Successful Entrepreneurship for Microsystems

Rakesh Kumar, Ph.D., Life Fellow IEEE
November 24, 2015
rakeshk@eng.ucsd.edu
Rakesh.tcx@gmail.com
858.945.3758

Teaching Assistants:
Dharmil Chandarana dharmil@ucsd.edu
Swetha Krishnakumar swk032@ucsd.edu

Course presented at UCSD CSE 190, Fall Quarter 2015
## Recent Acquisitions

### Amazon
- Twitch Aug 2014 Gaming $1 B

### Facebook:
- Instagram April 2012 (2011, sA $7M) Photo Sharing $1 B
- Face.com June 2012 (2010, sA$1M, t$5M) Face Recognition Program $0.1 B
- Oculus VR Mar 2014 (2012, KS, t$90M) Virtual Reality technology $2 B

### Google
- Dropcam Jun 2014 (2009, $50M) Home Monitoring $0.5 B

---

Amazon, Facebook, Google
...the New Conglomerates
...or the New Platform owners...or ?
Case Study – Facebook

- **Founded by Mark Zuckerberg at 23**
  - Was Psychology major at Harvard
  - Developed numerous social networking websites for fellow students
    - Coursematch, users could view people taking the same degree
    - Facemash, user could rate people’s attractiveness

- **“The Facebook” launched in February 2004**
  - Name taken from sheets of paper distributed to freshmen, profiling students and staff
  - 1200 students signed up within 24 hours!
  - Over half the undergraduate population signed up within 1 month!
  - Network extended to other Boston universities, Ivy league, and other US universities

- **Facebook.com launched in August 2005**
  - Address purchased for $200K
  - US High Schools could sign up in September 2005
  - Reached UK universities in October 2005
  - Expanded beyond educational institutions in September 2006, to anyone with a registered e-mail address
  - Still free to join

- **Revenue**
  - From advertising
  - 30M MAU’s (million active users) in July 2007

- **Legal issues**
  - Sued by ConnectU founders – Divya Narendra, Cameron and Tyler Winklevoss
  - Alleged copying of their ideas and coding
  - MarkZ worked for them as computer programmer while at Harvard

Case Study – Facebook, some facts

- Incorporated in Delaware in July 2004
- IPO in May 2012
- YE2014 stats
  - 9,200 employees

Ref: FB 2014 Annual Report
Case Study – Facebook, Overview from 2014 Annual Report

- **Mission** – give people the power to share and make the world more open and connected
- **Business focus** – create value for people, marketers, and developers
- **Create value for Facebook users**
  - Enable people to connect and share thru mobile devices and PCs
    - FB mobile app – 890M DAUs at YE14
    - Instagram app – enables photos and videos with customizable filter effects, and share
    - Messenger app – texting and online chat instantly, seamlessly integrates w FB on PCs
    - WhatsApp – cross-platform mobile messaging
- **Create value for Marketers**
  - Help marketers achieve their business objectives to drive online sales, in-store sales, or awareness of their brand
  - Ad planning tools aligned with Marketers’ goals
  - Most of the FB Revenue generator
- **Create value for Developers**
  - Support efforts to build, grow, and monetize their mobile and web applications
    - Provide development tools and APIs for easy integration with FB
    - Provide tools to increase exposure, distribution and engagement

Ref: FB 2014 Annual Report
## Case Study – Facebook, Income Statement

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Revenue</strong></td>
<td>12,466,000</td>
<td>7,872,000</td>
<td>5,089,000</td>
</tr>
<tr>
<td><strong>Cost of Revenue</strong></td>
<td>2,153,000</td>
<td>1,875,000</td>
<td>1,364,000</td>
</tr>
<tr>
<td><strong>Gross Profit</strong></td>
<td>10,313,000</td>
<td>5,997,000</td>
<td>3,725,000</td>
</tr>
</tbody>
</table>

