FEBRUARY 11, 2016

INDUSTRY ASSESSMENT

WIRELESS SEMICONDUCTOR SECTOR

Jeff Kent
University of Waterloo

Master's MBET Program

Table of Contents

1.0 Introduction

The semiconductor industry is big business and super competitive. At the current pace of technological development not all companies will be able to innovate their way to greater successes through their own R&D efforts. They will instead rely on mergers and acquisitions and partnership collaboration agreements in order to keep up with this dynamic industry. All semiconductor companies with wireless product offerings are scrambling to supply products for protocols that have traction and or are guessing which one(s) will be dominant in the Internet of Things (IoT). Because IoT will be so big and myriad of new applications demand better technologies, there has been much M&A action in the last year or so. I give several examples of such further in this report.

Through my extensive secondary research in my last report (Kent, 2015) and also in this report, plus my qualitative interviews that are detailed further in Tables 1 and 2, I have uncovered four key pattern trends pertaining to the current state of the wireless semiconductor sector. The key findings are: (1) Demand for Low Power Chipsets; (2) Compact Chipset Size is King; (3) Company Expansion of IoT Offerings; and (4) Alternative Technology Diversity. Another side bit of information I uncovered when attempting to find interviewees for my qualitative data is just how secretive, private, cautious and competitive the whole industry really is. For this report I contacted 22 major companies who had extensive wireless offerings with SoCs and MCUs etc. on numerous occasions and only received four interviews. In Table 3 there is a breakdown of the 18 companies who would not talk to me where I explain their product offerings, the attempts I made to contact them and the responses the companies gave me.

2.0 Interviewed Companies – Wireless Technologies

The following list of semiconductor companies have a wireless product offering and are in the Sub-GHz protocol segment and or also in the Low-Power, Wide-Area Network (LPWAN) wireless category field. These companies were the ones who actually were willing to answer my questions out of the 22 companies I approached to interview, see Table 3. The following information gives a short description of the company's core competencies, what they're currently working on or producing and what R&D they're working on for future products.

1. Silicon Labs: They primarily have wireless semiconductor solutions for protocols in the Zigbee, Thread, Bluetooth, 2.4GHz Wi-Fi, industrial-scientific-medical (ISM) Sub-GHz unlicensed bands and their own proprietary offerings. They currently have a line-up of 8-bit microcontroller units (MCUs) for the Internet of Things (IoT) applications. Their wireless ARM Cortex based MCU is a low power 32-bit design, the EFM32. The company also builds products for USB based connectivity.

2. Intel Corporation: This company has almost a wireless solution for any application, here are some of them. Their *Quark* system-on-chip (SoC) series is Intel's lowest power with a small size and single-core processor incorporating the use of Ethernet, PCI Express, USB 2.0, SD/SDIO/eMMC, SPI, UART, and I2C/GPIO designs. It can be used in many IoT applications for endpoint devices and intelligent gateways. Intel's *ATOM* SoC for intelligent systems uses 22nm process technology with 3-D tri-gate transistors. This series can be found in: digital signage, interactive agents, portable medical devices, industrial control systems and in-vehicle infotainment systems. The *Mobile U-Processor* offers a low power, multi-chip package (MCP) combining a 64-bit multicore processor and platform controller hub (PCH) using the 14nm process technology. It can be found in retail, industrial, healthcare and IoT applications. Intel's Ethernet MCU is a low power, small sized, single-port, gigabit LAN on motherboard (LOM) that has an integrated media access controller (MAC; for data transfer) and physical interface transceiver (PHY). They also have various Chipsets for I/O interfaces that can connect to modules supporting cellular, Bluetooth, Zigbee, Wi-Fi and 802.11ac Wi-Fi Smart, GNSS with on-chip navigation for efficient foreground and background location applications and other wireless protocols. Intel also has products in the nearfield communications (NFC) category. This technology allows for Bluetooth pairing (handover), reading/writing between devices, peer-to-peer mode, and card emulation.

