MATRIX VISION

mvBlueGEMINI Technical Manual (EN)

Version: 1.2.2

Date: 21.07.2016

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1 Imprint

1.1 Address

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The mvBlueGEMINI smart camera uses embedded Linux/GNU as its operating system. It also makes use of a number of freely available tools that are released under different open source licences. Some of these licences require us to republish the source code used including any modifications that may have been made. Theses sources are published on following website: http://gpl.matrix-vision.com/mvbluegemini/

2 Revisions

Rev.	Date	Description
1.2.2	21.07.2016	• Extended description of the LEDs. • Renamed ICS to mvIMPACT-CS • Added "Expert knowledge" in "Find object" and "Check object". • Corrected “User data length in bytes” of “Set inspection number”.
1.2	04.05.2016	• Added Testing the communication.
1.1	31.03.2016	• Added control commands. • Added details about the digital inputs and outputs.
1.02		• Added declaration of conformity.
1.01	11.01.2016	• Added more detail about power supply and scope of delivery. • Added accessories table.
1.0	21.12.2015	• First release

3 Notes, Warnings, Attentions

NOTE

A **note** indicates important information that helps you optimize usage of the products.

WARNING

A **warning** indicates how to avoid either potential damage to hardware or loss of data.

ATTENTION

An **attention** indicates a potential for property damage, personal injury, or death.

All due care and attention has been taken in preparing this manual. In view of our policy of continuous product improvement, however, we can accept no liability for completeness and correctness of the information contained in this manual. We make every effort to provide you with a flawless product.

In the context of the applicable statutory regulations, we shall accept no liability for direct damage, indirect damage or third-party damage resulting from the acquisition or operation of a MATRIX VISION product. Our liability for intent and gross negligence is unaffected. In any case, the extend of our liability shall be limited to the purchase price.

3.1 Declaration of Conformity statement

The manufacturer MATRIX VISION GmbH herewith declares, that this product complies with the provisions of the following European Directives:

CE	**2014/30/EU (EMC Directive)** based on the following harmonized standards *Electromagnetic compatibility (EMC)* • Interference emission EN 61000-6-3 / 2007 • Interference immunity EN 61000-6-2 / 2005

EG-Konformitätserklärung
Declaration of conformity

Der Hersteller
The Manufacturer

Matrix Vision GmbH
Talstraße 16
71570 Oppenweiler
Germany

erklärt hiermit, dass sein Produkt
herewith declares, that his product

Typbezeichnung: **mvBlueGEMINI**
Type: ***mvBlueGEMINI***

mit den Bestimmungen folgender Europäischer Richtlinien übereinstimmt:
complies with the provisions of the following European Directives:

2014/30/EU (EMV-Richtlinie) / *2014/35/EU (EMC Directive)*

auf Grundlage folgender harmonisierter Normen:
based on the following harmonized standards:

Elektromagnetische Verträglichkeit (EMV) / *Electromagnetic compatibility (EMC)*
Störaussendung / *Interference emission*
EN 61000-6-3 / 2007 + A1:2011 + Ber.1:2012

Störfestigkeit / *Interference immunity*
EN 61000-6-2 / 2005 + Ber.1:2005

Oppenweiler, 15.02.2016

i.V. Uwe Hagmaier
Leiter Entwicklung / *Head of Development*

Bitte beachten: Um die Einhaltung obiger Normen sicherzustellen, ist die Verwendung hochwertiger, vollständig geschirmter Anschlusskabel unbedingt erforderlich.
Please note: In order to fulfill the above standards, the use of high-quality, shielded connecting cables is required.

4 About this user manual

Purpose of this manual	This manual provides you with an overview of the smart camera's technical data and the handling of the camera. For a quick summary of the product, we recommend that you read the manual in the specified order.
Content of this manual	In the section entitled "**Proper use**" the camera will be introduced, followed by the camera's technical data and the scope of delivery. The subsequent "**First steps**" section, you will learn how to plug in the camera and how to connect it via your web browser. As soon as you are connected with the camera, you can create an inspection program. Please consult the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**". The next section **Updates** describes, how you can update the software of the smart camera. Technical details are explained in the **Appendix** and **Glossary**.

5 Proper use

The mvBlueGEMINI is a Smart Camera for creating inspection applications for different industrial areas. The camera provides a user interface for connecting the camera via your web browser over network. Furthermore you create and configure inspection programs with the user interface software "mvIMPACT Configuration Studio (mvIMPACT-CS)". You can monitor and analyze the results of the inspection program.

The user interface is kept simple and understandable in order to enable a fast learning process and to allow intuitive working. You will find more details in the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**".

6 Scope of delivery

The scope of delivery includes the following components:

- camera hardware
- already installed configuration software mvIMPACT-CS (**mvIMPACT C**onfiguration **S**tudio)

For connecting the camera, you will need the following accessories:

- a suitable power supply (via suitable power supply unit or via suitable M12 cable conntected to suitable power supply)
- a suitable lens as well as
- a suitablle network cable

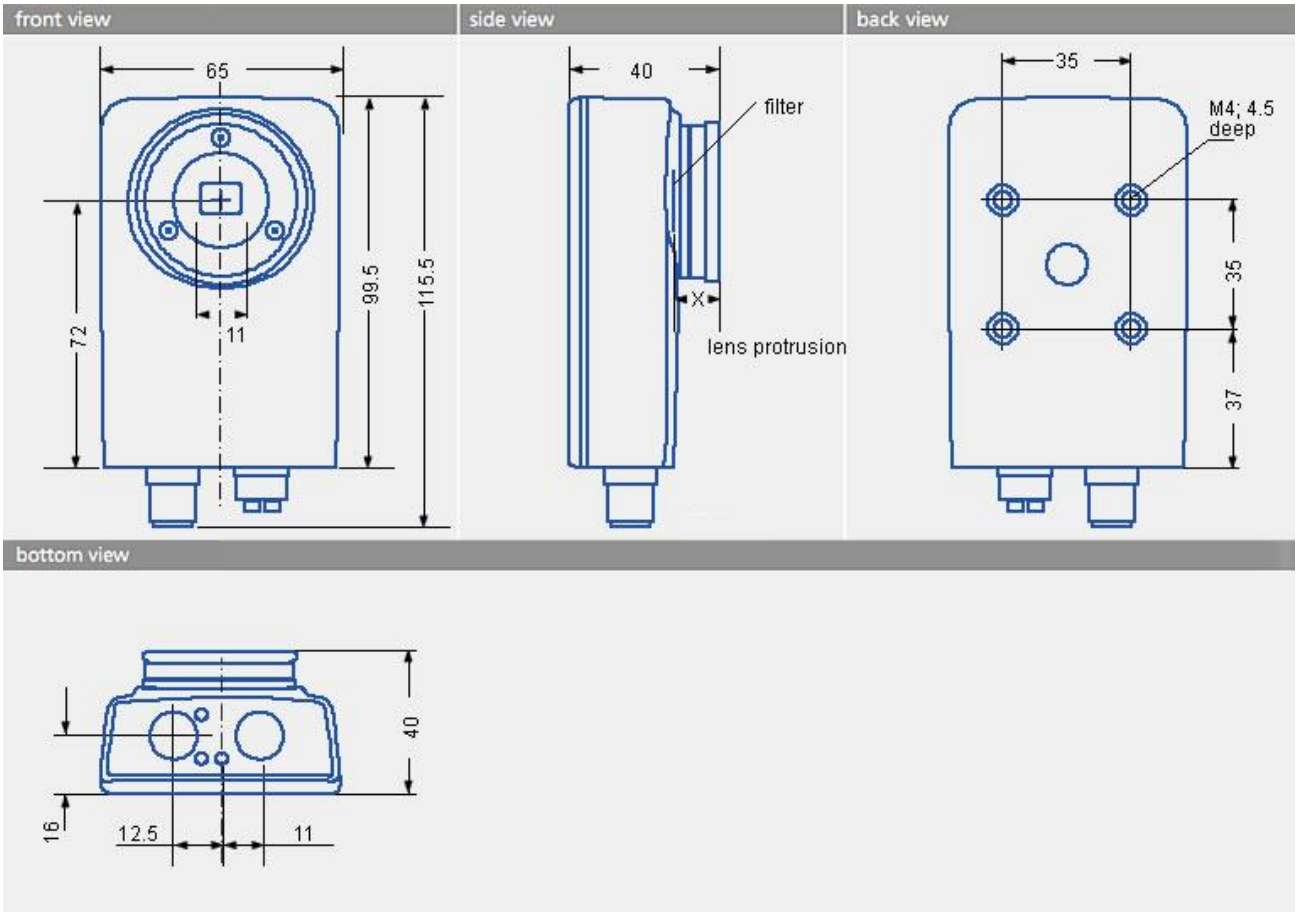
According to the application environment, a separate lighting system could be required.

