Axis Dome Camera - Video Authentication

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Contents

1 Setup

The setup documented follows the steps listed on the datasheet. A Windows-based system was used to locate the IP address of the Axis Dome camera and setup shared storage, while a Linux-based system was used for the rest of the project.

The camera is currently configured with factory settings, including the default IP address. To locate the IP address, use either AXIS Utility or the Axis Device Manager. In this demonstration, AXIS Utility was used. When AXIS IP Utility is opened and the camera is connected, it should automatically detect the camera. The camera's IP address will be displayed on the left-hand side. Copy this address into a browser to access the camera software.

The details for the account are:

User: `root`
Password: `Electronic1`

To turn on video signing from this window, navigate to `Video` → `Stream` → `General`.

2 Network Storage

There are two types of storage available: network storage and SD cards. The former was chosen.

First, a shared folder will need to be created on the Windows machine (this can be done on Linux too), which can be done by following this guide. Then, obtain the IP address of the machine hosting the shared folder. This can be done with:

Windows: `ipconfig`
Linux: `ip a`

Navigate to `System` → `Storage` → `Add Network Storage`. Enter the IP address of the host machine, along with the host's username, password, and the path to the shared folder. Leave all other settings at their default values.

3 Video Signing

AXIS cameras can utilise AXIS Edge Vault to sign videos. Ensure that the cameras in use have up-to-date firmware to enable video signing, as cameras straight from the box may not support this functionality. The process of video signing is outlined on pages 13 to 16 of the datasheet.

4 Framework Dependencies

The signed-video-framework requires several dependencies, which are listed below and can be found on their GitHub:

- `meson`
- `ninja`
- `OpenSSL`
- `libcheck`

To run the two applications, `signer` and `validator`, `GStreamer` will also be needed.

4.1 Meson and ninja

To install both `meson` and `ninja`, use the following commands:

```
$ pip install meson
$ pip install ninja
```

4.2 OpenSSL

To install `OpenSSL`, use the following commands:

```
$ git clone https://github.com/openssl/openssl
$ cd path/to/cloned/repo
$ ./Configure
$ make
$ make test
```

If the tests do not pass, you may need to run the commands by prepending `sudo`.

4.3 libcheck

To install `libcheck`, run the following command:

```
    $ sudo apt-get install check
```

4.4 GStreamer

To install `GStreamer`, run the following command:

```
$ apt-get install libgstreamer1.0-dev
libgstreamer-plugins-base1.0-dev
libgstreamer-plugins-bad1.0-dev
gstreamer1.0-plugins-base
gstreamer1.0-plugins-good
gstreamer1.0-plugins-bad
gstreamer1.0-plugins-ugly
gstreamer1.0-libav
gstreamer1.0-tools
gstreamer1.0-x
gstreamer1.0-alsa
gstreamer1.0-gl
gstreamer1.0-gtk3
gstreamer1.0-qt5
gstreamer1.0-pulseaudio
```

5 Framework

Both the signed-video-framework and signed-video-framework-examples repositories were cloned under the same parent directory. All subsequent commands in the framework, as well as those for the `validator` and `signer` sections, were run in the parent directory.

The framework supports both H.264 and H.265 encoding. Depending on the encoding type, the appropriate format should be used in the signer and validator commands.

To compile the framework to the run the two apps, use the following commands:

```
    $ meson --prefix $PWD/local_install signed-video-framework
```

```
  build
$ ninja -C build
$ meson install -C build
$ ninja -C build test
```

The unit tests should all pass if done correctly.

6 Signer

The commands listed below used to compile the validator can also be found on the AXIS Signer GitHub.

If the camera does not automatically perform the signing, the signer step can be done manually. To do this, you must first compile the signer by following the commands provided below:

```
$ export GST_PLUGIN_PATH=$PWD/my_installs
$ meson --prefix $PWD/my_installs -Dsigner=true signed-
  video-framework-examples build_signer
$ meson install -C build_signer
```

The `GST_PLUGIN_PATH` environment variable must be set to the local installation directory, as the signer application is implemented as a GStreamer element.

If the signer application is compiled successfully, it will be located in `local_install/bin/signer`.