3. Ambiq Micro: This young semiconductor company was founded by two PhD students from the University of Michigan's microcontroller lab. These guys specialize in *Subthreshold Power Optimized Technology* (SPOT; patented), which is used for ultra-low MCU power consumption. Ambiq Micro also currently has the world's lowest power

real-time clock (RTC) that can be used in numerous semiconductor applications especially for wearable technologies such as heart rate monitors (HRM). Using this RTC can reduce the power required by 20x or more and can be used to control the on/off of a sensor and wireless transceiver too, saving even more power. They can get the same performance from the industry leading ARM Cortex M4F microcontroller but with much less power consumption. Some product applications are in programmable smart credit cards using chips for security (they have batteries), medical wearables such as the MISFIT Shine 2 fitness and sleep monitor, other wearables using 'always-on' sensing technology and a variety of wireless sensors and IoT applications.

4. WAVIoT: Also a fairly new company coming into the IoT sector in 2011. WAVIoT is exploiting their own proprietary LPWAN Sub-GHz technology called NB-Fi (narrow band) protocol. They claim this system can provide over 5,000 channels in the 500 MHz frequency band with a spectrum utilization algorithm quite similar to LTE for high efficiency. They have wireless products in smart metering, electricity meters, domestic heat cost allocators, CO_2 sensors, thermoprobes, moisture sensors, parking occupancy sensors, pulse & serial interface modems, base stations, sector antennas, NB-Fi radio modules and development and signal testing kits. They are focusing on step-by-step client coverage, real life implementation and international expansion.

2.1 Interviewed Company Organizational Details – Table 1

Company Interviewed	Company Information	Interviewee
1. Silicon Labs – Austin, Texas	Founded in 1996, public in 2000 Market Capitalization: $1.704 billion Employees: 1,200, with 12 R&D locations worldwide 2015 Revenue: $645 M; IoT = 41% (+25.5%) R&D Expenses: $188 M (2015) or 29% of total revenues.	Vivek Mohan – Wireless Marketing Mgr.; contact through Dale Weisman – Global Public Relations Director
2. Intel Corp. – Santa Clara, California	Founded in July, 1968 Market Capitalization: $137.07 billion Employees: 106,700 worldwide 2015 Revenue: $55.4 B; IoT = 4.2% (+7%) R&D Expenses: $12.13 B (2015) or 22% of total revenues.	A senior wireless engineer; contact through Robert Colby – IT Dept.
3. Ambiq Micro – Austin, Texas	Founded in 2010: Scott Hanson & David Blaauw University of Michigan PhDs; microcontroller spin-off Cisco Ventures initial funding: $250,000 KPCB series 'C' Venture funding = $15.6 M VC Investors: AustinVentures, Mercury Fund, ARM Holdings PLC and Huron River Ventures 2015 Revenues: Estimated at $1.0+ million Employees: 50	Contact details confidential; through Alexandra Sorton – Public Relations Department
4. WAVIoT – Los Angeles, California	Founded in 2011 Privately held company 2015 Revenues: $1.0+ million Employees: 35 First LPWAN IaaS solutions provider (NB-Fi)	Yegor Popov – CEO and co-founder

3.0 Qualitative Interview Data – Table 2

For the entire interview transcript please see Appendix – B.

