mReplay 2.0

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May 2, 2007

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Introduction

Imagine being at Gillette Stadium on January 19, 2002 during the AFC Championship Game between the New England Patriots and the Oakland Raiders. As an avid fan, you weathered frigid temperatures and inhuman snow to observe, live and in-person, two Cinderella-story teams vie for a place in Super Bowl XXXVI.[1] Neither team had seen a Super Bowl in well over two decades; the champion of this crucial battle was to face an even greater foe in the form of the St. Louis Rams during the big game. However, at that moment in time, it was all about the Patriots and the Raiders. But in this scenario, you are not just any fan; you are part of the Raider Nation. To fulfill your overzealous commitment to the team, you had actually driven 3097 miles for 46 hours straight to Foxboro, Massachusetts. Your objective was to witness history first hand—despite the snow, sleep deprivation, bad smells, and awful weather—to behold your team as it obliterates a two-decade curse of failure. Your commitment drove you to stalk the Raiders, as they finally re-secured their rightful place in the annals of Super Bowl history.

Trailing 13-10, and facing first-and-10 from Oakland's 48-yard line with less than two minutes remaining, New England's quarterback Tom Brady was sacked by Charles Woodson, losing the football. Raiders linebacker Greg Biekert fell on the ball with 1:43 remaining and the play was ruled a fumble on the field, essentially ending the game for the Patriots. However, amid your elation that the Raiders had triumphed over the Patriots, the referees announced that the play was being reviewed. After a few minutes, it was ruled an incomplete pass. The ruling of referee Walt Coleman: while Brady was

[1] Silver, Michael. "Pat Answer." *Sports Illustrated* 11 Feb. 2002. 30 Apr. 2007 <http://sportsillustrated.cnn.com/football/features/superbowl/archives/36>.

trying to tuck the ball, his arm was moving forward, thus the play was ruled an incomplete pass. During the remaining 1:43, Patriots' kicker Adam Vinattieri was able to tie the game into overtime; Vinattieri later won the game for New England during overtime.

The point of this scenario were those minutes of uncertainty that you, the Raider Nation fan, experienced as the play was being reviewed. Although you rationalized that the ruling would certainly be in Oakland's favor given that Mr. Brady had clearly fumbled the football; he had pumped the ball, appearing to try tucking it away, when Woodson knocked it loose. However, rationalization is the sign of a desperate man. The point is not the referee's call or your reaction to it after the fact; but rather that number of minutes that may have appeared as an eternity as you endured second guessing, head scratching, soothing, justification, worry, and a host of other emotional extremes.

This heartbreaking tale personifies a problem faced by all sporting-event attending fans in which they receive less information about the sporting event than their at-home, television-watching counterparts. Either due to controversial calls or being relegated to the nose-bleed seats, live event attendees lack the nuanced details that slow motion replays allow for broadcast audiences of sporting events. This is where mReplay 2.0 comes in.

Initially introduced in 2005 as a graduate project on behalf of the School of Information Management and Systems at the University of California at Berkeley, the first mReplay extended this convenience to mobile-device-owning fans who attend sporting events. However, mReplay 2.0 goes beyond the 2005 project by introducing a new business model and a series of products incorporating technologies from popular social-networking and Web 2.0 multimedia sites such as YouTube. This paper will discuss mReplay 2.0 from two perspectives. First, it will review the technical blueprint of the current and future applications of mReplay 2.0. Second this paper will discuss the non-technical aspects such as the business models, social networking aspects, partnership options, potential customers, legal issues, and miscellaneous other environmental conditions.

Introducing the 2007 Team

Given that mReplay 2.0 is a product of the School of Information at the University of California at Berkeley, it is apt that the team behind the project draws from a diverse set of interdisciplinary knowledge. The team includes the following members:

- Yale Braunstein
- Jer-Yee Chuang
- Jeff Decker
- Michael Lee

Professor Braunstein is the graduate advisor to mReplay 2.0. Mr. Braunstein has authored and co-authored over 50 articles throughout the fields of economics and the economics of information systems. He has consulted on behalf of corporations and government entities, both domestically and abroad. Given his background in economics, Professor Braunstein will provide a strong foil to the technically inclined protégés under his liege; providing an overall balance to the project.

Mr. Chuang has experience with MySQL and relational database management systems. He has designed medium sized databases for real-world scenarios. His primary task on mReplay 2.0 is to evaluate and design the database structures utilized by the mReplay.com website. Mr. Decker brings many years of software engineering to the table. He will play the role of project manager and provide an overall vision for software implementation and design. Mr. Lee has over a decade of experience as a business analyst and network engineer; he has been tasked with writing the business plan, leading the quality assurance efforts, and managing the HCI studies involved with the project. All student members will also backfill for one another.

What Changed Since 2005?

In 2005, Patrick Riley of the School of Information Management and Systems at the University of California at Berkeley presented the first prototype of mReplay for his Masters project. It ran solely as a Java J2ME-based application on a second generation (2G) mobile telephone. The mobile phone environment has changed tremendously in the past two years, with the introduction of multimedia rich transitional (2.5G) and third generation (3G) mobile technologies. Secondly, upstarts such as Orb and Sling Media have proven their financial viability as companies that place shift video content from user owned hardware to their mobile devices. Finally, the Web 2.0 social networking market experienced a tremendous boost in the form of YouTube; a company which successfully created a business model around a market that allows users to upload and share videos. Because of these factors, we believe that mReplay is poised to have significant impact in this market.

First, the new iteration of mReplay is now available on a range of computing platforms; users are no longer limited to using mReplay products on mobile telephones. mReplay 2.0 is based around two offerings: mReplay Professional and mReplay.com. The former is a professional package that includes hardware TV tuners and software for users to install in their home systems. These capture video feeds from broadcast sporting events automatically, which then can then be replayed via their mobile telephones. This is at the pith of what the original mReplay project was about. The second offering, mReplay.com is an online service. It allows users to upload videos of sporting events, whether it is a captured feed from a professional sporting event or even a home video of a high-school football game. This mReplay.com service is the primary push of the 2007 UC Berkeley School of Information final Masters project.

Although the primary goal is to allow users on mobile devices to access their sports-related content, the openness of the backend platform permits users to watch their replays on other devices, such as Internet connected computers. However, for the mobile purists with the latest in mobile technology, the new mReplay 2.0 application will make use of Adobe Flash Lite on mobile platforms to provide a richer, fuller multimedia sporting experience.

Secondly, in 2005 Mr. Riley brought up the idea of fan democracy, in which users could vote in real time if a given play was accurate. Although this was a harbinger of social networking capabilities to come, it was limited in scope- both in the available responses (i.e. yes or no answers) and the fact that questions were not posed by the user. mReplay 2.0 goes far beyond this, and embraces social networking aspects popularized by YouTube. For example, sports fans can meet fellow fans, subscribe to the content of popular contributors, and pose and answer questions in real time.

Finally, the 2005 project failed to fully address the legal ramifications of video ownership and sharing. Traditionally, broadcast rights to video feeds are owned by the sporting leagues, stadium operators, and local broadcasters.[2] The 2005 project essentially fed video straight to a centralized location on the Internet for rebroadcast to

[2] Hu, Jim. "Baseball officials plan live video streaming." *News.com* 30 Oct. 2001. 30 Apr. 2007 <http://news.com.com/2100-1023-275123.html>.

any mReplay user. Though appropriate as proof of concept of an academic project, the practicality of building an infrastructure around this was stunted. However, this new version of mReplay allows for more flexibility in video content ownership and management. The professional package of mReplay 2.0 requires users to provide their own video for rebroadcasting to themselves. The only information that resides on mReplay's centralized servers is the metadata around the video feeds, necessary for searching and cataloguing, and the social networking aspects of the product.

Business Models

After Google's 2006 acquisition of YouTube,[3] Google CEO Eric Schmidt rationalized the $1.65 billion purchase by proclaiming online video as the next frontier for the Internet. Mr. Schmidt said, "The best chance for success for all the startups vying for attention is to either come out with a next-generation product that takes online video functionality to the next level, and/or target a specific niche market."[4] Given Mr. Schmidt's optimism, we ask: *what is the opportunity for mReplay 2.0?*

Presently, there is currently no online service providing exclusively instant on-demand sports videos. mReplay 2.0 combines the simplicity, functionality, and user-built strengths of YouTube with an emphasis on sports content similar to ESPN.com. Additionally, this version of mReplay 2.0 has the qualities of IPTV, search, social networking, and is embedded with other online communities.

With mReplay-themed products and services, users have the ability to easily share, watch, vote on, and discuss replays with other mReplay.com users.

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[3] Murchinson, Jon. "Google To Acquire YouTube for $1.65 Billion in Stock." *Google Press Center* 9 Oct. 2006. 30 Apr. 2007 <http://www.google.com/press/pressrel/google_youtube.html>.
[4] MacManus, Richard. "YouTube Wannabes: online video market post GooTube." *ZDNet* 15 Oct. 2006. 30 Apr. 2007 <http://blogs.zdnet.com/web2explorer/index.php?p=283>.

Furthermore, the mReplay system provides a unique medium for building a community of fans, whether it is for a popular professional baseball team, or a small high school football team.

Products and Services

Sporting fans attend live events to show their support for their teams, to enjoy the ambiance of a live game, and to just relish the thrill of being there. Simply, it is live, raw, and uncensored. By going to a live event, attendees gain the extra sights, sounds, and smells of fellow fans; however, they lose a little in terms of the presentation of the event itself (e.g., knowledge of what is going on in the field). On the other hand, fans watching the event on television receive more information about the event; such as slow-motion playbacks, highlights, overlaid scoring and statistics, and live commentary. For example, during Game 6 of the 2004 World Series Playoffs, over 25,000 mobile phone calls were made by attending fans to home viewers to determine what was going on during an umpire review of a controversial play. The mReplay 2.0 infrastructure will rectify this.

To briefly summarize the potential of mReplay 2.0, we envision its infrastructure will embody the following concepts:

- Platform independence; mReplay will work on mobile phones, PDAs, handheld video game systems, and Internet-enabled personal computers.
- Social-networking integration enabling voting, profile pages, fan interaction, and video uploads and sharing.
- Leverage existing 2.5 - 3G mobile networks to provide users with a highly responsive and rich experience.
- Primary client-side application will be coded in Adobe Flash Lite to provide the fullest user experience.
- The AutoPilot feature of mReplay Professional can be divided into two components; one deals with video feeds while the other addresses metadata and indexing. This flexibility allows for different revenue models to be pursued throughout the life of mReplay.

- True place-shifting. Fans are given complete control over which replays to watch and when to watch them, regardless if the game is live or occurred ten months ago.

As stated earlier, mReplay 2.0 consists of two sets of products and services, mReplay Professional and mReplay.com.

mReplay Professional

mReplay Professional is a complete package, that will provide a TV-tuner and the mReplay Capture Tools. In many regards, this follows mReplay 1.0's client-server model. The server is the home user's PC with the tuner card and mReplay Capture Tools, while the client is some other web-enabled PC or a mobile computing device. The server side (i.e., the AutoPilot Backend System) provides 10 second video feeds to clients, such as a mobile phone viewing mReplay.com. These feeds can be highlighted and extracted either manually or automatically; this will cater to the technically-challenged crowd while maintaining flexibility for power users. These tools will also provide automatic replay capture detection. This is accomplished by detecting what may be considered an interesting play, and then automatically clipping it into a Flash Lite video format that can be uploaded to the mReplay.com website.

The client-side application connects to various mReplay servers over the Internet either wired (for PCs) or wirelessly via the wireless access protocol (WAP) or 802.11 wireless networking (for mobiles). Users can call up replays from any point of any game that is within the server's storage. Aside from watching instant replays, users will be able to vote on particular polls regarding the game. For example, typical poll topics will include favorite player, best play of the game, or if they think an official call was accurate.

This setup provides the user the ability to watch and record a sports game, regardless of where they are, so long as the user has an Internet connection. For example, if the mReplay Professional user is in New York on a business trip, this user can still watch a local Bay Area college game on a 2.5-3G mobile mobile telephone or an Internet-connected personal computer. This user can also record highlights or the entire game remotely if he so chooses.

The mReplay Capture Tool allows for both automatic detection and creation of highlights; users are provided the additional flexibility for manually creating highlights. The automatic detection and highlight extraction is known as the Autopilot Backend System. With our easy tools for creating highlights, sports fans, coaches, family members, or friends, can quickly create a replay video of their favorite athletes. There would only be the one-time cost associated with this package, given the inclusion of a TV-capture card. Though, users would need minimal knowledge to install the device and its drivers.

mReplay.com

This website allows any Internet user to search, watch, vote on, share, collect and discuss sports highlights. With functionality similar to YouTube or other video sharing websites, mReplay specializes in sports replays; the highlights are uploaded by creators that have captured them using mReplay Professional. Users can then search against games, genres, players, and venues for replays, then watch them instantly. Even if a game is currently being played; they can watch, vote on, comment and share the replays as soon as 10 seconds after they have occurred live. A user can use mReplay.com to watch highlights, comment on, or share replays with friends and family from any location. mReplay.com provides this type of place-shifting technology in an easy to use, YouTube-like interface that millions of computer users are already familiar with. The following two examples demonstrate the potential value of mReplay.com.

Example 1: Parent of a High School Football Athlete

Imagine a high school parent who wants to help his son to obtain an athletic scholarship. He has already recorded his son's football games with his video camera, and knows the team also films each game. Furthermore, this parent has access to the team's video archives. By using the mReplay Capture Tool, he can within minutes create a multimedia profile page on mReplay.com showcasing his son's best touchdown receptions and a special section on how his son helped the team win the state division. He has also linked his son's profile page to his high school football team's page, and wrote messages to his son's top college choices with the link to his son's mReplay profile page.

