Digital Health-Data Platforms
Biometric data aggregation and their potential impact to centralize
Digital Health-Data

by

Lawrence G. Lam

B.S., Mechanical Engineering
University of California Los Angeles, 2001

Submitted to the System Design and Management Program
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Engineering and Management
at the
Massachusetts Institute of Technology
June 2015

© 2015 Lawrence G. Lam
All Rights Reserved

The author hereby grants to MIT permission to reproduce and to distribute publicly
to paper and electronic copies of this thesis document in whole or in part in any medium
now known or hereafter created.

Signature of Author

Signature redacted

Lawrence G. Lam
System Design & Management Program
May 9, 2015

Certified by

Signature redacted

Michael A. M. Davies, Thesis Supervisor
Senior Lecturer, Engineering Systems Division

Accepted by

Signature redacted

Patrick Hale, Director
System Design and Management Program
This page has been intentionally left blank.
Digital Health-Data Platforms
Biometric data aggregation and their potential impact to centralize Digital Health-Data

by

Lawrence G. Lam

Submitted to the System Design and Management Program on May 9, 2015 in Partial Fulfillment of the Requirements for the Degree of Master of Science in Engineering and Management

Abstract

Digital Health-Data is being collected at unprecedented rates today as biometric micro sensors continue to diffuse into our lives in the form of smart devices, wearables, and even clothing. From this data, we hope to learn more about preventative health so that we can spend less money on the doctor. To help users aggregate this perpetual growth of biometric "big" data, Apple HealthKit, Google Fit, and Samsung SAMI were each created with the hope of becoming the dominant design platform for Digital Health-Data.

The research for this paper consists of citings from technology strategy literature and relevant journalism articles regarding recent and past developments that pertain to the wearables market and the digitization movement of electronic health records (EHR) and protected health information (PHI) along with their rules and regulations. The culmination of these citations will contribute to my hypothesis where the analysis will attempt to support my recommendations for Apple, Google, and Samsung.

The ending chapters will encompass discussions around network effects and costs associated with multi-homing user data across multiple platforms and finally ending with my conclusion based on my hypothesis.

Thesis Supervisor: Michael A. Davies
Title: Senior Lecturer, Engineering Systems Division
This page has been intentionally left blank.
Preface

While trying to wrap up the final touches for this thesis it dawned on me that this research will mostly affect the lives of my children. When I first started my journey at the MIT System Design and Management program, my son Evan was just a 1-year old while my wife, Hae Hyoung, was 5-months pregnant with my daughter Charlize.

The world that my kids will grow up in will be flooded with a ubiquitous amount of biometric sensor data. The convergence of nanoelectronic technology and international manufacturing has now made it cost-efficient to implement sensors into anything with an electronic pulse. In my children's future, maybe wearables and smartphones will naturally be just an extension of their body and knowing your heart rate and amount of exercise for your age range becomes knowledge as common as knowing the alphabet. We all hope that by collecting biometric data today we will be making a positive impact on the medical world that transpires into meaningful preventative healthcare for the future of our children.

Therefore I have dedicated this research to my children with the goal of making the world they were born into a “less scary” place.
This page has been intentionally left blank.
Acknowledgements

First I would like to thank Pat Hale and the MIT System Design and Management program for the opportunity. It has been an amazing 18-month journey where I was able to push my academic boundaries in ways I never would have imagined.

Professor Michael Davies, thank you for your guidance in helping me shape my thesis. It was a long and arduous process but I am glad to have had you as my advisor. I know I was procrastinating at times but you provided the motivation when I needed it and showed patience with me when I felt lost with my topic.

To my friends, Sang and Robert, thank you for cheering me on to finish this life long goal of mine to get a graduate degree. Proudly, I now have an unusual amount of knowledge about osteoarthritis thanks to our conversations together. Thank you to my mom and mother-in-law for helping out when Charlize was born during my finals week. What a memory that was! Thank you sister for the care packages and thank you dad for always checking up on my family.

Finally, the most important thank you is to my wife Hae Hyoung. Without you (and the fortune teller) I do not think I would have applied to graduate school and I definitely would not have made it thru my homework. I guess it will be my turn to take care of our children, Evan and Charlize, and teach them what I learned in school while you take a very long vacation. I love you.
Good-bye MIT and thanks for all the fond memories.

~ Lawrence G. Lam
This page has been intentionally left blank.
Table of Contents

Abstract........................................................................................................................... 3

Preface ............................................................................................................................. 5

Acknowledgements .......................................................................................................... 7

List of Figures................................................................................................................ 13

List of Tables .................................................................................................................. 16

Chapter 1: Introduction................................................................................................. 18

  Motivation...................................................................................................................... 21
  Hypothesis ..................................................................................................................... 21
  Commonly Used Language .......................................................................................... 23
  Organization of Thesis................................................................................................. 26

Chapter 2: Background United States Health Market.................................................... 28

  United States Healthcare Market Size...................................................................... 28
  Electronic Health Records .......................................................................................... 32
  Regulation on Medical Devices .................................................................................. 32

Chapter 3: Digital Health-Data Platforms...................................................................... 35

Chapter 4: Apple............................................................................................................. 38

  Apple HealthKit Strategy............................................................................................ 40
  Apple Summary ........................................................................................................... 43

Chapter 5: Google.......................................................................................................... 44

  Google Fit Strategy...................................................................................................... 47
  Google Summary ......................................................................................................... 48
Chapter 6: Samsung ................................................................. 49

Samsung SAMI Strategy .................................................. 53
Samsung Summary ...................................................... 55

Chapter 7: Tizen Operating System .................................. 56

Tizen Good ................................................................. 58
Tizen Bad ................................................................. 59
Tizen Summary ...................................................... 61

Chapter 8: Discussion ...................................................... 63

Network Effects ............................................................. 63
Google Fit Network Effects ........................................... 64
Samsung SAMI Network Effects ...................................... 67
Apple HealthKit Network Effects ...................................... 70
Multi-Homing ............................................................. 72

Chapter 9: Conclusion ...................................................... 77

Limitations and Future Work .......................................... 79

Bibliography .................................................................. 81
This page has been intentionally left blank.
List of Figures

Figure 1 Research Approach Flow Chart.................................................................26
Figure 2 US Births from 1940 to 1994.................................................................29
Figure 3 Healthcare spending per capita .............................................................30
Figure 4 Apple and Samsung Smartphone Timeline........................................37
Figure 5 Smartphone Market Share 2008 – 2013...............................................38
Figure 6 Apple Store openings worldwide 2005 - 2013.......................................39
Figure 7 Apple slide for HealthKit hospital .......................................................40
Figure 8 Advertising revenue for Google versus US Print Media.......................44
Figure 9 Gartner Forecast Estimates Mobile OS Sales by Market Share.............45
Figure 10 Google Nexus smartphone evolution.................................................47
Figure 11 March 14, 2013 Samsung Galaxy S4 introduction event in New York...50
Figure 12 September 12, 2012 Apple IPhone 5 introduction event in San Francisco...51
Figure 13 IPhone 5 with Samsung components ..............................................53
Figure 14 Tizen Logos.......................................................................................58
Figure 15 Tizen Timeline of Developments......................................................62
Figure 16 One-sided network example of the telephone ...................................63
Figure 17 Google Fit 2-sided network effect.....................................................64
Figure 18 Android Wear smartwatch choices....................................................65
Figure 19 Android Support via Google Hangout...............................................66
Figure 18 Samsung SAMI 2-sided network effect............................................67
Figure 19 Samsung Tizen Simband.................................................................68
This page has been intentionally left blank.
List of Tables

Table 1 Life Expectancy World Ranking ................................................................. 19
Table 2 List of Apple HealthKit partnerships .......................................................... 41
Table 3 Google partnerships for Nexus smartphone Manufacturers ....................... 46
Table 4 Technical Specification for Samsung, Apple, and Google devices .............. 49
Table 5 Samsung supplier relationship table .......................................................... 52
Table 6 Global smartphone OS market share ......................................................... 57
Table 7 High level history of Tizen ....................................................................... 58
Table 8 Advantages and Disadvantages of multi-homing ........................................ 74
Table 9 Costs associated to multi-home data between iOS and Android ................. 74
This page has been intentionally left blank.
"We didn’t have smartphones ten years ago; or an explosion of new sensors and devices."