Company	Detailed Information
1. Silicon Labs – Vivek Mohan	**Vertical Markets Driving LPWAN:** Asset tracking; smart metering/grids; replacing 2G cellular; urban infrastructure – smart city; home automation & security. **LPWAN Challenges:** Lack of standardization; security being too fragmented from disparate organizations; cost of deployment. **Additional Technologies for Products:** Considering adding LPWAN technologies since no single one can satisfy all IoT applications. **Important LPWAN Technologies:** Sigfox; LoRa; Weightless; LTE-M; NB-IoT; and Dash7. **Standardizations:** Are following 3GPP (3rd Generation Partnership Project) standardization efforts.
2. Intel Corp. – Confidential source	**Vertical Markets Diving LPWAN:** Internet of Things; everything for low power, low cost and low bandwidth. **LPWAN Challenges:** Not much for technical; mostly with regulation, standardization and in politics. **Standardization:** Currently focusing on LPWAN for 3GPP for NB-LTE/IoT (narrow band) **LPWAN Technologies:** Will not support all, especially unlicensed spectrums LTE-U. Only going with standardized non-proprietary solutions.
3. Ambiq Micro – Confidential source	**Customer Application Examples:** The MISFIT Shine 2 fitness & sleep monitor; RTC in credit cards for dynamic security code on the signature strip; ultra-low power heart rate monitors. **Technology Their Customers Use:** LoRa is a good example. **M2M Customers & Cellular:** 2G, 3G and 4G technologies are less attractive to us. **Cellular Market Product Considerations:** Not in current roadmap.

4. WAVIoT – Yegor Popov	**Vertical Markets Driving LPWAN:** Smart metering; smart agriculture; running some pilot projects now with big retail chains, banks, infrastructure operators and security companies. **LPWAN Challenges:** Scalability, or number of nodes per gateway; total solution cost; other technical issues with each proprietary solution, i.e., Sigfox' poor performance, LoRa' limited 4-6 channels per spectrum, LTE-M' low efficiency and necessary system hardware updates. **Current or Future Products:** Smart water & electricity meters, domestic heat cost allocators, CO_2 sensors, thermoprobes, moisture sensors, parking occupancy sensors. **Additional Technologies for Products:** (Probably not); Mostly based on proprietary NB-Fi protocol with 5,000 channels in 500 MHz band.

3.1 Identified Patterns and Trends

Through my extensive secondary research (Kent, 2015) during this course assignment project working in the wireless LPWAN Chipset semiconductor sector and also from my primary qualitative interview data, even though the sample size was small, I did find some interesting and compelling pattern trends.

3.11 Demand for Low Power Chipsets:

The wireless semiconductor industry appears to be in a mad rush to come up with SoCs and MCUs that are ultra-low power consumers and therefore provide energy efficiency to the product application they are used in. Companies excelling at this effort are: Altera Corp., Ambiq Micro, Analog Devices, ARM Inc., Dialog Semi, Freescale (now NXP), Intel Corp., Libelium Comunicaciones, Silicon Labs and Toshiba America (TAEC) (Kent, 2015)(Table 2). Many products that are now evolving, such as, IoT wearable technologies, indoor/outdoor environment sensors, 'chip' credit cards, and many others, have a need for very long battery life. This need comes from the application device not having the capability to be opened in order to change the battery cell, they come in sealed units so the need for a very long battery life is evident. Once the IoT device stops working after five to ten years, the consumer will just throw it away or depending on the product and cost, have the manufacturer change the battery cell.

3.12 Compact Chipset Size is King:

A trend that has continued since Gordon Moore came up with *Moore's Law* – doubling of transistors in a circuit about every two years, is the trend to keep making SoCs and MCUs, along with every other component in an integrated circuit, smaller and smaller in size. This allows for integrating more than one component into one unit, such as, Intel's (Moore co-founded) Ethernet MCU, which combines a local area network (LAN) onto a motherboard (LOM) with an integrated MAC and PHY (Intel, 2016); ARM Inc.'s *Cortex* series of MCUs that are some of the most prolific and widely used designs in the world (Kent, 2015); Freescale's (NXP) ultra-thin 2.4 GHz product offerings and Libelium's *Waspmote* hardware architecture (Kent, 2015). The fact that these very powerful microcontrollers and system-on-chip processors are now so advanced and small, means we will see them in almost everything we do when we go about our daily lives. Some examples, such as, fitness and sleep monitors, watches, high-definition cameras, smart appliances, smart agriculture equipment, the connected automobile, autonomous vehicles, IoT sensors for monitoring and endless industrial applications.

