Project Report – Remote Monitoring Service

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1 Executive Summary

The Remote Monitoring Service is a network based service that provides live video stream to monitor natural habitats. This report documents necessary steps needed to successfully deploy such service. The required hardware is 1. a camera, 2. a transmitter, 3. batteries, 4. cables 5. gain antennas, 6. a receiver, 7. video encoder, and 8. DSL modem. Necessary software includes a web server and a video streaming server.

Traditionally, researchers observe natural habitat by going in the field and make manual observations. This is intrusive as presence of an observer may disturb and effect the behavior they are attempting to study. Most importantly to send a person in the field is costly, inconvenient and sometimes dangerous. The technology has improved to such an extent that we can provide a reliable network based remote monitoring service. However, the current state-of-the art solutions are geared towards providing such services where network is accessible, for example remote home monitoring services and other security based applications. Our solution is inspired by current technology but it is applied to monitoring natural habitats. Such regions are remote where network and electricity is usually not available.

Specifically, our project implements a remote monitoring service for a Bald Eagle nest at Jordan Lake, NC. The nest is located in a remote area, however, it is within 20 miles of downtown Raleigh, Durham and Chapel Hill. Most of the local residents of the triangle area are not aware of the fact that America's national bird is nesting in their backyard. In addition to providing tools to ornithologists for their research, another goal of this project is to raise awareness among local population about conservation and bio-diversity of the region they live in.

2 Introduction

Bald Eagles were classified as an endangered species in the U.S. because of dramatic population declines associated with pesticide (especially DDT) poisoning in the middle of the last century [1]. Populations began to recover after these pesticides were banned in the 1960s, and Bald Eagles were down-listed to Threatened in 1995. They were removed from the Endangered Species list in 2007. The birds are still classified as Threatened by the State of North Carolina. Populations in North Carolina have increased in recent decades and they began appearing on reservoirs in Central NC about 10 years ago. There are currently approximately 5 active nests on Jordan Lake.

2.1 Problem Statement

The fundamental problem that we attempt to solve is to provide a reliable live video stream from a Bald Eagle nest. The location of this nest is remote where there is no network connectivity or electricity. The problem of streaming live video from such a remote location can be segmented into following steps:

1. Hardware setup at the nest site.
2. Hardware setup at the base station.
3. Stream live video to client.

2.2 Related Work

There has been significant research in remote monitoring services. For use in remote areas, where access to network and electricity is none to nonexistent, wireless sensor networks are most prevalent. Such networks are typically battery powered and ideally designed autonomous operation in remote areas. They measure critical data like temperature, humidity and general state of the environment [5]. However, such remote monitoring services are limited in scope. The gathered data helps researchers recreate condition but lack visual information. Our project focuses on providing real-time live video feed to researcher.

There are many implementations of Eagle Cam. Most common one is BioDiversity Research Institute in Gorham, ME [2]. Almost all of these implementations have recorded video playback instead of live video stream. Our remote monitoring service is first of the kind in North Carolina and it is focused on providing reliable live video stream with an option to perform scheduled recording and ability to playback recorded clips.

2.3 Project Objectives

Along with providing researcher live video stream to observe Bald Eagle's nesting habits, the purpose of our project is to stimulate interest in these magnificent birds by letting people in the triangle know that Bald Eagles are now nesting right in their backyards. The nest we are monitoring has fledged young in each of the last three years, and it is located in close proximity to urban centers in Raleigh, Durham, and Chapel Hill. As long as they have access to suitable large nesting trees, undeveloped forested habitat along lakes and rivers, and uncontaminated fish to eat, Bald Eagles should continue to thrive in the region.

3 Proposed Design

A composite video signal of Red, Green and Blue (RGB) channels is acquired from a camera. This camera is mounted on top of the Bald Eagle nest. The nest is about 70 feet from the ground. Almost 150 feet of coaxial cable carries this video signal from the nest tree to a nearby tree, hereafter referred to as communication tree.

The communication tree houses a transmitter in a weatherproof field lock-box. The transmitter takes the video signal from the camera as an input. The lock-box secures two 12V batteries. These batteries carry power to the cameras on the nest tree via 150 feet of DC power cable. The same battery pack powers the transmitter. Midway up the communication tree, a transmit gain antenna is mounted that points towards the direction of a base station. A 50 feet long Radio Frequency (RF) cable takes the signal from the transmitter towards the transmit gain antenna.