To run the signer on a test file, first copy the test file into the same directory where the command is executed. In this case, the file should be placed in the parent directory:

```
$ ./local_install/bin/signer -c h264 test_h264.mp4
```

If the signer is successful, a new file with the prefix `signed_` should be generated.

7 Validator

The commands listed below used to compile the validator can also be found on the AXIS Validator GitHub.

```
$ meson --prefix $PWD/local_install -Dvalidator=true signed-
  video-framework-examples build_validator
$ meson install -C build_validator
```

If the validator application is compiled successfully, it will be located in `local_install/bin/validator`.

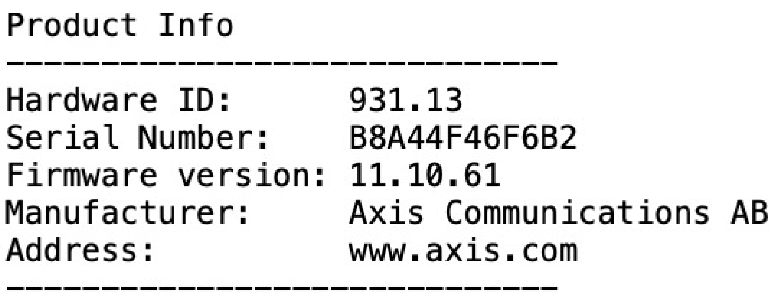
To run the validator on a test file, first copy the test file into the same directory where the command is executed. In this case, the file should be placed in the parent directory:

```
$ ./local_install/bin/validator -c h264 test_h264.mp4
```

The results can be viewed in the `validation_results` text file produced.

8 Product Information

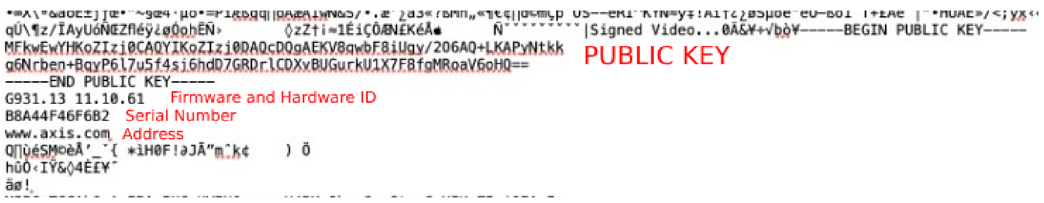
Figure 1 below illustrates the product information as displayed by the validator.



```
Product Info
-------------------------------
Hardware ID:       931.13
Serial Number:     B8A44F46F6B2
Firmware version:  11.10.61
Manufacturer:      Axis Communications AB
Address:           www.axis.com
-------------------------------
```

Figure 1: Product information displayed by the validator.

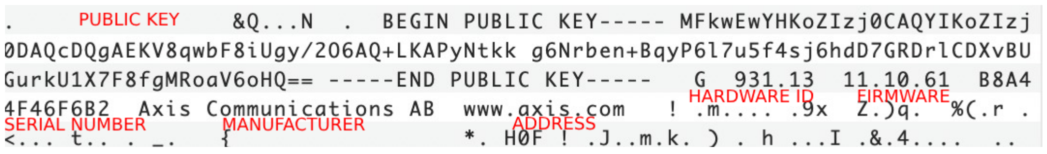
The validator retrieves this information from the metadata, which is stored within the MKV file, as demonstrated in Figure 2.



```
qÛ\¶z/ÏAyUóÑŒZñéÿ¿øÔohÊÑ›        ◊zZ†i≈1ÉiÇÖÆN£KéÅ●      Ñˇˇˇˇˇˇˇˇ|Signed Video...0Ä&¥+√bò¥-----BEGIN PUBLIC KEY-----
MFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAEKV8qwbF8iUgy/206AQ+LKAPyNtkk
g6Nrben+BqyP6l7u5f4sj6hdD7GRDrlCDXvBUGurkU1X7F8fgMRoaV6oHQ==
-----END PUBLIC KEY-----
G931.13 11.10.61
B8A44F46F6B2
www.axis.com
Q∏ùéSMœèÅ'_ˇ{ ∗iH0F!∂JÄ"mˆk¢     ) Ö
hûÒ‹IŸ&◊4È£¥ˇ
äø!
```

Figure 2: Metadata stored within the MKV file.

