

1. Problem

1.1 Historical Introduction

In the early 1900s, radio emerged as the first broadcast medium. Early companies such as the Radio Corporation of America (RCA), the America Telephone & Telegraph Company (AT&T), and General Electric (GE) sought to provide Americans with radio equipment and broadcast programs. In 1922, AT&T aired the first radio commercial and established a profitable paradigm for broadcast that was unchallenged for nearly a century [1]. To reach the most consumers, radio stations began playing music catering to the tastes of the majority. This led to the evolution of large broadcast corporations such as Clear Channel Communications, the National Broadcast Corporation (NBC), and the American Broadcast Corporation (ABC). These companies bought out independent radio stations to broadcast fixed format play lists that garnered the most listeners and profits. While existing independent stations were being purchased, substantial startup costs kept new stations from entering the market. According to [2] in 2001, "Clear Channel rules the horizon with 1,200 stations, which generate more than \$3 billion annually in revenues." This absence of independent stations left radio with a homogenized corporate structure.

The Internet boom of the 1990s provided a unique opportunity for independent broadcasters by offering a medium that was largely untouched by the recording and broadcast industries. By broadcasting online, independent stations avoided the infrastructure costs inherent in building radio towers and laying cable. The Internet, however, was a new technology and the applications designed to work with it were rudimentary compared to the Internet applications of today. The first Internet radio stations were poorly organized and used an amalgam of technologies, including video conferencing software and Voice over IP (VoIP).

In the mid 1990s, many large-scale Internet radio services forged standards for Internet radio. RealAudio, launched by RealNetworks in 1995, created the first widespread Internet radio standard. This standard enhanced the reputability of Internet radio and led to a rise in content providers for streaming media. More recently, the freely available SHOUTcast plugin has allowed anyone with a copy of the Winamp software to host an Internet radio station, drastically increasing the number of streaming content providers.

Today, Internet radio has become a viable alternative to traditional radio broadcasts. In a study conducted by Arbitron Inc./Edison Media Research in 2006, approximately 30 million people listened to Internet radio over the course of a single week in January [3]. The medium, according to Steve Haarhoff in 2002, "[is] predominantly a workplace phenomenon" [4]. The connection between the workplace and Internet radio underscores the acceptance of this medium in settings where computers are at hand.

Internet radio offers listeners the unique opportunity to choose their programming from a multitude of both independent and corporate owned stations. Despite the popularity of Internet radio, the medium does not have the portability of traditional broadcast radio and satellite radio services. By utilizing already widely available 802.11b wireless networks, WiRAD gives Internet radio the portability that more corporate controlled mediums enjoy and allows small stations to reach an audience outside of the workplace.

1.2 Market and Competitive Analysis

Although other portable streaming technologies exist, they are targeted at platforms inaccessible to the independent artist. Cellular service providers already have the infrastructure to wirelessly deliver streaming media and are in the process of deploying devices to process and view such media. Verizon and

Sprint have created broadband media delivery services known as VCAST [5] and Sprint TV [6], respectively. So far, these services are available only in limited metropolitan markets. Satellite radio is an alternative wireless streaming technology that is available in all areas. This technology has been primarily concentrated in car-audio and wearable receivers by XM and Sirius Satellite Radio. These two companies offer subscription packages for which users must pay a monthly service charge in addition to the price of the radio receiver and its installation. Unfortunately, these technologies suffer from the same content drawback as conventional radio: namely, that high costs are prohibitive to independent stations and broadcast slots are available only to large corporations.

Portable media players, such as the iPod by Apple and the Zen by Creative, are another alternative to WiRAD. Rather than playing streaming media, audio is stored on internal drives for later consumption. For small storage, these devices use expensive Flash memory; for larger storage, magnetic drives with unreliable moving parts are utilized. In both cases, such portable media players must include expensive onboard storage. Additionally, the content of non-streaming devices is limited to static data, whereas streaming devices are capable of reporting dynamic data such as stock quotes, sports scores, and weather information in real time. Apple's popular iPod serves as WiRAD's main non-broadcast competitor. Models of the iPod media player range in cost from \$69 to \$399 [7] and in January of 2005, iPod sales had garnered \$2.8 billion in gross revenue [8]. Nonetheless, at a cost of \$100, the WiRAD has few competitors in either the streaming or non-streaming portable media technologies.

