Learn forensic methods and procedures
for iOS data acquisition and analysis

iOS Forensic Analysis

for iPhone, iPad and iPod touch

Sean Morrissey

Foreword by Rob Lee, SANS Institute

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This book is dedicated to all those in uniform who serve our country and communities.

They work tirelessly to keep us safe and go mostly unappreciated.

I thank all who serve and keep us safe

Contents at a Glance

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Foreword

Sometimes when you fly, you have a chance to see what consumers are using for personal devices. You could tell e-books were taking off when you started seeing them regularly on planes. On the last trip I took, I was amazed to see the number of people using Apple iPads on the plane. In every row, at least one person was using an Apple iPad. Unseen, of course, was the Apple iPhone, but I knew that probably just as many individuals were using that device daily as well. Out of all my friends, I would say at least 50 percent of them have an Apple iPhone. In my family, we all own one, including my extended family. The dominance of Apple mobile devices is clear.

Every individual who uses an Apple device has detailed information about their daily habits stored on their personal mobile devices—more than we have ever seen on computer workstations or laptops. Since the devices are portable and usually never leave the side of the individual using it, they are considered trusted. As a result, the amount of data one might be able to recover from these devices during an investigation is crucial to case work today and in the future.

As businesses begin to adopt Apple devices into their infrastructure and assign them to their employees, knowing how to properly examine and recover detailed evidence from these mobile devices is something that is going to grow significantly beyond just a law enforcement requirement.

Running on each one of these devices is a proprietary operating system based on Mac OS X called iOS, and this book will aid any investigator in understanding and learning the latest iOS analysis techniques. Law enforcement and IT security will need to have the knowledge to properly acquire and analyze data from these devices, which are being adopted quicker than any other technology for personal use. Forensic analysis of iOS is no longer an option on your resume; it is a critical skill. This book helps bridge a crucial gap in knowledge that currently exists with many forensics professionals. Thanks go to Sean for taking the time to write this wonderful book and continuing to share his knowledge with the community.

Rob Lee
SANS Institute

About the Author

Sean Morrissey is currently a computer and mobile forensics analyst for a federal agency and is a contributing editor for *Digital Forensics Magazine*. Sean is married to his wife of 23 years, Dawn, and also has one son, Robert, who is currently serving in the U.S. Army. Sean is a graduate of Creighton University and following college was an officer in the U.S. Army. After military service, Sean's career moved to law enforcement where he was a police officer and sheriff's deputy in Maryland. Following service as a law enforcement officer, training became an important part of Sean's development. Sean was a military trainer in Africa and an instructor of forensics at the Defense Cyber Crime Center. During this time, Sean gained certifications as a Certified Digital Media Collector (CDMC) and Certified Digital Forensic Examiner (CDFE) and was a lead author on the book *Mac OS X, iPod, and iPhone Forensic Analysis* (Syngress, 2008).

Sean also founded Katana Forensics from his roots as a law enforcement officer for departments that didn't have the luxury of gaining access to high-priced tools. Katana was founded to create quality forensic tools that all levels of law enforcement can use.

About the Technical Reviewer

Tony Campbell is an independent security consultant, writer, speaker, and publisher who specializes in developing secure architectures, writing security policy, and implementing low-level security engineering for government and private sector clients. He is also responsible for TR Media's *Digital Forensics Magazine* (`www.digitalforensicsmagazine.com`), an independent publication targeting the computer forensics community that now ships to more than 30 countries worldwide. Previously in his long and varied IT career, Tony worked in publishing as part of the Apress editorial team (after working on three Windows-related books for Apress), and he has written or contributed to a further six independent technology books and has written more than 200 articles for various computer magazines, such as *Windows XP Answers*, *Windows XP: The Official Magazine*, and *Windows Vista: The Official Magazine*. In the far and distant past, Tony worked in the British Meteorological Office where he trained as a weatherman; however, after failing the compulsory screen test with too many ummms, uhhhhs, and odd expressions, he decided a job in IT better suited his demeanor.

Tony now lives in Reading, Berkshire, in the United Kingdom and can be contacted via the *Digital Forensics Magazine* web site.

Acknowledgments

First I would like to thank my two contributors, Chris Cook for his legal analysis and Alex Levinson for his expertise in network forensics.

Chris Cook is both an attorney and computer forensic analyst. He has extensive education and experience in the areas of computer forensics, cyber crime, and e-discovery. Chris is an active member of the bar in Texas and the District of Columbia. He holds a juris doctorate degree from the Catholic University of America, Columbus School of Law; a master's of forensic science in computer forensics from George Washington University; and a bachelor's degree with special honors in government from the University of Texas at Austin. Chris currently provides direct legal and computer forensics support to a federal government agency. Chris recently worked as a discovery manager for an international computer forensics and e-discovery consulting firm. Chris has also worked as a staff attorney for a global securities practice law firm in the Washington, DC, area where he assisted with the representation of corporate clients involving sensitive enforcement matters brought by the Securities and Exchange Commission (SEC) and other federal regulators.

Alex Levinson is an undergraduate student at the Rochester Institute of Technology, with a major in information security and forensics. Following high school in Indiana, Alex moved to San Francisco and attended Heald College of San Francisco for Information Technology with an emphasis in network security. He transferred to Rochester Institute of Technology in the spring of 2009. Alex has a diverse background spanning offensive and defensive cyber security, forensics, and software development. Alex was a top placing competitor in the 2010 US Cyber Challenge and has been published in IEEE for his work in mobile forensics. Alex joined Sean as the senior engineer of Katana Forensics in the spring of 2010.