At the base station, which is a shed with electricity and Digital Subscriber Line (DSL) network connection, a receive gain antenna is mounted on top of the shed that is pointing towards the transmit gain antenna. A 20 feet RF cable from the receive antenna goes into a receiver. The receiver converts the RF signal back into composite analog video. This video signal is an input to MG3500 digital video encoder manufactured by Maxim Inc [3]. The MG3500 converts analog video input to H.264 digitally encoded video. The output of the MG3500 goes into DSL modem. The DSL modem is configured to have a static IP address with a pinhole to the MG3500 board.

The H.264 encoded video from MG3500 goes into a video streaming server at NCSU facilities. The user wanting to view live video first load a web page, served by a web server at NCSU. The user then click on play icon. This user action sends a message to streaming server to start uploading live video to client PC. When the page response is received two things happen, one is a flash player download and the other is streaming server IP address is received. Thereafter, streaming server IP address is used by the client to connect and receive video from the streaming server.

3.1 Required Resources

The remote monitoring service required system components are shown in table 1.

Remote Monitoring Service System Components		
Nest Tree	Camera 1 Supercircuits with No IR LED's Camera 2 Supercircuits with No IR LED's Cabling to Ground Len=150 feet	 DC Power Cable (2) 200 mA (fused) Coax Cable (2)
Communication Tree	Antenna Transmitter Power Control 25W Solar Panel	RF Cable Mechanical Mount Undervoltage Circuit Off at Dusk Circuit Package and Mounting
Field Lock-box	Battery Spares	 Connectors Transmitter
Base Station	Antenna Receiver MG3500EVP Maxim Board DSL Connection	
NCSU Facilities	Web Server Access Domain Name Media Server Access Software	
Client	Browser	IE FireFox Safari Chrom

Table 1: System Components

3.2 Plan of Work

Our plan is to install camera on the nest tree and transmitter and field lock-box on at the communication tree by October 12th. The receiver will be located at a base station within 1/2 miles of the nest by October 19th. After installation of the camera, transmitter and receiver, there will be on site video and wireless transmission range and quality tests.

H.264 video stream will be pushed, via Internet, to a video streaming server located at NCSU by November 2nd. Video streaming server and web server at NCSU will be setup by November 23. A user friendly webpage for viewing live video is tested by November 30th.

4 Implementation

The proposed design as described in section 3 is implemented. The figure 1 illustrates our implementation.