However, the ”manufacturer” field could not be located in the MKV file when opened as a text file. To find the manufacturer, Hex Fiend was used to decode sections of the video stream as shown below.



```
.            &Q...N   .   BEGIN PUBLIC KEY----- MFkwEwYHKoZIzj0CAQYIKoZIzj
0DAQcDQgAEKV8qwbF8iUgy/2O6AQ+LKAPyNtkk g6Nrben+BqyP6l7u5f4sj6hdD7GRDrlCDXvBU
GurkU1X7F8fgMRoaV6oHQ== -----END PUBLIC KEY-----   G  931.13  11.10.61  B8A4
4F46F6B2  Axis Communications AB  www.axis.com   !  .m.... .9x  Z.)q.  %(.r .
<... t.. . _.     {                *. H0F ! .J..m.k. ) . h ...I .&.4....  ..
```

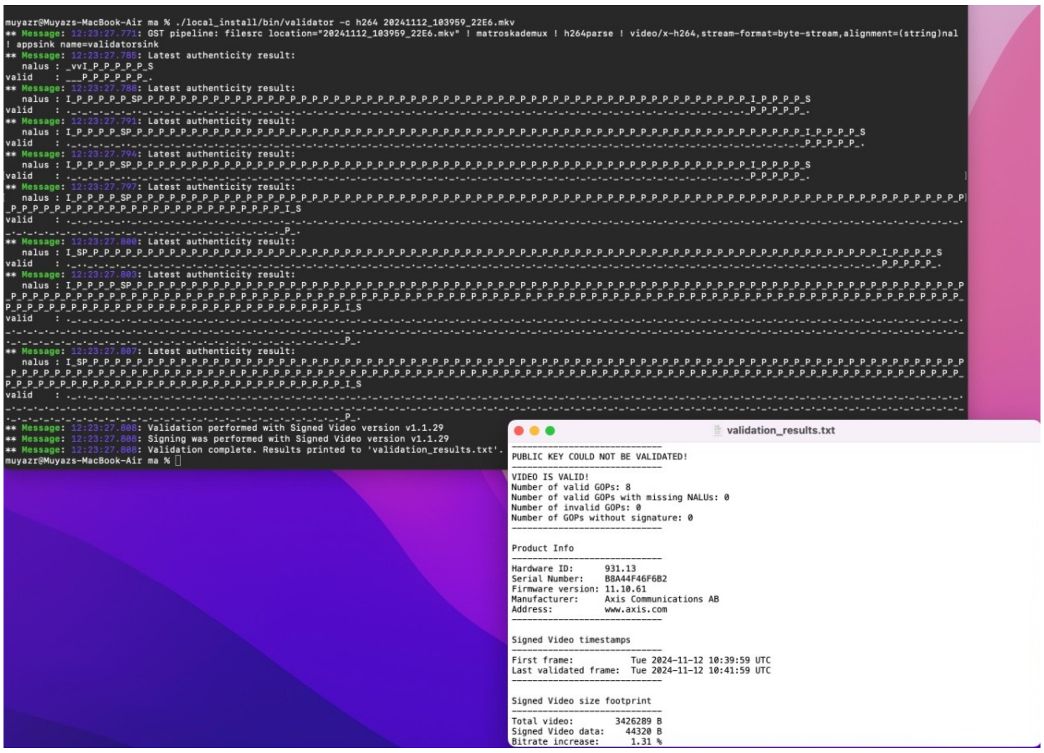
Figure 3: MKV file decoded using Hex Fiend.

This indicates the ”manufacturer” field is embedded within the video stream.

