
# UM Cluster: Service of Distributed Calculations

This manual leads you through the basic features of the deployment and usage of service of distributed calculations of Universal Mechanism software within the corporate network. The features of network settings and operating system parameters necessary for the successful usage of service of distributed calculations are discussed. It is strongly recommended to encourage your network administrator to read this document due to the fact that the installation and operation of the service of distributed calculations affects not only your computer but other computers in the network. Note that the significant part of the initial deployment of the service can be performed only under an administrator's account.

**2024**

# Contents

# 1. UM Cluster: Service of Distributed Calculations

Service of distributed calculations **UM Cluster** is a part of **Universal Mechanism** software and is the extension of **UM Experiments** module. **UM Cluster** is designed for distributed execution of scanning projects on the user's computer and other computers in the corporate network. **UM Cluster** allows you to use the computing power of all computers in your corporate network for the calculation of your scanning projects. **UM Cluster** consists of the server and client parts. If you are familiar with the principles of computer networks based on OS Windows, start reading this document from the Sect. 1.3 "*Getting started using UM Cluster Server*", page 1-18, that is devoted to practical aspects of the deployment of **UM Cluster** in a corporate network.

### Compatibility

Components of the service of distributed calculations work under Windows 7/8/8.1/10, Windows Server 2012R2/2016/2019. Only 64 bit versions are supported. **UM Cluster** reqiures TCP/IP v. 4. TCP/IP. The TCP/IP v.6 is not supported.

### Copyright and trademarks

## 1.1. Structure and files of UM Cluster

Files of **UM Cluster** are located in \bin directory of the root directory of Universal Mechanism software. **UM Cluster** consists of the following components.

- **UMServer.exe** is the server of the computational cluster.
- **clustsrv.exe** is the client of the computational cluster. The client is implemented as a system service (in terms of Windows) that is controlled by the server. clustsrv.exe has no user interface.
- **UMSolver.exe** is the stand along solver used by the client of the cluster. UMSolver.exe has no user interface.
- **UMMonitor.exe** is a program for configuring client computer access permissions and displaying the status of calculations on the client side. This program does not directly take part in calculations.

UMServer.exe manages the execution of projects. All the other files listed in the above list constitute the so-called client part, which enables the execution of calculations on remote computers. The client part of the cluster is installed on computers using a stand-alone installation package or directly from the cluster server. The details of the interaction between the client and server parts can be found in the Sect. 1.2.1.7 "*Configuring client computers*", p. 1-7.

## 1.2. Introduction to deployment of UM Cluster

### 1.2.1. Basics of Windows-based networks

Distributed calculations assume the use of the resources of other computers available in your corporate network. It makes possible to significantly reduce the computation time of scanning projects. The price for this is the need to have basic knowledge in the field of Windows-based networks. Most probably you know the number of computers in your network and have an idea of its computing power. In this case you only need to turn on that computers, install **UM Cluster Client**, add them into **UM Cluster Server** and start using them. Please note if a computer is in your office and turned on it does not guarantee that you will be able to include this computer to **UM Cluster**. First of all, remote computers should be properly configured and available in the network.

This section briefly describes the basic principles and terms that are used in Windows-based networks. The section is intended to give the user the required minimum of knowledge that will allow more confident using the server of distributed calculations in practice in cases if your company/laboratory has no any network administrator.

#### 1.2.1.1. The general concept of computer network

Computer network is a set of computers and other devices that can communicate coherently, using certain types of electrical signals, and in a similar way to interpret these signals, converting them into useful information. Logical rules, by which signals are transformed into meaningful

information, are called protocol. At the logical level information is controlled by so-called protocols, which are built into the operating system. **UM Cluster** treats standard protocols that are available in the Windows.

#### 1.2.1.2. TCP/IP protocols. Addressing the network

Starting with Windows NT all operating systems from Microsoft Corporation are bundled with the built-in network environment based on TCP/IP version 4. Properly configured network environment supposes that each computer has a couple of unique descriptors: an IP-address and a name.

| | |
|---|---|
| **Important!** | **UM Cluster** is designed to work with computers using IP version 4 addressing. Recently, computer communities are actively working on transferring networks to work with TCP / IP version 6. **UM Cluster** does not support TCP/IP v. 6 protocol. |

#### 1.2.1.3. Computer names

The family of Windows operating systems under the name of the computer usually means a so-called NetBIOS-name, which consists of no more than 15 characters. NetBIOS names can include symbols of national alphabets. Computer names are easier to remember by users, but network programs use only IP-addresses for communication and information exchange. Software service that translates a computer name to an IP-address is called name resolution. The basic name resolution services are as follows:

- Lmhost (local file);
- DNS (Domain Name System) service is multi-rank, the most widespread and universal for all operating systems;
- Wins (obsolete network);
- Windows peer-to-peer broadcast service based on NetBIOS names.

#### 1.2.1.4. Setting up TCP/IP-protocol in Windows

| | |
|---|---|
| **Note 1.** | It is assumed that the user's computer, on which the Universal Mechanism is installed, is a member of a local network built using Ethernet technology. |
| **Note 2.** | Changing the network settings of a computer is a privileged operation and requires administrative rights. Depending on the security policy defined by network administrators, if any, you, as a computer user, may or may not have such rights. If you have such rights, you should be careful when changing network parameters. Wrong actions can lead to disruption of the stable operation of the network, not only of your but also of other computers on the network. |
| **Note 3.** | All computer names and IP-addresses in this section and below are given as examples. Your network may have different addresses. |

Despite significant evolutionary changes in the line of operating systems by Microsoft, since Windows 95 and Windows NT, the graphic user interface of software responsible for configuring the network settings of computers has not changed. Click on **Network** icon on the desktop

and then select **Properties** menu item from the context menu. Further click on adapter settings, select a connection from the context menu again and choose **Properties**, see Figure below.

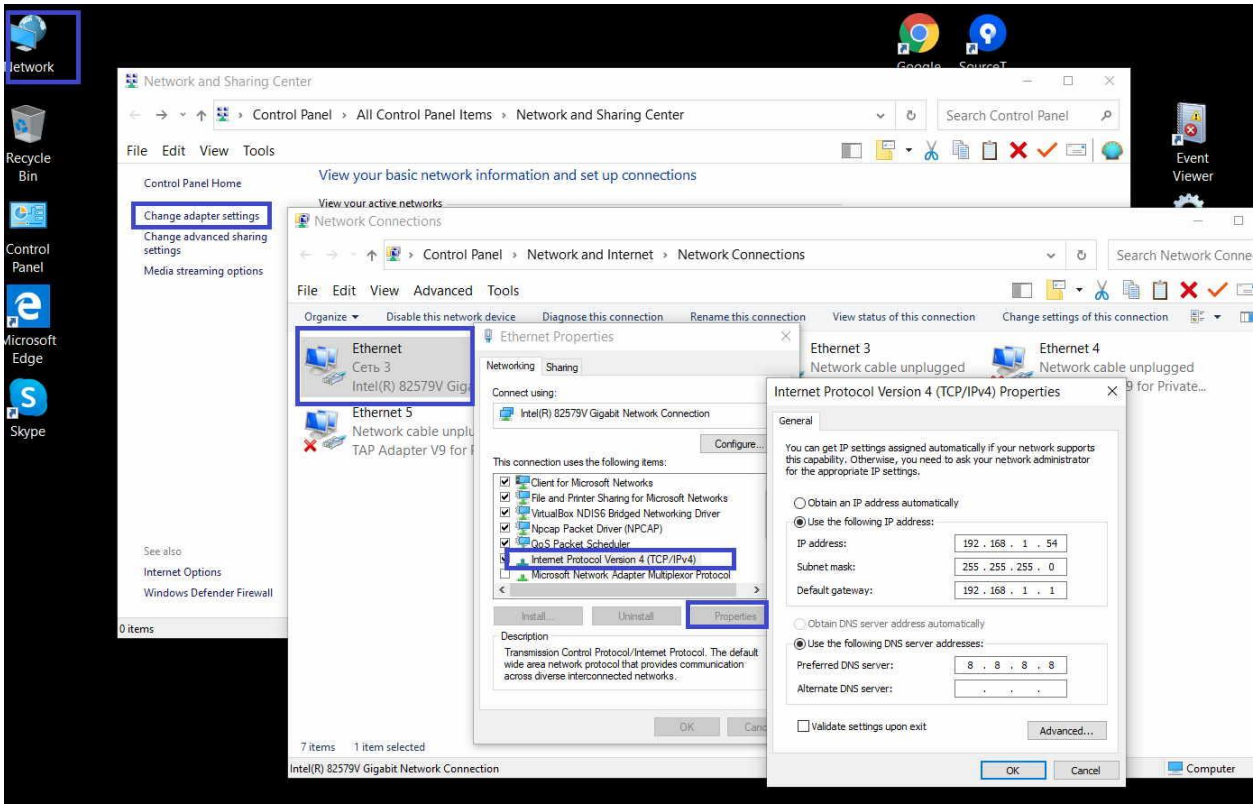


Figure 1.1. TCP/IP Settings (Windows10)

### 1.2.1.5. Command line programs

For diagnostics of computer settings, including network settings, Windows provides a set of small command-line programs. For many users, the use of the windows is more familiar and comfortable; however, need to use command line programs can be for the following reasons:

- not all command-line programs have Windows-GUI-based analogues;
- location of Windows diagnostic programs (menus, buttons) can change their location in different versions of Windows;
- the path to the windows is often deeply nested and it is necessary to sequentially open multiple windows or menus to run the program.

**Note** We recommend you to copy the shortcut **Start** -> **All Programs** -> **Accessories** -> **Command Prompt** to the desktop.

For the description of the networks, this guide will use Windows GUI programs, but in some situations command-line programs are irreplaceable.

### 1.2.1.6. Network computer interaction

The Sect. 1.2.1.2 "*TCP/IP protocols. Addressing the network*", page 1-5 describes the fact that each computer on the network has the unique address, and a computer, at the request of an-

other, using higher-level protocols, can return some useful information, such as web pages or the exact time for a specific time zone. In computer terminology, the computer making a request is called a client. A computer that returns some information in response to a request is called a server. A program that runs on a server and processes a request is called a service.

The **netstat –ano** command displays a list of all TCP/IP connections in the [address: port] format, additionally indicating the state of the connection and the identifier of the process that opened the connection.

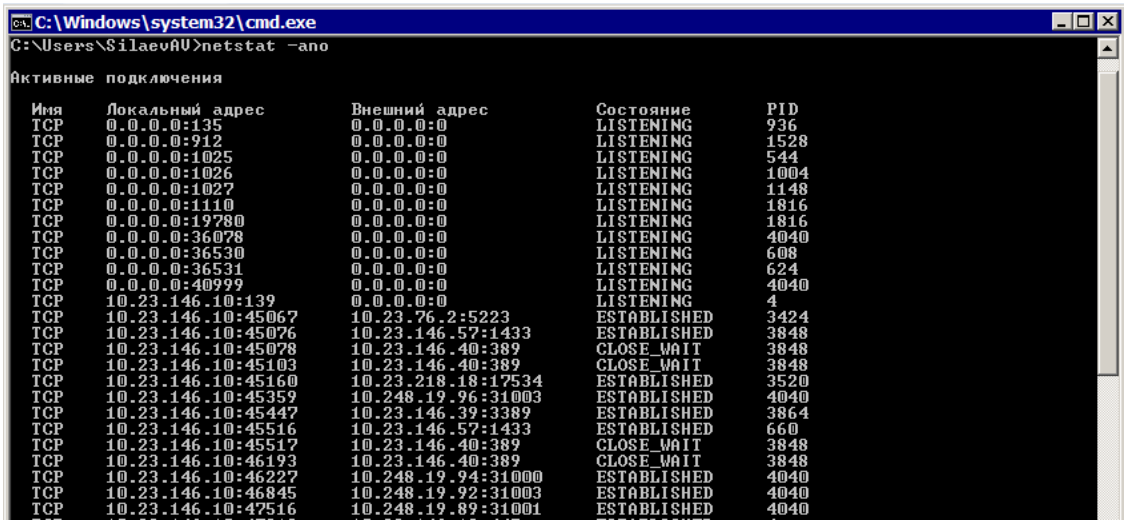


Figure 1.2. Open network ports on computer (Windows7)

### 1.2.1.7. Configuring client computers

To use a computer as a client one it should be properly configured and a client part of UM Cluster should be installed on it. You can download the client part of the cluster via this link: http://www.universalmechanism.com/en/pages/index.php?id=3.

The **Universal Mechanism** software starting from version 9 includes a stand-alone installation package for the client part of the cluster. Besides the installing application itself, it also configures a computer. During the initial configuration, the operating system components that limit the network capabilities of client operating systems (Windows 7/8/10) are being adapted. From now on all manipulations with client programs, such as deleting or updating them, can be performed remotely from any server in the cluster. Familiarization with the operating system mechanisms that **UM Cluster** relies on is optional, you can skip this material and go to the Sect 1.2.4.4 "*Configuring interaction with the cluster server*", page 1-16.

The initial configuration of the client computers is performed during the installation of the client part of the cluster or using the **UM Monitor** program.

Starting with Windows 2000, network operations of all Windows operating systems all closely connected with the **RPC** (Remote Procedure Call) protocol, which allows you to perform many operations both at local and (if you have certain rights) at remote computers. RPC protocol is supported by *Server* and the *Remote registry* system services. **RPC** protocol supports particularly the following operations:

- copying files;
- management of the system registry;

- management of system services.

Of course, for Windows to allow remote programs to perform these actions, it is necessary that the following conditions should be satisfied.

1. User on **Cluster Server** must have administrative rights for the server and client computers.

2. Windows firewall should allow connections to the client computer.

3. **Network access: Sharing and security model** for local accounts should be set to **Classic: local users authenticate as themselves**.

4. *Server* and *Remote registry* system services should be *Running*.

5. UAC mechanism on client operating systems must be disabled.

The second and the third conditions above are satisfied by default on server operating systems (Windows Server 2003/2008/2012/2016/2019). Correspondent settings in personal operating systems (Windows Vista/7/8/10) should be turned on manually. *Server* service and *Remote Registry* service are running by default, but can be stopped by the user.

**How to determine if the Server service is started? Start -> Control Panel ->Administrative Tools > Services -> Server** system service and check its status, see Figure 1.3.

The client part of **UM Cluster** is implemented as a service and running independently of the user sessions on remote computers. No matter what rights have the active users on client computers, as well as even whether there are active sessions on them.

Security issues are discussed in the Sect. 1.2.4 "*Windows security*", page 1-13.