6.1 Accessories

Article name	Description
KS-RJ45-M12-8X x.xx AL	Network cable, M12 connector, 8-pin X-coded, Cat.6A, length up to 20 m
KS-M12-PWR-IO xx.x	Shielded connection cable mvBlueGEMINI, M12 male connector to prepared wires, UL/CSA, drag chain, up to 20 m
mv-X I/O-BOX	Break-out box for mvBlueGEMINI for connecting the camera and testing of the digital inputs and outputs
MV-TRIPOD ADAPTER GEMINI	Tripod adapter for mvBlueGEMINI
MV-TRIPOD ARM	1/4" Tripod with locking arm and two ball head joints
MV LENS TUBE GEMINI 54	Lens protections tube, IP67, length 54mm
MV-DC2401 GEM IO	Power supply 24V / 1.5 A for mvBlueGEMINI with Dig. I/O on separate cable, length Power 2.0m, I/O 1.0m

7 Technical data

7.1 Dimensional drawing



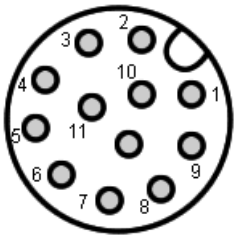
X	12 mm

7.2 Connections

7.2.1 PWR/IO

Manufacturer	Binder
Description	Flanschstecker, M12 x 1, 10,5 mm
Number of contacts	12
Area	M12-A
Order code	09 3491 550 12
	713/763

Figure 1 Power / IO connector



Pin	Signal	Color
1	VIN_L+	brown
2	VIN_L-	blue
3	RS232RX	white
4	RS232TX	green
5	SPSIO1	pink
6	SPSGND	yellow
7	SPSIO0	black
8	SPSIO2	gray
9	SPSIO3	red

Pin	Signal	Color
10	SPSIO4	violet
11	SPSIO5	gray/pink
12	NC	red/blue

7.2.1.1 Characteristics of the I/Os

- SPSIO0 - SPSIO5 are digital in-/outputs. Each of them could be used as an input, output, trigger line or for controlling flash lights.
- The inputs switch at approx. 11.3V (supply voltage > 18V; i.e. PLC).
- The inputs switch at approx. 50% of the supply voltage (supply voltage <= 18V).
- Max. output voltage for each output is 200mA.
- Current limited output (< 450mA)
- 5 µs input filter for spike suppression
- Reverse polarity protection
- Overtemperature protection

Digital input

Delay time	typ. 3.3 µs

Measurement conditions: V_{CC} = 24V

Digital output

Delay time	typ. 6.3 µs

Measurement conditions: V_{CC} = 24V; R_L = 1MΩ

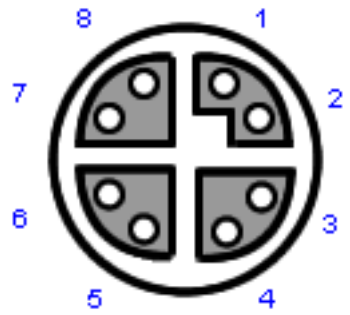
NOTE

Delay time can increase with higher load.

7.2.2 LAN

Manufacturer	Binder
Description	x-coded flange receptacle
Number of contacts	8
Area	M12-D, M12-X
Order code	99 3782 210 08
	Serien 825/876

Figure 2 x-coded flange receptacle



Pin	Signal
1	MDX0+
2	MDX0-
3	MDX1+
4	MDX1-
5	MDX3+
6	MDX3-
7	MDX2-
8	MDX2+

NOTE

The Ethernet signals are galvanically isolated from the camera electronics.

7.3 LED states

7.3.1 PWR (Power)

Color	Description
Green	Power on
Green flashing	FPGA loaded. **Once software is running:** Software is in *Configruation* mode.
Green permanent	Inspection programm is running.
Red flashing	Software updating. **WARNING** DO NOT disconnect from power supply.
Red permanent	Software stalled, please reboot.

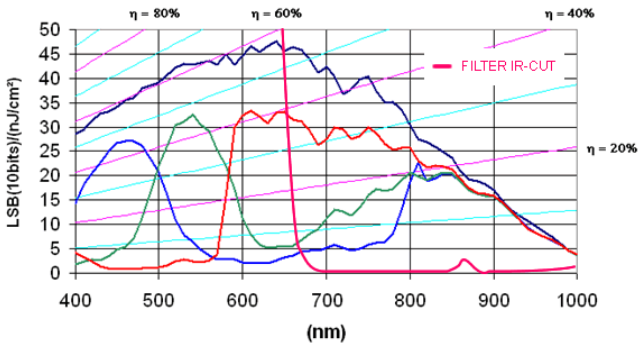
7.3.2 NET (Netzwerk)

Color	Description
Green	Link
Orange flashing	Activity

7.3.3 I/O (Digital inputs and outputs

The LED "I/O" is not implemented in this software version.

7.4 Image sensor

CMOS	
Model[1]	G / C
Resolution	1280 x 1024
MPixel	1.3
Shutter type	Pipelined / Global
Sensor size	1/1.8"
Unit cell size [µm]	5.3 x 5.3
Exposure time	10 µs - 1 s
ADC resolution / output	10 bit (10-8 companding) → 8 bit
SNR	41 dB
DR (normal / HDR)	62 dB / -
Trigger (HW / SW)	yes / yes
Spectral densitivity	
Sensor manufacturer	E2V
Sensor name	EV76C560

[1] G = Gray scale, C = Color

7.5 Hardware

- FPGA/SoC with Dual-Core Cortex-A9 each with 800 MHz
- 1 GB DDR3 SDRAM memory
- 4 GB NAND Flash
- *Connections:*
  - 1 GBit Ethernet LAN,
  - 6 digital in-/outputs (valid modes: input, output, trigger, flash)
- Size without lens (B x H x L): 65 x 40 x 99.5 mm
- IP67
- Power consumption less than 5W
- Power supply: 12V to 24V DC +/- 10%
  - Power consumption: 360mA @12V or 180mA @24V
- Permissible ambient temperature
  - operation: 0 °C .. +55 °C, without airflow
  - storage: -25 °C .. +70 °C
- RoHS

7.6 Software

- Operating system: Linux®
- Configuration software mvIMPACT Configuartion Studio (mvIMPACT-CS) with modern and intuitive user interface

8 First steps

8.1 Connect the smart camera

Figure 3 Connector side

- Connect the smart camera with the local network using the **NET** (2) connector .
- Power the camera using the connector **PWR/IO** (1).
- Now, the smart camera will start which will take approx. 30 seconds.
- The smart camera will load the most recently opened inspection program and will continue with the most recently used operating mode (active/inactive).

8.2 Connect with the smart camera

- The camera is configured via PC, tablet or smartphone. It is assumed that the device used for this purpose
  - has **a minimum resolution of 1024 x 768 pixels**,
  - has **an supported web browser (Minimum: Mozilla Firefox Version 11 or Google Chrome Version 16) and**

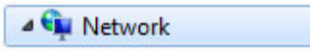
  - **is connected to the same network** as the camera. In Windows, you need to apply the setting **"Obtain an IP address automatically" (DHCP)** for the network adapter for the PC or smart camera.

- Access is then via the web browser. To go to the configuration software page,
  a. open the web browser,
  b. enter the address or URL of the device on which mvIMPACT-CS is running.

     For the mvBlueGEMINI smart camera, this may look something like: "*http://gemini-000110*".
  c. Confirm your entries.
     Please replace *000110* with the serial number of the used smart camera (without "MS"). You will find the serial number on the rear side of the camera printed on a label (starting with "MS").
- If there are other smart cameras in the network, you can also connect to them.

  If you are connected to the smart camera correctly, you will see the homepage of mvIMPACT Configuration Studios (mvIMPACT-CS).

Alternatively, you can use Windows Explorer to find the smart camera or the PC in the network. To do this, select the network folder



, to display all connected network devices.

8.2.1 If you wish to access ICS in another subnetwork ...

- Subnetworks have been explicitly created to arrange computers into various networks, with these boundaries restricting access.
- Refer to your IT administrator to set up access to the smart camera or PC. You can find useful tips in the appendix "Notes about network connections".

8.3 How to continue?

You are connected to the smart camera via browser and the homepage of mvIMPACT Configuration Studios (mvIMPACT-CS) is displayed. Now, you can create your first inspection program with mvIMPACT-CS. For this, please consult the "**mvIMPACT Configuration Studio (mvIMPACT-CS) User Manual**".

9 Updates

9.1 Update software

Periodically, we publish software updates on our website. The updates contain bug fixes, performance optimization, or functional extensions.

NOTE

We recommend updating the camera from time to time to derive maximum benefit from the camera.

Please follow these steps to update the camera:

1. Download the latest update file from our website (https://www.matrix-vision.com/) and save it locally on your computer.
2. Press the keys **Windows + R**, enter the address of the update directory (e.g. *gemini-000110**updates*), and confirm with **Enter**.