Second, I would like to thank the following companies that donated demonstration software: Access Data, Guidance Software, Paraben, Oxygen, Susteen, and Alwin Troost. Without them this book would not have been possible. Thank you also goes to TechInsights and Semiconductor Insights for providing iDevice hardware images.

I would like to also thank Apress and Tony Campbell, who were instrumental in this book getting published.

Lastly, I would like to thank my wife, Dawn, who put up with me during the past year while I wrote this book.

Introduction

This book was a journey that began with the introduction of the iPhone 2G back in January 2007. This fascinating piece of engineering took the cell phone market by storm. Since then, manufacturers have done everything they can to knock Apple off the smartphone hill. Android has crept up but just hasn't measured up to the total experience that Steve Jobs and Apple has given its users of mobile devices. With the iPod, Apple changed the way we consume multimedia; with the iPhone, Apple changed the way we communicate and use cell phones. The iPad was yet another revelation. The iPad has seemed to squash the sales of netbooks. With the rise in popularity of these devices, they've also become more and more prevalent in criminal cases.

This book will take you down the road of examining these devices, from the hardware that powers them to the software that runs these amazing marvels of technology. We will examine all facets of forensics, from the incident response of these devices to tools that assist in examining an iDevice (any iPhone, iPad, or iPod) and from GPS to property lists. We will examine some legal implications that involve the iPhone and jailbreaking. As you will see in this book, the canons of forensics should be maintained, and procedures that are derived from underground sources, however they are measured, should be used as tools of last resort. You'll learn that the process of least invasive to most invasive should be paramount to mobile forensics. Examiners are constantly looking to examine phones quicker but not necessarily sticking to the traditions of forensics. This book will show that there can be a huge number of artifacts that can be located in the logical space. Immediately diving into breaking the phone is not a preferred method. You will see that these methods can be destructive and therefore detrimental to a case. Along with the devices, there are now approximately 300,000+ applications in circulation, not counting those from the third-party Cydia store. Some of these applications can look very innocent but at the same time can be very dangerous. Examiners tend to overlook the world of third-party apps. This book will teach you which applications are best for finding artifacts that can help in solving crimes.

This book will also help you form strategies for artifact retrieval and analysis. Imagine that an iPhone has been given to you for analysis. What do you do? This book will help you in formulating a game plan and maximize the data that can be retrieved from these devices. Do you use a logical forensic tool? Do you go in for the kill and jailbreak the phone and access the RAW device? These are questions that need to be answered by the examiner and stay within his skill set in order to keep from destroying the evidence at hand.

Although we can only guess what Apple has in store for us in the future, it is very clear that any future iDevice will not look too much different internally in reference to the structure of the data. So, a good foundation in iOS forensics will aid in analyzing any devices potentially released in the future by Apple. This book will give that foundation so that you can analyze any iDevice and report the artifacts.

Chapter 1

History of Apple Mobile Devices

Before we delve into artifacts and analysis, let's take a look at the history of Apple's mobile devices. Apple had a history of trials and failures until the release of the iPhone, which is the phone that actually changed the mobile phone game. For instance, in 1988, Apple started the development of the Newton (see Figure 1–1), an early version of a PDA tablet. The first Newton project was the Message Pad 100, released in August 1993, and the last was MessagePad 2100, released in November 1997. The Newton line of products was subsequently killed upon the return of Steve Jobs to Apple in 1997.

Figure 1–1. *The Apple Message Pad vs. the Apple products of today (courtesy of Apple)*

There were six models of the Newton, and all had an ARM processor, with a clock speed of 20MHz to 162MHz. The Message Pad also had its own operating system called NewtonOS. The platform had a touchscreen, handwriting recognition, and applications that were able to share information in "soups." Soups were not unlike what we see in the iPhone's databases, where one application can refer to data in another application. For example, the `SMS` database can cross-reference data in the `AddressBook` database, and you can see names in place of phone numbers in the GUI.

The Newton had a calendar, contacts, and notes—everything a normal PDA used at that time. Despite this, the device just didn't seem to grasp the attention of the general public. Instead, devices such as the Palm were leading in the personal digital assistant (PDA) market.

The failure of the Newton didn't seem to deter Steve Jobs, who just returned to Apple as CEO, in developing newer technologies. In fact, it soon became evident that Steve Jobs' focus was to bring Apple back from the brink of death and develop new technologies. Before the birth of the iPhone, Steve Jobs turned his focus to a device that would forever change Apple—the iPod. The iPod (and iTunes) was the springboard for the eventual inception of the iPhone and iPad.

The iPod

The Apple iPod didn't ignore Apple's PDA roots. Each iPod had the ability to store calendar and contact information, and subsequent generations of iPods gave the consumer the ability to view photos and then video. The original iPod was capable only of syncing with a Mac because of its FireWire interface. Windows users saw the utility of the iPod and were clamoring for it, so Apple switched to USB and has never looked back.

The sales of iPods soared into the stratosphere and, with more than 300 million iPods sold worldwide, forever changed the landscape of how consumers listen, view, and purchase multimedia. As opposed to the failure of the Newton, the iPod was a success story that numerous competitors attempted to match but failed. The iPod and eventual success of its Mac lines of computers changed the way that consumers saw Apple; they began to look to Apple for future innovations and devices that again would change our world.

