# Installation Manual

# TVCaster, CodecCaster, RelayCaster and PolyCaster

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This document describes the installation of GMIT's server hardware used for the software 'TV-Caster', 'CodecCaster', 'RelayCaster', and 'PolyCaster'.

Please carefully read these instructions. Please change all passwords mentioned in the following. Notice that any changes of the configuration of the system, which are not described in the following, will render your warranty void. So, please do not use any other configuration tool, and do not manually change the system or network configuration by editing files.

Please send all support request to support@gmit-gmbh.de or contact us by phone during GMIT business hours.

# 1. Revision History

**Table 1. Revision History**

| Revision | Comment |
|---|---|
| February 23, 2010 | Initial version |
| September 19, 2010 | Added information that multicast streams are sent through the 'GbE' network interface |
| December 03, 2010 | Combined the installation manual for products TVCaster, CodecCaster and RelayCaster |
| March 21, 2011 | Added information regarding firewall configuration to Section 3.1 |
| May 24, 2011 | Added information regarding support requests |
| Aug 30, 2012 | Updated Section 2 to state that configuration of a valid NTP server is required for correctly sending streams |
| Nov 14, 2012 | Added new Section 2.7 which describes how to change network settings via console or remote login |
| Dec 18, 2012 | Added new Section 7 which describes the RAID; removed deprecated section. |
| Feb 13, 2013 | Extended for PolyCaster. |
| Nov 19, 2013 | Extended for PolyCaster 200, 300, 1000, 2000. |
|  | Added note about CodecCaster 8000 HD that it does not provide an integrated display. |
| Apr 17, 2014 | Updated Section Section 2.6 which includes now screenshots to explain how to set-up network configuration in more detail. |
| Jan 15, 2015 | Updated Section Section 3.1 on how to access TVCaster/CodecCaster/RelayCaster/Polycaster behind a firewall. |
| Feb 11, 2016 | Updated Section on network devices for RelayCaster and CodecCaster. |
| Feb 24, 2016 | Revised Section on network devices. |
| Nov 10, 2016 | Added additional information for RelayCaster One. |

# 2. Setting up the Network Configuration

## 2.1. General

Your system provides several network interfaces. The 'Mgmt', or management interface, is for connecting to your network of trusted hosts. The Ethernet interfaces ('GbE', 'GbE-2', 'GbE-3', 'GbE-4', 'GbE-5'), are for connecting to your network of untrusted hosts and to send or receive data streams. Note that the network ports 'GbE', 'GbE-2' and 'GbE-3' are 1 Gigabit interfaces, while 'GbE-4' and 'GbE-5' are 10 Gigabit interfaces. Please see below, which of these network interfaces are available on your system.

**Important note: All products require that a different IP address is set on all network interfaces.**

**Important note: All products require that an NTP server is configured for correctly sending streams. How to configure NTP server and validate its configuration is described at the end of this section.**

**Table 2. Features available for network interfaces**

| Feature | GbE | Mgmt |
|---|---|---|
| Streaming to unicast addresses | see below | see below |
| Streaming to multicast addresses | see below | see below |
| Receiving from unicast addresses* | see below | see below |
| Receiving from multicast addresses* | see below | see below |
| Webinterface with http | | X** |
| Webinterface with https | | X** |
| Remote access with ftp | | X** |
| Remote access with ssh | | X** |

\* CodecCaster, RelayCaster, and PolyCaster only
\*\* Please note that the Mgmt port should be only available in trusted network.

RelayCaster One by default has no active firewall.

The following table shows the default values of the network configuration. Please note that the network ports 'GbE', 'GbE-2' and 'GbE-3' are 1 Gigabit interfaces, while 'GbE-4' and 'GbE-5' are 10 Gigabit interfaces.