   NOTE

   Please note the correct entry of the characters ****.

   NOTE

   In rare cases, the username (address of the camera, e.g. *gemini-000110*) and the corresponding password (blank password) will be requested.

3. Copy the update file into the folder *updates*. The update process will start automatically, which can take up to 5 minutes. The LED status indicator "PWR (Power)" will flash red during the update process and the camera is not available.

   ATTENTION

   Do not switch off the camera during the update process. This may cause irremediable damage to the camera.

4. After a few minutes, the update is finished and the LED status indicator "PWR (Power)" will change to green. The camera is then ready to use.

10 Appendix

10.1 Control commands

10.1.1 Communication via UDP

It is possible to control the smart camera using so-called UDP sockets via the Ethernet interface. For this, the port 36701 is used.

NOTE

To communicate via UDP, you have to set the *Mode* in the camera's system menu ("*System settings -> communication*") to "**UDP**".

The smart camera expects a *Connect* message to create a connection. Afterwards, the smart camera will start to send result data. A *Disconnect* message closes the connection and the sender of the *Disconnect* message has to close the socket.

The smart camera supports one active UDP connection. If a UDP connection exists, it will be closed as soon as another *Connect* message is recieved. The camera ignores invalid messages.

10.1.1.1 Message structure

A message consists of unsigned 32 bit values and byte strings. They are transmitted in Little Endian format and the lowest value byte is sent first.

There are three different message categories:

1. *Messages from the smart camera*
    a. Result container
2. *Messages to the smart camera without answer*
    a. Disconnect
    b. Set input data
    c. Trigger inspection
    d. Start inspection
    e. Stop inspection
    f. Restart camera
    g. Set inspection number
    h. Set date and time
3. *Messages to the smart camera with an answer after an action*

a. Connect
b. Change inspection
c. Get date and time
d. Get program number

All messages have the same structure:

Lenght in bytes	Structure	Description
4	uint32	Magic number: 42565350_{hex}
4	uint32	User data length in bytes
4	uint32	Message ID
4	uint8[]	User data

Messages are ignored by the camera which do not comply with the given format (wrong "magic number", wrong length, unknown message ID). The "magic number" is used to avoid accidential transmissions. It is recommended to check the "magic number" in the control software.

Every message has a unique ID:

ID	Message
01_{hex}	Connect
02_{hex}	Disconnect
20_{hex}	Result container
30_{hex}	Get program number
31_{hex}	Change inspection program
32_{hex}	Get date and time
33_{hex}	Set date and time
34_{hex}	Set input data
35_{hex}	Set inspection number
40_{hex}	Trigger inspection
41_{hex}	Start inspection
42_{hex}	Stop inspection

ID	Message
43_{hex}	Restart camera

Connect

The *Connect* message creates a connection to the smart camera.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	01_{hex}	Message ID

The smart camera answers with a *Connect* message.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	04_{hex}	User data length in bytes
4	uint32	01_{hex}	Message ID
4	uint32	01_{hex}	Version of the protocol

Disconnect

With the *Disconnect* message the connection will be disconnected. No more result data will be transmitted.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	02_{hex}	Message ID

Result container

If an inspection program uses a "Send results" tool, the inspection program will send the result data in this message after processing the inspection program.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32		User data length in bytes
4	uint32	20_{hex}	Message ID
4	uint32		Inspection ID. The **mvIMPACT Configuration Studio (mvIMPACT-CS)** can manage various inspection programs. Each of this program has a unique inspection ID. This section indicates the inspection, which created the result container.
x	uint8[]		Result data as specified in **mvIMPACT Configuration Studio (mvIMPACT-CS) -> tool "Send results"**.

Get program number

Gets the program number of the active inspection.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	00_{hex}	User data length in bytes
4	uint32	30_{hex}	Message ID

The smart camera answers with a status message containing the program number.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	04_{hex}	User data length in bytes
4	uint32	30_{hex}	Message ID
4	uint32	01_{hex}	Program ID

Change Inspection program

A change is possible, when the following conditions are fulfilled.

- No client is in the config mode.
- The current inspection is stopped.
- The number of the inspection program which should be loaded is not zero.
- The inspection program which should be loaded is available on the camera.
- No other inspection program is currently loaded or duplicated.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	04_{hex}	User data length in bytes
4	uint32	31_{hex}	Message ID
4	uint32	01_{hex}	Program ID

The smart camera answers with a status message containing the program number.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	08_{hex}	User data length in bytes
4	uint32	31_{hex}	Message ID
4	uint32	00_{hex}	Status
4	uint32	01_{hex}	Program ID

The status has a value of 00_{hex} if the mentioned conditions are fulfilled and the inspection program gets loaded. In this case the program ID of the status message is equal to the number in the change request. If one of the conditions is not fullfilled the inspection program is not changed. The message then contains a status of 01_{hex} as well as the programm ID of the program that is still loaded.

Get date and time

Get the current date and time from a smart camera.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	00_{hex}	User data length in bytes
4	uint32	32_{hex}	Message ID

The smart camera answers with the current date and time.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	$_{18hex}$	User data length in bytes
4	uint32	32_{hex}	Message ID
4	uint32		Year
4	uint32		Month
4	uint32		Day
4	uint32		Hour
4	uint32		Minute
4	uint32		Second

Set date and time

Set date and time on a smart camera.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic Number
4	uint32	$_{18hex}$	User data length in bytes
4	uint32	33_{hex}	Message ID
4	uint32		Year
4	uint32		Month

Lenght in bytes	Structure	Value	Description
4	uint32		Day
4	uint32		Hour
4	uint32		Minute
4	uint32		Second

The camera may discard or convert invalid values.

To set date and time to 2016-06-25 10:11:12 send the following data (hex):
50535642180000003300000E00700000600000019000000A0000000B0000000C000000

Set input data

Some inspections require input data which are compared with the acquired data of the smart camera. These data can be sent to the smart camera using this message. The tool "**Receive data**" interprets the input data.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32		User data length in bytes
4	uint32	34_{hex}	Message ID
4	uint8[]		Input data for the inspection as specified in **mvIMPACT Configuration Studio (mvIMPACT-CS)**.

Trigger inspection

Is sent to the smart camera to trigger an inspection.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	40_{hex}	Message ID

Start inspection

Is sent to the smart camera to start the inspection. The behavior of the smart camera depends on the **mvIMPACT Configuration Studio (mvIMPACT-CS)** settings. Untriggered inspections will start immediately and will transmit results continuously while triggered inspections will wait for a trigger signal.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	41_{hex}	Message ID

Stop inspection

Is sent to the camera to stop an inspection. Untriggered inspections will stop and will not send results anymore while triggered inspections will ignore further trigger signals.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	42_{hex}	Message ID

Restart camera

Restarts the camera. After this message, the network connection will be lost and will be established after the restart. The restart will take approximately 30 seconds.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	00_{hex}	User data length in bytes
4	uint32	43_{hex}	Message ID

Set inspection number

Set the inspection number for the next inspection.

Lenght in bytes	Structure	Value	Description
4	uint32	42565350_{hex}	Magic number
4	uint32	04_{hex}	User data length in bytes
4	uint32	35_{hex}	Message ID
4	uint32	01_{hex}	Inspection number