3.13 Company Expansion of IoT Offerings:

By looking at the financial data in various company's annual reports and in press releases, I can ascertain there is a pattern from both SME's and large corporations, of their increasing focus towards the Internet of Things (IoT). The following randomly picked companies have some salient data indicating this IoT trend by showing they have a large and increasing focus on the IoT wireless sector. See Appendix – A chart.

1. Silicon Labs – Their 2015 IoT segment revenues increased by 25.5% from 2014, to $262.33 M. This is an increase of $53.3. At the same time their R&D expense has increased $15.1 M or by 8.7% over 2014, to $188 million total (Silicon Labs, 2016).

2. Intel Corporation – Even though Intel's overall 2015 revenues were down 1% to $55.4 B, their IoT segment revenue increased 7% to $2.3 B. Their R&D expense of $12.13 B was up by 5.1% or $591 M over 2014. The company also purchased Altera Corp. in order to shore up their IoT technologies (Intel Corp., 2016).

3. NXP Semiconductors – NXP's 2015 product revenues increased by 8.7% or $478 M from 2014 to $5.96 B. Their *Secure Interface & Infrastructure Group* revenue was up by

10% or $104 from 2014 to $1.14 B, which was due in part to their acquisition of Freescale for their IoT product expertise. NXP's R&D expenses increased by 16.6% or $127 M from 2014 to $890 M. This was 14.6% of total revenues (NXP Semi., 2016).

4. Microchip Technology – Microchip acquired Micrel and is now acquiring Atmel Corp. in order to strengthen their IoT market share. Microchip's fiscal 2015 revenues increased 11.2% or $215.8 M from fiscal 2014 to $2.15 B. Their *Microcontrollers* segment increased revenues by 64.9% to $1.39 B while their *Analog, Interface & Mixed Signal Products* segment increased their revenues by 23.3% to $501 M. Microchip's R&D expense was up by $44.5 M or 14.6% from 2014 to $349.5 M (Microchip, 2015).

5. Sierra Wireless – This Canadian company had increased revenue of 10.8% from 2014 to $607.8 M. Sierra's newly formed IoT *Cloud & Connectivity Services* segment had inaugural revenues of $21.4 M and a gross margin of 41.8%. Their R&D expense went down by $6.9 M or (8.6%) from 2014 to $74 M (Sierra Wireless, 2016).

6. Texas Instruments – Overall 2015 revenues were down $45M or (.34%) from 2014 to $13 B. Their *Embedded Processing* products segment was higher by 2% or $47 M over 2014 to $2.79 B. R&D expense declined $78 M or (5.7%) from 2014 to $1.28 B and was 9.9% of total revenues (Texas Instruments, 2016).

Looking at all of this movement towards IoT and the increased results within the sector, this trend should continue for some time. This is definitely a good place to be if your company can supply or design a differentiated IoT product, such as, a wireless LPWAN Chipset that can be integrated with many devices by numerous manufacturers.

3.14 Alternative Technology Diversity:

The wireless semiconductor industry is a multi billion-dollar industry and many companies are involved with the R&D and manufacturing of SoCs, MCUs, wireless RF infrastructure products as well as general industry and application specific integrated circuits (ASICs). Because there are so many players in the industry and so many application needs, there are many different wireless spectrum protocols. I found that many of the large wireless semiconductor manufacturers offer various products to the many different industry standard protocols, such as, Zigbee, 2.4 GHz Wi-Fi and Wi-Fi

