The output layer, which is assigned the z-value 6, is treated accordingly. Now the network may be rotated to any position (figure 11.6, left).

Finally the central projection and the illumination may be turned on (figure 11.6, right).

These are the links in the wire-frame model (figure 11.7, left).The network with links in the solid model looks like figure 11.7 (right).

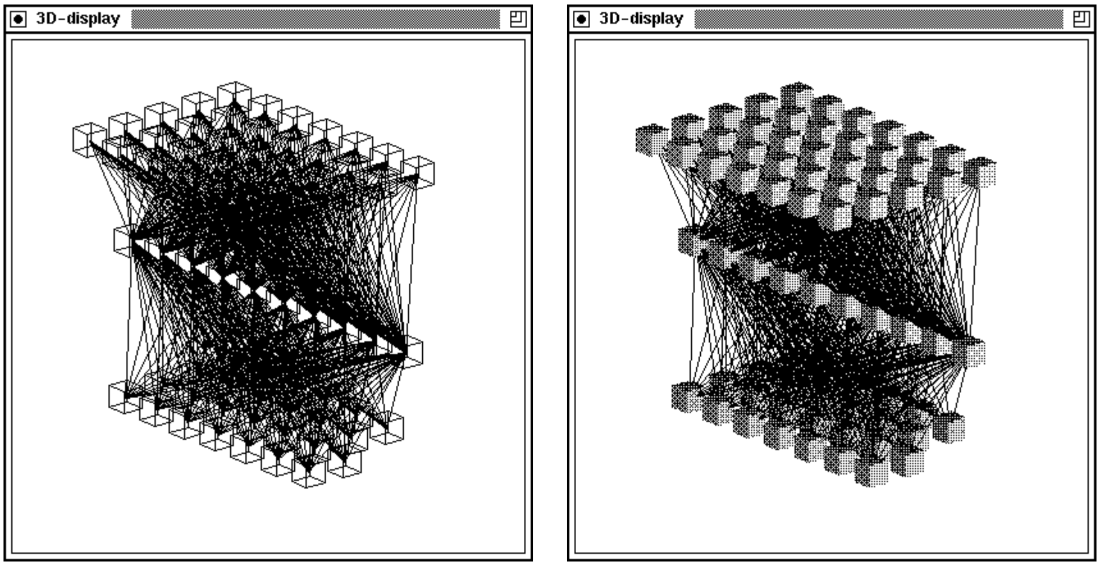

Figure 11.7: Network with links in the wireframe model (left) and in the solid model (right)

11.2.4 3D-Control Panel

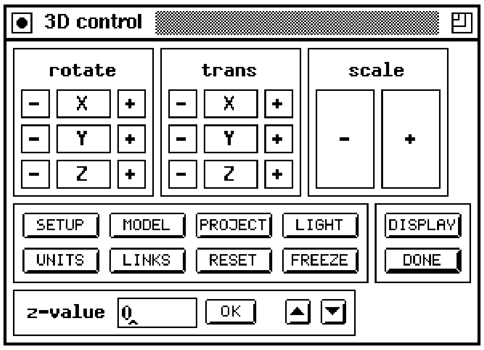

Figure 11.8: Control Panel

The 3D-control panel is used to control the display panel. It consists of four sections (panel):

1. the transformation panels

- `rotate`: rotates the 3D-display along the x-, y- or z-axis
- `trans`: transposes the 3D-display along the x-, y- or z-axis
- `scale`: scales the 3D-display

2. the command panel with the buttons
   - `SETUP`: basic settings like rotation angles are selected
   - `MODEL`: switch between solid model and wireframe model
   - `PROJECT`: selects parallel or central projection
   - `LIGHT`: chooses lighting parameter
   - `UNITS`: selects various unit display options
   - `LINKS`: selects link display options
   - `RESET`: resets all 3D settings to their original values
   - `FREEZE`: freezes the 3D-display
3. the panel with the buttons
   - `DISPLAY`: opens the 3D-display (max. one)
   - `DONE`: closes the 3D-display window and the 3D-control window and exits the 3D visualization component
4. the z-value panel: used for input of z-values either directly or incrementally with the arrow buttons

11.2.4.1 Transformation Panels

With the transformation panels, the position and size of the network can be controlled.