Example 2: A Member of the Raider Nation

We revisit the dramatic event outlined above in the opening paragraphs; the advent of a diehard, obsessed member of the Raider Nation. This fan wants to make available all of the most exciting plays in the Raiders' history. This fan can use the mReplay Professional device to automatically capture and parse the replays and generate game summaries. He can also take footage of previous Raiders games and easily create replays and game summaries. Lastly, he can upload and share these replays online at a site like mReplay.com, all fans could enjoy them anytime and anywhere.

Promotion and Marketing

Beta Release

Given the grassroots, user-community approach we are pushing for mReplay 2.0, we feel that anything short of a viral marketing campaign would be a disservice to the mReplay umbrella of goods and services. We expect to use viral techniques to disseminate news while simultaneously generating buzz about mReplay 2.0. This will allow us to develop our service while building a robust user base and minimizing advertising costs. We will also pursue cross-advertising schemes with potential partners and other websites.

This approach is currently very trendy within the realm of information systems. YouTube promotion was an obvious inspiration; but other traditional corporate entities have also successfully used viral advertising. For example, Microsoft used a very successful ilovebees.com to virally promote its Halo 2 video game in 2004.[5] Ultimately, this approach is extremely amenable to mReplay because many sports fans are expected to talk about the service with others during the process of a game when important plays occur (i.e. a touchdown in football or a major foul call in the last two minutes of a basketball game). After games are over, people are likely to gather to watch their favorite replays and share opinions as to what actually happened.

Public Release

Upon public release of the site, there will be a heavy promotion drive geared towards college sporting events; specifically football and basketball venues. Again, the goal is to minimize direct advertising expenditures and let word-of-mouth drive the

[5] Thorsen, Tor. "Ilovebees.com pinpoints upcoming Halo 2 events." *GameSpot News* 2 Nov. 2004. 18 Feb. 2007 <http://www.gamespot.com/news/2004/11/02/news_6112051.html>.

product. Much like viral campaigning, college sports venues provide an inexpensive, yet-highly zealous crowd to promote against. Eventually, we may also consider online advertising using the major networks; however, this is subject to how we manage partnerships. Our paid advertising will primarily be used to promote our platform services (not the website). Viral networking will continue to play an important role in this phase and will be enhanced through our mainstream means of advertising.

Projected Business Opportunities

After a semester of review and discussion with various sources, we devised three initial targets for projected business opportunities. These are in hardware and software sales, an ad-based model around free Internet service, and partnerships.

Hardware and Software Sales

The main drive of this opportunity is the mReplay Professional package, given that it consists of both hardware and software. The hardware being the capture device, while the software will be used to extract (either on autopilot or manually) sports replays, and provide the remote viewing possibilities of watching and capturing sports games. Based on current MSRP costs of compatible USB TV tuners on the market, we believe this package would be roughly $100. Furthermore, given that the hardware and software reside on the user's home system, they own the content for personal use. This should sufficiently allow us to skirt any legal issues regarding our liability in re-broadcasting video feeds.

As an option to maximize the various business opportunities, mReplay 2.0 may be released in multiple phases. Hardware and software sales would be relevant to the first phase of mReplay 2.0. Given the hardware and software nature of this opportunity, mReplay can be marketed to the Build-it Yourself (BIY) crowd. Hardware and software sales may also allow us to purse an original-equipment manufacturing (OEM) channel in which we sell build-to-order, home media PCs powered by mReplay 2.0. There is potential for this given the possibility of users preferring not to build their own Autopilot servers at home, already having a heavily loaded PC, or simply desire a system dedicated to sports replays. This also feeds into another area of opportunity, partnerships; we may be able to find applicable OEM or system sellers that are interested in preloading mReplay wares on their devices. For example, we could negotiate with Dell to preload mReplay software.

Free Internet Service

With mReplay.com, we can support a various types of advertisements; this includes targeted textual advertisements, video clips, or Flash-animated montages. Based on conservative models, we have estimated cash flows relating to mReplay.com's advertisement-based income in Appendix A. Users can also upload their own replays that they have manually edited and recorded with their own capture cards (and our capture software); similar to how users currently use YouTube.

Partnerships

mReplay Professional and mReplay.com products and services provide us with a unique opportunity to pursue partnerships. These include, but are not limited to, sporting leagues, providing teams, and companies (i.e. sports-marketing firms). For example, a viable partnership would include hardware TV tuners for the mReplay Professional package, or NFL films as an online avenue for its NFL-video service. We believe mReplay 2.0 would be a lucrative partner given its advanced automatic replay capture technology, advertisement-revenue sharing potential, and cross-marketing capabilities. Other partnerships could include deals with an exclusive search engine company, or having mReplay videos embedded in other sports-related websites. An example of the latter would be Rivals.com,[6] which is a fan-based enthusiast site that documents which high school athletes are signing with specific collegiate teams.

As suggested in the *Hardware and Software Sales* section, if mReplay products gain sufficient traction, the software may capture the attention of large-scale DVR or systems providers. This will enable tremendous cross-marketing capabilities, and each participating actor to concentrate on their respective specialties. Potential partners within this space would include Comcast, DirecTV, Microsoft, and Sling Media.

Potential Audience

The consumers interested in mReplay Professional are more likely the avid sporting fans who want to provide highlights for their favorite teams, thus feeling more involved with their teams. These zealous sports fans also do not want to miss a single game, even if they have business trips during the season, and can use mReplay to place-shift the games to their remote location. This is extremely valuable, considering that technically savvy sporting fans between the ages of 18 and 34 are a prime marketing target.[7]

Another group likely to be interested in purchasing mReplay Professional would be those who are employed by sports teams. For example, this includes athletic directors of collegiate programs, high school coaches and their staffs, or talent scouts.

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[6] Mills, Elinor. “Report: Yahoo vying to buy Rivals.com.” *News.com* 12 Apr. 2007. 30 Apr. 2007 <http://news.com.com/8301-10784_3-6175619-7.html>.
[7] Stanton, David. “Staying a Step Ahead of the New Marketing Paradigm: Artie Bulgrin.” *Knowledge Networks* 1 Nov. 2005. 30 Apr. 2007 <http://www.intersurvey.com/know/2005/fall/4-2_bulgrin.htm>.

Lastly, we believe parents with young athletes would want to capture and share sports highlights. This includes a wide range, from parents of little leaguers to those with ambitions of their children playing in collegiate athletics. mReplay 2.0 products and services would provide these parents with the tools to easily broadcast their kid's sports highlights and games to anyone with a 2.5-3G mobile mobile device or Internet-enabled personal computer.

Given any user can visit mReplay.com, this obviously covers an eclectic mix including sporting enthusiasts, athletes who wish to study other players, coaches for purposes, sports historians, journalists, casual fans, and more. Other users may be business individuals who travel quite often yet do not want to miss any games or memorable plays. Some of these users will likely just watch the videos; others may also share them with friends, fellow aficionados, or rival team fans. Some of these users will want to contribute to the discussion regarding a particular highlight, such as a controversial call, and leave either text comments or video comments.

Other sports enthusiasts will take advantage of the social networking aspects of mReplay 2.0 products and services. For example, some users may opt to subscribe to their favorite mReplay Pro contributors or favorite team profile pages to automatically receive updates on new replays when they are available; this is similar to the RSS model of Web 2.0 enabled websites. Others will use mReplay to meet fellow fans, or use mReplay to broadcast replays of players that they hope will go on to the next level of competition. Lastly, users at the stadium who have recorded their *in stadium* experience can also upload their personal videos that they captured with their digital camera or camera phone.

The third audience or users of our service will include companies that wish to align themselves with the leader in sports replays. They would use mReplay 2.0 products and services either to give their team more visibility, or to enhance their own specific services. As stated earlier, Rivals.com would be a strong example of such an audience.

Market Analysis

mReplay 2.0 is in position to becoming the first mover in the mobile sports-replay market. This amalgam industry essentially leverages four separate industries that are tremendously visible, but are plagued with competition and high barriers of entry. These sectors are the mobile networking (including Internet services), digital video recording (DVR), personal computing, and sporting event industries. The following facts from each of these domains provide the justification as to why we believe mReplay will become a successful venture:

- Over 219.4 million Americans are mobile phone users.[8]
- Over 205 million Americans are Internet users.[9]
- 34% of American Internet users have connected to the Internet via a wireless or mobile device.[10]
- 34% of mobile users who access the Internet earn over $75,000/year;[11] approximately 61.8% higher than the average household income of the United States.[12]
- 30% of mobile users who access the Internet are between the ages of 18 and 29; 49% are between the ages of 30 and 49.[13]

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[8] United States. The Central Intelligence Agency. The World Factbook: United States. 30 Apr. 2007 <https://www.cia.gov/cia/publications/factbook/geos/us.html#Comm >.
[9] United States. The Central Intelligence Agency. The World Factbook: United States. 30 Apr. 2007 <https://www.cia.gov/cia/publications/factbook/geos/us.html#Comm>.
[10] Horrigan, John. "Wireless Internet Access." *Pew Internet & American Life Project* 5 Feb. 2007. 23 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.
[11] Horrigan, John. "Wireless Internet Access." *Pew Internet & American Life Project* 5 Feb. 2007. 23 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.
[12] United States. Department of Commerce. Income, Poverty, and Health Insurance Coverage in the United States: 2005. By Carmen DeNavas-Walt, Bernadette D. Proctor, and Cheryl Hill Lee. Aug. 2006. 21 Apr. 2007 <http://www.census.gov/prod/2006pubs/p60-231.pdf>.

- The number of Americans with home broadband access jumped to 84 million by March 2006, and increase of 40% from the year before.[14]
- 11.2% of adult households own a DVR in 2006, up from 8.6% in 2005.[15]
- Spectator spending for sporting events is a $26.17 billion industry; of which, $11.74 billion is used on ticket sales alone.[16]

These statistics suggest that the realm of mobile sports replays consists of a technically savvy user base that is well versed in networking technologies and is familiar with HCI issues as they pertain to mobile telephones and digital video applications. More importantly, this user base has a large amount of disposable income available. Furthermore, these users fall into an age bracket that is highly targeted by the advertising industry.

Potential Competitors

We believe mReplay 2.0 is positioned to exploit a first-mover advantage. As stipulated earlier, the market mReplay will operate in is a combination of four other industries: mobile telephony, DVR, personal computing, and the spectator sporting events. There are competitors in each of these different segments that, at first, may be considered potential threats to MRI's entry into the mobile sports replay market. These essentially fall into two camps, live Mobile TV and video-on-demand (VOD) services.

Mobile television essentially allows users the ability to view television directly on their 3G mobile devices. Currently, there are two competing standards, Digital Video Broadcasting for Handhelds (DVB-H) and Digital Multimedia Broadcasting (DMB); the

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[13] Horrigan, John. "Wireless Internet Access." *Pew Internet & American Life Project* 5 Feb. 2007. 23 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.
[14] Horrigan, John. "Home Broadband Adoption 2006." *Pew Internet & American Life Project* 28 May 2006. 21 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.
[15] Kelly, Anne Marie. "Adults With Digital Video Recorders Upscale And Print-Oriented." *Mediamark Research Inc.* 26 Jul. 2006. 27 Apr. 2007 <http://www.mediamark.com/MRI/docs/press/pr_07-26-06_DVRs.htm>.
[16] "About Us – The Sports Industry." *Street & Smith's SportsBusiness Journal* 2007. 4 Apr. 2007 <http://www.sportsbusinessjournal.com/index.cfm?fuseaction=page.feature&featureId=43>.

former has gained traction throughout Europe, while DMB is readily available throughout Korea. Unlike mReplay, Mobile TV has a broader appeal in that users can watch any television, not just sports replays. Mobile TV feeds also include audio.

To mReplay's advantage, Mobile television signals are not on demand; it is just a unidirectional television signal. As such, Mobile TV users will not have the VCR-like functionality afforded to mReplay users. Secondly, special 3G telephones with a television antenna is required to receive a signal; this immediately limits the viability of Mobile television given that only a handful of devices support the technology. In addition, network support from the mobile provider is required for DVB-H or DMB. Currently, only Verizon Mobile provides support for broadcast-capable television signals.[17] The requirement for a special phone, service provider, and value-added service contracts becomes an onus on users. Finally, Mobile TV lacks the social networking aspects offered by mReplay. Standards such as DVB-H and DMB cannot natively accommodate for the social networking aspects that mReplay 2.0 includies. One possibility to incorporate social networking with DVB-H and DMB is if mobile network providers wrapped social networking components around the video standards as a value-added option.