### Operating Expenses

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Development</td>
<td>2,666,000</td>
<td>1,415,000</td>
<td>1,399,000</td>
</tr>
<tr>
<td>Selling General and Administrative</td>
<td>2,653,000</td>
<td>1,778,000</td>
<td>1,788,000</td>
</tr>
<tr>
<td>Non Recurring</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Operating Expenses</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Operating Income or Loss

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Income from Continuing Operations</td>
<td>4,994,000</td>
<td>2,804,000</td>
<td>538,000</td>
</tr>
<tr>
<td>Total Other Income/Expenses Net</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Earnings Before Interest And Taxes</td>
<td>4,910,000</td>
<td>2,754,000</td>
<td>494,000</td>
</tr>
<tr>
<td>Interest Expense</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Income Before Tax</td>
<td>4,910,000</td>
<td>2,754,000</td>
<td>494,000</td>
</tr>
<tr>
<td>Income Tax Expense</td>
<td>1,970,000</td>
<td>1,254,000</td>
<td>441,000</td>
</tr>
<tr>
<td>Minority Interest</td>
<td>(15,000)</td>
<td>(9,000)</td>
<td>(21,000)</td>
</tr>
<tr>
<td><strong>Net Income From Continuing Ops</strong></td>
<td>2,925,000</td>
<td>1,491,000</td>
<td>32,000</td>
</tr>
</tbody>
</table>

### Non-recurring Events

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Discontinued Operations</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Extraordinary Items</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Effect Of Accounting Changes</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other Items</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Net Income

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred Stock And Other Adjustments</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Net Income Applicable To Common Shares</strong></td>
<td>2,925,000</td>
<td>1,491,000</td>
<td>32,000</td>
</tr>
</tbody>
</table>
Case Study – WhatsApp

- **Founded by Brian Acton and Jan Koum in February 2009**
  - Had worked together at Yahoo
  - Spent a combined 20 years at Yahoo…hated the ad-selling campaign
  - Messaging Apps
  - Developers in Russia

- **Revenue model**
  - Charge iPhone users $0.99 upon installation, one time fee
  - Charge Android users $0.99/year
  - 250M users every month

- **Acquired by Facebook in February 2014 for $19B**
  - 800M MAUs in April 2015
  - Stayed small, ~50 employees

Ref: Business Insider

https://en.wikipedia.org/wiki/WhatsApp
Creative
Customer Focus
Persistence

two guys in San Francisco can’t pay rent
they think to rent out 3 air mattresses on floor to people and serve breakfast
2007
they make a simple website (a blog with maps) airbedandbreakfast.com
2 men, 1 woman showed up, paying $80 each
after guests left they thought this could be a big idea
2009
they invited former roommate as a co-founder to build the site
2008
launched at SXSW - got two bookings

one week later
went door-to-door in NYC and took photos of listed houses
realized photos of places were not pretty
were making $200 a week, not growing

2010-2011
sold “Obama O’s” cereal before the election, for $40 each making $30,000

made $400 a week started to grow
were rejected by a famous VC in New York (Fred Wilson)
Barry Manilow’s (a famous singer) drummer rents an entire house
raised $600,000 seed round from Sequoia
raised $7.2 million, then $112 million from many investors and Ashton Kutcher

$10 BILLION VALUATION

based on reports in Telegraph, WSJ, and The Atlantic
Fabless Company Lifecycle and Phases

Top-tier Phase: Large Co’s
- MANY Designs
- Revenue ≥ $1 B

Growth Phase: Mid-size Co’s
- 10’s of Designs
- Revenue ≤ $1 B

The Start-up /Small Co. Phase
- Company Formation
- Funding
- Target Product
- Implementation Methodology
- Design
- Target Customer(s)
- Process Technology
- Package
- Cost
- Exit Strategies...

- Few Designs
- Revenue ≤ $100M

CSR [$800M]
Dialog [$297M]
Entropic Comm. [$210M]
PMC-Sierra [$635M]
QLogic [$591M]
Rambus [$323M]
Silicon Image [$191M]
Spreadtrum [$346M]

- Altera [$1.954B]
- Broadcom [$6.589B]
- Marvell [$3.62B]
- MediaTek [$3.907B]
- nVidia [$3.543B]
- Qualcomm [$10.991B]
- ST-Ericsson [$2.3B]
- Xilinx [$2.31B]
- AMD [$6.494B]
- ...
- ...