**Table 3. Network configuration defaults**

| Hostname | tvcaster | codeccaster | relaycaster | polycaster |
|---|---|
| Domain | gmit-gmbh.de |
| IP GbE | 192.168.002.254 |
| Netmask GbE | 255.255.255.000 |
| Gateway GbE | 0.0.0.0 |
| IP GbE-2 | 192.168.003.254 |
| Netmask GbE-2 | 255.255.255.000 |
| Gateway GbE-2 | 0.0.0.0 |
| IP GbE-3 | 192.168.003.254 |
| Netmask GbE-3 | 255.255.255.000 |
| Gateway GbE-3 | 0.0.0.0 |
| IP GbE-4 | 192.168.004.254 |
| Netmask GbE-4 | 255.255.255.000 |

| Gateway GbE-4 | 0.0.0.0 |
|---|---|
| IP GbE-5 | 192.168.005.254 |
| Netmask GbE-5 | 255.255.255.000 |
| Gateway GbE-5 | 0.0.0.0 |
| IP Mgmt | 192.168.001.254 |
| Netmask Mgmt | 255.255.255.000 |
| Gateway Mgmt | 192.168.001.001 |
| DNS | 192.168.001.005 |
| NTP Server | 192.168.001.005 |

## 2.2. TVCaster Systems

The following tables show which network interfaces are available on a specific TVCaster model for streaming.

**Table 4. Available network interfaces for TVCaster Systems for unicast output**

| System | GbE | Mgmt |
|---|---|---|
| TVCaster | X | X |

Please note that unicast streaming is routed automatically, i.e. if a unicast stream is sent between systems that have network interfaces in the same subnetwork (e.g. 192.168.2.X and 192.168.2.Y), then the stream will automatically be routed through these network interfaces if an IP within the subnetwork is given as destination.

**Table 5. Available network interfaces for TVCaster Systems for multicast output**

| System | GbE | Mgmt |
|---|---|---|
| TVCaster | X | |

## 2.3. CodecCaster Systems

**Important note: A CodecCaster 8000 HD or CodecCaster NG-8 systems provide eight transcoding nodes. Each transcoding node provides an 'Mgmt' and 'GbE' Ethernet interface that has to be configured independently.** .

The following tables show which network interfaces are available on a specific CodecCaster model for

streaming.

**Table 6. Available network interfaces for CodecCaster Systems for unicast streaming**

| System | GbE | GbE-2 | GbE-3 | Mgmt |
|---|---|---|---|---|
| CodecCaster NG-1 | X | | | X |
| CodecCaster NG-8 | X | | | X |
| CodecCaster 1000 | X | X | X | X |
| CodecCaster 8000 | X | | | X |

Please note that unicast streaming is routed automatically, i.e. if a unicast stream is sent between systems that have network interfaces in the same subnetwork (e.g. 192.168.2.X and 192.168.2.Y), then the stream will automatically be routed through these network interfaces if an IP within the subnetwork is given as destination.

**Table 7. Available network interfaces for CodecCaster Systems for multicast streaming (The factory setting for outgoing multicast streams is GbE and for incoming multicast streams Mgmt)**

| System | GbE | GbE-2 | GbE-3 | Mgmt |
|---|---|---|---|---|
| CodecCaster NG-1 | X | | | X |
| CodecCaster NG-8 | X | | | X |
| CodecCaster 1000 | X | X | X | X |
| CodecCaster 8000 | X | | | X |

## 2.4. RelayCaster Systems

The following tables show which network interfaces are available on a specific RelayCaster model for streaming. RelayCaster One provides one integrated network port and optional external USB network adapters.

**Table 8. Available network interfaces for RelayCaster Systems for unicast streaming**

| System | GbE | GbE-2 | GbE-3 | Mgmt |
|---|---|---|---|---|
| RelayCaster 200 | X | | | X |
| RelayCaster 1000 | X | X | X | X |
| RelayCaster One | X | | | X |

Please note that unicast streaming is routed automatically, i.e. if a unicast stream is sent between systems

that have network interfaces in the same subnetwork (e.g. 192.168.2.X and 192.168.2.Y), then the stream will automatically be routed through these network interfaces if an IP within the subnetwork is given as destination.