Video-on-demand allows users to select and watch pre-established video files over a network. Within the realm of mobile VOD, the source material is streamed to the client's mobile device. As content is downloaded from the video servers, a buffer is established to allow users to view the video as it is downloaded; buffering also enables VCR-like functionality. Mobile providers such as Amp'd, AT&T/Cingular, and Sprint

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[17] Segan, Sascha. "Verizon V Cast Mobile TV." *PC Magazine* 23 Mar. 2007. 10 Apr. 2007 <http://www.pcmag.com/article2/0,1895,2108819,00.asp>.

offer the closest mReplay-like experience in that the VOD streams are *clip-cast*; that is, they are short two to three-minute clips or recaps of popular programs, chosen and streamed to the handset like Internet video.[18] Finally, VOD and clip-casts pander to a broader market in which all video content is applicable, not just sports-centric material. In addition, clip-cast content is typically buried under a hierarchy of difficult to use menus that force users to wait and re-buffer before they appear in a thumbnail-sized window. The mReplay infrastructure skirts this by empowering users with the freedom to choose their client device; whether it is a small 3G mobile device or a widescreen television connected to an Internet-capable PC. Examples of VOD services include Amp'd TV, AT&T/Cingular's MobiTV, Orb Networks, Sling Media's Slingbox, and Sprint TV Live.[19]

In many respects, these video servers provide functionality similar to mReplay's Autopilot Backend Systems. However, the key difference here is mReplay's sport-centric theme. The client-side application was designed specifically for the HCI mindset of a sporting fan. Rather than navigate convoluted menus and grids representing a TV Guide-like environment, mReplay lists one-line entries representing key plays throughout a given game. Secondly, VOD is typically a value-added service that requires an additional monthly service charge. So aside from requiring a 3G data plan, users will need to pay additional fees to receive content; much of which is not sports-related. For example, AT&T/Cingular requires users to pay an additional $19.99/month for access to the 3G Media Net data plan for unlimited data capability; obtaining special

[18] Segan, Sascha. "Buying Guide: I Want My Mobile TV." *PC Magazine* 4 Apr. 2007. 10 Apr. 2007 <http://www.pcmag.com/article2/0,1759,2109214,00.asp>.
[19] Segan, Sascha. "Buying Guide: I Want My Mobile TV." *PC Magazine* 4 Apr. 2007. 10 Apr. 2007 <http://www.pcmag.com/article2/0,1759,2109214,00.asp>.

content from ESPN, HBO, Univision, and other channels requires an additional charge that ranges from $3.99 to $5.99 per month per provider.

Legal Considerations

The original version of mReplay never truly addressed the legal ramifications of shared video content; this was perfectly reasonable given that it was purely an academic project, and there were few precedents of video sharing sites being attacked by corporate interests. However, in the two years since the original mReplay project was presented, the legal landscape has changed because of new challenges brought upon by innovative technologies and the business models that go along with them. Embedded video, multimedia blogs, Flickr, Google News, MySpace, and YouTube have all experienced heavy popularity growth during the two-year time frame between mReplay releases; these examples provide the necessary context for our legal considerations.

The first form of protection comes by way of the doctrine of fair use, which stipulates that an author may make limited use of another author's work without asking permission.[20] This doctrine is based on the idea that the public is allowed to use portions of copyrighted materials for purposes of commentary, criticism, news reporting, research, nonprofit educational usage, and parody. The four general rules to determining whether fair-use is applicable include the following:

- *Copies*: Source material copied verbatim without any transformative properties are usually considered a violation of fair use.
- *Competition*: Depriving the source of its livelihood, the less likely it can be considered fair use.

[20] "When Copying is Okay: The Fair Use Rule." *Nolo* 2007. 2 May 2007 <http://www.nolo.com/article.cfm/pg/1/objectId/C3E49F67-1AA3-4293-9312FE5C119B5806/catId/B2BF24DF-082A-4813-A840F5080C3EAB71/310/276/240/ART/>.

- *Quantity*: The more that is taken from the source, the less likely it can be justified as fair use.
- *Quality*: The more valuable the source material, the less likely it can be justified as fair use.

These four points allude to the idea that fair-use violations are of often the result of commercial gain. Now it is arguable that the mReplay system clearly violates all of these tests. However, upon closer inspection, this is not the case. First, the fact that users do not copy an entire game verbatim, but rather are limited to 10-second replays passes both the copies and the quantity tests. Second, these 10-second clips, relative to an entire game, are arguably less valuable than the source material as a whole. Finally, given that none of the major sports leagues have provided a mobile-replay service, the competition argument is somewhat unjustified. Furthermore, mReplay's commercial ventures can also be rationalized as beneficial to the source providers by providing an ancillary service that generates attention—and ultimately revenue—for the former.

Ironically, the second form of protection comes from the Digital Millennium Copyright Act (DMCA), a law that has generally been considered an obstacle to fair use.[21] This is because of the DMCA's *safe harbor* provision, which essentially protects the online service provider (OSP). This was added to the 1998 law to prevent the DMCA from neutering the Internet during its infancy; if every OSP was liable for anything any user did without its knowledge, the result would be very limited access to the Internet. Currently, YouTube is providing us with a precedent from this playbook.

As an OSP, YouTube is relying on its safe harbor status to provide an out for any copyright-infringement liability. Although a disgruntled copyright owner such as NBC or

[21] McCullah, Declan. "The Hill's property rights showdown." *News.com* 22 Jun. 2004. 2 May 2007 <http://news.com.com/The+Hills+property+rights+showdown/2008-1025_3-5243241.html>.

Viacom can supply the company with a legal notice of infringement, YouTube can still remain in the clear by merely identifying the infringing material and removing it; they are safe from damages. This is because YouTube is only hosting the videos. The company is not doing anything illegal in itself, but rather some of its users are. Adding fuel to this debate is the argument that YouTube has recently countered Viacom's lawsuit, stating that it has gone "above and beyond" the DMCA's requirements to deal with copyright infringement.[22]

However, YouTube's DMCA protection is contingent on its online service provider status; if the company loses its identity as an OSP, it can lose safe harbor. For example, one condition for possibly losing safe harbor is by showing how YouTube has directly profited by its user's malfeasance. This is completely viable in light of a somewhat analogous case of *MGM Studios vs. Grokster;*[23] in this situation, the legitimate uses of peer-to-peer networking ultimately failed to protect Grokster from the misbehavior of its clientele.

We make no promises that these are the necessary and finalized legal protections; from the examples provided, this is obviously a work-in-progress situation. However, it does bring to light some important points. First, YouTube—with Google's $144.8 billion market capitalization behind them—has the resources to test the limits of copyright law and answer some important legal questions. Are clips of longer video programs fair use? Does a company that attracts so much copyrighted material have a

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[22] "Google: Viacom suit threatens Internet." *CNNMoney.com* 1 May 2007. 2 May 2007 <http://money.cnn.com/2007/05/01/technology/bc.google.viacom.reut/?postversion=2007050107>.
[23] McGuire, David. "At a Glance: MGM v. Grokster." *Washington Post* 28 Mar. 2005. 2 May 2007 <http://www.washingtonpost.com/wp-srv/technology/articles/groksterprimer_033805.htm>.

chance to fight off charges of inducing or aiding copyright infringement? Does YouTube have a responsibility to make it impossible to download videos from their site?

Second, the attention brought upon by battles between content owners and video sharing sites somewhat legitimizes what we are trying to do with mReplay 2.0. We are no longer looking at it as a pedantic exercise as what is technically possible; but rather, is it practically, financially, and socially responsible? As students in a graduate program, we depend on research and lab-like environments to determine facts. Watching heavyweights such as Google and Viacom fight it out serves as our own little simulations.

Technology Review

Given that the mReplay Professional portion closely embodies the original 2005 project, the goal of the 2007 University of California at Berkeley School of Information team is to focus on the mReplay.com component. Although this paper makes a fair attempt at providing a well-rounded view of all aspects of the mReplay 2.0 infrastructure, the technology review will focus primarily on what the current team has done. However, we have dedicated a discussion on the mobile application at the end of this technology review section. Furthermore, the mobile landscape will also be revisited towards the end of the paper from the non-technical perspective.

Our plan of action for mReplay 2.0 was to develop the mReplay.com portion of mReplay 2.0. This is a website that will provide an interface for sports fans to share short video clips from their events. Additional functionality will allow fans to share replays, vote on clips (i.e. *did the player's foot go out of bounds?*), frame marking (i.e. mark the specific region of a frame showing the players foot is out of bounds), and clip search. An additional objective of the beta site is to create an interface for needs and usability assessment for the public release of mReplay 2.0 sometime in Q4 of 2007.

Release of this site will not be widely announced. Use of this site will be available to anyone who happens to know about it and use it, which primarily consists of stakeholders associated with the mReplay 2.0 project. Another important thing to note is mReplay goes beyond the School of Information; this project has already been presented to an angel investor for further development; much of this will occur after the 2007 team graduates from the University of California at Berkeley. As such, needs and usability assessment will be performed between June and September 2007, while development of the new public system is underway.

Preliminary Needs Assessment

Site functionality is based on the perceived user needs; specifically any sports fans. Given that the developers of this project are also avid sports fans, we have generated much of the list of user needs for the beta release of mReplay.com. We then pared the list down to allow for the development of a functional beta site in a short time allotted for this 2007 School of Information Master's project.

Video Extraction and Upload

Given that video extraction and uploading is the pith of mReplay 2.0, this task needs to be simplified as much as possible. To simplify this task, mReplay.com will provide a very easy-to-use form that asks the users to submit the following pieces of information:

- Event type
- Event date & time
- Copyright (if applicable)

- Title for clip
- Private or shared
- Clip file

Much of this information will later be used as metadata for textual searches against our database. Video clips will automatically be uploaded by the mReplay Capture and Analytics System. However, during our testing, both of these upload mechanisms have presented challenges. The first is in respects to how much information about a particular clip is stored. For example, the automated mechanism will store the exact time, sport, event, and other information about the clip; however, we are not certain about the level of detail that users will be willing (or need) to manually submit through and online form.

As an alternative, we are considering a simpler frontend to the form on mReplay.com, one that only asks for a clip title and filename. Once the clip is saved on our server, we will provide another form for the user to provide additional data about the clip (including linking the clip to a major sport event such as an NFL game). This is strictly optional; if they choose not to fill out the additional form, then the clip will simply be private and viewable only by the user's friends. This is analogous to Google providing a default search box on its website, sufficient to a majority of its users, while also providing a detailed *Advanced Search* option for fine-tune search.

User Management

Standard functionality for users to create an account and login to their account will be provided. Any user will be able to browse, search, and view public clips; however, an account will be required for users to create clips, mark frames, and vote. The options on the website for user management include the following:

- Create/edit account
- Login
- Manage frames, clips, and events
- Logout

User Interactivity

Given that social networking is a major push for this iteration of mReplay, the mReplay.com will include many options to foster interaction between users. These features aim to enhance the user experience and cause users to come back to view the clip more than once. For example, if there is a clip of a controversial call, we expect that there will be a poll asking users if the call was legitimate. In addition users will make comments that share their opinion. We feel that users will want to share the clips with friends to prove their point of view, show off an admirable play, or simply for bragging rights. This will become even more of a vivid experience given the power of mobile networks; this will allow users to feel a real and unfettered connection to their sporting event in real time, despite their locale. The options for user interactivity include:

- Clip search, browse, and view
- Frame marking
- Voting and rating
- Clip sharing
- Commenting
- Links to profile pages
- Subscription feeds to mReplay Professional users

Systems Administration

Administrative features facilitate the process of managing the site. The usage statistics subsystem will provide information useful for determining what users are using; this will also aid in further development. The automation subsystem will provide an interface for the capture and analytics project. This is so that events can be created and clips added from major sporting events automatically and in real-time. The monitoring subsystem will keep track of events that occur and log them. The features of interest on the site include:

- Browse/edit/delete users/groups/frames/clips/events
- Manage polls and ratings
- Usage statistics subsystem
- Automation subsystem
- Monitoring subsystem

Physical Implementation

There are two types of technologies involved the projects. They fall along server-side and client-side technologies.

Server-side Technologies

The goal is to setup a secure, stable, and reliable environment that can be expanded rapidly and in a timely manner. The initial hardware setup will include a single Linux box that is running a database and web server with limited bandwidth. As demand increases, we will expand our hardware and bandwidth requirements. We have identified the programming environment to consist of a standardized LAMP stack—based on Linux, Apache, MySQL, and the PHP development language.

Client-side Technologies

The goal is to provide a rich, interactive user experience that is simple and easy to use. Graphics will be kept to a minimum and the necessary (and useful) features will be prominent. We want the system to harness these technologies to fulfill a social and user need. Applicable technologies within the client-side include Asynchronous JavaScript (AJAX), Flash Video, JavaScript, SVG, XHTML, and XML.

User Interface Design

mReplay 2.0 will feature a clean and simple design, similar to the YouTube and Google experience. Basically, we expect to provide a minimalistic and simple interface to allow users to do exactly what they want. There are two basic page layouts for the beta site; the first is the homepage while the second is a standardized template used for the inside pages on mReplay.com.

Home Page Design

The home page will be composed of three panes from top to bottom. The top pane will hold the logo, a search box, and two navigation bars. The first navigation bar will be specific to the user (i.e. *Sign Up, Login, My Account,* and *Help*). The second navigation bar will be used for video browsing and uploading. The video browsing will consist of a single link to a page where users can browse through videos through filtering mechanisms (i.e. by date, sport, or most popular).

Most recently added videos will be shown in the middle pane and will scroll from right to left. Every thirty seconds, the page will refresh the feed and update the respective panes. Each video will be represented by a single frame (an image file) along with pertinent textual information above around it. Users can click on the frame to view the video. All videos represented in this pane will be approved by an administrator (i.e. a local high school video that was just uploaded will not be shown in this pane by default). Usually it will consist of major sporting event video replays. Eventually users will be allowed to customize the video feed presented in this pane.

Below the top two panes will be a list of the most popular video clips that are publicly available. Videos will be presented from top to bottom (most popular to least). There is debate as to the value of this content; some argue in favor of not including this pane while others would like to see other content. Usability testing will determine the final layout of the public mReplay 2.0 website.

Inside Page Design

Each inside page will consist of the same top pane as the home page. Below the top pane there will be a sidebar on the right and an information area on the left. For example, if the page displays a video clip, then the information displayed on the right sidebar will hold contextually specific interactions, such as a list of related videos. Below the video, user comments will be displayed; user ratings and voting information will also be available. Another example is the case where a user is uploading a video; in this scenario, the right sidebar might contain help information and the information area will hold the form that the user will fill in.