Source: GSA
Circa 2011
A few case-study examples

Entropic Communications
2010 Revenue: $210M
Cable-connected home entertainment, MoCA

Qualcomm
Founded: 1985  IPO: 1991
2010 Revenue: $10,991M
CDMA/Wireless Chip-sets and Licensing

Silicon Image
Founded: 1995  IPO: 1999
2010 Revenue: $191M
Digital Video interface, HDMI

Rambus
Founded: 1990  IPO: 1997
2010 Revenue: $323M
Memory interface Licensing
A Case Study: Qualcomm – Fabless and IP Company

“Qualcomm started with a creative mentality that called for groundbreaking ideas, novel implementations next and minimal corporate bureaucracy last”

(D. Mock)

Based on:

• David Mock, “The Qualcomm Equation”, American Management Ass., 2005)
Case Study – Qualcomm

▪ History:
  ▪ http://www.qualcomm.com/who_we_are/history.html
  ▪ Founded in 1985 by Irwin Jacobs, Andrew Viterbi, and 5 others
  ▪ QUALity COMMunications

▪ Intellectual Property
  ▪ Patents in digital signal processing
  ▪ Currently ~7200 patents

▪ First Product
  ▪ OmniTRACS – satellite based commercial mobile system for the transportation industry
    ▪ Currently the largest such system

▪ CDMA (code division multiple access) technology
  ▪ Introduced in 1989,Shortly after approval of TDMA (time division multiple access) technology by the Telecommunications Industry Association
  ▪ After a long drawn out battle, CDMA has become widely used
  ▪ First cellular phone based on CDMA technology introduced ~1990-91
  ▪ Currently, 3G phones based on CDMA technology are pervasive
  ▪ 145 telecommunications equipment manufacturers license technology from Qualcomm
Qualcomm Revenue, Stock Price Trend

Qualcomm Revenue Trend

Year

Revenue, $B

0 2 4 6 8 10 12

99 00 01 02 03 04 05 06 07 08


©2015 TCX Inc
Qualcomm at a Glance

- Largest Fabless company (also largest IP comp.)
- 6th largest semiconductor company
- Revenue of $10.2B in 2011
- Focuses on wireless communication products based on CDMA technology
- Founded in 1985 by a star group of engineers:
  - Irwin Jacobs (Prof. USD)
  - Andrew Viterbi
  - Klein Gilhousen and four other colleagues
- All were respected engineers with a brilliant reputation who made significant contributions to wireless communications and information theory.
- They had the expertise and vision to transform wireless communications using new digital technologies
Qualcomm business model

- Continued **focus on innovation** and improve CDMA such that equipment manufacturers increasingly depended on Qualcomm’s technology (and IP): licensing revenue.
- Provides its customers with the technology needed to introduce new products and services, integrated Qualcomm’s technology.
- Qualcomm makes its patent portfolio available to companies that produces CDMA chips, handsets and infrastructure.
Qualcomm business model

(Source: “Creating Qualcomm”, Stanford Business case, 05/08)
Continued R&D investment

QUALCOMM's Fiscal Year R&D Investments
2000 To 2007

Annual R&D Expenditures
($US Billions)

R&D Expenditures as a Percent of Revenues

2000 2001 2002 2003 2004 2005 2006 2007

$0.34 $0.42 $0.45 $0.52 $0.72 $1.01 $1.54 1.83

0% 5% 10% 15% 20% 25%

©2015 TCX Inc
Success with IFM* model for Leading-edge (LE) Mobile products

QCT Record MSM Shipments
CAGR > 30%

* IFM: Integrated Fabless Manufacturing
What is Qualcomm’s successful strategy?