The Evolution of Apple iPhones

The iPod kicked off the revitalization of Apple, but it's the iPhone that has made it last. Apple took what it learned from the success of the iPod and applied it to the world of mobile communications.

The ROCKR

Before Apple decided to eventually come out with its own cell phone, in 2005 it had a joint venture with Motorola with the ROCKR, as shown in Figure 1–2.

Figure 1–2. *The ROCKR (courtesy of Motorola)*

The ROCKR was the first cell phone that had a version of iTunes, but in 2006 Apple discontinued its support of iTunes on the ROCKR. So, it was surprising that Steve Jobs and Apple would release a cell phone that would revolutionize the cellular industry. Even though the ROCKR was another failure of Apple, it was seen as a testing ground for the iPhone.

Hence, in January 2007, Steve Jobs introduced the iPhone to the world. It was a Multi-Touch device that had its own operating system, iPhone OS. Bringing back the PDA roots of the Newton and the iTunes from the ROCKR, it was a game changer in the cell phone market.

The Apple iPhone 2G

The first iPhone was referred to as the 2G, shown in Figure 1–3.

Figure 1–3. *The Apple iPhone 2G (courtesy of Apple)*

The iPhone was capable of using the second-generation cellular network Edge. The iPhone 2G also had the ability to communicate with 802.11 technology and used

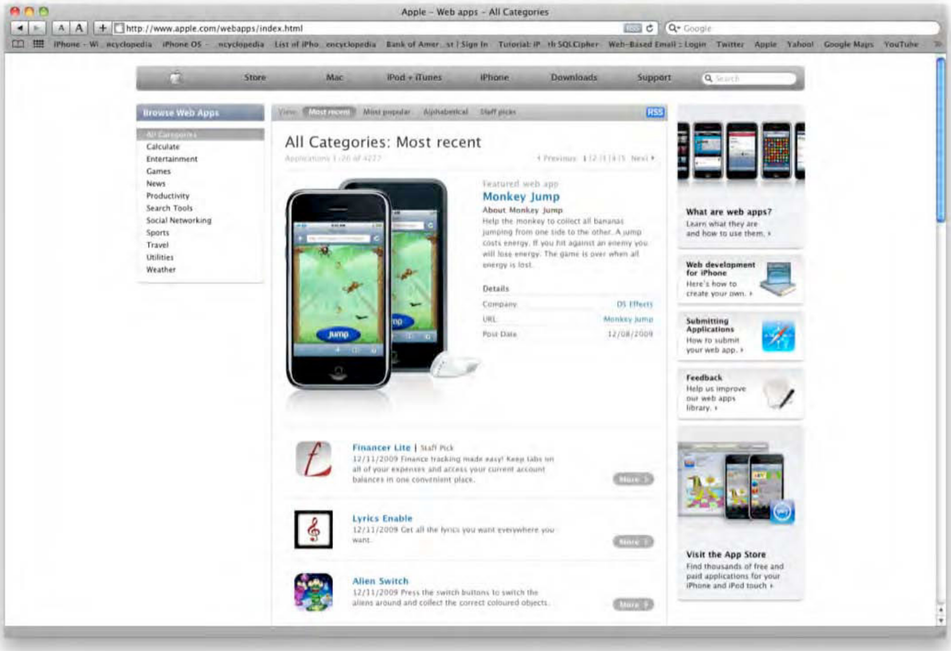
Bluetooth for accessories such as hands-free headsets. The Apple 2G iPhone was first released with 4GB of internal storage and then released in September 2007 with 8GB and 16GB versions. New technologies such as a MultiTouch input method from the user interface were a huge breakthrough for Apple (and cell phones in general). The main functions of the iPhone were not just cellular communication, but web access, e-mail, and PDA functions. The Apple iPhone also connected to iTunes and YouTube.

The iPhone was clearly designed to be used as a multiple application device, not just a cell phone. Since the App Store didn't exist yet, the iPhone was able to place web apps on its device. These web apps were the precursor to the apps that are now seen on today's iPhones. (Web apps were just links to web site pages that run a given function.)

Web Apps

Prior to the App Store and during iPhone OS version 1.0, Apple created web applications that were similar to widgets on the Mac platform. These apps were small applications in the following categories: Calculate, Entertainment, Games, Productivity, Search Tools, Sports, Travel, Utilities, and Weather. The applications were accessible from Safari and on the iPhone home screen, as shown in Figure 1–4. These applications didn't generate any data on the iPhone except for the icon on the screen and its hyperlink.

These web apps still exist, and some are still being developed. The numbers are not anywhere the size of the App Store, but they were the precursor to the tremendous success of the App Store.



All Categories: Most recent

Applications 1-20 of 4227

‹ Previous 1 | 2 | 3 | 4 | 5 Next ›

Featured web app

Monkey Jump

About Monkey Jump

Help the monkey to collect all bananas jumping from one side to the other. A jump costs energy. If you hit against an enemy you will lose energy. The game is over when all energy is lost.

Details

Company	DS Effects
URL	Monkey Jump
Post Date	12/08/2009

Financer Lite | Staff Pick
12/11/2009 Finance tracking made easy! Keep tabs on all of your expenses and access your current account balances in one convenient place.

Lyrics Enable
12/11/2009 Get all the lyrics you want everywhere you want.

