360° Webcams for Zoos and Aquariums

Final Presentation

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Overview

- Introduction
- Design
- Implementation
- Testing
- Lessons Learned and Summary
- Q&A
- *Demo Video*

Introduction

What is True 360?

- Startup founded by ISU undergraduate entrepreneur
- Mission: *“Create immersive 360° experiences for zoos and aquariums.”*

Problems/Needs

1. Accessible easy-to-use 360° webcam system
2. Boost social media presence and improve marketing strategies
3. Lack the resources necessary to analyze hours of footage

Market Survey: Zoos

- San Diego Zoo, Smithsonian's National Zoo, Woodland Park Zoo
  - Live footage
  - Not 360° interactive
  - Positioned outside exhibit
  - Low-resolution
  - Sponsored

Market Survey: Pelco VMS

- Security-oriented
- Panoramic/360° footage capabilities
- Computer vision analytics overlays
- Desktop client
- Low-resolution (5 MP) IP 360° camera

Solution

- 360° footage management system
  - Microservices architecture
  - Embedded camera control program
  - Computer vision footage curation
  - Web application

Design

Functional Requirements

- Remotely start and stop recordings
- View camera recording status
- Archive recorded footage
- Detect and extract motion to usable clips
- View raw archives and processed clips
- Download archives and clips

Non-Functional Requirements

- Accessible from exhibits across the country
- Support multiple simultaneous users/webcams
- Support up to 4K footage resolution
- Support future scalability
- Intuitive user interface

Constraints

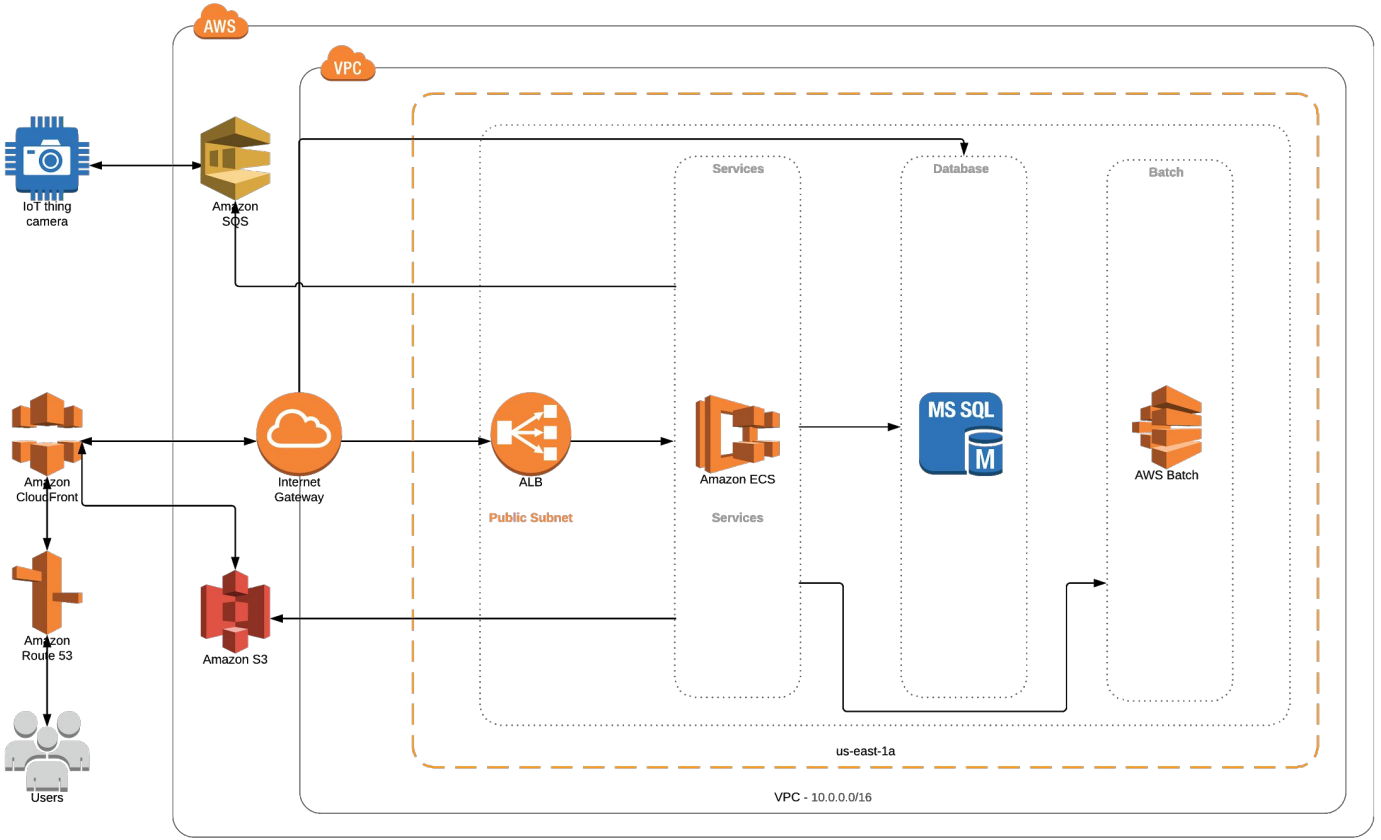
- Programmable 360° camera API availability
- Slow Internet speeds within zoos
- Remote webcam access once installed