Smart, Bluetooth and Bluetooth Smart (BLE), Sigfox, LoRa Alliance and others. Some of these companies are even in a consortium or partnership alliance for promoting a specific technology designed for a specific industry spectrum (LoRa). Many companies, though already in an alliance of sorts, even have their own proprietary technologies they are promoting and are even still interested in other Sub-GHz LPWAN technologies. The competition is fierce and no organization wants to let a differentiated and interesting technology, that is gaining in market traction, get ahead of what they are currently offering. Such companies are: Cisco Systems' membership in the LoRa Alliance, they also have their own *Aironet* and *Meraki* cloud-managed access point technology; Silicon Labs' membership with Sigfox, they also have their *EZR* family of proprietary Sub-GHz low power microcontrollers; Microchip Technology is a member of the LoRa Alliance and also have their proprietary *MiWi* series of products; Texas Instruments is a member of the Sigfox partnership and has a proprietary product line-up called *SimpleLink* that they promote; Libelium is a member of the LoRa Alliance and promotes their *Waspmote* brand and Link Labs has their Symphony Link wireless LPWAN MCUs that can be used within the LoRaWAN network or in other LPWAN networks (Kent, 2015).

3.2 Implications from Findings

What could these four main trends mean to a company for example like *Eleven-x* who work out of Waterloo's Accelerator Centre and are hoping to partner with someone for their innovative LPWAN Chipset designs?

Due to the nature of the wireless semiconductor business and the fast-paced dynamic movement of technological change, there are many companies within the wireless MCU sector that are open to new partnerships if a company can offer a very compelling design advantage. If Waterloo's *Eleven-x* Sub-GHz Chipset designs can be a market differentiator by having very low energy consumption with a relatively small size to what their competitors are offering, there is a very good chance the company will be successful in forming a partnership licensing agreement for their designs. The emerging technology applications in the market are demanding very low power and small sized wireless SoCs and MCUs in order to have the ability to integrate them within the new trending electronic products as mentioned previously in 3.1.1 and 3.1.2.

4.0 Contacted Companies & Responses for Interviews – Table 3

Company	Wireless Technology Products	Attempts – Responses
1. **Analog Devices –** One Technology Way, Norwood, Massachusetts	Low power radio frequency (RF) and microwave control products; broadband transmitters for 3G, 4G and LTE.	[redacted] Robin Getz of their university program & Linda Kincaid in PR [redacted]
2. Atmel Corp. (Microchip) – 1600 Technology Dr., San Jose, California	IoT MCU devices for Zigbee, Wi-Fi, Bluetooth Smart (BLE) and RFID devices using ISO 14443-B standard.	[redacted] Agnes Toan of Corp. Comm. [redacted] Yuchung Wang [redacted]
3. Cisco Systems – 170 W. Tasman Dr., San Jose, California	A LoRa Alliance member; Proprietary "Aironet & Meraki" indoor and outdoor cloud-managed access point (AP) system; IoT products for 2.4GHz Wi-Fi and Wi-Fi Smart and Wave 2-based Wi-Fi standards for indoor/oudoor APs; cloud-managed devices and LAN controllers.	[redacted] Wayne Cuervo the Dir. of IOE Innovation Ctr. [redacted] . Emailed Scott Herron [redacted]
4. Cypress Semi. – 198 Champion Court, San Jose, California	Programmable SoCs for Bluetooth and BTE; 32-Bit ARM Cortex MCUs; Solar powered IoT device development and also 2.4 GHz USB NX/NL/LP products.	[redacted] Emailed Nella Filice & Julie Golding both of C-J Microsystems [redacted]
5. Dialog Semi. – 100 Longwater Ave., Green Park, Reading, UK	Smallest, lowest power, most integrated Bluetooth Smart (BLE) SoC with software over-the-air (OTA) updates; Bluetooth 4.1 BLE Cortex M0 OTA processors; BLE 4.2 for wearables, wireless charging, data retention without power.	[redacted] Lauren Ofstedahl of Corp. Comm. [redacted] Dan Harper, Senior Dir. Americas [redacted] Mark de Clercq, Product Marketing Group Mgr. [redacted]

