



ZABBIX 5.0

Certified Specialist Training

Day 1

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Facilities

Introduction

- ⚡ Background/company
- ⚡ Experience with CLI Unix like systems
- ⚡ Experience with Zabbix
- ⚡ Experience with other monitoring solutions
- ⚡ Current Zabbix deployments

Questions at any moment are encouraged!

We suppose that attendees of this course have basic Linux knowledge. For the practical tasks use the "Lab manual" - it provides all required details.

	Monday	Tuesday - Thursday	Friday
09.00-11.30		Zabbix 5.0 Certified Specialist	
10.00-11.30	Zabbix 5.0 Certified Specialist		
11.30-11.45	Break		
11.45-13.00	Zabbix 5.0 Certified Specialist		
13.00-14.00	Lunch Break; Q/A session		
14.00-15.30	Zabbix 5.0 Certified Specialist		Advanced Topics
15.30-15.45	Break		Certification and presentation of certificates
15.45-17.50	Zabbix 5.0 Certified Specialist		

AGENDA

Architecture



Preparations



Installation



Interface
&
Users



Definitions



Monitoring



Hosts
&
Host groups



Items
&
Preprocessing



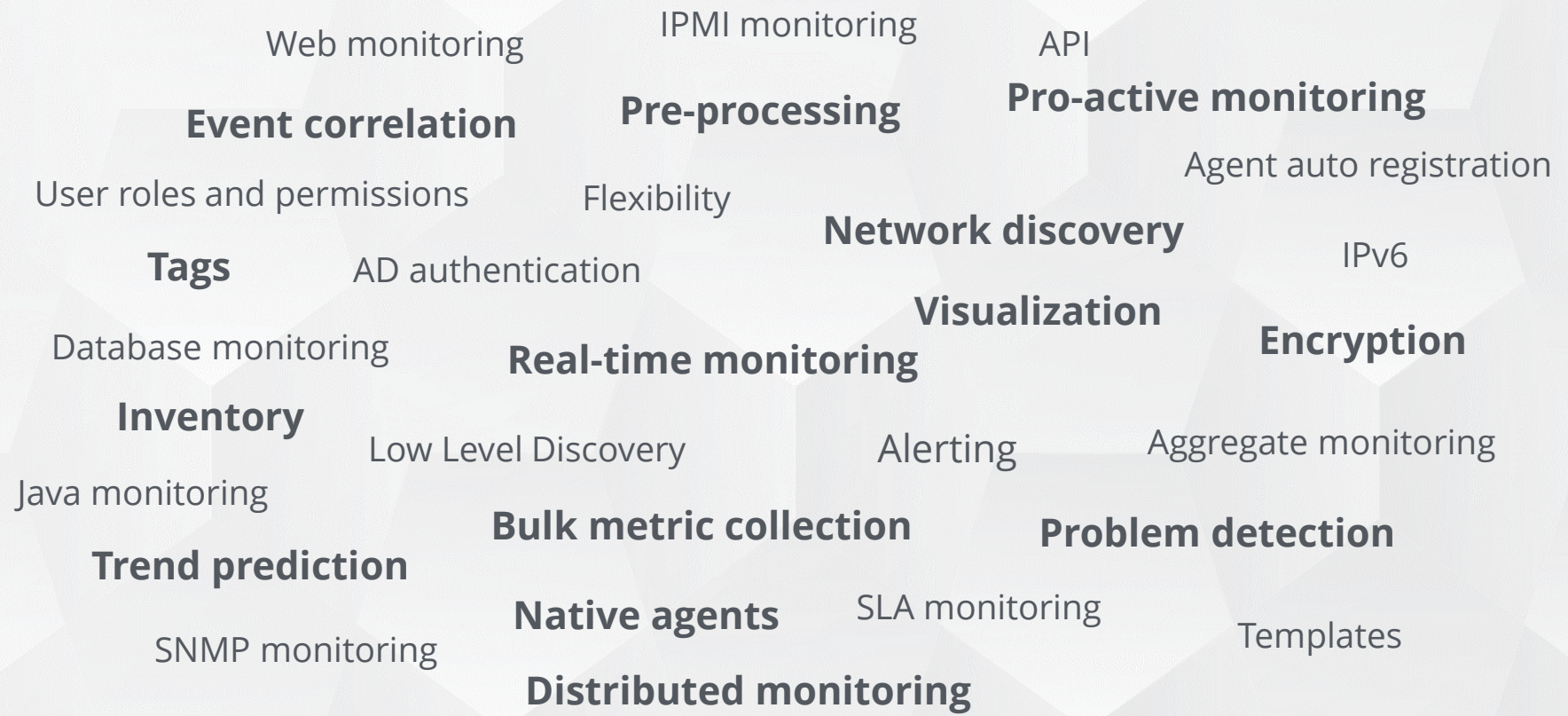
Agent-less
Checks





Intro

Zabbix is the ultimate enterprise - class monitoring platform





Keep things simple (KISS)

Be efficient: use as few system resources as possible (memory/CPU usage)

Very high performance and high-quality product

Low number of third-party dependencies

Written and distributed under the GPL (General Public License) version 2

Frontend

- ⚡ Open and customisable

Everything is stored in a relational database

C language for the server, proxy and agent

- ⚡ Best performance

- ⚡ Lowest footprint and resource usage

- ⚡ Linux agent uses less than a megabyte of RAM

- ⚡ (736K on 64bit; excluding shared libraries)

GO language for the agent 2

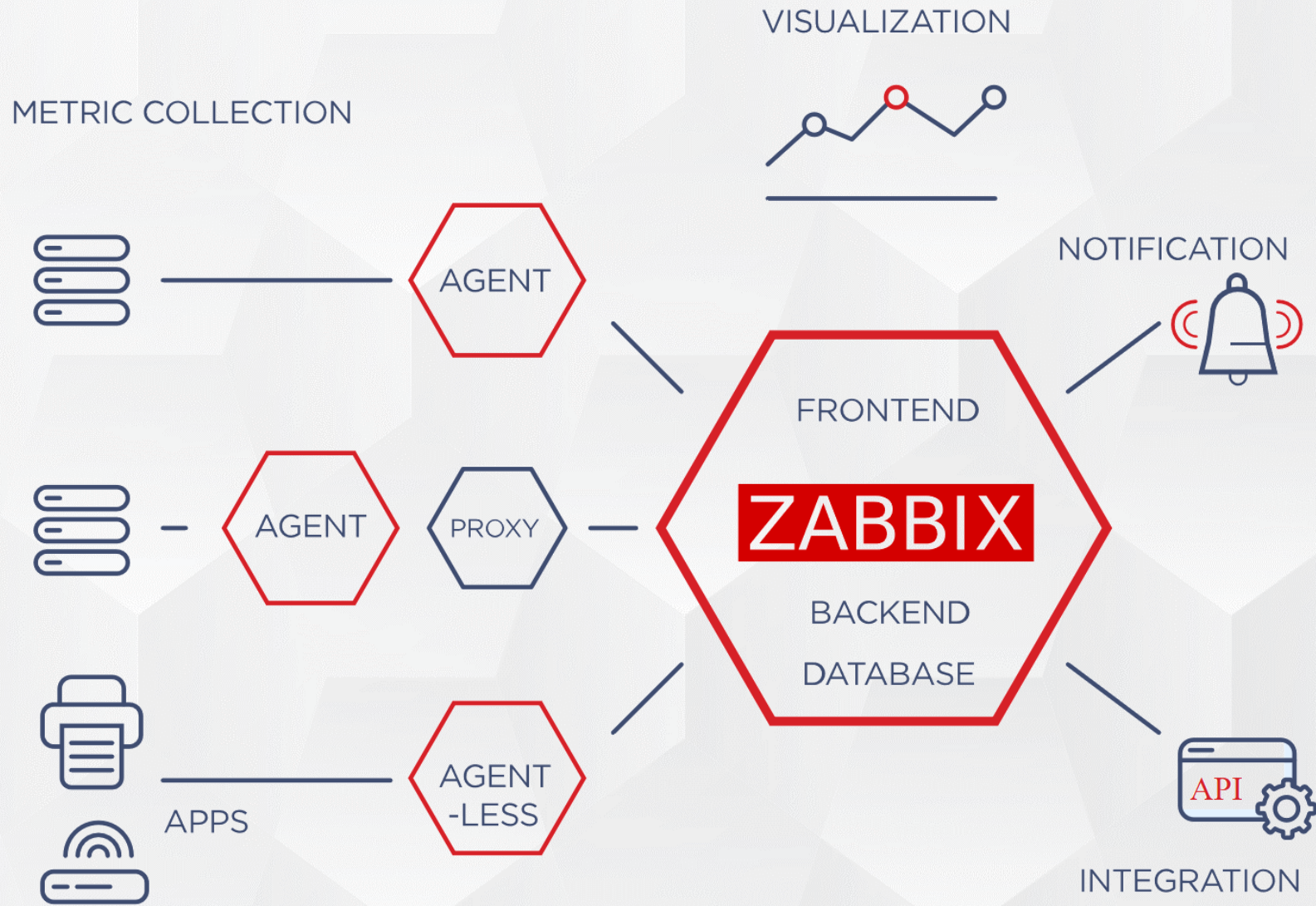
- ⚡ provides more options for plugin developers