Again, these are all preliminary design decisions. These are subject to change, depending on the results of our usability studies.

Database Design

The database will consist of approximately twenty tables that will maintain records about users, clips, comments, events, voting, and so on. The following is a brief discussion of each table and their respective function.

The first set of tables relates to users and contains information about them. These allow a user to login, create an account, join a group, and have an identity that allows them to interact with others and the system itself:

- *User*: Contains user specific information such as username and password. It links to any table wherein the user interacts with a feature that has a table (i.e. voting).
- *User Group Relation*: Bridges the many-to-many relation between groups and users. Users can be a member of many groups and groups can have many members.

- *Group*: This table contains a list of all groups. Eventually the groups will have clips associated with them as well as other functionality. For now the interaction is kept to a minimum.

A second set of tables relates to the video clips that are taken from events. There are four entities as of this time. The relationship is such that an event must have a minimum of one or more clips, and that a clip must have zero or more frames. Each event has one event type:

- *Frame*: Holds individual frame information. When an individual frame within a clip is marked (by a user), then it is added to this table. Users can then mark a region of a frame and use that as a basis for interaction. For instance, foul call is made and a user finds the specific frame where the event occurred. The user puts a square on the region of the frame where the foul occurred to show others what happened.
- *Clip*: Contains a list of clips, the events they are associated with, and the location of the clip in the file system.
- *Event*: Each event corresponds to a real-world sporting event (i.e. a basketball game). These events are then associated with individual clips that correspond to significant plays that took place during the event (i.e. a foul call, a slam dunk, a pivotal possession change, etc.).
- *Event Type*: This contains a list of event types that can be created. Obvious examples are NFL Game, MLB Game, College Football, and NHL Hockey.

A final set of tables relates to the user interaction that takes place between each other and the media. Each event, clip, or frame will be able to associate with a set of ratings, polls, or user comments. This is what powers the social networking aspects of mReplay 2.0. These tables link to the user and corresponding media tables:

- *Event/Clip/Frame Rating*: This table manages individual user ratings for specific media. Each rating is associated with a user, a media table, and a rating data table.
- *Event/Clip/Frame Rating Data*: The rating data is necessary to keep track of metadata each individual rating that is taking place for a given media.
- *Event/Clip/Frame Vote*: This table maintains individual user votes for a specific piece of media.
- *Event/Clip/Frame Vote Data*: Voting data is necessary to keep track of meta-data each individual poll that is taking place for a given media.
- *Event/Clip/Frame Comment* : This table deals with individual user comments for specific media.

Mobile Technologies

Developing mobile applications comes with several challenges, such as the limitations of devices; and hardware and software divergence. For mReplay 2.0 to work with mobile devices, there are two primary challenges. First, because of the hardware limitations of mobile devices, video playback is generally limited by the codecs supported by the device hardware; as of this time, there is no universal codec supported by all devices.

The second challenge is finding a common platform for development, deployment, and execution of the mReplay application on mobile devices. Several different platforms exist and will be discussed later.

Limitations of Mobile and Wireless Devices

There are several limitations[24] presented by mobile applications including speed of CPU and amount of ram, screen size, and networks and connectivity. Each of these (and more) are discussed below.

CPU Speed and RAM Size

At present, the CPU speed of mobile devices is in the range of 300-500MHz. RAM is also very limited. This makes it difficult for CPU and memory intensive applications to function smoothly. For instance, video applications must be scaled down (in terms of quality and length), but this gives the user a watered-down experience. Video can be processed on a separate chip, but this means that each device may support only one or two video codecs; making it harder for applications to work with all

[24] Mikhalenko, Peter V. "Best practices for mobile Web application development." *TechRepublic* 18 Jul. 2006. 2 May 2007 <http://articles.techrepublic.com.com/5100-3513_11-6095452.html>.

devices. Flash Lite is most limited with RAM. The player is allocated 400Kb and the application is given 350Kb for whatever it needs.

Display Size, Resolution and Color

A variety of display resolutions and sizes exist. This means that applications need to be developed to handle differences. Flash Lite handles this area well because it supports scalable vector graphics. Unfortunately video content is designed for one resolution, presenting a challenge for mReplay. One solution is to choose the most common resolution and test the application on devices run at this resolution. However, we expect that by 2008, color phones will have reached a 96% penetration rate.[25] All phones will support at least 16-bit color display, which should present few limitations for mobile application development.

Networks and connectivity

With the advent of 2.5G and 3G (and 4G in the future) networks speeds are slowly becoming fast enough to handle higher data rates. Even if network speeds are fast enough, users may decide to not allow the application to have network connectivity. Further, not all devices have 3G coverage or GPRS connectivity. This presents challenges for applications developed on any platform. Allowing users to cache data for offline use is one consideration, but is not desirable for social networking applications that rely on always-on network connectivity. Fortunately more users in North America are becoming data centric, and persistent connectivity is less of an issue.

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[25] Jakhanwal, Vinita. "Mobile Phones Migrate to TFT-LCD Displays." *iSuppli Applied Market Intelligence* 14 Feb. 2005. 2 May 2007 <http://www.isuppli.com/marketwatch/default.asp?id=283>.

Data storage

Mobile devices are equipped with increasingly more storage (ranging from a base memory of 64MB-512MB and upwards). The storage can also be increased by an additional 1-2GB through the use of specialized media cards.

Human Computer Interaction

User interaction with mobile applications is much more challenging than with computer applications. Users expect near-real time response in terms of loading and getting the response expected. This is especially critical with real-time applications that deliver video and other media content. This requires the user interface to be easy-to-use and work well on each device that it runs on (contrasted with the typical mouse and keyboard found on a computer).

Mobile Application Development Platforms

Several application development platforms for mobile devices are presented in this section; we summarize each of their advantages and disadvantages. Flash Lite is the current platform of choice for mReplay 2.0 because it has many distinctive features that add to a more fulfilling experience for the user.

Java 2 Mobile Edition

Java 2 Mobile Edition (J2ME) is arguably the most established platform for creating applications on a variety of devices. This is primarily because of its small form factor and ease-of-use. There are several advantages that J2ME offers. It is object oriented, mature, and enforces best programming practices. Furthermore, due to its maturity, its virtual machine is fairly fast, provides a secure sandbox for applications to operate, and has a large community of developers. The disadvantages are that it has device-dependent behavior because of the various profiles and configurations.

Symbian Native C++

This framework allows C++ applications to run natively on the device. However, it is less portable, but offers more speed and more control over the device. Everything is natively compiled and there are a vast number of C++ libraries that have been developed over the past four decades. Furthermore, Symbian Native C++ has the ability to interact with local storage and low level features of the hardware itself. Its disadvantages are its steep learning curve and long development cycles.

Binary Runtime Environment for Wireless (BREW)

Developed by QUALCOMM for CDMA-based phones, it provides an SDK for testing applications written in C and C++. It provides all the functionality of C++. It also provides security since all programs must be digitally signed to run on a device. However, this in turn requires an application review process by QUALCOMM. BREW also provides an online marketplace for distribution and sale of applications. On the downside BREW requires specific handset support. It also shares many of the negative aspects of C++, such as lax memory management and the steep learning curve.

Python for Symbian

A language favored by many as a great example programming language. It allows the program to write using object oriented, structured, or functional programming paradigms. Python applications may be compiled and natively installed using the Python SDK, but it still requires an interpreter on the mobile device. Further, it supports all of a phone’s capabilities. On the downside, Python does not provide a graphical API which means that the developer has to write their own rudimentary graphical routines. Further, there is a limited user community and the API is specific to the Symbian platform.

Flash Lite

The Adobe Flashe Lite platform is a subset of the Flash platform for desktops. It provides a subset of the standard functionality as well as functionality designed for mobile devices. Flash Lite is appealing because it brings with it all the advantages of Flash; this includes a 97% penetration rate on desktops, scalable vector graphics, software and hardware platform independence, and *Action Scripting*. The main disadvantage of Flash Lite is that it is relatively new. However, Flash Lite 2.1 offers most of the functionality of Flash Player 7 including Action Script 2. It also provides XMLSocket connection support and video playback.

Three primary components compose the Adobe Flash suite of applications for its mobile platform: (1) Flash for Pocket PC, (2) Flash Lite, and (3)FlashCast. Flash for Pocket PC and Flash Lite allow Flash applications to run on devices that have the player installed; FlashCast is a streaming technology that allows distribution of rich media services over a dedicated mobile network.

For the mReplay 2.0 project, the Flash Lite platform is the top choice because it offers streaming video and it is expected to have a high penetration rate in the near future.

Search Technologies

The mReplay 2.0 can potentially house a tremendous number of individual, 10-second video clips. Thus, given that we have positioned mReplay as an easy-to-use solution that allows for users to easily interact with one another and the system as a whole; we need to devise a better solution for navigating the multimedia database. A straight forward directory listing is insufficient. For this phase of the release, we are relying on the database design to perform sufficient query lookups; however, in the long run we are not confident that this is scalable. As such, this is an appropriate time to discuss search engines and the future of mReplay.

Search engines have become the enabler of the consumer Internet. Regardless if the focus is on static content or dynamic material, search engines facilitate information retrieval for the lay person. On a given day, approximately 60 million Americans use a search engine to locate information, making it the second most-used activity on the Internet behind e-mail.[26] Furthermore, major search providers such as Google, Microsoft Live Search, Yahoo, and Ask.com index 8, 5, 4, and 2.3 billion documents, respectively.[27] The corpus of documents managed by these Internet powerhouses allow for the average consumer to search for anything, ranging from the frivolous to the serious.

This situation begs the question, *what is a document?*[28] Superficially and traditionally, this would refer to a textual record. By this definition, typical information retrieval systems embodied by Google, Microsoft, Yahoo, and Ask.com are more than capable of handling textual requests; their recall and precision at fulfilling a user's request from multi-billion document corpuses is extremely accurate. This is not

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[26] Raine, Lee and Jeremy Shermak. "Search Engine use November 2005." *Pew Internet & American Life Project* 2 Nov 2005. 19 Feb. 2007 <http://www.pewinternet.org/pdfs/PIP_SearchData_1105.pdf>.
[27] Glassman, Mark. "Are Bigger Search Engines Better?" *The New York Times* 22 Nov. 2004. 21 Feb. 2007 <http://www.nytimes.com/ref/business/media/041122MOSTWANTED.html?ex=1101877200&en=e71524f6>.
[28] Buckland, Michael. "What is a document?" *Journal of the American Society of Information Science* Sept. 1997. 28 Feb. 2007 <http://www.ischool.berkeley.edu/~buckland/whatdoc.html>.

surprising, given the advances of modern technology, the modern search algorithms, and highly tuned search indices used by these corporate giants. However, by changing the definition of a document to include non-textual elements (i.e. audio and video) these consumer-grade search engines become woefully inadequate. This is what mReplay 2.0 has done; it effectively enables a corpus exclusively of 10-second multimedia segments.

Multimedia search is becoming more important for several reasons. First, content has obviously extended beyond simple ASCII text. Secondly, as broadband capability continues to develop, users will consume larger amounts of multimedia-based data.[29] This is especially poignant considering that, as of March 2006, there are over 84 million broadband connections in the United States.[30] Finally, as networking becomes more pervasive, users are beginning to access the Internet via mobile devices, such as mobile phones and handheld computers that are aimed at delivering information in non-textual formats. For example, the growth trend in the United States for mobile devices is expected to sustain itself; with the number of mobile users surpassing the number of land-line subscriptions in the future.[31] These are all relevant issues to the realm of mReplay 2.0.

We will evaluate the current commercial systems of using textual metadata to catalog collections of multimedia. Secondly, we will review the landscape of forthcoming content-based image retrieval (CBIR) systems that profile certain

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[29] Horrigan, John. "Adoption of Broadband to the Home." *Pew Internet & American Life Project* 23 May 2003. 21 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Broadband_adoption.pdf>.
[30] Horrigan, John. "Home Broadband Adoption 2006." *Pew Internet & American Life Project* 28 May 2006. 21 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.
[31] Horrigan, John. "Wireless Internet Access." *Pew Internet & American Life Project* 5 Feb. 2007. 23 Apr. 2007 <http://www.pewinternet.org/pdfs/PIP_Wireless.Use.pdf>.

characteristics of multimedia objects, which in turn provides the basis of a search query; this is the distinction of looking for a file labeled Tom Brady versus locating a video file similar to a provided video of Mr. Brady.

Text-based vs. Content-based Search Engines

In general, text-based search engines require some degree of manual annotation of the metadata for multimedia files. There are a few limitations to this approach. First, the corpus of multimedia objects is typically large; thus extremely inefficient for human crawlers to navigate and tag objects as necessary. Secondly, even if all documents could initially be tagged; the tagging is only valid for one language. Furthermore, there are problems with the perception of those tasked with the tagging. For example, the amount of subjectivity involved combined with the fact that many objects are multi-faceted can lead to improper or inconsistent tagging. Finally, text-based annotations are of no use in which the queries cannot be described. This can happen when dealing with images that may seemingly be random splashes of color; this picture may seem random to a human indexer, however there may be value just in the ratio of colors or shapes present within the image. This is evident in reliable message detection in steganographic work.[32]

Search engines such as Google, Microsoft Live Search, Yahoo, and Ask.com have alleviated some of the difficulties associated with traditional text-based search engines, such as manual annotation of indexes. These providers are extremely accurate at answering queries for textual information because of their vast indices have been automatically created from words that were culled, stemmed, and processed from

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[32] Yu, Xiaoyi, Tieniu Tan, and Yunhong Wang. "Reliable detection of BPCS – steganography in natural images." *Third International Conference on Image and Graphics* Dec. 2004. 28 Mar. 2007 <http://ieeexplore.ieee.org/Xplore/login.jsp?url=/iel5/9682/30566/01410452.pdf?arnumber=1410452>.

text-based documents. For example, entering the words *Oakland Raiders* into Google with the intent of locating a text file concerning canines is a natural exercise; ultimately, the words Oakland Raiders will or will not be matched against the index for documents containing the word. Furthermore, providers such as Google and Yahoo are becoming heavyweights within the video-search engine space. Here, they apply their text-based technologies to the corpus of multimedia they maintain; their indexes are created from words associated with the videos. Although the specifics of their search and index algorithms are subject to trade secrets, companies such as Google and Yahoo are likely to consider the filename of the image, identifying ALT tags within the HTML code, words that appear close to the image within the HTML markup, the use of any META tags for the websites, and the nature of web site providing the image as factors when automatically indexing their image repositories.