- Was able to build long-term sustainable position based on its technology
- Clever strategy as the latecomer; was not taken seriously
- Unique strategy: licensed technology and sold chips:
  - Focus on system-level IP, creating more value
  - Very strong IP strategy that built large barriers to entry (over 10,000 patents)
  - Used chip business to speed up acceptance of CDMA; were able to improve on CDMA through their direct experience with chip design and test.
- Leveraged standard bodies effectively and used it to get sustainable returns
Intel Corporation
and
The Future of the Microprocessor Business


Source: J. Van der Spiegel, UPenn
Brief History INTEL

- 1968: Intel was founded by A. Grove, R. Noyce, and G. Moore (all from Fairchild)
- Focus was on memory chips: DRAM.
  - Positioned itself as the “Memory Company”
  - Considered memory its core business
  - Memories provided 90% of revenues in the ‘70’s
- Up to that time Magnetic core or ferrite-cores memories were the main memories in computers:
  - Large and Slow

Core memory

↑ 1 mm
First 1K DRAM

- Many companies tried to manufacture DRAM in the late '60s and early '70s.
- Intel focused on **MOS technology** and succeeded in 1970
- **1970**: Intel introduced the first 1Kbyte DRAM (1103):
  - Instant success, replacing core magnetic memories
  - Smaller, faster
  - Intel enjoyed **2 years of market dominance**
DRAM product time line

Figure 2. DRAM product introduction timeline, 1968–1985.

Source: Intel documents, Dataquest

(Burgelman, INTEL, Standford Univ. Case Study)
Intel’s DRAM Market Share


Brief History

- **1971:** Intel introduces the 4004:
  - **4-bit** processor; BCD arithmetic
  - Designed for Busicom’s calculators
  - Intel got nonexclusive rights for the 4004!
  - Intel considered originally the microprocessor as a means to sell more memories

- **8-bit microprocessors**
  - **8008:** 8-bit, poorly designed
  - **8080** (1974): 8-bit databus and 16–bit address bus
  - **6800** (1975) from Motorola:
    - Much cleaner architecture than the 8080
  - **Aggressive marketing** by Intel and availability of software for the 8080 gave Intel a lead.
**Brief History: 8-bits µP**

- **6801, 6805 (1979):**
  - Further improvements over the 6800 (fewer instructions, saving silicon; basis for RISC processor)

- **Z80 (Zilog):**
  - Advancement over the 8080; compatible with 8080 instructions
  - Used in the first personal computers; quite popular

- **MOS Technology: 6501, similar to the 6800 but instructions were not compatible**
Brief History: 16-bits µP

➢ TMS9900 of TI:
   ➢ First 16-bit processor.
   ➢ Superior to the 8086; did not get full support from TI.
   ➢ Was never very popular

➢ 8086:
   ➢ Largely based on the 8080 (16 bit extension)
   ➢ Limited to 640 Kbyte of Memory!
   ➢ Not well optimized

➢ 68000 (Motorola)
   ➢ Started from scratch, resulting in a cleaner and superior architecture
   ➢ 32-bit architecture (address and data registers)
   ➢ Motorola did not advertise this as a 32-bit processor
   ➢ Used in the first PCs: Apple, Atari, Amiga (1st multimedia processor with GUI)

➢ 68020 (1984): extension of the 68000 (indirect memory addressing)
80x86 Family of µP

- Intel introduced the co-processor 8087 for the 8086
- 8088
  - Based on the 16-bit 8086 with an 8-bit memory bus; 4.77 MHz
  - Intel launched an aggressive marketing campaign, "Project Crush"
  - Was adapted in the 1st PC of IBM! Helped Intel win the whole industry design; made it the dominant architecture.
  - Intel had 12 licensees (AMD, Fujitsu, Siemens,...) as second-sources (an industry standard way of doing business to ensure supply); Intel reaped 30% of the 8088 revenues.
80x86 Family of µP