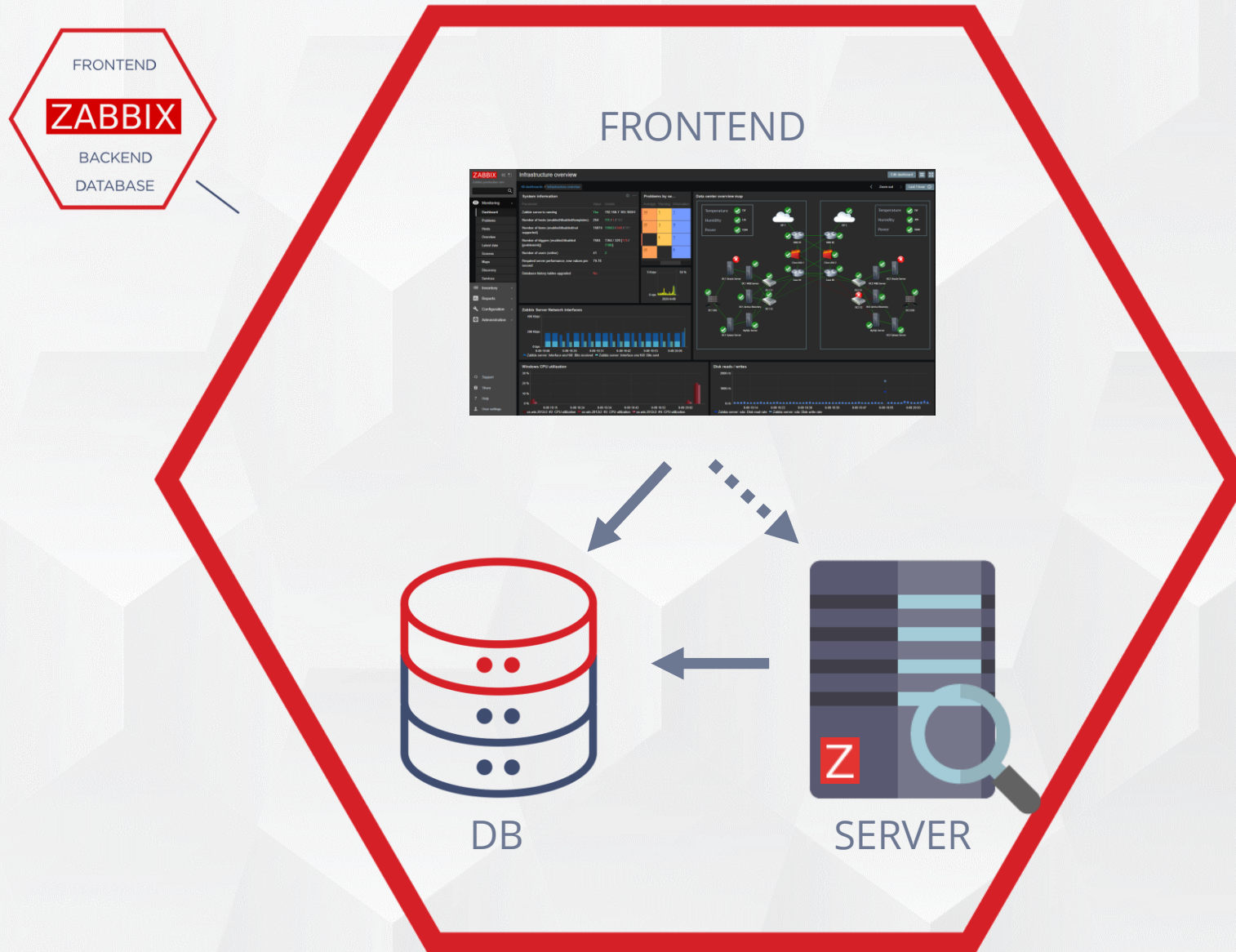
Can be used in an embedded environment

- ⚡ SQLite for proxy, very small footprint

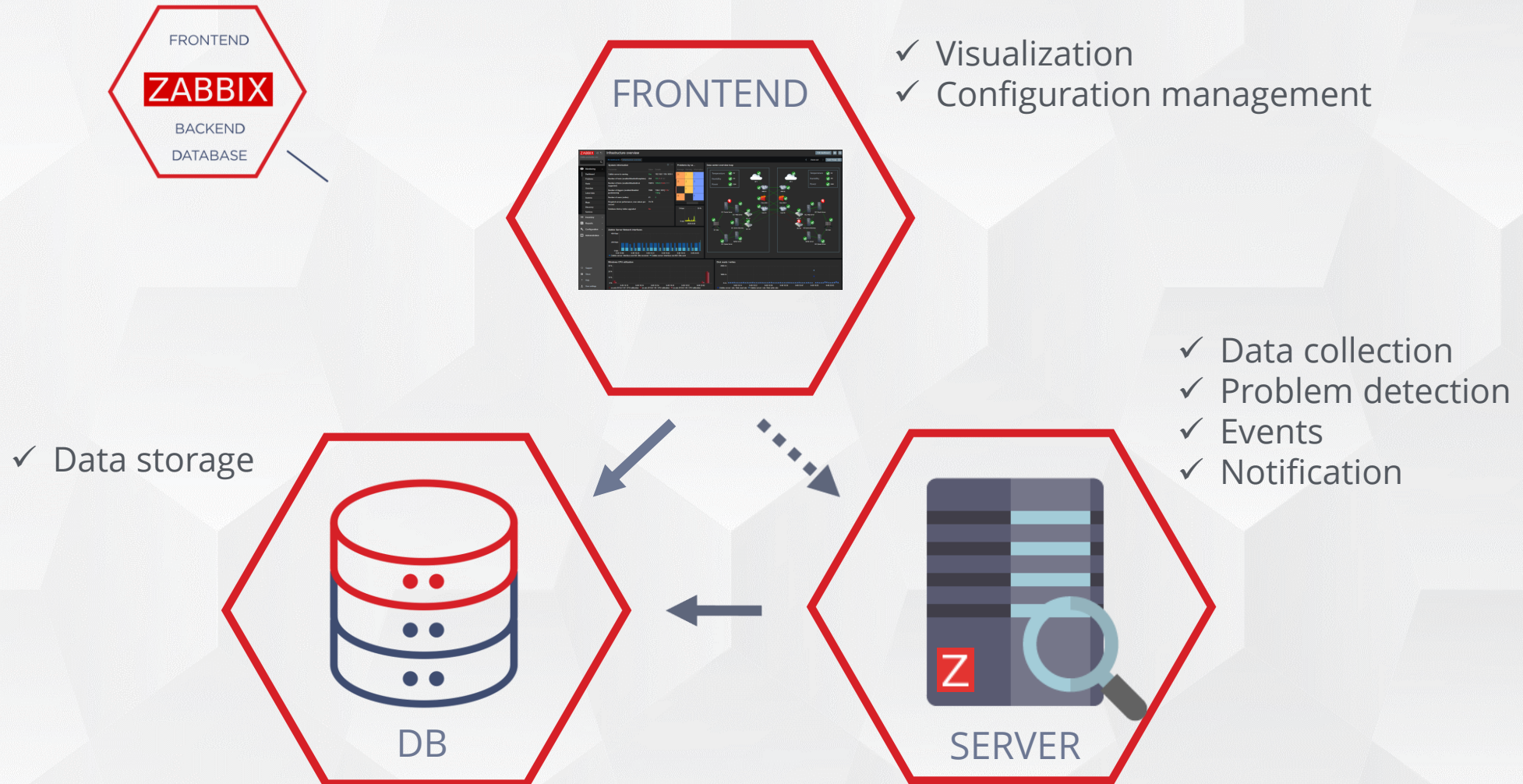


Architecture





INSTANCE ON SEPARATED SERVERS





Distributed monitoring

Zabbix provides an effective and reliable way of monitoring a distributed IT infrastructure using Zabbix proxies

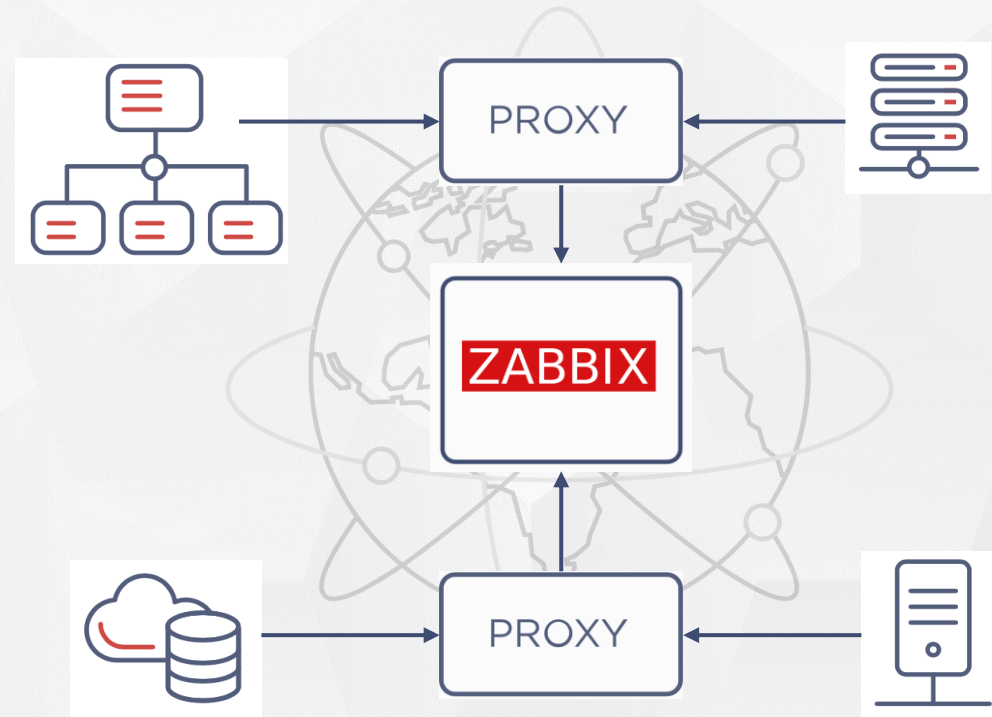
- ⚡ Monitor behind firewalls, DMZ
- ⚡ Collect data in case of network issues
- ⚡ Remotely run custom scripts on monitored hosts
- ⚡ Collect data locally and push data to a central Zabbix server



https://www.zabbix.com/documentation/current/manual/distributed_monitoring

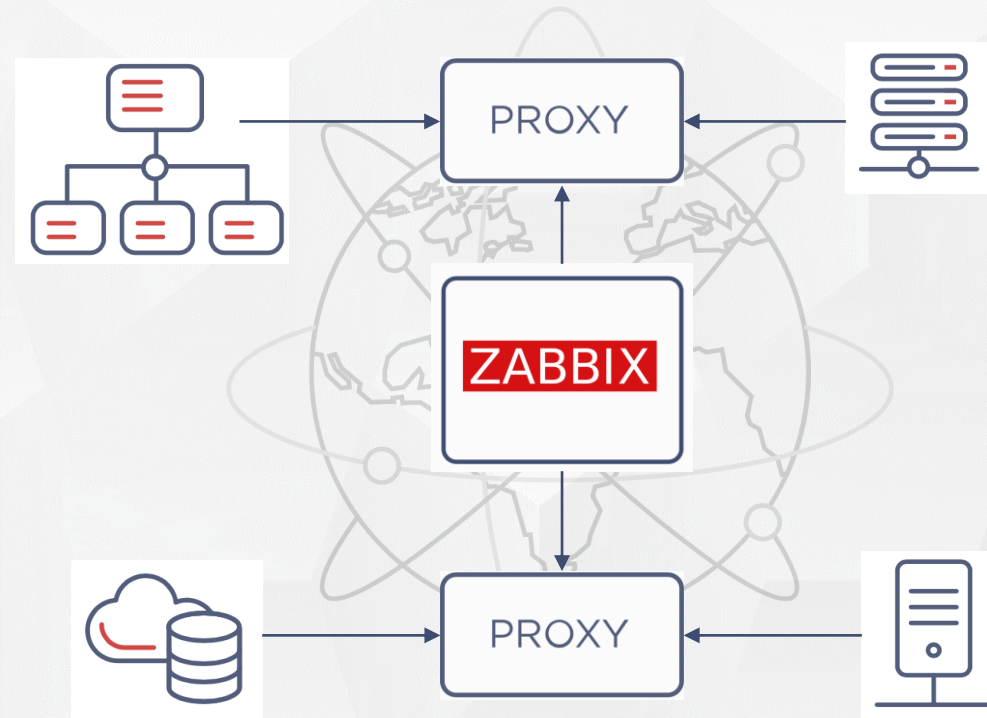
DISTRIBUTED MONITORING - ACTIVE PROXY

Active proxy will connect to Zabbix server and request configuration data




DISTRIBUTED MONITORING - PASSIVE PROXY

- ⚡ Zabbix server connects to the passive proxy
- ⚡ The server requires only one TCP connection to the proxy.
 - Easier to get around a firewall as only one firewall rule is needed



- Centralized monitoring
- Proxy can collect data and perform preprocessing steps
- Zabbix server controls configuration of all proxies
- Supports any platform the server supports
- Supports any database the server supports
- Can use different DBs on the server & proxies
- Can create SQLite DB automatically
- Can buffer data in case of communication problems
- Choose the direction of connection

 Don't use the same DB and schema for proxy & server!!!



Preparations

For Zabbix server to operate properly, the OS must be prepared.

⚡ Setup NTP client

- It is very important to have a precise system date
- It is strongly recommended to maintain synchronized system date on all systems Zabbix components are running on

⚡ Change time zone

- To write correct timestamps in Zabbix logs
- Zabbix server time zone is used for maintenance periods, time-based trigger functions, etc.

⚡ Firewall

- Zabbix server will have a lot of outgoing/incoming connections to different devices and network ports; a firewall must be configured to allow this interaction

⚡ Built in access control systems may block Zabbix server components

- SELINUX
- AppArmor
- Other security tools

To setup NTP on Centos8 "Chrony" can be used:

🔊 Install chrony

```
# dnf install chrony
```

🔊 Enable and start

```
# systemctl enable chronyd --now
```

🔊 Check pool servers

```
# chronyc sources
```

🔊 Or use your own NTP server

```
# vi /etc/chrony.conf  
Add line: Server <IP/DNS>  
# systemctl restart chronyd
```

🔊 If firewall is enabled:

```
# firewall-cmd --permanent --add-service=ntp  
# firewall-cmd --reload
```

Show current time zone setup

```
# timedatectl status
```

Show the list of time zones

```
# timedatectl list-timezones | grep <name>
```

Set time zone

```
# timedatectl set-timezone Europe/Riga
```

Wizard to find time zones

```
# tzselect
```

*Zabbix stores time for values in unixtime

When done, check the settings again

```
# timedatectl status
Local time: Wed 2020-02-19 15:26:25 EET
Universal time: Wed 2020-02-19 13:26:25 UTC
RTC time: Wed 2020-02-19 13:26:25
Time zone: Europe/Riga (EET, +0200)
System clock synchronized: yes
NTP service: active
RTC in local TZ: no
```

Check status

```
# systemctl status firewalld
• firewalld.service - firewalld - dynamic firewall daemon
  Loaded: loaded (/usr/lib/systemd/system/firewalld.service; enabled; vendor preset: enabled)
  Active: active (running) since Wed 2020-02-19 16:20:43 EET; 35min left
  Docs: man:firewalld(1)
  Main PID: 900 (firewalld)
```

Add exclusions for the web server, Zabbix server and Zabbix agent

```
firewall-cmd --permanent --add-service=http
firewall-cmd --permanent --zone=public --add-port=10051/tcp
firewall-cmd --permanent --zone=public --add-port=10050/tcp
firewall-cmd --reload
```



In this training, we will not use a firewall. It is considered a Professional level topic.

Check status

```
# sestatus
SELinux status:          enabled
SELinuxfs mount:        /sys/fs/selinux
SELinux root directory: /etc/selinux
Loaded policy name:      targeted
Current mode:            enforcing
Mode from config file:   enforcing
...
```

If enabled (enforcing):

⚡ need to introduce policies to allow processes to run and interact with each other

To set it to permissive mode and disable on the next reboot

```
# setenforce 0
# vi /etc/selinux/config
SELINUX=disabled
```

Make sure you have the latest policies installed.



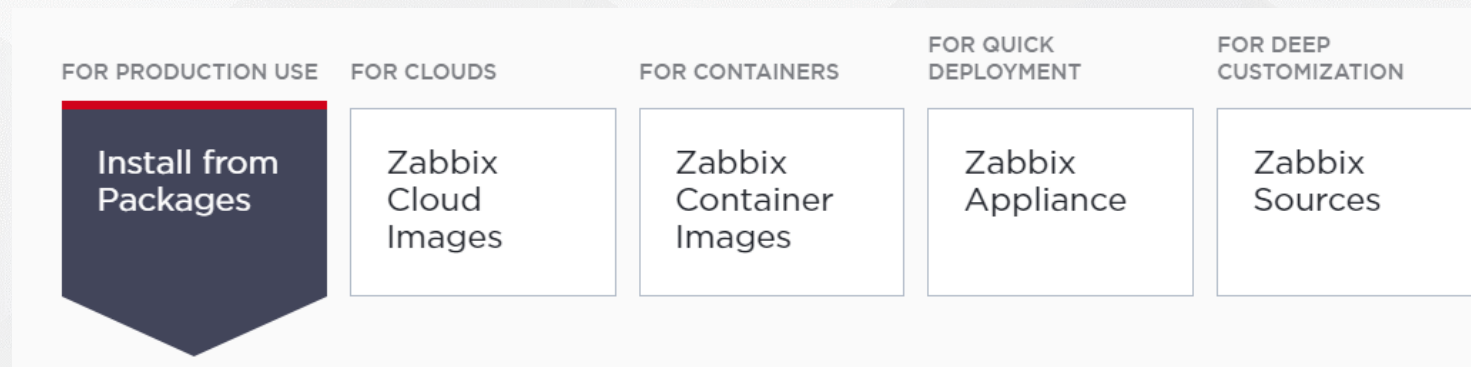
For this course, SELinux is disabled; its settings are covered in the Expert training.