9 Findings

9.1 Validating Non-Tampered Camera Footage

Figure 4 below demonstrates running the validator on a signed video captured by the AXIS Dome camera.



```
muyazr@Muyazs-MacBook-Air ma % ./local_install/bin/validator -c h264 20241112_103959_22E6.mkv
** Message: 12:23:27.771: GST pipeline: filesrc location="20241112_103959_22E6.mkv" ! matroskademux ! h264parse ! video/x-h264,stream-format=byte-stream,alignment=(string)nal
! appsink name=validatorsink
** Message: 12:23:27.785: Latest authenticity result:
   nalus : _vvI_P_P_P_P_P_S
valid    : ___P_P_P_P_P_P_.
** Message: 12:23:27.788: Latest authenticity result:
   nalus : I_P_P_P_P_P_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._.P_P_P_P_P_.
** Message: 12:23:27.791: Latest authenticity result:
   nalus : I_P_P_P_P_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._.P_P_P_P_P_.
** Message: 12:23:27.794: Latest authenticity result:
   nalus : I_P_P_P_P_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._.P_P_P_P_P_.
** Message: 12:23:27.797: Latest authenticity result:
   nalus : I_P_P_P_P_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._
_._._._._._._._._._._._._._._._._._._._._._._._._._._P_.
** Message: 12:23:27.800: Latest authenticity result:
   nalus : I_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._.P_P_P_P_P_.
** Message: 12:23:27.803: Latest authenticity result:
   nalus : I_P_P_P_P_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._
_._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._
._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._P_.
** Message: 12:23:27.807: Latest authenticity result:
   nalus : I_SP_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_S
valid    : ._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._
_._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._
._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._._P_.
** Message: 12:23:27.808: Validation performed with Signed Video version v1.1.29
** Message: 12:23:27.808: Signing was performed with Signed Video version v1.1.29
** Message: 12:23:27.808: Validation complete. Results printed to 'validation_results.txt'.
muyazr@Muyazs-MacBook-Air ma % 
```

```
-----------------------------
PUBLIC KEY COULD NOT BE VALIDATED!
-----------------------------
VIDEO IS VALID!
Number of valid GOPs: 8
Number of valid GOPs with missing NALUs: 0
Number of invalid GOPs: 0
Number of GOPs without signature: 0
-----------------------------

Product Info
-----------------------------
Hardware ID:      931.13
Serial Number:    B8A44F46F6B2
Firmware version: 11.10.61
Manufacturer:     Axis Communications AB
Address:          www.axis.com
-----------------------------

Signed Video timestamps
-----------------------------
First frame:           Tue 2024-11-12 10:39:59 UTC
Last validated frame:  Tue 2024-11-12 10:41:59 UTC
-----------------------------

Signed Video size footprint
-----------------------------
Total video:        3426289 B
Signed Video data:    44320 B
Bitrate increase:      1.31 %
```

Figure 4: Running the validator on a signed video from the AXIS Dome camera.

As shown in Figure 4, the video is validated, indicating that both the public key is valid and the video has not been tampered with. This aligns with our expectations. However, it also shown that the public key cannot be validated. This means the validator is unable to confirm the authenticity of the public key itself. As stated by the developers on GitHub, this is outside the scope of the framework's purpose:

> ”The framework signals the video as authentic, assuming the public key can be trusted. Validating the public key is out of scope.”