80286 (1982):
- 16-bit databus, 24-bit address bus (similar to the 68000), allowing 16MByte of memory addressing.
- 6 MHz – 20 MHz
- In 1984, IBM adopted the 286 for the AT PC!
- Intel reduced the number of licensees to 4; captured 70% of revenues!
- Intel launched another aggressive marketing campaign: Checkmate, resulting in many design wins (making it virtually an industry standard).
80x86 Family of µP

80386 (1985):

- 32-bit address and databus; better performance
- IBM was hesitant to adopt the 386 for its PC.
- Compaq took advantage of the void and used the 80386 in its PC, leaping ahead of IBM.
- 386 was a strategic inflection point in the industry (A. Grove): IBM lost its stronghold on the PC market!
- The 386 was an instant success, allowing Intel to charge premium.
- Intel decided to be the only provider by expanding its manufacturing capabilities; was able to convince IBM to accept a sole-source; retained 100% profit.
- AMD sued Intel; AMD won the rights to the microcode of the 386.
PC market before and after the 386

Before 1985

IBM

Licence

Licence

Licence

Up to 286

After 1985

Intel

OEM

OEM

OEM

From 386

Industry became more horizontal; became more dependent on each other

(Source: Intel Corp, R. Casadesus-Mananell; HBS)
Pentium Family of μP

- 80586 (1993): called **Pentium**
  - 64-bit databus
  - Similar to the 486
  - Superscaler (multiple instructions per clock cycle)

- Marketing campaign (‘90-’93): “**Intel Inside**”:
  - Received with skepticism by OEM; in the end everybody bought into it.
  - Helped turn the PC in a commodity with Intel the big “Brand” name.

- 1993: Design flaw in Pentium discovered:
  - Under fierce media criticism, and pressure of IBM, Intel decided to replace the Pentiums
  - This flaw cost $475M!

- Pentium III (1997):
  - MMX, Multi-processing
  - Intel backed Rambus; turned out to cause problems and to be expensive.

- P4 (1998):
  - Hyper-threading (HT): can execute two software threads in parallel

http://en.wikipedia.org/wiki/
Pentium Family diversification

- To sustain the competitive advantage Intel introduced low-cost (sub $1000 PC); and high-end microprocessors

- **Celeron (1998-)**:
  - low cost version of the Pentium II;
  - competing with Cyrix 6x86 and AMD K6

- **Xeon (’98-05)**:
  - high performance (with HT) server applications and PC intended for multiple-processor machines
  - 32- and 64-bit versions

- **Itanium (’01; Intel and HP)**
  - 64-bit, 6 Inst. per cycle
  - Intended for technical computing market
  - Sold poorly; considered expensive and slow

- **Pentium D and Extreme Edition (2005)**:
  - Multi Core processors (with HT)
  - Contains two or more execution processors on one chip

- **Core 2 Duo** and Core 2 Quad processor cores (2006-2007);
  - Multicore processor: eight and more cores per chip.

- **Atom** Processor (2008)

http://www.intel.com/technology/
Intel in Microprocessors

Why was Intel so successful in the microprocessor business?

1. Creating value by becoming the standard
2. Capturing the value by becoming a proprietary standard
3. Sustaining value by counteracting any threats

IBM chose the Intel architecture which made it the dominant one. Thus Intel became the standard!
How then, did Intel manage to make money from its standard?

- By making the standard proprietary. This allowed Intel to capture the value!

- How did it become proprietary?
  1. Enforcing Intellectual property: suing companies who copied its microcode (sued successfully NEC).
  2. Cutting number of licenses from 12 to 4 for the 286.
  3. Aggressive marketing: Checkmate campaign: helped strengthen Intel’s position as the standard.
  4. Building production capacity so that it did not need to license to others.
  5. Convinced IBM to go with Intel as the sole-source manufacturer.
  6. By becoming the sole-source, Intel reaped 100% of the profits!
  7. In summary: to make this happen: huge capital was needed; process capabilities and IP protection.

