Security Cam, CCTV Via Web Browser

Introduction

This is a Network Video Recorder accessed through a web browser, designed to run on a Raspberry pi. Access can be either direct or through a Cloud service. There is no live implementation of the Cloud Service, but the source code is freely available at https://github.com/richard-austin/cloud-server. It requires network cameras providing RTSP streams with the video encoded as H264 or H265. No encoding of video streams is done as, running on a Raspberry pi, this would be too CPU intensive. Audio streams in any format other than AAC are encoded to AAC.

Run Time Platform for NVR

Raspberry pi running headless (server) version of Ubuntu 23.04 (Lunar Lobster).

Security

The NVR is designed to run on a LAN which is protected from unauthorised external access. From within the LAN, access to administrative functions is possible. Secure authenticated access is obtained through ports 443 and 446 via nginx. These ports, plus port 80, are set up for port forwarding on the router when direct access is used.

When the NVR is accessed through the Cloud service, port forwarding is not required as all communication is through a client connection that the NVR makes to the Cloud service.

NVR features

- Secure authenticated web access.
- Live, low latency (approx 1 second) video from network cameras with RTSP source.
- Onvif device and capabilities discovery.
- View individual or all cameras on one page.
- Recordings of motion events, selectable by date and time.
- Recordings triggered by Motion service (https://github.com/Motion-Project/motion)
- Recordings triggered by FTP of an image from camera (can be used with cameras which can ftp an image on detecting motion).
- Quick setup of certain camera parameters for SV3C type cameras.
- Hosting of camera admin page, This allows secure access to camera web admin outside the LAN. This feature requires access through port 446 as well as the usual https port 443.
- Configuration editor supporting Onvif camera discovery.
- email notification if public IP address changes (when using port forwarding).
- Initial set up of user account from LAN only. Subsequent changes can be done when logged in through existing account.
- Get NVR LAN IP addresses.
- Get Local Wi-Fi details.
- Set/unset NVR Wi-Fi access.
- Enable/Disable access through Cloud server.
- All parts of project and dependencies deployed using deb file.

Web Front End

The Web Front End (client) is an Angular application using Angular CLI version 12.0.5 or later. To get more help on the Angular CLI use `ng help` or go check out the Angular CLI Overview and Command Reference page.

Web Back End

The Web Back End (server) is a Grails application, running on Tomcat 9, which provides a Restful API for the Angular Web Front End. It provides the calls to get and set application data as well as configuring the Camera setup.

Media Server

This provides a fragmented MP4 stream for each camera which forms the media source for the Media Source Extensions video implementation used on the Web Front End. ffmpeg connects to a camera RTSP output and converts that to fmp4 which can optionally include the audio stream. ffmpeg feeds the input to the media server with an http stream while the media server supports web socket connections through which the media streams are read. The media streams are also available through http connections which are used when recordings are made.

The Media Server is written in go (golang) and cross compiled for the ARM 64 architecture of the Raspberry pi.

Wi-Fi Setup Service

This runs as a Linux service as root user. It is a web application written in Python, used to list Wi-Fi access points, list the NVR's LAN IP addresses and set up the NVR Wi-Fi and credentials. It also stops and starts the media server, recording service and the motion service during and after configuration updates.

Camera Recordings Service

This is an FTP server to which cameras can be set up to ftp an image file when they detect motion. In response to receiving the image file, this server starts recording from the appropriate (http output) stream on the media server, making a recording of minimum length 30 seconds, but extended by a further 30 seconds when another image file is FTP'd before a recording is completed.

Use of the Camera Recordings Service is configurable from the cameras configuration page and is an alternative to the recording being triggered by the Motion service.

Motion Service

Provides motion detection and recording. Motion is a third party project. On this NVR, Motion can detect and record motion on one stream (usually the lower resolution stream to keep CPU usage down) and trigger a recording on another (usually the higher resolution) stream so that recordings in both resolutions are made.

Configurable from the cameras configuration page.

nginx

nginx is a reverse proxy which all client access to the NVR passes through.

nginx functions on the NVR

- TLS encryption of traffic.
- Translation from Tomcat port 8080 to HTTPS port 443.
- HTTP redirect from port 80.
- Webserver, live and recorded streams made available through a single port (443) at their designated URLs.
- Makes the unauthenticated live and recorded stream dependent on the web application authentication so that they cannot be accessed without the user having logged in.