In the `rotate` panel, the net is rotated around the x-, y-, or z-axis. The `+` buttons rotate clockwise, the `-` buttons counterclockwise. The center fields `X`, `Y` and `Z` are no buttons but framed in similar way for pleasant viewing.

In the `trans` panel, the net is moved along the x-, y-, or z-axis. The `+` buttons move to the right, the `-` buttons to the left. The center fields `X`, `Y` and `Z` are no buttons but framed in similar way for pleasant viewing.

In the `scale` panel, the net can be shrunk or enlarged.

11.2.4.2 Setup Panel

In the `base` column of the setup panel, the transformation parameters can be set explicitly to certain values. The rotation angle is given in degrees as a nine digit float number, the transposition is given in pixels, the scale factor relative to 1. Upon opening the window, the fields contain the values set by the transformation panels, or the values read from the

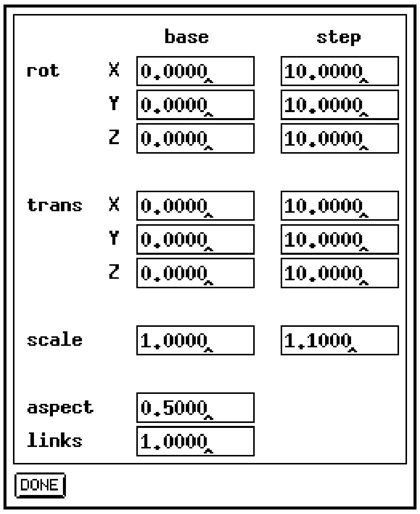

Figure 11.9: Setup Panel

configuration file. The default value for all fields is zero. The net is then displayed just as in the 2D-display.

In the `step` column the step size for the transformations can be set. The default for rotation is ten degrees, the default for moving is 10 pixel. The scaling factor is set to 1.1.

In the `aspect` field the ratio between edge length of the units and distance between units is set. Default is edge length equals distance.

With `links` the scale factor for drawing links can be set. It is set to 1.0 by default.

The `DONE` button closes the panel and redraws the net.

11.2.4.3 Model Panel

In the model panel the representation of the units is set. With the `WIRE` button a wire frame model representation is selected. The units then consist only of edges and appear transparent.

The `SOLID` button creates a solid representation of the net. Here all hidden lines are eliminated. The units' surfaces are shaded according to the illumination parameters if no other value determines the color of the units.

When the net is to be changed, the user is advised to use the wire frame model until the desired configuration is reached. This speeds up the display by an order of magnitude.

11.2.4.4 Project Panel

Here the kind of projection is selected.

`PARALLEL` selects parallel projection, i.e. parallels in the original space remain parallel.

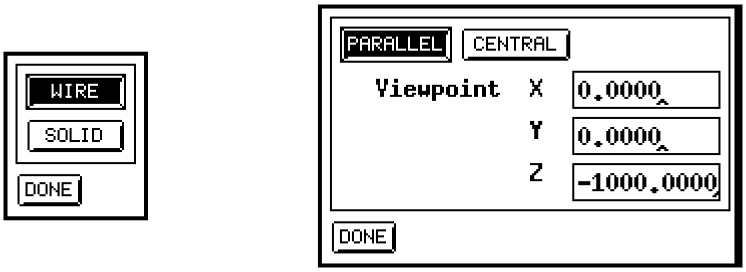

Figure 11.10: Model Panel (left) and Project Panel (right)

CENTRAL selects central projection, i.e. parallels in original original space intersect in the display.

With the `Viewpoint` fields, the position of the viewer can be set. Default is the point (0, 0, -1000) which is on the negative z-axis. When the viewer approaches the origin the network appears more distorted.

11.2.4.5 Light Panel

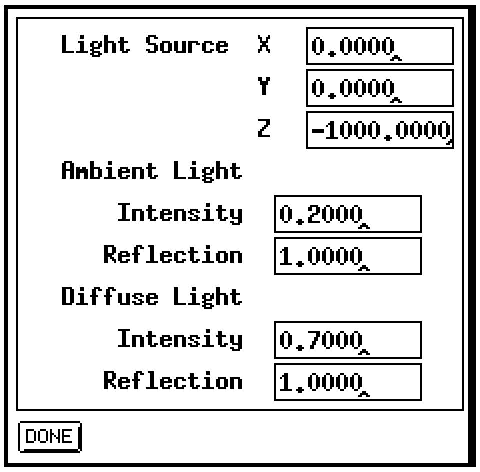

Figure 11.11: Light Panel

In the light panel, position and parameters of the light source can be set. The fields `Position` determine the location of the source. It is set to (0, 0, -1000) by default, which is the point of the viewer. This means that the net is illuminated exactly from the front. A point in positive z-range is not advisable, since all surfaces would then be shaded.