Among other issues, please note the following:

- Hereinafter, under possibility of interaction between the **UM Cluster Server** and client computers means availability of RPC protocol on remote computers.
- Despite the fact that, by default, all systems are almost ready to interact, you should understand that, in general, normal operation of RPC protocol is determined by a dozen options of computer security. Set any of such options to disabled state can disrupt the entire chain of interaction between the client and the server. The main options, except the exotic ones, are described in this document.
- If the client computer is part of Active Directory, some security settings are determined by rules of corporate network implicitly through group policies. *Active Directory* security settings usually have higher priority over local settings. In this case, most probably you should contact your system administrator to define network and security settings properly.

In *Active Directory* environment, the corporate settings on which the operation of the cluster depends may be more favorable by default than in a simple local network, because domain computers are located in a trusted environment and are under the supervision of network administrators.

**Computer management console**

This console contains a lot of useful information about your computer. To open the console click the right mouse button on the **My computer** and select the **Manage** menu item. Click the **Connect to another computer** context menu item in **Computer Management**. It is possible to

connect to another computer, if you know administrator's user name and password on that remote computer and *Server* system service is running on the remote computer.

Please note once again how important that the *Server* system service should be running on the remote computer.

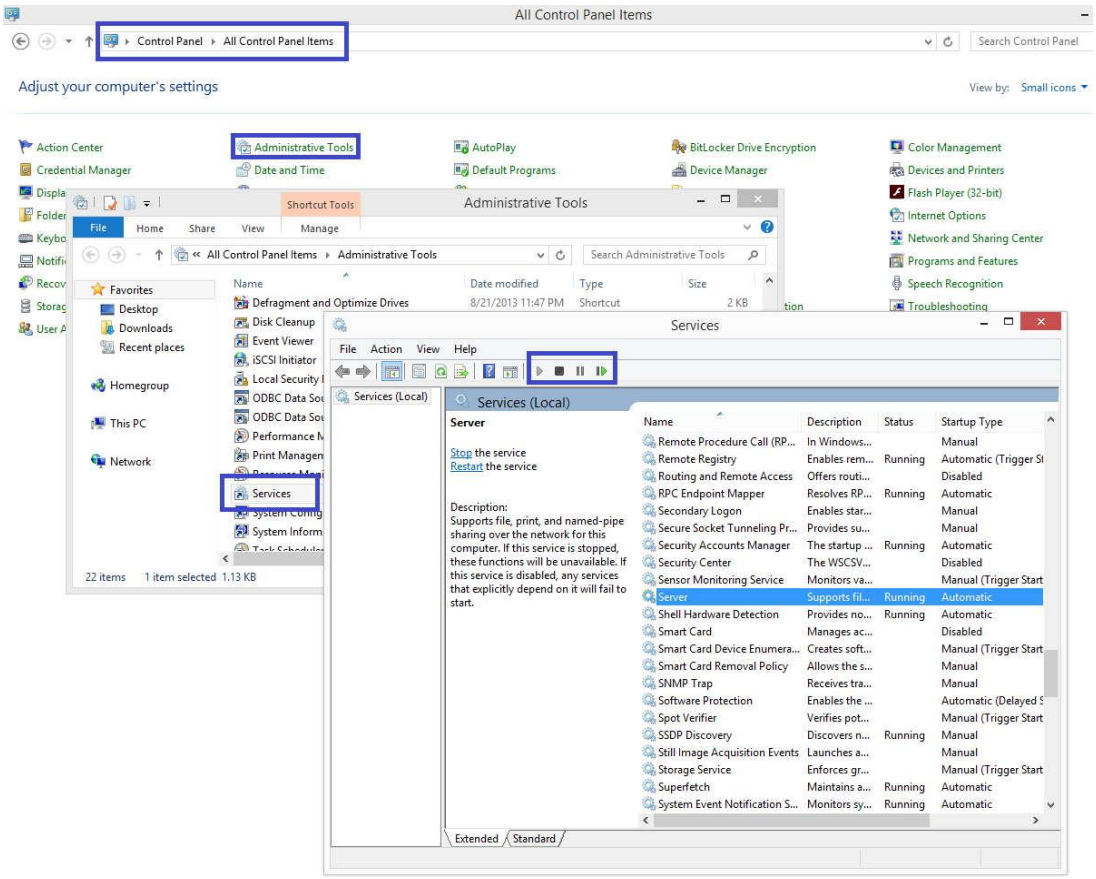


Figure 1.3. Control Panel / Services (Windows 8.1)

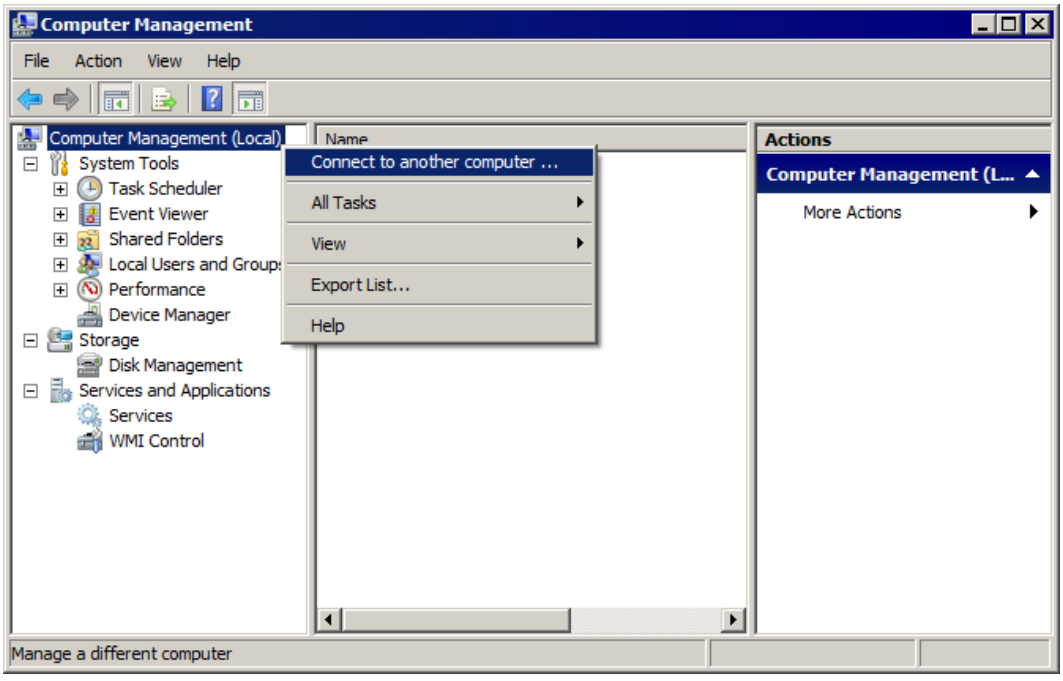


Figure 1.4. Manage remote computer (Windows 7)

### 1.2.1.8. Troubleshooting

**How to know your own computer name and IP-address?**

One of ways to know that through the dialog window is described in the Sect. 1.2.1.4 "*Setting up TCP/IP-protocol in Windows*", page 1-5. Sometimes it is easier to determine computer name and its IP-address with the help of **ipconfig** command line program.

Run **ipconfig /all** in the command window to determine full information about the network settings.

**How to determine if the remote computer is visible in the network?**

You can use ping command. Input the following command line: **ping [computer name or address]**. For example, **ping 192.168.1.10**. Result of running ping command will show you if the remote computer is available or not.

As a rule, diagnostics of all networked devices starts with the **ping** command. This command sends to the remote computer or other device special packets and waits for the response of the remote device. Based on the response it concludes if device is active or not and the speed of a possible exchange of information in the network is determined.

The **ping** command is very simple. It does not define any type of device or services. In addition, if the device is not received an answer that does not mean that the specified address does not exist. Sometimes special programs called *firewalls*, distributed as a part of operating system or antivirus software, may prohibit the sending of ping responses for security reasons.

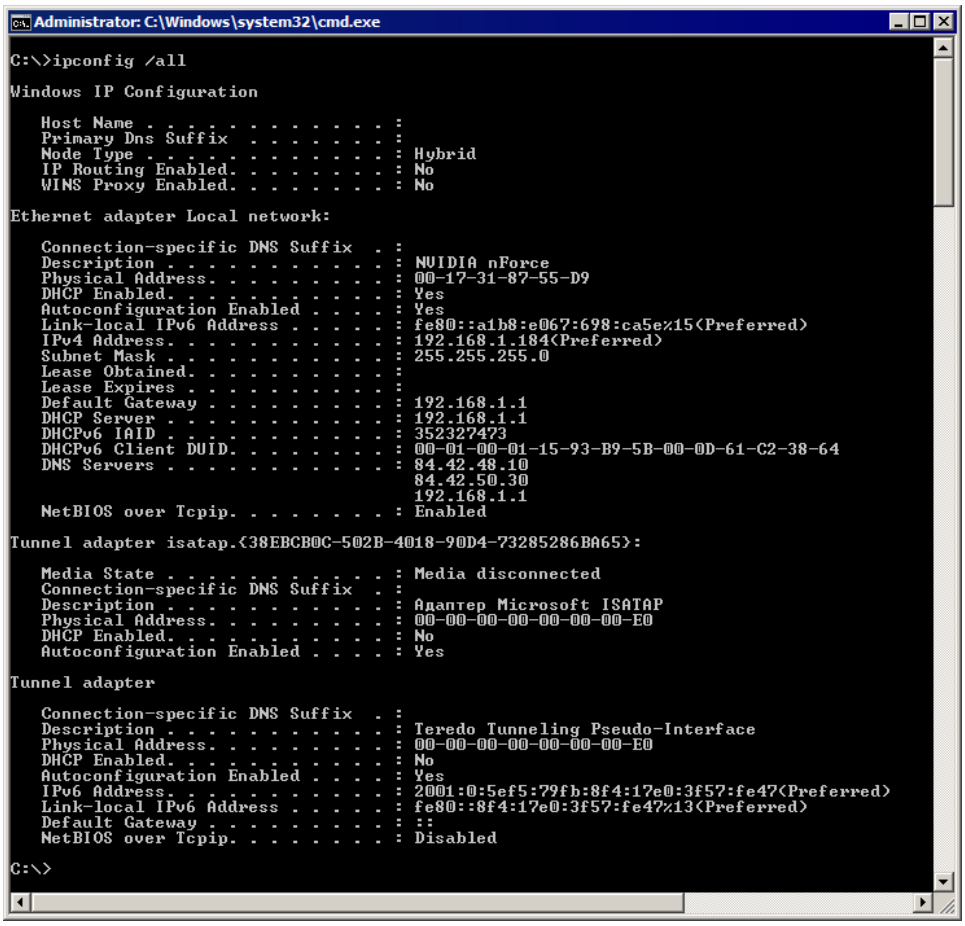


Figure 1.5. Network setting via ipconfig /all (Windows 7)

### 1.2.2. Windows operating systems

There may be different versions of Windows operating systems in your corporate network. All Windows operating systems are divided into personal and server ones. As a rule, the appearance of new personal operating system is accompanied by the release of the new server one. The table below shows pairs of corresponding systems.

| Personal operating system | Supported by UM Cluster | Server operating system | Supported by UM Cluster |
|---|---|---|---|
| Windows 2000 Professional | No | Windows 2000 Server | No |
| Windows XP | No | Windows Server 2003 | No |
| Windows Vista | No | Windows Server 2008 | No |
| Windows 7 | Yes | Windows Server 2008R2 | Yes |
| Windows 8 | Not tested | Windows Server 2012 | Not tested |
| Windows 8,1 | Yes | Windows Server 2012R2 | Yes |
| Windows 10 | Yes | Windows Server 2016/2019 | Yes |

Personal systems react on the user activity faster, whereas the server systems prefer to serve background processes. Regarding running of UM scanning projects there is no big difference between personal and server operating systems. It is mainly determined by hardware performances. You can install both the client and server parts of the cluster on any type of supported operating systems.

### 1.2.3. Computer's hardware configuration and performance

In terms of **UM Cluster** the cluster performance is, in fact, time spent for the running project. Due to the large number of possible situations defined above circumstances, let us consider the most general issues regarding the performance of computational cluster.

A separate numerical experiment is the quantum of the cluster. In case of distributed computing, each experiment can be run on a server computer and on any computer with an installed client part of **UM Cluster**. The successful execution of all numerical experiments means the successful execution of the whole project. Remote running of a separate numerical experiment assumes the following steps:

- preparing input data;
- waiting for the available CPU/core on remote/local computer;
- copying input files;
- running the numerical experiment;
- returning result files;
- removal the temporary files on remote computers.

General performance of the cluster surely depends on many variable factors:

- complexity of the project (the number of experiments in the project and their "severity");

- the number of client computers you can use;
- number of available CPU/cores on remote computers;
- the performance of client computers;
- restrictions by users of remote computers for using whole computer or some CPU core by **UM Cluster** (set in **UM Monitor**);
- whether the cluster server will also act as a client;
- speed of communication between cluster computers;
- loading the client computer by other tasks;
- size of input and output files;
- antivirus software on client computers.

Due to the large number of possible situations determined by the listed circumstances, let us outline the most general considerations about computing performance.

Regarding the influence of the hardware configuration on time consuming for calculation of numerical experiments under **UM Cluster**, the most important characteristics are **CPU frequency** and the **number of CPU cores**. Other configuration parameters do not influence on speed of calculations significantly.

Ideal, but in the most cases unrealistic solution, is to use dedicated servers as clients of **UM Cluster**. Modern cloud technologies give the users a possibility to use cloud or dedicated servers on demand. Therefore, when you turn on a remote computer or server in the cluster list of clients is necessary to consider its role in the normal functioning of the enterprise. If a computer has important server functions (SQL, WEB server) you should be careful to start using it within **UM Cluster**. It is recommended that you limit the number of available CPU cores on it with the help of **UM Cluster Server** or **UM Monitor**.

The use of server systems that actively use hardware often does not affect the calculations as much as the copying of data. So, for example, SQL server applications load the disk system significantly, and the cluster server spends most of its time waiting for the result, and not on the calculation of the experiment itself.

Using remote computers as clients of **UM Cluster** you should note its daily load profile, see *Figure 1.25. UM Monitor: Permission to use processors by time* Most probably you can use more CPU cores of remote computer during the lunch, meetings or in the night.

As a rule, modern Windows operating systems, especially server ones, scale well and some additional computational load due to **UM Cluster** does break down remote computer. Usually you can use 2-4 CPU cores of 4- or 8-core computers without bringing any discomfort to remote users and slowing down other important server systems.

The best cluster performance without introducing discomfort for remote users and slowing down other important server systems can only be achieved empirically, based on the idea of your own computer set and network topology and quality.

## 1.2.4. Windows security

### 1.2.4.1. Administrative security

The previous section describes some of the steps for configuring the client computers, and getting some important parameters of their state. Please note, that Windows operating system considers many changes as potentially hazardous. So Windows architecture provides self-protection and limitation of user rights in many situations. The so-called administrative security is a subsystem of Windows that is designed to restrict the rights of different users in the system.