Alien Switch
12/11/2009 Press the switch buttons to switch the aliens around and collect the correct coloured objects.

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Here's how to create your own. ›

Submitting Applications
How to submit your web app. ›

Feedback
Help us improve our web apps library. ›

Visit the App Store
Find thousands of free and paid applications for your iPhone and iPod touch ›

Figure 1–4. *Apple web applications, the precursor to the iTunes App Store*

Competitive Advantages

The iPhone connected people, and the integration of the iPhone camera was a first step in a quest to remove the need for digital cameras and use your iDevice to capture your life.

Apple also showed that keeping with one carrier increased the sales of the device, and competitors mimicked that model—some with more success than others. Research in Motion (RIM) developed the Blackberry Storm and was connected to Verizon, Palm's Pre was developed by Palm and was connected to Sprint, and Google's Nexus was connected to T-Mobile. Most of these eventually split from their exclusive carriers and branched out to other carriers; however, Apple did not. Apple has stuck with AT&T, even with the complaints about service, and the iPhone has been a cash cow for both Apple and AT&T.

Since the iPhone's release, other manufacturers have been scrambling to match Apple and produce other smartphones to compete. Research in Motion developed the Storm and Storm 2 in hopes of keeping its edge over Apple. Palm developed the Palm Pre, which was seen as a failure that brought the eventual demise of Palm. HTC developed numerous Android-powered devices, and Motorola developed the Droid. Every competing device was always asked, "Is this the iPhone killer?" Every device just didn't seem to match the capabilities of the iPhone. Apple also never stood still, and again the mystique of the "new iPhone" continued to propel the iPhone's sales and reach.

The Motorola Droid also hasn't generated the same buzz as even one release of any of the iPhones. The Google Nexus 1, even with its impressive hardware, has been beset with problems, and any problems that arise from the phone gets directed to the manufacturer of the phone, in this case HTC. The Nexus was quietly removed from the market, and other generations of HTC and Motorola phones have attempted to compete directly with the iPhone. Still, Apple has still stayed above the rest with the ability to support not only the hardware but also the operating system.

The 3G iPhone

The second generation of iPhones commonly referred to as the 3G was the iPhone that switch from the Edge network to the faster 3G network. Figure 1–5 shows the updated iPhone 3G.

Figure 1–5. *The Apple iPhone 3G (courtesy of Apple)*

Apple released the iPhone 3G in June 2008 and by June 2009 had two variants, 8GB and 16GB models. The 16GB iPhones were the first iPhones available in black and white. The biggest feature of the 3G iPhone was that is contained Assisted GPS. This gave more functionality to the Google Maps applications, allowing the user to use this application as a simple GPS turn-by-turn road map. The GPS was not that accurate, but with future firmware updates, the device got better. The GPS function of the 3GS also allowed geotagging of images that were taken from the internal camera, which was previously seen only in high-end digital cameras. This allowed investigators to place a subject at a certain place at a point in time.

Version 2.0 of the firmware also saw the debut of the App Store. This was a marketplace that would offer applications to users of the iPhone. Nobody thought that the App Store would be the premiere model for other manufacturers to follow. For example, Android released the Android Market to showcase and sell apps, Palm Pre's has an App Catalog, and RIM has its own version of an app store. To date, Apple has 300,000+ applications in its store. Its competitors haven't even come close to the effectiveness of Apple's App Store. The applications, which are developed by an army of developers who utilize the software development kit (SDK), can take advantage of the phone's accelerometer, GPS, video, audio, and PDA functions.

The 3G[S] iPhone

In June 2009, Apple released its newest iPhone, the iPhone 3G[S], shown in Figure 1–6.

Figure 1–6. *The Apple iPhone 3G[S] (courtesy of Apple)*

The 3G[S] was also the released with the new 3.0 software. The 3G[S] arrived with a compass and a new 3.0-megapixel camera that was able to shoot and edit video. The 3.0 software was also a boom for developers because it was given access to third-party hardware via the USB port and Bluetooth. The 3GS was another game changer with the addition of the two new technologies on the phone. The video capability was a good boost for Apple and for investigators, because even when a video is taken and possibly edited, the original stays on the phone, until it is eventually deleted. The 3.0 software also added voice recordings, which added one more possible artifact to investigators. The GPS on the phone was more capable and with better accuracy. The compass added a compass heading to the geotagging feature, so now you can gather images with latitude, longitude, altitude, and compass headings. The phone still maintained its relationship with AT&T.

The iPhone 4

The iPhone 4 (shown in Figure 1–7) was a center of controversy and drama. Leaks of the new device were becoming more and more intense until Gawker Media/Gizmodo purchased a device that later was revealed as the fourth-generation iPhone.

Figure 1–7. *The Apple iPhone 4G (courtesy of Apple)*

On June 21, 2010, Steve Jobs announced at the Worldwide Developers Conference the introduction of the new iPhone 4. The iPhone 4 was a completely redesign from Jonathan Ive, who heads the Industrial Design team at Apple. The stainless steel case was incorporated as part of the new antennae system on the phone. The iPhone 4 was centered on a new processor and a larger battery. A front-facing camera that used Apple's Face Time technology was a mode for video conferencing with iPhones and other devices and carriers. The iPhone 4 sported a new 5-megapixel camera and LED flash.