6. Freescale Semi. – 6501 William Cannon Dr., W, Austin, Texas (Acquired by NXP 2016)	IoT ultra low power MCUs in Sub-GHz; Ultra-thin 2.4 GHz products; Bluetooth and BLE ARM Cortex M0+ and transceivers; Thread networking 802.15.4 Chipsets (mesh); Products for Zigbee & MCUs for Meter-Bus (M-Bus).	[redacted] Bill Krakar[redacted]
7. Inventek Systems – 2 Republic Rd., Billerica, Massachusetts	Full-service IoT connectivity focused on Wi-Fi, Bluetooth and BLE, Near Field Communications (NFC), GPS, Combo-radios, Broadcom WICED, and Antenna embedded modular solutions.	[redacted]
8. Libelium Comuniacaciones – C/ Escatron, 16 Edificio Libelium, Zaragoza, Spain	Proprietary "Waspmote" hardware architecture with very low power consumption; 17 different wireless interfaces for their technology incl. short, med. and long range protocols; A member of the LoRa Alliance.	[redacted] David Gascon, CTO [redacted]
9. Link Labs – 130 Holiday Court, Annapolis, Maryland	IoT bi-directional RF transceiver modules for Symphony Link and LoRaWAN using 915 MHz ISM bands and 868 MHz ETSI bands; also M2M gateways for LoRa networks.	[redacted]
10. Microchip Technology – 2355 West Chandler Blvd., Chandler, Arizona	LoRa Alliance member; Bluetooth MCUs; embedded Wi-Fi; IoT modules for LoRaWAN network; 2.4 GHz & Sub-GHz MCUs; embedded Zigbee RF4CE and Pro/Smart; also Mi-Wi proprietary products.	[redacted] Emailed Sarah Broome[redacted]
11. NXP Semi. – High Tech Campus 60, 5656 AG Eindhoven, The Netherlands	Global manufacturing conglomerate who recently acquired Freescale. Product line-up includes IoT MCUs for Wi-Fi, NFC, Bluetooth and Smart BLE and Zigbee protocols.	[redacted] Jacey Zuniga, Corp. PR Mgr. [redacted] Hillary Cain, Marketing & Comm. Mgr. [redacted]
12. ON Semiconductor – 5005 East McDowell Rd., Phoenix, Arizona	High speed SerDes ASICs; memory and parallel interfaces; MCUs for ARM, PPC, 8051/52; and R-Core proprietary 16-Bit audio DSPs.	[redacted] Kris Martino, Corp. Comm. Mgr. [redacted]

13. Qualcomm – 5775 Morehouse Dr., San Diego, California	RF 360 and X12 LTE 820 processors for 2.4GHz Wi-Fi SoC; 2x2 MU-MIMO and Tri-band; LTE-U for connections in licensed & unlicensed spectrum.	[redacted]
14. RF Micro Devices – 7628 Thorndike Rd., North Carolina	IoT; Cellular Offload; DB/DC; MIMO; MU-MIMO; HE Wi-Fi; Cellular front-end; discrete power amplifiers and LNAs; high-performance switches; RF infrastructure components.	[redacted]
15. Semtech – 200 Flynn Rd., Camarillo, California	Developer of the LoRa chirped spread spectrum (CSS) radio modulation format and uses LPWAN within the LoRa Alliance; IoT and M2M RF transceivers, transmitters and receivers operating in 433, 868, and 915 MHz license-free ISM bands (Industry, Science, Medical).	[redacted] David Guerra, PR [redacted] Ashley Adelman [redacted]
16. Sierra Wireless – 13811 Wireless Way, Richmond, British Columbia	IoT Device-to-Cloud modules, Legato open-sourced Linux-based, ARM processors with firmware-over-the-air (FOTA), cellular 3G/4G; gateway solutions; programmable modems for 2G/3G connectivity; railway mobile RF modules (MRM) for GSM-R cab radios.	[redacted]
17. Texas Instruments – 12500 TI Blvd., Dallas, Texas	Sigfox partner; Wireless network processors; Smart RF transceivers; IoT MCUs for embedded Wi-Fi Internet-on-Chip technology; products for numerous protocols incl. 2.4GHz and Sub GHz for Bluetooth and BLE, 6LowPAN, ZigBee & ZigBee RF4CE, ISM Bands; also proprietary 'SimpleLink' products.	[redacted] Artem Aginskiy [redacted]
18. Toshiba America – 2825 N. First St., San Jose, California	Integrated circuits (ICs) for Bluetooth and Bluetooth Smart (BLE), very low power RF ICs for proprietary “TransferJet” close range connectivity protocol.	1[redacted] Deborah Chalmers, PR for TAEC [redacted] Lisa Gillette-Martin, Corp. Comm. [redacted]