Each user in Windows has his/her own account. When a user logs into the system, i.e. enters his/her username and password, Windows creates for the user a personal session that keeps information about user rights in the system. Any application running inherits this personal information. Any action that the user attempts to commit is checked by the operating system.

There are following basic groups of users:

- administrators;
- users;
- guests.

Your account is in one of these groups that defines your rights in the system. Generally speaking, your account can belong to several groups. This document does not address such situations.

For correct operation of **UM Cluster** your account should be in "Administrators" group on server and client computers, as the only administrator privileges can perform the following steps:

- change network settings;
- install the programs and services remotely;
- use the registry on remote computers;
- copy files to system directories on a remote computer and remove them;
- obtain the parameters of remote computers to estimate their performance.

**How to know if a user is in "Administrators" group?**

**Approach 1.** Run the command line program **net user <user name>**. See **Local Group Memberships**, see Figure 1.6.

**Approach 2. My computer -> Context menu -> Manage -> Local Users and Groups -> Groups -> Administrators** and look for the given user, see Figure 1.7.

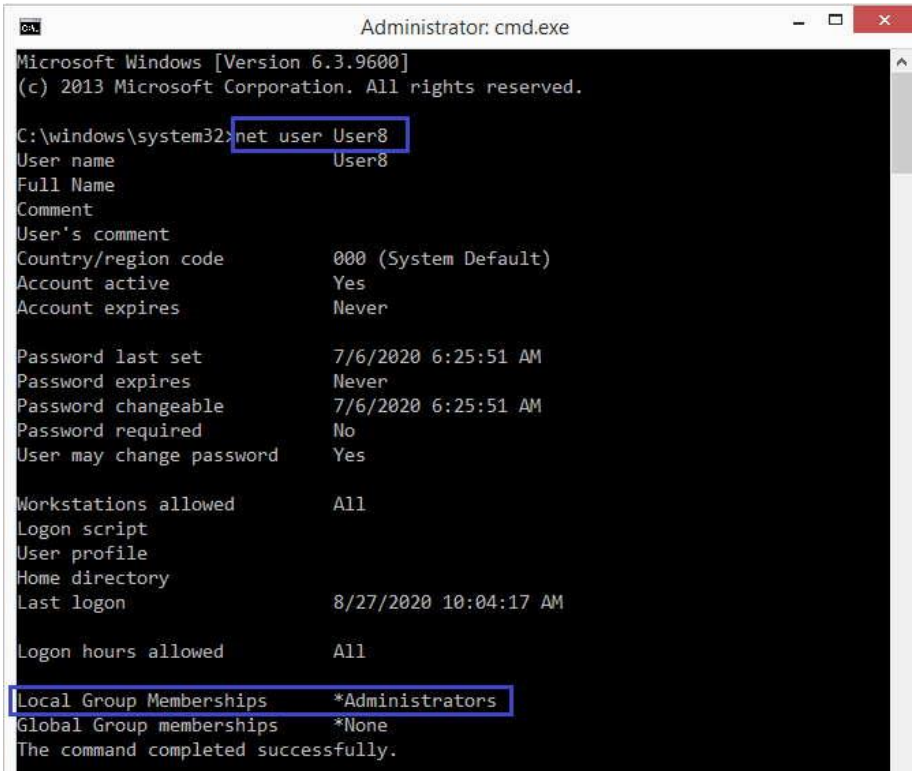


Figure 1.6. net user command (Windows 8.1)

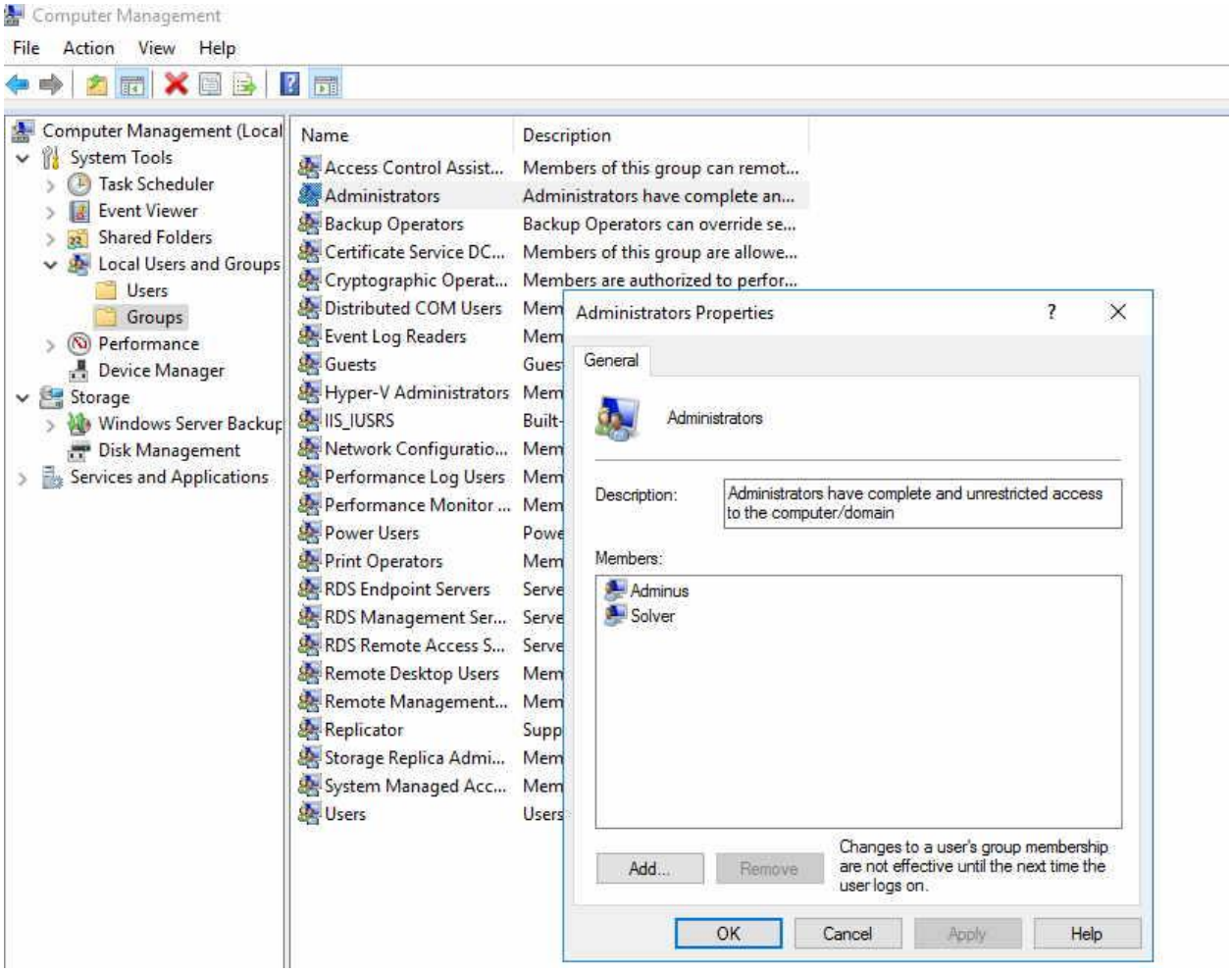


Figure 1.7. Computer management / Local users and groups (Windows 10)

### 1.2.4.2. Windows Vista+ and User Access Control (UAC)

Starting from Windows Vista, operating system from Microsoft has a special component named UAC (User Access Control). The component is active by default. UAC requests to start some programs with an administrator account. Besides that, UAC does not allow remote work with the registry of a computer that makes impossible the normal functioning of **UM Cluster**. On **UM Cluster** client computers UAC must be disabled, see *Figure 1.7. Disabling UAC (*Windows 7) You can do that via the control panel. It needs to reboot the computer after disabling UAC.

**Note.** Server operating systems have UAC disabled by default.

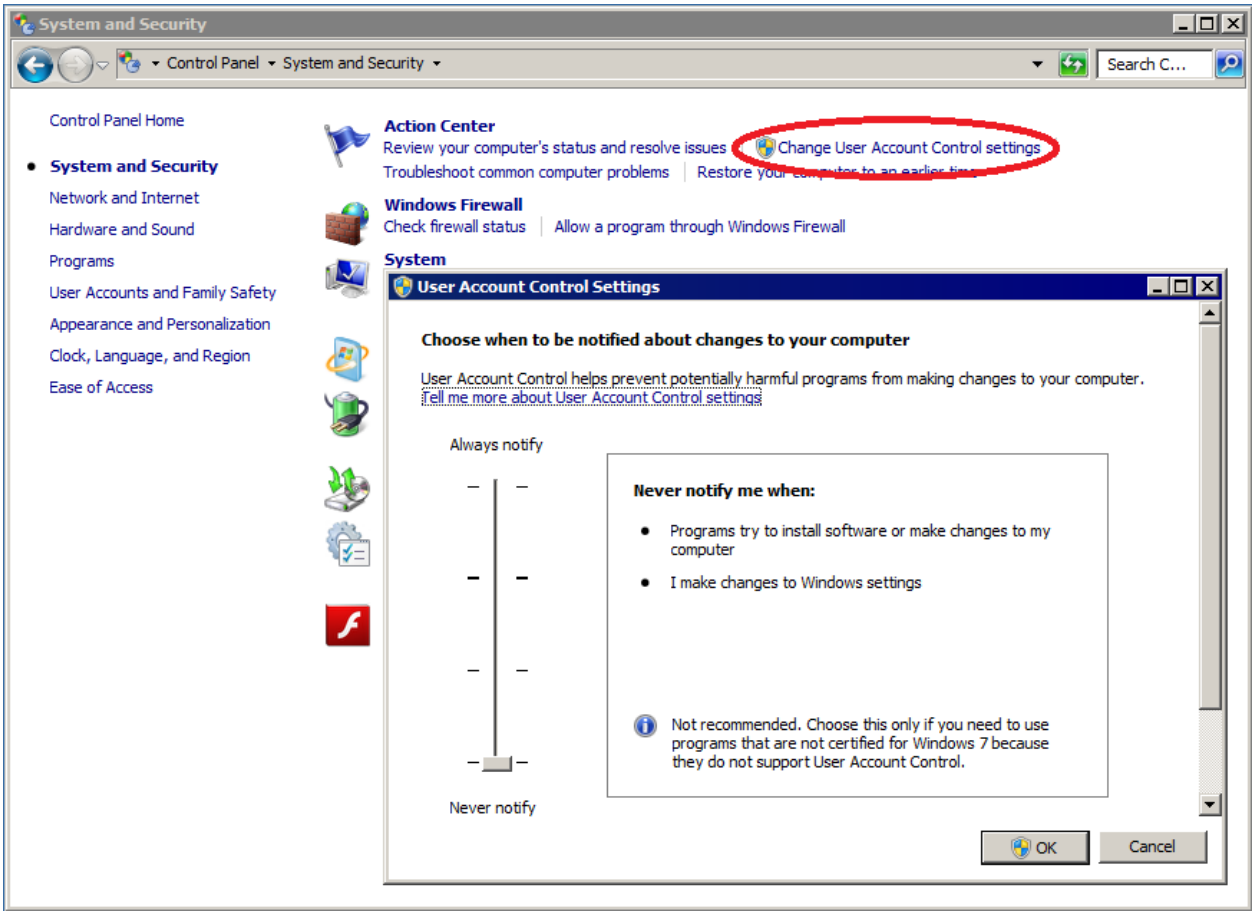


Figure 1.7. Disabling UAC (Windows 7)

### 1.2.4.3. Network security

Network security provides mechanisms that fully or partly limit the access to this computer from the network. In Windows, this mechanism is referred to as the firewall software, which, starting from version Windows XP SP2, is an internal component of the system and is activated during the first run after installation of the system.

### 1.2.4.4. Configuring interaction with the cluster server

When you install a cluster client from a stand-alone package, the computer is automatically configured for the first time to be used as a cluster client. In the future, you can monitor the state of the client computer using the **UM Monitor** program. The **Network Availability** tab displays the status of the operating system components important to the cluster client.

Using **UM Cluster Monitor** (see Figure 1.8) you can see that the computer cannot take part in distributed computing. The state of following components prevent normal interaction between the client computer and cluster server:

- **UAC** is enabled;
- The **server** service is disabled or not started;
- The **remoteregistry** service is disabled or not started;
- **Windows firewall** is active but UM cluster client rules are not defined.

UAC is enabled on it, the server and remote registry services are disabled, the firewall is enabled (all labels are displayed in red). Pressing the button **Allow the use of this computer in distributed computing** removes restrictions on network interaction with the cluster server.

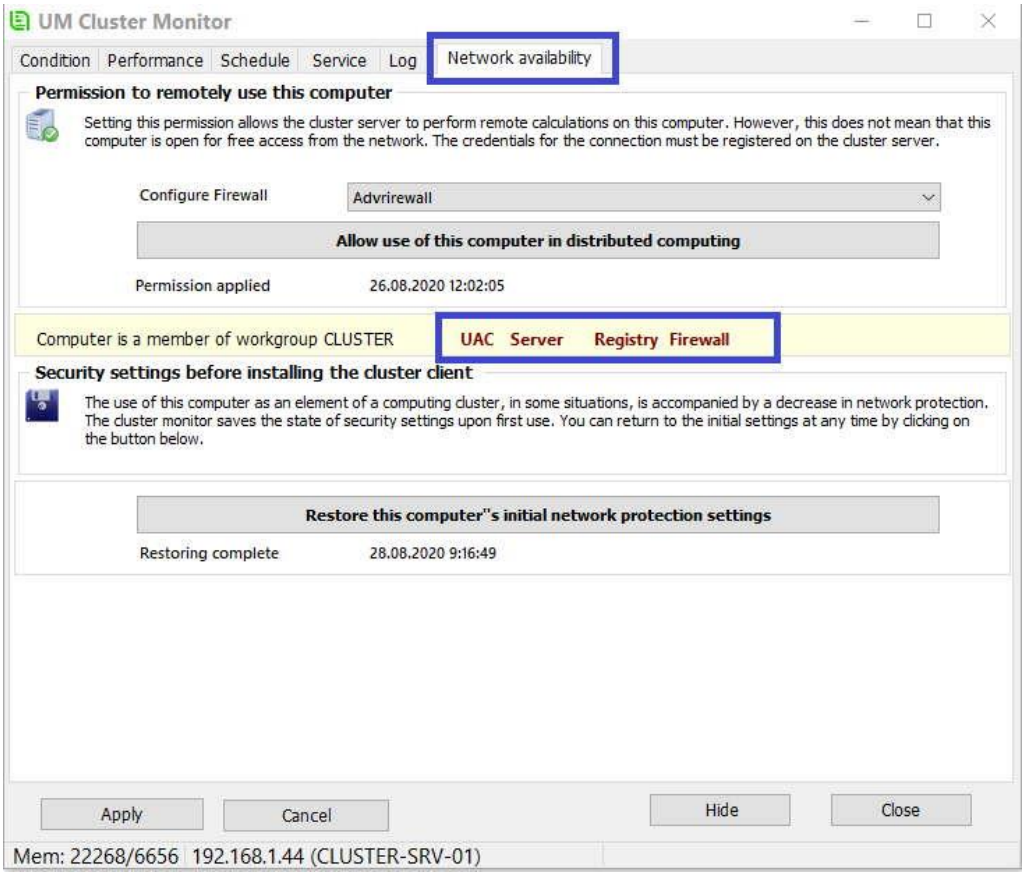


Figure 1.8. Monitor. Computer network availability control.

