transistors
That gets you the ability to make deeper pipelines, bigger caches, etc.
It also gets you smaller dimensions
Smaller dimensions means you can do these things with less cost and less power

How do you break a dominance this strong?

Apple, again
Apple wanted a tablet computer
They wanted it to have a long battery life
Untethered, natural computing everywhere


Not that one


This
one


Newton
MessagePad

And then came Nokia

The first phone that was more than an implementation of theITU standard
Apps: Calculator, clock, calendar, currency converter, snake game
Better SMS UX
Needs a CPU!

How do you break a dominance this strong?

And you need knowledge workers
They want mobile devices now
They want to get information anywhere, anytime
In parts of the world, knowledge workers never used a PC, they can skip over the PC

Billions and billions

PCs topped out at around 400 million units and are in decline, currently about 300 million units

Why? They no longer dominate manufacturing economics

PCs were used by many people who did not need them because they were the least expensive way to access information

Mobile dominance

People are choosing mobile devices
Mobile device component economics has broken the stranglehold of PC economics
Mobile shifted the emphasis to power efficiency
ARM's business model steered around Intel's unassailable fortress: Intel's fabs

Imaging

Imaging has been driven by its role in smart mobile device

Like GPUs and storage, the center pf gravity in imaging is moving toward mass-market devices

Prediction: High-end cameras will become arrays of devices, photography will become computational

What's after mobile?

IoT will drive unit volumes in the 10s of billions
Different peripherals will be SoC integrated
Different applications
ARM will carry their advantage in power management into IoT

The future is here...

...just not evenly distributed
Near 20 billion ARM CPUs annually in embedded processors, compared to a little under 2 billion in mobile devices

Different peripherals

Proximity sensors
Temperature
Barometric pressure sensors
Position sensors
Magnetic field sensors
Acceleration sensors
Microphones
Magnetometers
Flow sensors
Pressure sensors

Sensors ride the wave of billions of units

Like CPUs and storage for PCs…
Like cameras for mobile phones…
Sensors will become inexpensive, small, and highly capable
Some of this already happened for mobile devices

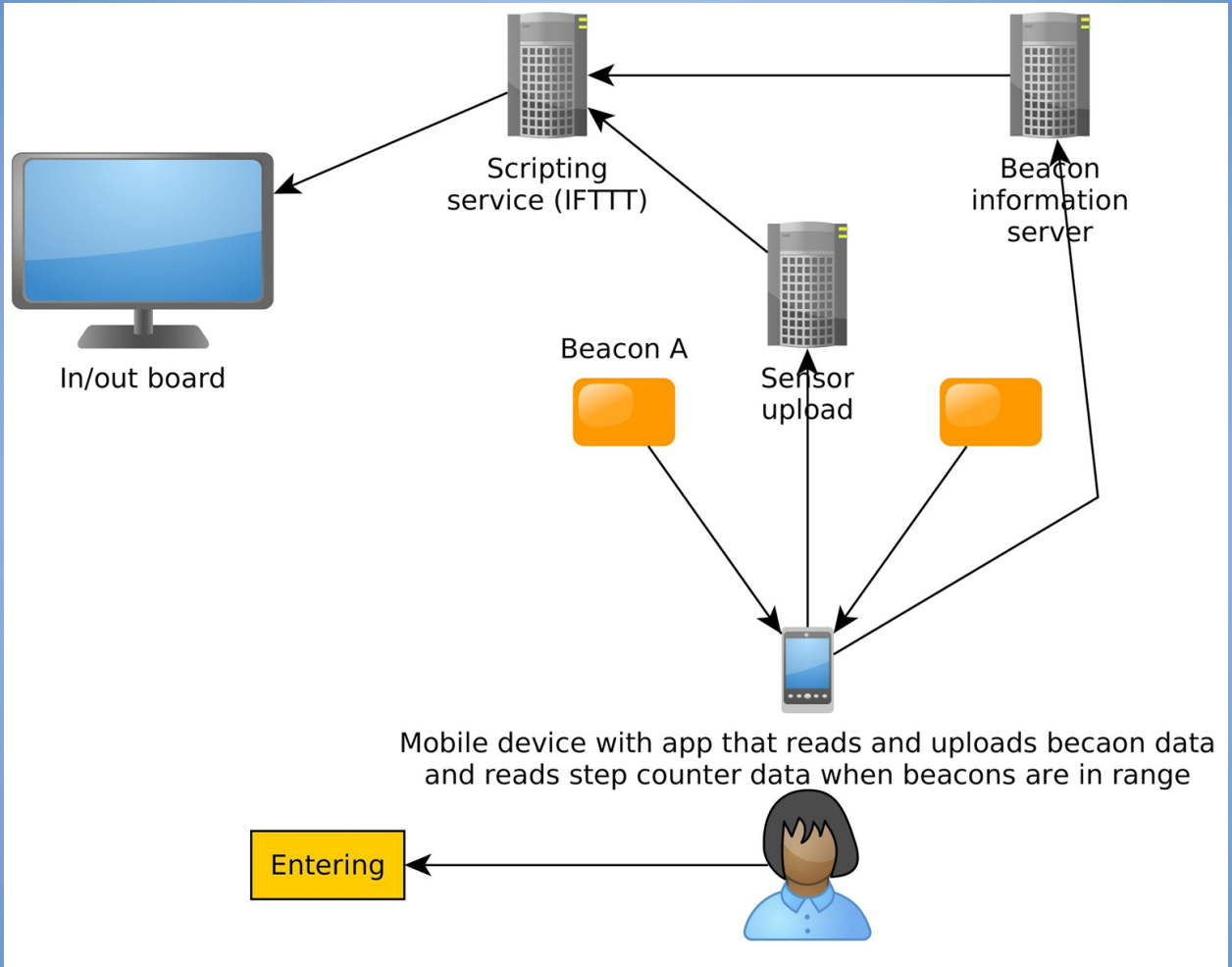
Application ideas will come from looking ahead down the price curve for sensors

Who will drive adoption

Knowledge workers
They wanted to do their own analysis
They wanted to be mobile
The apps that will drive IoT adoption will be compelling to knowledge workers

Instant information

From sensors, to storage, to analysis, to Web scripting, to presentation


Scripting service (IFTTT)
Beacon information server
In/out board
Beacon A
Sensor upload
Mobile device with app that reads and uploads becaon data and reads step counter data when beacons are in range
Entering

I want to hear from you

Radio experts
Sensor experts
SoC architects