Server, DB, GUI installation

There are five ways of getting Zabbix:

- ⚡ Install it from the official packages
- ⚡ Use Zabbix Cloud images
- ⚡ Deploy from containers
- ⚡ Download the virtual appliance
- ⚡ Download the latest source archive and compile it yourself



<https://www.zabbix.com/download>

FOR PRODUCTION USE

FOR CLOUDS

FOR CONTAINERS

FOR QUICK DEPLOYMENT

FOR DEEP CUSTOMIZATION

FOR AGENT DEPLOYMENT

Install from Packages

Zabbix Cloud Images

Zabbix Container Images

Zabbix Appliance

Zabbix Sources

Zabbix Agents

1

Choose your platform

ZABBIX VERSION	OS DISTRIBUTION	OS VERSION	DATABASE [?]	WEB SERVER
5.0 LTS	Red Hat Enterprise Linux	8	MySQL	Apache
4.4	CentOS	7	PostgreSQL	NGINX
4.0 LTS	Oracle Linux	6		
3.0 LTS	Ubuntu			
	Debian			

2

Install and configure Zabbix server

a. Install Zabbix repository

```
# rpm -Uvh https://repo.zabbix.com/zabbix  
# dnf clean all
```

b. Install Zabbix server, frontend, agent

3

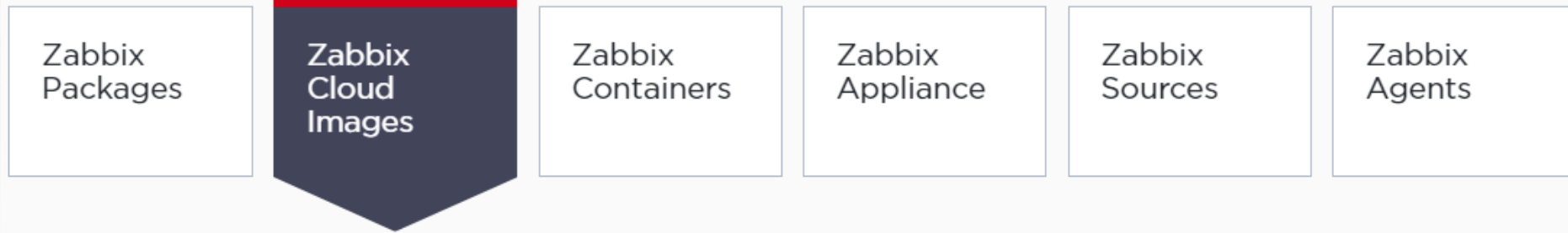
Start using Zabbix

Read in documentation: [Quickstart guide](#)

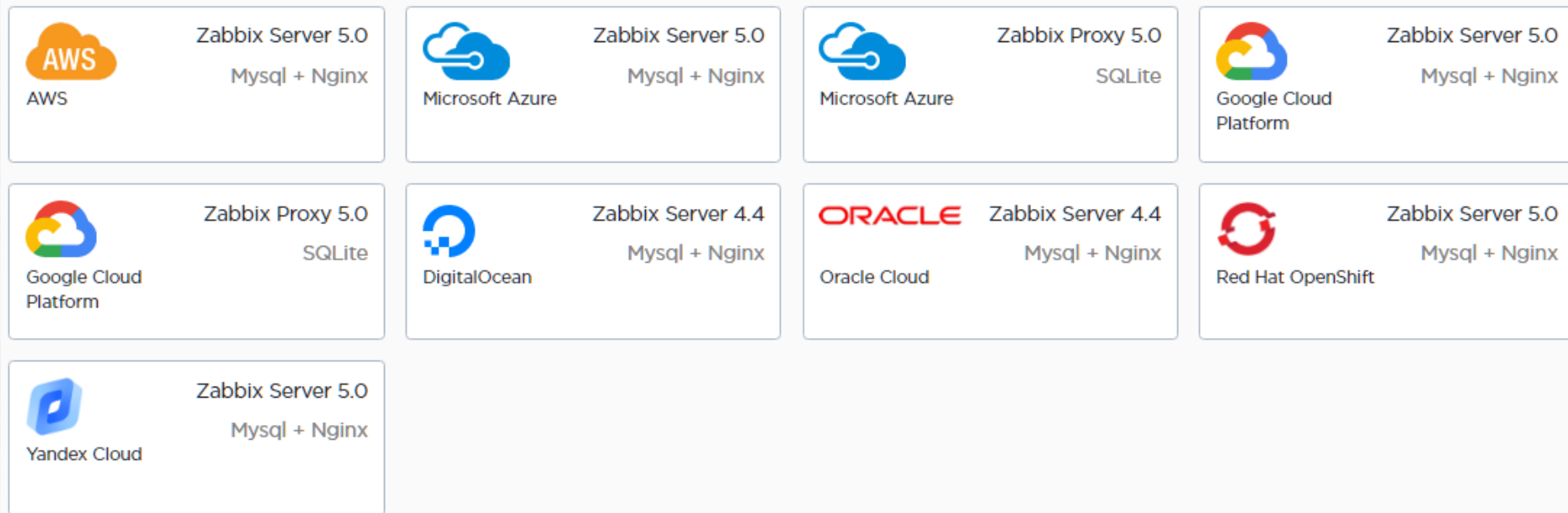
Watch video guide:



Zabbix server installation explained



Zabbix Cloud Images



 https://www.zabbix.com/cloud_images

FOR PRODUCTION USE

FOR CLOUDS

FOR CONTAINERS

FOR QUICK DEPLOYMENT

FOR DEEP CUSTOMIZATION

FOR AGENT DEPLOYMENT

Install from Packages

Zabbix Cloud Images

Zabbix Container Images

Zabbix Appliance

Zabbix Sources

Zabbix Agents

Documentation

Zabbix Installation from containers

Read manual

Zabbix Docker Repository GitHub



Official Dockerfiles

Zabbix Docker Component Repositories

Zabbix Docker hub



Zabbix Server
MySQL



Zabbix Server
PostgreSQL



Zabbix Proxy
SQLite3



Zabbix Proxy
MySQL



Zabbix Frontend
Apache, MySQL



Zabbix Frontend
Apache, PostgreSQL



Zabbix Frontend
Nginx, MySQL



Zabbix Frontend
Nginx, PostgreSQL



Zabbix Agent
TLS encryption



Zabbix Appliance
Nginx, MySQL



Zabbix Java Gateway



Zabbix SNMP traps

Video guide



https://www.zabbix.com/container_images

FOR PRODUCTION USE

FOR CLOUDS

FOR CONTAINERS

FOR QUICK
DEPLOYMENT

FOR DEEP
CUSTOMIZATION

FOR AGENT
DEPLOYMENT

Install from
Packages

Zabbix
Cloud
Images

Zabbix
Container
Images

Zabbix
Appliance

Zabbix
Sources

Zabbix
Agents

Install Zabbix Appliance

Zabbix 5.0 LTS

Zabbix 4.4


Zabbix 4.0 LTS

Zabbix 3.0 LTS

Version	Release	Date	Platform	Release Notes	Zabbix Manual	Download
Zabbix 5.0 LTS	5.0.0	May 12, 2020	Installation CD/DVD (.iso)			Download
Zabbix 5.0 LTS	5.0.0	May 12, 2020	VMWare (.vmx)			Download
Zabbix 5.0 LTS	5.0.0	May 12, 2020	Open virtualization format (.ovf)			Download
Zabbix 5.0 LTS	5.0.0	May 12, 2020	Microsoft Hyper-V 2012			Download

https://www.zabbix.com/download_appliance

Operating system	Database	Additional libraries
<ul style="list-style-type: none">- Linux<ul style="list-style-type: none">- Red Hat- Debian/Ubuntu- SUSE Linux- Solaris- AIX- HP-UX- FreeBSD- OpenBSD- MacOS	<ul style="list-style-type: none">- MySQL (5.5.62 - 8.0.x)- MySQL forks<ul style="list-style-type: none">- MariaDB- Percona- PostgreSQL (9.2.24 or later)<ul style="list-style-type: none">- TimescaleDB- Oracle (11.2 or later) - Elasticsearch<ul style="list-style-type: none">- experimental- only for history	<ul style="list-style-type: none">- PCRE: libpcre3- Bulk metrics: libevent- Compression: zlib- SNMP: net-snmp- Web: libcurl- SSH: libssh2- IPMI: OpenIPMI- VMware: libxml2- ODBC: unixODBC- Encryption: OpenSSL

 Use what is already familiar to you!

RHEL/CentOS

```
# dnf install https://repo.zabbix.com/zabbix/5.0/rhel/8/x86_64/zabbix-release-5.0-1.el8.noarch.rpm
# dnf clean all
# dnf install zabbix-server-mysql
```

Debian/Ubuntu/Raspbian

```
# wget https://repo.zabbix.com/zabbix/5.0/ubuntu/pool/main/z/zabbix-release/zabbix-release_5.0-1+focal_all.deb
# dpkg -i zabbix-release_5.0-1+focal_all.deb
# apt update
# apt install zabbix-server-mysql
```

SUSE Linux Enterprise Server

```
# rpm -Uvh --nosignature https://repo.zabbix.com/zabbix/5.0/sles/15/x86_64/zabbix-release-5.0-1.el15.noarch.rpm
# zypper --gpg-auto-import-keys refresh 'Zabbix Official Repository'
# zypper install zabbix-server-mysql
```


Install MySQL Server

```
# dnf -y install mysql-server
```

Start MySQL and set a root password

```
# systemctl start mysqld  
## On production systems secure your instance  
# mysql_secure_installation
```

To connect to MySQL from the command line

```
# mysql -u<user_name> -p <database_name>
```

```
Enter password: <your_password>
```



If you use older MySQL distributive, check this setting: `innodb_file_per_table=on`

Log in to MySQL and create Zabbix database and user

```
# mysql -uroot -p<password>
mysql> create database zabbix character set utf8 collate utf8_bin;
mysql> create user 'zabbix'@'localhost' identified by 'P455w0RD';
mysql> grant all privileges on zabbix.* to 'zabbix'@'localhost';
mysql> quit;
```

- ⚡ character set utf8 - support for multilingualism
- ⚡ collate utf8_bin - case sensitiveness of stored data

⚠ Missing collation is known to cause failed queries

Load compressed SQL files that contain

- ⚡ DB schema
- ⚡ Initial configuration
- ⚡ Pictures

```
# cd /usr/share/doc/zabbix-server-mysql-5.*
# zcat create.sql.gz | mysql -uzabbix -pP455w0RD zabbix
```

Configure Zabbix server

```
# vi /etc/zabbix/zabbix_server.conf
DBHost=localhost
DBName=zabbix
DBUser=zabbix
DBPassword=P455w0RD
```

Start Zabbix server

```
# systemctl start zabbix-server
```

Enable auto start for the services

```
# systemctl enable zabbix-server
# systemctl enable mysqld
```



If SELinux is in enforcing mode, new SELinux policies must be applied.

Check status

```
# systemctl status zabbix-server
```

- zabbix-server.service - Zabbix Server

Loaded: loaded (/usr/lib/systemd/system/zabbix-server.service; **enabled**; vendor preset: disabled)

Active: **active (running)** since Sun 2020-05-17 18:28:39 EEST; 17h ago

Process: 7263 ExecStop=/bin/kill -SIGTERM \$MAINPID (code=exited, status=0/SUCCESS)

Process: 7266 ExecStart=/usr/sbin/zabbix_server -c \$CONFFILE (code=exited, status=0/SUCCESS)

Main PID: 7269 (zabbix_server)

Tasks: 38

Memory: 54.6M

Check the log file for errors

```
# tail /var/log/zabbix/zabbix_server.log
```



If you encounter critical error messages, resolve the problem before proceeding.