**Table 9. Available network interfaces for RelayCaster Systems for multicast streaming (The factory setting for outgoing multicast streams is GbE and for incoming multicast streams Mgmt)**

| System | GbE | GbE-2 | GbE-3 | Mgmt |
|---|---|---|---|---|
| RelayCaster 200 | X | | | X |
| RelayCaster 1000 | X | X | X | X |
| RelayCaster One | X | | | X |

## 2.5. PolyCaster Systems

The following tables show which network interfaces are available on a specific PolyCaster model for streaming. Please note that the network ports 'GbE', 'GbE-2' and 'GbE-3' are 1 Gigabit interfaces, while 'GbE-4' and 'GbE-5' are 10 Gigabit interfaces.

**Table 10. Available network interfaces for all PolyCaster Systems for multicast and unicast streaming**

| System | Mgmt |
|---|---|
| Unicast Input | X |
| Multicast Input | X |

**Table 11. Available network interfaces for PolyCaster Systems for HTTP based streaming**

| System | GbE | GbE-2 | GbE-3 | GbE-4 | GbE-5 | Mgmt |
|---|---|---|---|---|---|---|
| PolyCaster 100 | X | | | | | X* |
| PolyCaster 200 | X | X | | | | X* |
| PolyCaster 300 | X | X | X | | | X* |
| PolyCaster 1000 | | | | X | | X* |
| PolyCaster 2000 | | | | X | X | X* |

\* Please note that the Mgmt port should be only available in trusted network.
  So HTTP based streaming over Mgmt port is just considered for monitoring streams.

## 2.6. Setting up the Network Configuration via integrated display

**Important note: CodecCaster 8000 HD and CodecCaster NG-8 and RelayCaster One and all software-only products do not provide an integrated display. Please refer to Section 2.7 on how to configure these systems.** .

### 2.6.1. General Information and Requirements

As can be seen in Figure 1 your system provides following four control keys underneath LCD (from left to right):

- **up** and **down** key for changing the current value.

- **right** key to proceed to next value.

- **Enter** key to confirm your changes in the current dialog and to step to next dialog.

### 2.6.2. Using Integrated display

Setting up the network configuration has to be done as follows.

- Please make sure that all network interfaces are connected to your network.
- Please make sure that you have all required network addresses for the interfaces of your system. Please refer to table Table 3 to see available network information as well as their default values. If you do not know these values please contact your system or network administrator.
- Power on and boot the system and pay attention to the messages shown on the integrated display.
- If the message **Setup network? Press any key** appears (see image Figure 1 ) press any of the four control keys to enter the setup.

**Figure 1. If LCD shows this message press any of the four control keys enter network setup.**



- As soon as you entered network setup you have to enter following information after each other using for control keys under LCD.

Important note: please make sure that you enter IP addresses with leading zeros, e.g. use '192.168.001.001'.

Important note: These values are very specific to your own network setup. In case you do not know which values has to be used please contact your system or network administrator.

Following dialogues will appear in LCD.

1. **Hostname: relaycaster**

    Example: Set hostname to **relaycaster1** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

2. **Domain: gmit-gmbh.de**

    Example: Set domain to **mydomain.com**

3. **IP GbE: 192.168.002.254**

    Example: Set IP GbE to **192.168.002.010** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

4. **Netmask GbE: 255.255.255.000**

Example: Set Netmask GbE to **255.255.000.000** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

5. **Gateway GbE: 000.000.000.000**

Example: Set Gateway GbE to **192.168.002.001** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

6. Appears only if your system is a PolyCaster 200, PolyCaster 300 or if your RelayCaster or Codec-Caster has a eth2 network device:

   **IP GbE-2: 192.168.003.254**

   Example: Set IP GbE-2 to **192.168.003.010** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

7. Appears only if your system is a PolyCaster 200, PolyCaster 300 or if your RelayCaster or Codec-Caster has a eth2 network device:

   **Netmask GbE-2: 255.255.255.000**

   Example: Set Netmask GbE-2 to **255.255.000.000** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