©2015 TCX Inc
ARM Holdings Milestones

1995
ARM announced the Thumb architecture extension, which gives 32-bit RISC performance at 16-bit system cost and offers industry-leading code density
ARM launched Software Development Toolkit
First StrongARM core from Digital Semiconductor

1994
AKM (Asahi Kasei Microsystems) and Samsung licensed ARM technology
ARM opened offices in Los Gatos, California, USA; and Tokyo, Japan

1993
Cirrus Logic and Texas Instruments licensed ARM technology
Nippon Investment and Finance became ARM's fourth investor
ARM introduced the ARM7 core

1992
GEC Plessey and Sharp licensed ARM technology

1991
ARM introduced its first embeddable RISC core, the ARM6 solution

1990
Advanced RISC Machines (ARM) spins out of Acorn and Apple Computer’s collaboration efforts with a charter to create a new microprocessor standard.
VLSI Technology becomes an investor and the first licensee

1987
Acorn's ARM processor debuts as the first RISC processor for low-cost PCs

1985
Acorn Computer Group developed the world's first commercial RISC processor

2000
Agilent, Altera, Micronas, Mitsubishi, Motorola, Sanyo, Triscend and ZTEIC licensed ARM technology
ARM launched SecurCore family for smartcards
ARM acquired Allant Software and Infinite Designs
ARM invested $2m in Parthus Technologies plc
ARM formed equity alliance with CoWare
TSMC and UMC became members of ARM Foundry Program

1999
LSI Logic, STMicroelectronics and Fujitsu licensed ARM technology
ARM joined FTSE 100 Index
ARM introduced PrimeCell peripherals
ARM announced synthesizable ARM9E processor with enhanced signal processing
ARM acquired Micrologic

1998
HP, IBM, Matsushita, Seiko Epson and Qualcomm licensed ARM technology
Flotation of ARM Holdings plc on LSE and NASDAQ (17 April 1998)
ARM developed synthesizable version of the ARM7TDMI core
ARM Partners shipped more than 50 million ARM Powered products

1997
Hyundai, Lucent, Philips, Rockwell and Sony licensed ARM technology
ARM and Sun announced direct JavaOS support for ARM RISC architecture
ARM acquired 45% shareholding in PALMCHIP
ARM9TDMI family announced

1996
Alcatel, OKI, Rohm and Yamaha licensed ARM technology
ARM and VLSI Technology introduced the ARM810 microprocessor
ARM and Microsoft worked together to extend Windows CE to the ARM architecture
ARM Holdings Milestones

2003
ARM acquired Adelante Technologies, Belgium
TrustZone technology announced, providing a secure platform at the heart of ARM cores
AMBA 3.0 (AXI) methodology announced
STMicroelectronics and Texas Instruments joined by ARM and Nokia as founding members of the MIPI Alliance, to define open standards for mobile application processors
CoreSight real-time debug and trace solution for multi-core systems announced

2002
ARM announced that it had shipped over one billion of its microprocessor cores to date
ARM technology licensed to Seagate, Broadcom, Philips, Matsushita, Micrel, eSilicon, Chip Express and ITRI
ARM launched the ARM11 microarchitecture
ARM launches its RealView family of development tools
Flextronics became the first ARM Licensing Partner program member, allowing it to sub-license ARM technology to its own customers

2001
ARM's share of the 32-bit embedded RISC microprocessor market grew to 76.8 per cent
ARM announced new ARMv6 architecture
Fujitsu, Global UniChip, Samsung and Zeevo licensed ARM technology
ARM acquired key technologies and an embedded debug design team from Noral Micrologics Ltd
Warren East appointed Chief Executive Officer
ARM Connected Community established

2007
Five billionth ARM Powered processor shipped to the mobile device market
ARM Cortex-M1 processor launched – the first ARM processor designed specifically for implementation on FPGAs
AMBA Adaptive Verification IP launched
RealView Profiler for Embedded Software Analysis introduced
ARM unveils Cortex-A9 processors for scalable performance and low-power designs
ARM Introduces SecurCore SC300 Processor For Smart Card Applications
Warren East, CEO, wins Orange Business Leader of the Year Award