10.1.1.2 Testing the communication

Under Linux

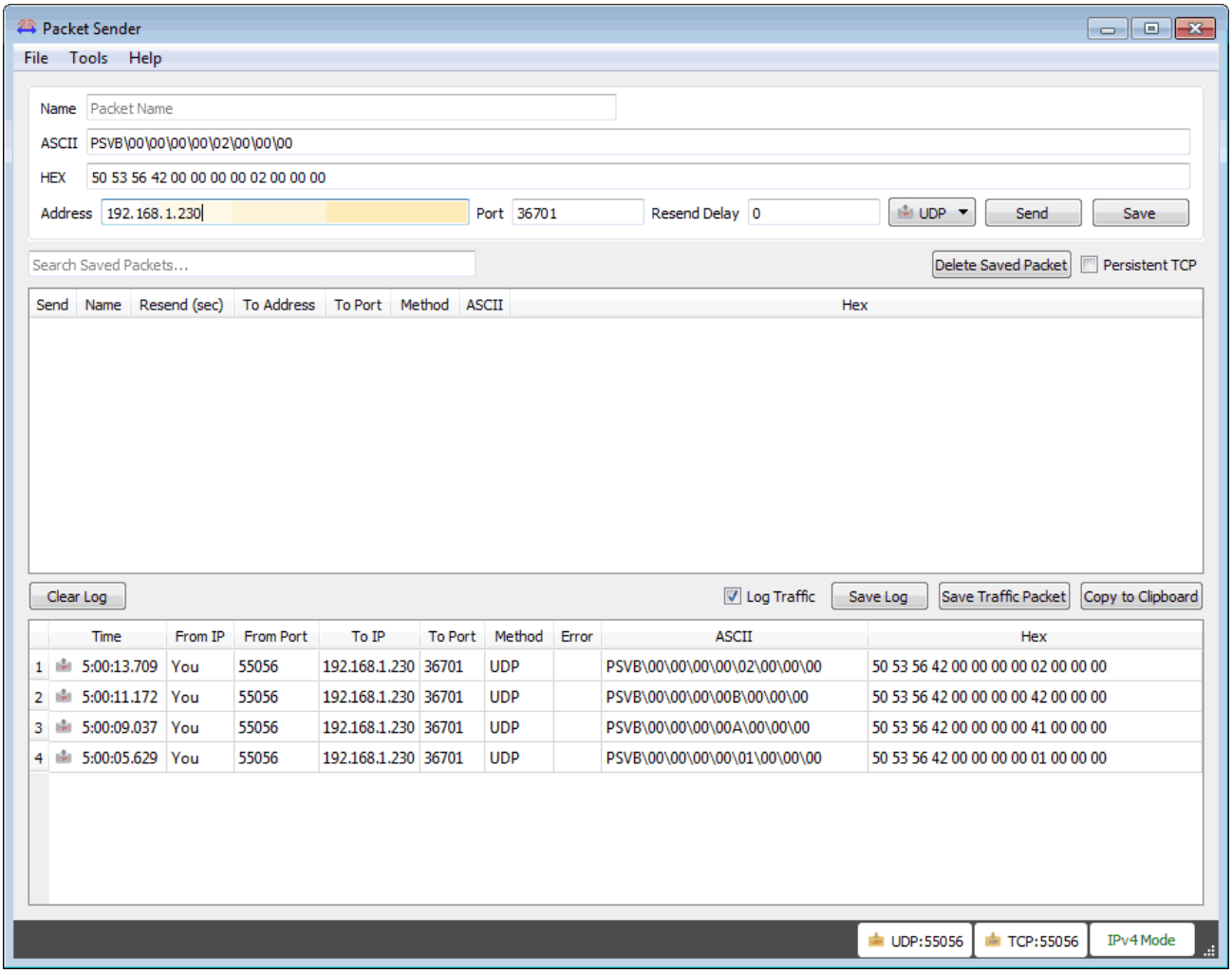
For testing the UDP communication you can use the tool **Netcat** under Linux. The following console prompts will open a connection to the camera, start and stop the current inspection, and close the connection.
In this example the IP address of the smart camera is 192.168.1.230. The port 60001 is used to get results from the camera.

```
# Connect
echo -n -e '\x50\x53\x56\x42\x00\x00\x00\x00\x01\x00\x00\x00' | nc -
uw 1 -p 60001 192.168.1.230 36701
# Start inspection:
echo -n -e '\x50\x53\x56\x42\x00\x00\x00\x00\x41\x00\x00\x00' | nc -
uw 1 -p 60001 192.168.1.230 36701
# Stop inspection:
echo -n -e '\x50\x53\x56\x42\x00\x00\x00\x00\x42\x00\x00\x00' | nc -
uw 1 -p 60001 192.168.1.230 36701
# Disconnect:
echo -n -e '\x50\x53\x56\x42\x00\x00\x00\x00\x01\x00\x00\x00' | nc -
uw 1 -p 60001 192.168.1.230 36701
```

Under Windows

For testing the UDP communication you can use the tool **Packet Sender** (https://packetsender.com) under Windows. The following console prompts will open a connection to the camera, start and stop the current inspection, and close the connection.
In this example the IP address of the smart camera is 192.168.1.230.

Figure 4 Packet Sender - for testing the UDP communication



10.2 Troubleshooting table

Error	Cause	Action
No connection to the camera possible	Incorrect network configuration	Check and implement the measures defined in the "Notes on network connections" chapter. Alternative access to the camera (direct connection): 1. Disconnect the camera's power supply. 2. Use a PC/laptop with an Ethernet port. 3. Disconnect the PC from all networks by removing all network cables and disabling the WLAN (if present). 4. Establish a direct connection between the PC and the camera by connecting the camera's network cable directly to the PC's Ethernet port. Do not use any switches/routers/hubs. 5. Restore the camera's power supply. 6. The camera now starts up and establishes a network address with the connected PC. This may take up to 5 minutes. 7. Follow the sequence mentioned in the "First steps" chapter under "Connecting with the smart camera" 8. Open the system settings and check the camera's network configuration. In case of doubt, consult an IT expert.
No connection to the camera possible	Incorrect configuration of PC - Wrong IP address	If you cannot get an connection to the camera as described before, it could be possible, that your PC/laptop doesn't find the camera because it doesn't negotiate an IP address with the camera. Please ensure that your PC retrieves it's IP address automatically (DHCP): 1. Open the settings of your network adapter and there the settings of the internet protocoll (TCP/version 4) 2. Set the IP address to *automatically* 3. Inside the tab alternative configuration also set the IP address to *autmatically*

Error	Cause	Action
		4. Close the windows and restart the PC 5. Retry the previously described way
No connection to the camera possible	Incorrect configuration of PC - NetBIOS name (*http://gemini-nnnnnn*) of the smart camera is not dissolved	If you still cannot get an connection to the camera as described before, it could be possible, that your PC/laptop cannot dissolve the NetBIOS name (*http://gemini-nnnnnn*) of the smart camera. Please check the "Node Type" of your PC: 1. Open the command promt of your system. 2. Enter *ipconfig /all*. You will find the entry "**Node Type**" in "**Windows IP Configuration**". Here should be "**Hybrid**". Otherwise, change the entry in the following way: https://msdn.microsoft.com/en-us//library/cc757386(v=ws.10).aspx If you still cannot connect to the camera, using Intel network cards, try to install the driver without "*Intel PROSet for Windows Device Manager*" and without "*Advanced Network Services*" or to deinstall both options.
No connection to the camera possible (especially with laptops)	Incorrect configuration of PC - NetBIOS name (*http://gemini-nnnnnn*) of the smart camera is not dissolved because of a WiFi connection	Because of a WiFi connection, the DNS server of your internet service provider is used to resolve the NetBIOS name (*http://gemini-nnnnnn*) of the smart camera. The DNS server, of course, does not know the address *http://gemini-nnnnnn* and responds with an error messsage. Please 1. turn off the WiFi module and 2. reboot the laptop. Now, you can check, if the camera was resolved using the Windows shell: 1. Click on the Windows start button and 2. enter *cmd*. 3. Enter *nbtstat -c*. All resolved NetBIOS names will be listed and you should find the smart camera there:

Error	Cause	Action
		C:\Users\war>nbtstat -c Ethernet: Node IpAddress: [0.0.0.0] Scope Id: [] No names in cache Local Area Connection: Node IpAddress: [169.254.93.40] Scope Id: [] NetBIOS Remote Cache Name Table Name Type Host Address Life [sec] --- GEMINI-NNNNNN <20> UNIQUE 169.254.4.9 540 GEMINI-NNNNNN <00> UNIQUE 169.254.4.9 549 You can also reach the camera with the IP address directly (in this sample 169,254.4.9).
Connection to the camera possible, however a dialog appears, that the connection to the camera was lost	Firewall active	Please add *http://gemini-** as trusted web addresses to your firewall settings.
Action menu "Monitor": No fluent display or freeze of the browser	Display device is too weak	Deactivate the live image diplay: 1. Change to the action menu "Configuration". 2. Select the Tool "Get image". 3. Deactivate the checkbox "outImage" in the result table. 4. Repeat this step for every used "Get image" and "Find object" tool.

Error	Cause	Action

10.3 Notes on network connections

10.3.1 Background information

The user would like to connect to the smart camera with their client via web browser. For this to work,

1. the smart camera's IP address or host name must be known or found, and
2. a data packet route to this IP address or host name must exist.

Point 2 is relatively simple, as only a single route has to exist between the client and the server. Routers (and routing tables) as well as port forwarding are available for this purpose. However, for point 1, conveniently locating the smart camera, the mDNS broadcasts must be available, which is normally suppressed by routers. The server essentially publishes its settings via Avahi and mDNS. The client can initially use the host name printed on the smart camera.

Different problems need to be overcome with different solutions depending on the network topology. These are discussed below.

10.3.2 Terms (simplified description)

- **Switch** is a simple distributor of network packages in a subnet. Both mDNS packages as well as packages directly on another computer are permitted.
- **Router** separates subnets, i.e. a router can forward queries from one subnet to another subnet. NAT is generally used, i.e. the router replaces the querying IP address with its own. This means that external access to the computer behind the router is not possible. mDNS broadcasts are also not transmitted.
- **Firewall** behaves in a similar manner to a router, but it also filters the content of the network packages.