You can use the following command line parameters with Zabbix server

```
## to get more usage information:  
# zabbix_server -h  
## to get zabbix daemon version:  
# zabbix_server -V
```

Server can be started with a different configuration file or/and in the foreground

```
# zabbix_server -c /tmp/test_zabbix_server.conf  
# zabbix_server -f
```

Zabbix server runtime control options

```
# zabbix_server --runtime-control <option>  
# zabbix_server --runtime-control config_cache_reload  
# zabbix_server --runtime-control log_level_increase=1869  
# zabbix_server -R log_level_decrease="history syncer",4  
# zabbix_server -R housekeeper_execute  
# zabbix_server -R snmp_cache_reload
```



<https://www.zabbix.com/documentation/5.0/manual/concepts/server>



Frontend installation

Component	Requirement
Browser	Mozilla Firefox, Chrome, Safari, Edge, Opera Other browsers (Vivaldi) may work as well
Back-end	Apache (1.3.12 or later), Lighttpd, Nginx
PHP version	7.2.0 or later
PHP database support	php-mysql, php-pgsql, php-sqlora
PHP modules	php-bcmath, php-gd(2.0.28 or later), php-xml(2.6.15 or later), php-xmlreader, php-xmlwriter, php-session, php-net-socket, php-mbstring, PNG/JPEG/FreeType support, php-gettext, php-ldap
Other requirements	Some distributions might split out core PHP features in packages like php7-ctype, php-session or php7-xml/php7-dom



<https://www.zabbix.com/documentation/5.0/manual/installation/requirements>

RHEL/CentOS

```
# dnf install zabbix-web-mysql zabbix-apache-conf
```

⚡ Edit /etc/php-fpm.d/zabbix.conf to configure PHP

- Uncomment and change time zone

```
; php_value[date.timezone] = Europe/Riga
```

⚡ Enable and start

```
# systemctl start httpd php-fpm  
# systemctl enable httpd php-fpm
```

Debian/Ubuntu/Raspbian

```
# apt install zabbix-frontend-php
```

⚡ Edit /etc/zabbix/apache.conf to configure PHP (the same change as for the RHEL)

SUSE Linux Enterprise Server

```
# zypper install zabbix-server-mysql zabbix-apache-conf
```

⚡ Edit /etc/apache2/conf.d/zabbix.conf to configure PHP (the same change as for the RHEL)

Edit /etc/php-fpm.d/zabbix.conf

```
pm = dynamic      ## php-fpm settings
pm.max_children = 50
pm.start_servers = 5
pm.min_spare_servers = 5
pm.max_spare_servers = 35

php_value[session.save_handler] = files
php_value[session.save_path]    = /var/opt/rh/rh-php72/lib/php/session/

php_value[max_execution_time] = 300
php_value[memory_limit] = 128M
php_value[post_max_size] = 16M
php_value[upload_max_filesize] = 2M
php_value[max_input_time] = 300
php_value[max_input_vars] = 10000
php_value[date.timezone] = Europe/Riga
```

Start and enable auto start for Apache

```
# systemctl start httpd php-fpm
# systemctl enable httpd php-fpm
```

Open Zabbix frontend from a web browser

🔗 <http://<DNS or IP>/zabbix>



If a firewall is enabled, add new firewall rules to allow HTTP traffic

ZABBIX

- Welcome
- Check of pre-requisites
- Configure DB connection
- Zabbix server details
- Pre-installation summary
- Install

Check of pre-requisites

	Current value	Required	
PHP version	7.2.24	7.2.0	OK

ZABBIX

- Welcome
- Check of pre-requisites
- Configure DB connection
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- Pre-installation summary
- Install

Configure DB connection

Please create database manually, and set the configuration parameters for connection to this database. Press "Next step" button when done.

Database type:

Database host:

Database port:

Database name:

User:

Password:

TLS encryption:

ZABBIX

- Welcome
- Check of pre-requisites
- Configure DB connection
- Zabbix server details
- Pre-installation summary
- Install

Zabbix server details

Please enter the host name or host IP address and port number of the Zabbix server, as well as the name of the installation (optional).

Host:

Port:

Name:

Congratulations! You have successfully installed Zabbix frontend.

Configuration file "/etc/zabbix/web/zabbix.conf.php" created.

 [The wizard creates: /etc/zabbix/web/zabbix.conf.php](#)

PRACTICAL SETUP

1. Install

- MySQL 8 server
- Zabbix Server
- Frontend

2. Create Zabbix DB

3. Configure:

- Zabbix server
- Frontend

4. Start and check status of

- Web server
- Zabbix server

5. Check log files to see if the server and all subprocesses have started

6. Login to the frontend using user: Admin, password: zabbix



Zabbix interface

In your browser open the URL:

🔗 `http://<ip_or_name>/zabbix`

ZABBIX

Username
Admin

Password
•••••

Remember me for 30 days

Sign in

[Help](#) • [Support](#)

Enter credentials
Username: Admin
Password: zabbix

Save cookie
Sign in = Login

Main menu

Links

ZABBIX << < > >>
Zabbix production env

Monitoring >
Dashboard
Problems
Hosts
Overview
Latest data
Screens
Maps
Discovery
Services

Inventory >
Reports >
Configuration >
Administration >

Support
Share
Help
User settings
Sign out

Main window

Edit dashboard

Global view

All dashboards / Global view

Parameter	Value	Details
Zabbix server is running	Yes	192.168.7.105:10051
Number of hosts (enabled/disabled)	111	110 / 1
Number of templates	160	
Number of items (enabled/disabled/not supported)	16199	15196 / 638 / 365
Number of triggers (enabled/disabled [problem/ok])	7027	6710 / 317 [177 / 6533]
Number of users (online)	42	2
Required server performance, new values per second	75.8	
Database history tables upgraded	No	

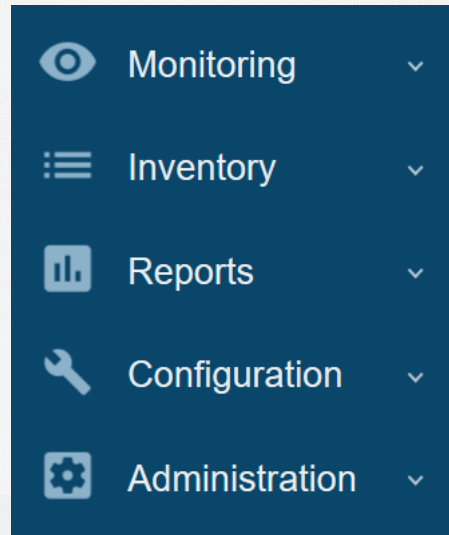
Zabbix agent host availability

Category	Count
Available	18
Not available	5
Unknown	17
Total	40

Local

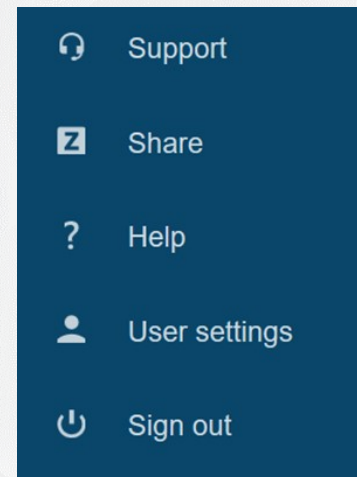
Problems by severity (Global)

Severity	Count
Disaster	0
High	2
Average	78
Warning	20
Information	11
Not classified	0



Main menu:

- Is all about displaying data
- Provides an overview of inventory data
- Contains a variety of predefined reports
- Contains sections for setting up Zabbix
- Is for administrative Zabbix functions






Links:





- Contact Zabbix support
- <https://share.zabbix.com>
- Link to the documentation
- Current user profile settings
- Log out

Access to the frontend menu sections depends on the user type.






Zabbix User

-  Monitoring ▼
-  Inventory ▼
-  Reports ▼



Zabbix Admin

-  Monitoring ▼
-  Inventory ▼
-  Reports ▼
-  Configuration ▼

Zabbix Super Admin

-  Monitoring ▼
-  Inventory ▼
-  Reports ▼
-  Configuration ▼
-  Administration ▼



- ⚡ Menu can be collapsed to small icons or hidden completely
- ⚡ Global search is for hosts, host groups and templates
- ⚡ In the monitoring section, frontend can be switched to kiosk mode 
- ⚡ To exit kiosk mode, point to the upper right corner and press 

Type any string

Linux 🔍

linux01.training.lan

linux02.training.lan

📶 If there are hosts that include the string, a dropdown will appear, listing all matching hosts

Search: Linux

Hosts

Hosts														
Host	IP	DNS	Latest data	Problems	Graphs	Screens	Web	Applications	Items	Triggers	Graphs	Discovery	Web	
linux01.training.lan	172.17.0.1	{HOST.HOST}	Latest data	Problems	Graphs	Screens	Web	Applications 16	Items 64	Triggers 23	Graphs 12	Discovery 5	Web	
linux02.training.lan	172.17.0.1	{HOST.HOST}	Latest data	Problems	Graphs	Screens	Web	Applications 16	Items 64	Triggers 23	Graphs 12	Discovery 5	Web	

Displaying 2 of 2 found

Host Groups

Host groups						
Host group	Latest data	Problems	Web	Hosts	Templates	
Linux servers	Latest data	Problems	Web	Hosts 2	Templates	

Displaying 1 of 1 found

Templates

Templates							
Template	Applications	Items	Triggers	Graphs	Screens	Discovery	Web
Template Module Linux block devices by Zabbix agent	Applications 2	Items 1	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux block devices by Zabbix agent active	Applications 2	Items 1	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux block devices SNMPv2	Applications 1	Items	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux CPU by Zabbix agent	Applications 1	Items 17	Triggers 2	Graphs 4	Screens	Discovery	Web

- Each entry provides links to monitoring and configuration data
- A simple way to open items configuration or list of problems

Search: Linux

Hosts													
Host	IP	DNS	Latest data	Problems	Graphs	Screens	Web	Applications	Items	Triggers	Graphs	Discovery	Web
linux01.training.lan	172.17.0.1	{HOST.HOST}	Latest data	Problems	Graphs	Screens	Web	Applications 16	Items 64	Triggers 23	Graphs 12	Discovery 5	Web
linux02.training.lan	172.17.0.1	{HOST.HOST}	Latest data	Problems	Graphs	Screens	Web	Applications 16	Items 64	Triggers 23	Graphs 12	Discovery 5	Web

configuration **monitoring** **configuration** Displaying 2 of 2 found

Host groups					
Host group	Latest data	Problems	Web	Hosts	Templates
Linux servers	Latest data	Problems	Web	Hosts 2	Templates

configuration **monitoring** **configuration** Displaying 1 of 1 found

Templates							
Template	Applications	Items	Triggers	Graphs	Screens	Discovery	Web
Template Module Linux block devices by Zabbix agent	Applications 2	Items 1	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux block devices by Zabbix agent active	Applications 2	Items 1	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux block devices SNMPv2	Applications 1	Items	Triggers	Graphs	Screens	Discovery 1	Web
Template Module Linux CPU by Zabbix agent	Applications 1	Items 17	Triggers 2	Graphs 4	Screens	Discovery	Web

configuration



How to create a new user

Administration > Users

- ⚡ Shows a list of existing users
- ⚡ Filter section to find specific ones
- ⚡ Single or multiple user: [Block]/[Unblock], [Delete]
- ⚡ To add a new user: Press the [Create user] button in the upper right corner

Users

User group: All ▼
Create user

Alias
Name
Surname

User type
Any
Zabbix User
Zabbix Admin
Zabbix Super Admin

Apply
Reset

<input type="checkbox"/>	Alias ▲	Name	Surname	User type	Groups	Is online?	Login	Frontend access	Debug mode	Status
<input type="checkbox"/>	Admin	Zabbix	Administrator	Zabbix Super Admin	Zabbix administrators	Yes (2020-04-20 13:49:10)	Ok	System default	Disabled	Enabled
<input type="checkbox"/>	guest			Zabbix User	Disabled, Guests	No	Ok	Internal	Disabled	Disabled
<input checked="" type="checkbox"/>	student-X			Zabbix Super Admin	Zabbix administrators	Yes (2020-04-20 13:48:54)	Ok	System default	Disabled	Enabled

Displaying 3 of 3 found

1 selected
Unblock
Delete

Fields in the user settings:

- ⚡ Alias will be used for login
- ⚡ Name, Surname
- ⚡ Groups
- ⚡ Password
- ⚡ Language
- ⚡ Theme
- ⚡ Auto login/logout
- ⚡ Refresh rate of some pages
- ⚡ How many rows to display
- ⚡ URL - redirection after login

Users

User
Media
Permissions

* Alias

Name

Surname

* Groups

Zabbix administrators ✕

Select

* Password

* Password (once again)

Password is not mandatory for non internal authentication type.

Language

English (en_GB) ▾

Theme

System default ▾

Auto-login

Auto-logout

15m

* Refresh

* Rows per page

URL (after login)

Update
Delete
Cancel

User media settings:

- ⚡ Usually e-mail, phone number or other identifier
- ⚡ Active based on time period
- ⚡ Active based on severity
- ⚡ One or more user media
- ⚡ Not visible for Zabbix User

Media

Type:

* Send to: [Remove](#)

[Add](#)

* When active:

Use if severity: Not classified
 Information
 Warning
 Average
 High
 Disaster

Enabled:

[Add](#) [Cancel](#)

User profile: Zabbix User

[User](#) [Media](#) [Messaging](#)

Media	Type	Send to	When active	Use if s	Enabled
	Email	user_email@private.home	6-7,00:00-24:00	N I V	<input type="checkbox"/>
	Email (HTML)	user@working.email	1-5,08:00-18:00	N I W A H D	<input checked="" type="checkbox"/>
	Jira	username	1-7,00:00-24:00	N I W A H D	Disabled
	SMS	+37109876543	1-7,00:00-24:00	N I W A H D	Enabled

[Add](#)

[Update](#) [Cancel](#)

Pick User type:

- ⚡ Zabbix Super Admin: No limitations
- ⚡ Zabbix User and Admin: Permissions are based on Host groups and Tags

User Media **Permissions**

User type: Zabbix Super Admin ▾

Permissions: Host group: *All groups* Permissions: Read-write

Permissions can be assigned for user groups only

Update Delete Cancel

User groups

User group Permissions Tag filter

Permissions	Host group	Permissions
	<i>All groups</i>	None
	Linux servers	Read-write Read Deny None
	Training/Servers	Read-write Read Deny None
	Zabbix servers	Read-write Read Deny None