With the `Ambient Light` fields, the parameters for the background light are set.

`Intensity` sets the intensity of the background brightness.

`Reflection` is the reflection constant for the background reflection. ($0 \leq$ Ref. ≤ 1)

The fields `Diffuse Light` determine the parameters for diffuse reflection.

`Intensity` sets the intensity of the light source.

`Reflection` is the reflection constant for diffuse reflection. ($0 \leq$ Ref. ≤ 1)

11.2.4.6 Unit Panel

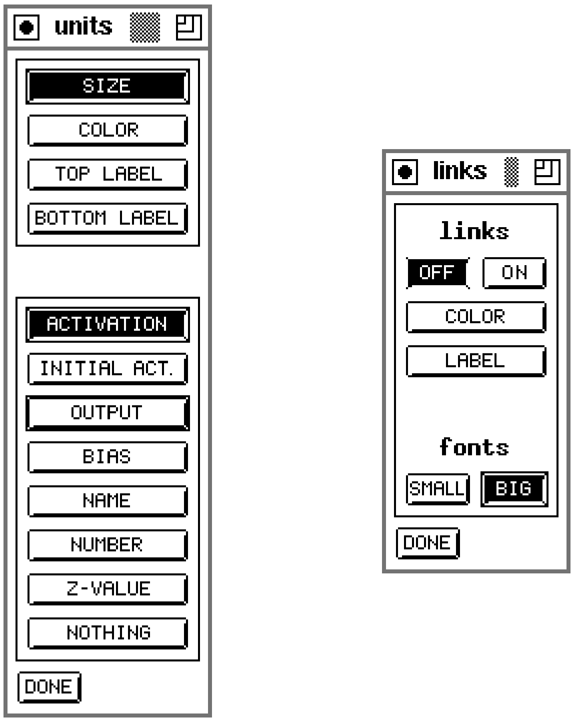

Figure 11.12: Unit Panel (left) and Link Panel (right)

With the unit panel the representation of the units can be set. The upper part shows the various properties that can be used to display the values:

- SIZE: a value is represented by the size of the unit. The maximum size is defined by the `Aspect` field in the setup panel. Negative and small positive values are not displayed.
- COLOR: a value is represented by the color of the unit. A positive value is displayed green, a negative red. This option is available only on color terminals.
- TOP LABEL: a value is described by a string in the upper right corner of the unit.
- BOTTOM LABEL: a value is described by a string in the lower right corner of the unit.

In the lower part the type of the displayed value, selected by a button in the upper part, can be set. It is displayed by

- ACTIVATION: the current activation of the unit.
- INITIAL ACT.: the initial activation of the unit.
- OUTPUT: the output value of the unit.
- BIAS: the threshold of the unit.
- NAME: the name of the unit.
- NUMBER: the number of the unit.
- Z-VALUE: the z-coordinate of the unit.
- NOTHING: no value.

The options `NAME`, `NUMBER` and `Z-value` can be used only with the top or bottom label. The other values can be combined freely, so that four values can be displayed simultaneously.

11.2.4.7 Links Panel

In the links panel the representation of the links can be switched on and off with the buttons ON and OFF. The button COLOR forces color representation of the links (only with color monitors), and the button LABEL writes the weights of the links in the middle.

In the `fonts` part of the panel, the fonts for labeling the links can be selected. The button SMALL activates the 5×8 font, the button BIG the 8×14 font

11.2.4.8 Reset Button

With the RESET button the values for moving and rotating are set to zero. The scaling factor is set to one.

11.2.4.9 Freeze Button

The FREEZE button keeps the network from being redrawn.

11.2.5 3D-Display Window

In the display window the network is shown (see figure 11.7). It has no buttons, since it is fully controlled by the control panel. It is opened by the DISPLAY button of the control panel. When the control panel is closed, the display window is closed as well.

Note: The 3D-display is only a display window, while the 2D-display windows have a graphical editor integrated. There is also no possibility to print the 3D-display via the print panel.