8. Appears only if your system is a PolyCaster 200, PolyCaster 300 or if your RelayCaster or Codec-Caster has a eth2 network device:

   **Gateway GbE-2: 000.000.000.000**

   Example: Set Gateway GbE-2 to **192.168.003.001** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

9. Appears only if your system is a PolyCaster 300 or if your RelayCaster or CodecCaster has a eth3 network device:

   **IP GbE-3: 192.168.004.254**

   Example: Set IP GbE-3 to **192.168.004.010** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

10. Appears only if your system is a PolyCaster 300 or if your RelayCaster or CodecCaster has a eth3 network device:

    **Netmask GbE-3: 255.255.255.000**

    Example: Set Netmask GbE-3 to **255.255.000.000** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

11. Appears only if your system is a PolyCaster 300 or if your RelayCaster or CodecCaster has a eth3 network device:

    **Gateway GbE-3: 000.000.000.000**

    Example: Set Gateway GbE-3 to **192.168.004.001** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

12. Appears only if your system is a PolyCaster 1000 or PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth4 network device:

    **IP GbE-4: 192.168.005.254**

    Example: Set IP GbE-4 to **192.168.005.010**using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

13. Appears only if your system is a PolyCaster 1000 or PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth4 network device:

    **Netmask GbE-4: 255.255.255.000**

    Example: Set Netmask GbE-4 to **255.255.000.000** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

14. Appears only if your system is a PolyCaster 1000 or PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth4 network device:

    **Gateway GbE-4: 000.000.000.000**

    Example: Set Gateway GbE-4 to **192.168.005.001** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

15. Appears only if your system is a PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth5 network device:

    **IP GbE-5: 192.168.006.254**

    Example: Set IP GbE-5 to **192.168.006.010** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

16. Appears only if your system is a PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth5 network device:

    **Netmask GbE-5: 255.255.255.000**

    Example: Set Netmask GbE-5 to **255.255.000.000**using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

17. Appears only if your system is a PolyCaster 2000 or if your RelayCaster or CodecCaster has a eth5 network device:

    **Gateway GbE-5: 000.000.000.000**

    Example: Set Gateway GbE-5 to **192.168.006.001** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

18. **IP Mgmt: 192.168.001.254**

    Example: Set IP Mgmt to **192.168.001.010** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

19. **Netmask Mgmt: 255.255.255.000**

    Example: Set Netmask Mgmt to **255.255.000.000** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

20. **Gateway Mgmt: 192.168.001.001**

    Example: Set Gateway Mgmt to **192.168.001.002** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

21. **DNS: 192.168.001.001**

Example: Set DNS to **192.168.001.002**using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

22. **NTP Server: 192.168.001.005**

Example: Set NTP Server to **192.168.001.002** using control keys **up**, **down**, and **right**. Press 'Enter' to go to next dialogue.

- Please make sure that you complete all dialogues without powering down or rebooting the system.
- Please do NOT use any other tools, such as OpenSuse's yast or yast2, for configuring the network interfaces.
- **Important note: All products require that an NTP server is configured for correctly sending streams.** .

After configuring all network parameters including NTP server and system runs for longer time, login to the system via ssh as user root to verify that NTP service has a good synchronization to the used NTP server. Please refer to online resource http://support.ntp.org/bin/view/Support/TroubleshootingNTP#Section_9.4. how to check quality of the used NTP server. The offset to the used NTP server should be less than 250ms.

## 2.7. Setting up the Network Configuration via console

**Important note: If you change network configuration current config files of the system are deleted.** .

Setting up the network configuration can also be done via console either by directly logging into the system or via remote log-in using ssh.

To directly log in to the system via console:

- Connect a keyboard and screen to the system.
- Power on and boot the system.
- If the log-in prompt appears login to system as user root. Default password is described in Section 4.

For remote login you have to use ssh:

- Please make sure that Mgmt network interface is connected to your network.

- Power on and boot system.

- Login via ssh as described in Section 4.

After logging in to the system as user root (either via ssh or console) execute following steps.