- Sumit Rana, CTO Epic Systems – February 2015

Chapter 1: Introduction

The average life expectancy for a person in the US is only 78.5 years which is more than 10 years behind when compared to the leading country Monaco’s 89.7 years. This deficiency is not due to a lack of spending as the US spends the largest percentage of its GDP on healthcare when compared to any other country in the world. To help change this paradox, engineering companies are making a bet that people will turn to technology to better understand their health.

1 http://www.reuters.com/article/2015/02/05/us-apple-hospitals-exclusive-idUSKBN0L90G920150205 retrieved February 22, 2015
Digital Health-Data is being collected at unprecedented rates today as biometric micro sensors continue to diffuse into our lives in the form of smart devices, wearables, and even clothing. From this data, we hope to learn more about preventative health so that we can spend less money on the doctor. To help users aggregate this perpetual growth of biometric “big” data, Apple, Google, and Samsung have each created a Digital Health-Data Platform: Apple HealthKit, Google Fit, and Samsung SAMI.

The foundation of this thesis will examine each of the Digital Health-Data platforms offered from the Big-3 and include my hypothesis of where users will be most attracted.
to store their data based on the ecosystem of resources that particular player offers as well as the added value progress being made. Discussion will encompass the option to multi-home the data between two platforms and whether network effects would have enough influence in determining where a user may store their data.

It should be noted that Microsoft and Amazon have made late attempts to join the Digital Health-Data race but both with premature products. Microsoft announced Microsoft Health platform on October 29, 2014 including Microsoft Band. However, functionality is lacking for both including the health data analytics that are suppose to guide Microsoft Band users with "Actionable insights for healthier living."³ Amazon posted a whitepaper on March 13, 2015 titled “Creating HIPAA-Compliant Medical Data Applications with AWS” as a guide to use Amazon Web Services. The move was likely to introduce more players that could take away market share from the Big-3 Digital Health Data platforms.⁴ While the poorly received Amazon Fire smartphone was announced June 18, 2014 but has made little to no impact to incumbent smartphone makers Samsung and Apple mostly due to running a premature Fire Operating System and not having enough applications developed yet.⁵

---

Motivation

Fitness and athletics have always been very important to me. I find sports and being active not only fun, but also healthy, which allows me to live pain free. When I experienced a herniated disc at just 14 years old, staying fit throughout my life suddenly became necessary in order to move without discomfort. Remembering the pain I experienced just sitting in my desk is not something I would want to experience again. All my hard work, the hours spent at rehabilitation, the visits to MRI and CT scan centers are the only reminders I need to keep myself motivated to stay fit.

Being a Mechanical Engineer by training, I am fascinated by the myriad of sensor technologies that are diffusing in the form of wearables and smart electronics today. Collecting data to monitor my fitness activity has never been easier. I can track my heart rate during my bike rides, monitor the number of steps I take running between classes, and understand my body temperature fluctuations during my workouts. All of my biometric data is collected without my need to manually input anything.

With all my collected data, now the question becomes:

Where should I store all my biometric data to help me better understand my health?

Hypothesis

My hypothesis is the following statement:

The organization that creates the most value for its customer will be entrusted as the keeper of his/her health data.
Support for my hypothesis will reveal itself through out this thesis. It will mainly come down to the organization that offers the most fringe benefits in addition to the main objective of supporting aggregated biometric data.
Commonly Used Language

This section will be a reference list for the commonly used language mentioned throughout this paper.

**Big-3** – A commonly used analogy in sports to describe the 3-best players however, in the context of this thesis the 3-best players are Samsung, Apple, and Google.

**Business Associate (BA)** – Defined as anyone with access to Protected Health Information (PHI) and provides support in treatment, payment or operations. The HIPAA Rules generally require that covered entities and business associates enter into contracts with their business associates to ensure that the business associates will appropriately safeguard PHI.⁶

**Business Associate Agreement (BAA)** – A HIPAA business associate agreement (BAA) is a contract between a HIPAA covered entity and a HIPAA business associate (BA) that is used to protect personal health information (PHI) in accordance with HIPAA guidelines.

**Covered Entity (CE)** – Anyone who provides treatment, payment, and operations in healthcare. This can include:

1. A health plan.
2. A health care clearinghouse.
3. A health care provider who transmits any health information in electronic form in connection with a transaction.⁷

---

**Disruptive Technology** – A product/technology that typically underperforms established products/technology in mainstream markets but have fridge features that appeal to new customers who are willing to adapt early before maturation. Other attributes of a disruptive technology are typically cheaper, simpler, smaller, and frequently more convenient to use (Christensen, 1997).

**Dominant Design** – A common term referred by Abernathy and Utterback, is used to signify the emergence of a product design or a combination of elements that has become the de facto standard in the market due to its widespread adoption (Utterback, 1994).

**Electronic Health Records (EHR)** – An electronic health record (EHR) is a digital version of a patient’s paper chart. EHRs are real-time, patient-centered records that make information available instantly and securely to authorized users.

**Mobile Medical Application (MMA)** – Mobile apps are software programs that run on smartphones and other mobile communication devices. They can also be accessories that attach to a smartphone or other mobile communication devices, or a combination of accessories and software. Mobile medical apps are medical devices that are mobile apps that meet the definition of a medical device and are an accessory to a regulated medical device or transform a mobile platform into a regulated medical device. Consumers can use both mobile medical apps and mobile apps to manage their own health and wellness, such as to monitor their caloric intake for healthy weight maintenance.  

---

8 [http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/ConnectedHealth/MobileMedicalApplications/ucm255978.htm](http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/ConnectedHealth/MobileMedicalApplications/ucm255978.htm) retrieved January 25, 2015
**Platform** – A platform product is built around a preexisting technological subsystem (a technology platform). Examples of such platforms include the Apple iPhone, Windows OS, and the Sony PlayStation. Huge investments were made in developing these platforms, and therefore every attempt is made to incorporate them into several different products. Products built on technology platforms are much simpler to develop than if the technology were developed from scratch. For this reason, and because of the possible sharing of costs across several products, a firm may be able to offer a platform product in markets that could not justify the development of a unique technology (Eppinger & Ulrich, 2000).

**Protected Health Information (PHI)** – Any information about health status, provision of health care, or payment for health care that can be linked to a specific individual that can be transmitted or maintained in any form or medium by a Covered Entity or its Business Associate.
Organization of Thesis

The research for this paper consists of citings from technology strategy literature and relevant journalism articles regarding recent and past developments that pertain to the wearables market and the digitization movement of electronic health records (EHR) and protected health information (PHI) along with their rules and regulations. The culmination of these citations will contribute to my hypothesis where the analysis will attempt to support my recommendations for Apple, Google, and Samsung and finally lead to my conclusion.

Starting from Chapter 2, a description of the United States healthcare industry is looked at in detail to understand the impact potential. A market analysis will be provided to speculate size while implying financial potential for the Big-3. Laws and regulations are also examined in this chapter as EHR/PHI technology remains nascent and continues to mature — so do the rules.
Chapter 3 introduces the competitive landscape among the Big-3 to become the dominant design platform for Digital Health-Data aggregation. Each of the Big-3 has unique strengths that defined their identity that led to their successes, which will be discussed in Chapters 4 thru 6. It will be these strengths that the Big-3 will draw from to create the ecosystem for end-users who will ultimately decide which Digital Health-Data platform will house their biometric data. Chapter 7 will discuss the Tizen OS project led by Samsung and their efforts to introduce Tizen as an alternative open source OS for electronic devices to compete with Google’s Android OS. The ending chapters will encompass discussions around network effects and costs associated with multi-homing user data across multiple platforms and finally ending with my conclusion based on my hypothesis.
"It's like a tapeworm (US health care spending) eating at our economic body (17% of GDP)."

- Warren Buffet, CEO Berkshire Hathaway – March 2010

Chapter 2: Background United States Health Market

United States Healthcare Market Size

United States Healthcare spending reached $2.8 trillion in 2012 with spending estimates increasing to $5 trillion by 2022 according to a government report from the Centers for Medicare and Medicaid Service under the category National Healthcare Expenditures. Increased spending can partly be attributed to the aging Baby Boomer generation who were born from 1946 to 1964 (Lancaster & Stillman, 2002). Approximately 78 million Americans were born during this period where historians have explained the "boom" in births from soldiers returning home after World War II to start families.