Operating Environment

- Exhibits vary widely in:
  - Climate
  - Temperature
  - Indoor/outdoor
  - Water/no water

TRUE360 ARCHITECTURE

Tarek Yacoub | December 2, 2018



Architecture

- Microservices architecture
  - Decoupled functionality of backend to services that handles a specific aspect of the system
  - Allows for scaling of each service depending on demand.
  - Simplifies developer collaboration

Architecture

- Async communication
  - Ensures that message between the embedded board and the web application is not lost
    - If camera crashed, it will still be able to retrieve message that were sent when it was off
  - Removes the need to store and maintain IP addresses within communication-service and embedded program.

Architecture

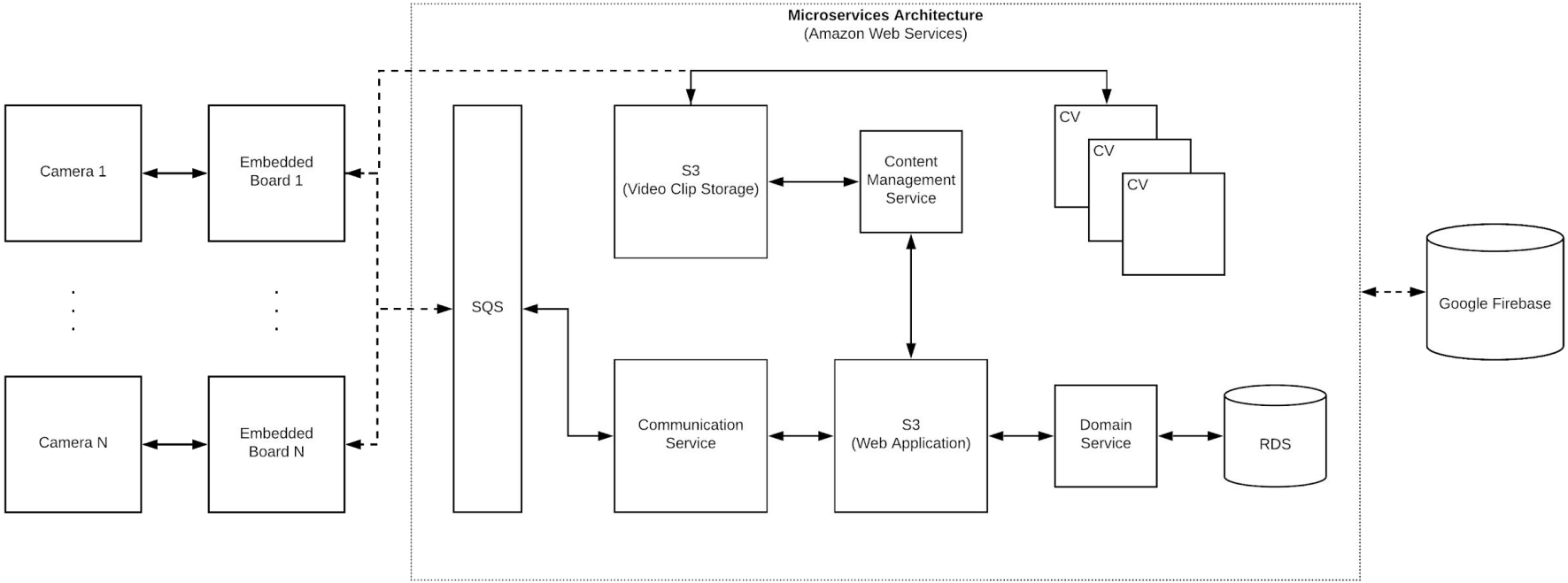
- Batch processing
  - Adds the ability to handle multiple processes, max is 6 processes concurrently at the moment.
  - Pulls code from EC2 container registry (ECR) to execute code, which allows for easy updates
  - Errors are contained in each process