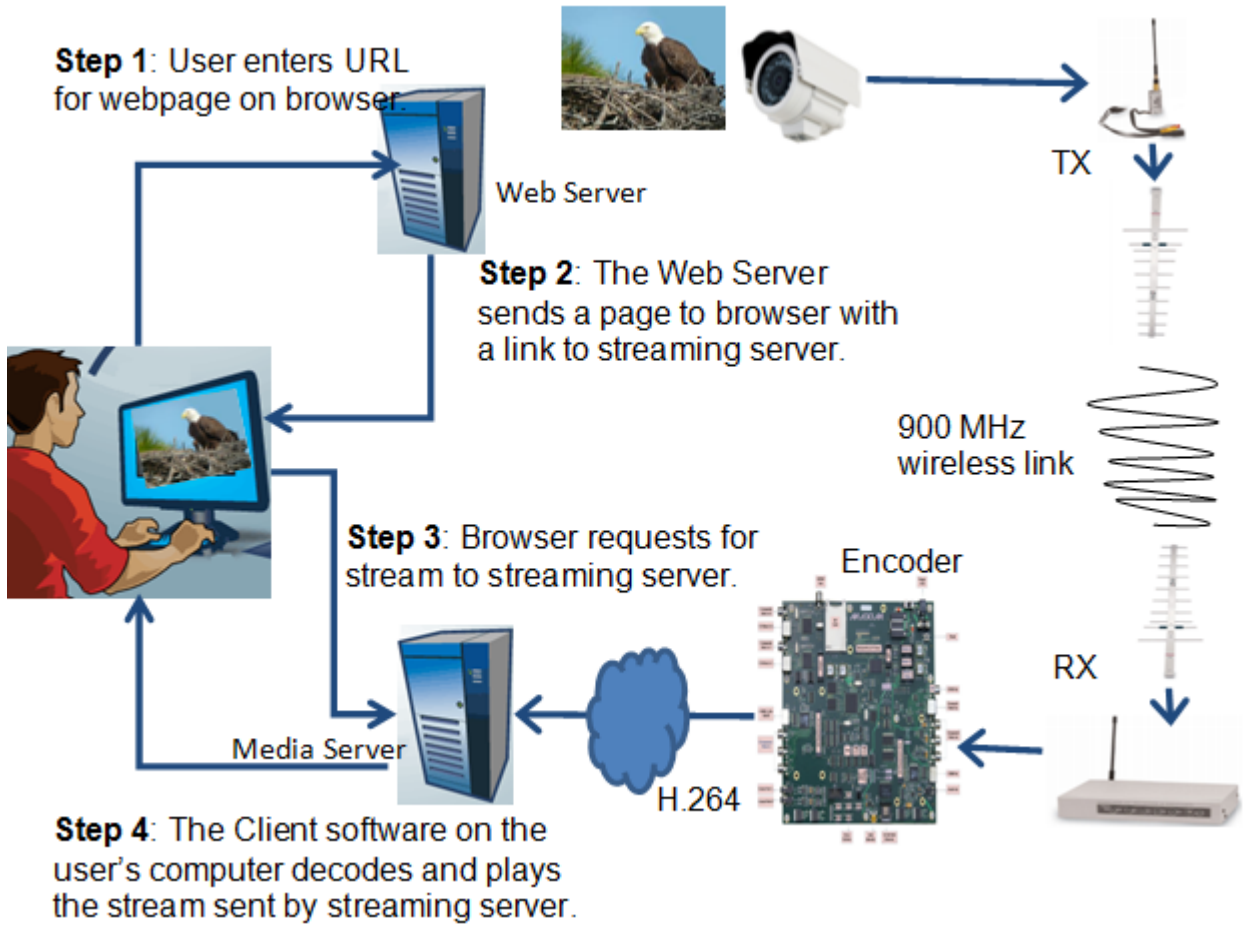

Figure 1: Overall design implementation of remote monitoring service

5 Service Requirements

In order to deem project a success, following service requirements are to be satisfied.

5.1 Service Level Agreement (SLA)

Transmitter is to remain operational from dawn to dusk. Photocell is to to shutdown the system at night to conserve battery life. There is overcharge protection in case solar panel is too efficient due to too many sunny days. The receiver and the encoder are to operate with a UPS and surge protection. The encoder is to reboot and self-start the LUA script to automatically start streaming after a power failure. Service is to remain up at all times. During day time a copy of the live stream is to be saved. This saved copy is to be replay with the live stream is not available.

5.2 Quality of Service (QoS)

Analog wireless transmission is to be less than 1 second. The encoder is to take no more than 5 seconds. Encoding type is H.264, MPEG4 with 30 frames per second at 480 pixel frame size. Network delay is dependent on streaming server to client connection. Connection delay is dependent on setup time by server, generation of Session Descriptor File (SDP) by the encoder and implementation of the streaming server. Packet loss and jitter are not applicable as video is live and video encoder buffer is set.

5.3 Quality of Experience (QoE)

Viewing live video webpage from various browser is not to impact users quality of experience. The look and feel of the webpage is to be user friendly. Embedded video player with Javascript/Flash is to be used which takes less power and can run on different type of web browsers.

5.4 Web Server

Apache web server is used on www.basic.ncsu.edu. This web server hosts Biodiversity and Spatial Information Center at NCSU. The remote monitoring service for Bald Eagle nest is hosted under subfolder called eaglecam. The domain name is http://www.basic.ncsu.edu/eaglecam.

5.5 Streaming Server

The development version of Wowza streaming server is used [4]. This version allows 10 simultaneous connections. In the initial stages of this project Wowza development version is used for proof of concept. Once all of the kinks have been removed, a licence for commercial version shall be purchased by the customer. Wowza supports Abobe/Flash player. It takes Real-time Streaming Protocol (RTSP) stream and converts it to proprietary Real Time Messaging Protocol (RTMP). Application is configured using application.xml file. We support two type of applications one is Nest Live which display's live video stream and the other is Video-on-Demand which playback saved videos. Each of these applications use their own application.xml files.

6 Results

Our initial webpage is shown in figure 2. User clicks on JWPlayer, play icon to start live stream.