The launch of the iPhone 4 was also the launch of iOS 4, a newer and more powerful operating system. iOS4 gave the development community five APIs in order to multitask operations on the iPhone. The user was also allowed to change the environment by replacing the wallpaper and lockdown screens. With applications such as iMovie, video editing was also possible, not just clipping in iOS3. Face Time, a new application that allowed for video chat via Wi-Fi, was not available at first on the 3G network.

The Apple iPad

The Apple iPad was announced on January 26, 2010 (shown in Figure 1–8).

Figure 1–8. *The Apple iPad (courtesy of Apple)*

When Steve Jobs announced this device, there was a sense that Apple was shifting the way we do things again. Like the iPod changed the way we consume media and like the iPhone forever changed the way cell phones are produced and used, the iPad can change the way we read. It's not meant to replace the iPod or iPhone but to complement them.

So, what does this mean for forensics? There will be a huge migration in doing productivity work, and we will be begin to find artifacts that we've never seen before on an iDevice, such as numerous documents, spreadsheets, and PDFs. As more developers take advantage of syncing items from a computer to the iPad, these type of artifacts will grow exponentially. The first iPad uses iPhone OS 3.2, which means all the things we have been doing with the iPhone and iPod touch will still apply. In 2010, there will be an upgrade available to iOS4, which has some differences. It has a mini-SIM card, but it's unable to use the 3G network to place calls. It's larger than an iPod touch, so it's not as portable. It has the same processor as the iPhone 4 and comes in 16GB, 32GB, and 64GB variations.

Under the Surface: iPhone and iPad Hardware

How the interface functions in the iPhone 2G, 3G, and 3GS hasn't changed too much over the years. The major exterior change from the iPhone 2G to the iPhone 3G was the switch from a stainless steel housing to a hard plastic one, and then the iPhone 4 made a radical change to the design of the iPhone line. The 2G, 3G, 3GS iPhone devices have a slot on top for a SIM card, volume control, a ringer on/off button, and two speakers and one microphone. The iPhone started with a 2-megapixel camera, and in the iPhone 3G/3GS it was changed to a 3-megapixel camera. In the following sections of this chapter, you will see the operation, use, and guts of iDevices.

2G iPhone Internals

Figures 1–9 and 1–10 show the internals of the iPhone 2G. You will see in the development of the iPhone how things get small and in the iPhone 4 how things get even smaller in order to make room for a larger battery.

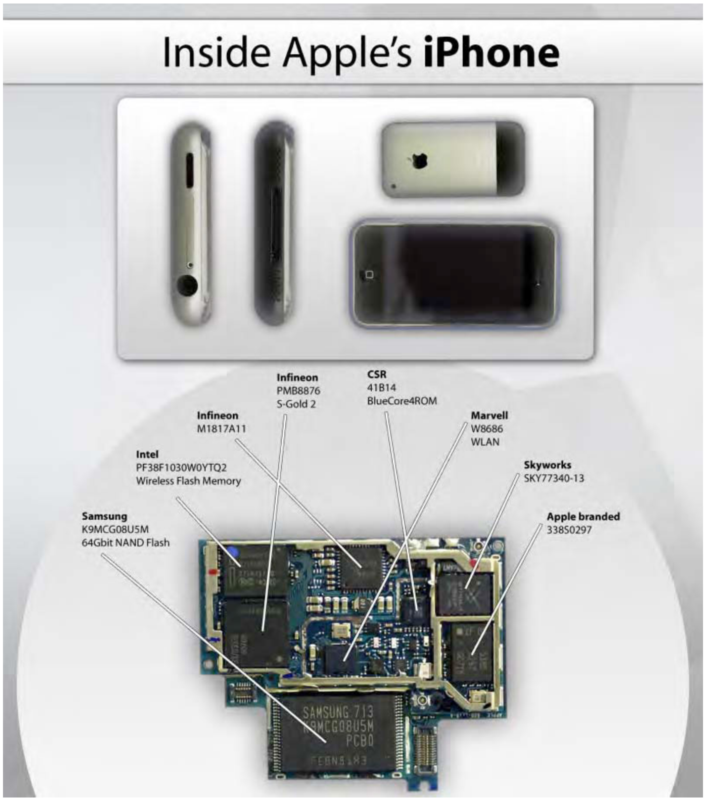
Inside Apple's iPhone
Infineon PMB8876 S-Gold 2
CSR 41B14 BlueCore4ROM
Infineon M1817A11
Marvell W8686 WLAN
Intel PF38F1030W0YTQ2 Wireless Flash Memory
Skyworks SKY77340-13
Samsung K9MCG08U5M 64Gbit NAND Flash
Apple branded 338S0297
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Figure 1–9. *The internals of the Apple iPhone 2G (courtesy of Semiconductor Insights)*