Architecture

- Web Application
  - Globally accessible, offsite archive access
  - Continuous integration → continuous updates
  - No-refresh, single-page UI meets modern UX expectations
  - 360° video viewer makes archive viewing interactive/immersive

Implementation

System Diagram



Microservicess

- Content Management Service
  - Manages archived and processed videos
  - Stores uploads to AWS S3
- Communication Service
  - Communication between front-end and embedded devices.
  - Async messaging with SQS
- Domain Service
  - Users and zoo content registration and storage
  - Storage using AWS RDS
  - Firebase Authentication
- Activity Monitoring Service
  - Batch processing using AWS Batch

Embedded Component

- Acts as a proxy of the camera
- Uses SQS to push/pop messages to/from the communication queue
- Uses the open-source software Ffmpeg to capture footage from Garmin Virb
- Uploads the footage to a S3 bucket for storage
- Submit a job to the batch process for later processing

Computer Vision

- Frame comparison for activity monitoring
- Created training and testing video clips for image recognition model
- Set up framework for future computer vision use cases

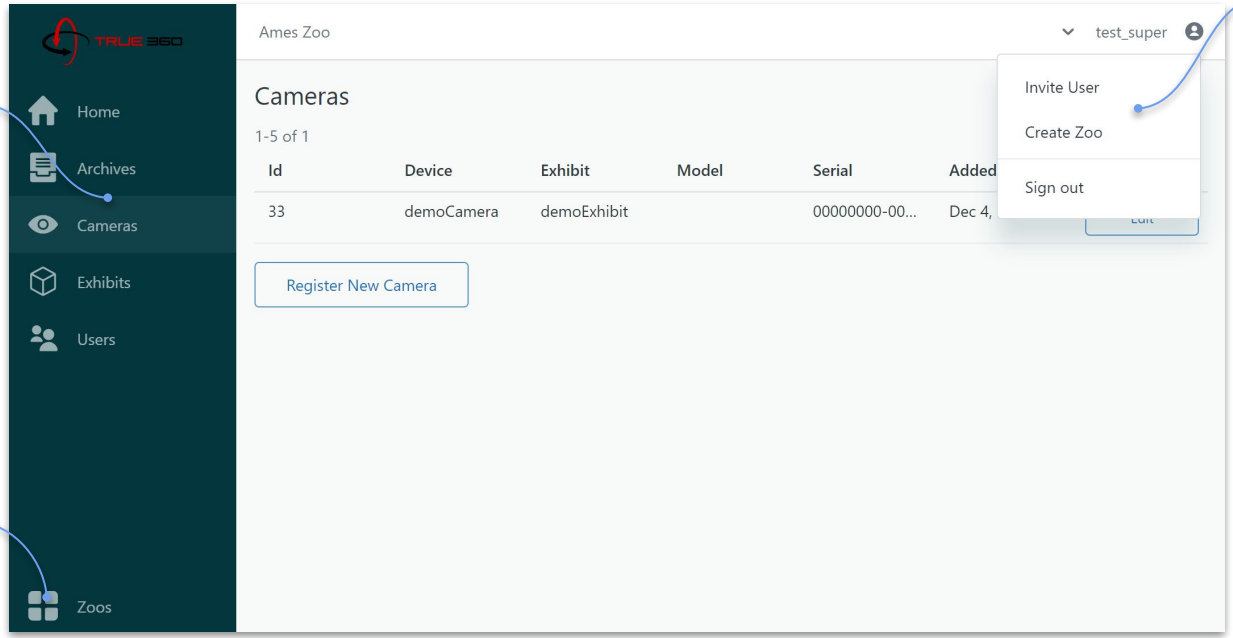
Web Application

- React.js
  - Cascading state, component-based JavaScript library for building responsive User Interfaces
- Redux
  - Single source of truth, immutable global state management library
- Zendesk Garden
  - Open-source, customizable, well-maintained React library for UI components (buttons, modals, etc.)
  - WCAG 2.0 Accessibility
- Deployment/Hosting
  - Continuous Integration and Continuous Deployment to AWS S3