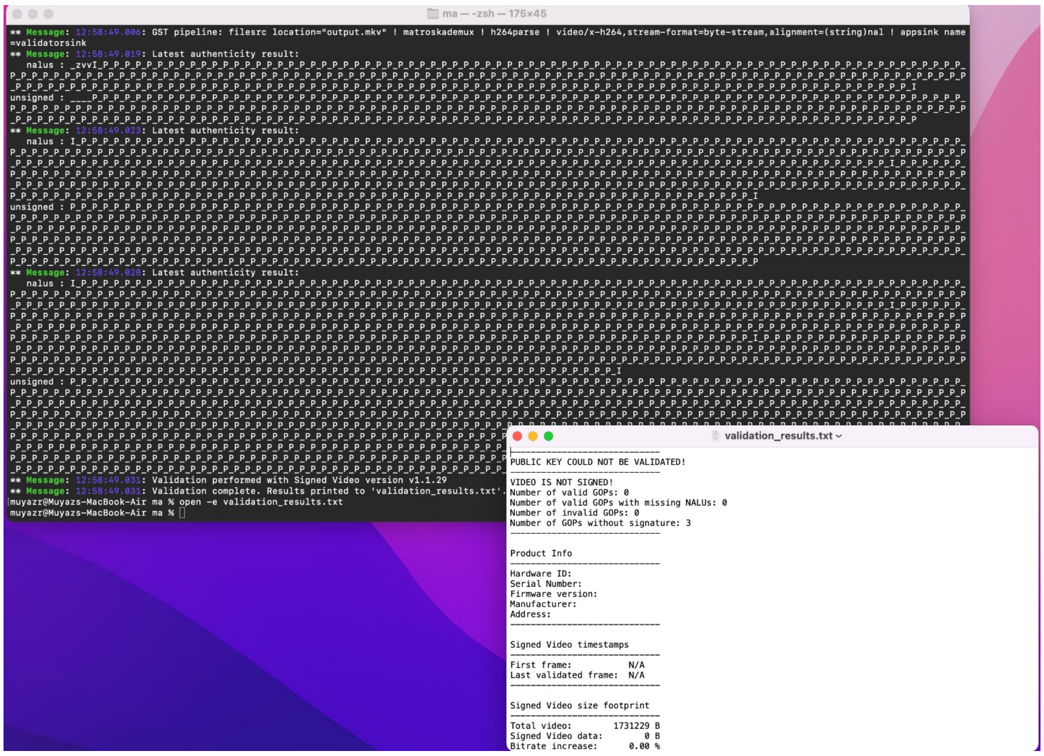
Possible solutions to address this issue include validating the public key through a Certificate Authority or implementing a lookup system to verify whether the public key in question is included in a trusted collection of public keys.

9.2 Validating Tampered Camera Footage

A PNG image was inserted into the signed video from the above section. This was accomplished using `ffmpeg` with the following command:

```
$ ffmpeg -i input_video.mkv -i image.png -filter_complex
  "overlay=x=10:y=10" -c:a copy output_video.mkv
```

Figure 5 below shows the result of running the validator on this altered signed video captured by the AXIS Dome camera.



```
** Message: 12:58:49.006: GST pipeline: filesrc location="output.mkv" ! matroskademux ! h264parse ! video/x-h264,stream-format=byte-stream,alignment=(string)nal ! appsink name
=validatorsink
** Message: 12:58:49.019: Latest authenticity result:
   nalus : _zvvI_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I
unsigned : ____P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
** Message: 12:58:49.023: Latest authenticity result:
   nalus : I_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I
unsigned : P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
** Message: 12:58:49.028: Latest authenticity result:
   nalus : I_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_I
unsigned : P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P
_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_P_
** Message: 12:58:49.031: Validation performed with Signed Video version v1.1.29
** Message: 12:58:49.031: Validation complete. Results printed to 'validation_results.txt'.
muyazr@Muyazs-MacBook-Air ma % open -e validation_results.txt
muyazr@Muyazs-MacBook-Air ma % 
```

```
-----------------------------
PUBLIC KEY COULD NOT BE VALIDATED!
-----------------------------
VIDEO IS NOT SIGNED!
Number of valid GOPs: 0
Number of valid GOPs with missing NALUs: 0
Number of invalid GOPs: 0
Number of GOPs without signature: 3
-----------------------------

Product Info
-----------------------------
Hardware ID:
Serial Number:
Firmware version:
Manufacturer:
Address:
-----------------------------

Signed Video timestamps
-----------------------------
First frame:           N/A
Last validated frame:  N/A
-----------------------------

Signed Video size footprint
-----------------------------
Total video:         1731229 B
Signed Video data:         0 B
Bitrate increase:       0.00 %
```

Figure 5: Running the validator on a tampered signed video from the AXIS Dome camera.

Once again, the public key could not be validated. The validator correctly rejected the video, but it was not marked as invalid. Instead, the video was labeled as ”not signed” rather than ”invalid”.

I believe this issue arises from the video being altered. In the original signed video, there were 8 signed GOPs (Group of Pictures), whereas the altered video shows only 3 unsigned GOPs. However, I don't see this as a problem because all the videos produced by the AXIS Dome camera are expected to be signed. If the validator returns "unsigned," it clearly indicates that the video has been tampered with.