However, using Google or Yahoo's image facility to locate the same search term is not as natural as their text-based searches. First, the search is somewhat contingent on the meta-data revolving around the multimedia documents. Going back to the Oakland Raiders example, regardless if the multimedia object embodies an Oakland Raider, a query's success is ultimately determined if either search term is attached to the video as part of its meta-data. This of course, is not guaranteed; there is nothing inherent for automatically yet accurately generated metadata information is attached to multimedia objects as they are created. Secondly, a video containing scenes of a football player is only semantically meaningful to a human, not an information retrieval system. Although the same argument can be made about a text document with the words Oakland Raiders; multimedia searches are handicapped against text-based systems given the latter's inherent ability to naturally index the content without metadata or manual intervention from the content owner.

Content-based search engines have been devised to rectify the shortcomings of text-based search technologies that have been applied to multimedia data. These systems analyze the content of a multimedia document for its features; for example, a content-based system for image or video data would particularly query for color, resolution, shapes, textures, and other visual cues that can be derived from the file.[33] This ultimately takes the responsibility of forming the query away from the user since each multimedia object is described by its given features rather than arbitrarily assigned metadata tags. Once this multimedia file has been analyzed, it can be compared against other prefiled objects in a multimedia database. Content-based technology lends itself particularly well to queries by example;[34] for example, rather than searching for the words Oakland Raider, a user provides an image of a Bill Romanowski to the system and queries for images similar to the picture. The content-based system will extract features from this image and construct a query around them; this query will be used to compare the features against other profiled features in the database, and relevant images similar to that of the Oakland linebacker will be presented to the user.

Textual searches currently work hand-in-hand with our system; this is because users are presented with a form on the interactive website that requests additional metadata annotation about the videos they are uploading. However, there are two

[33] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

[34] Hove, Lars-Jacob. "Extending Image Retrieval Systems with a Thesaurus for Shapes." *Institute for Information and Media Science, University of Bergen* 12 Oct. 2004. 28 Apr. 2007 <http://www.nik.no/2004/bidrag/Hove.pdf>.

disadvantages to this. First, most of the metadata submissions are optional; as stated earlier, users can opt for a minimized version of the submission page that only requires name of file and title. Secondly, even if users opt to fill out the full version of the submission form, their descriptions are a series of individualized entries that may or may not sufficiently capture the full essence of what occurred within the 10-second clip. For example, back to our opening example of Mr. Brady and the Patriots; the user can annotate this crucial 10-second clip as *tuck* and the event type as *AFC Championship*. However, a separate user looking for the same content may be searching for a file called *Woodson* and an event type of *2002 disappointment*. The descriptions are too subjective and limited to scale effectively.

Content-based image retrieval systems attempt to associate some form of semantic value to image and video data; the goal is to achieve some degree of knowledge from the content of the file itself rather than from metadata about the file. The reason for manual annotation of metadata is due to human superiority over technology when it comes to applying semantics and meaning to visual data. However, with the advancement of both computing power and artificial intelligence, this gap is being mitigated. For automated indexers of visual data, the core of content-based retrieval revolves around two factors, primitive feature extraction and multidimensional indexing.

Whole Image vs. Subimage Matching

Before jumping into the realm of primitive feature extraction, it is important to make a distinction between objects within an image and the image itself. Retrieval can be divided into one of two classes, whole image and subimage matches. The former refers to an entire image, and a query is matched against entire images within a content-based image retrieval (CBIR) system. Whole match is commonly used in photographic-retrieval systems. In these types of scenarios, a single vector of features is quantified from each photograph and used for indexing purposes. Systems such as QBIC use this methodology.

While most classical CBIR systems are based on overall image comparisons, users are generally interested in searching for objects within the image; this is known as a sub-image match.[35] For example, a picture consisting of a Rams-Packer game may be classified by the system as a football game; but a user may be particularly interested in a Brett Favre in one section of the overall scene. Assuming users are looking for Mr. Favre, the CBIR should retrieve images containing this subregion. This is a somewhat difficult task given that IR systems have enough trouble discerning semantics from an overall picture, let alone a specific region of a picture. Furthermore, the different sub-image regions of a visual file may allow for multi-faceted, inconsistent, or incorrect classification of a photo. Sub-image regions are important to CBIR system because much of the color, texture, and shape differentiation occur at this level.

Primitive Feature Extraction

Much of this section's discussion on content systems has primarily dealt with feature extraction; that is, looking for general properties of colors, textures, and shapes. These are the most widely used areas of feature extraction for current CBIRs. As

[35] Sebe, Nicu, Michael S. Lew, and Dionysius P. Huijsmans. "Multi-scale sub-image search." *Proceedings of the seventh ACM international conference on Multimedia*. New York: ACM Press, 1999. 79 – 82. <http://portal.acm.org/citation.cfm?id=319901>.

CBIRs continued to advance, domain-specific features that are highly dependent of the application using the CBIR were able to perform facial and biometric identification.[36]

For color, histograms are traditionally used to denote the probability of the intensities of the red, green, and blue (RGB) color channels.[37] For example, the QBIC system makes extensive use of histogram similarities to extract color features. However, as the volume of image data increases, histograms have failed to scale. As a result, some CBIRs have looked at the use of color moments and sets to accommodate the influx of additional visual data. Color moments are calculations that provide a measurement for color similarities between images by looking at vectors in their mean, variance, and the skewness calculations.[38] Systems that make use of color moments include WebSEEk.[39]

Texture refers to the visual patterns that have properties of homogeneity that are contingent on the existence of multiple sets of colors and intensities.[40] Given that textures are inherent to all objects, they reveal important clues about the objects and their relationship to their environment. Within the realm of CBIR, there are certain

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[36] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

[37] "Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

[38] Shih, Jau-Ling and Ling-Hwei Chen. "Color Image Retrieval Based on Primitives of Color Moments." *Proceedings of the 5th International Conference on Recent Advances in Visual Information Systems*. London: ACM Press, 2002. 88 – 94. <http://portal.acm.org/citation.cfm?id=647062.714606>.

[39] Smith, John R. and Shih-Fu Chang. "Visually Searching the Web for Content." *IEEE Multimedia*. Los Alamitos: IEEE Computer Society Press, 1997. 12 – 20. <www.ee.columbia.edu/dvmm/publications/96/**web**seek-mm-mag.pdf>.

[40] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

factors of texture measurements that should be reviewed; these include the amount of contrast, coarseness, directionality, randomness, and regularity of patterns and textures.

However, texture retrieval is considered difficult for content-based image retrieval technologies. This is due to the fact that there is simply no single, uniform, and quantitative definition of what makes up a texture in visual data. Texture analysis has a long history; as such the algorithms for detection run the gamut from using random field models to multiresolution filtering techniques.[41] Further aggravating the problem is that textures cannot be represented by the most atomic value within a video frame, the pixel. For the most part, texture retrieval in CBIR systems requires segmenting an image into groups of different texture regions and then running the given texture analysis algorithms over each segment.[42]

Like textures, shape is difficult to index and search against given the inherent complexities involved with representing a multitude of shapes. This is simply not a matter of square versus circle; systems must account for a variety of factors which includes collisions of multiple shapes, the effects of illumination and shadows, issues revolved around a 3D object represented in two-dimensional space, and more. Despite the difficulties inherent to shape detection, shape is one of the core low level features for extraction within CBIR. Generally speaking, shape descriptors utilized fall within one of two camps, contour or region based.

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[41] Fauzi, Mohammad F. A. and Paul H. Lewis. "Texture-based Image Retrieval Using Multiscale Sub-image Matching." *Proceedings of IS&T/SPIE's 15th Annual Symposium Electronic Imaging: Image and Video Communications and Processing*. Santa Clara: SPIE, 2003. 407 – 416. <http://eprints.ecs.soton.ac.uk/8015/>.

[42] Fauzi, Mohammad F. A. and Paul H. Lewis. "Texture-based Image Retrieval Using Multiscale Sub-image Matching." *Proceedings of IS&T/SPIE's 15th Annual Symposium Electronic Imaging: Image and Video Communications and Processing*. Santa Clara: SPIE, 2003. 407 – 416. <http://eprints.ecs.soton.ac.uk/8015/>.

Contour-based methods utilize shape boundary information critical to human perception in judging the similarities in shapes;[43] however, this type of information is not always available. Examples of contour-based methodologies include Fourier descriptors (FD) and curvature scale space descriptors (CSSD). Alternatively, region-based methodologies only leverage the shape interior information and do not require the shape boundary information, thus are applicable to more generic shapes.[44] The disadvantage is that region-based methods cannot discern specific features local to the shapes. Examples of these types of region-based moments include grid descriptors (GD) and Zernike moment descriptors (ZMD). Ultimately, a combination of both categories of shape descriptors is optimal. Given that shape detection in CBIRs should be affine invariant, capable, concise, and easy to derive and matching;[45] methods such as CSSD, FD, GD, and ZMD are ideal for CBIR shape indexing.

Multidimensional Indexing

One key trait of multimedia, in comparison to text-based records, is that the files are large. As multimedia search becomes practical, the backend databases used to power multimedia search will become enormous. For example, the EOS Data and Information System (EDIS) is expected to collect roughly one terabyte per day of

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[43] Zhang, Dengsheng and Guojun Lu. “Content-Based Shape Retrieval Using Different Shape Descriptors: A Comparative Study.” *2001 IEEE International Conference on Multimedia and Expo (ICME ’01)*. Los Alamitos: IEEE Computer Society Press, 2001. 289 – 293. <http://ieeexplore.ieee.org/iel5/8766/27769/01237928.pdf>.

[44] Zhang, Dengsheng and Guojun Lu. “Content-Based Shape Retrieval Using Different Shape Descriptors: A Comparative Study.” *2001 IEEE International Conference on Multimedia and Expo (ICME ’01)*. Los Alamitos: IEEE Computer Society Press, 2001. 289 – 293. <http://ieeexplore.ieee.org/iel5/8766/27769/01237928.pdf>.

[45] Zhang, Dengsheng and Guojun Lu. “Content-Based Shape Retrieval Using Different Shape Descriptors: A Comparative Study.” *2001 IEEE International Conference on Multimedia and Expo (ICME ’01)*. Los Alamitos: IEEE Computer Society Press, 2001. 289 – 293. <http://ieeexplore.ieee.org/iel5/8766/27769/01237928.pdf>.

satellite imagery data.[46] Multidimensional indexing is needed to scale with database growth. Basically, multidimensional indexing plays a role in speeding up query performance for content-based image retrieval systems.

One dimensional indexing schemes associated with low-level database management systems (DBMS) only assume a single search key; furthermore, they only locate records that match a single, given search key. Given the prevalence of primitive features such as color and shape, and domain-specific features such as facial and biometric data; there is a need to inspect data that exists in multiple dimensions. Multidimensional indexing allows for this, by creating distinct indices against separate search fields.

Work in the field of multidimensional indexing has been ongoing for the past three decades;[47] it is neither new nor exclusive to content-based image retrieval systems. Much of work in this area was the result of research in computational geometry, database management systems, and pattern recognition.[48] Examples of multidimensional indexing algorithms include the bucketing algorithm, k-d tree, and quad-tree.

For the most part, the existing research in multidimensional indexing approaches have dealt with identification and improving indexing techniques that are scalable to the

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[46] Le Moigne, J. and J.A. Smith. "Image registration and fusion for NASA remotely sensed imagery." *Proceedings of the Third International Conference on Information Fusion*. Los Alamitos: IEEE Computer Society Press, 2000. 10 - 13. <http://ieeexplore.ieee.org/iel5/6940/18695/00862667.pdf?tp=&isnumber=&arnumber=862667>.

[47] Bohm, Christian, Stefan Berchtold, Hans-Peter Kriegel, and Urs Michel. "Multidimensional Index Structures in Relational Databases." *Journal of Intelligent Information Systems* 15.1 (2000). 21 Feb. 2007 <http://infolab.usc.edu/csci599/Fall2002/paper/IS2_multidimensional-index-structures-in.pdf>.

[48] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

multidimensional nature of image retrieval. However, other aspects important to CBIRs, such as Euclidian measurements of similarities between images, have not been deeply explored by the classical algorithms. To address these shortcomings, research in the fields of clustering and neural networks has been applied to CBIR.

Within CBIR, clustering can be applied to re-group the images within the repository according to their similarities. This has the benefit of homing retrieval to limited subsets of the index, thus reducing recall while increasing precision.[49] Furthermore, response time for such a system should improve given the fewer items within the subset corpora.