---

Spending can also be attributed to an estimated 45 million residents who are without medical insurance coverage in the US. The US spends 17% of Gross Domestic Product on healthcare, which is far more than any other country in the world (Reid, 2010). These facts, among others that go beyond the scope of this thesis, make a compelling case that healthcare spending is important to people and that makes the healthcare market an intriguing one to Samsung, Google, and Apple in regards to becoming the dominant design (Utterback, 1994) platform for Digital-Health Data aggregation.

Figure 2 US Births from 1940 to 1994\(^\text{11}\)

\[\text{http://www.bbhq.com/homrstat.htm}\]

retrieved November 11, 2014
HIPAA

The Health Insurance Portability and Accountability Act (HIPAA) was enacted August 21, 1996 by US Congress and signed by President Bill Clinton. HIPAA provides a set of security standards or general requirements for protecting sensitive patient health information as electronic health records (EHR) continue to standardize. More specifically, the HIPAA Privacy Rule addresses the saving, accessing and sharing of medical and personal information of any individual, while the HIPAA Security Rule outlines national security standards to protect health data created, received, maintained or transmitted electronically.

---

HIPAA compliance is required from any covered entity (CE) or business associate (BA) that handles or hosts protected health information (PHI) to ensure that all required physical, network, and process security measures are in place and followed.

- Physical safeguards include limited facility access and control, with authorized access in place. All covered entities, or companies that must be HIPAA compliant, must have policies about use and access to workstations and electronic media. This includes transferring, removing, disposing and re-using electronic media and PHI.

- Technical safeguards require access control to allow only the authorized to access electronic protected health data. Access control includes using unique user IDs, an emergency access procedure, automatic log off and encryption and decryption.

- Audit reports, or tracking logs, must be implemented to keep records of activity on hardware and software. This is especially useful to pinpoint the source or cause of any security violations.

- Technical policies should also cover integrity controls, or measures put in place to confirm that PHI has not been altered or destroyed. IT disaster recovery and offsite backup are key to ensure that any electronic media errors or failures can be quickly remedied and patient health information can be recovered accurately and intact.

- Network, or transmission, security is the last technical safeguard required of HIPAA compliant hosts to protect against unauthorized public access of PHI.
This concerns all methods of transmitting data including email, Internet, private network, or cloud service.

Electronic Health Records

The American Recovery and Reinvestment Act (ARRA) was approved by Congress on February 13, 2009 and signed into law 4-days later by President Barack Obama. As part of the ARRA passing, the Health Information Technology for Economic and Clinical Health (HITECH) Act was enacted which provided financial incentives to health care providers to adopt and make “meaningful use” of electronic health records. The interpretation of “meaningful use” is subjective which is speculated as the reason why health care providers may be looking at Apple, Samsung, and Google for guidance and innovation in this regard.

Regulation on Medical Devices

With the diffusion of smartphone technology, an emergence of medical device inventions has been created for diagnosing, tracking, and prevention of disease in the form of smartphone mobile medical applications (MMAs) and add-on devices. This continued emergence of new medical devices has acted as a catalyst for the FDA in redefining regulations. The FDA’s primary role is ensuring that patients stay safe and new technologies work as intended.16

16 http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/ConnectedHealth/default.htm retrieved November 11, 2014
“Many mobile apps are not medical devices (meaning such mobile apps do not meet the definition of a device under section 201(h) of the Federal Food, Drug, and Cosmetic Act (FD&C Act)), and FDA does not regulate them. Some mobile apps may meet the definition of a medical device but because they pose a lower risk to the public, FDA intends to exercise enforcement discretion over these devices (meaning it will not enforce requirements under the FD&C Act). The majority of mobile apps on the market at this time fit into these two categories.” 17

According to an MIT Technology Review article, the FDA has primarily created three categories specifically for MMAs: 18

- **Unregulated:** This lowest tier consists of wellness-focused apps such as exercise trackers and heart-rate monitors that many consumers use in their fitness regimens.

- **Enforcement discretion:** This middle category includes disease-focused apps that work as simple professional calculators (for instance, measuring and calculating mean arterial pressure, or assessing a Glasgow Coma Scale score); or that provide coaching for patients with conditions such as cardiovascular disease, hypertension, diabetes, and obesity.


• **Regulated**: This highest tier consists of specific patient- or disease-monitoring and treatment-responses, such as infusion pumps, which act as medical devices and could cause harm to patients if faulty.

The Big-3 have all been pro-active in engaging FDA early as the MMA industry continues to transpire and mature. Apple executives met with the United States Food and Drug Administration (FDA) in December 2013 before the launch of iPhone 6 and Apple Watch.\(^\text{19}\) In early January 2014, Google also had similar meetings with the FDA regarding their exploration of bio-sensing wearables in the form of contact lenses and Google Glass.\(^\text{20}\) Meanwhile, Samsung filed for FDA clearance in July 2013 and received it January 2014 regarding its S-Health app, which is categorized as a cardiology signal transmitter.\(^\text{21}\) It should be noted that these progressions all took place before the announcements of Samsung SAMI, Apple HealthKit, and Google Fit.

---


"Google Health never took off because consumers actually don't want to aggregate their data. They want meaning, rewards and a feedback loop."

- Derek Newell, CEO digital health care platform Jiff – June 2014

Chapter 3: Digital Health-Data Platforms

With the US Healthcare spending estimated at $2.8 trillion in 2012\(^{22}\), the race is on among Apple, Samsung, and Google (i.e. the "Big-3") to become the dominant design (Utterback, 1994) platform for Digital Health-Data aggregation. The Big-3 have each created their own versions of a Digital Health-Data platform: Samsung SAMI, Apple HealthKit, and Google Fit – all of whom announced their respective platforms within a span of 28 days of each other.

- **May 28, 2014** Samsung SAMI announcement\(^{23}\)
- **June 3, 2014** Apple HealthKit announcement\(^{24}\)
- **June 25, 2014** Google Fit announcement\(^{25}\)

As per definition (Eppinger & Ulrich, 2000), a platform product is built around a preexisting technological subsystem, in this case a smartphone OS. These Digital Health-Data platforms will look to aggregate user data collected from the myriad of

\(^{25}\) https://www.google.com/events/io retrieved November 24, 2014
sensors that are diffusing among wearable enthusiasts as well as from strategic partnerships associated with Digital Health-Data. Other known attributes among the three platforms (at the time of this writing) are:

- SAMI stands for Samsung Architecture for Multimodal Interaction\textsuperscript{26}

- Samsung SAMI and Google Fit will store user data in their respective cloud solutions. Apple HealthKit will not store user collected health data in the iCloud.\textsuperscript{27}

- Apple HealthKit will provide read-only permission directly to its data from Bluetooth connected devices as well as from developed applications. Google Fit does not support Bluetooth connected devices and will require an application layer to access its data.\textsuperscript{28}

- All three platforms will need to comply with the data security regulations described under the Heath Insurance Portability and Accountability Act (HIPAA) if they begin handling Digital Health-Data on behalf of another party defined as a Business Associate Agreement (BAA).

- No functionality will be provided to share individually collected user data with another party. This rule is true among all three platforms.

Each of the Big-3 players has employed a different strategic approach based on their core strength of their business (Shaprio & Varian, 1999): Samsung in Hardware, Apple

\textsuperscript{28} http://littlegreensoftware.com/apple-healthkit-google-fit-health-apps-illustrated-guide/ retrieved November 24, 2014
in Design, and Google in Search. The following sections will examine that perspective of identifying the unique approaches employed by Samsung, Apple, and Google in becoming the dominant Digital Health-Data platform and their capacity to formulate strategy into action.

Figure 4 Apple and Samsung Smartphone Timeline

**iPhone Product Timeline**

Apple & Samsung

![iPhone Product Timeline](image)

---

Chapter 4: Apple

Unlike Samsung, Apple has found success not from having the best hardware but from having the best-designed hardware, which adds a different dimension to the customer experience. This strategy has played well for Apple time and time again. Product examples such as the Macintosh for personal computers, the iPod for mp3 music, the iPhone for smartphones, and (very likely) the Apple Watch for wearables -- where other device manufacturers were first to market, but Apple would eventually gain popularity upon release of their better-designed products. This proved to be the case with Nokia dominating close to 45% of the smartphone market in 2008 but eventually conceding that lead to Apple (as well as Samsung) in 2011.