## 1.2.5. Typical problems

**UM Cluster** is a distributed system. Its proper functioning depends on a variety of security and network settings and circumstances. If you encounter problems when working with a remote client, you first need to clarify the following issues:

- Was the remote computer turned on when the problem occurred? Anything can happen, for example, a power cut or equipment failure…
- Whether the remote computer is available in the network (use ping [IP-address/name] to check)? Large networks are divided into segments with switches that can also be broken.
- Is any anti-virus program installed on remote computer? Both anti-virus and malicious programs can block network components.

If you did not recognize a problem within the list above, you should find the problem among settings of operating systems.

During the installation of client software and running projects, **UM Cluster Server** maintains detailed error log. Errors are typically related to Windows and caused by not properly configured operating system or restrictions on the execution of certain operations. In most cases, the cause of the error is treated definitely. Please find some typical error codes in the table below.

In the case of intensive use of some remote computers with client operating systems (Windows XP/7/8/10), the cluster server may encounter all sorts of errors caused by denial of service to server commands. These may be errors related to the inability to obtain the results of calculations or errors in deleting temporary files on client computers. In this case, on client computers, it is recommended to change the **LargeSystemCache** registry value under **HKLM\SYSTEM\CurrentControlSet\Control\Session Manager\Memory Management**.

Instead of the default value 0, set the value to 1. Changing this setting provides more stable operation of the server components of the operating system under heavy load conditions.

| Error code | Cause | Troubleshooting |
|---|---|---|
| **53** [The network path was not found] | Most probably *Server* system service is disabled on the remote computer. | Run Server system service on the remote computer (see *Figure 1.3. Control Panel / Services (Windows 8.1)* |
| **67** [The network name cannot be found] | Administrative settings, UAC components or malware disable access to network resources on a computer (disks, system registry) | Disable **UAC** component on the remote computer. (see *Figure 1.7. Disabling UAC (Windows 7)).* |
| **1219** [Multiple connections to a server or shared resource by the same user, using more than one user name, are not allowed] | There is RPC-connection to the remote computer from yours via **UM Cluster Server** or other software. | Close another program that uses the same connection if any or log out from the current active user session and log in again. |

| | | |
|---|---|---|
| **1326** [Logon failure: unknown user name or bad password] | 1. Incorrect user name or password<br>2. Network access: Sharing and security model for local accounts set to Guest only: Local users authenticate as Guest. | 1. Check user name and password.<br><br>2. Set Network access: Sharing and security model for local accounts to Classic: Local users authenticate as themselves. |
| **1722** [RPC-server is unavailable.]<br>6 [Incorrect descriptor]. | 1. Remote computer is overloaded with RPC-requests.<br>2. Incorrectly configured network adapter. | You need to check out settings of the network adaptor. Most probably the problem is in **Speed/Duplex** parameter. As a rule, **Speed/Duplex = Auto** is the optimal setting for most cases. It is recommended to reboot computer after changing settings. It is strongly recommended to have up-to-date drivers for network adaptor. You can download up-to-date drivers on the manufacturer's web site. |

## 1.3. Getting started using UM Cluster Server

### 1.3.1. Necessary steps to run your first project

Prior to run your first scanning project you should come through the following steps:

- If your company/laboratory has a system administrator, you'd better give him/her this manual to read.
- Select computers from your corporate network that will be used as **UM Cluster** clients.
- Determine IP-addresses or range(s) of IP-addresses of the computers that will be used as **UM Cluster** clients, use the **IP-addresses range** group, see Figure 1.9.
- Input a list of accounts (user name and password) to connect to remote computers. Use **Manage Accounts->Create account** button, see Figure 1.9.
- Check out settings on client computers, see Sect. 1.2.1.7 "*Configuring client computers*" and Sect. 1.2.4.1 "*Administrative security*".
- Create a list of UM Cluster clients. You can do it manually adding computers one by one or automatically with the help of the built-in scanner. It is faster to scan all computers from the specified range automatically with the help of **Add computers to list** button, Figure 1.9.
- Install client software on client computers if the **Install client programs** option was not selected when creating the list of computers. Installation of client software does not need to restart computers after it.

### 1.3.2. User interface

The program has a pretty simple interface. All management of client computers and project execution is concentrated in a single window. A list of client computers is displayed on the left side of the window. The right side of the window contains the following tabs:

- **Scanning**;
- **Computer list wizard**;
- **Computers**;
- **Client event logs**;
- **Remote desktop**.

The program records all events and actions. The details of event registration is determined by the **Level for logging operations** parameter in the program settings dialog, which is called by pressing the F5 key, see the Sect. 1.7 "*UM Cluster Server settings*". Messages about events related to the operation of the program as a whole are displayed in a list at the bottom of the main window. Events describing the states of various processes are displayed in context logs.

At any moment in time, the program can be in one of four states:

- Idle;
- Installing/Uninstalling clients;
- Initialization of project execution;
- Scanning (project execution).

The current state is shown in the status line; see the Figure 1.9. The current state limits the available operations. For example, you cannot delete the client computer during the scanning.

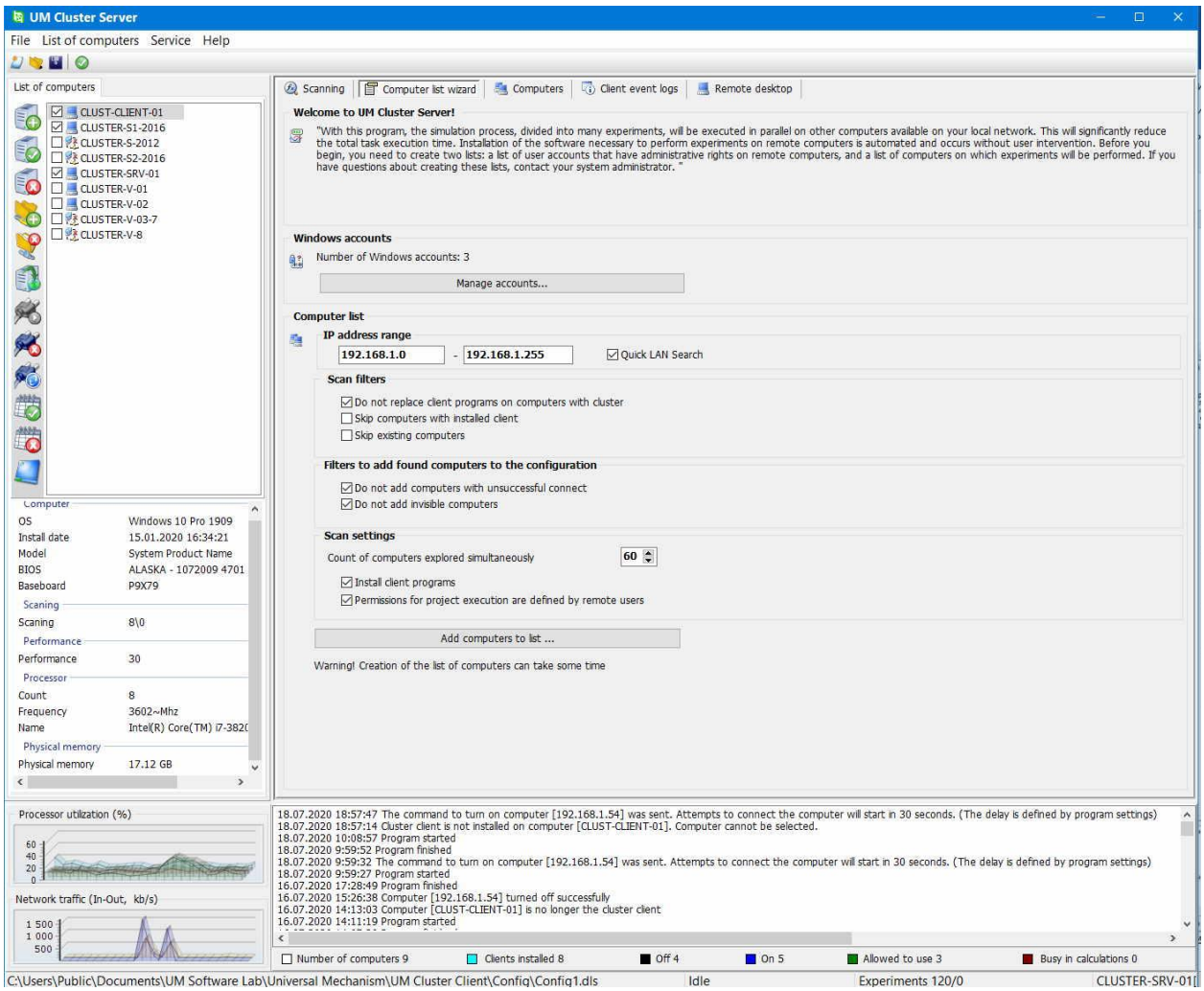


Figure 1.9. UM Cluster Server

The main operations of the program are performed using the buttons on the left control panel. Below is their list and purpose.

**Add computer**. A new dialog window appears, see Figure 1.10. Minimal mandatory parameters are as follows: a computer name or IP-address, a user name and a password.

**Computer properties.** The same dialog window appears, see Figure 1.10. The user can change some computer parameters, except Hardware parameters.

**Remove computer.** This menu item or button removes the selected computer from the list. The command does not uninstall client programs if any. Use Uninstall client programs on computers first.

**Computer properties.** The same dialog window appears, see Figure 1.10. The user can change some computer parameters, except Hardware parameters.

**Remove computer.** This menu item or button removes the selected computer from the list. The command does not uninstall client programs if any. Use Uninstall client programs on computers first.

**Install client programs on computers.** It initiates a remote installation of client programs. Installation rules are defined by the settings on the **Computer list wizard** tab.

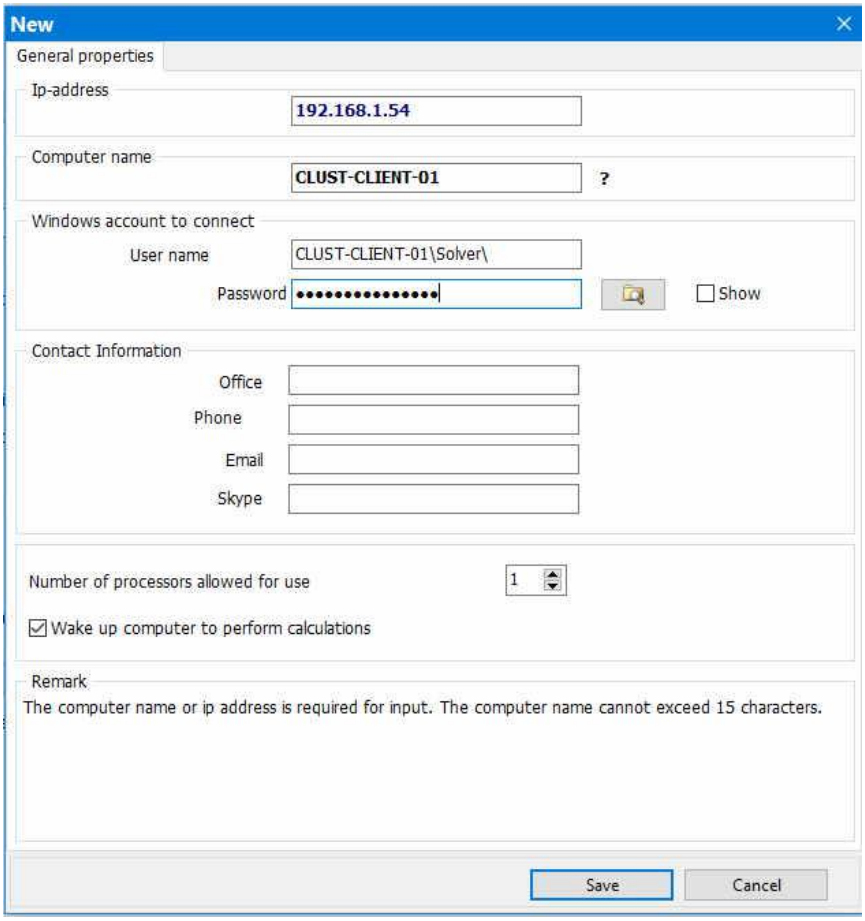


Figure 1.10. Add computer to list or change it properties

**Uninstall client programs on computers.** It initiates a remote complete uninstallation of client programs on all *selected* computers except computers with installed **UM Cluster Server**.

**Get computer parameters.** This command starts gathering the computer parameters. Successful gathering the parameters itself means that the client computer is configured properly for using within the **UM Cluster**. No installed client programs need for gathering computer parameters. You can use this command as a test of operability of the remote computer as a cluster client.

**Power on computer.** Remote turning on the computer. Please note that remote computer should have hardware support, see the Sect. 1.9 "*Remote powering on/off computers*", page 1-32 for details. Please also note that it needs correspondent BIOS (UEFI) and Windows settings. To have a possibility of remote turning on the computer you should firstly get computer parameters to define its MAC-address. Tick **Wake up computer to perform calculations**, see Figure 1.10.

**Power off computer.** This action shutdowns a computer remotely.

**Restart computer.** This action reboots a computer remotely.

**Select all computers.** All computers are marked as enabled for posterior distributed calculation of a scanning project.

**Deselect all computers.** There are no computers, enabled for distributed calculation.

**Connect to remote desktop.** This operation makes easier remote configuring of the computer. Please note that the remote session finishes the current interactive session of the user if any.