5.0 Conclusion

The semiconductor sector has been quite dynamic in 2015 with a number of M&A deals ($100 B), such as: Intel acquiring Altera; NXP acquiring Freescale; Microchip acquiring Micrel and now Atmel; Avago acquiring Broadcom; Cypress acquired Spansion. M&A activity has continued so far in 2016 with Cisco acquiring Jasper Technologies and Sony acquiring Altair. A lot of this is due in part to positioning for the advancement in the IoT sector, which will be the next technological frontier and a big proponent of the Web 3.0. In wireless semiconductor MCUs and SoCs, innovations are coming from many companies for ultra-low power and smaller and smaller sized ICs in order to align the circuits with what the applications want to build. Technology is moving very swiftly and tech application companies are coming out with more ways for integrating the new technological advancements into exciting products the market is willing to buy.

If a company is lagging behind in a technology area and has enough cash set aside, they need to look at making an acquisition or coming to a collaboration partnership agreement with a company that has some interesting and innovative ideas and designs preferably within the IoT space. I think the latter situation might be a stretch since I contacted numerous companies many times to assist me with input into this project report and did not have much success. This sector is extremely competitive and nobody wants to be caught off-guard by letting some information slip by in an interview. They may also be thinking that if another company finds out how great their IoT ideas are for example in LPWAN, they could be the subject of a takeover, which is happening a lot to public companies as previously mentioned.

The primary data of this report and the secondary data of this and my last report (Kent, 2015) shows there is an increase in IoT related revenues and R&D by anywhere from 10% to 25% for 2014 and 2015. This will most likely continue going forward for several years if not a decade. It is an exciting time to be in the wireless semiconductor business and being innovative and careful is crucial.

6.0 References

Intel Corp. (2016, January 14). *Products*; *Investor Financial News Report*. Retrieved on February 10, 2016 from Intel corporation website, http://www.intc.com/investornews.cfm

Kent, Jeff. (2015, December 10). *Industry Analysis Report: Wireless Semiconductor Sector*. Graduate BET 608 Course, University of Waterloo. Waterloo, Ontario.

Microchip Technology. (2015, July 10). *Annual Reports*. Retrieved on February 10, 2016 from Microchip website, http://www.microchip.com/sec/annual/FY15/2015%20Proxy%20Statement%20and%20Annual%20Report.pdf