10.3.3 Server and client not separated by a firewall

10.3.3.1 Server and client live in the same subnet (e.g. DHCP or fixed IP)

The server now has the problem of having to find the IP address. The possible solutions are:

- In the case of DHCP, the IP address can be read out in the DHCP server, but requires read rights to the DHCP server.

- Start the delivered script and display an overview of the smart camera. Select a smart camera and access its URL via web browser.
- Start a local instance of the ICS server (offline version) and connect with "localhost" via web browser. Then select the desired smart camera in the browser.
- Call up a central but local instance in the intranet. This is where a small web server is running, which identifies all smart cameras in the local network via Avahi and makes them available for selection.

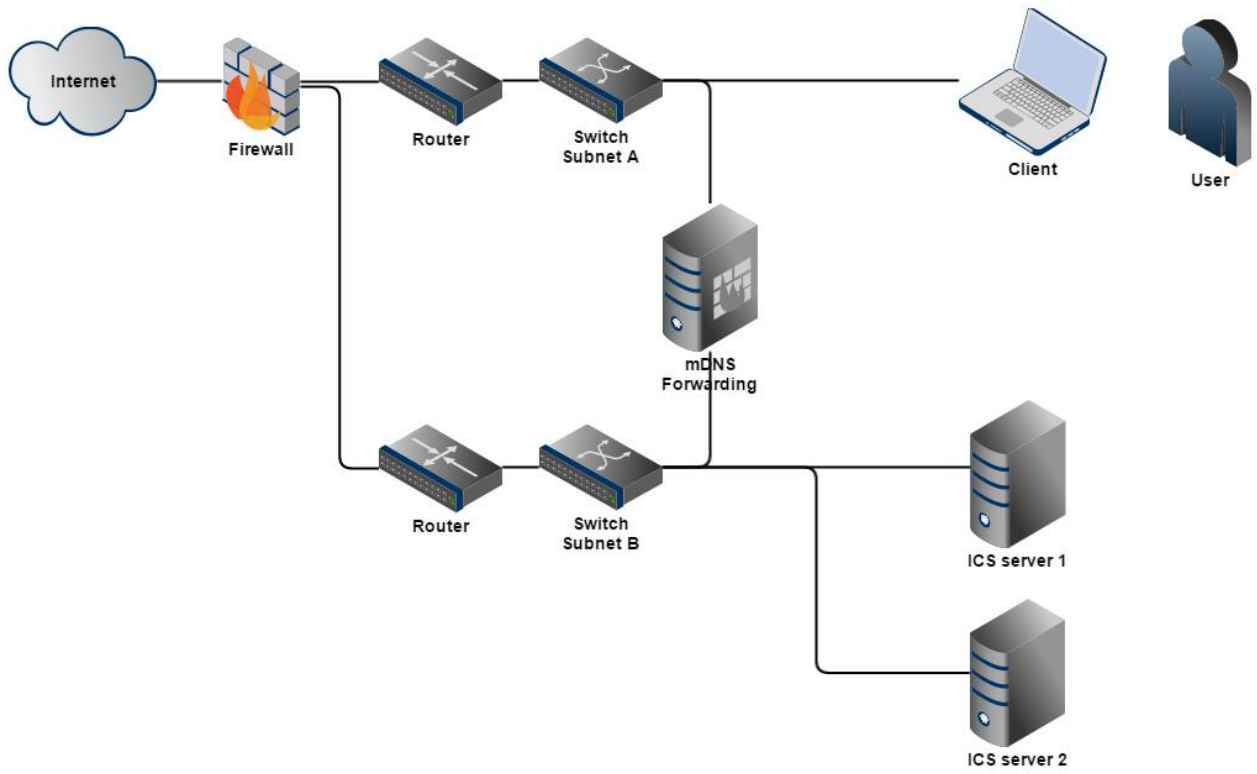
10.3.3.2 Server uses a Zero-Conf address and a fixed IP in an external subnet

The client then also has to use a Zero-Conf address (set "dynamic IP address" under Windows with no DHCP server in the network). This can be achieved by connecting the camera directly to the client PC. The second or third solution from *"Server and client live in the same subnet (e.g. DHCP or fixed IP)"* can then be used.

10.3.3.3 Server and client live in different IP subnets

The mDNS packages are not transmitted beyond subnet boundaries as standard. The possible solutions are:

- An additional (Linux) computer, which connects both subnets, i.e. has access to both subnets and is configured so that it forwards mDNS queries to the other subnet (=Avahi reflector), is required.

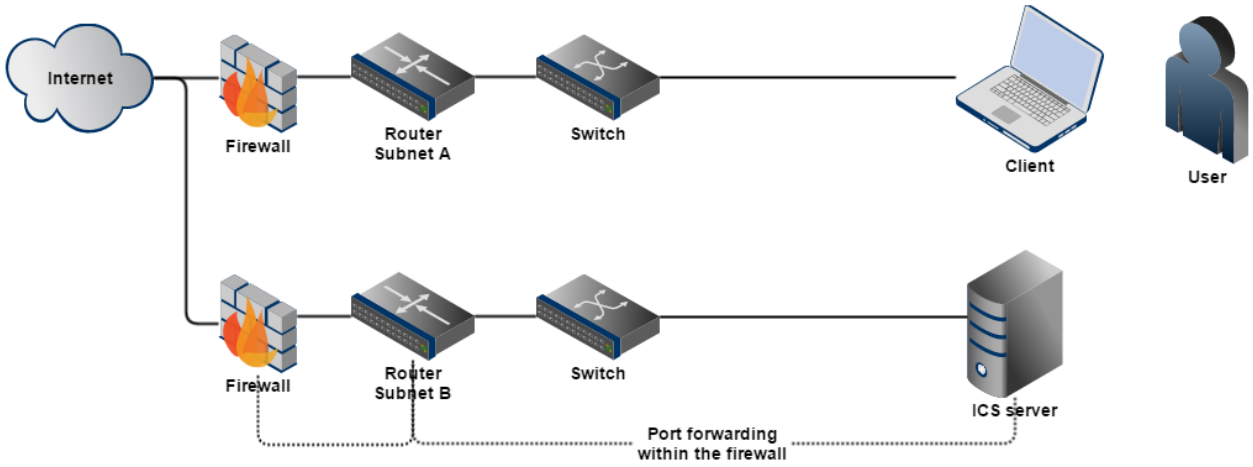


10.3.4 Server and client separated by a firewall

In this case, the server and client are in different IP subnets without loss of generality.

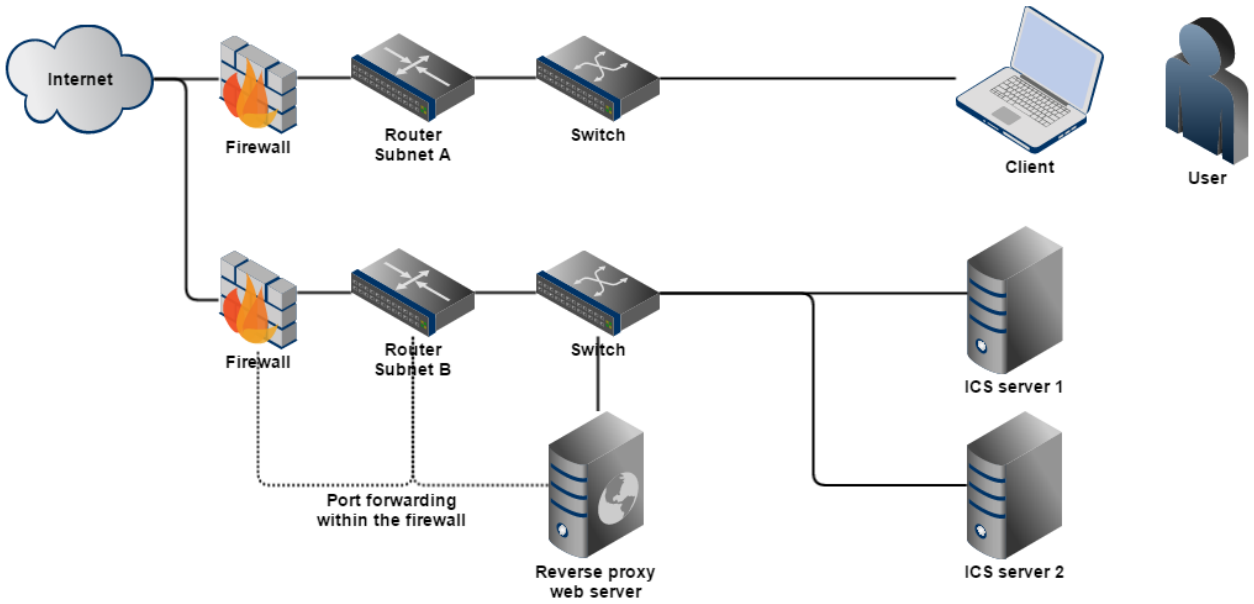
10.3.4.1 Static port forwarding

The easiest access to a smart camera behind a firewall is established by port forwarding. In this case, the firewall forwards all queries on one of its ports to a specific smart camera port, i.e. this forwarding must be manually configured for every smart camera. The Avahi service is not used. The client accesses the open firewall port externally.