- Change to directory providing tool for changing network configuration by entering following commands:

```
# For TVCaster
cd /home/nmm/nmm3_tvcaster/bin/

# For CodecCaster
cd /home/nmm/nmm3_codeccaster/bin/

# For RelayCaster
cd /home/nmm/nmm3_relaycaster/bin/

# For PolyCaster
cd /home/nmm/nmm3_polycaster/bin/
```

- Start tool for changing network configuration by entering following command:

```
# For TVCaster
./wrapper.sh nmm_lcd_setup -c -T

# For CodecCaster
./wrapper.sh nmm_lcd_setup -c -C

# For RelayCaster
./wrapper.sh nmm_lcd_setup -c -R

# For PolyCaster
./wrapper.sh nmm_lcd_setup -c -P
```

- If the message **Setup network? Press any key** appears press enter to enter the setup.

- In the following dialogues, current network parameters are printed to console. After a specific setting is printed, you have to enter the new value. Note: If you press enter without entering a new value the system keeps the current shown setting.

- After changing all settings you have to reboot the system using following command

```
reboot
```

- Please do NOT use any other tools, such as OpenSuse's yast or yast2, for configuring the network interfaces.

- **Important note: All products require that an NTP server is configured for correctly sending streams.** .

After configuring all network parameters including NTP server and system runs for longer time, login to the system via ssh as user root to verify that NTP service has a good synchronization to the used NTP server. Please refer to online resource http://support.ntp.org/bin/view/Support/TroubleshootingNTP#Section_9.4. how to check quality of the used NTP server. The offset to the used NTP server should be less than 250ms.

# 3. Accessing the Web Interface

To access the web interface of the PolyCaster, start your web browser and connect to **http://<IP_ADDRESS_OF_POLYCASTER>:88** (e.g. http://192.168.1.254:88) or **https://<IP_ADDRESS_OF_POLYCASTER>** (e.g. https://192.168.1.254).

To access the web interface of all other servers, start your web browser and connect to **http://<IP_ADDRESS_OF_SYSTEM>** (e.g. http://192.168.1.254) or **https://<IP_ADDRESS_OF_SYSTEM>** (e.g. https://192.168.1.254).

Please note that CodecCaster 8000 HD and CodecCaster NG-8 systems have eight transcoding nodes, each of them providing its own web interface via a dedicated 'Mgmt' network interface.

When connecting using https you need to confirm the certificate.

**Table 12. https certificate**

| Serial Number | 00:B6:DB:C0:A8:A6:0D:20:22 |
|---|---|
| MD5 Fingerprint | 9D:69:73:36:5F:7D:86:44:9D:49:27:CA:0E:1F:81:EA |

To pass the authentification, you need to provide the username and the password, which default to:

**Table 13. Authentification factory defaults**

| username | password |
|---|---|
| admin | password |

This password can be changed on the 'Info' page of the webinterface.

## 3.1. Firewall/Router configuration

If your TVCaster/CodecCaster/RelayCaster/PolyCaster has a local IP address but is connected to the Internet through a router or firewall you can configure these products through the Internet. In this case your router or firewall has to forward TCP traffic received from the Internet for the following ports to TVCaster/CodecCaster/RelayCaster/PolyCaster:

- TCP traffic on Port 80: Forwarding port 80 is required to access the web interface of TVCaster/CodecCaster/RelayCaster.

- TCP traffic on Port 88: Forwarding port 88 is required to access the web interface of PolyCaster.

- TCP traffic on Port 80: Forwarding port 80 is required to access the HTTP based streaming of PolyCaster.

- TCP traffic on Port 8111: Forwarding port 8111 is required to send control commands via XML-RPC to TVCaster/CodecCaster/RelayCaster/PolyCaster.

  Note: Forwarding of this port is only required if sender of XML-RPC commands access a TVCaster/CodecCaster/RelayCaster/PolyCaster behind a firewall/router. If access to web interface is sufficient forwarding of this port is not required.

For information how to configure your firewall or router please contact your system administrator or device manufacturer.