Development

Platform for Development

- Ubuntu 23.04 (Lunar Lobster) on PC

The following are what is used to build this project:-

- go version go1.20.1
- Angular CLI: 15.2.0 or greater
- Node: 18.17.1
- npm: 9.9.7
- Package Manager: npm 9.6.7
- Grails Version: 5.3.2
- JVM Version: 18.0.2-ea
- Gradle 7.4.2
- Python 3.11.4

Set up build environment

- git clone git@github.com:richard-austin/security-cam.git
- cd security-cam
- gradle init

Build for deployment to Raspberry pi

- ./gradlew buildDebFile

When the build completes navigate to where the .deb file was created:-

- cd xtrn-scripts-and-config/deb-file-creation
- scp the .deb file to the Raspberry pi

Installation on the Raspberry pi

- sudo apt update
- sudo apt upgrade (restart if advised to after upgrade)

- Navigate to where the .deb file is located
- sudo apt install ./*deb_file_name*.deb
- Wait for installation to complete.
- The Tomcat web server will take 1 - 2 minutes to start the application.
- *If this is the first installation on the Raspberry pi..*
    - Make a note of the product key (a few lines up). This will be required if you use the Cloud Service to connect to the NVR.
    - *Generate the site certificate..*
        - cd /etc/security-cam
        - sudo ./install-cert.sh
        - Fill in the details it requests (don't put in any information you are not happy with being publicly visible, for example you may want to put in a fake email address etc.)

Setup for Direct Access (Browser to NVR)

Set up user account

To log into the NVR when accessing it directly, a user account must be set up. This is done using the Create User Account application (cua) which is accessible from the LAN without being logged in. Be sure port 8080 on the Raspberry pi is not accessible from outside the secure LAN. cua is also available when logged into the NVT from "Admin Functions" on the General menu.

- From a separate device on the LAN, open a browser and go to http://*raspberry_pi_ip_addr*:8080/cua
- Click on the hamburger icon at the top left of the page.
- Select "Create or Update User Account" from the menu.
- Enter the required user name.
- Enter the password, then again in Confirm Password
- Enter the email address you will use for forgotten password etc.
- Enter email again in Confirm email address.
- Click Update Account to confirm

Setup SMTP email Client

The email address set up in the previous section is where warning emails are sent if the public IP address changes (when NVR is used on an internet connection with dynamic IP), or for reset password links to be sent when password is forgotten. To do this, the NVR email client must be logged into an SMTP client

- Click on the hamburger icon at the top left of the page.
- Select Set Up "SMTP Client" from the menu.
- If the SMTP connection is to be authenticated (normally the case)...
    - Check the Authenticated checkbox.
    - Enter the SMTP password.
    - Enter the SMTP password again to confirm.
- If TLS encryption is to be used (normally the case)...
    - Check the TLS Encrypted checkbox.