Neural networks attempt to simulate processing and memory abstractions consistent with human information processing. Logically, these networks attempt to simulate the parallel architecture of sentient beings. In terms of topologies, neural networks are akin to symmetrical multiprocessing (SMP) systems that operate in a parallel computing environment. As such, the infrastructure consists of a high degree of interconnection, capable of delivering simple scalar messages and processing elements.[50]

Most importantly, much like the human brain, there is an element of adaptive interaction and learning between components. This interactivity goes hand-in-hand with the concept of relevance feedback and the berry picking model popular with information retrieval systems. In terms of neural nets applied to multimedia search, the system can

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[49] Borowski, Marion, Lars Brocker, Stephan Heisterkamp, and Jobst Loffler. "Structuring the Visual Content of Digital Libraries Using CBIR Systems." *Proceedings of the IEEE International Conference on Information Visualization*. London: IEEE Computer Society Press, 2000. 288 – 293. <http://ieeexplore.ieee.org/iel5/6925/18614/00859770.pdf?tp=&isnumber=&arnumber=859770>.

[50] Smith, Leslie. "An Introduction to Neural Networks." *University of Stirling, Department of Cognitive and Computational Neuroscience* 25 Oct. 1996. 30 Mar. 2007 <http://www.cs.stir.ac.uk/~lss/NNIntro/InvSlides.html>.

learn what a user considers similar between various images via continual, human feedback.[51] Although this requires more involvement than one-time categorization techniques, the use of relevance feedback and neural networks allow for finer nuanced generic and domain-specific features to be extracted and indexed against.

CBIR Implementations

As previously stated, most commercial deployments of multimedia search engines have text-based backends. Image retrieval is no different. Despite this dearth of actively used CBIRs on the Internet, the research in content-based image retrieval has been extremely vigorous since the 1990s. This section will address the gains made in these areas by showcasing a timeline of some actual CBIR implementations; this includes currently available systems and future works in progress. It should be noted that these CBIR examples support basic options such as random browsing, search by example, search by sketch, and navigation via image categories.[52] Many of these CBIRs are open source; thus should mesh well within the mReplay 2.0 infrastructure.

QBIC

IBM deployed one of the first CBIR projects, known as Query by Image Content (QBIC) in 1995. The system content-based features allow allows users to support queries based on existing images, user-constructed sketches, selected colors and texture patterns, camera and object motion, and other miscellaneous graphical

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[51] Muneesawang, P., and Guan L. "A Neural network Approach for Learning Image Similarity in Adaptive CBIR." *2001 IEEE Fourth Workshop on Multimedia Signal Processing*. Cannes: IEEE Computer Society Press, 2001. 257 – 262. <http://ieeexplore.ieee.org/iel5/7618/20767/00962743.pdf?tp=&isnumber=&arnumber=962743>.

[52] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

information.[53] Furthermore, users can annotate results, allowing for textual queries to apply against QBIC''s multidimensional indexing subsystem, KLT. However, feature extraction options are mutually exclusive; users can only use a single atomic feature as the basis of their queries.

The data held within the database includes still frames of isolated images and contiguous frames to represent video data. For still images, the system was capable of performing both whole and sub-image matching. For video data, QBIC is intelligent enough to detect which frames makes up a given video. This is normally done by examining deltas between congruent frames; if too many differences occur that cause the median value to overcome a predefined threshold (i.e. camera view changes angle), then the last delta is considered the end of the video sequence. Given that mReplay is a system that captures small snippets of sport's plays on video, a system like QBIC could be applied to assist users in locating sporting plays of interest to them.

Virage

Virage is a CBIR very similar to QBIC in that it supports visual queries based on colors, textures, and shape boundary information. Unlike QBIC, Virage also allows users to amalgamate combinations of feature extraction options to make highly customized queries. Furthermore, the different weighting factors could be applied to different features that make up the query. In terms of metadata tagging capabilities,

[53] Flickner, Myron, Harpreet Sawhney, Wayne Niblack, Jonathan Ashley, Qian Huang, Byron Dom, Monika Gorkani, Jim Hafner, Denis Lee, Dragutin Petkovic, David Steele, and Peter Yanker. "Query by Image and Video Content: The QBIC System." *Computers* 28.9 (1995). 21 Feb. 2007 <http://ieeexplore.ieee.org/iel1/2/9181/00410146.pdf?arnumber=410146>.

Virage has speech-to-text technology to automatically generate transcripts from audio feeds; this will aid in annotation and indexing purposes.[54]

VIrage is also the first system to make use of both primitive and domain-specific feature extractions. For example, VIrage's video forensic capabilities allow for facial recognition within the domain of security-related video search. Virage is also looking toward deploying search facilities against Web 2.0 IPTV feeds for extraction against a range parameters including audio, scene, speaker, location, key frame, on-screen text, face, token, and concepts.[55]

{Visual|Web }SEEk

The Digital Video Multimedia (DVMM) Laboratory at Columbia University released a series of IR systems that focused multimedia indexing and management, feature extraction, object and text recognition, and pervasive media. The first of which was VisualSEEK, a typical CBIR that allowed users to form queries by diagramming spatial arrangements of color regions; the system would return images based on similarities of color and spatial layouts within image regions of the user's sketch.[56] For example, if a user drew a white circle in a field of dark blue, the system would return images of a full moon.

Though VisualSEEk was limited to feature extractions based on color and spatiality, its greater significance may be the fact that it lead the way for the development of WebSEEk. WebSEEk is a search engine geared towards the Internet,

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[54] "Video Search and IPTV." *Virage, Inc.* 2007. 18 Feb. 2007 <http://www.virage.com/content/pathways/video_search_iptv/index.en.html>.
[55] "Video Search and IPTV." *Virage, Inc.* 2007. 18 Feb. 2007 <http://www.virage.com/content/pathways/video_search_iptv/index.en.html>.
[56] Smith, John R. and Shih-Fu Chang. "VisualSEEk: A fully automated content-based image query system." *Proceedings of the fourth ACM international conference on Multimedia*. Boston: ACM Press, 1997. 87 – 98. <http://www.ee.columbia.edu/ln/dvmm/publications/96/smith96f.pdf>.

much like Ask.com or Google. However, its focus was on content-based image retrieval. It consisted of three main modules: (1) frame collection, (2) subject classification and indexing, and (3) search, browse, and retrieval modules.[57] These modules allowed WebSEEk to extract key values and HTML tags for indexing, and to combine these results with CBIR functionality provided by the VIsualSEEk engine to local binary color sets and histograms.[58] WebSEEk also supported text-based queries as well.

Project Development Timeline

Although we stipulated that mReplay is a long-term project that goes beyond our May 2007 graduation dates; for the purpose of this portion of the project, development of the beta site occurred between March and May of 2007. We followed standard systems analysis and design procedures. Progress and continual feedback was demonstrated during weekly meetings between student team members, and bi-monthly meetings with Professor Braunstein. However, the primary method of communications between members was via e-mail, instant messaging, and Google Groups. The following is a summary of milestones.

March 1, 2007 – Development Environment Established

At this point the hardware and software environment was already deployed and installed, so as to allow the database implementer to create the instance of the MySQL database that would power mReplay.com. At this time, the software architect also

[57] Rui, Yong, Thomas S. Huang, and Shih-Fu Chang. "Image Retrieval: Current Techniques, Promising Directions, and Open Issues." *Journal of Visual Communications and Image Representation* 7 Jan. 1999. 20 Feb. 2007 <http://www.csee.umbc.edu/~pmundur/courses/CMSC691M-04/deep_rui99_cbir_survey.pdf>.

[58] Jorgensen, Corinne. "Access to Pictorial Material: A Review of Current Research and Future Prospects." *Computers and the Humanities* 33 (1999). 28 Feb. 2007 <http://www.springerlink.com/content/w53542u5541x1524/fulltext.pdf>.

began work on the site. The project was only identified via its IP address, so as to limit access to team members privy to this knowledge. Albeit not the ideal means of access control, this method of security by obscurity was sufficient considering the small number of developers and the overall low-key nature of the project. The key points achieved by the March 1st milestone were:

- Single machine connected to the Internet
- Software loaded with Ubuntu Linux 6.06, Apache 2, and MySQL 4
- User accounts setup for team members to access code base
- Daily backups established
- Subversion repository for codebase
- Bugzilla configured for tracking bugs

March 15, 2007 – Progress Reports from Software Architects

By this time the skeleton site was in place. Furthermore, the database had been designed and instantiated two weeks earlier, so a connection was established between the running Apache configuration and the configured MySQL database. Finally, a minimal user interface was deployed so as to perform barebones usability testing on video uploads and viewing. The key accomplishments for the March 15th milestone were:

- User account creation and login
- Upload and view videos
- Video categorization for search and browse
- Video comments

April 3, 2007 – Quality Assurance Begins and the Second Progress Report

Most of the basic functionality for the site was ready for team to test against. Mr. Lee began the process of quality assurance, and other team members assisted in the efforts by providing a minimum of three hours of their time between the April 3rd and the 17th. The key accomplishments for this milestone were:

- Voting and ratings system established

- Three hours of quality assurance from each member logged

April 17th – Regression Testing and Fixes and the Third Progress Report

Each team member had already spent and logged their three hours of quality assurance testing against the development site. At this point regression testing began and an official list of bugzilla tracking tickets was created to log the progress. Mr. Lee focused on bug fixes, while Mr. Decker continued development in key areas. Mr. Lee and Mr. Chuang also completed the rough draft of the business plan for an outside angel investor. The key accomplishments for this milestone were:

- Administrative section under development
- Frame system established
- Major bugs fixed
- Begin development of static site at www.mreplay.com
- Prepare to setup beta.mreplay.com for interactive site

May 1, 2007 – Beta Interactive Site Launched

At this point the site interactive beta.mreplay.com site had launched to a small group of users. The informational site at www.mreplay.com also went live. The next phase of development begins; however, this portion of the timeline goes beyond the scope of this paper.

The Mobile Landscape

Given the importance of mobility in mReplay, some discussion regarding the existing and future of mobile networks should be discussed. This section will review the history of mobile networks capable of supporting mReplay products and services on the client side.

Mobile Technology Overview

The history of mobile networks within the United States is heavily storied. There are three, officially identified generations of technologies, first generation (1G), 2G, and 3G. There are also interim technologies to bridge the gap between standards. Furthermore, there are future standards that have yet to be fully fleshed out, such as fourth generation (4G); and to some extent, broadband wireless standards such as WiMAX and WiBro.

Second Generation Systems

As subscription rates and usage increased within the 1G landscape, the limitations of analog technologies became more obvious. To resolve these problems, mobile providers turned to digital signaling. 2G is a generalization used to describe the advent of digital technology to mobile systems. 2G is also the minimum standard required for mReplay products and services to operate. However, it is important to note that 2G was not a clarion call for new services such as mReplay; its overarching goal at the time was to improve the voice quality and capacity of 1G. As 2G matured, other technologies such as Mobile Data Packet Data (CDPD), were developed parallel to 2G; these addendum technologies were specifically created to address data far-reaching data services such as mReplay.

Transitional Systems

Before jumping into the realm of 3G technologies, there is one more area of mobile networking that should be addressed: the transitional technologies that fall between 2G and 3G deployments. For the most part, these transitional changes to the mobile landscape have been dubbed 2.5G (and in some cases, 2.75G).

An important note is the fact that 2G and 2.5G were the dominant technologies during the 2005 write-up on the first revision of mReplay. Many of the comments Mr. Riley made during the University of California at Berkeley School of Information Management and Systems Master's presentation are salient, given the prevalence of 2 and 2.5G technologies at the time.

Whereas 2G and 3G are officially defined terms, 2.5G mobile technology is more of a creation of marketing specialists rather than official standards bodies such as 3GPP or the CDG. Though 1G and 2G have a clear line of demarcation, 2.5G has elements that can be considered both 2G and 3G based. 2.5G shares the packet-switched nature and enhanced data rates of 3G for an always-on data connection, but can also use the existing 2G infrastructure of CDMA and GSM networks to deliver voice traffic.[59]

This move towards packet-switched technologies becomes especially poignant in the face of up-and-coming Internet technologies. For example, consider the effects as they apply to mReplay Professional in its client-server form; this is a technology in which the transmission and presentation of information from the Internet are geared towards mobile devices as the client. An always-on, packet-switched network allows these content-rich mReplay sessions to operate on a per-transaction cost rather than a per-minute-of-usage basis (as is the case with a circuit-switched network, in which an end-to-end tunnel is established and maintained for the duration of a call). This leads to other advantages such as autonomous service realization through the always-on capability. We expect the social networking aspects of mReplay to take advantage of this *always-on* mentality. For example, a 2.5G subscriber will not need to manually

[59] "3G: Don't believe the hype." *News.com* 22 Jun. 2002. 30 Apr. 2007 <http://news.com.com/3G+Dont+believe+the+hype/2009-1033_3-938522.html>.

initiate a connection to the mReplay service for updates, but rather update notifications and links will be pushed to the user's devices based on subscribed mReplay 2.0 preferences.

Third Generation Systems

Much of this section has already alluded to the rapid increase in the demand for data services within the mobile industry. The push from analog 1G to higher-speed 2.5G networks serves as proof of the industry attempting to prepare for the onslaught of these data services. 3G is the moniker that has received much of the attention as the enabler for high-speed data for the wireless mobility market.

In 2005, 3G deployments were nascent. However, now the technology is readily available by all major mobile providers with the exception of T-Mobile USA. Though 2.5G systems have sufficiently addressed the current needs of mReplay 2.0, we expect post 2.0 releases to exploit the enhanced data bandwidth capabilities of 3 and 4G networking. For example, the additional support for voice and data traffic will allow a future upgrade path of mReplay in which the social networking aspects encompass multimedia, such as real-time video and audio between participants rating a mobile replay. Despite the fact that mReplay has gone multiplatform, and that other non-mobile network platforms such as 802.11a/b/g (WiFi) already support the high bandwidth requirements of such an endeavor; mobile replays on mobile technology is still a primary market given the ubiquity of mobile telephones.