# 4. Accessing the System with ssh

To pass the authentification, you need to provide the username and the password, which default to:

**Table 14. Authentification factory defaults**

| username | password |
| --- | --- |
| root | rootarnual |
| nmm | nmmarnual |

These passwords can be changed as follows: log in with ssh as root and run 'passwd' for changing the root password, and 'passwd nmm' for changing the nmm password.

# 5. Accessing the System with ftp

To access the system using ftp, start your ftp client and connect to **ftp://ftp@<IP_ADDRESS_OF_SYSTEM>/** (e.g. ftp://ftp@192.168.1.254).

To pass the authentification, you need to provide the username and the password, which default to:

**Table 15. Authentification factory defaults**

| username | password |
|----------|----------|
| ftp | ftparnual |

This password can be changed as follows: log in with ssh as root and run 'passwd ftp'.

# 6. Accessing the System with XML-RPC

To access the XML-RPC server which allows to control the system use an XML-RPC client and connect to **https://<IP_ADDRESS_OF_SYSTEM>:8111/RPC2**.

When connecting you need to confirm the certificate.

**Table 16. https certificate**

| Serial Number | 00:99:6C:A2:68:3F:F3:36:FC |
|---------------|----------------------------|
| MD5 Fingerprint | 75:9E:C2:6C:24:94:98:FF:A2:BA:68:82:7D:63:0E:94 |

To pass the authentification, you need to provide the username and the password, which default to:

**Table 17. Authentification factory defaults**

| username | password |
|----------|----------|
| rpcnmm | rpcarnual |

This password cannot be changed.

# 7. RAID

All GMIT servers are optionally available with RAID. This is a RAID1 consisting of two mirrored disks. Following sections describe the usage of the RAID. Please carefully read all instructions. Not following these instructions precisely will result in your system to become unusable and your warranty to become void. All operations not described in the following are not supported and will result in your system to become unusable and your warranty to become void.

## 7.1. Monitoring

For being notified about RAID failures, you have to check the RAID log files in the 'Info' section of the web interface of the server regularly. In addition, an email notification can be set up as follows.

- Log in as 'root' using ssh as described in Section 4.
- Change to directory 'cd /home/nmm/nmm3_<product name>/bin/raid/'
- Run the command './motama_raid_setup_email.sh'
- Follow the instructions given.

For removing the email notification, following steps need to be done.

- Log in as 'root' using ssh as described in Section 4.
- Change to directory 'cd /home/nmm/nmm3_<product name>/bin/raid/'
- Run the command './motama_raid_setup_email.sh'
- Follow the instructions given.

## 7.2. Identifying Disks

All RAID operations require that you are able to identify disks. This operation is described in the following.

- Log in as 'root' using ssh as described in Section 4.
- Change to directory 'cd /home/nmm/nmm3_<product name>/bin/raid/'
- Run the command './motama_raid_find_disk.sh'
- Follow the instructions given.

## 7.3. Replacing a Failed Disk

If a disk fails, you need to replace it with a new disk. This operation needs to be done while the system is running. This operation requires that you have available a new disk, which is identical to the failed disk.

- Log in as 'root' using ssh as described in Section 4.
- Change to directory 'cd /home/nmm/nmm3_<product name>/bin/raid/'
- Run the command './motama_raid_remove_disk.sh'
- Follow the instructions given.
- Run the command './motama_raid_add_disk.sh'
- Follow the instructions given.

# 8. Mounting recommendations

The GMIT products are designed to be mounted in a 19 inch rack and are therefore delivered with fixing brackets. Further the following recommendations should be regarded:

- Put only 2 devices on one another to a unit
- When putting more than two devices to a unit ensure proper cooling
- Use shelves to reduce the weight on the brackets
- Leave at least 1U free air space between the units to ensure proper cooling
- Leave enough free air space to each side of a device to ensure proper cooling
- Prevent to cover the fans and ensure adequate air flows to the intakes of the devices
- Do not place a unit near a source of heat