1.3 Problem Statement

A need exists for an inexpensive and portable wireless device for accessing Internet radio stations via an already developed and widely available wireless infrastructure. Low cost and portability are both necessary qualities for such a device to be competitive with traditional radio technologies and non-streaming media players. WiRAD allows access to Internet radio stations via 802.11b while incorporating the design concepts of low cost and portability. The cost of WiRAD is kept low by eliminating onboard storage, which is used in many popular digital music players. Costs are also minimized through a design that incorporates a small microcontroller used in conjunction with numerous specialized integrated circuits, rather than an expensive general-purpose microprocessor.

Portability, the second characteristic necessary for WiRAD to be competitive, consists of three important aspects relevant to this application: battery life, size, and network compatibility. WiRAD battery life is addressed through power conscious use of the onboard wireless module and use of low power integrated circuits. Device size is also managed by careful integrated circuit selection. The final issue of network compatibility is trivial, due to the widespread deployment of the 802.11b wireless technology used in WiRAD.

1.4 Implications of Success

With its lower infrastructure-related startup costs, WiRAD will likely completely supplant the underdeveloped cellular streaming media technologies. The already developed satellite radio market may prove more resilient. While in-home satellite radio receivers could be easily replaced by WiRAD devices, automotive units are less likely to be replaced due to the lack of 802.11b coverage on most highways. Regarding non-streaming portable media players, WiRAD, with a cost comparable to low-end iPods, is poised to steal much of the iPod market share, which in April of 2006 accounted for 60% of the non-streaming portable media player market [9].

In addition to the economic implications of large scale WiRAD deployment, there are social implications. These low cost wireless Internet radio receivers provide one of the most affordable outlets to the Internet

yet. As Internet radio increases in popularity, talk shows and news programs, as well as music, will be added to the list of available content. It is easy to conceive of books, web pages, financial data, and many other types of information being translated into this medium. Additionally, WiRAD's ability to receive broadcasts from a personal computer suggests numerous applications, such as a home computer using text-to-speech technology to read a user's email to him or her aloud. This connectivity presents users with an unprecedented availability of information.

1.5 References

- [1] S. E. Schoenherr, "History of Radio," [Online document], 2001 August 29, [cited 2006 August 28], Available HTTP:
<http://history.acusd.edu/gen/recording/radio.html>
- [2] E. Boehlert, "Radio's big bully." [Online document], 2001 April 30, [cited 2006 September 6], Available HTTP:
http://archive.salon.com/ent/feature/2001/04/30/clear_channel/index.html
- [3] Arbitron Inc., Edison Media Research, "The Infinite Dial: Radio's Digital Platforms," [Online document], 2006, [cited 28 August 2006], Available HTTP:
http://www.arbitron.com/downloads/digital_radio_study.pdf
- [4] M. Zacks, "Party's Over: Bills Come Due for Internet Radio," *IEEE Internet Computing*, July/August 2002, pp. 12-13.
- [5] Verizon Inc., "Verizon Wireless Get It Now VCAST," [Online document], 2006, [cited 2006 August 28], Available HTTP:
<http://getitnow.vzwshop.com/index.aspx?id=vcast>
- [6] Sprint Nextel Inc., "SPRINT PCS," [Online document], 2006 [cited 2006 August 28], Available HTTP:
<http://www1.sprintpcs.com/explore/ueContent.jsp?scTopic=multimedia100>
- [7] Apple Computer Inc., "Apple - iPod Family," [Online document], 2006 [cited 2006 August 28], Available HTTP:
<http://www.apple.com/ipod/>
- [8] Forbes.com Inc., "When iPod Sales Run Out of Steam," [Online document], 2006 [cited 2006 August 28], Available HTTP:
http://www.forbes.com/personaltech/2005/01/14/cx_ah_0114tentech.html
- [9] Epoch Times International, "The Epoch Times | Apple Profit Rises, iPod Sales Strong," [Online document], 2006 [cited 2006 August 28], Available HTTP:
<http://www.theepochtimes.com/news/6-4-20/40600.html>