Figure 5 Smartphone Market Share 2008 – 2013
Though less than Samsung, Apple relies on 270 carriers in 100 countries to distribute its iPhone. However, this distribution strategy does not include the 390 Apple Store retail outlets, which accounted for $18B USD sales in 2012. Since 2005, the Apple stores have added more clout to Apple’s reputation for design and presentation. The stores also boast the Apple Genius Bar where customers can receive service and have questions answered by an Apple Genius employee. As Apple continues to rollout their HealthKit platform, Apple Stores will once again play a vital role because the Genius Bar will likely be a starting point for HealthKit related support questions, a distinguishable advantage both Samsung and Google do not have.

Figure 6 Apple Store openings worldwide 2005 - 2013

Number of Apple stores worldwide from 2005 to 2013

![Bar chart showing the number of Apple stores worldwide from 2005 to 2013.](http://www.statista.com/statistics/273480/number-of-apple-stores-worldwide-since-2005/)

Apple HealthKit Strategy

During the announcement for Apple HealthKit on June 3, 2014, Apple Senior Vice President Craig Federighi pointed to a slide that listed a number of hospital partnerships that were either targets or confirmed to be aligned with HealthKit.31

Figure 7 Apple slide for HealthKit hospital

Unlike their competition, it would appear that Apple has taken a more pro-active approach in formulating partnerships to standardize HealthKit. The collected list of HealthKit partners below contains the original 22 hospitals mentioned in the slide alongside other partnerships including two very important strategic alliances with Electronic Health Record (EHR) providers Epic Systems and Allscripts Healthcare Solutions.

“Apple’s HealthKit has tremendous potential to help close the gap between consumer collected data and data collected in traditional healthcare settings,” said Epic president Carl Dvorak in an email to VentureBeat. “The Epic customer community, which provides care to over 170 million patients a year, will be able to use HealthKit through Epic’s MyChart application—the most used patient portal in the U.S.”

Table 2 List of Apple HealthKit partnerships

<table>
<thead>
<tr>
<th>No.</th>
<th>Provider</th>
<th>State</th>
<th>Beds</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mount Sinai</td>
<td>NY</td>
<td>1,171</td>
<td>Hospital</td>
</tr>
<tr>
<td>2</td>
<td>Cincinnati Children’s Hospital</td>
<td>OH</td>
<td>598</td>
<td>Hospital</td>
</tr>
<tr>
<td>3</td>
<td>Stanford Hospitals and Clinics</td>
<td>CA</td>
<td>613</td>
<td>Hospital</td>
</tr>
<tr>
<td>4</td>
<td>Penn Medicine</td>
<td>PA</td>
<td>1,637</td>
<td>Hospital</td>
</tr>
<tr>
<td>5</td>
<td>Yale New Haven Health</td>
<td>CT</td>
<td>2,130</td>
<td>Hospital</td>
</tr>
<tr>
<td>6</td>
<td>Cambridge University Hospitals NHS</td>
<td>UK</td>
<td>1,180</td>
<td>Hospital</td>
</tr>
<tr>
<td></td>
<td>Foundation Trust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Oregon Health &amp; Science University</td>
<td>OR</td>
<td>560</td>
<td>Hospital</td>
</tr>
<tr>
<td>8</td>
<td>University of Iowa Health Care</td>
<td>IA</td>
<td>705</td>
<td>Hospital</td>
</tr>
<tr>
<td>9</td>
<td>Texas Health Resource</td>
<td>TX</td>
<td>3,200</td>
<td>Hospital</td>
</tr>
<tr>
<td>10</td>
<td>UCLA Health</td>
<td>CA</td>
<td>786</td>
<td>Hospital</td>
</tr>
<tr>
<td>11</td>
<td>Sutter Health</td>
<td>CA</td>
<td>5,397</td>
<td>Hospital</td>
</tr>
<tr>
<td>12</td>
<td>Cleveland Clinic</td>
<td>OH</td>
<td>4,450</td>
<td>Hospital</td>
</tr>
</tbody>
</table>

As mentioned earlier, Apple HealthKit, Samsung SAMI, and Google Fit will not include any functionality to share user-collected data with another party. This ensures compliance with HIPAA standards regarding Digital Health-Data privacy. Apple will need to work together with the EHR providers who are more familiar with HIPAA standards to ensure compliance especially if Apple’s goal is to create an ecosystem that alerts doctors about any health concerns related to the user collected health-data.
Apple Summary

In summary, Apple has put themselves in a good position with HealthKit for a few reasons:

- Apple has continued their tradition of gaining market share from the loyalty of their brand strength. Their commitment to better-designed products with the IPhone 6 and Apple Watch has continued to impress and build upon their reputation for being a high-end manufacturer of smartphones and now wearables.

- Apple’s execution to become the dominant design platform for Digital Health-Data will be hard to match if they are able to capitalize on all the partnerships with HealthKit as per mentioned in the media. This would include leading Electronic Health Record providers Epic Systems and Allscripts Healthcare Solutions.

- The biggest obstacle for automated health analytics to alert medical providers will be the HIPAA compliance. Under the HIPAA Privacy Rule, covered entities must provide patients with a Notice of Privacy Practices\(^{33}\) that specifies an individual’s legal rights and the covered entity’s legal duties with respect to the use and disclosure of protected health information (PHI).\(^{34}\) This regulation speaks directly to Apple if HealthKit is the chosen standard for sharing patient information with hospitals for the EHR providers.


Chapter 5: Google

The Internet search market has become synonymous with the phrase “just Google it,” as the default action. Since its search bar launch in 1998, Google has become a dominant and powerful company generating over $20B annually since 2008. Its primary strength comes from search advertising as print media continues to concede market share to digital content.

Figure 8 Advertising revenue for Google versus US Print Media

* Excludes advertising on newspaper websites

---

Google created another source of revenue by giving away the Android OS. Since being acquired by Google in 2004, Android has surpassed Apple iOS in 2010 and has consistently owned more than 50% of the mobile OS market since 2012. However, Android OS is an open-source software stack therefore Google does not sell licenses to make money, but instead it has served as a diffusion strategy for Google's suite of products that include Gmail, Google Maps, Google Search, and Google Play Store.

Figure 9 Gartner Forecast Estimates Mobile OS Sales by Market Share

Gartner Forecast Estimates Mobile OS Sales by Market Share (2009-2016)

Source: Gartner
Forecast: Mobile Devices by Open Operating System, Worldwide, 2009-2016, 2Q12 Update

By relying on third party device makers who utilize Android OS, Google is able to source potential customer sales from each Android installation thru their product suite without having to manufacture their own hardware. It should be noted that Google does endorse the Nexus line as their flagship for devices, however, manufacturing is entirely handled by third party OEM device makers with Google managing software development, hardware design, marketing, and support. A history of past Nexus line smartphone partnerships include:37

<table>
<thead>
<tr>
<th>Release Date</th>
<th>OEM</th>
<th>Name</th>
<th>Android Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 2010</td>
<td>HTC</td>
<td>Nexus One</td>
<td>2.1 Eclair</td>
</tr>
<tr>
<td>December 2010</td>
<td>Samsung</td>
<td>Nexus S</td>
<td>2.3 Gingerbread</td>
</tr>
<tr>
<td>October 2011</td>
<td>Samsung</td>
<td>Galaxy Nexus</td>
<td>4.0 Ice Cream Sandwich</td>
</tr>
<tr>
<td>October 2012</td>
<td>LG</td>
<td>Nexus 4</td>
<td>4.1 Jelly Bean</td>
</tr>
<tr>
<td>October 2013</td>
<td>LG</td>
<td>Nexus 5</td>
<td>4.4 KitKat</td>
</tr>
<tr>
<td>October 2014</td>
<td>Motorola</td>
<td>Nexus 6</td>
<td>5.0 Lollipop</td>
</tr>
</tbody>
</table>

Google is no stranger to Digital Health-Data as they once ventured into the same foray with Google Health on May 20, 2008. It was later shut down January 1, 2012 where it was hastily handed over to Marissa Mayer. Many theories were formulated regarding the reason for Google Health’s failure including the idea of users needing to manually input their records.