⚠ Permissions will be reviewed later! For now we will use only Super Admin



User profile

User profile: Zabbix User

User Media Messaging

Support

Share

Help

User settings

Sign out

Password

Language

Theme

Auto-login

Auto-logout

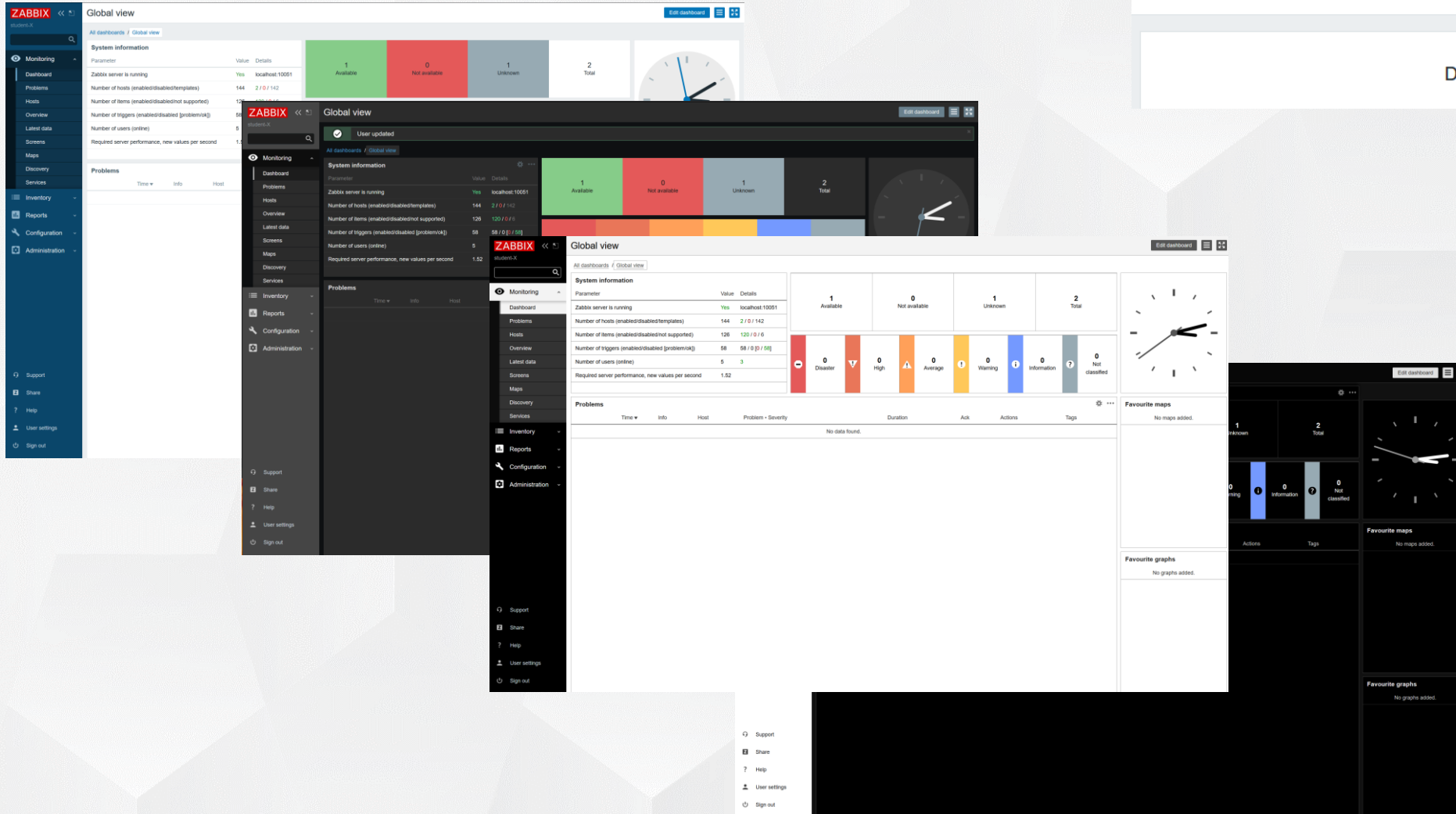
* Refresh

* Rows per page

URL (after login)

- ⚡ Password
- ⚡ Select the interface language
- ⚡ Select a color theme
- ⚡ Auto login/logout
- ⚡ Refresh interval for Monitoring menu
- ⚡ Rows per page in the lists
- ⚡ Specific URL after login (instead of Monitoring > Dashboard)
- ⚡ For Zabbix internal links use relative paths

The system default theme can be set in the Administration > GUI section



Show desktop popup for events

- ⚡ Per user (can't be set by admin)
- ⚡ Timeout
- ⚡ Play sound once/10 sec/forever
- ⚡ Different sounds depending on severity
- ⚡ Snooze/mute
- ⚡ Show suppressed problems

User profile: Zabbix User

User Media Messaging

Frontend messaging

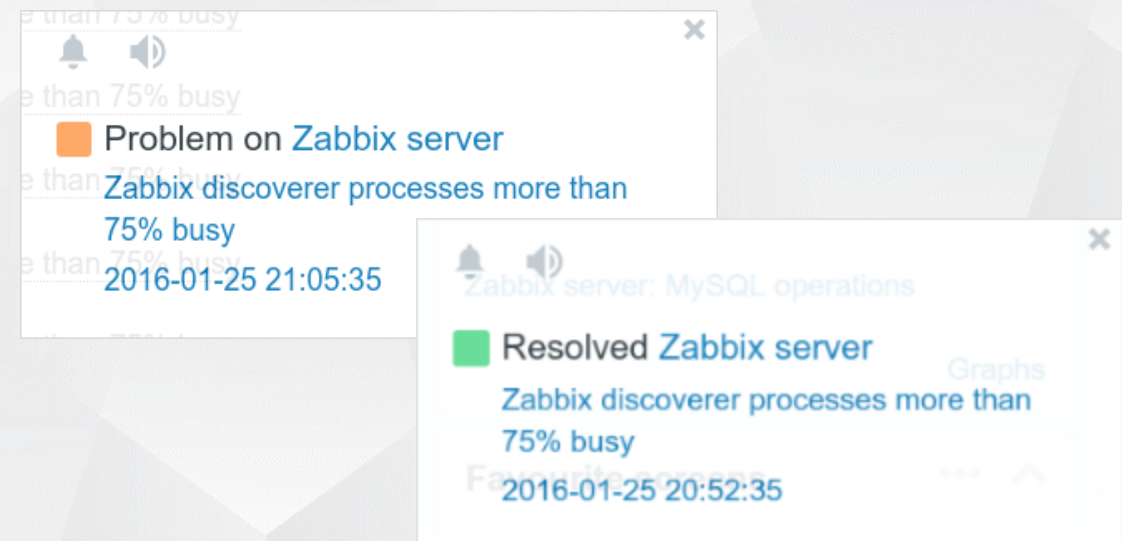
Message timeout

Play sound

Trigger severity

<input checked="" type="checkbox"/> Recovery	<input type="text" value="alarm_ok"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> Not classified	<input type="text" value="no_sound"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> Information	<input type="text" value="alarm_information"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> Warning	<input type="text" value="alarm_warning"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> Average	<input type="text" value="alarm_average"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> High	<input type="text" value="alarm_high"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>
<input checked="" type="checkbox"/> Disaster	<input type="text" value="alarm_disaster"/>	<input type="text" value="Play"/>	<input type="text" value="Stop"/>

Show suppressed problems



PRACTICAL SETUP

1. Create a new user group: Training
2. Create a new Zabbix user
 - Alias: use your training virtual machine hostname (student-XX)
 - Create a secure password
 - Other fields are optional
3. Add to the "Training" user group
4. User type: Zabbix Super Admin
5. Log out and log in with your newly created user
6. Change password for user "Admin" to "P455w0RD"



In all the following labs replace XX in names with your student number





Definitions

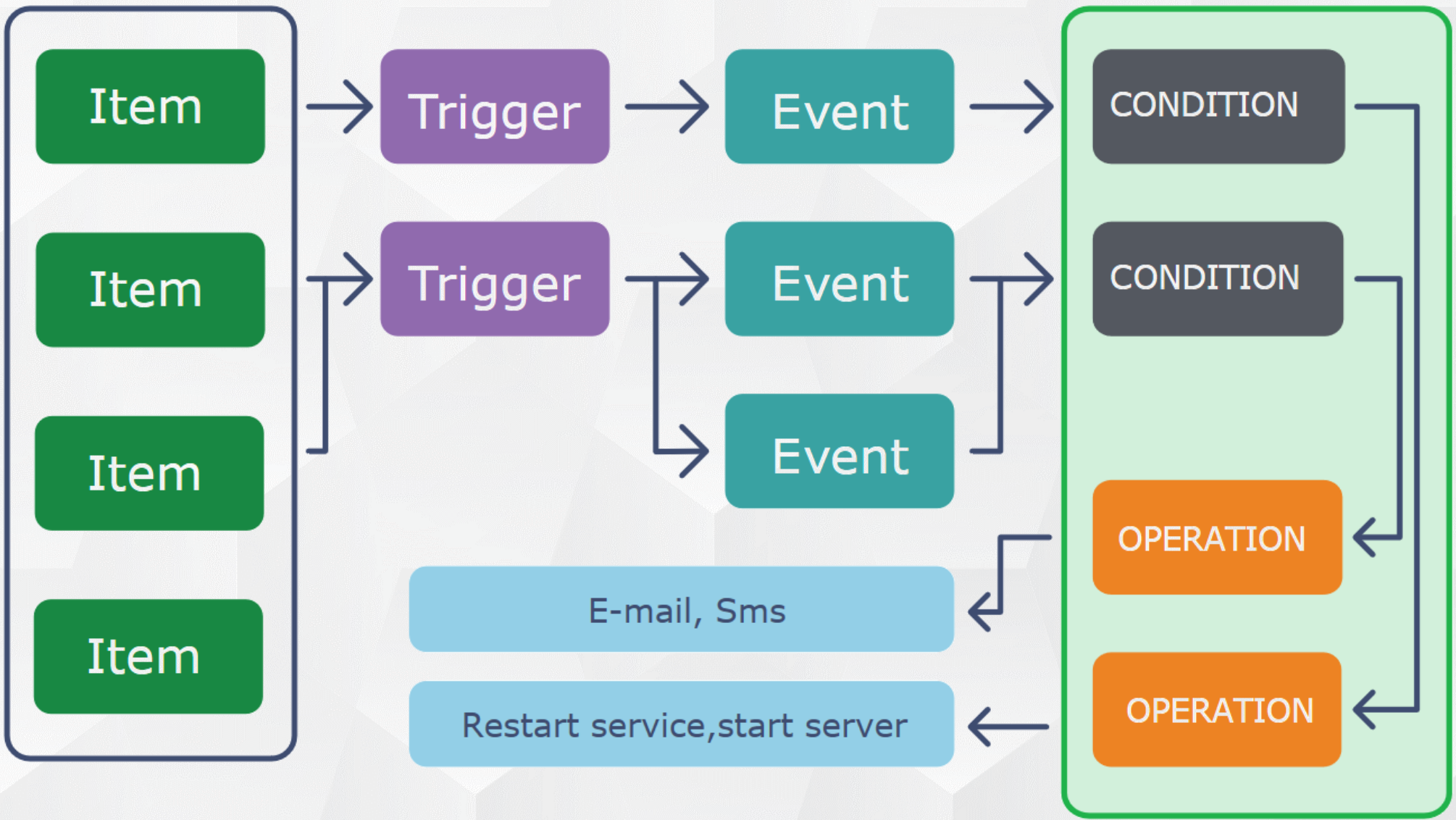
Definition	Description
Host	Any device, system or application that you want to monitor
Host Group	Logical grouping of hosts or templates
Item	Source of information / metric
Application	Logical grouping of items
Trigger	Expression representing problem condition
Template	Set of entities (items, triggers, etc.) ready to be applied to one or several hosts
Event	Element state change
Tag	Pre-defined marker for an event
Action	Set of operations based on events filtered by conditions
Operation	Execution of a command (notification, remote command, configuration change)



<https://www.zabbix.com/documentation/5.0/manual/definitions>

HOST

ACTION





Monitoring > Hosts

Monitoring > Hosts

- Section provides an easy way to see the status
- Navigate to configuration, latest data, problems and other sections
- See tags and number of problems for specific hosts

Hosts

Filters

Name

Host groups

IP

DNS

Port

Severity Not classified Warning High Information Average Disaster

Status

Tags

tag

Show hosts in maintenance Show suppressed problems

Name	Interface	Availability	Tags	Problems	Status	Latest data	Problems	Graphs	Screens	Web
Apache Node1	192.168.7.105: 10050	ZBX SNMP JMX IPMI	Service: Zabbix Type: Web Engine		Enabled	Latest data	Problems	Graphs 4	Screens 1	Web
HOST	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
Inventory	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
Latest data	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs 14	Screens 2	Web
Problems	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs 14	Screens 2	Web
Graphs	2.168.7.101: 10050	ZBX SNMP JMX IPMI		1	Enabled	Latest data	Problems 1	Graphs 14	Screens 2	Web
Screens	2.168.7.102: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs 14	Screens 2	Web
Web	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
Configuration	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
SCRIPTS	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
Detect operating system	7.0.0.1: 10050	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs 8	Screens 1	Web
Ping	7.0.0.1: 161	ZBX SNMP JMX IPMI			Enabled	Latest data	Problems	Graphs	Screens	Web
Traceroute	2.168.7.101: 10050	ZBX SNMP JMX IPMI		1	Enabled	Latest data	Problems 1	Graphs 9	Screens 1	Web