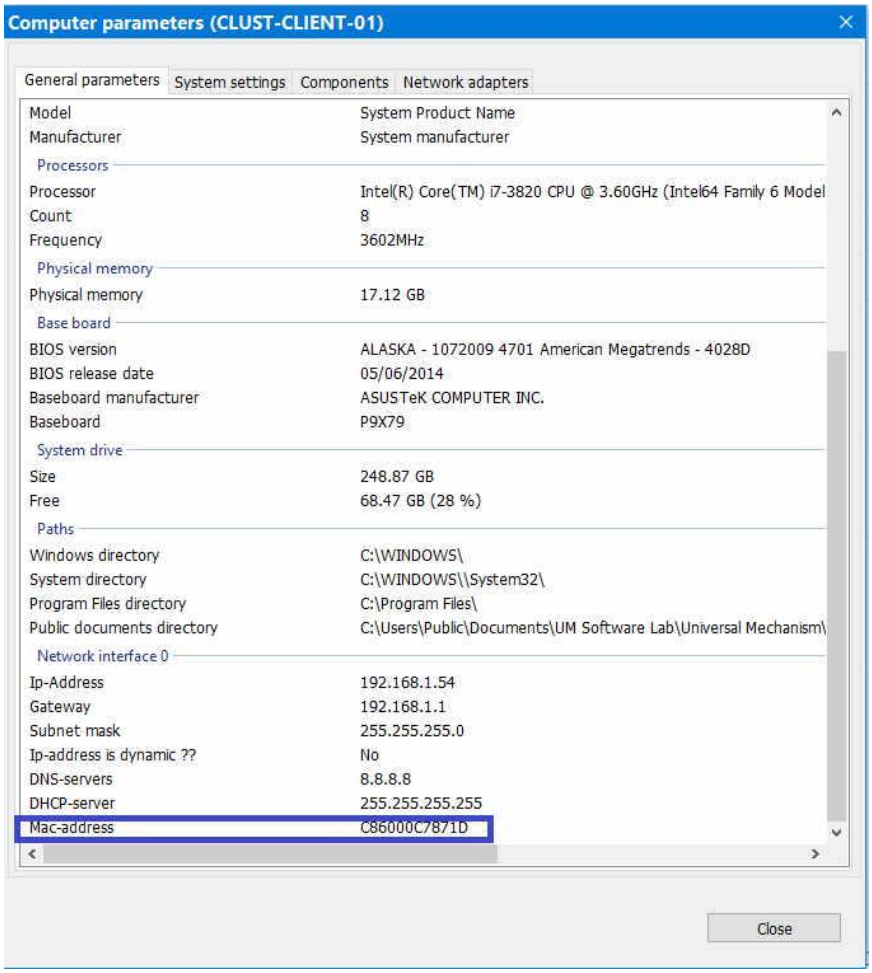


Figure 1.11. Computers hardware parameters and MAC-address

# 1.4. Creating list of computers

## 1.4.1. Computer list wizard

You should use Wizard if you know pretty well your corporate network and IP-address of its computers. Perhaps at the very beginning it is better to add one or two computers manually and try to work with them. The wizard should be considered as a tool that takes less time to add all computers of your corporate network as clients of your UM Cluster. Some computers from the specified address range may be disabled. The list of computers stored between sessions of the program, and later it can be completed both manually and re-running the wizard. Lists of computers and accounts associated with them are available only for the **UM Cluster** program. This data is stored encrypted and protected by strong cryptographic algorithms.

If you fulfil first 5 steps from the Sect. 1.3.1 "*Necessary steps to run your first project*", page 1-18, you can start adding computers to your own cluster. You can use controls in **Parameters / List of computers** to fill your UM Cluster easier and faster. Let us consider the options in details (See Figure 1.9).

**Range of IP-addresses.** Range of IP-addresses in your corporate network that you would like to add into your **UM Cluster**.

**Quick LAN Search.** This setting dramatically speeds up the search for computers on the network, but does not guarantee that all computers will be found.

**Do not replace client's programs on computer with cluster.** If it turns out that the remote computer is also a cluster server, reinstallation of client programs on it will not be performed.

**Skip computers with installed client.** If the client programs are already installed on the computer, they will not be reinstalled (even if their version is outdated).

**Skip existing computers.** When searching for computers in the current network range, processing of computers already present in the current list will not be performed. Regardless of whether the client is installed on them or not.

**Do not add computers with unsuccessful connect.** Computer can be visible but this fact itself is not enough for connecting the computer and remote installing the client programs. There are two typical reasons for that. The first one is that Server system service is not run on remote computer, see the Sect. 1.2.1.7 "*Configuring client computers*", page 1-7, for details. The second one is that there is no one valid user account for connecting the computer.

**Do not add invisible computers**. The selected check box will not include unreported computers in the list. When deciding to add, the presence of a response from the computer is taken into account. Recall, if you are sure that a certain computer is turned on and configured properly at the time of creating the list, but it does not respond to the ping command, then a firewall or a third-party network filter is active on it. If you are interested in using this computer as a cluster client, this computer needs additional configuration.

**Install remote client. UM Cluster Server** can automatically install client programs on properly configured remote computers. You can turn off Install remote client flag and install client programs later. In this case, only hardware inventory of computers in the current network range will be performed**.**

**Permissions for project execution are defined by remote users.** This setting allows remote installation of client programs on client computers but in order to use this computer for distributed calculations you will need explicit permission of the remote user in **UM Monitor**. The user controls the permissions using the **UM Monitor** program, which is an integral component of the client side of the UM distributed computing service and is installed automatically along with other components.

**Count of computers explored simultaneously.** Scanning the network is accompanied by many input-output operations with significant latency. In order to accelerate scanning the network you can run several scanning threads. It is recommended to use 40-100 threads. Default value is 60.

Click "**Add computers to list…"** button to start network scanning and adding the computers to the list of client ones. Detailed event log is available during the scanning. Depending on the selected network range, the installation time may take several minutes.

When connecting to computers for installing clients, **UM Cluster Server** will iterate over accounts that were previously created by the user. The account, which will be used to successfully connect to the computer, is automatically linked to this computer and will be used in the future to perform experiments on this computer.

In case of successful installation of the client part, the computer is assigned the status of the client, which means that such a computer can be selected to carry out projects.

### 1.4.2. Other devices found on the network

While scanning a range of IP-addresses, the server can detect a variety of network devices that it could not identify as a computer on which the cluster client can be installed. It can be the following situations.

- Computers running under Windows with locked network capabilities.
- Computers and mobile devices running under other operating systems (Linux, Android, Mac OS, etc.).
- Network printers, switches, routers.

The cluster server places the IP-addresses of these devices on the exclusion list so as not to waste time identifying them in the future. This list of exclusions is available in the program settings. Any device can be removed from this list through the settings if the program has identified it incorrectly.

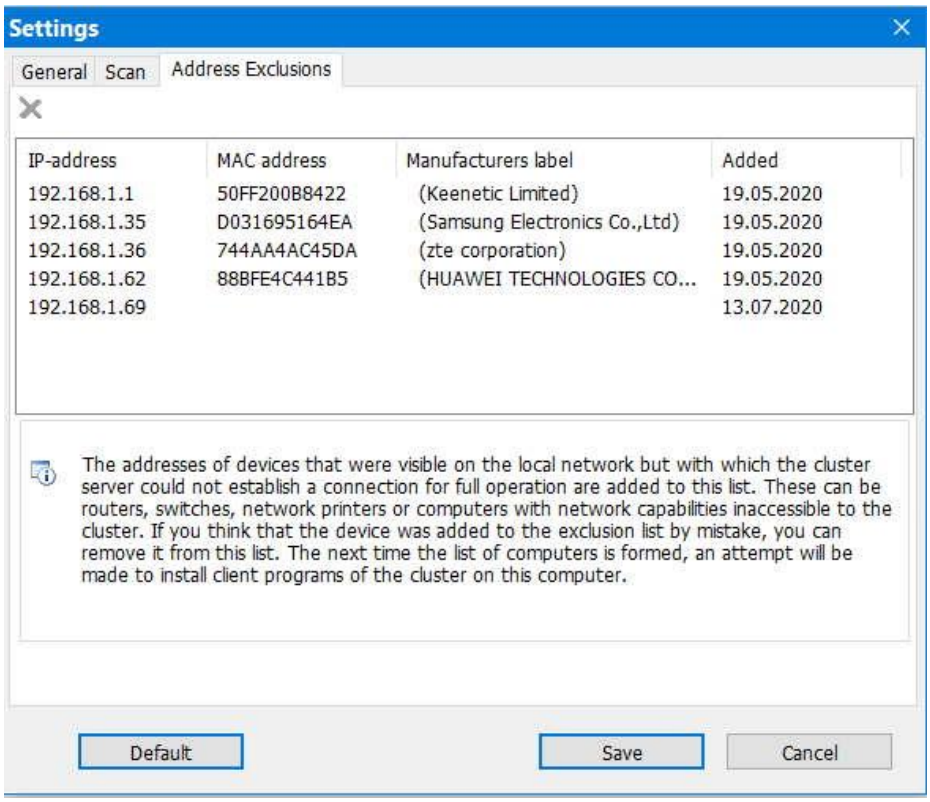


Figure 1.12. List of excluded IP-addresses

### 1.4.3. Adding client computers manually

If you are going to use just a few computers as clients in your **UM Cluster**, you can add them all manually. In contrast to the automatic generation of the list of computers, manual adding does not perform the installation of client software or gathering information about remote computers. You should perform these operations separately from the context menu or with the buttons on the left panel of the main window of **UM Cluster Server**.

### 1.4.4. Group operations in the list of computers

You can perform installation (update) operations of client versions with respect to a group of computers selected in the current list. A computer is added to the selected list when you click on it while holding down the *Ctrl* key. You can remove a computer from the list of selected ones by clicking on it again with the left mouse button.

Now, when you click the **Install client programs on a computer** button, the same installation steps will be performed that are performed when the installation wizard is launched (the **Add computers to list…** button). The settings of the installation wizard and its filters will also be taken into account when starting the installation from the pane of the list of computers.

After selecting computers in the specified way, you can also uninstall the client parts of the cluster for a group of remote computers.

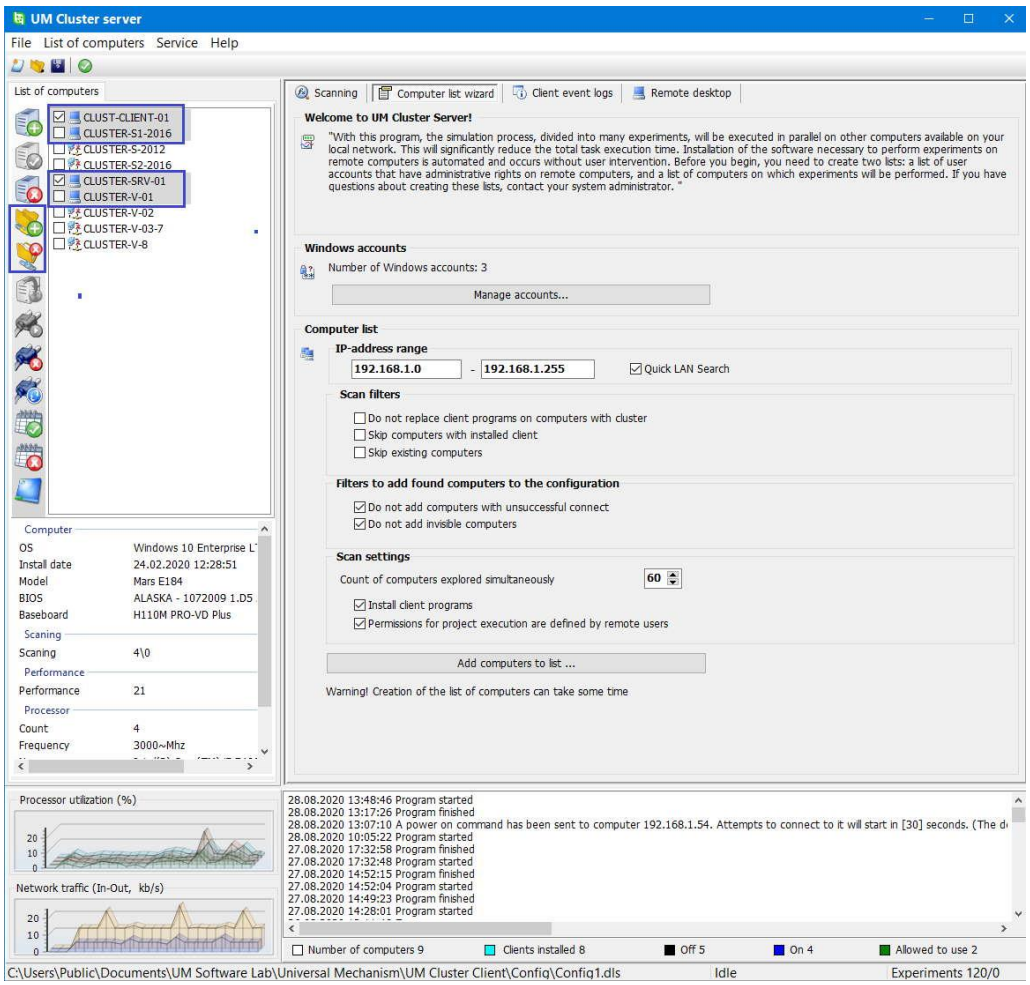


Figure 1.13. Multiple selection from a list of computers

### 1.4.5. Using remote computers for scanning

After successful installation of client programs on a client computer you can use it for distributed calculations of scanning projects. To use a computer, you should turn on the correspondent check box in the list of computers. You will not be able to turn on the check box if the client programs are not installed on the computer.

### 1.4.6. Several UM Cluster servers in one network

It is a quite normal situation when **UM Cluster Server** is installed and run on several computers in one network. Please address the following issues if several **UM Cluster Servers** may work in your network simultaneously. But since the described cluster as a distributed system does not have a common control center, you should be prepared for some side effects of its operation, none of which, however, is critical, and some even simplify the work.

**Firstly**, any computer with **UM Cluster Server** installed is also a client at the same time, if the prohibitive settings are not set by the **UM Monitor** program. At any time, a cluster user can find that his computer is executing tasks received over the network. The user can limit the number of allowed processors or completely prohibit the use of his/her computer, but already started experiments cannot be interrupted.

**Secondly,** each server stores information about the state of client computers, but this state can be changed externally. For example, one server considers a certain computer to be a client computer, while another, for some reason, removed the client programs from this computer. When the project is running, the cluster will receive a message that it cannot work on this computer. At the same time, if during the installation of client programs on a computer by a cluster it turns out that they have already been installed by another cluster and the versions are the same, the installation will not be performed, and the computer will receive the client status.

**Thirdly**, the cluster server cannot always count on all available processors of client computers. Cluster servers compete with each other to take over the processor on the client computer. There is no distribution mechanism, the seizure occurs randomly, which, by and large, achieves equal ownership of processors for different servers in the cluster. The cluster server cannot reserve the processors of the client computer for the entire project. It uses the processor, performing a single experiment, after which the resources are redistributed.

## 1.5. Removal of client programs

Removal of client programs is fully automated, and, like the installation, is performed remotely. If the client part was installed locally using a stand-alone installation package, it can also be uninstalled locally via the standard **Add/Remove Programs** console of the operating system.