“Google Health never took off because consumers actually don’t want to aggregate their data,” Derek Newell, CEO digital health care platform Jiff – June 2014.\(^{38}\)

Needless to say, Google learned from Google Health and is now marketing Google Fit as mainly a fitness data aggregation platform for wearables to automatically upload to. Google is essentially setting a more proximate objective (Rumelt, 2011) of aggregating

\(^{38}\) [Link](http://www.forbes.com/sites/parmyolson/2014/06/12/exclusive-google-to-launch-health-service-google-fit-at-developers-conference/) retrieved November 25, 2014
fit data instead of the heavily regulated health data therefore simplifying the problem to one it can actually solve.

Google Summary

In summary, Google’s strength in search advertising and Android OS should continue to further its reach into the daily lives of customers who use their products.

- Google will continue to dominate its search business market share as no pertinent threats are seen in the foreseeable future. Products such as Google Now and “OK Google” will only increase people’s reliance on Google, which further strengthens loyalty from existing customers.

- By learning from the mistakes of Google Health, the Google Fit product should concentrate its core strength on the automation of collecting fitness data thru the myriad of sensors and smartphones using Android while ensuring HIPAA compliance for Protected Health Information (PHI) by requesting for a Business Associate Agreement (BAA) from its users.39

- Google should also leverage its strength in software development and continue to innovate the web services it provides to 3rd party developers who want to utilize Google Fit as their platform for collecting sensor data. This strategy further strengthens their reach to customers with Android, which hosts the suite of products that Google monetizes from.

---

Chapter 6: Samsung

Samsung created their dominance in the hardware category by offering devices that have traditionally outperformed its competitors in technical specification metrics. However, this gap has closed recently as competitors have released comparable smartphones with regard to increasing both screen size and performance as witnessed from Apple’s iPhone 6 Plus and Google’s endorsed Nexus 6 manufactured from Motorola.

Table 4 Technical Specification for Samsung, Apple, and Google devices

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Cost 16 GB</th>
<th>Cost 32GB</th>
<th>Cost 64GB</th>
<th>$ per 16 GB</th>
<th>$ per 32 GB</th>
<th>$ per 64 GB</th>
<th>Battery</th>
<th>OS</th>
<th>Processor</th>
<th>CPU</th>
<th>GPU</th>
<th>RAM</th>
<th>Dimensions</th>
<th>Weight</th>
<th>Screen Size</th>
<th>Screen type</th>
<th>Resolution</th>
<th>Pixel density ppi</th>
<th>Camera (front)</th>
<th>Camera (rear)</th>
<th>Video</th>
<th>Touch ID</th>
<th>Intelligent Assistant</th>
<th>Heart Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung</td>
<td>Note 4</td>
<td>$ 749.00</td>
<td>$ 949.00</td>
<td>n/a</td>
<td>$ 18.72</td>
<td>$ 21.81</td>
<td>$ 23.41</td>
<td>3220 mAh</td>
<td>Android 4.4</td>
<td>Quad core 2.5GHz</td>
<td>Adreno 420</td>
<td>3 GB</td>
<td>72.5mm x 155.5mm x 8.5mm</td>
<td>176 grams</td>
<td>5.7 inches</td>
<td>AMOLED</td>
<td>1280 x 1440 pixel</td>
<td>5.4 megapixel</td>
<td>8 megapixel</td>
<td>1080p@30fps</td>
<td>Fingerprint Scanner</td>
<td>Yes</td>
<td>Ok Google</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samsung</td>
<td>Galaxy S5</td>
<td>$ 649.00</td>
<td>$ 749.00</td>
<td>n/a</td>
<td>$ 18.72</td>
<td>$ 21.81</td>
<td>$ 23.41</td>
<td>2800 mAh</td>
<td>Android 4.4</td>
<td>Quad core 1.9GHz</td>
<td>Adreno 330</td>
<td>2 GB</td>
<td>62.5mm x 143.9mm x 8.5mm</td>
<td>145 grams</td>
<td>5.1 inches</td>
<td>AMOLED</td>
<td>1920 x 1080 pixel</td>
<td>4.3 megapixel</td>
<td>13 megapixel</td>
<td>720p@60fps</td>
<td>Fingerprint Scanner</td>
<td>Yes</td>
<td>Ok Google</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>iPhone 6 Plus</td>
<td>$ 649.00</td>
<td>$ 749.00</td>
<td>n/a</td>
<td>$ 18.72</td>
<td>$ 21.81</td>
<td>$ 23.41</td>
<td>2915 mAh</td>
<td>iOS 8</td>
<td>Quad core 1.8GHz</td>
<td>Apple A8</td>
<td>1 GB</td>
<td>142.6mm x 71.4mm x 7.1mm</td>
<td>172 grams</td>
<td>5.5 inches</td>
<td>IPS</td>
<td>1920 x 1080 pixel</td>
<td>8.2 megapixel</td>
<td>12 megapixel</td>
<td>1080p@30fps</td>
<td>Touch ID Fingerprint Sensor</td>
<td>No</td>
<td>OK Google</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Google (Motorola)</td>
<td>Nexus 6</td>
<td>n/a</td>
<td>$ 649.00</td>
<td>n/a</td>
<td>$ 13.27</td>
<td>$ 20.28</td>
<td>$ 26.28</td>
<td>3220 mAh</td>
<td>Android 5.0</td>
<td>Quad core 2.7GHz</td>
<td>Adreno 420</td>
<td>3 GB</td>
<td>82.98mm x 159.26mm x 10.06mm</td>
<td>184 grams</td>
<td>5.96 inches</td>
<td>AMOLED</td>
<td>2560 x 1440 pixel</td>
<td>59 megapixel</td>
<td>21 megapixel</td>
<td>1920p@60fps</td>
<td>Fingerprint Scanner</td>
<td>n/a</td>
<td>OK Google</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

43 http://www.google.com/nexus/6/ retrieved November 15, 2014
Nonetheless, Samsung still possesses a ubiquitous and powerful supply chain distribution that sets them apart from competitors. Their ability to diffuse Samsung branded hardware worldwide is unmatched. Affirmation of this claim was made when Samsung CEO Jong-Kyun Shin officially announced during Samsung’s Galaxy S4 event in New York on March 14, 2013 that Samsung devices had partnered with 327 mobile carriers in 155 countries\textsuperscript{44}.

Figure 11 March 14, 2013 Samsung Galaxy S4 introduction event in New York

In other words, 21\% more carriers and 55\% more countries than when compared to Apple’s 270 mobile carriers in 100 countries which was confirmed by Apple Vice

\textsuperscript{44} https://www.youtube.com/watch?v=Yaw6CSaPufk&t=598 retrieved December 24, 2014
President Phil Schiller in San Francisco on September 12, 2012 during Apple's iPhone 5 introduction⁴⁵.

Another strength for Samsung is its manufacturing expertise in smartphone components. The following figure supplied by JPMorgan shows this breakdown in further detail. Please note:

- Samsung Electronic Corporate (SEC) supplies memory, processors, and cameras
- Samsung Display Corporation (SDC) supplies displays including touch screen
- Samsung SDI (Samsung Display Digital Interface Internet) supplies batteries

With so many components being sourced from Samsung, many mobile phone and wearable hardware manufactures are essentially dependent on Samsung including Apple IPhone, which outsources their processor and memory from Samsung. This component dependency has created possible opportunities for Samsung to partner with some of these hardware wearable manufactures to entice them to use Samsung SAMI.