2006
IEEE honors ARM with its 2006 Corporate Innovation Recognition award.
ARM Cortex-A8 processor recognized as "Best In 2005" by four leading electronics industry publications

2005
ARM listed by Electronic Business as one of the ten most significant companies in electronics over the past 30 years
ARM acquired Keil Software
ARM Cortex-A8 processor announced
ARM launched DesignStart Program

2004
ARM acquired Artisan Components Inc.
The ARM Cortex family of processors, based on the ARMv7 architecture, is announced. The ARM Cortex-M3 is announced in conjunction, as the first of the new family of processors
ARM Cortex-M3 processor announced, the first of a new Cortex family of processor cores
NEON media acceleration technology announced
ARM technology licensed to Aplix, Atheros, Broadcom, CSR, Kawasaki, NEC, Socle, Sony Ericsson, Thomson, Toshiba, Samsung and ZRRT
ARM acquired Axys Design Automation
MPCore multiprocessor launched, the first integrated multiprocessor

©2015 TCX Inc
ARM Holdings Milestones

2010
Giesecke & Devrient secure mobile payments announcement via ARM TrustZone and G&D’s Mobicore technologies
ARM launches Cortex-M4 processor for high performance digital signal control
ARM together with key Partners form Linaro to speed rollout of Linux based devices
Microsoft becomes ARM Architecture Licensee
ARM & TSMC sign long-term agreement to achieve optimized Systems-on-Chip based on ARM processors, extending down to 20nm
ARM extends performance range of processor offering with the Cortex-A15 MPCore processor
ARM Mali becomes the most widely licensed embedded GPU architecture
ARM Mali-T604 Graphics Processing Unit introduced providing industry-leading graphics performance with an energy-efficient profile
ARM announces Corelink 400 series of AMBA 4 protocol-compliant system IP

2009
ARM announces 2GHz capable Cortex-A9 dual core processor implementation
ARM invests in Japanese software vendor eSOL to develop enhanced platforms for next-generation automotive electronics
ARM launches its smallest, lowest power, most energy efficient processor, Cortex-M0
ARM Ltd. receives Best Companies accreditation
ARM extends its leadership in media processing by acquiring Logipard AB

2008
ARM announces 10 billionth processor shipment
ARM wins Britain's Top Employer Award 2008 from crf.com
ARM announces Industry First silicon-on-Insulator Physical IP for IBM's 45nm SOI Foundry
ARM Mali-200 GPU Worlds First to achieve Khronos Open GL ES 2.0 conformance at 1080p HDTV resolution

2012
ARM, Gemalto and G&D form joint venture to deliver next-generation mobile security
First Windows RT (Windows on ARM) devices revealed
ARM, AMD, Imagination, MediaTek and Texas Instruments founding members of Heterogeneous System Architecture (HSA) Foundation
ARM and TSMC work together on FinFET process technology for next-generation 64-bit ARM processors
ARM forms first UK forum to create technology blueprint “Internet of Things” devices
ARM named one of Britain’s Top Employers
MIT Technology Review named ARM in its list of 50 Most Innovative Companies

2011
ARM ranked #12 in FastCompany's 50 Most Innovative Companies
WIRED magazine named Warren East in the UK’s Most Influential Leaders
ARM CEO Warren East makes Barron’s list of the World’s Top 30 CEOs
ARM was again included in the FTSE4Good Index, designed to measure the performance of companies that meet globally-recognized corporate responsibility standards
ARM granted Queen’s Award for Enterprise (Innovation Category)
Microsoft unveils Windows on ARM at CES 2011
IBM and ARM collaborate to provide comprehensive design platforms down to 14nm
ARM and UMC extend partnership into 28nm
Cortex-A7 processor launched
Big.LITTLE processing announced, linking Cortex-A15 and Cortex-A7 processors
ARMv8 architecture unveiled at TechCon
AMP announce license and plans for first ARMv8-based processor
ARM Mali-T658 GPU launched
ARM expands R&D presence in Taiwan with Hsinchu Design Center
ARM and Avnet launch Embedded Software Store (ESS)
ARM, Cadence and TSMC tape out first 20nm Cortex-A15 multicore processor
## ARM Holdings Revenue Growth