Links to other sections

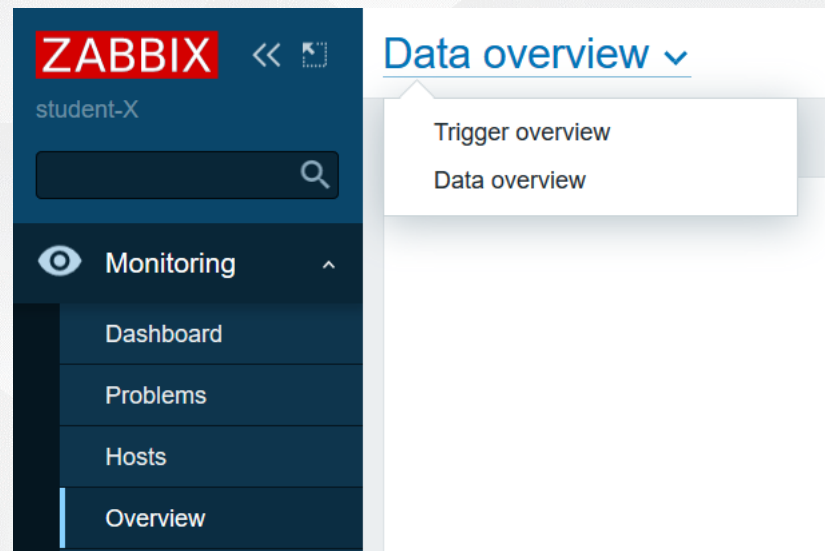
Filters will be adjusted automatically



Monitoring > Overview

Monitoring > Overview > Data

- 📶 Performance data for a group of servers
- 📶 Displays problems
- 📶 Quick navigation to Graphs and Plain text data



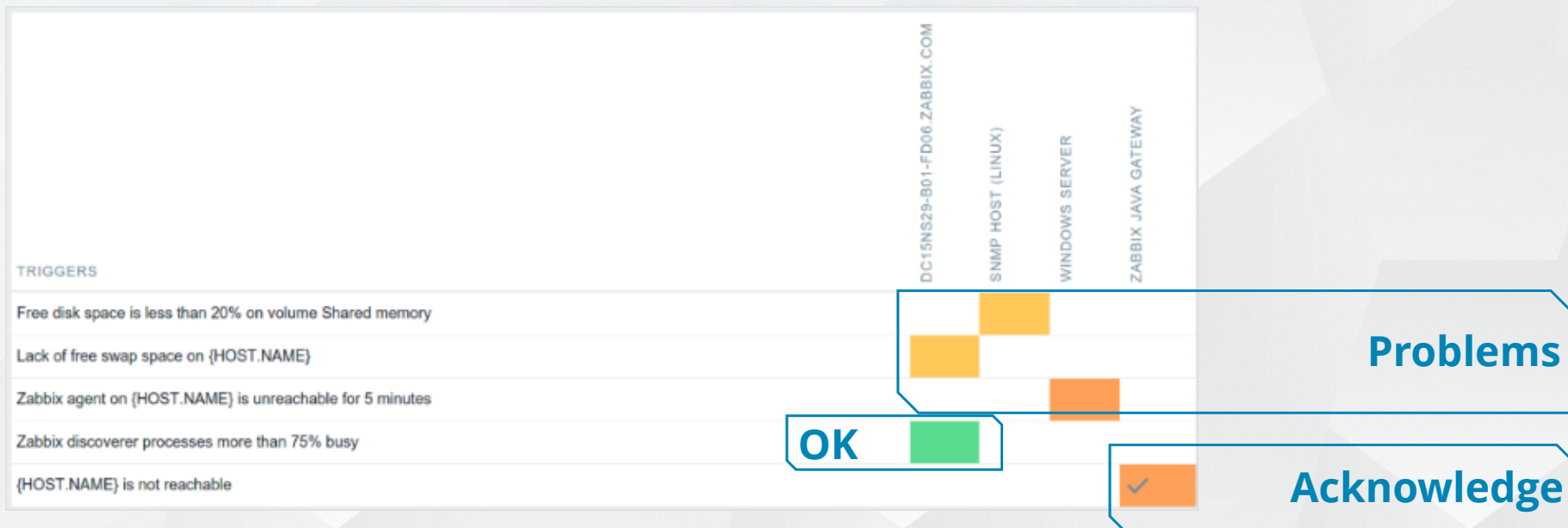
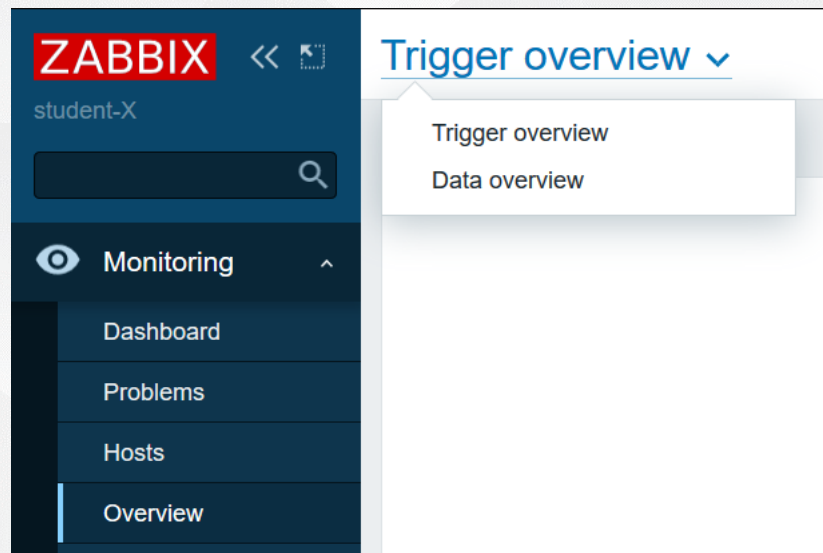
	OPENSUSE_13.1_TF	WINDOWS SERVER
Items		
Average number of bytes read from the disk Hard disk 1	0 Bps	0 Bps
Average number of bytes written to the disk Hard disk 1	0 Bps	0 Bps
Average number of reads from the disk Hard disk 1	0	0
Average number of writes to the disk Hard disk 1	0	0
Ballooned memory	0 B	0 B
Cluster name		
Committed storage space	4.55 GB	4.9 GB
Compressed memory	0 B	0 B
CPU ready	11 %	15 %

Hosts

Values

Monitoring > Overview > Triggers

- 📶 Status of a group of servers
- 📶 Different colours for different trigger severities
- 📶 Blinking on a change
- 📶 Quick navigation to Events and Graphs





Monitoring > Latest data

Monitoring > Latest data

- Performance data for a selected server/group
- Simple graphs
- Plain text information
- Configuration details

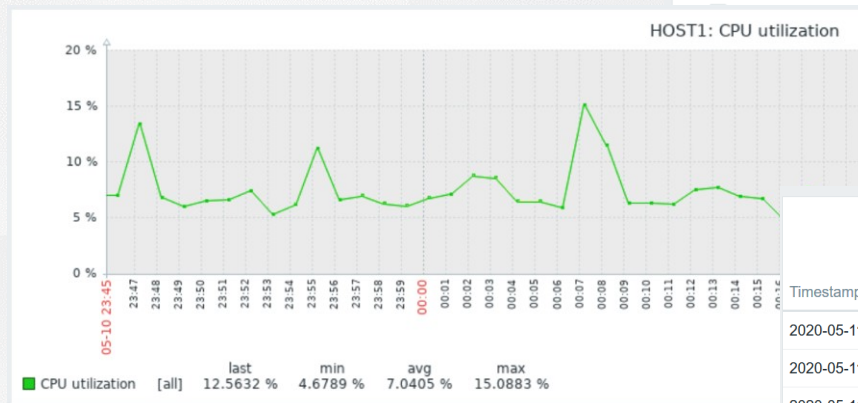
Latest data Filter

Host groups Name

Hosts Show items without data

Application Show details



<input type="checkbox"/> Host	Name ▲	Last check	Last value	Change
▼	HOST1	CPU (17 Items)		
<input type="checkbox"/>	Context switches per second	2020-05-11 00:36:16	419.1302	-9.843 Graph
<input type="checkbox"/>	CPU guest nice time	2020-05-11 00:36:18	0 %	Graph
<input type="checkbox"/>	CPU guest time	2020-05-11 00:36:17	0 %	Graph
<input type="checkbox"/>	CPU idle time	2020-05-11 00:36:19	94.1117 %	+0.1413 % Graph
<input type="checkbox"/>	CPU interrupt time	2020-05-11 00:36:20	0 %	Graph





Timestamp	CPU utilization
2020-05-11 00:49:19	6.7686
2020-05-11 00:48:19	6.2112
2020-05-11 00:47:19	13.0523
2020-05-11 00:46:19	7.8293
2020-05-11 00:45:19	12.5632
2020-05-11 00:44:19	12.1528
2020-05-11 00:43:19	6.6711


Time selector

- ⚡ There is a time period selector in the upper right corner
- ⚡ It allows to select the required period with a mouse click
- ⚡ This allows to show values for a specific time period

HOST1: CPU utilization View as  

< Zoom out > 

From 

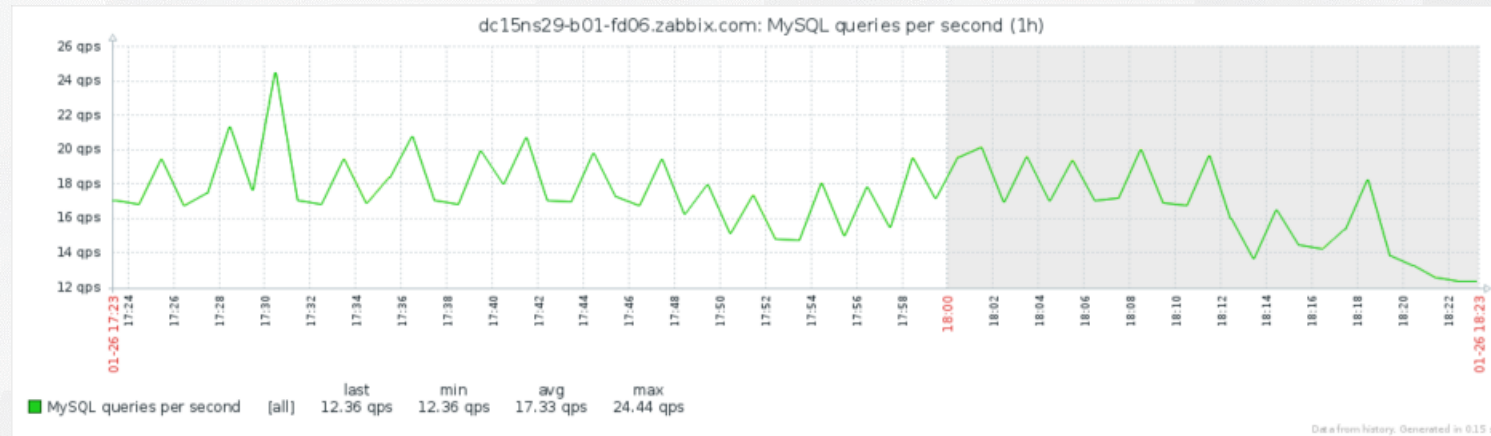
To 

[Apply](#)

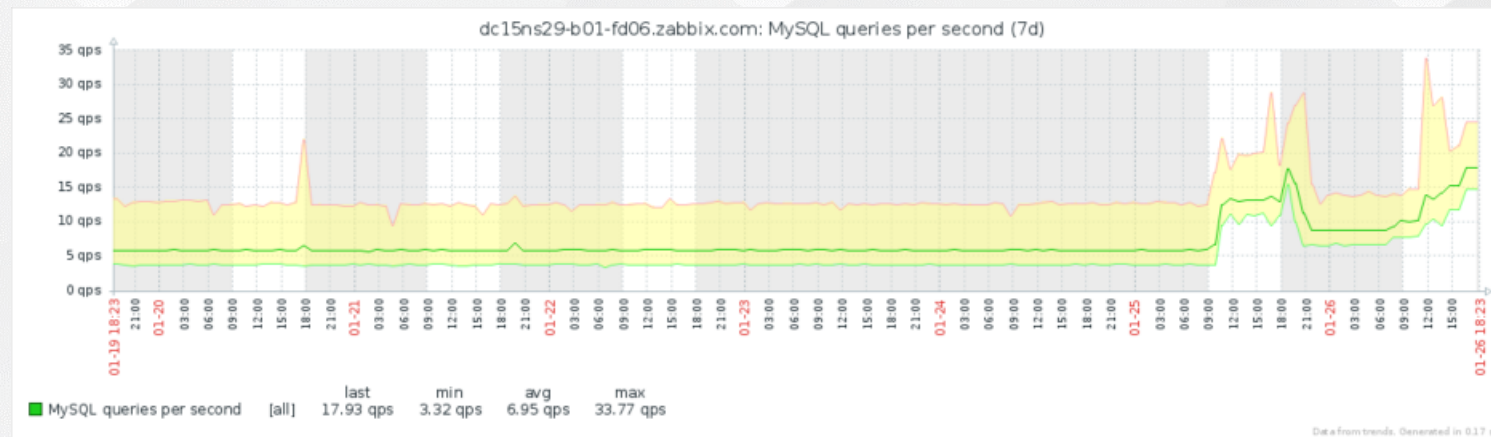
Last 2 days	Yesterday	Today	Last 5 minutes
Last 7 days	Day before yesterday	Today so far	Last 15 minutes
Last 30 days	This day last week	This week	Last 30 minutes
Last 3 months	Previous week	This week so far	Last 1 hour
Last 6 months	Previous month	This month	Last 3 hours
Last 1 year	Previous year	This month so far	Last 6 hours
Last 2 years		This year	Last 12 hours
		This year so far	Last 1 day