10.3.4.2 Reverse proxy with dynamic subdomains

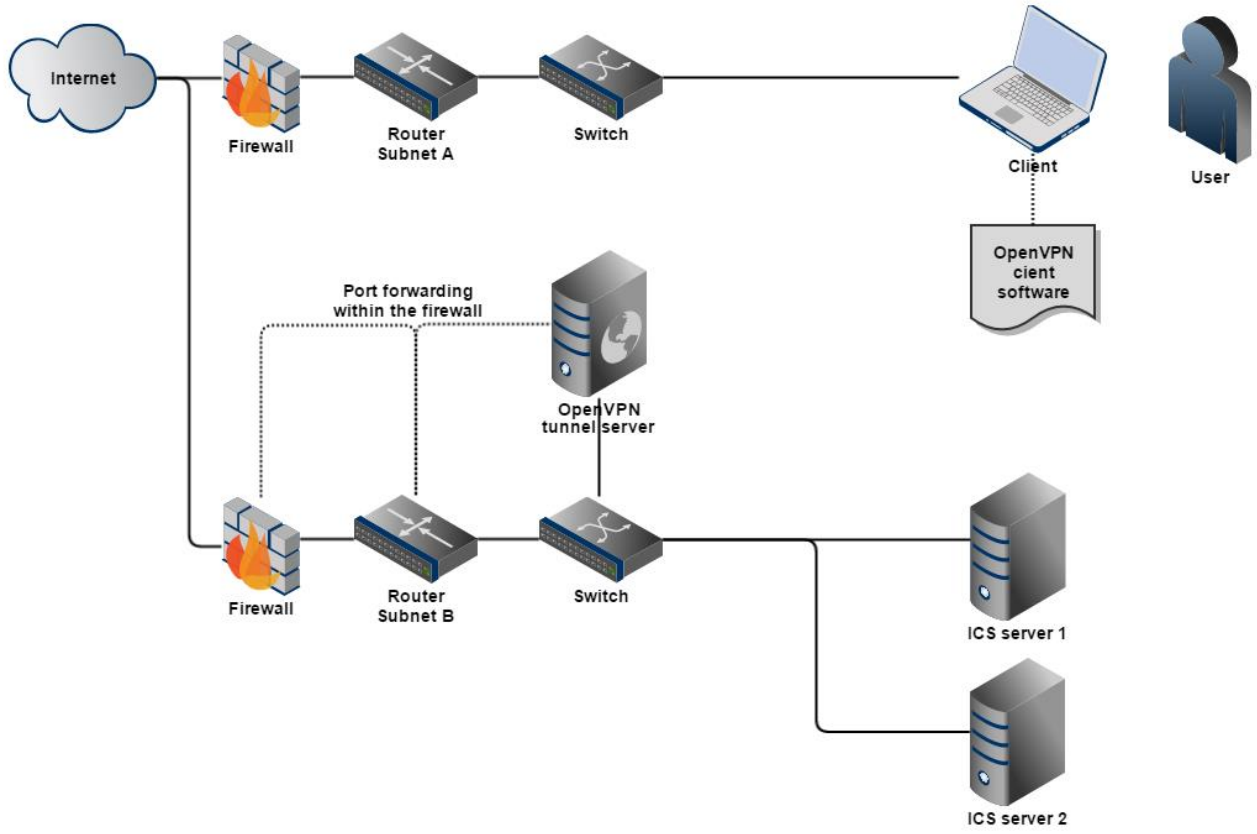
An Avahi service is also running on the reverse proxy web server, which automatically publishes all smart cameras as subdomains and makes these available in its function as a reverse proxy. The reverse proxy also requires port forwarding to be set up in the firewall (see https://confluence.matrix-vision.com/x/ewKW).



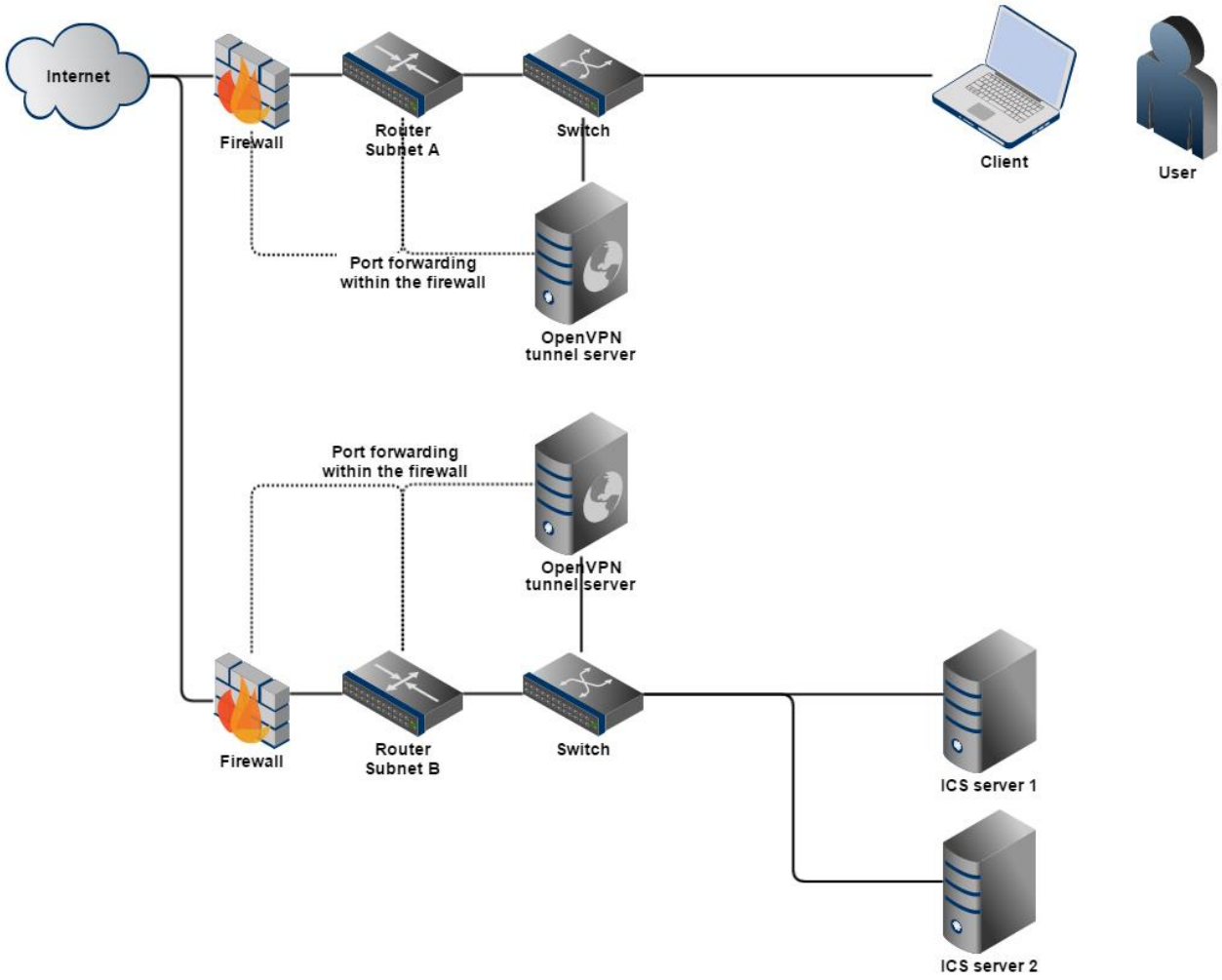
10.3.4.3 OpenVPN as a bridge between two subnets

An OpenVPN server functions as a bridge and connects two subnets (see http://www.heise.de/netze/artikel/Bridge-Modus-224072.html and https://docs.openvpn.net/how-to-tutorialsguides/virtual-platforms/site-to-site-layer-2-bridging-using-openvpn-access-server/). In this case, the two Open VPN servers must be configured so that they transmit direct network packages as well as mDNS broadcasts. This either takes place by establishing forwarding as is the case in "Server and client live in different IP subnets" or configuring the VPN so that the client and server are located in the same subnet.

Versions with OpenVPN client



Versions with OpenVPN bridge


Internet
Firewall
Router
Subnet A
Switch
Client
User
Port forwarding
within the firewall
OpenVPN
tunnel server
Port forwarding
within the firewall
OpenVPN
tunnel server
Firewall
Router
Subnet B
Switch
ICS server 1
ICS server 2

10.4 Choice of the right lens and lighting system

10.4.1 Find the correct lens

Lenses are the starting point of the image processing signal path and shape the light information. The better the optics and the more time you've invested in this issue, the better the source material for the image processing. In the following you will find an overview of the essential properties, sizes and contexts.