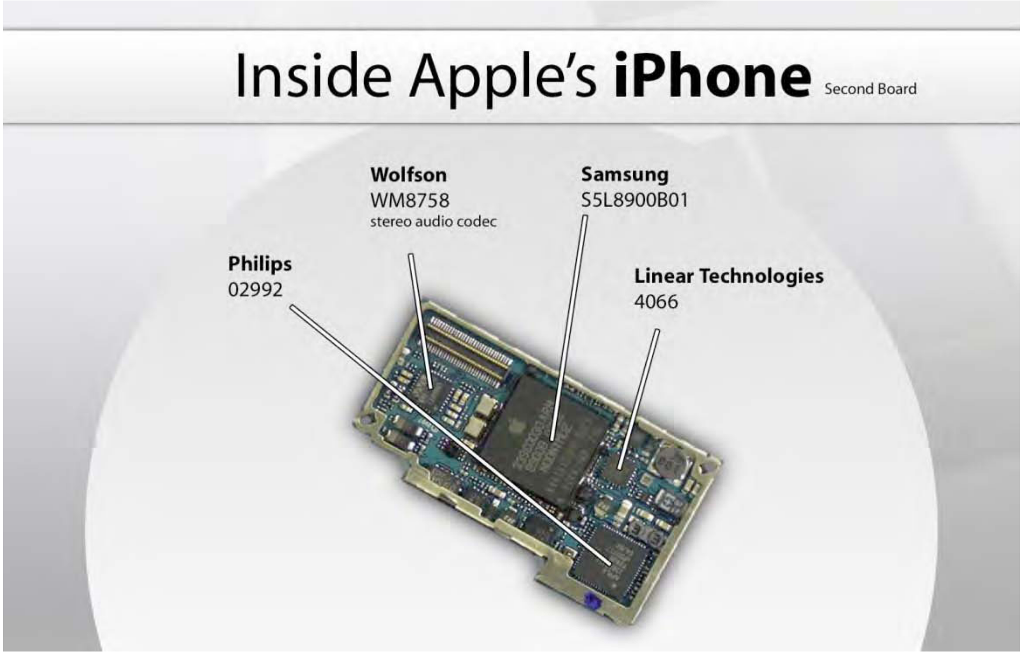

Inside Apple's iPhone Second Board
Wolfson WM8758 stereo audio codec
Samsung S5L8900B01
Philips 02992
Linear Technologies 4066

Figure 1–10. *Another view inside the Apple iPhone 2G (courtesy of Semiconductor Insights)*

The 2G exterior is unique compared to all the versions of the iPhone. The front of the phone is the iconic black with a silver rim. The rear is aluminum, and a portion at the bottom is black. The iPhone 2G does not have a removable battery, which has been a matter of soreness for users who never received long life from its internal power supply.

The iPhone 2G was released in June 2007 and was discontinued in July 2008. The OS that was released with the 2G was OS 1.0, and owners of the 2G iPhone are still able to upgrade to the latest version of the operating system, which currently is 3.*x*. The hardware of this phone gave unprecedented access to the Internet via the 2G Edge network with a wireless connection, and the screen made cruising the Internet easier than any other phone that had been developed at that time. With full rendering of web pages, pinching and zooming made navigating around a web page better than any other phone at that time. Also, 2G provided the ability to listen to music and watch video and send and receive e-mail. Table 1–2 breaks down the 2G hardware.