Chapter 12

SNNS for Workstation Clusters

Training several neural networks on a single workstation may require a large amount of training time, if performed on a single workstation. Dividing the training task among several workstations on a LAN (local area network) may significantly decrease the overall training time. This version of SNNS for workstation clusters allows to train several (possibly different) networks on different workstations and to control them with a single graphical user-interface.

The kernel interface has been extended for this purpose by an *rpc* module that is controlled by the graphical user-interface xgui. The module was named *rpc* because the communication among the workstations is performed via the rpc (remote procedure call) protocol.

This parallel SNNS version supports the following methods of parallelism:

- training different networks in parallel, each with its own pattern file,
- training several copies of the same network with different parameters or different initialization in parallel, each with its own (copied) pattern file, or
- an arbitrary combination of the above two methods.

The parallel version currently does NOT support dividing the training of a single network over several workstations. This might be added in a future version, if it can be implemented efficiently enough.

The extension consists of two programs:

- `xguirpc`: SNNS simulator program (xgui, simulator kernel, and rpc module linked into one executable program). This program is the graphical user-interface, which controls the different simulator kernels. It has the same functionality as the xgui (snns) program plus different panels to control the rpc-interface. To use multiple simulator kernels, one may start as many `kernelrpc` programs as desired.
- `kernelrpc`: simulator kernel linked with the rpc module (the server). This program is the stand alone simulator kernel with rpc module, which is controlled from the `xguirpc` program. Each kernel has is own net, pattern sets and configurations.

The files are located in the directory

<snns-root>/rpc/bin/<architecture>

where <architecture> is one of the currently supported machine architectures. We have tested it on an Intel Paragon and single CPU Sun SparcStations, and Linux systems. To use the program efficiently on multi-CPU systems like the DEC Alpha some adjustments in the libraries might be necessary.

The easiest way to start a new simulator kernel is from the **new panel** called by pressing the `NEW` button in the **SNNS rpc panel** (see 12.2.1).

If the networks are to be trained without human supervision, a similar functionality may also be obtained by starting a copy of the batch SNNS simulator `snnsbat` on each workstation.

12.1 SNNS RPC Programs

Xguirpc

`Xguirpc` has the same options as `xgui`. Additionally there is one more option:

`-force`:
The force option is instructing `xguirpc` to delete the portmap number of an old `xguirpc`. This option is only necessary if an `xguirpc` was not terminated correctly on the machine. Only the last registered `xguirpc` will receive messages from the simulator kernel. This implies that a user can run only one `xguirpc` on a computer.

Kernelrpc

`Kernelrpc` has the following options:

- `uid` <xguirpc.user-id>: the user-id of the `xguirpc` user,
- `host` <xgui_rpc_host>: the host-name of the `xguirpc`,
- `program` <xgui_program_number>: the program number under which the `xguirpc` is registered at the portmapper,
- `version` <xgui_version_number>: the version number under which the `xguirpc` is registered at the portmapper,
- `type` <type>: kernel type (normal or masters),
- `net` <net-name>: the name of a network file that is to be loaded,
- `pat` <pat-name>: the name of a pattern file that is to be loaded. This option may be given more than once.

If `kernelrpc` is started without any options the kernel will wait a short period of time. If there is no connection to an `xguirpc` the `kernelrpc` will be aborted. The default waiting time is set to 15 minutes. The simplest way to start `kernelrpc` is with the help of the **New panel** of the rpc module, because all options are set automatically. It is possible to run up to 10 `kernelrpc`s at the same time on one computer.

In some networks problems occur, caused by the domain name. If NIS (SUN Yellow pages) is activated, the function `getdomainname` does not deliver the correct domain name. However, this problem can be solved, if the environment variable DOMAINNAME is set to the correct domain name.

`Example:` On our Sun workstations `getdomainname` returns `infra` instead of `informatik.uni-stuttgart.de`. To solve this problem, we type: `setenv DOMAINNAME informatik.uni-stuttgart.de`. The best way to achieve this is to add the above line to the `.cshrc` file.

12.2 Control Panels

The distribution of SNNS onto the workstation cluster and the distributed execution of the training and recall is controlled via several windows. The main control panel, the **rpc panel**, is opened by clicking the rpc button in the manager panel.