## 1.6. Running scanning projects

You should use **UM Simulation** program to create and run scanning projects. When running **UM Cluster Server** starts looking for available CPU cores and sends source data for numerical experiments if any available CPU cores. You can run a few copies of **UM Simulation** program on a computer and run several scanning projects. In such a case **UM Cluster Server** keeps all assigned scanning projects in a queue but runs the only one from this queue. **UM Cluster Server** runs scanning projects from the queue one by one.

You can see the list of all currently running experiments in the right side of the main window of the **UM Cluster Server**.

During the running the project a user can do the follows.

- Cancel the execution of the scan project.

- Pause/stop running the project.
- Include and exclude client computers from the list of currently used for the calculation of scanning projects. While excluding a computer, currently running numerical experiments will not be stopped, just new experiments will not be sent to the just excluded client.
- Change the number of available CPU cores on each computer on the server side. Do not be confused with the similar setting on the client part that is set with the help of **UM Monitor**.
- Read remotely client system event log for every selected computer.

During running the projects, you cannot install and remove client programs on any client computers.

Main window of **UM Cluster Server** during running a project is shown below in Figure 1.14. This simple project consists of 27 experiments and runs on four computers. In the lower part of the window, a detailed log of each experiment is displayed.

During the execution of the project, in the central part of the scan window, the **Task time allocation** diagram is displayed. It helps the user to get a visual representation of the efficiency of using the available computer set and the optimal settings that affect the scanning process. This diagram shows what the proportion of the time spent on the implementation of each of the stages of the calculation.

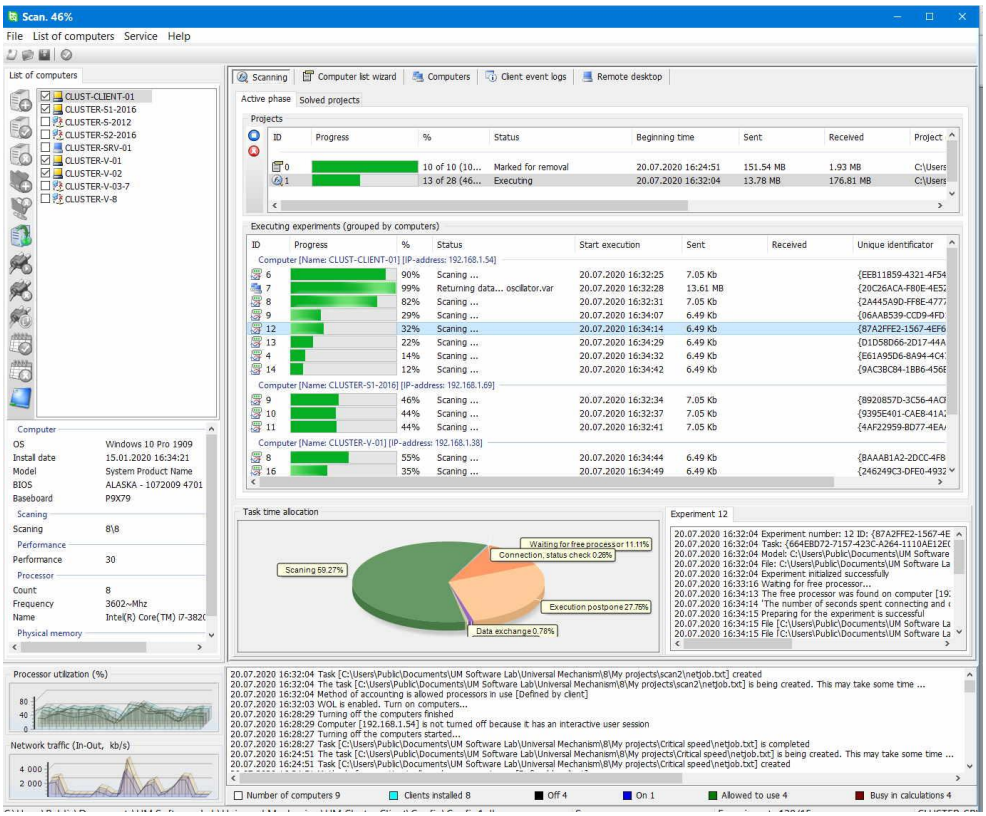


Figure 1.14. Running a project

On the diagram shown in Figure 1.14 you can see the follows.

- A lot of time spent waiting for a free processor i.e. the number of experiments in the project exceeds the number of available cores.

- A lot of time spent waiting for a free OS thread. In this case, it is necessary to increase the value of the parameter in the settings, which determines the number of simultaneously performed experiments.
- Long communication time i.e. network problems.
- Large execution latency in projects with lots of experimentation.

After the completion of the project, information about it is moved to the **Solved projects** tab.

## 1.7. UM Cluster Server settings

The settings window is invoked by pressing the F5 key. This section provides a brief description of the options that can be changed that affect the appearance of the program and the behavior of the server when running scan projects.

**Level of logging operations.** This parameter determines the level of logging the execution of operations associated with the implementation of projects. The value specified in this window affects not only the operation of the server, but also the operation of client programs installed from this server.

**Event log size for every computer.** Each computer included in the cluster list has a special local log, which stores records of some important events from the server's point of view that occur during the execution of projects. As a rule, these are messages about problems and errors. If a cluster server encounters a certain number of critical computer-related errors that prevent the normal execution of scan projects, it excludes such a computer from the list of selected ones, while issuing a message to the main program log. Detailed information about computer errors is available in the computer properties window on the **Events** tab.

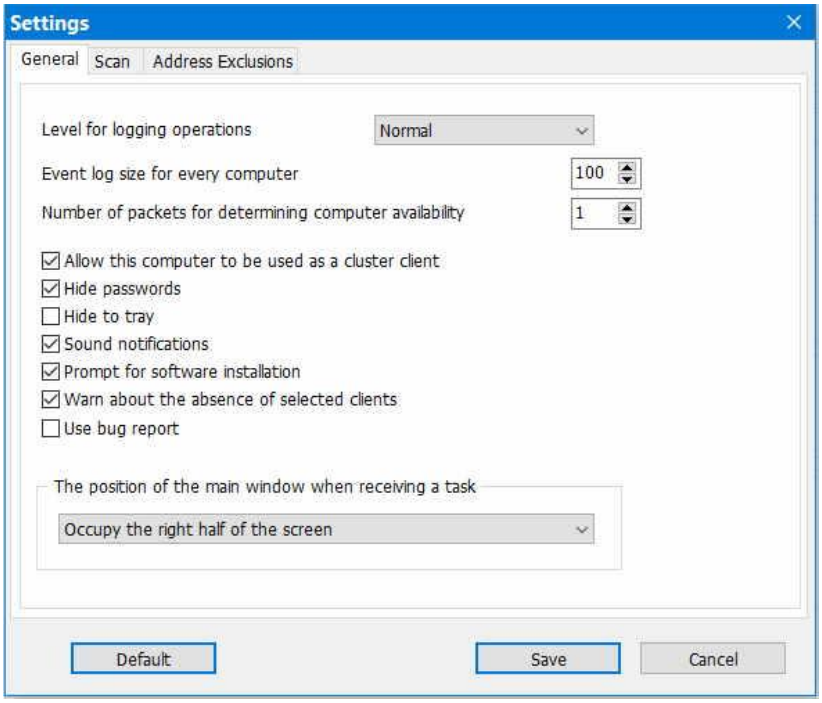


Figure 1.15. Server settings

**Number of packets to determining computer availability.** This setting refers to background diagnostics of the computer's network availability. The larger the number, the more accu-

rately it is determined whether the computer is visible on the network. But the slower the program reacts to changes in the state of computers. In fast and reliable networks, this parameter is recommended to be set to 1. The default is 2, the maximum value is 4.

**Allow this computer to be user as Cluster client.** If this setting is enabled, when receiving a task, experiments will be performed not only on remote computers, but also on the cluster server, that controls the execution of this task. It should be taken into account that the including the server in the calculations may affect the overall performance of the task if the server has to manage a large number of concurrently executed experiments on remote computers. It is not recommended to enable this setting if the number of simultaneous experiments is more than 40 (5 eight-processor computers). Also, on the server computer, it is necessary to limit the number of processors allowed for performing experiments, so as not to deprive the server of hardware resources. The setting is disabled by default.

The following settings determine the behavior of the cluster server directly when calculating projects.

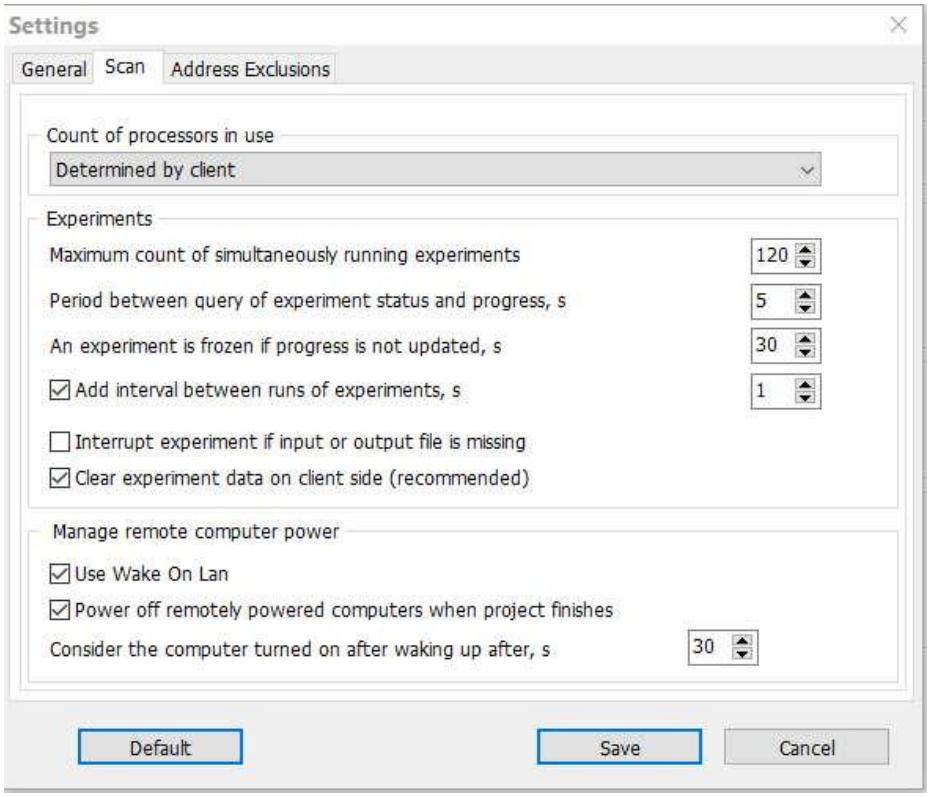


Figure 1.16. Scan settings

**Count of processor in use.** This setting determines the restriction model of using processors. When a new remote computer is added to the list of the cluster, all processors of the computer are allowed from the server's point of view. You can change the number of allowed processors in the computer properties dialog. On the client side, the limits are set by the remote user using the **UM Monitor** program. By default, client settings take priority, but the cluster user can set the priority of server settings. By changing this setting, you must be sure that the increased load on the remote computer will not cause inconvenience to the computer user, or, if we are talking about the server, the work of important services will not slow down. If the server priority is se-

lected, but the monitor on the remote computer has set the **Prevent use of this computer** option, such a computer cannot be used in projects.

**Maximum count of simultaneously running experiments.** From the point of view of the cluster server, a value that approximately corresponds to the total number of processors used in the project (on all available computers) is considered reasonable. If the number of available processors is significantly more than this value, it will affect performance. The maximum available value is 200 experiments. By default, this parameter is 64.

**Period between query of experiment status and progress.** During scanning, the cluster server monitors the execution of each experiment on client side by periodically exchanging information with these computers. This parameter sets the frequency with which information is exchanged. An approximate rule for changing this parameter is as follows: the more experiments in the project and the longer they are, the more desirable it is to increase this parameter, since frequent status queries on other computers create an additional load, primarily on the cluster server. By default, the parameter is 5 seconds.

**An experiment is "frozen" if progress is not updated, s.** Before deciding whether to perform each experiment on a remote computer, the cluster server performs a series of checks on this computer and, if problems are found, excludes the computer from the list of selected ones. However, malfunctions and abnormal situations that disrupt the interaction between the cluster and the client computer can also occur during the experiment. In this situation, the cluster waits for the specified number of seconds for signs of activity and normal operation of the client side. If this does not happen, the computer is excluded from the selection list, and the experiment is transferred to another computer. By default, this parameter is equal to 600 s (10 min).

**Add interval between runs of experiments.** It determines whether the launch of experiments at the start of the project will be spaced in time and what is the interval between starts. This is necessary to mitigate the load on the I/O subsystem of the operating system at the start of the project. At this moment, a massive parallel distribution of tasks to remote computers begins, which can lead to a "freeze" of the project. The setting is enabled by default. The default interval between runs of experiments is 4 seconds.

**Clear experiment data on client side.** The setting is enabled by default. Disabled for debugging purposes to diagnose problems on client computers.

**Use Wake On Lan.** If this setting is selected, a network power-on signal will be sent to the computers involved in the project.

**Power off remotely powered computers when project finishes.** Please note: only those computers that were powered on via cluster before the execution of the project will be powered off. Moreover, if, after remotely turning on the computer, an interactive user login was made on it, the computer will not be powered off either.

**Consider the computer turned on after waking up after, s.** If a remote computer has changed its status in the list from inactive to active 10-20 seconds after wake on LAN, this does not mean that it is completely ready to work as a cluster client. By default, the parameter is 60 seconds. High-performance personal computers are available even after a shorter period of time. Powerful industrial servers often take longer to enter a fully functional state. Since this latency is the same for your entire set of computers, you should assign a value to it taking into account the boot time of the slowest computer.

When describing the tuning parameters, the most general recommendations are given. Experience gained from using the cluster will help you determine the most balanced parameters for your situation.

## 1.8. System logs of client computers

All the main components of the cluster including the server, the monitor and the agent register important events in a special system log, which is created when the client program is installed on the computer. The contents of the log can be viewed both by standard tools of the operating system, and directly from the cluster. The cluster server can read the logs of all client computers. In addition, the server can flush these logs and export them in .xml format.