10.4.1.1 Limits and settings of a lens

Image field size

With the image filed sizes you can extract first information about the boundary conditions of an image. Here, the focal length of a normal lens corresponds to the diagonal of the image field.
For example, an 8 mm lens behaves like a wide angle lens in combination with a 1 inch sensor. In contrast, the same lens behaves like a telephoto lens in combination with a 1/4 inch sensor. For industrial purposes, sensor sizes from 1 inch and smaller are common.

	Image field	Diagonal
4/3 inch	17.3 mm * 13.0 mm	23 mm
1 inch	12.8 mm * 9.6 mm	16 mm
2/3 inch	8.8 mm * 6.6 mm	11 mm
1/1,8 inch	6.7 mm * 5.4 mm	8,61 mm
1/2 inch	6.4 mm * 4.8 mm	8 mm
1/3 inch	4.8 mm * 3.6 mm	6 mm
1/4 inch	3.2 mm * 2.4 mm	4 mm

Components of a lens

Using a lens, the **focal length** defines the image angle and for this reason the scale between object and image.
You can adapt two properties of the lens:

- **Focus**
  - a sharp image is possible even with different object distances
  - a scale on the lens indicates distance between object and image (from the minimum distance to infinity)
  - a closer focus is possible using spacers

- **Aperture**
  - an opening through which light travels (narrow aperture = less light)
  - a scale indicates the f-number (high value = narrow aperture)
  - has direct impact on the imaging quality (determines resolution and depth of field).

Calculate the image

Using the formula for a single lens is the easiest way to calculate an image. At least, it is possible to indicate the boundary conditions for a test setup's concept.
The accuracy of measurement specifies how many measuring points are needed in the object. With it and setting the image detail, you can determine the camera.

Example: If an accuracy (M) of 0.1 mm is needed, you have to use twice as many resolution points (F; according to the sampling theorem), which results in a measurement resolution (A) of 0.05 mm:

```
M = F * A
A = M / F => A = 0.1 / 2 = 0.05
```

The sensor of the mvBlueGEMINI has a pixel size (P) of 0.0053 mm (5.3 µm), which will lead to an image scale of approx. 1/10:

```
A = V * P
V = A / P => V = 0.05 / 0.0053 = 9.43 (~ 10)
```

With the sensor size of 6.7 mm * 5.4 mm (1/1.8 inch), you can view an object of 67 mm * 54 mm in an image.
Example of further such correlations:

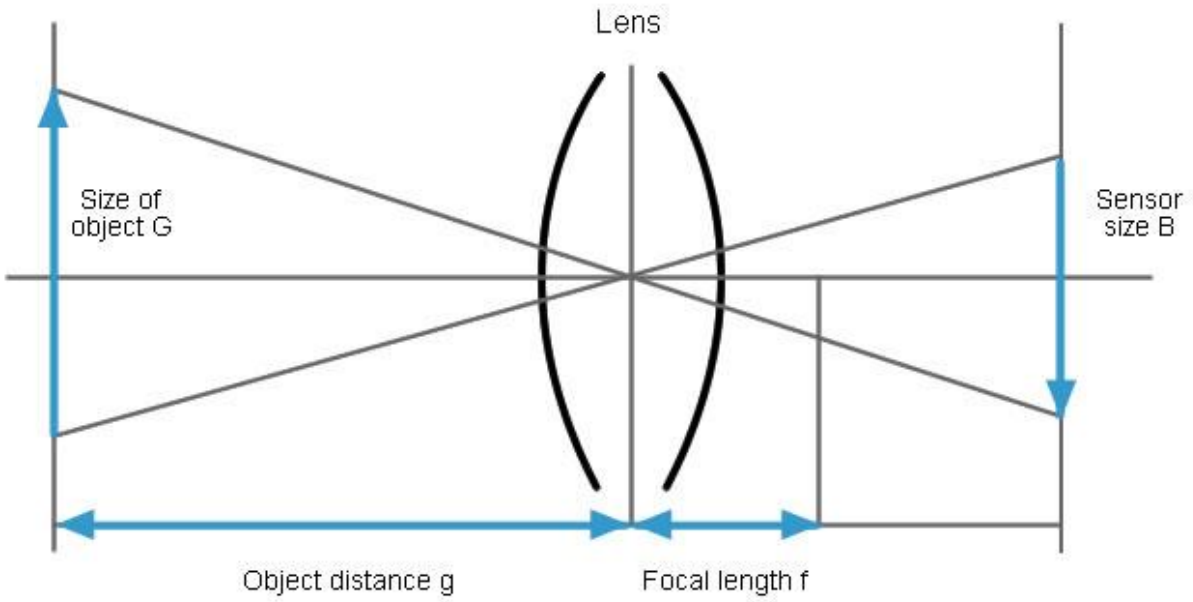
Accuracy of measurement Resolution	Number of points	Object field Size of the object
2 µ 1 µ	4000 x 2600	4 mm * 2.6 mm
20 µ 10 µ	4000 x 2600	40 mm * 26 mm
40 µ 20 µ	4000 x 2600	80 mm * 52 mm
200 µ 100 µ	4000 x 2600	400 mm * 260 mm

With these considerations you can check, if you can image the object with the **camera**'s **sensor**.

Choice of the lens

You can calculate further parameters using the following formula (the focal length with the given object distance, or with the given focal length the object distance):

Figure 5 Focal length formula




```
f = g * B / (G + B)
```

If the size of the sensor (B), the size of the object (G), and the object distance (g) are known, you can calculate the needed focal length.

For a rough calculation a swift procedure is enough. If the object distance is noticeably larger than the focal length, you will have the image scale immediately.

```
f / g = B / G                    # if G > 10 * B
```

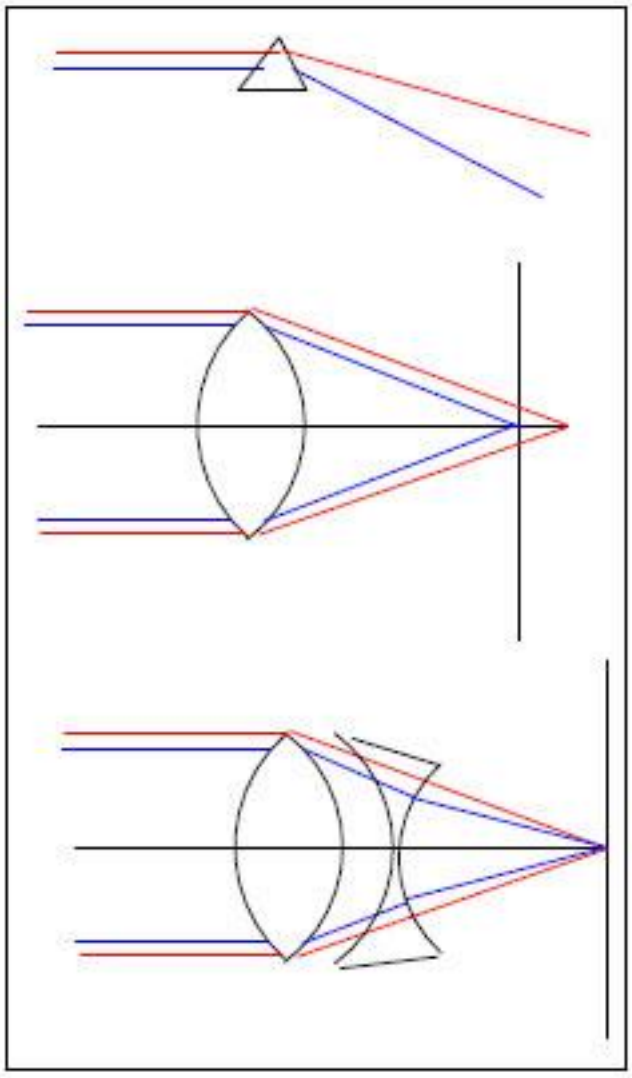
On our website, we offer a lens calculator:

http://www.matrix-vision.com/lens-calculator.html	

Because single lenses have strong aberrations, several lenses are used to compensate these errors.
The wavelength of the light has a great influence on the image. For each wavelength, the image quality is good and/or is sharp in different spots.
By the use of the mentioned corrections with several lenses, it is tried to consolidate these levels.

An **achromatic lens**, for example. is a lens **with two corrected colors**. Other wavelengths vary from it a bit.
An **apochromatic lens** is a lens which is optimized for three wavelengths.