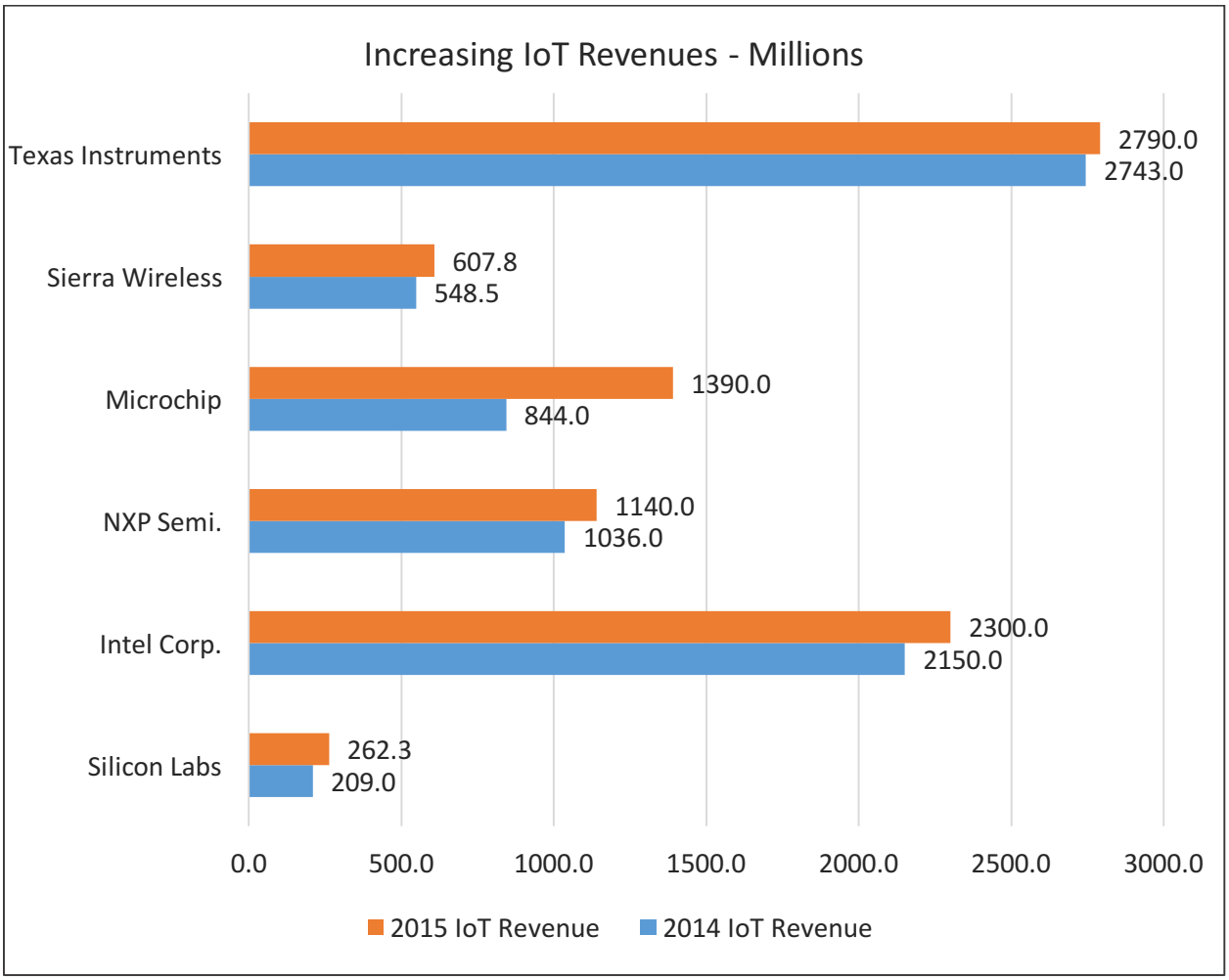
NXP Semiconductors. (2016, February 3). *Financial Press Releases*. Retrieved on February 10, 2016 from NXP website, http://investors.nxp.com/phoenix.zhtml?c=209114&p=irol-newsArticle&ID=2135489

Sierra Wireless. (2016, February 4). *Q4 2015 Press Release*. Retrieved on February 10, 2016 from Sierra Wireless' website, http://www.sierrawireless.com/company/investor-information/quarterly-results/

Silicon Labs. (2016, February 5). *Annual Report Form 10-K*. Retrieved on February 10, 2016 from Silicon Labs website, http://investor.silabs.com/sec.cfm

Texas Instruments. (2016, January 27). *4Q 2015 Earnings Report*. Retrieved on December 10, 2016 from Texas Instruments' website, http://www.ti.com/corp/docs/investor_relations/earnings.html

7.0 Appendix A: Increasing Company IoT Related Revenues – Chart



8.0 Appendix B: Qualitative Interview Transcripts

All were removed for confidentiality reasons.