Table 5 Samsung supplier relationship table

<table>
<thead>
<tr>
<th>Components</th>
<th>Galaxy S III</th>
<th>Detailed Components</th>
<th>Supplier</th>
<th>Rev. Exposure (FY12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>13.0</td>
<td>NAND (Internal Memory)</td>
<td>SEC</td>
<td>SEC (6%)</td>
</tr>
<tr>
<td></td>
<td>12.6</td>
<td>mobile DRAM</td>
<td>SEC</td>
<td>SEC (4%)</td>
</tr>
<tr>
<td>Display &amp; Touch Screen</td>
<td>51.5</td>
<td>OLED panel</td>
<td>SDC</td>
<td>SDC (6%)</td>
</tr>
<tr>
<td></td>
<td>37.5</td>
<td>OLED material</td>
<td>SDC</td>
<td>SDC (6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LCD panel</td>
<td>SDC</td>
<td>SDC (6%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobile BLU</td>
<td>SDC</td>
<td>SDC (6%)</td>
</tr>
<tr>
<td>Touch Screen</td>
<td>14.0</td>
<td>Touch Panel module</td>
<td>Iljin Display</td>
<td>Iljin (95%), S-MAC (95%), Meitas (80%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Touch Panel sensor</td>
<td>S-MLG</td>
<td>Meitas (80%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Driver IC</td>
<td>SDC, Siliconworks</td>
<td>SDC small mobile (&lt;60%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SDC small mobile (&lt;60%), S-MAC (&lt;60%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SDC small mobile (&lt;60%), S-MAC (&lt;60%), Meitas (&lt;60%)</td>
</tr>
<tr>
<td>Processor</td>
<td>25.3</td>
<td>Application Processor</td>
<td>SEC, Qualcomm</td>
<td>SEC (2%), Qualcomm (18%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MCC</td>
<td>SEMCO</td>
<td>SEMCO (2%), Samsung (20%)</td>
</tr>
<tr>
<td>Camera(s)</td>
<td>19.6</td>
<td>Camera module</td>
<td>SEMCO, Parvoo</td>
<td>SEMCO (25%), Parvoo (30%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Image sensors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Components</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Camera lens</td>
<td>SEC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximity Sensor</td>
<td>SEC</td>
<td></td>
</tr>
<tr>
<td>Wireless section -</td>
<td>38.0</td>
<td>Baseband chip</td>
<td>Qualcomm, Intel, SEC</td>
<td>Intel (1%), Qualcomm (1%)</td>
</tr>
<tr>
<td>BBR/RF/PA</td>
<td></td>
<td>Radio Frequency chip</td>
<td>Partron</td>
<td>Partron (40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Amplifier chip</td>
<td>Skyworks</td>
<td>Skyworks (40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTE, HSPA, Mobile</td>
<td>Qualcomm, SEC</td>
<td>Qualcomm (50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>User Interface &amp; Sensors</td>
<td>6.9</td>
<td>Accelerometer</td>
<td>ST Micro</td>
<td>ST Micro (~50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gyroscope</td>
<td>ST Micro</td>
<td>ST Micro (~50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure sensor</td>
<td>Partron</td>
<td>Partron (~50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Audio Interface</td>
<td>Wulfson Micro</td>
<td>Wulfson Micro (~50%)</td>
</tr>
<tr>
<td>WLAN/Bluetooth/GPS</td>
<td>6.5</td>
<td>WLAN</td>
<td>Broadcom</td>
<td>Broadcom (17%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FM Transceiver</td>
<td>Infineon</td>
<td>Infineon (5%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bluetooth</td>
<td>Broadcom, Murata, Partron, Amotech</td>
<td>Broadcom (~45%), Partron (~45%), Amotech (~45%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wi-Fi</td>
<td>Broadcom, Murata, Partron</td>
<td>Broadcom (~45%), Partron (~45%), Amotech (~45%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NFC Chipset</td>
<td>NXP, Partron, Amotech</td>
<td>Partron (~45%), Amotech (~45%)</td>
</tr>
<tr>
<td>Power Management</td>
<td>10.0</td>
<td>Power Management IC</td>
<td>Macron, T1, Silicon Micro, Magchip</td>
<td>Macron, T1, Silicon Micro, Magchip</td>
</tr>
<tr>
<td>Battery</td>
<td>4.5</td>
<td>Battery Pack</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Battery Cell</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Battery Components</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material</td>
<td>Power Logic, 5in Materials</td>
<td>Power Logic, 5in Materials (50%)</td>
</tr>
<tr>
<td>Mechanical</td>
<td>38.0</td>
<td>PCB / PPCB / P-CSP</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Microphone</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speaker receiver</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Casing</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LCD Bracket</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Earphone</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case</td>
<td>Samsung SDI</td>
<td>Samsung SDI (100%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Charger</td>
<td>RF Tech</td>
<td>RF Tech (~40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power</td>
<td>RF Tech</td>
<td>RF Tech (~40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulator</td>
<td>RF Tech</td>
<td>RF Tech (~40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Box Contents</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>BOM Cost</td>
<td>237.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing Cost</td>
<td>16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOM Cost + Materials</td>
<td>253.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smartphone ASP (US$)</td>
<td>550.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gartner, Company data. J.P. Morgan estimates. *Supplier revenue exposure data based on company data. BOM cost based on Galaxy SIII, component supply status based on overall Samsung smartphone lineup. Supplier list includes companies above US $1 billion market cap only. Revenue exposure % stands for total Samsung Electronics.

Samsung SAMI Strategy

Samsung has traditionally relied on their own strengths in manufacturing and distribution to independently create and diffuse their own wearable devices that include a fitness bracelet Simband and Smartwatch Gear 2 Neo. In some ways this independent attitude has hindered their growth potential as a Health-Data platform business with SAMI. For example, Samsung decided not to capitalize on its component supplier relationship with smartphone maker HTC, which Samsung SDI supplied screens for in 2010 among other components. HTC president Jack Tong even accused
Samsung of using its component supplier dependency as a means to delay competitor smartphone launches:

“We found that key component supply can be used as a competitive weapon,” HTC president Jack Tong explaining his reasoning for switching away from Samsung supplied displays.47

This behavior cost Samsung a formidable partnership opportunity with HTC, which resulted in lost market share for their Health-Data aggregation SAMI platform. As a consequence, HTC decided to partner with San Francisco startup Fitbit instead, who was an early entrant in the wearables space and looking to establish their very own health data aggregation platform called The One48.

Samsung has also struggled in removing its own dependency on Google’s Android OS. Samsung has been trying to launch devices on their own Tizen OS, which will better align with their data aggregation strategy to SAMI while disrupting (Christensen, 1997) their reliance on Google’s Android OS. Samsung has experienced moderate success with deploying Tizen electronic devices. Samsung’s attempt at disrupting the mobile OS market is further examined in detail from the Tizen section of this thesis.

Samsung Summary

In summary, Samsung could be in better position with SAMI if a couple scenarios play out in their favor:

- Create partnerships with other device makers to embrace both Tizen and SAMI. Samsung has traditionally relied on their own strengths in manufacturing and distribution, but to create a Health-Data aggregation ecosystem, they should want other device makers to rely on SAMI as well which means fostering relationships instead of alienating competition as they have done in the past.

- Establish a niche market for Tizen OS with wearables and smart devices other than just a smartphone to allow an ecosystem to develop. This ecosystem will likely make the smartphone market more receptive to the idea of accepting a 3rd smartphone OS where a Samsung Tizen smartphone could seamlessly integrate with Tizen wearable and smart devices which will ultimately provide more customer data for SAMI and smart device sales for Samsung.

- Samsung must reduce their reliance on Google’s Android ecosystem, which houses many Google products such as Maps, Search, and Play Apps store. Currently Samsung continues to develop smart devices that rely on the Android OS. Developing the Tizen OS strategy will reduce the amount of user traffic that Google continues to source as potential customer sales from Samsung products that run Android.
"We feel Tizen has no chance to be successful."

- Richard Yu, CEO Huawei -- Aug 2014

Chapter 7: Tizen Operating System

Google’s Android OS has been the most popular smartphone OS since 2012 in terms of market share sales.49 Android’s dominance ironically can be attributed to the popularity of Samsung’s lead in smartphones which run on Google’s OS. This is why the Tizen OS has the potential to disrupt (Christensen, 1997) the smartphone OS market and why Samsung has such a vested interest. Tizen could create an opportunity for Samsung to customize user experience with Samsung mobile products instead of the Google products bundled with Android.