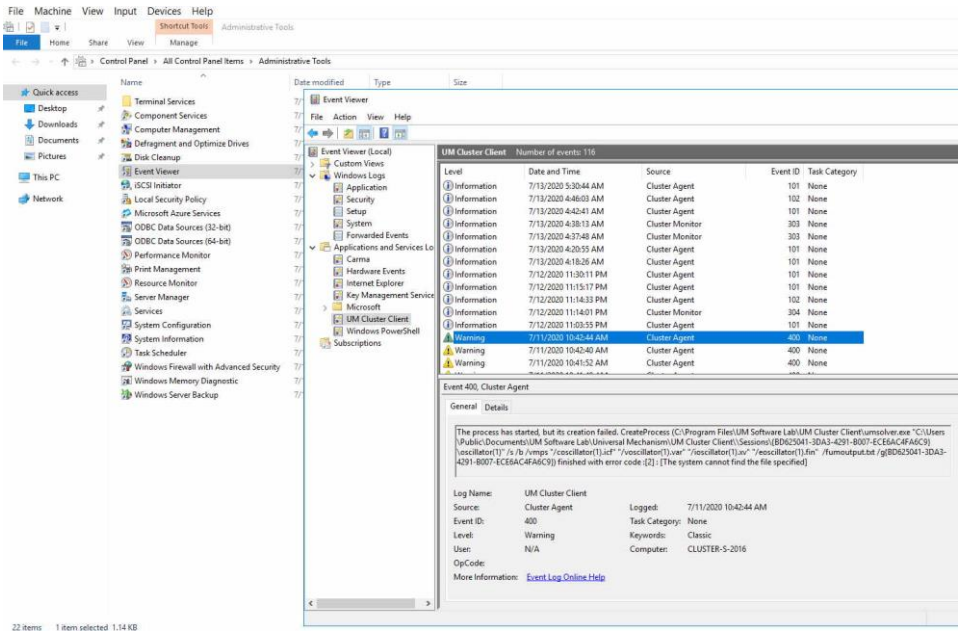


Figure 1.17. Viewing the system client log using the operating system

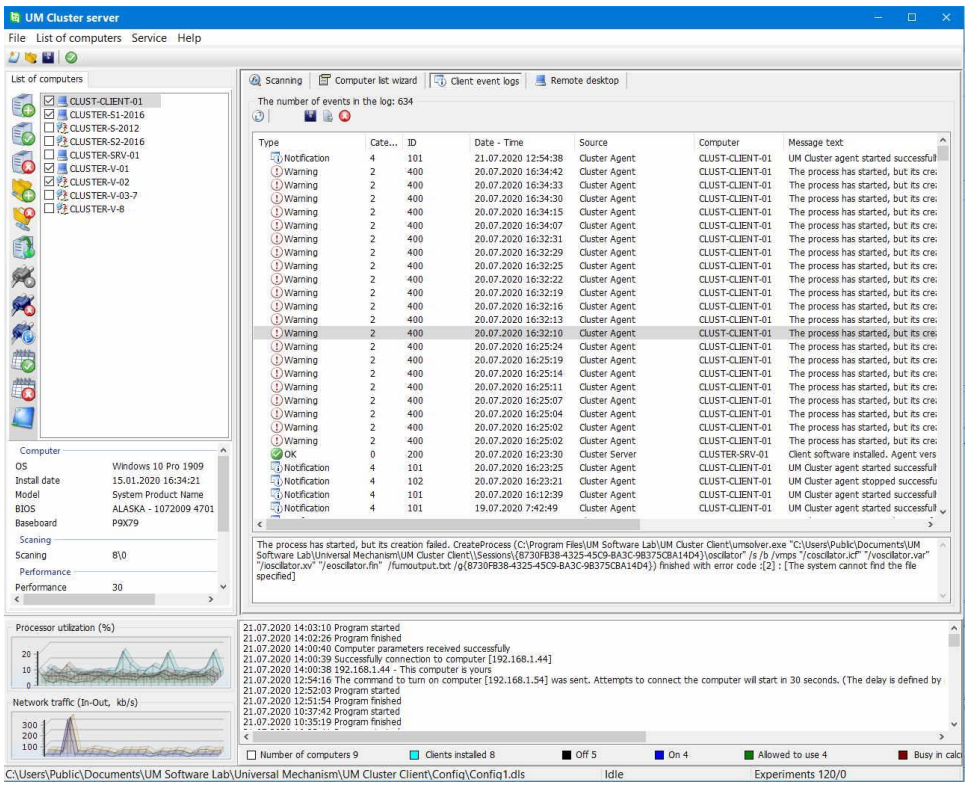


Figure 1.18. Viewing the system client log inside the UM Cluster Server

# 1.9. Remote powering on/off computers

**UM Cluster Server** allows you to remotely turn on client computers to use their resources when calculating projects and turn off previously turned on computers when tasks that are queued or are interrupted. To do this, the hardware of client computers and the operating system installed on them must be configured in a certain way.

## 1.9.1. Network adapter settings

Sometimes it needs to configure settings of a network adaptor to make WOL possible. Use **Control Panel -> Device Manager -> Network adapters** to access network adapter properties.

The pictures Figure 1.20 and Figure 1.21 show signs that the computer can be configured to wake on the network:

- In the properties of the network card there is a **Power management** tab.
- On the **Advanced** tab, the **Wake on Magic Packet** setting is available. It may be different, but carrying the same meaning description of the setting.

After setting the specified parameters, the computer will manage commands to turn on over the network.

If these tabs are not visible in the properties of the network adapter, then it is recommended to do the follows (the sequence is important).

- Install new drivers for the network adapter.
- Configure BIOS (UEFI) of the computer.

Setup **BIOS** (**UEFI**) is considered in the Sect 1.9.2 "*Configure BIOS (UEFI)*", page 1-35.

To install new drivers on the network adapter, you can use the built-in Windows driver update mechanisms. This method is easy to use, but, unfortunately, it often does not work.

In the properties window of the network adapter, go to the **Driver** tab and click on the **Update driver** button, as shown in the figure below.

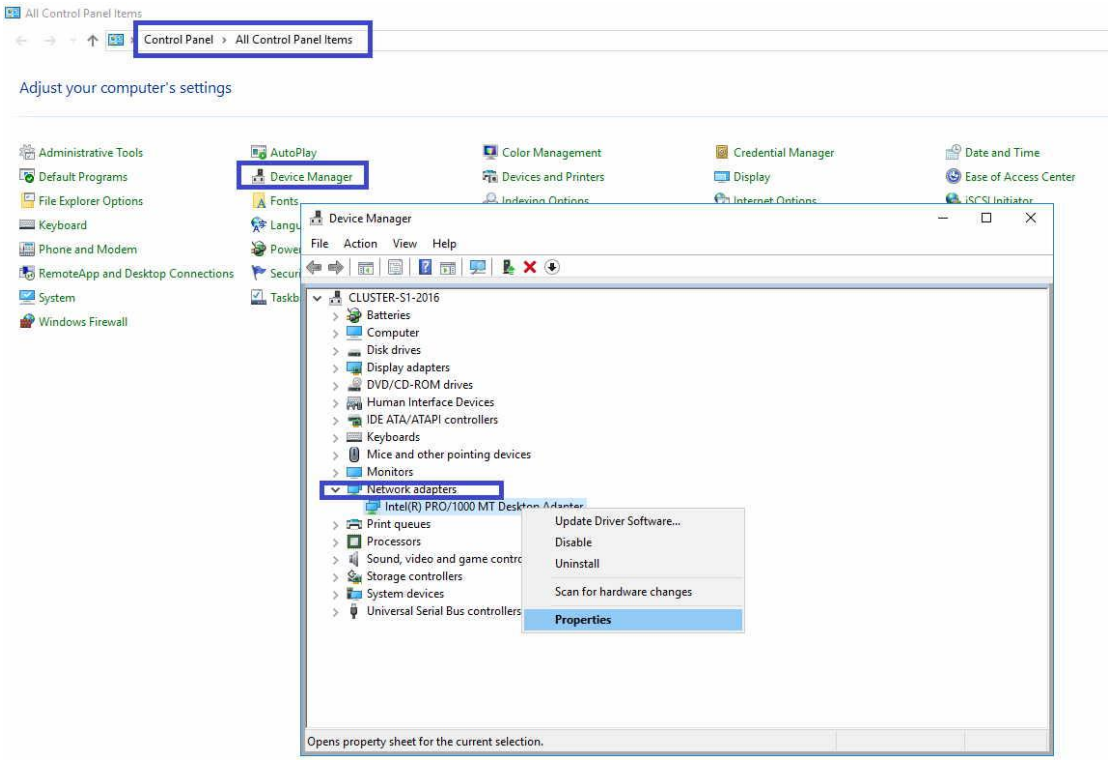


Figure 1.19. Network adapter properties (Windows 10)

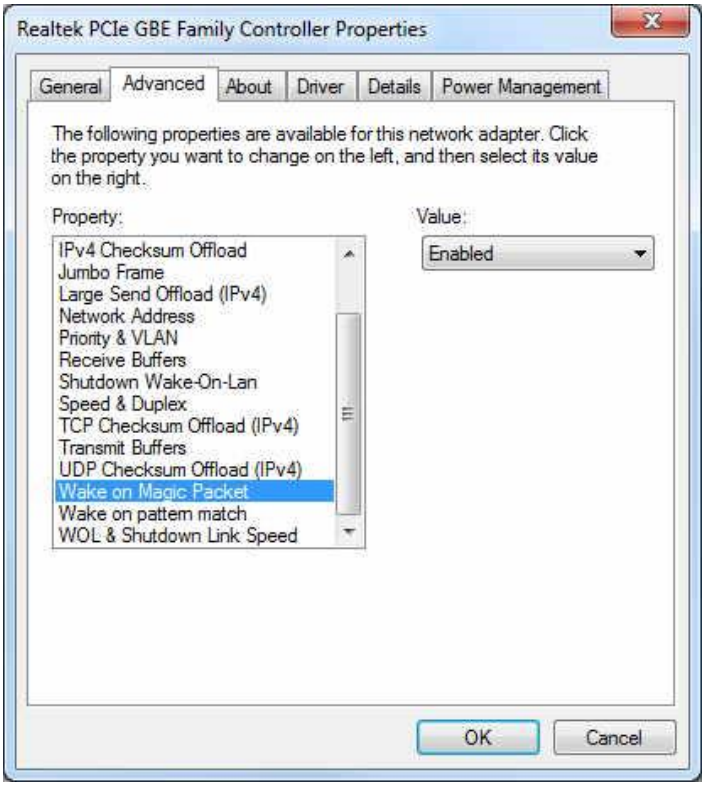


Figure 1.20. Network adapter properties. **Advanced** tab.

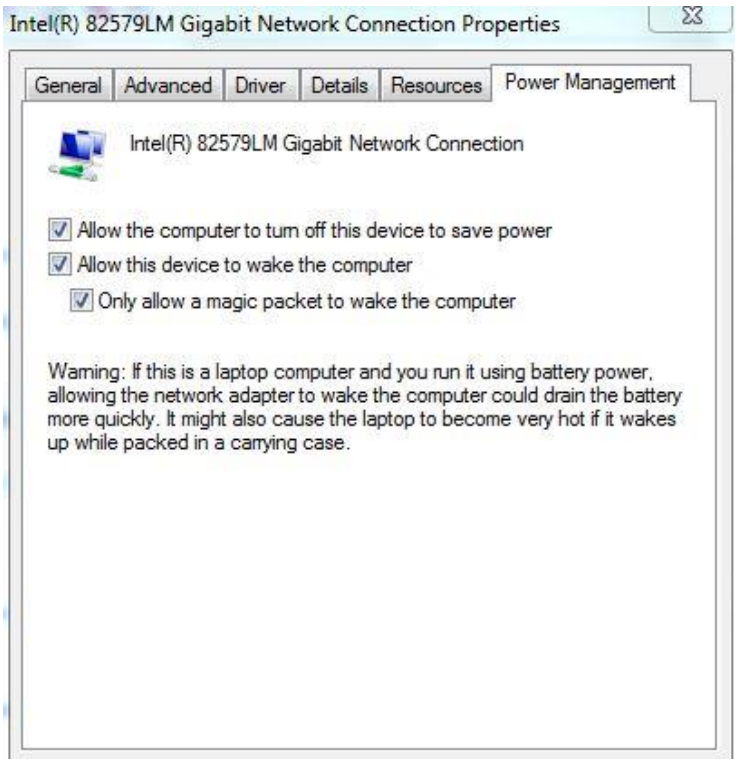


Figure 1.21. Network adapter properties. **Power Management** tab.

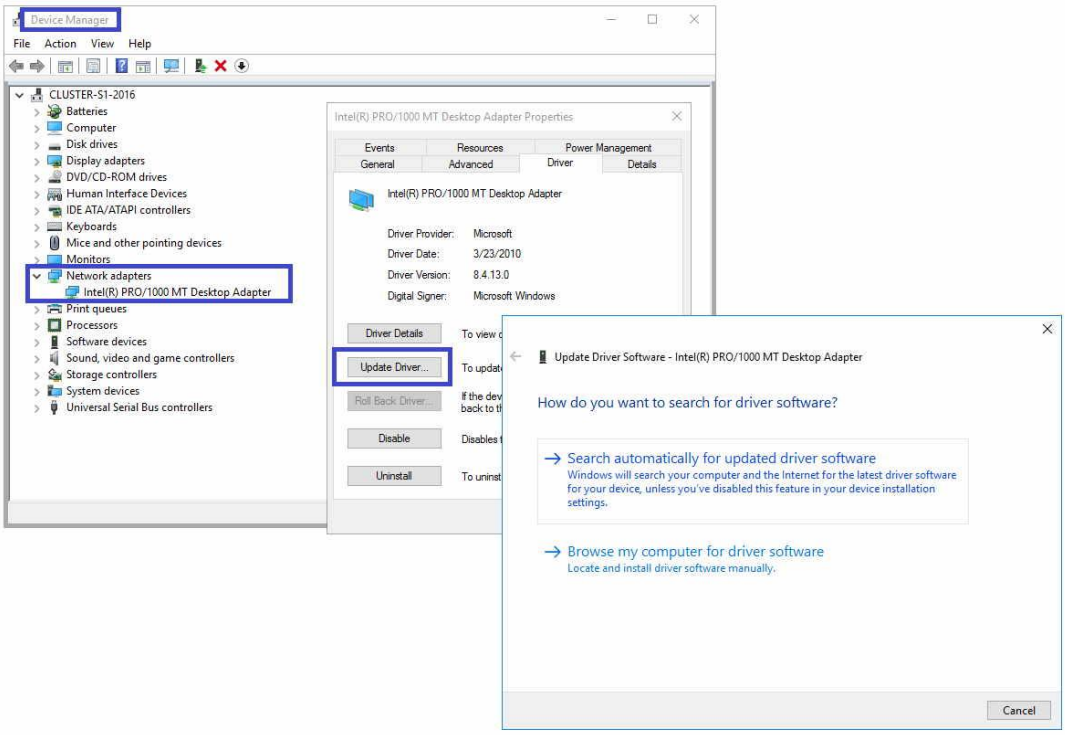


Figure 1.22. Update network adapter driver (Windows 10)

In the opened window, select the **Search automatically for updated driver software** item. If the driver search results in the message "*The most suitable drivers for this device are already installed*", then the drivers will have to be updated manually. If the system updates the drivers, then you need to reboot the computer and make sure that the settings for waking the computer

over the network, described at the beginning of this section, have become available. If they are still not visible, then the drivers must be updated manually.