User Interface: General

Sidebar: global zoo context based navigation

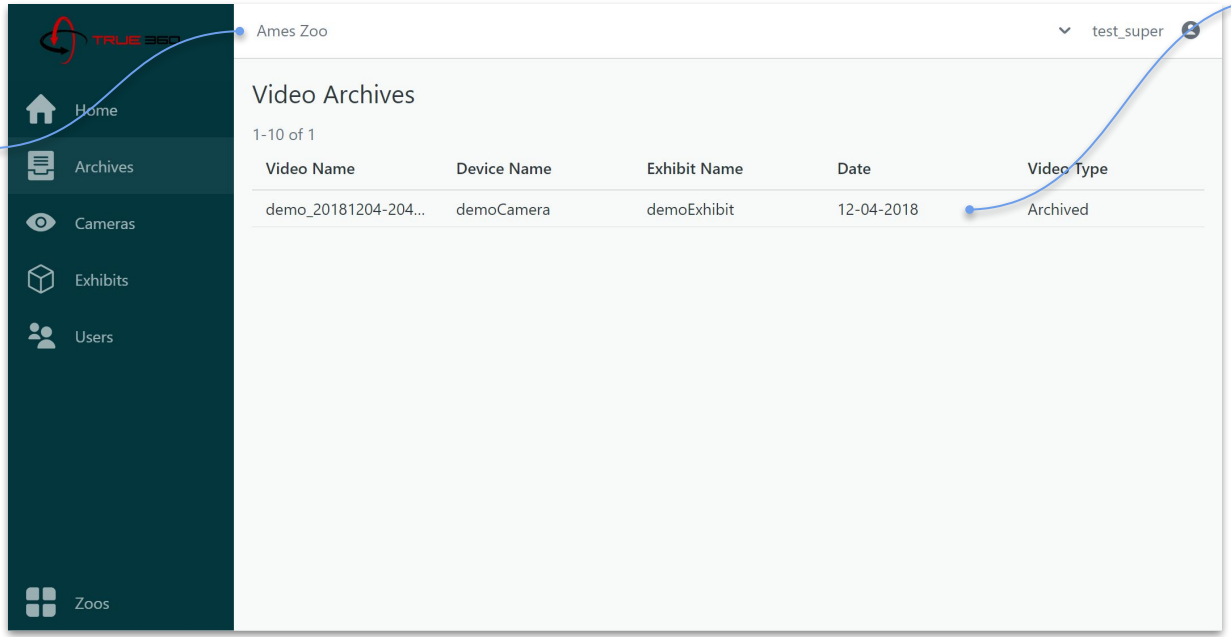
Admin/user action menu



Global zoo context menu

User Interface: Archive Viewing

Current zoo context indicator

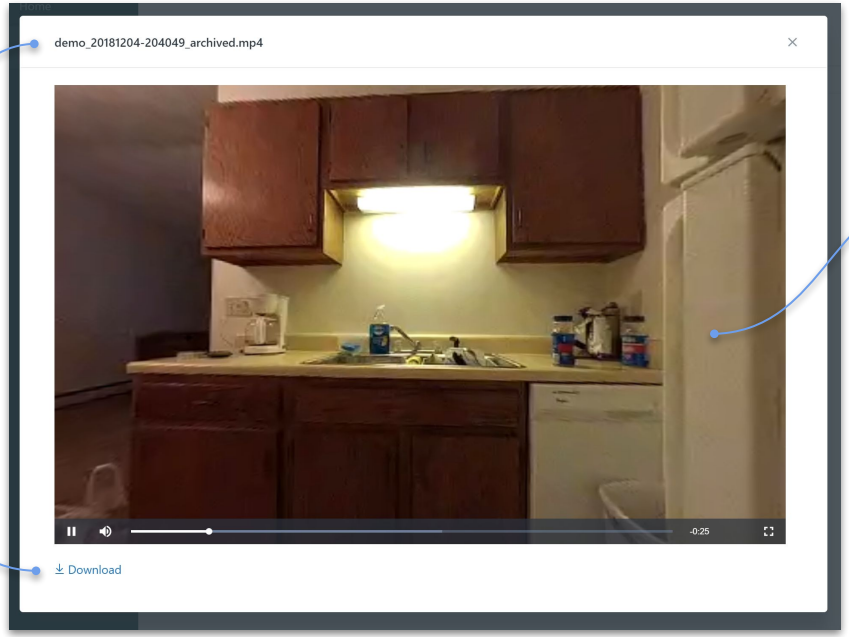


Detailed video archive file information table

User Interface: Video Viewing

Filename of video

Download link to locally store video



Click-and-drag, zoom-able 360° video viewer

Testing

Testing Plan

- Manual system/integration testing
- Scenarios
  - Full-system
  - Storage
  - Timing
  - Behavioral
- Validation testing

Testing Results and Evaluation

- Embedded
  - Elephant device on AWS stable for 3 weeks
- System
  - One-hour stress test
- Client
  - Full app flow successful (Invite → Sign On → Video Viewing)