With [Zoom out] and arrows, users can shift or expand the graph time frame

History (raw data)



Trends (min, avg, max)



AD-HOC GRAPHS FOR SEVERAL ITEMS

Latest data



Filter

Select multiple items

<input type="checkbox"/> Host	Name ▲	Last check	Last value	Change	
▼ HOST1	Interface eth0 (2 Items)				
<input checked="" type="checkbox"/>	Interface eth0: Bits received	2020-05-11 00:59:33	12.55 Kbps	+824 bps	Graph
<input checked="" type="checkbox"/>	Interface eth0: Bits sent	2020-05-11 00:59:36	26.38 Kbps	+3.86 Kbps	Graph

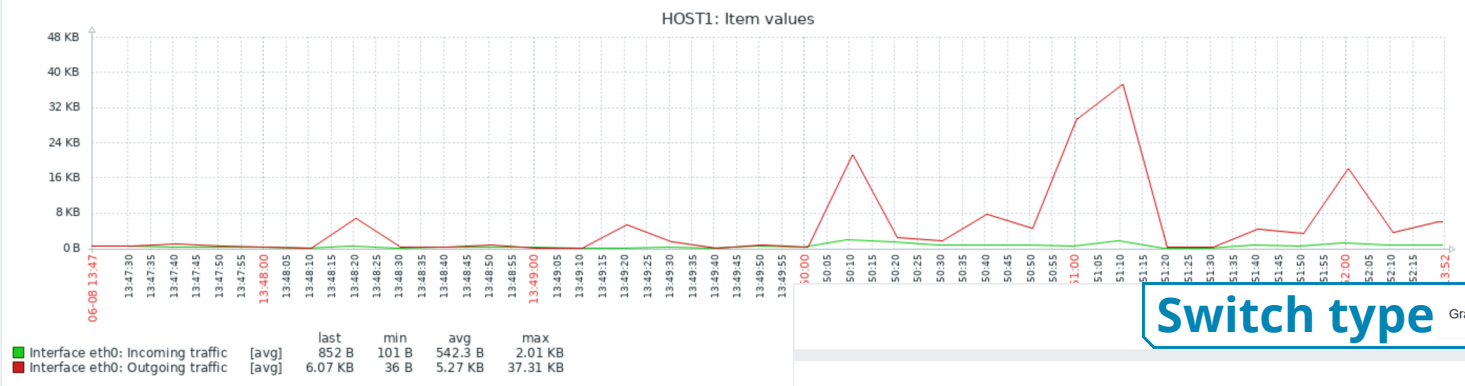
Displaying 2 of 2 found

Choose type

2 selected

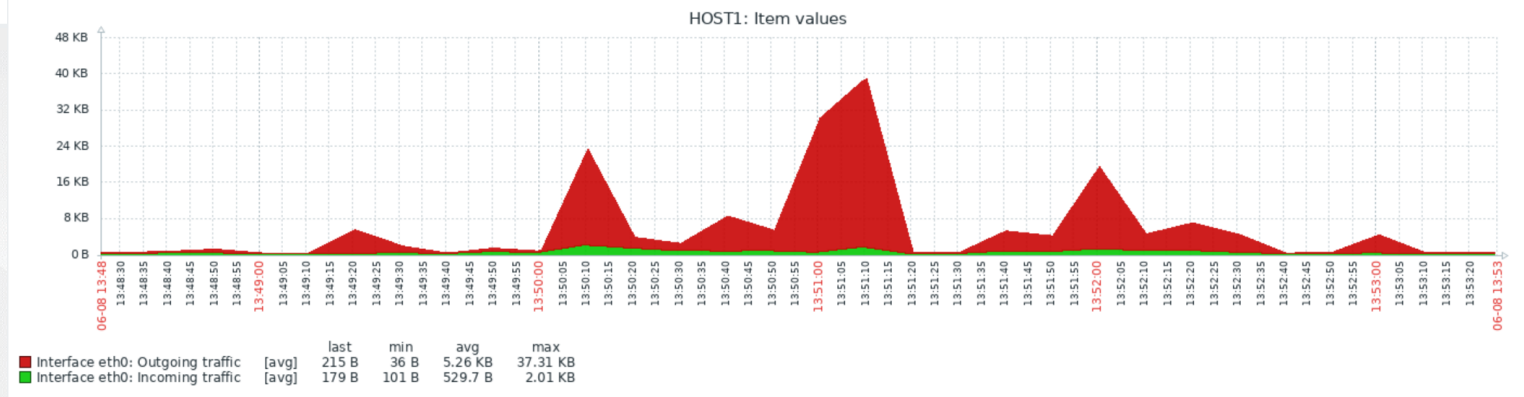
Display stacked graph

Display graph



Switch type

Graph type Normal Stacked





Host groups

Host groups

- ⚡ Are used for logical grouping of hosts and/or templates
- ⚡ Permissions are assigned using host groups only
- ⚡ Can be used in filters based on a group name
- ⚡ Nested representation of host groups is accomplished by using the '/' forward slash to create multi-level grouping

Examples:

Applications
Network
Servers
Servers/Cloud
Servers/Windows

Location
Location/Africa
Location/Europe
Location/Japan
Location/North America

Templates
Templates/Official
Templates/Services
Templates/Vendors
Templates/Vendors/HP

- ⚡ A host group may contain multiple hosts
- ⚡ A host can belong to any number of host groups
- ⚡ Enable and Disable buttons will enable/disable all hosts belonging to the selected groups
- ⚡ Delete button:
 - Will unassign hosts from this group and delete the host group
 - An operation will fail if this is the only group for some hosts

Host groups
Create host group

Filter

Name

Apply
Reset

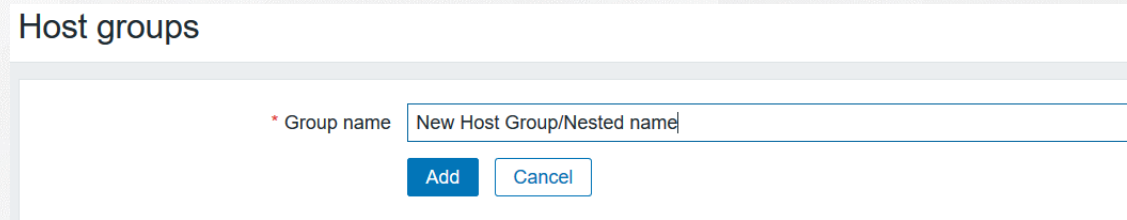
<input type="checkbox"/> Name ▲	Hosts	Templates	Members	Info
<input checked="" type="checkbox"/> Linux servers	Hosts 2	Templates	linux01.training.lan, linux02.training.lan	
<input type="checkbox"/> Templates Linux servers	Hosts	Templates 4	Template OS Linux by Prom, Template OS Linux by Zabbix agent, Template OS Linux by Zabbix agent active, Template OS Linux SNMPv2	

Displaying 2 of 2 found

1 selected
Enable hosts
Disable hosts
Delete

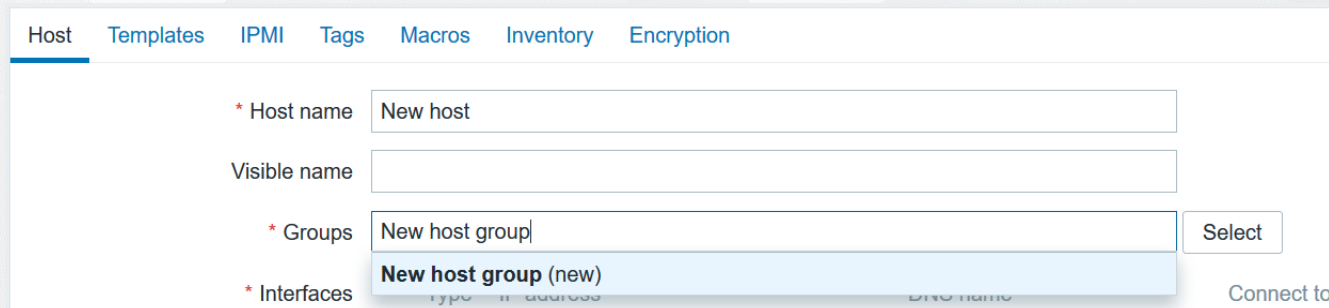
Configuration > Host groups > [Create host group]

⚡ Type a unique name and press [Add]



Alternatively, the same can be done from the Host configuration form
Configuration > Hosts > [Create host]

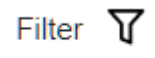
⚡ Type a unique name like "New host group" and click on "New host group (new)"

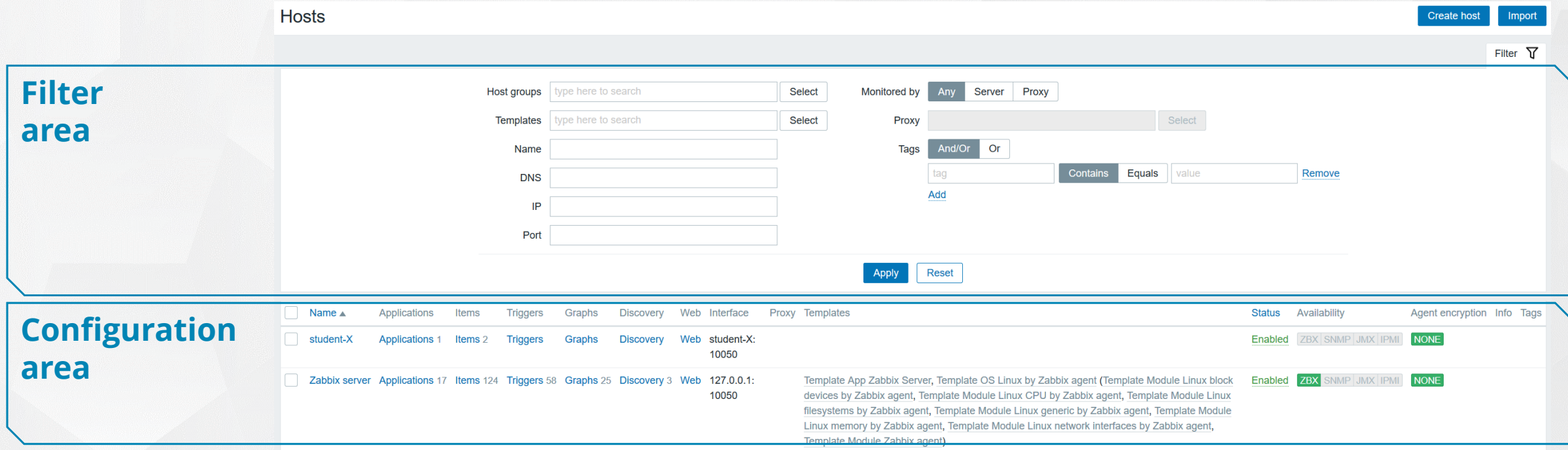




Hosts

The section where users can create and configure hosts

- Filter area allows to find specific hosts based on a host group, a host name, etc.
 - The filter can be displayed or hidden by clicking on the filter sign 
- Configuration area allows to change host properties
 - Clicking on a host name will open the host configuration form
 - Clicking on an entity name will open its configuration page



Filter area

Hosts Create host Import Filter

Host groups Select

Templates Select

Name

DNS

IP

Port

Monitored by Any Server Proxy

Proxy Select

Tags And/Or Or

Contains Equals Remove

[Add](#)

Apply Reset

Configuration area

<input type="checkbox"/>	Name ▲	Applications	Items	Triggers	Graphs	Discovery	Web	Interface	Proxy	Templates	Status	Availability	Agent encryption	Info	Tags
<input type="checkbox"/>	student-X	Applications 1	Items 2	Triggers	Graphs	Discovery	Web	student-X: 10050			Enabled	ZBX SNMP JMX IPMI	NONE		
<input type="checkbox"/>	Zabbix server	Applications 17	Items 124	Triggers 58	Graphs 25	Discovery 3	Web	127.0.0.1: 10050		Template App Zabbix Server, Template OS Linux by Zabbix agent (Template Module Linux block devices by Zabbix agent, Template Module Linux CPU by Zabbix agent, Template Module Linux filesystems by Zabbix agent, Template Module Linux generic by Zabbix agent, Template Module Linux memory by Zabbix agent, Template Module Linux network interfaces by Zabbix agent, Template Module Zabbix agent)	Enabled	ZBX SNMP JMX IPMI	NONE		

The Host tab contains general host attributes

All mandatory input fields are marked with a red asterisk.

Hosts

All hosts / Zabbix server Enabled ZBX SNMP JMX IPMI Applications 16 Items 112 Triggers 60 Graphs 20 Discovery rules 3 Web scenarios

Host
Templates
IPMI
Tags
Macros
Inventory
Encryption

Configuration tabs

General attributes

* Host name

Visible name

* Groups Select
type here to search

* Interfaces	Type	IP address	DNS name	Connect to	Port	Default
Agent		<input style="width: 100%;" type="text" value="127.0.0.1"/>	<input style="width: 100%;" type="text"/>	<input checked="" type="radio"/> IP <input type="radio"/> DNS	<input style="width: 100%;" type="text" value="10050"/>	<input checked="" type="radio"/> Remove

[Add](#)

Description

Monitored by proxy v

Enabled

Host name (must be defined)

- ⚡ Is case sensitive and must be unique
- ⚡ This is the "technical" name of the host
- ⚡ Alphanumeric characters, spaces, dots, dashes and underscores are allowed
- ⚡ Leading and trailing spaces are not allowed

Visible name (optional)

- ⚡ Can be empty – a "Host name" will be used instead
- ⚡ If defined, it is also case sensitive and must be unique
- ⚡ If a "Visible name" is set, it will be used in all frontend sections for visualisation
- ⚡ Has UTF-8 support, local languages can be used

* Host name

Visible name

Host groups

- A host must have at least one host group
- Select button allows to select one or more existing groups
- Groups input field can also be used to
 - Create and link the host to a new group - by typing a non-existing group name
 - Find and link the host to an existing group - by typing a part of the group name and selecting it

The screenshot illustrates the process of assigning host groups in Zabbix. On the left, a form field labeled '* Groups' contains the text 'Dev'. Below the input field, a dropdown menu is open, showing a list of existing host groups: 'Templates/Network devices', 'Development/Servers', and 'Dev (new)'. A blue arrow points from the 'Select' button in the form to the 'Host groups' dialog box on the right. The dialog box, titled 'Host groups', contains a list of host groups with checkboxes. The 'Linux servers' and 'Production/Servers' groups are selected, indicated by blue checkmarks and yellow highlighting. The 'Select' and 'Cancel' buttons are visible at the bottom right of the dialog box.