Figure 6 Lens correction



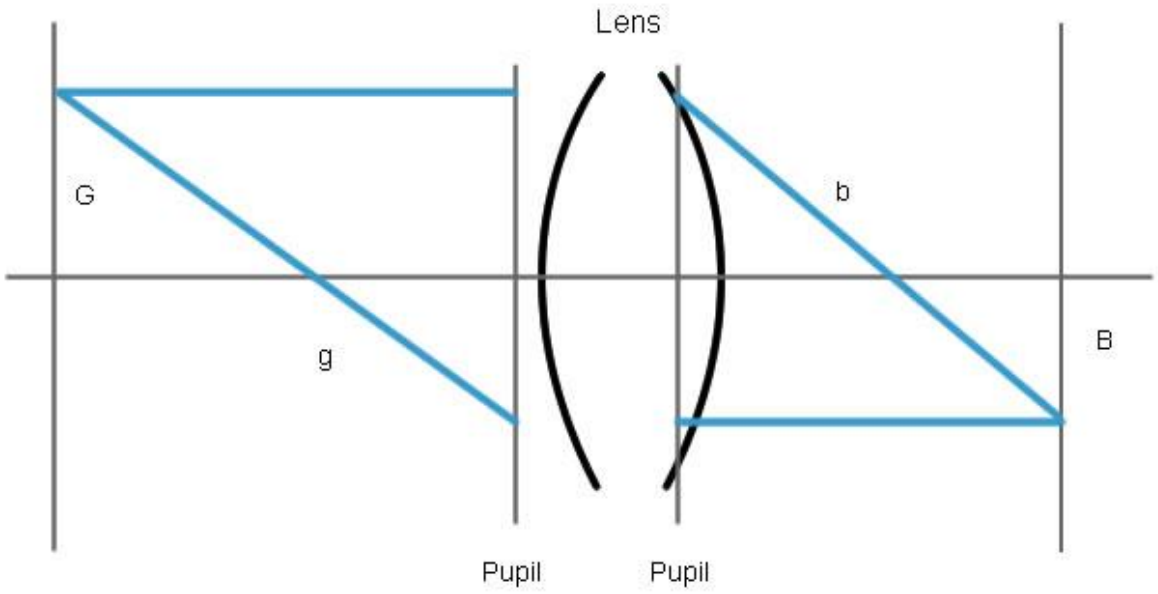
Zoom lenses ofter consist of 10 or more lenses.

Real lenses have an entrance pupil and an exit pupil. The parameters b and g are calculated starting from these levels. If the distance of the levels equals h (also called main level), the total setting distance e is between object and image.

```
e = g + h + b
```

h equals 0 with a single lens.

Figure 7 Setting level



The parameter h is usually not known. With the mvBlueGEMINI, h is usually very small.
For this reason, the formula without h is used in test setup concepts.

It should be possible to set every lens to infinity. In this case, the

```
Distance between lens and image = focal length
```

Therefore, each lens should be fixed in a different way. To avoid this, camera classes have fixed distances, called **flange focal distance**. C-mount lenses, for example, have a flange focal distance of 17.5 mm, which is independent from the focal length (CS-mount = 12.5 mm). With the help of adapters, lenses with longer flange focal distances can be mounted on cameras with shorter distances. This will not work vice versa because you will not reach infinity then.

The resolution - a little physics

Actually, you have to consider the **wavelength of the light**, because the light makes the image.
The wavelength of the visible light is between 0.4 µm and 0.6 µm.
The smallest imaged point results from the aperture which will never be smaller than 0.5 µm.
Realistic figures are between 2 µm and 5 µm.

```
B = 1.22 * 2 * λ * F / D
```

```
B = Diffraction disk or point image
F = Focal length
D = Aperture diameter
```

Example with green light and λ = 0.5 µm

F-number F/D	Diameter diffraction disk
1	1.25 µm
4	5 µm
16	20 µm

10.4.2 Find the correct lighting system

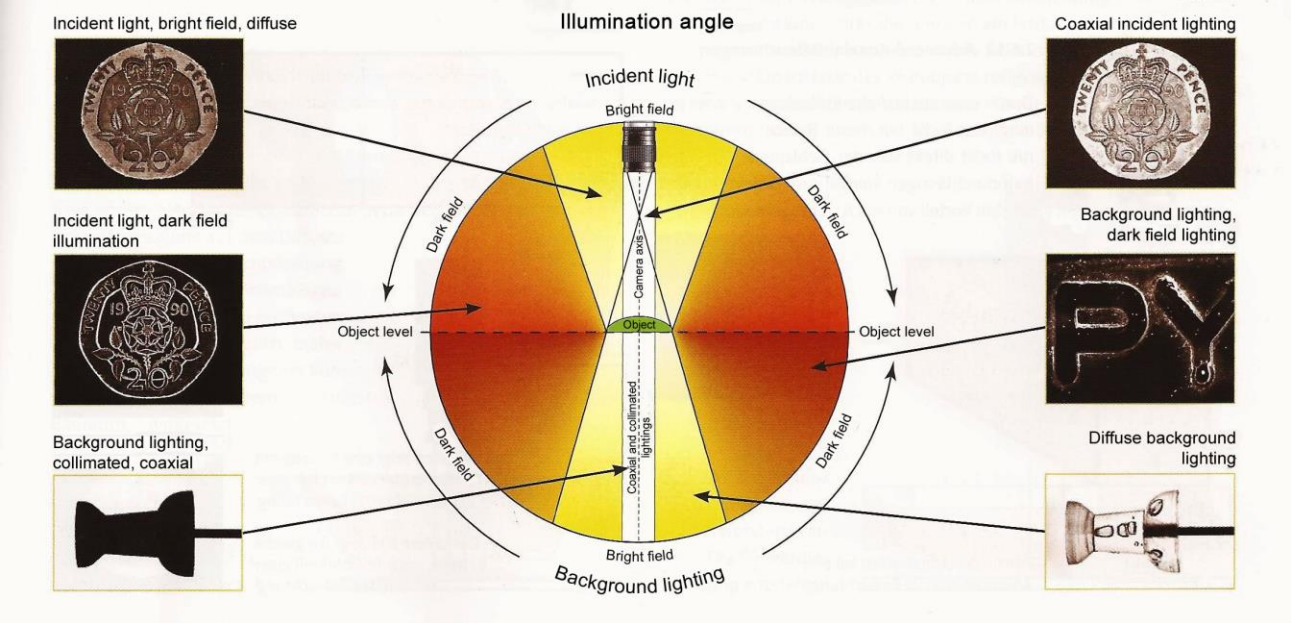
Besides optics, the illumination is an important point, which is critical for good results in the image processing. The golden rule is: create contrast.

A lighting system can be homogeneous or structured. Following table shows the effects and the characteristics of lighting systems:

	Effects	Light specifications
Without structure	• light on object • light as a contrast to the object • no information by the light • information from the object	• must be homogeneous • must be time stable • must be broadband in color
With structure	• underlines specific characteristics • color changes contrast of details • projected lines perform a coordinate transformation • usually disturbing reflections become information	• is definied structured • is limited to light bands

10.4.2.1 Direction of the light

Figure 8 Direction of the light



Source: https://wiki.zimt.uni-siegen.de/fertigungsautomatisierung/index.php/Beleuchtungstechniken_f%C3%BCr_die_industrielle_Bildverarbeitung

According to the direction, there are different possible uses:

Direction	Angle	Applications	Speciality
Background lighting	Bright field	• transparent and opaque as well as flat or spatial parts • often in combination with diffuse or telecentric lighting • suitable for testing bore holes • Preferred lighting system for presence monitoring (binary image)	• uniformly bright, high-contrast image • almost binary attributes
	Dark field	• Transparent test objects like glass or plastics • Very small distance between test objects and lens possible	• surface characteristics as light details on a dark background

Direction	Angle	Applications	Speciality
Incident lighting	Bright field	• suitable for transparent and opaque parts (glass, metal, plastics) • also suitable for rough, poorly reflecting surfaces	• uniformly bright, well-contrasted image • possible with coaxial mirror lighting
	Dark field	• emphasizing shapes, scratches, cracks, etc. • determines both, engraved and raised structures • suitable for transparent and opaque parts • particularly suitable for surface inspections, also highly reflective parts	• difficult with dirt

10.4.2.2 Lighting structure

Besides homogenous light there are following lighting structures:

Dimensions	Illuminant	Procedure	Speciality
0	Light point	Triangulation	• light beam is sent to the surface obliquely • if the object's distance changes in front of the lens, the point where the light passes the lens will move laterally • the lateral movement will be displayed and measured • the lateral offset of the image is a measure for the change in distance
1	Light line	Light section method	• oblique projection • translate depth information in image coordinates (e.g. z in x) • expand the triangulation principle to many parallel measurements (here the Y coordinate)

Dimensions	Illuminant	Procedure	Speciality
2	Light grid	Grid projection method	• phase shift process returns dense spatial information

10.4.2.3 Further factors

Further factors of lighting systems are:

- **wavelength**
  - color
- **type of lamp**
  - incandescent lamp
  - discharge lamp
  - LED
- **long-term behavior**
  - aging
  - pollution
- **short-term behavior**
  - AC/DC supply
  - radio-frequency operation
  - flash