Client Feedback

- Continuous feedback
  - Weekly meetings with client
  - Feature demos
- Client priority shift
  - From: sponsored live-stream media service
  - To: 360° footage management system

Lessons Learned and Summary

Challenges

- Microservices can be complex
- Sending commands to camera from Web App
- Requirements for computer vision
- Video encodings
- Scalable system infrastructure
- Limited access to hardware
- Budget constraints

Successes

- Development cycle
  - CI/CD
  - Code review process
- Scalable system
  - Cloud services
- Working prototype

Future Work

- Developing a custom webcam with Insta360
- Install system at zoos/aquariums
- Interactive VR kiosks

Summary

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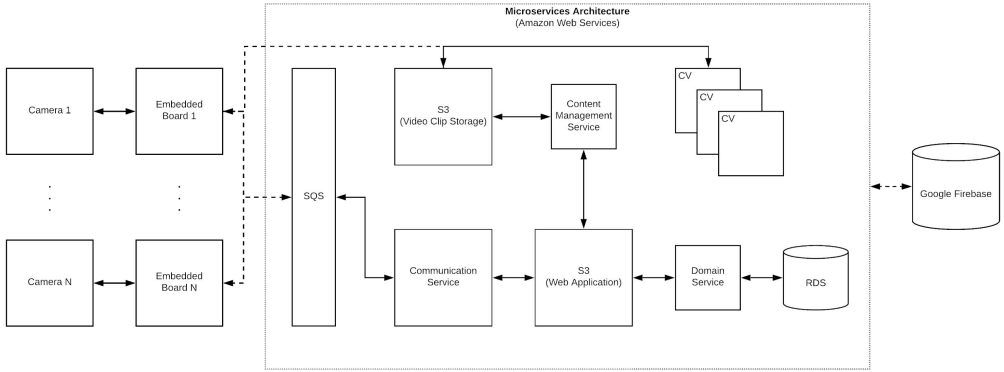

Q&A

Demo Video