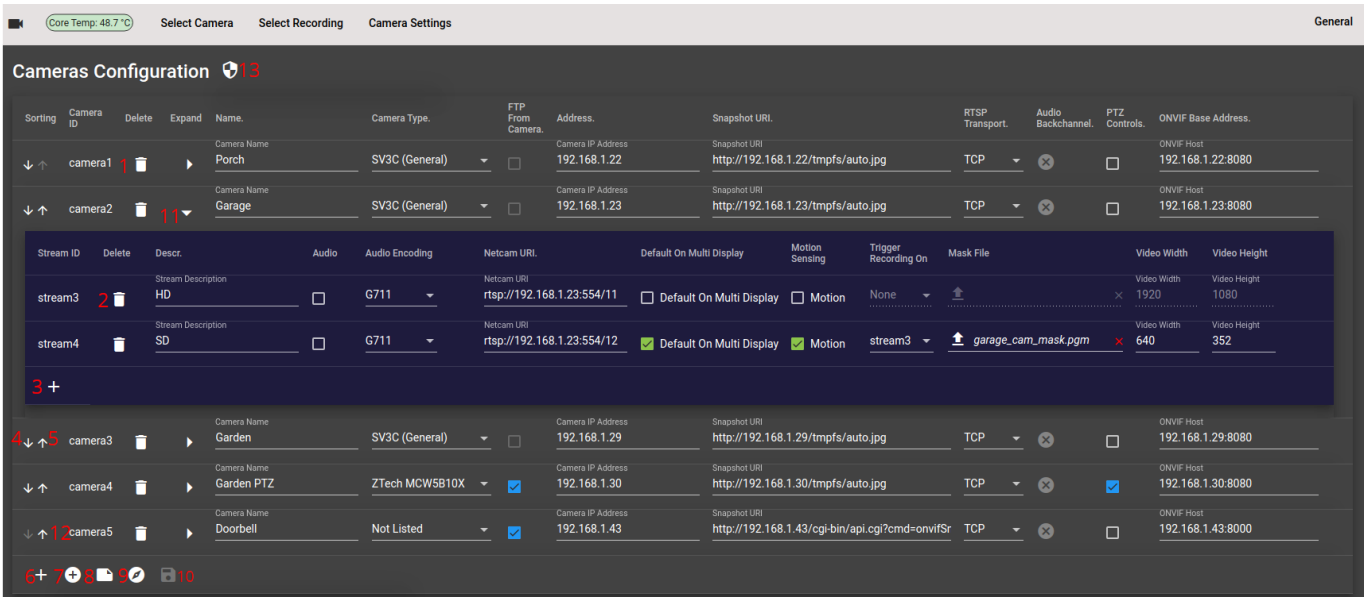
    - Enter the host name for the SMTP client to trust (normally the SMTP host name).
- Enter the SMTP host name
- Enter the SMTP port
- Enter the "from" (sender) address these email will appear to come from
- Click confirm.

Login to the NVR

- Set a browser to https://*ip_addrs_of_raspberry_pi*
- Ignore the warning which may be given as a result of the homer generated site certificate and continue to the log in dialogue box.
- Enter the username and password set up under "Set up user account". You can check "Remember me" to skip having to log in in future.

Set Up Cameras

The NVR must be configured to use your cameras. The configuration editor can be found at General -> Cameras Configuration.



Cameras Configuration Editor button numbering

Config page button functions

Button Number	Button	Function
1		Delete the corresponding camera and its streams. Disabled when there is only one camera
2		Delete the corresponding stream. Disabled when the stream is the only one on the camera.
3		Add a new stream. This will be unpopulated and all fields will need manual entry/setup.

Button Number	Button	Function
4	↓	Move the corresponding camera down one place in the list. The camera streams will be listed on the selection menus in the same order as they appear on this list.
5	↑	Move the corresponding camera up one place in the list. The camera streams will be listed on the selection menus in the same order as they appear on this list.
6	+	Add a new camera. This will add a camera with one stream, with all fields unpopulated. All fields will need to be populated manually.
7	⊕	Add a new camera. You enter the Onvif URL for the required camera, and the camera details will be returned with camera specific data populated. Intended for when General Onvif Discovery has not picked up the camera or a new camera is added to an existing setup. This is the preferred way to add a single camera.
8	🗀	Start a new configuration. After conformation, any camera data will be cleared and a single unpopulated camera/stream will be added.
9	🧭	General Onvif discovery. After confirmation, the Onvif function will try to discover cameras on the network. Any that are found will have their characteristics populated.
10	💾	Save configuration. Any changes made with the editor will only become active after saving with this function.
11	▶	Show the cameras streams
11 *	▼	Hide the cameras streams
12	camera(*n*)	Camera ID. Click on this to show a snapshot from the camera. Note that this will require that the camera credentials are set up correctly (button 13 🛡)
13	🛡	Set or change the user name and password used to access features on the cameras. Note that this currently requires all the cameras on the network to have the same credentials.

* Button style toggles with context

Onvif

With thanks to https://github.com/fpompermaier/onvif

The NVR supports Onvif camera discovery and population of parameters. This should be used when supported by your cameras. Click on button 9 🧭 (Perform onvif LAN search for cameras) to locate cameras on the LAN. Before you can save the configuration you need to complete any missing fields (typically the camera names and stream descriptions). When done, click on button 10 💾 to commit the current configuration

Camera not found

If any cameras do not respond to the multicast probe, they will not be listed after Onvif discovery. Where Onvif is supported you can search for individual cameras by their Onvif URL Click button 7 ⊕, enter the Onvif URL (for example http://192.168.1.43:8080/onvif/device_service, where the IP address is the IP of the camera). This will add the parameters for the specified camera to the list. You then just need to complete the name and description fields.