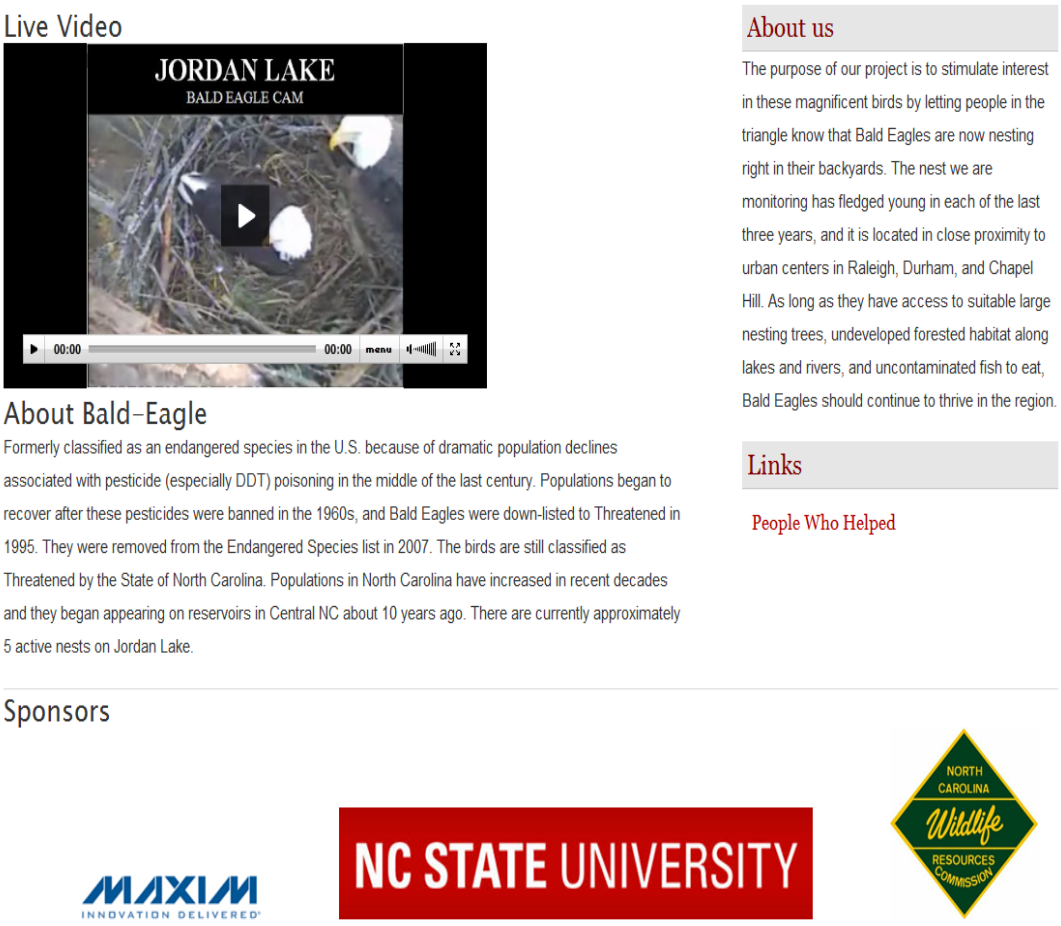

Figure 2: Live Video Webpage

7 Future Work

This project has unique challenges. Working in the field and getting results right the first time is a miracle. We faced issues with getting right signal strength from the transmitter. All lab tests and field range tests were favorable. However, when integrating entire system together would cause receive signal strength to be very weak.

Form several experimentations, it is our conclusion that excessively long video cable is inducing noise and reducing signal strength. When the signal travel through air it further reduces strength and therefore at the receive end we get a very weak

signal and therefore noisy video or no video.

On the network side, we are observing that Wowza streaming server requires RTP over TCP. If we set our encoder for RTP over TCP, we start getting congestion due to packet retransmission. Eventually video encoder buffer overflows and we do not see any new video frame for several minutes. We need to figure out the configuration for Wowza such that is requires RTP over UDP.

Both these issues need to be addressed and resolved. We are committed to provide satisfactory results to our customers and will keep working to achieve the desired results.

8 Conclusions

Several people from various departments at NCSU and from industry collaborated and contributed their time and effort voluntarily. There is something about watching nature at work without disturbing it and admiring the majesty of it. When the Lineberger Tree Service first put up the camera it was unknown if that nest will get occupied in future. We took a risk and it paid off.

Although we are not receiving live pictures from the nest at the moment, we placed a DVR in our field lock-box. It allowed as to capture nesting Bald Eagles incubating an egg. These archived videos are part of our webpage. We already have several hits on our page with a lot of buzz and excitement about seeing live video. We have been successful in creating awareness about our local biodiversity among general public. We will continue our effort in that regard. Figure 3 show a picture we captured from our remote camera.

References

[1] "Bald Eagle–Haliaeetus leucocephalus: The Birds of North America Online". `http://bna.birds.cornell.edu/bna/species/506`.

[2] "BioDiversity Research Institute". `http://www.briloon.org`.

[3] "MG3500". `http://www.maxim-ic.com/datasheet/index.mvp/id/6092/t/al`.

[4] "Wowza Forum". `http://www.wowzamedia.com/forums/content.php`.

[5] A. Mainwaring, D. Culler, J. Polastre, R. Szewczyk, and J. Anderson. Wireless sensor networks for habitat monitoring. *Communications of the ACM*, 47(6):34–40, 2004.

Figure 3: Live Video Capture from Nest Site