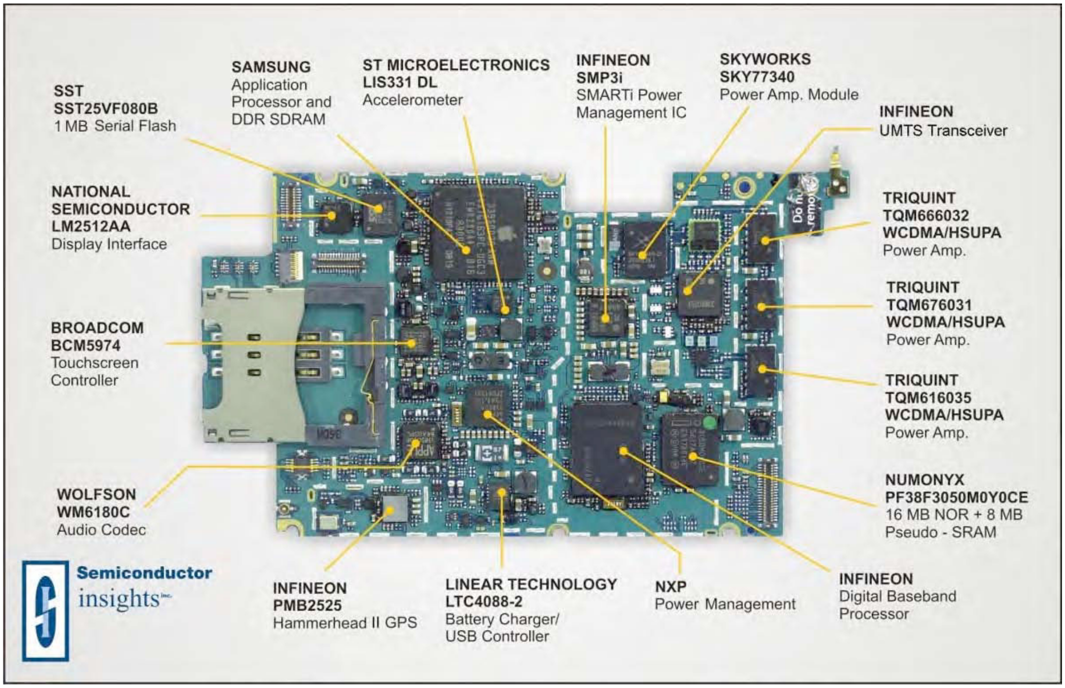
Table 1–1. *2G Hardware*

2G Hardware	Manufacturer	Description
Application processor	Samsung	SSI8900B01. A chip that has an ARM11766JZF-S CPU core, 16KB L1 cache. This chip has an eight-stage integer pipeline, ARM Trust Zone, MBX Lite 3D graphics co-processor at 60MHz, a vector floating-point coprocessor, and 128MB DDR integrated SDRAM. The Samsung SS18900B01 has a maximum clock speed of 667MHz.
Baseband processor	Infineon	PMB8876 S-Gold Quad Band GSM/GPRS/Edge 850/900/1800/1900MHz.
Connectivity	Marvell	W8686 802.11 b/g.
	CSR	41B14 Blucore4ROM (Bluetooth).
Graphics	PowerVR	MBX Lite 3D graphics co-processor at 60MHz.
Memory		128MB DRAM.
Display	Phillips	LPCC2221/02992 Touchscreen controller.
	National Semiconductor	24-bit RGB display interface.
		Glass capacitive Multi-Touchtouchscreen, with a resolution of 320×480 and was scratch resistant was made on the device. The Multi-Touch sensor could distinguish between a finger rather than a stylus. A stylus did not conduct enough electrical connectivity to activate the Multi-Touch sensor.
Audio	Wolfson	WM8758 Stereo audio codec.
Storage	Samsung	K9MCG08USM 64Gb NAND flash memory chip in 4GB, 8GB, and 16GB.
USB	Apple	30 pin USB proprietary connection.
Camera		2.0 Megapixel.
Sensors		Ambient Light, Proximity, Moisture.

3G iPhone Internals

As it be came to be, Apple released a major change to the iPhone in its appearance and added some performance upgrades. The most pronounced was the addition of GPS, which gave developers another arena to add functionality to their applications. The iPhone 3G also switched from the Edge network to the 3G network that improved network performance.

This model was release with a lot of fanfare in July 2008. The hardware was faster, the storage was bigger, and it came in black and white cases. The upgrade in power and speed became important with the introduction of the App Store. The iPhone 3G became a complete package that now could do just about anything with apps. Figure 1–11 gives insight to the internals of the iPhone 3G. The daughterboard is lost, and all is placed on one circuit board. Table 1–11 breaks down the hardware.


SST SST25VF080B 1 MB Serial Flash
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ST MICROELECTRONICS LIS331 DL Accelerometer
INFINEON SMP3i SMARTi Power Management IC
SKYWORKS SKY77340 Power Amp. Module
INFINEON UMTS Transceiver
NATIONAL SEMICONDUCTOR LM2512AA Display Interface
TRIQUINT TQM666032 WCDMA/HSUPA Power Amp.
TRIQUINT TQM676031 WCDMA/HSUPA Power Amp.
BROADCOM BCM5974 Touchscreen Controller
TRIQUINT TQM616035 WCDMA/HSUPA Power Amp.
NUMONYX PF38F3050M0Y0CE 16 MB NOR + 8 MB Pseudo - SRAM
WOLFSON WM6180C Audio Codec
Semiconductor insights
INFINEON PMB2525 Hammerhead II GPS
LINEAR TECHNOLOGY LTC4088-2 Battery Charger/ USB Controller
NXP Power Management
INFINEON Digital Baseband Processor

Figure 1–11. *The internals of the Apple iPhone 3G (courtesy of Semiconductor Insights)*

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3G Hardware	Manufacturer	Description
Application processor	Samsung	SSI8900B01. A chip that has an ARM11766JZF-S CPU core, 16KB L1 cache. This chip has an 8-stage integer pipeline, ARM Trust Zone, a vector floating-point coprocessor, and 128MB DDR integrated SDRAM. The Samsung SS18900B01 has a maximum clock speed of 667MHz.
Baseband processor	Infineon	PMB8878 X-Gold Tri-Band UMTS/HSDPA 850/1900/2100MHz.
Connectivity	Marvell	W8686 802.11 b/g.
	CSR	41B14 Blucore4ROM (Bluetooth).
Graphics	PowerVR	MBX Lite 3D graphics co-processor at 60MHz.
GPS	Infineon	Hammerhead II AGPS Assisted GPS chip that gives the iPhone location services.
Memory		128MB DRAM.
Display	Broadcom	BCM5974 Touchscreen Controller.
	National Semiconductor	LM2512AA 24-bit RGB display.
		Glass capacitive Multi-Touchtouchscreen, with a resolution of 320×480 and was scratch resistant. The Multi-Touch sensor could distinguish between a finger rather than a stylus. A stylus did not conduct enough electrical connectivity to activate the Multi-Touch sensor.
Audio	Wolfson	WM8758 Stereo audio codec.
Storage	Samsung	K9MCG08USM 64Gbit NAND flash memory chip in 8GB and 16GB.
USB	Apple	30-pin USB proprietary connection.
Camera		2.0 megapixel.
Sensors		Ambient Light, Proximity, Moisture.

iPhone 3G[S] Internals

The iPhone 3GS was a dramatic change from the 3G with improvements in the operating system, such as an upgraded processor, voice control, and an improved camera that allowed the capture of video.

The 3G[S] was released on June 3, 2009. iOS 3 was released with this iPhone. The 3GS gave the ability to create video from the iPhone camera, it had a faster processor, and it was hailed as a faster platform than its predecessor, the iPhone 3G. The iPhone 3GS did out-perform the 3G, but it still was plagued with problems with its reception. Some hoped for tethering, which never produced itself in the United States. However, survey after survey showed that owners of the iPhone 3GS were generally pleased even though the service provider, AT&T, consistently took flak for inferior performance. Figure 1–12 shows the insides of the iPhone 3G. Table 1–3 breaks down the hardware.

