Circa 1985

* Other names and brands may be claimed as the property of others.
Digital Revolution unfolds

IBM PC/AT

1985

1990

1995

100M units PC

2000

2005

1 Billion Internet Connected PC

2010

2015

15B Internet connected devices

3B Internet Users

Source: Intel, ITU, Morgan Stanley, IDC, Gartner, Internet Live Stats

* Other names and brands may be claimed as the property of others.
It has just begun

Source: Intel, ITU, Morgan Stanley, IDC, Gartner, Internet Live Stats

* Other names and brands may be claimed as the property of others.
IOT - Fueling the revolution

Built-in, secure, interconnected intelligence

50B DEVICES *

44 ZETABYTES **

IMC/EDC: The Digital Universe of Opportunities

* IDC

** IMC/EDC: The Digital Universe of Opportunities
The upward spiral
PC – Experience innovation continues

**DESKTOPS**
- NO WIRES
  - Wireless Display
  - Wireless Data
  - Wireless Charging
  - Wireless Docking

**NOTEBOOK & 2 in 1s**
- NO PASSWORDS
  - YAP – You are the Password

**NATURAL USER INTERFACE**
- Front Facing 3D
- Rear Facing 3D
- Voice Assistant

**ACROSS ALL O/S**

* Other names and brands may be claimed as the property of others.
Smart phones – Globalization of innovation

Local Brands Smartphone Growth in 3 years

Sources: IDC SCD Tracker Q3’14
So what do these market trends mean?
If it is not smart,
it is time for it to be smart

If it is smart,
it computes and it connects
If it computes and connects, it does it on silicon
Semiconductors
The foundational core of the digital revolution
A lasting semiconductor trend

Integration
Integration – a lasting trend
Integration – a lasting trend

1985

- Cache TAG SRAM
- Cache Control
- Clock Gen
- DRAM Control
- Intel 386™ Processor
- Intel 786 Graphics Co-processor
- Intel 387 Math Co-processor
- DRAM

2011

- Sandy Bridge Processor
- DRAM
Integration – a lasting trend

Memory
- SRAM
- DRAM
- NAND Flash
- NOR Flash

Graphics

WiFi

I/O

Processor
- CPU
- GPU

IO/Analog
- USB
- Audio Codec
- Video Enc
- Video Dec
- Imaging
- Display
- Power Mgt

Memory

Sensor
- 3-Axis
- Accelerometer
- 3-Axis
- Gyroscope
- Compass

Wireless
- Wi-Fi
- GSM
- Edge
- 3G
- 4G/LTE
- Blue Tooth
- GPS
- FM

Baseband
- Transceiver
- Power Amp
- Front End
What is the enabler of this lasting trend?
Moore’s Law economics

Exponential decrease in cost per transistor

Normalized Cost per Transistor ($/transistor)

Source: Intel
Moore’s Law economics

Exponential decrease in cost per transistor

But the cost of processed silicon is going up..

Source: Intel
Moore’s Law economics

 normalized capital growth ($/mm²)

 normalized area/transistor growth (mm²/transistor)

 normalized cost per transistor ($/transistor)

 Source: Intel

* Forecast
‘The important thing is that Moore's Law is exponential, and no exponential is forever... But we can delay forever’

- Gordon Moore, ISSCC 2003
Delaying Forever

Future Technology Options

Expect More From Moore

Future options subject to change

Source: Intel
Silicon technology challenges and opportunities
The challenge of integrating transistors that serve different power-performance needs

Lower Transistor Leakage

- 1x
- 0.1x
- 0.01x
- 0.001x

Higher Transistor Performance (Switching Speed)

- Server computing
- Client computing
- Mobile computing
- Always-on always-connected circuits

Source: Intel
The challenge of integrating transistors that serve different power-performance needs

Lower Transistor Leakage

65nm 45nm 32nm 22nm 14nm

Higher Transistor Performance (Switching Speed)

Always-on always-connected circuits

Server computing

Client computing

Mobile computing

Source: Intel
Integrating system functions on a chip requires multidimensional technology envelope expansion.
Integrating system functions on a chip requires multidimensional technology envelope expansion.
Integrating system functions on a chip requires multi-dimensional technology envelope expansion.
Integrating system functions on a chip requires multidimensional technology envelope expansion.
Heterogeneous Integration
Packaging technology for multi-component integration

Today
- Reduced Form Factor: Intel Atom Package on Package
- Performance Boost: Intel Core w/Iris Pro Graphics CPU + eDRAM
- Increased Functionality: Intel Core i7 Logic Integration CPU + PCH

Tomorrow
- Reduced Form Factor: 3D Chip Stacking
- Performance Boost: High Density Interconnects
- Increased Functionality: System in Package
Embedded Multi-die Interconnect Bridge (EMIB)

An elegant approach to in-package high density interconnect of heterogeneous die
Design challenges & opportunities in integration
System driven design

Trade-off decisions
Design complexity

Cost of Implementing Complex Design

Source: IBS, July 2013
Taming Complexity

Design for Reuse: Effort amortization & TTM
Taming Complexity

Design for Reuse: Effort amortization & TTM

Design for flexibility: Multi-party sourcing
Taming Complexity

- Design for Reuse: Effort amortization & TTM
- Design for flexibility: Multi-party sourcing
- Design for test: Proactive decisions
Taming Complexity

Design for Reuse: Effort amortization & TTM

Design for flexibility: Multi-party sourcing

Design for test: Proactive decisions

Design for yield: Logic redundancy & repair
Taming Complexity

Design for Reuse: Effort amortization & TTM

Design for flexibility: Multi-party sourcing

Design for test: Proactive decisions

Design for yield: Logic redundancy & repair

Design for reliability: Thermals
Taming Complexity

- Design for Reuse: Effort amortization & TTM
- Design for flexibility: Multi-party sourcing
- Design for test: Proactive decisions
- Design for yield: Logic redundancy & repair
- Design for reliability: Thermals
- Design for productivity: ASIC
India’s role in the smart & connected world

- Visionary policy
- Investment
- Local innovation & Entrepreneurship
Summary

• The digital revolution is entering a new phase of growth with IOT
• Integration will continue to be the driving semiconductor trend enabled by Moore’s Law
• Technologists and designers will work together, just as they always have, to overcome challenges and to make the most of opportunities.
• Pro-growth policy, investments, innovation and entrepreneurship will help India seize this moment of opportunity
Each of us has a role to play in the ride to our future
My role is to deliver on the following promise...

If it computes and connects, it does it best with Intel.

Intel Custom Foundry
Leading at the Edge of Moore’s Law
May you do well in delivering on your own promise...
Thank you
Q & A
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Abstract

In this talk we will start with an assessment of where we are in building a smart and connected world and add to it some trends that suggest where we are headed. We will then discuss what it means to the semiconductor industry and what we must collectively do as silicon technologists and designers to enable our future and to thrive in our journey to it.