The most substantial upgrades offered over 2G are 3G's enhanced capacity to support more voice and data traffic and the capability to sustain faster data throughput at a marginal cost. From the mobile operator's perspective, the expense and difficulty in migrating to 3G can be rationalized in terms of increased capacity, more efficient use of the radio spectrum, and the ability to offer newer value-added services to its subscribers. We feel that as 3G networks become practical, our chances to pursue partnerships will mobile service providers increases due to their need to demonstrate high-speed, mobile data services with multimedia-rich services such as mReplay 2.0.

These value-added services—especially multimedia—are the primary drivers towards 3G technology. Aside from mReplay 2.0, other better known multimedia drivers include the before-mentioned DVB-H and DMB standards, streaming video clips, music downloads, *Multimedia Messaging Service* (MMS), photography, online-gaming, and real-time television; these have all been heralded as the killer apps that will leverage the high-speed, packet transfers afforded by 3G technologies.[60] This falls into line with observations that mobile entertainment will also spur 3G development.[61]

Another factor driving 3G deployment is available disposable income by subscriber. For example, just the fact that all of the major operators currently (or plan to) offer the *mobiTV* service for a monthly premium is evidence of all of these 3G drivers.[62] Furthermore, the four countries with the highest 3G licensing costs—Germany, UK, Italy, and South Korea—have an average GDP per capita of $29,175 (US), approximately 191.75 percent over the global GDP per capita of $10,000 (US).[63,64] This falls in line with our demographic market of quasi-affluent individuals

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[60] "Video Top Reason Wireless Subscribers Will Upgrade to 3G." *Datacomm Research Company* 10 Sep. 2003. 26 Apr. 2007 <http://www.datacommresearch.com/reports/highlights/mobilemovies.asp>.
[61] "Entertainment is catalyst for 3G growth." *3GNewsroom.com* 18 Nov. 2004. 28 Apr. 2007 <http://www.3gnewsroom.com/3g_news/nov_04/news_5204.shtml>.
[62] "Television on the go." *MobiTV* 2007. 11 Mar. 2007. <http://www.mobitv.com/press/press.php?i=press/press_indystar_111305>.
[63] "3G License Information." *3GNewsroom.com* 2007. 28 Apr. 2007 <http://www.3gnewsroom.com/3g_licenses_db/index.shtml>.

who are technically savvy and have spent roughly $26.17 billion on the sporting events' industry.[65]

Mobile Operators

As of 2006, the United States has 233 million mobile subscribers, roughly a 77.6% wireless penetration rate for the entire population.[66] This is an increase of approximately 25 million subscriptions from the previous year.[67] Approximately 9.6 percent of all American households are wireless-only, meaning no land lines.[68] However, it is important to note that other global regions—both rich and poor—have higher wireless-only penetration rates. For example, 29.9 percent of South Korean households are wireless only;[69] another example is Africa, which in 2001, became the first region where the number of mobile subscribers outpaced landlines.[70]

According to the *Mobile Telephone and Internet Association* (CTIA), there are over 180 mobile operators in the United States.[71] Of the 230 million subscribers, the top five mobile operators possess 91.3% of the subscription base. This is an incredibly wide market that we are confident mReplay 2.0 can flourish in.

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[64] United States. The Central Intelligence Agency. The World Factbook: World. 30 Apr. 2007 <https://www.cia.gov/cia/publications/factbook/geos/xx.html#Econ>.
[65] "About Us – The Sports Industry." *Street & Smith's SportsBusiness Journal* 2007. 4 Apr. 2007 <http://www.sportsbusinessjournal.com/index.cfm?fuseaction=page.feature&featureId=43>.
[66] Farren, Joseph and Raquel Lopez. "Wireless Quick Facts." *CTIA: The Wireless Association* Dec. 2006. 30 Apr. 2007 <http://www.ctia.org/media/industry_info/index.cfm/AID/10323>.
[67] "Annualized Wireless Industry Survey Results – December 1985 to December 2006." *CTIA: The Wireless Association* Dec. 2006. 30 Apr. 2007 <http://files.ctia.org/pdf/CTIA_Survey_Year_End_2006_Graphics.pdf>
[68] United States. National Center for Health Statistics. Wireless Substitution: Preliminary Data from the January-June 2006 National Health Interview Survey. By Stephen J. Blumberg and Julian V. Luke. 18 Jan. 2007. 22 Feb. 2007 <http://www.cdc.gov/nchs/products/pubs/pubd/hestats/wireless2006/wireless2006.htm>.
[69] United States. The Central Intelligence Agency. The World Factbook: Korea, South. 30 Apr. 2007 <https://www.cia.gov/cia/publications/factbook/geos/ks.html>.
[70] Butler, Rhett. "Cell phones may help save Africa." *Mongabay.com*. 18 Jul. 2005. 6 Feb. 2007 <http://news.mongabay.com/2005/0712-rhett_butler.html>.
[71] Farren, Joseph and Raquel Lopez. "Wireless Quick Facts." *CTIA: The Wireless Association* Dec. 2006. 30 Apr. 2007 <http://www.ctia.org/media/industry_info/index.cfm/AID/10323>.

Name	Technology	Number of Subscribers (millions)
Alltel	CDMA, GSM, TDMA	11.82[72]
Cingular /ATT	GSM, TDMA, UMTS	61[73]
Sprint Nextel	CDMA, iDEN	53.1[74]
T-Mobile USA	GSM	25[75]
Verizon Wireless	CDMA	59.1[76]

Table 1

Table 1 summarizes these top five mobile operators in the United States. The industry as a whole generated total revenues of $125 billion for 2006.[77] Not including spectrum fees, wireless companies have spent approximately $199 billion as of 2005, or $20 billion a year, in capital to improve their networks.[78] The industry has approximately 253,000 direct employees,[79] and collectively pages $11 billion in annual wages.[80]

Of the 180 registered mobile licenses in the United States, about 40 are *Mobile Virtual Network Operators* (MVNO). Globally, there is some contentious debate as to what qualifies as an MNVO. For example, some analysts believe MVNOs must have a distinct network code and its own SIM cards; whereas in the UK, MVNOs can existing

72 "Alltell drops after wireline spin-off." *TeleGeography: A Research Division of Primetrica, Inc*. 21 Feb. 2007. 23 Mar. 2007 <http://www.telegeography.com/cu/article.php?article_id=16749>.
73 "Cingular Wireless Reports Fourth-Quarter 2006 Results." *Cingular MediaRoom*. 23 Mar. 2007 <http://cingular.mediaroom.com/index.php?s=press_releases&item=1833>.
74 "Sprint Nextel Schedules Fourth-Quarter, Full-Year 2006 Earnings Release and Conference Call." *Sprint* 14 Feb. 2006. 22 Mar. 2007 <http://www2.sprint.com/mr/news_dtl.do?id=15400>.
75 T-Mobile USA hits 25 million." *TeleGeography: A Research Division of Primetrica, Inc*. 29 Jan. 2007. 24 Mar. 2007 <http://www.telegeography.com/cu/article.php?article_id=16403>.
76 Taylor, Paul. "Verizon wireless closes gap with Cingular." *Financial Times* 29 Jan. 2007. 23 Mar. 2007 <http://www.ft.com/cms/s/8f2bc588-afab-11db-94ab-0000779e2340.html>.
77 Annualized Wireless Industry Survey Results – December 1985 to December 2006." *CTIA: The Wireless Association* Dec. 2006. 30 Apr. 2007 <http://files.ctia.org/pdf/CTIA_Survey_Year_End_2006_Graphics.pdf>
78 "100 Wireless Quick Facts V." *CTIA: The Wireless Association* 2007. 30 Apr. 2007 <http://www.ctia.org/media/industry_info/index.cfm/AID/10380>.
79 Annualized Wireless Industry Survey Results – December 1985 to December 2006." *CTIA: The Wireless Association* Dec. 2006. 30 Apr. 2007 <http://files.ctia.org/pdf/CTIA_Survey_Year_End_2006_Graphics.pdf>
80 "100 Wireless Quick Facts V." *CTIA: The Wireless Association* 2007. 30 Apr. 2007 <http://www.ctia.org/media/industry_info/index.cfm/AID/10381>.

without SIM cards but are referred to as *Enhanced Service Providers* (ESP).[81] This paper defines an MVNO as not owning a licensed frequency spectrum or the associated BSS infrastructure; and that their business model is to sell mobile services under its brand name, but using a separate operator's network. Despite the backend logistics, service offerings are completely transparent to subscribers in that there is no quality distinction versus a MVNO and a non-virtual operator. These MVNOs serve approximately 10% of all wireless customers in the United States.[82] Some of the more popular ones include AMP'D Mobile, Helio, and Virgin Mobile; which utilize Verizon, Sprint, and T-Mobile's infrastructure, respectively.

Given that the expenses associated with infrastructure deployment and spectrum licenses are major barriers of entry into the realm of mobile networks, the rise of MVNOs has allowed for new players to enter the market and to effectively complete against entrenched competitors. This is practical, given that T-Mobile recently expended $4.19 billion during the recent Advanced Wireless Services auction held by the FCC just to acquire 3G spectrum licenses.[83] Furthermore, the company expects to spend an additional $2.66 billion to physically deploy the 3G offerings.[84] The rise of MVNOs—especially those that aimed towards multimedia and social networks—will further push the viability of mReplay.

[81] Varoutas, D., D. Katsianis, Th. Sphicopoulos, K. Stordahl and I. Welling. "On the Economics of 3G Mobile Virtual Network Operators (MVNOs). *Wireless Personal Communications* 36.2 (2006). 19 Mar. 2007 <http://www.springerlink.com/content/p1145p2870731278/>.
[82] "100 Wireless Quick Facts V." *CTIA: The Wireless Association* 2007. 30 Apr. 2007 <http://www.ctia.org/media/industry_info/index.cfm/AID/10384>.
[83] United States. Federal Communications Commission. FCC Advanced Wireless Services Auction No. 66. 20 Sep. 2006. 28 Apr. 2007 <http://wireless.fcc.gov/auctions/66/charts/66press_3.pdf>.
[84] Reardon, Marguerite. "T-Mobile outlines plans for 3G network." News.com 6 Oct. 2006. 28 Apr. 2007 <http://news.com.com/T-Mobile+outlines+plans+for+3G+network/2100-1039_3-6123480.html>.

Conclusion

We have presented a semester's worth of work on mReplay 2.0. Despite all of the progress made, more still needs to be done. As suggested by Mr. Schmidt's at the beginning of this paper, the realm of online videos is still virgin territory; all aspects regarding this new frontier—from legal concerns to technical limitations—are still in a state of flux. As extensive as this project has been, it currently serves as nothing more than a primer to the potential for cohesive relationship between online video and the Internet.

Appendix A (Cash Flow Analysis)

Summary

mREPLAY

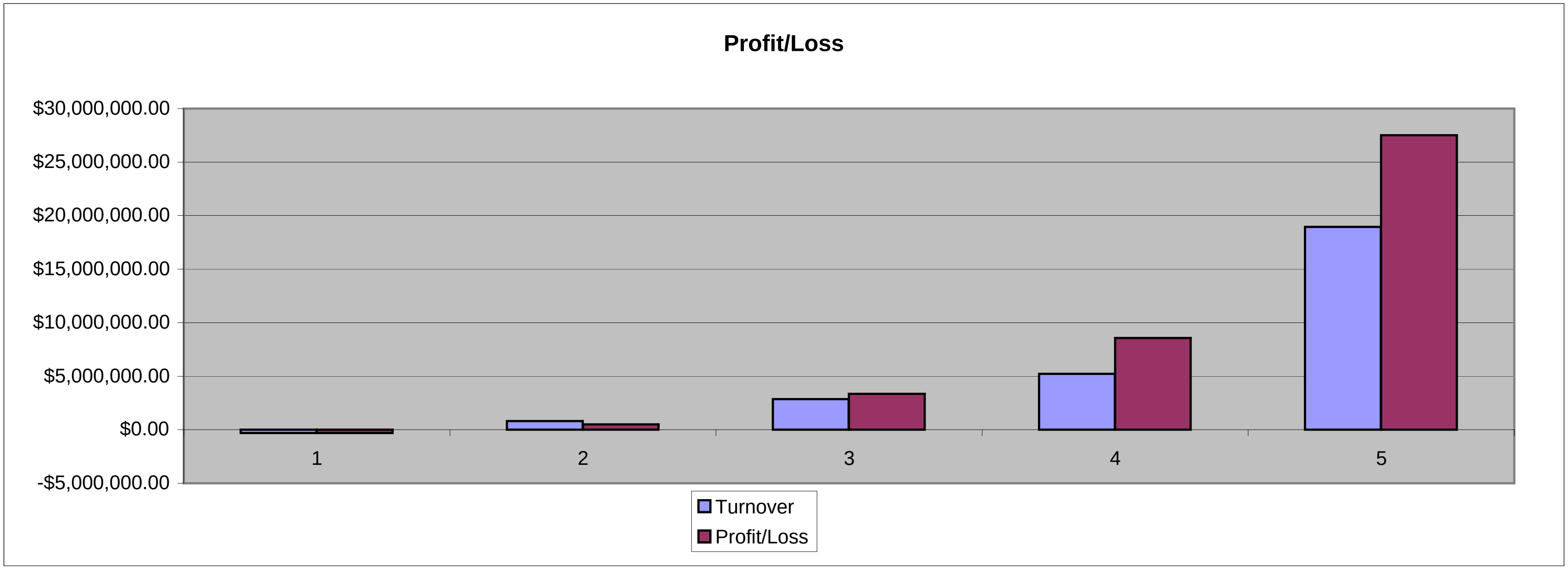
Investment needed:	$1,000,000.00
Return after 5 years:	$10,000,000.00