12.2.1 SNNS RPC Panel

This panel is the control center of the communication module. In this panel the simulator kernel with which the graphical user-interface will interact is selected. Choose a row and click `SWITCH TO`, to specify a simulator kernel to contact. The displays and the control panel will then be updated.

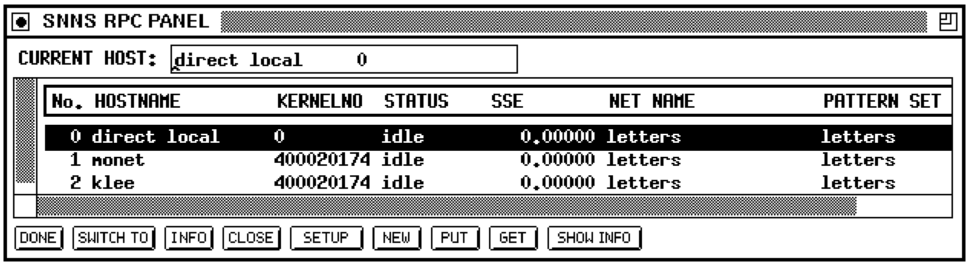

Figure 12.1: The RPC Panel

With this panel the current simulator kernel, shown in the top row, is chosen.

The buttons and fields of this panel (shown in figure 12.1) have the following functionality:

1. **CURRENT HOST** gives the name of the host computer on which the currently selected `kernelrpc` program is running.
2. The **list window** displays the list of all currently registered `kernelrpc` programs.

3. `SWITCH TO` switches to the selected simulator kernel.

4. `INFO` displays information about the selected simulator kernel. No switch of the simulator kernel takes place. The information displyed includes: Network names or comments which are saved in the network description.

5. `CLOSE` closes the selected simulator kernel. Before this process is completed, the system switches to 'direct local'. This simulator kernel is special because it is not using the standard communication protocol. It is impossible to delete this kernel because it is linked directly to the graphical user-interface. If the graphical user-interface is started, the standard simulation kernel is 'direct local'. The only difference between a 'direct local' rpc kernel and the standard SNNS kernel without rpc interface is the existence of the `RPC` button in the **Manager panel** with the added rpc functionality.

6. `SETUP` opens the **Setup panel**. In this panel the current settings of the marked kernel are displayed and can be modified. These settings are described in section 12.2.2.

7. `NEW` creates the **New panel**. With this panel it is possible to start new simulator kernels on different computers or to link already existing kernels. The **New panel** is described in section 12.2.3.

8. `PUT` and `GET` change the net and the patterns within the selected kernel.

9. `SHOW INFO` selects the information, which is displayed in the `list window`.

10. `DONE` closes the **rpc panel**.

12.2.2 RPC Setup Panel

With the help of this panel the current settings of the marked simulator kernel are displayed and modified.

- `UDP` and `TCP` switch between the connection types UDP and TCP. If the connection type is changed, the current connection is terminated and a new connection is established. `UDP` and `TCP` are the two possible protocols that are build directly upon the internet protocol (IP). `UDP` (unreliable datagram protocol) is a little bit faster than `TCP`. Since `TCP` is more reliable we recomend it for usage with `xguirpc`.

- `NORMAL` and `COOP-MASTER` set the mode of the kernel. The function of the coop-master mode has not been implemented in this release of the SNNS.

- `Standard timeout` The waiting interval of the graphical user-interface, which is used to determine when an rpc error should be displayed.

- `Long duration timeout` The long duration timeout field is responsible for the waiting time in the learning process. It specifies the time `xguirpc` will wait for a `kernlrpc` program to finish a training cycle. If there is no response within that period of time `xguirpc` will assume an errror in the program execution. This value

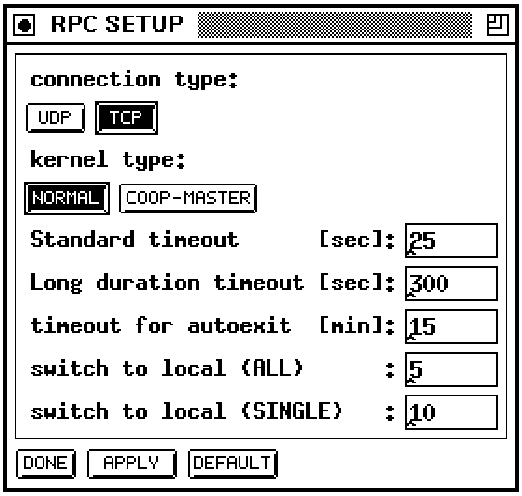

Figure 12.2: The RPC Setup Panel

should be rather large for big nets or pattern sets, otherwise an error will be displayed even if there is actually none.