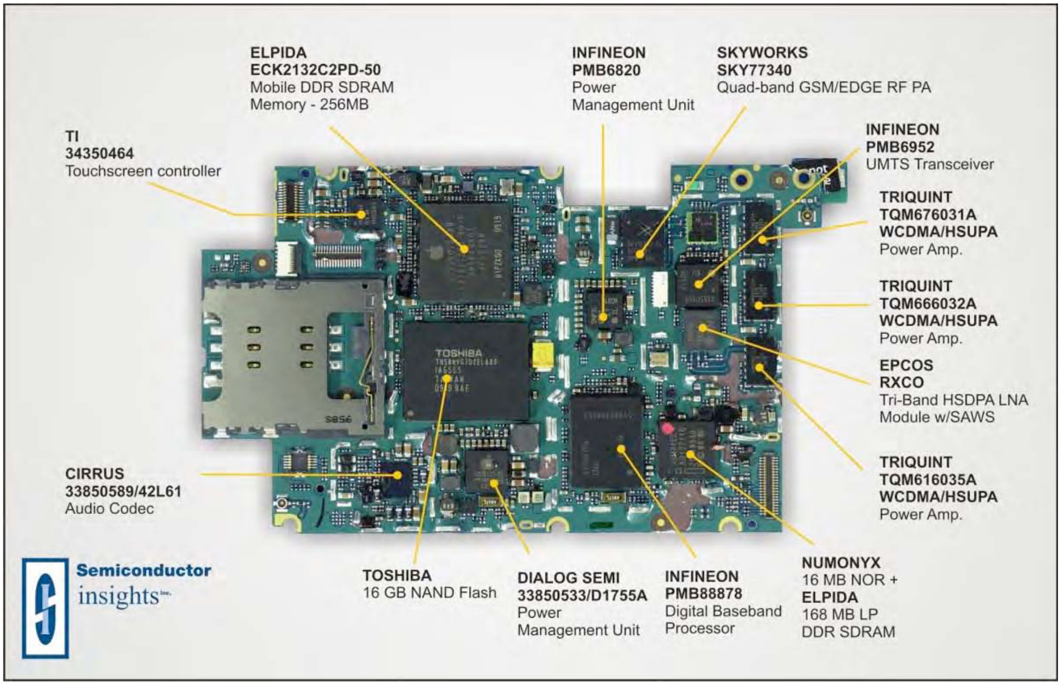
ELPIDA ECK2132C2PD-50 Mobile DDR SDRAM Memory - 256MB
INFINEON PMB6820 Power Management Unit
SKYWORKS SKY77340 Quad-band GSM/EDGE RF PA
TI 34350464 Touchscreen controller
INFINEON PMB6952 UMTS Transceiver
TRIQUINT TQM676031A WCDMA/HSUPA Power Amp.
TRIQUINT TQM666032A WCDMA/HSUPA Power Amp.
EPCOS RXCO Tri-Band HSDPA LNA Module w/SAWS
CIRRUS 33850589/42L61 Audio Codec
TRIQUINT TQM616035A WCDMA/HSUPA Power Amp.
Semiconductor insights
TOSHIBA 16 GB NAND Flash
DIALOG SEMI 33850533/D1755A Power Management Unit
INFINEON PMB88878 Digital Baseband Processor
NUMONYX 16 MB NOR + ELPIDA 168 MB LP DDR SDRAM

Figure 1–12. *Another view inside the Apple iPhone 3G (courtesy of Semiconductor Insights)*

Table 1–3. *3GS Hardware*

3GS Hardware	Manufacturer	Description
Application processor	Samsung	Samsung S5PC100 is 32-bit ARM Cortex A8 RISC microprocessor and a 64/32-bit internal bus architecture; could operate up to 833MHz. The iPhone 3G[S] was under-clocked at 600MHz to conserve battery life.
Baseband processor	Infineon	PMB8878 X-Gold Tri-Band UMTS/HSDPA 850,1900, 2100MHz.
Connectivity	Broadcom	BCM4325 802.11a/b/g . Bluetooth2.1+EDR.
Graphics	PowerVR	200MHz SGX.
GPS	Infineon	Hammerhead II AGPS. Gave the iPhone geotagging capabilities.
Memory		256MB DRAM.
Display	TI	34350464 touchscreen controller. Glass oelophobic technology Multi-Touch touchscreen, with a resolution of 320×480, and was scratch resistant and fingerprint resistive.
Audio	Cirrus	33850589/42L61 Audio Codec.
Storage	Toshiba	TH58NVG702 NAND flash memory chip 16GB and 32GB.
USB	Apple	30-pin USB proprietary connection.
Camera		3.0-megapixel with video with a rate of 30fps.
Sensors		Ambient Light, Proximity, Moisture.

iPhone 4 Internals

The iPhone 4 was a radical new design from its predecessors. Made of Helicopter (Gorilla) glass and stainless steel, this iPhone compared to the iPhone 3GS seemed more of a phone and less of a toy. The ruggedness brings back memories of the iPhone 2G but with a classic and more substantive mobile phone experience. The iPhone 4 came with two cameras, one front facing and one rear facing. A new feature called Face Time brought communicating to a higher level. Now we are able to see those we talk to,