Like Android, Tizen is an open source Operating System that is based on the Linux kernel. Tizen's origin can be traced back to the merging of Nokia's Maemo and Intel's Moblin OS projects as well as several other Linux projects including Samsung owned endeavors LiMo and Bada.
Table 7 High level history of Tizen

A history of IT that leads to Tizen

- 2005: Maemo (Nokia)
- 2007: Moblin (Intel)
- 2007: LiMo (Motorola, NEC, NTT, DoCoMo, Orange, Panasonic, Vodafone)
- 2010: MeeGo (Nokia, Intel, other major hardware & software companies)
- 2010: Bada (Samsung: for less Android dependence)
- 2011: MeeGo abandoned by Nokia (for Windows Phone)
- 2011: MeeGo abandoned by Intel and then by its other supporters
- 2011: LiMo 4 (LiMo Foundation – Samsung collaboration with the EFL project (Carsten Haitzler – Rasterman)
- 2011: Intel joins LiMo, which is renamed to Tizen
- 2012: LiMo Foundation is renamed to Tizen Association
- 2012: Samsung has aim to merge Bada with Tizen

Tizen Good

Samsung has experienced small successes in showing off the potential of the Tizen OS. Samsung successfully deployed a smart camera model NX300M with Tizen as the

OS. The news that Tizen was the installed OS was quietly revealed more than a month after it debuted in October 2013. The Tizen OS was also made available to Samsung Galaxy Gear watch owners on July 2014 as an optional OS upgrade over pre-installed Android when it debuted September 2013. Early adopters of the watch were enticed by the doubling of supported applications to 140 on Tizen. Subsequent smart watch releases for Galaxy Gear 2 and Gear 2 Neo, both in May 2014, have Tizen OS pre-installed. A smartphone named Samsung Z was shown at the San Francisco Tizen Developers Conference on June 2014 where deployment plans were announced. However, the deployments for a Tizen smartphone would prove too ambitious for Samsung the first two times because releases in Japan and Russia were abruptly cancelled. However, the third time proved to be the charm as Samsung was able to finally release a Tizen smartphone in January 2015 with a low-end version called Samsung Z1 in India that will sell for $90 USD. Most recently, Samsung has announced that all of its Smart TVs in 2015 will come equipped with Tizen OS.

Tizen Bad

In Japan, the country's largest mobile service provider DoCoMo had scheduled a Samsung smartphone running the Tizen OS to be released in January 2014. Instead

DoCoMo cited slow growth in the Japanese smartphone market, which ultimately led to canceling the phone's debut.

"The market is not big enough to support three operating systems at this time," a rep for Japanese phone network NTT Docomo told The Wall Street Journal.

Still, considering that Roy Sugimura is both DoCoMo’s Director of Technology and Chairman of the Tizen Association, there is a high likelihood that a Tizen based smartphone will be released in Japan at a future date.58

In Russia, a Tizen smartphone called the Samsung Z was expected to be unveiled at a developer’s conference in Moscow on July 10 2014. Instead a few days before the conference, Samsung cancelled its plan to release the Samsung Z and provided a brief statement:

“The (Samsung Z) smartphone will appear on the Russian market later, when we can offer our users a fullest portfolio of applications.”

The sudden cancellation may have contributed to why the Moscow Developer Conference was reported to have such a low turnout, as many breakout sessions were

only half full as reported by the Wall Street Journal.\textsuperscript{59} This trend is consistent with what happened at a San Francisco Developer Conference held a month earlier in June 2014, which was reported to have about 600 Tizen developers in attendance compared with 6,000 that attended Apple’s iOS event the day before.\textsuperscript{60} Samsung even tried to increase attendance at the San Francisco event by giving away a free Samsung Galaxy Gear 2 smartwatch and an Intel NUC mini PC to registered attendees.\textsuperscript{61}

Tizen Summary

The idea of introducing the Tizen OS as a 3\textsuperscript{rd} smartphone OS option is intriguing. It would disrupt not just Samsung's but also other mobile manufacturers’ dependence on Android OS that would rather customize an OS towards their brand and away from Google. Samsung may be better served by spinning off a separate independent organization to help further the innovation necessary for Tizen OS to become a viable mobile OS option (Christensen, 1997). This strategy would enable Samsung to segregate their business and commercialization objectives for their hardware businesses away from their Research and Development objectives for creating the SAMI platform with a Tizen OS backbone.


**January** - Intel LiMo project renamed to Tizen

**February** - Samsung merges Bada with Tizen

**September** - Samsung releases smartcamera NX300M and smartwatch Galaxy Gear

**January** - Japan, Samsung Tizen debut smartphone cancelled

**May** - Samsung releases Galaxy Gear 2 and Gear 2 Neo smartwatch with Tizen pre-installed

**June** - San Francisco Tizen conference, Samsung Z announced but only 600 developers in attendance

**July** - Russia, Samsung Z smartphone debut cancelled

**July** - Samsung releases Galaxy Gear Tizen OS upgrade

**January** - India, Samsung Z1 debuts as first Tizen smartphone

**January** - Samsung announces all their Smart TVs will run Tizen OS
Chapter 8: Discussion

Network Effects

There are two types of network effects: one-sided and two-sided. One-sided network effects can be defined as when greater value is created due to increasing membership within the network. For example, having a telephone only benefits you when another user also owns a telephone.

Figure 16 One-sided network example of the telephone\(^\text{62}\)

The one-sided network benefit could apply with each of the platforms from the Big-3 since a user can compare biometric data with individuals who have similar demographics to gain insight with their own health. However, this benefit remains an unknown until the maturity of these platforms is reached from enough users joining which will result in enough biometric data growing big enough (i.e. becoming big data) over time. Security of identity will also be a major issue as these platforms mature due

to the sensitive nature of displaying private health data such that identity cannot be traced back to the original user who will ultimately decide if to grant permission to release his/her data. I can imagine a scenario where life insurance agencies begin raising premiums for individuals who belong to higher risk groups that possess trending attributes which often lead to heart attacks.

With two-sided network effects, the platform’s value to any given user largely depends on the number of users on the network’s other side. The two sides are attracted to each other and value grows as the platform matches demand from both sides. Keeping aligned with the strict boundaries implied with this definition, each of the Big-3: Google, Samsung, and Apple, all have end users on one side of the network that contribute value by adding biometric data collected from wearable sensors and smart electronics. On the other side of the network is where the differentiation among Apple, Samsung, and Google needs to be elaborated on.

**Google Fit Network Effects**

Figure 17 Google Fit 2-sided network effect

---

As mentioned in the Google chapter, 3rd party device makers create hardware where Google only provides software support if the device is run on Android. This approach empowers users with the ability to choose from the multitude of hardware device choices while enabling Google to further its reach to customers thru Google products that come preinstalled on Android.

Figure 18 Android Wear smartwatch choices

With regard to Google Fit, the strategy is no different except that the OS is now Android Wear -- a slimmed down version that allows for customized application development for
wearables. An estimated 720,000 Android Wear devices have been shipped in 2014 that include major manufacturers Motorola, LG, Sony, and Samsung. To further entice users towards Android products, Google has been testing a virtual version of a “Google Support Genius Bar” based on Google’s Hangout technology that will help support Android device owners.

Figure 19 Android Support via Google Hangout

Google has also attempted their own wearable designs to attract additional users to the Google Fit platform. Designs such as Google Glasses, which is still searching for a

---

suitable niche market, and the rumored smart contact lens being developed with Novartis, that will help diabetic patients manage glucose level detection. With all these different types of wearable options, the primary value back to the users who have loaded their biometric data to Google Fit is a plethora of wearable devices to choose from that run on Android Wear.

Samsung SAMI Network Effects

Figure 20 Samsung SAMI 2-sided network effect

Samsung has taken a hardware approach with SAMI by offering the Tizen Simband to academic medical center University of California San Francisco and nanoelectronic sensor research center IMEC\textsuperscript{67}. These partnerships with UCSF and IMEC were formed to help address the convergence of technology and medicine, which transpired

Samsung to create the UCSF-Digital Health Innovation Lab.\textsuperscript{68} This lab will allow innovators and entrepreneurs to validate their technologies and accelerate the adoption of preventative (as opposed to reactive) health solutions.

Figure 21 Samsung Tizen Simband

On November 12, 2014, Samsung made available on their website http://voiceofthebody.io the Tizen Simband hardware, software, and industrial designs as open-source to allow for an innovative ecosystem to develop around the Simband.\textsuperscript{69} This philanthropic approach from Samsung enables outside manufacturers to create swappable watchband modules catered to the specifications of the Simband with any sensor combination of their choosing.