- `Timeout for autoexit` is responsible to specify how long a simulator kernel will wait without receiving any messages before it automatically stops. This value is entered in minutes.
- `switch to local (ALL)` Specifies the threshold for asynchronous execution mode. If there are fewer training cycles specified in the control panel, `xguirpc` will wait for the remote host to finish learning (synchronous mode). If there are more training cycles specified, `xguirpc` will start training on the remote host and then immediately switch back to 'direct local' to allow the user further input as long as `kernlrpc` is executing training on the remote host (asynchronous mode). This value is relevant only for the training of all patterns.
- `switch to local (SINGLE)` Same as `switch to local (ALL)` but with relevance only to learning a single pattern.
- `APPLY` All entered values are set only after this button is pressed.
- `DEFAULT` will use the default values.
- `DONE` closes the window.

12.2.3 New Panel

The **New panel** is used to start new simulator kernels on different computers. A computer host name is required in the first line (it is also possible to select one from the list by clicking on it with the left mouse button). The second line specifies the path to the desired rpc kernel. Remember to seltect an rpc kernel of the correct computer architecture, if you are working with a heterogeneous workstation cluster. Different calling parameters can be added in the third line.

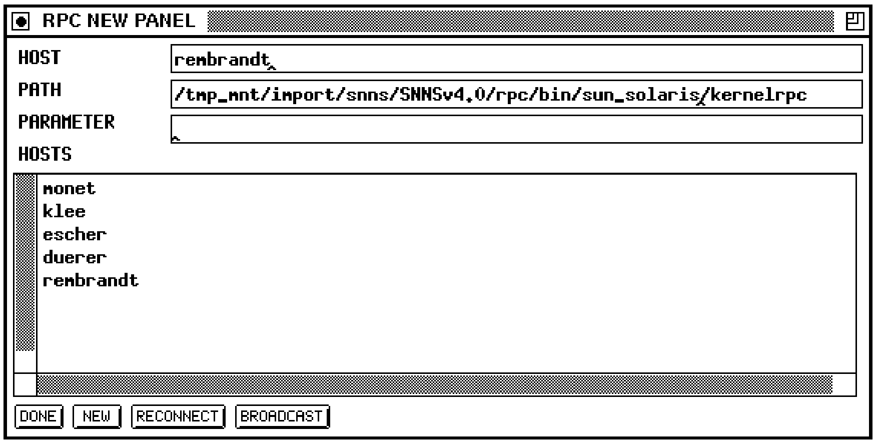

Figure 12.3: The RPC New Panel

The `NEW` button starts a new rpc kernel. To start the program, **`xguirpc`** uses the 'rsh'-instruction to execute a command on a remote computer system. The newly started simulator kernel receives the computer name, portmap number and version of the computer on which the graphical user-interface is running. After a successful start of the simulator kernel, the kernel registers with the graphical user-interface. The kernel is then included in the 'host-list' of the **rpc panel**.

If the new kernel is not listed in the 'host-list' of the **rpc panel** within a couple of seconds, it might be due to the fact that the given path is invalid on the specified machine (e.g. wrong mount prefix). In this case try to determine the correct path and try again.

With the `RECONNECT` and the `BROADCAST` buttons, different already existing simulator kernels can be connected with the graphical user-interface. The difference between those two buttons is that `RECONNECT` selects a specific computer and `BROADCAST` sends a signal to all computers in the LAN. It is not guaranteed that all computers will actually receive the signal.

12.2.4 Transfer Panels

To transfer patterns or networks to or from a local simulator kernel, the transfer panels can be used.

If the **Get** panel is chosen, it is necessary to have 'direct-local' as a current host and to have a remote simulator kernel marked with the mouse. The simulator kernel, which the nets and/or the patterns will be transfered to, can be chosen with the two arrows. Note that help files will be created in the directory /tmp as the transfer takes place. Those files will be deleted after the transfer. It is necessary to make sure that enough disk space in /tmp is available.