Cameras can also be added manually by clicking on button 6 ＋ . In this case you will have to enter all parameters yourself, so it's not recommended unless Onvif is not supported on the device.

Camera Parameters

Parameter/Control	Function	Set by Onvif Discovery
Sorting	Up and down arrows move camera position in the list, and correspondingly on the menus.	N/A
Camera ID	Map key of the camera. Clicking on this displays a snapshot from that camera.	N/A
Delete	Delete this camera and its streams from the configuration.	N/A
Expand	Show/hide the cameras streams.	N/A
Name	The name of the camera as it will appear on the menus.	No
Camera Type	Select SV3C, ZTech MCW5B10X or Not Listed. The named options enable some admin functions under Camera Settings -> Quick camera Setup	No
FTP From camera	If checked, the camera ftp-ing an image to *./camera_map_key* will trigger a recording. This is not available if Motion Sensing is set on any of the camera streams.	No
Address	Camera IP address	Yes
Snapshot URI	The URL which returns a snapshot image from the camera.	Yes
RTSP Transport	Determine whether to use TCP or UDP for the RTSP video/audio stream.	No
Audio Backchannel	Enable use of the cameras Audio backchannel for two way audio (if camera supports Onvif Profile T backchannel). (⊗ inactive, ✓ active. Click to toggle).	Yes
PTZ Controls	Enable PTZ cameras on the live stream view. This requires that the camera supports Onvif PTZ control.	No
Onvif Base Address	IP address and port of the cameras Onvif SOAP web service.	Yes

Stream Parameters

Parameter/Control	Function	Set by Onvif Discovery
Stream ID	Map key of the stream	N/A
Delete	Delete this stream from the camera.	N/A
Descr.	Description of the stream (typically HD/SD). This is appended to the camera name on the menus.	No
Audio	Check to include the cameras audio with the video (if present).	No
Audio Encoding	Set to the audio encoding on the cameras RTSP stream. If the audio format is AAC, it will be passed through as is, otherwise it will be encoded to AAC.	Yes
Netcam URI,	The RTSP url used for the video/audio feed from the stream.	Yes
Default On Multi Display	Sets the stream for this camera which is shown by default on the Multi C amera View. Other camera streams can be selected from the Multi Camera View.	N/A
Motion Sensing	If checked, the motion service will be used to detect motion from this stream. To keep CPU usage down, it's best to select a lower resolution stream. Not available if FTP is selected on the camera.	N/A
Trigger Recording On	When Motion Sensing is selected for the stream, you can select another (usually higher resolution) stream to record from in addition to this stream. Both streams will be selectable on the Select Recording menu.	N/A
Mask File	Select a mask file for this stream in the motion service. (see https://motion-project.github.io/motion_config.html#mask_file).	N/A
Video Width	For motion Service, the width of the video stream in pixels (see https://motion-project.github.io/motion_config.html#width)	Yes
Video Height	For Motion Service, the height of the video stream in pixels (see https://motion-project.github.io/motion_config.html#height)	Yes

Using the NVR

The Menus

The NVR has a menu bar at the top of the page. On a PC screen this menu bar will normally show the menu names, though on a mobile device a hamburger icon must be tapped to reveal them.

If no function is selected, the page below will be blank.

Select Camera

This menu allows selection of live video/audio camera streams. The names are listed in the form *Camera Name(Stream Description)* so there can be more than one stream per camera

Multi Camera View

The last option on the Select Camera menu is Multi Camera View. This shows one stream from each camera in the configuration. The default stream shown for a camera will be the one selected as Default On Multi Display. Camera streams can be switched from the menu shown when you click the ⚙ button at the top left of the page.

Select Recording

This menu allows selection of recordings made on camera streams. The names are listed in the form *Camera Name(Stream Description)* On selection, the latest recording on that stream will be shown. Earlier recordings can be selected from the date control and Motion Events selector in the top left of the page.