Patrick Riley

Last updated: 4/17/2007

Timetable	Period 1	Period 2	Period 3	Period 4	Period 5
Months	4	7	13	12	24
Milestones	Development	Release USA	Release Europe	Strong growth	Normal growth

Value of MReplay	Period 1	Period 2	Period 3	Period 4	Period 5
Turnover	-$304,000.00	$803,358.33	$2,855,137.50	$5,221,500.00	$18,941,000.00
Users					
Europe	0	0	450,000	1,000,000	2,000,000
US	0	100,000	200,000	225,000	425,000
Market Share					
PC fan					
Europe	0%	0%	2%	4%	11%
US	0%	3%	7%	13%	26%
Mobile Fan					
Europe	0%	0%	23%	50%	100%
US	0%	1%	3%	3%	5%


Profit/Loss
$30,000,000.00
$25,000,000.00
$20,000,000.00
$15,000,000.00
$10,000,000.00
$5,000,000.00
$0.00
-$5,000,000.00
1
2
3
4
5
Turnover
Profit/Loss

Assumptions

mREPLAY

A:Timetable	Period 1	Period 2	Period 3	Period 4	Period 5
Months	4	7	13	12	24
Milestones	Development	Release USA	Release Europe	Strong growth	Normal growth

B: Market: Number of requests* per year	Europe	US
Focused sport	soccer	baseball, football, basketball
Number of sport fans	23,000,000	88,000,000
Number of important sport events per year	700	5,000
Average number of highlights in one match	20	20
Mobile phone fan market		
Number of sport fans going to the stadium	2,000,000	8,000,000
Average number of people watching a match at the stadium	25,700	30,000
Average number of non-attendees watching the highlights of a match on their mobile phone	5,000	6,000
Percentage of highlights per match that will be requested by one of our users at that match	10%	10%
PC fan market		
Number of fans watching matches at home at the PC	230,000	880,000
Average number of people watching one match at the PC	11,500	44,000
Percentage of highlights per match that will be requested by one of our users at that match	20%	20%
Request and click		
Percentage of requests that result in click	1%	2%

C: Costs					
Fixed Costs	Germany	US			
Cost for foundation of company (GmbH)	$25,000	$20,000			
Setup of hardware	$20,000	$20,000			
Legal costs	$5,000	$5,000			
Development					
Development of software for PC + Siemens Set-Top (outsourced)	$50,000				
Development of website	$1,000				
Non-Fixed Costs (per month)	Period 1	Period 2	Period 3	Period 4	Period 5
Marketing					
Low-Level Marketing (conferences + universities + matches)	$10,000	$10,000	$30,000	$30,000	$30,000
Marketing in sport magazines per month	$10,000	$15,000	$50,000	$50,000	$50,000
Marketing in wall street journal	$20,000	$30,000	$0	$0	$0
Office					
Rent	$3,000	$3,000	$6,000	$6,000	$6,000
Office supplies	$500	$500	$1,000	$1,000	$1,000
Staff cost					
Wage for CEO	$5,000	$5,000	$8,000	$10,000	$10,000
Wage for CFO	$3,000	$3,000	$5,000	$6,000	$6,000
Wage for rest of staff	$500	$5,000	$10,000	$10,000	$10,000
Overhead	$0	$1,000	$1,000	$500	$500
Maintenance					
Website	$0	$500	$500	$500	$500
System	$0	$3,000	$6,000	$6,000	$6,000
Operation Costs (per sale)					
Costs for PC software sales (shipping, billing etc.) per sale	$10				

D: Sales	Period 1	Period 2	Period 3	Period 4	Period 5
USA					
Expected number of Pro Units sold per period	0	25,000	50,000	75,000	200,000
Europe					
Expected number of bundles sold per period	0	0	200,000	300,000	700,000
Expected Number of PC softwares sold per period	0	0	14,000	25,000	60,000

E: Revenues	
Revenue per bundle	$50.00
Revenue per request* by Ads	$0.10
Additional revenue per click on a Ad	$0.20

*Request is a user request for watching one arbitrary highlight of an arbitrary match

Costs

mREPLAY

Fixed Costs	Period 1	Period 2	Period 3	Period 4	Period 5	Total
Cost for foundation of company (GmbH)	$25,000	$20,000	$0	$0	$0	$45,000
Setup of hardware	$20,000	$20,000	$0	$0	$0	$40,000
Legal Costs	$5,000	$5,000	$0	$0	$0	$10,000
Development						
Development of Pro software	$50,000	$0	$0	$0	$0	$50,000
Development of website	$1,000	$0	$0	$0	$0	$1,000

Non-Fixed Costs	Period 1	Period 2	Period 3	Period 4	Period 5	Total
Marketing						
Conferences etc.	$40,000	$70,000	$390,000	$360,000	$720,000	$1,580,000
Marketing in sport magazines per month	$40,000	$105,000	$650,000	$600,000	$1,200,000	$2,595,000
Marketing in wall street journal	$80,000	$210,000	$0	$0	$0	$290,000
Office						
Rent	$12,000	$21,000	$78,000	$72,000	$144,000	$327,000
Office supplies	$2,000	$3,500	$13,000	$12,000	$24,000	$54,500
Staff cost						
Wage for CEO	$20,000	$35,000	$104,000	$120,000	$240,000	$519,000
Wage for CFO	$12,000	$21,000	$65,000	$72,000	$144,000	$314,000
Wage for rest of staff	$2,000	$35,000	$130,000	$120,000	$240,000	$527,000
Overhead	$0	$7,000	$13,000	$6,000	$12,000	$38,000
Maintenance						
Website	$0	$3,500	$6,500	$6,000	$12,000	$28,000
System	$0	$21,000	$78,000	$72,000	$144,000	$315,000

Operation Costs	Period 1	Period 2	Period 3	Period 4	Period 5	Total
Sales cost (Pro hardware)	$0.00	$0.00	$140,000.00	$250,000.00	$600,000.00	$990,000.00

Total	$309,000.00	$577,000.00	$1,667,500.00	$1,690,000.00	$3,480,000.00	$7,723,500.00

Revenue

mREPLAY

Revenue of Sales	Period 1	Period 2	Period 3	Period 4	Period 5	Total
Revenue of Pro devices	$0.00	$1,250,000.00	$2,500,000.00	$3,750,000.00	$10,000,000.00	$17,500,000.00

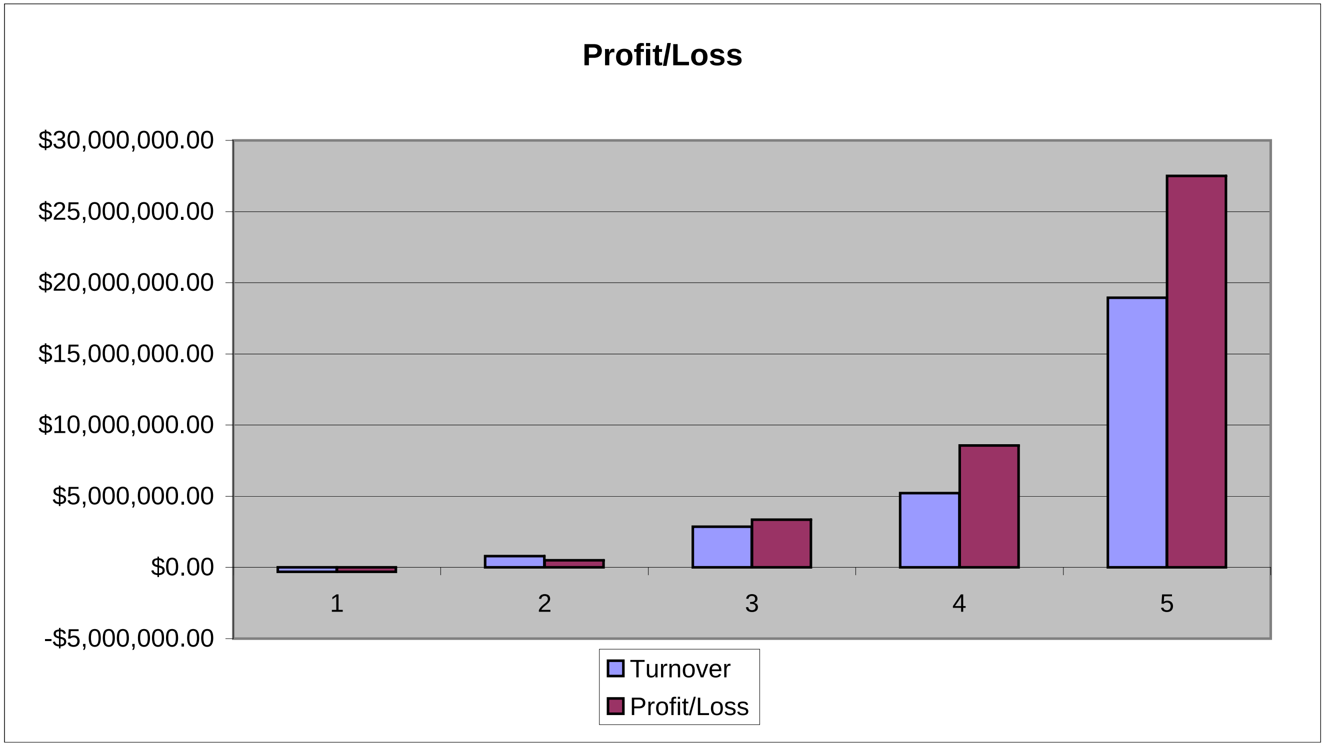
Revenue of advertisement	Period 1	Period 2	Period 3	Period 4	Period 5	Total
Online and mobile phone market United States						
Expected number of users	0	100,000	450,000	1,000,000	2,000,000	
Market share	0%	5%	23%	50%	100%	
Number of our users watching a certain match	0	1,535	6,908	15,350	30,700	
Number of requests per match	0	3,070	13,815	30,700	61,400	
Number of total requests	0	1,253,583	10,476,375	21,490,000	85,960,000	
Revenue of advertisement	0 €	$125,358.33	$1,047,637.50	$2,149,000.00	$8,596,000.00	$11,917,995.83

Europe						
Expected number of users = Number of bundles sold per period + Users of the previous period	0	0	200,000	225,000	425,000	
Market share	0%	0%	3%	3%	5%	
Number of our users watching a certain match	0	0	900	1,013	1,913	
Number of requests per match	0	0	1,800	2,025	3,825	
Number of total requests	0	0	9,750,000	10,125,000	38,250,000	
Revenue of advertisement	$0.00	$0.00	$975,000.00	$1,012,500.00	$3,825,000.00	$5,812,500.00

Total		$1,375,358.33	$4,522,637.50	$6,911,500.00	$22,421,000.00	$35,230,495.83

Profit & Loss

Profit / Loss	Period 1	Period 2	Period 3	Period 4	Period 5
Total Fixed Costs	-$96,000.00	-$40,000.00	$0.00	$0.00	$0.00
Total Non-Fixed Costs	-$208,000.00	-$532,000.00	-$1,527,500.00	-$1,440,000.00	-$2,880,000.00
Total Operations Costs	$0.00	$0.00	-$140,000.00	-$250,000.00	-$600,000.00
Total Costs	-$304,000.00	-$572,000.00	-$1,667,500.00	-$1,690,000.00	-$3,480,000.00
Total Revenues	$0.00	$1,375,358.33	$4,522,637.50	$6,911,500.00	$22,421,000.00
Turnover	-$304,000.00	$803,358.33	$2,855,137.50	$5,221,500.00	$18,941,000.00
Profit/Loss	-$304,000.00	$499,358.33	$3,354,495.83	$8,575,995.83	$27,516,995.83



Cash Flow

Cash Out	Period 1	Period 2	Period 3	Period 4	Period 5
Total Fixed Costs	-$96,000.00	-$40,000.00	$0.00	$0.00	$0.00
Total Non-Fixed Costs	-$208,000.00	-$532,000.00	-$1,527,500.00	-$1,440,000.00	-$2,880,000.00
Total Operations Costs	$0.00	$0.00	-$140,000.00	-$250,000.00	-$600,000.00
Return of investment	$0.00	$0.00	$0.00	$0.00	-$10,000,000.00
Total Cash Out	-$304,000.00	-$572,000.00	-$1,667,500.00	-$1,690,000.00	-$13,480,000.00

Cash In	Period 1	Period 2	Period 3	Period 4	Period 5		
Initial Capital	$1,000,000.00	$0.00	$0.00	$0.00	$0.00		
Total Revenues	$0.00	$1,375,358.33	$4,522,637.50	$6,911,500.00	$22,421,000.00		
Total Cash In	$1,000,000.00	$1,375,358.33	$4,522,637.50	$6,911,500.00	$22,421,000.00		
(Net out)	-$1,000,000.00	$1,375,358.33	$4,522,637.50	$6,911,500.00	$22,421,000.00		
Cash Flow	Period 1	Period 2	Period 3	Period 4	Period 5		
Cash Flow	$696,000.00	$1,499,358.33	$4,354,495.83	$9,575,995.83	$18,516,995.83		
(Net out)	-$1,000,000.00	$0.00	$0.00	$0.00	$10,000,000.00	IRR	78%