To manually install drivers, you need to find the installation package on the Internet by the name of the network adapter and run it on your computer. For well-known hardware manufacturers there are special portals for updating drivers and programs that make this operation very easy. For example, for Intel hardware, all drivers can be updated here.

### 1.9.2. Configure BIOS (UEFI)

Remote turning on the computer is possible if a motherboard and a network adapter of the computer support *Wake on Lan (WOL)* technology. As a rule, all modern computers have this capability. You only need to activate it with the **BIOS** settings **(Basic Input-Output System)**. In more modern computers, such a system is called **UEFI (Unified Extensible Firmware Interface)**. The **BIOS** program is embedded in the computer's motherboard, it starts to run first on the computer, immediately after pressing the power button and before the operating system logo appears. The program performs primary diagnostics of the equipment: the presence of hard disks, physical memory, video adapter performance, etc. If all tests pass successfully, the operating system starts loading. In addition, the program allows you to configure some hardware parameters, including the activation of WOL technology. Entering the setup program occurs by pressing a specific key on the keyboard, which button is usually depending on the manufacturer of the motherboard, the method of entry is usually indicated immediately after turning on the computer, before loading the operating system. Most often these are the *Delete* or *F2* keys. Modern operating systems can boot so quickly that pressing Del or F2 to enter the **BIOS** does not have time to work. There is an alternative solution for Windows 10, which can be found, for example, here.

The **Network Power On** setting is usually located under **Advanced-> Power**. In the latest operating systems, the **Advanced -> APM (Advanced Power Management)** section is more common.

You can check the operability of the network wake-up mechanism directly from the cluster server, using the power button, as shown in the figure below.

Notice that the ability to turn on remotely is disabled by default and must be configured individually through computer properties. The global setting **Use Wake On Lan,** see Figure 1.16, means that during the project execution only those computers will be remotely turned on for which it was explicitly allowed in computer properties, see Figure 1.10.

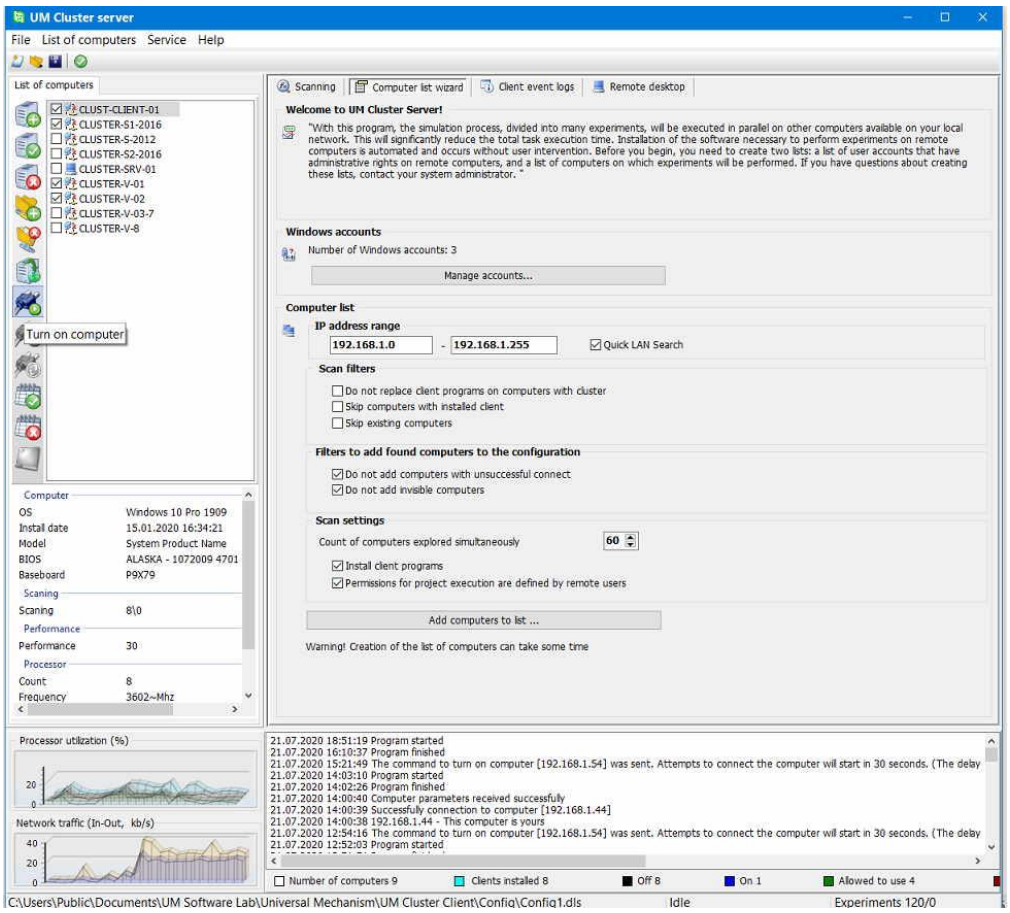


Figure 1.23. Power computer on over network

## 1.10. UM Monitor

**UM Monitor** is part of a client computer. The program can be installed on the client computer either locally using a stand-alone installation package, or remotely from a cluster server.

**UM Monitor** solves the following tasks.

- **UM Monitor** performs the initial configuration of the operating system, which removes restrictions that prevent interaction with the cluster server (if this was not done previously by the installation program).
- **UM Monitor** displays the current state of the client: a list of active experiments, duration of execution, address of the server that initiated the scan.
- It allows a user on a remote computer to control the use of his or her computer as a cluster client and to configure a flexible hourly permission plan to use a specific number of processors.
- It also helps to controls the amount of disk space used by client applications. In case of failures in the work of the client, caused by various reasons, allows you to delete temporary cluster files.

All prohibitive settings in **UM Monitor** do not neither run new but nor stop currently running numerical experiments.

**UM Monitor** is automatically launched on the client computer every time a user logs on to the system. By default, the program is minimized in the lower right corner of the screen. When the solver is launched on a computer, the program icon changes from static to animated one.

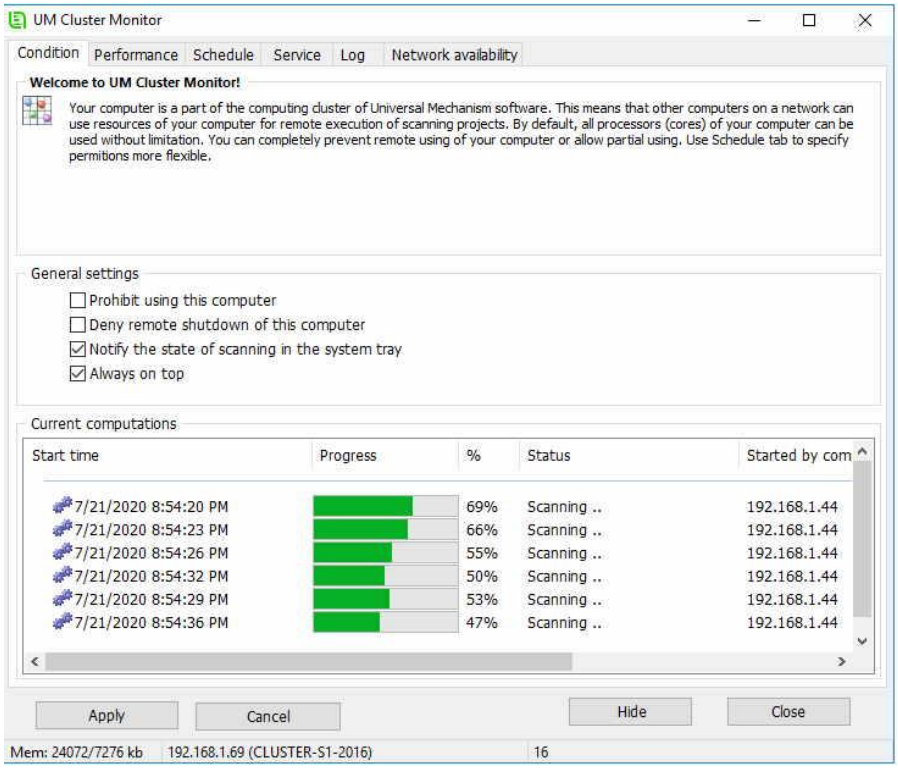


Figure 1.24. UM Monitor: currently running experiments

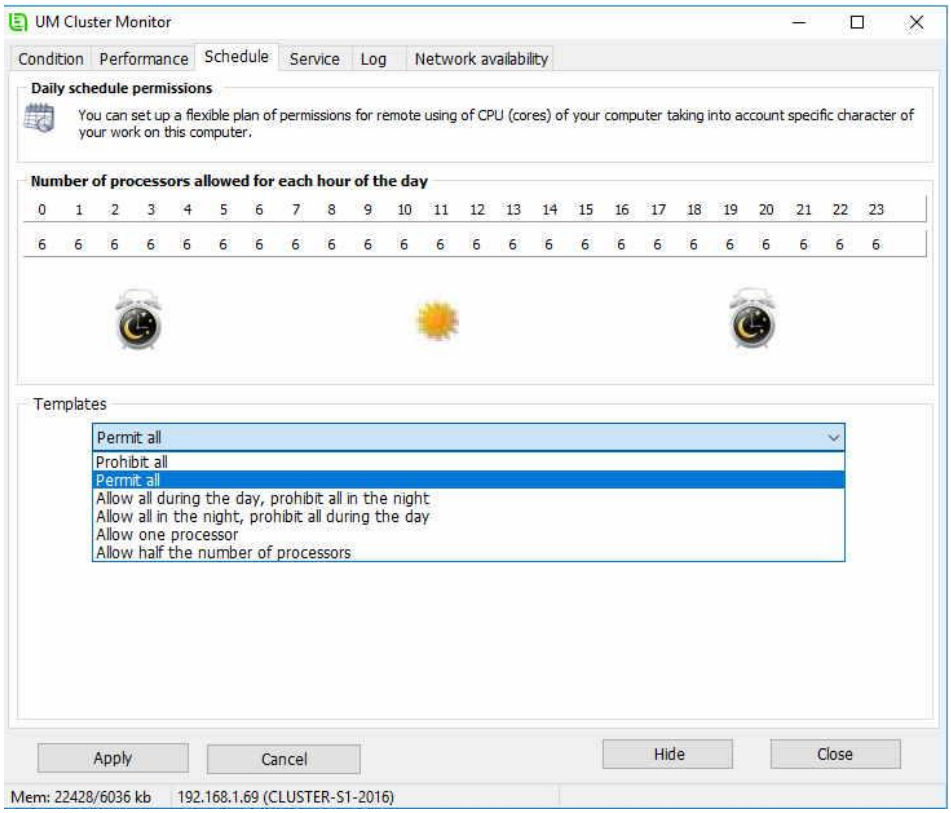


Figure 1.25. UM Monitor: Permission to use processors by time

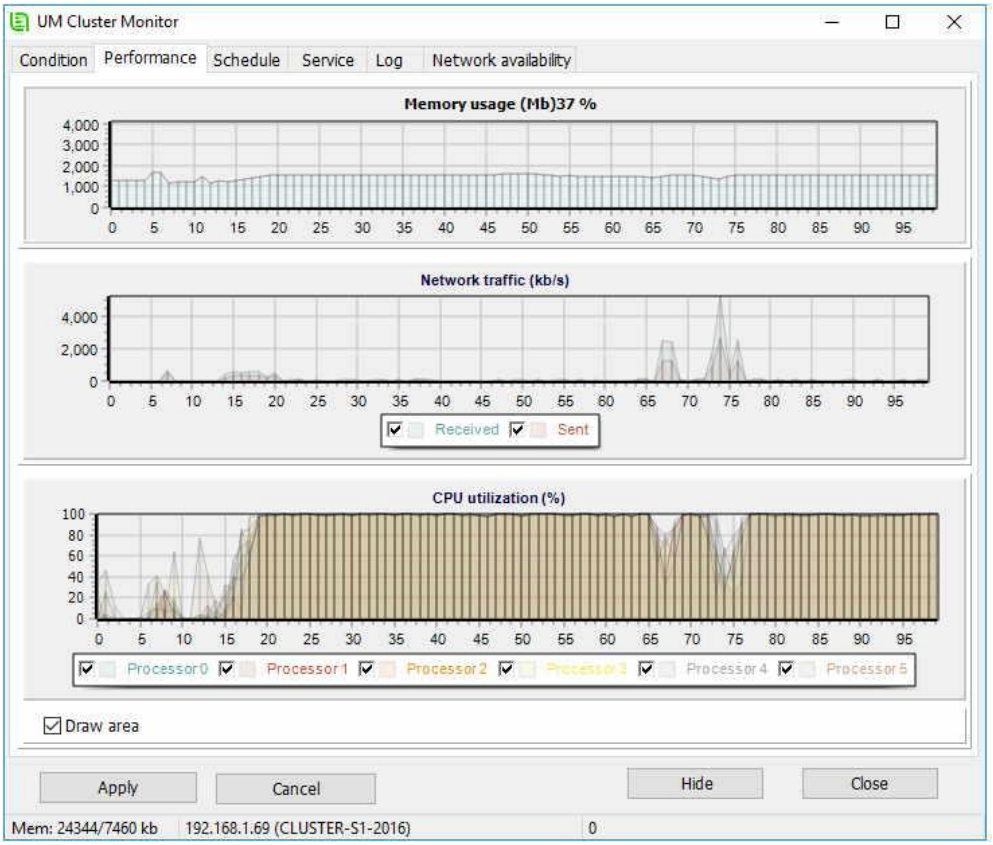


Figure 1.26. UM Monitor: Using system resources while running experiments

## 1.11. Appendix. Basic ideas

**Computer cluster** is a collection of computers connected by the network, with special software that allows you to perform complex engineering and scientific calculations. Overall coordination of the interaction is performed by one or several computers, called servers. From the user point of view, there is no matter locally or remotely computational resources are available. A cluster is the cheapest way to organize distributed computing.

**User Access Control (UAC).** It is a component of Microsoft Windows operating systems starting from Windows Vista. The component requests user confirmation for each operation that needs administrator's rights. Computers administrator can turn off the UAC using the **Control panel**. Please address to https://en.wikipedia.org/wiki/User_Account_Control for more details.

**Wake On Lan (WOL).** It is a hardware technology that allows to power on computers remotely via the network connection. WOL parameters are set in BIOS program. Sometimes WOL needs some special settings of the network adapter.