\textsuperscript{69} http://samsungdevcon.com/sessions/9700/subject/building-to-the-simband retrieved February 8, 2015
It is important to note that the Simband is not going to be a consumer device that can be purchased from retail (yet) but instead it is primarily a "Toolkit" (Von Hippel, 2005) to help advance medical research in the form of biometric sensors and their impact towards preventative healthcare. Therefore, the primary value back to the user who uploads biometric data to SAMI will be knowledge back from the research findings discovered at the Samsung Digital Health Innovation Lab in the hope that preventative health products will be discovered as a result.
Apple is trying to build an ecosystem of partnerships for those who upload biometric data to HealthKit where the other side of the network will have a growing list of EHR providers and hospital partnerships. Unlike their competition, Apple has taken the strategic approach of forming partnerships to standardize HealthKit. Currently HealthKit partners include 22 hospitals as per mentioned from the Apple chapter alongside two very important strategic alliances with Electronic Health Record (EHR) providers Epic Systems and Allscripts Healthcare Solutions. Hospitals are spending millions of dollars to upgrade their IT systems and implement EHR systems in order to meet new federal guidelines mandated by the Affordable Care Act. Under the federal mandate, health providers will receive incentives to switch from paper-based to electronic systems. Those providers face penalties if they have not made the switch by 2015.70 Knowing that EHR is where the industry is heading, Apple is building their ecosystem to integrate

hospitals and healthcare providers with meaningful biometric data collected from their HealthKit platform.

According to Reuters, Apple has launched a pilot program with 14 confirmed hospitals to help physicians use HealthKit to monitor patients with chronic conditions such as diabetes or high blood pressure for early signs of trouble. Hospitals are incentivized to use HealthKit to help avoid repeat admissions which are now penalized under new U.S. government guidelines Section 3025 of the Affordable Care Act section 1886(q).\textsuperscript{71}

\textsuperscript{71} http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html retrieved February 22, 2015
"If we had more data, like daily weights, we could give the patient a call before they need to be hospitalized," said Ochsner Health Systems Chief Clinical Transformation Officer Dr. Richard Milani. 72

As mentioned before, per HIPAA compliance a business associate agreement (BAA) contract must be reached between a user and Apple in order for HealthKit data to be viewed by the individual's healthcare provider of choice. Once consent is given, the primary value back to a user who uploads biometric data to HealthKit will be centralizing all of his/her Digital Health-Data with the integrated hospitals and EHR providers who have partnered with Apple.

Multi-Homing

In the context of this paper, multi-homing is the idea of storing your biometric data under two or more platforms. Multi-homing between Samsung and Google would be easier since both devices operate on the Android OS. This is why Tizen will be an interesting development to watch for because the current landscape is only between iOS for HealthKit and Android for both SAMI and Fit. Multi-homing across operating systems like Apple's iOS and Google's Android (or Samsung's Tizen) will be a lot more painful because data will have to be manually copied. There are currently no features or developed applications that will allow data to be ported between iOS and Android for obvious reasons.

72 http://www.reuters.com/article/2015/02/05/us-apple-hospitals-exclusive-idUSKBN0L90G920150205 retrieved February 22, 2015
An advantage of multi-homing your biometric data would be that a user is no longer obligated to choose one ecosystem since he/she could take advantage of all the value created from each of them. However, the burden of having to manually update data to each platform would be a huge disadvantage that would likely discourage anybody from multi-homing. The following table outlines some of the advantages and disadvantages of multi-homing between platforms.
Table 8 Advantages and Disadvantages of multi-homing\textsuperscript{73}

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data is platform agnostic</td>
<td>Time lost manually updating data between two platforms</td>
</tr>
<tr>
<td>Access across each Big-3 ecosystem generated value</td>
<td>Cost of procuring two or more devices that live on iOS, Android, and Tizen</td>
</tr>
<tr>
<td>Plethora of developed applications to download from</td>
<td>Time lost learning tools and applications specific to platform</td>
</tr>
<tr>
<td></td>
<td>No automated features to keep data up-to-date</td>
</tr>
</tbody>
</table>

Cost would be a major disadvantage of multi-homing between iOS and Android since the user would need to procure an Apple and an Android device. Cost is minimal when sharing data between SAMI and Fit since both platforms could reside on a single Android device. However, if SAMI moves to Tizen as per Samsung plans, cost would go up as the situation would be similar to that of multi-homing between iOS and Android.

Table 9 Costs associated to multi-home data between iOS and Android\textsuperscript{74}

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost smartphone Android</td>
<td>$750 USD (Samsung Galaxy Note 4)</td>
</tr>
</tbody>
</table>

\textsuperscript{73} http://events.linuxfoundation.org/sites/events/files/als13_dupuis_tizen.pdf retrieved November 15, 2014  
\textsuperscript{74} http://events.linuxfoundation.org/sites/events/files/als13_dupuis_tizen.pdf retrieved November 15, 2014
<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost smartphone iOS</td>
<td>$750 USD (Apple IPhone 6)</td>
</tr>
<tr>
<td>Cost wearable device Android</td>
<td>$250 USD (Moto 360)</td>
</tr>
<tr>
<td>Cost wearable device iOS</td>
<td>$350 USD (Apple Watch)</td>
</tr>
<tr>
<td>Time update data across 2x</td>
<td>$27 = 3 Hours x $9 USD min wage in CA</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td><strong>$2127 USD (approx.)</strong></td>
</tr>
</tbody>
</table>
This page has been intentionally left blank.
Chapter 9: Conclusion

Google, Samsung, and Apple will continue to try and create value within their respective ecosystems for the Digital Health-Data platforms they are pushing to become the dominant design (Utterback, 1994). Each has employed a different strategy that caters to the strength of their business as a means of distinguishing value back to the customer network. Going back to my original hypothesis presented from the introduction:

The organization that creates the most value for its customer will be entrusted as the keeper of his/her health data.

It would be convenient to just declare a single winner in this race and end this thesis but it would be an opinionated conclusion. The definition of “value” is actually subjective to the need of each individual customer.

For Apple HealthKit, a tipping point (Gladwell, 2000) could be achieved if enough partnerships are formed from the side of Hospitals and EHR businesses. The perceived value is found not from just aggregating biometric data for a user but also interpreting the data in a useful manner that seamlessly integrates with hospitals and EHR providers to deliver preventative healthcare. Apple HealthKit suddenly becomes convenient since your EHR, PHI, and biometric Digital Health-Data are all centrally accessible.
The tipping point for Samsung SAMI could be in the form of a medical research break thru from an outside entrepreneur who chose to use the Samsung Simband as their hardware. As a result, Samsung decides to commercialize Simband and SAMI suddenly develops a legion of users where Tizen finally becomes a realistic threat to Android’s market share. The customer would now see value in owning a Simband where he/she could interpret their biometric Digital Health-Data in ways Apple and Google hardware could not.

Google Fit’s tipping point could come from one of its unique wearable offerings. The smart contact lens would be a medical innovation the world has never seen before. Diabetic patients would value having a pain free detection method for measuring glucose levels within their body without having to draw blood. According to a 2014 statistical report from the Centers for Disease Control and Prevention, there are approximately 29 million people affected by diabetes in the United States.75

Declaring a single winner among Apple HealthKit, Samsung SAMI, and Google Fit in the race to become the dominant design of Digital Health-Data platforms is simply not feasible because the definition of “value” is subjective to the individual. In spite of this revelation, a clear popular choice could still emerge over time where the value from that ecosystem is perceived to be greater from one platform over the next. Only time will tell.

Limitations and Future Work

The major limiting factor with my research was basically timing. Digital Health-Data platforms and biometric sensor electronics (i.e. "wearables") are still a nascent industry. At the time of this writing, it has been less than 1 year since Apple HealthKit, Google Fit, and Samsung SAMI announced their plans in becoming the dominant design platform for Digital Health-Data aggregation. Apple only recently announced an event to finally unveil their version of a smartwatch scheduled for March 9, 2015.76 Google may be shutting down their glasses initiative to create a better market for their glucose contact lens.77 Samsung plans to release the Galaxy S6 smartphone which will be the most powerful yet but most expensive at $1000.78

An opportunity for future research would need to wait for these technologies to diffuse further into our lives. With analytic tools and cloud data platforms becoming more powerful and ubiquitous, finding correlative properties from enough aggregated biometric data should become easier in the future. Preventative healthcare is still an elusive problem that academics and healthcare professionals are still hoping to define using big data analytics. Until enough biometric data is aggregated onto HealthKit, Fit, or SAMI, we can only speculate if wearable technology will reveal new information about a person’s health and if these platform initiatives from Apple, Samsung, and Google will positively impact the digitization effort of Electronic Health Records and finally centralize Digital Health-Data.

This page has been intentionally left blank.
Bibliography