<table>
<thead>
<tr>
<th>PERIOD ENDING</th>
<th>31-Dec-11</th>
<th>31-Dec-10</th>
<th>31-Dec-09</th>
<th>31-Dec-00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Revenue, $ (000)</td>
<td>764,358</td>
<td>636,588</td>
<td>492,567</td>
<td>126,336</td>
</tr>
<tr>
<td>Cost of Revenue, $ (000)</td>
<td>43,029</td>
<td>40,818</td>
<td>41,132</td>
<td>24,155</td>
</tr>
<tr>
<td>Gross Profit, $ (000)</td>
<td>721,329</td>
<td>595,770</td>
<td>451,435</td>
<td>150,491</td>
</tr>
</tbody>
</table>
Example Case Study – Entropic Communications

Entropic Communications EN2210 Coaxial Network Controller for c.Link Home Networking
http://www.entropic.com/solutions/cable#cable2
Includes a block diagram.
Assume implementation in 90nm CMOS process technology

Market and applications : c.Link Home Networking

Time to first silicon tapeout was about 3 years
Time to hi volume production was about 6 years
They had to create a market for their solution
Peregrine Semiconductor

- Founded in 1989
- Unique technology (Silicon on Sapphire) to fabricate CMOS chips to replace GaAs devices
- Today shipping Ultra CMOS Integrated RF Front End chips for Mobile, Wireless Infrastructure, Broadband, high performance application
- Shipments:
  - first 100 IC chips in 5 years
  - 1 billionth chip in 21 years
  - 2 billionth chip in 24 years
- Revenue
  - $10M in 14 years
  - $50M in 18 years
  - $100M in 22 years
  - $200M in 23 years
- Capital
  - Round 1: ~$1.5M
  - Round 2: ~$4M
  - Cum thru Round “X”: ~$200M
  - Spent >$500M in 20+ years
Example Case Study – Echelon

Echelon’s FT Network Chip
Data Sheet

Technology description and application
http://www.echelon.com/products/pyxos/

Refer to Figure 4.6.
It may not be the very exact chip, but its close.
Case Study – Analog Devices

Silicon Image

Silicon Image has a host of IC products in the HDMI and other DTV applications.

They are a fabless company that had $295M revenue in 2006

http://www.siliconimage.com/products/
http://www.siliconimage.com/aboutus/factsheet.aspx

Founded January 1995 Funding Publicly held
NASDAQ: SIMG Corporate Headquarters 1060 East Arques Ave.
Sunnyvale, CA 94085
Phone: 408-616-4000

Wireless MEMS, Sensors and other applications

Implantable wireless MEMS sensors for medical use
http://www.techbriefs.com/content/view/73/34/

Find terrorists in caves…

MEMS for wireless applications
http://rfdesign.com/mag/radio_mems_wireless_apps/

Digital Microphones – Akustica

http://www.akustica.com/
In-class Quiz 10-1

- List 3 companies whose Case Studies were discussed in this class
Business Plan example Table of Contents

- Executive Summary
  - Objectives
  - Mission
  - Key to Success

- Company Summary
  - Startup Summary
  - Management Team
  - Technical Team
  - Company Locations and Facilities

- Market Analysis
  - Industry Overview
  - Market Size
  - Market Opportunities
  - Competition

- Product Summary
  - Product Description
  - Sourcing and Technologies
  - Product Development Schedules
  - Competitive Analysis
  - Product Advantages
  - Product Roadmaps

- Marketing and Sales Strategy
  - Targeted Markets
  - Customers
  - Strategic Alliances
  - Advertising and Promotion
  - Selling Tactics

- Manufacturing and Operations Plan
  - Wafer Sourcing
  - Backend Manufacturing Plan

- Organization and Personnel Plan
  - Organization
  - Personnel Plan

- Financial Plan