Host interfaces

Several host interface types are supported

- Zabbix Agent
- SNMP
- JMX
- IPMI

Interface used for monitoring cannot be removed

Use bulk requests option allows to enable/disable bulk data collection for SNMP

* Interfaces	Type	IP address	DNS name	Connect to	Port	Default
Agent		127.0.0.1		IP DNS	10050	<input checked="" type="radio"/> Remove
Agent			hostname.local.lan	IP DNS	10050	<input type="radio"/> Remove
SNMP		127.0.0.1		IP DNS	161	<input checked="" type="radio"/> Remove
* SNMP version		SNMPv2				
* SNMP community		{\${SNMP_COMMUNITY}}				
		<input checked="" type="checkbox"/> Use bulk requests				
JMX		127.0.0.1		IP DNS	12345	<input checked="" type="radio"/> Remove
IPMI		127.0.0.1		IP DNS	623	<input checked="" type="radio"/> Remove

Add

Description

- Agent
- SNMP
- JMX
- IPMI



At least one interface must be defined for a host, even if it is not used

Templates

⚡ In this section users can

- See linked templates
- Unlink
- Unlink and clear

Host **Templates** IPMI Tags Macros Inventory Encryption

Linked templates	Name	Action
	Template OS Linux by Zabbix agent	Unlink Unlink and clear

Link new templates

Template App Apache by HTTP ✕
type here to search Select

Update Clone Full clone Delete Cancel

⚡ Link existing templates

- Auto lookup field
- Select from list

Templates ✕

Host group Templates/Applications ✕ Select

Name

Template App Apache by HTTP

Template App Apache by Zabbix agent

IPMI settings

⚡ Needed if a host has an IPMI interface

⚡ This section controls settings for

- Authentication algorithms
- Privilege level
- Username
- Password

The screenshot shows the Zabbix configuration page for a host's IPMI settings. The navigation tabs at the top are Host, Templates, IPMI (selected), Tags, Macros, Inventory, and Encryption. The configuration is divided into two sections: Authentication algorithm and Privilege level. The Authentication algorithm dropdown menu is open, showing options: Default (selected), None, MD2, MD5, Straight, OEM, and RMCP+. The Privilege level dropdown menu is also open, showing options: Callback, User (selected), Operator, Admin, and OEM. Below these dropdowns are two text input fields for Username and Password. At the bottom of the form are five buttons: Update (highlighted in blue), Clone, Full clone, Delete, and Cancel.

Host-level tags

- ⚡ Event tags are realized as a pair of the tag name and value
- ⚡ You can either use just the name or pair it with a value
 - MySQL
 - Service: MySQL
 - Application: Java
- ⚡ All problems of this host will be tagged with the values entered here
- ⚡ Macros are supported in tags

The screenshot shows the Zabbix web interface for configuring host tags. The 'Tags' tab is selected in the top navigation bar. Below the navigation bar, there are two rows of tag configuration. Each row has a 'Name' input field, a 'Value' input field, and an 'Action' link. The first row has 'Location' in the Name field and 'Riga' in the Value field, with a 'Remove' link. The second row has 'Environment' in the Name field and 'Training' in the Value field, with a 'Remove' link. Below the input fields, there is an 'Add' link and a row of buttons: 'Update', 'Clone', 'Full clone', 'Delete', and 'Cancel'.

Name	Value	Action
<input type="text" value="Location"/>	<input type="text" value="Riga"/>	Remove
<input type="text" value="Environment"/>	<input type="text" value="Training"/>	Remove

[Add](#)

⚠ Tags are covered in the problem detection topics

Host level user macros

Macros Inventory Encryption

Host macros Inherited and host macros

Macro	Value	Type	Description	Action
{\$USER.MACRO}	Value	T	description	Remove
{\$USER.MACRO.MASKED}	●●●●●●●●	🔒	description	Remove

[Add](#)

- T Text
- 🔒 Secret text

Two types:

- ⚡ Text (visible to all users with Read-Write access)
- ⚡ Secret text (masked - no way of seeing values)

⚠️ Macros are covered in the upcoming topics

Host inventory

- ⚡ Manual or Automatic way of storing values from hosts for later use (like a variable)
- ⚡ Gives users an option to overview/find hosts by values in the fields
- ⚡ Stored information can be used later in the
 - Media (emails, SMS, etc.)
 - Tags
 - Scripts

Host
Templates
IPMI
Tags
Macros
Inventory
Encryption

Disabled
Manual
Automatic

Type

Type (Full details)

Name ← Hostname

⚠ The inventory is covered in the upcoming topics

Configuration > Hosts

[Mass update] allows to modify

- Host groups
- Description
- Proxy
- Status
- Templates
- IPMI
- Tags
- Inventory
- Encryption

<input checked="" type="checkbox"/>	Name ▾	Applications	Items	Triggers	G
<input checked="" type="checkbox"/>	net.cisco.c7600.d2	Applications 9	Items 18	Triggers 9	G
<input checked="" type="checkbox"/>	net.cisco.c7600.d1	Applications 9	Items 18	Triggers 9	G

2 selected

Hosts

Host Templates IPMI Tags Inventory Encryption

Host groups

type here to search

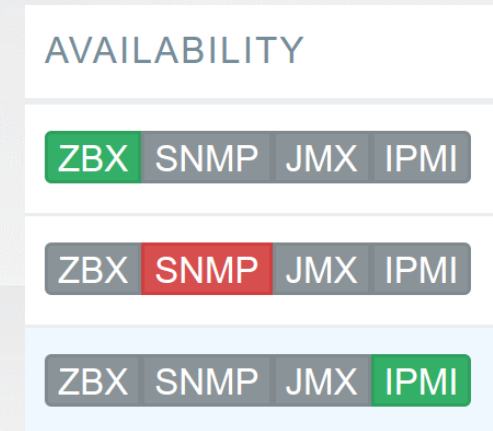
Description

Monitored by proxy (no proxy) ▾

Status Enabled ▾

Availability is kept for 4 different types of checks separately

- 📶 ZBX Zabbix passive agent
- 📶 SNMP Simple Network Management Protocol
- 📶 JMX Java Management Extensions
- 📶 IPMI Intelligent Platform Management Interface



Error messages are preserved for each interface status

Calculated by the server internally

Shown in the list and the host properties

Green - available

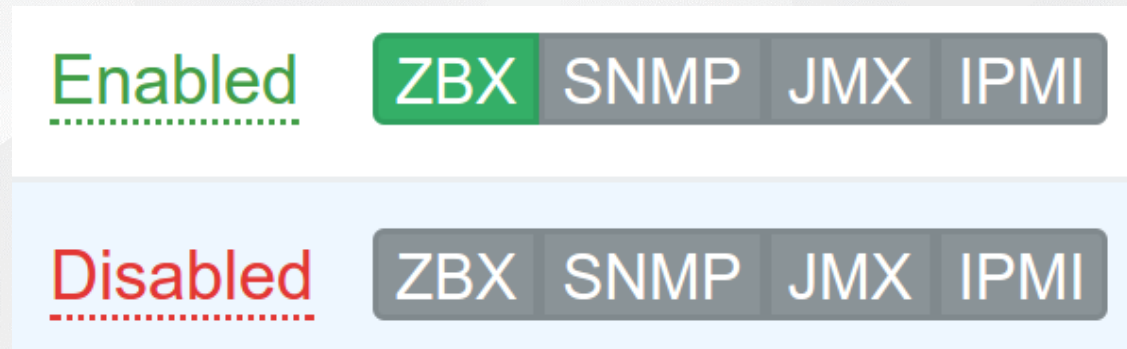
Red - not available (error upon mouseover)

Gray - unknown or not configured

Get value from agent failed: cannot connect to [[student-xx]:10050]: [111] Connection refused

Zabbix server will set the host availability icon to gray if

- ⚡ There are no enabled items on the corresponding interface
- ⚡ The host has been switched to be monitored by other server or proxy (until config cache updates)
- ⚡ The host is monitored by a proxy that appears to be offline
- ⚡ The host is disabled



PRACTICAL SETUP

1. Create new host groups:

- Training
- Training/Servers

2. Create a new host:

- Host name: Training-VM-XX
- Host group: Training/Servers

3. Add a Host-level tag:

- Tag name: Location Value: <use your current Training location>



Items

Item (an individual metric) - gathers data from a host or performs calculations

Workflow usually is

- ⚡ Create a new host or use an existing one
- ⚡ Create a new item and set parameters
 - Name
 - Type
 - Key (must be unique on a host)
 - Data type
 - Update interval
 - Other (Authentication, data storage periods)

Some items will need 4-5 parameters, others - more than 10



<https://www.zabbix.com/documentation/5.0/manual/config/items/item>

Configuration > Hosts > Items [Create item]

Item Preprocessing

* Name

Type

* Key

Type of information

Units

* Update interval

Type	Interval	Period	Action
Flexible Scheduling	50s	1-7,00:00-24:00	Remove

[Add](#)

* History storage period

* Trend storage period

Show value

New application

Applications

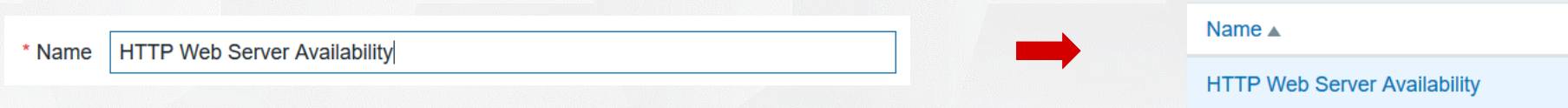
- None-
- CPU
- Filesystems
- General
- Memory
- Network interfaces
- OS
- Performance
- Processes
- Security

Populates host inventory field

Description

- ⚡ All mandatory input fields are marked with a red asterisks
- ⚡ The form changes according to the selected Type and other parameters
- ⚡ Some values like an Update interval can be set to 0 or left blank
- ⚡ [Select] button for the Key field displays list of keys for the selected item type
- ⚡ Some items (such as SNMP and JMX) need to have corresponding interface on a host.

This is how the item will be named and displayed in the other frontend sections

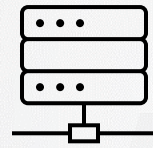


Naming guide:

- ⚡ Choose a simple, descriptive name for each item.
- ⚡ Prefix item names (metric) with object name (metric location):
 - <metric location>: <metric name>, for example:
 - Interface eth0: Bits in
 - Interface eth0: Bits out
- ⚡ You may use the # if the metric location is just a number or index:
 - #0: CPU utilization
 - #1: CPU utilization
- ⚡ Consider adding suffixes such as “per second”, “per hour”, etc., to describe the metric better.

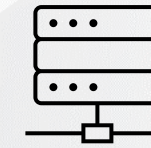


<https://www.zabbix.com/documentation/guidelines/doc>



Passive (Polling)

- Zabbix agent
- Simple check (agent-less)
- SNMP agent (v1, v2, v3)
- IPMI agent
- JMX agent
- HTTP agent
- SSH agent (pass/key)
- Telnet agent
- Database monitor (ODBC)
- External check



Active (Trapping)

- Zabbix agent (active)
- SNMP trap
- Zabbix trapper
- HTTP agent if "Enable trapping" is set



Other (processed internally)

- Zabbix internal
- Zabbix aggregated and calculated
- Dependent item

General syntax:

* Key

⚡ Key

- Predefined for some item types (Zabbix agent, Internal items, Simple checks, etc.)
- Free form string for other types (SNMP, Zabbix trapper, HTTP agent, etc.)
- Must be unique per host/template

⚡ Parameters

- Some parameters are mandatory and must be specified
- The "<>" means optional parameter

⚡ Quick reference in the frontend by pressing the [Select] button right to the item key field

Standard items ✕

Type

Key	Name
db.odbc.select[<unique short description>,<dsn>,<connection string>]	Return first column of the first row of the SQL query result.
db.odbc.discovery[<unique short description>,<dsn>,<connection string>]	Transform SQL query result into a JSON array for low-level discovery.
db.odbc.get[<unique short description>,<dsn>,<connection string>]	Transform SQL query result into a JSON array.



https://www.zabbix.com/documentation/5.0/manual/config/items/itemtypes/zabbix_agent

Flexible

```
net.tcp.listen[631]
system.hw.cpu[<cpu>,<info>]
vfs.file.contents[file,<encoding>]
```

Non-flexible

```
agent.ping
system.boottime
vfs.fs.get
```

Examples:

```
net.if.in[if,<mode>]
```

```
net.if.in[eth0]
```

```
net.if.in[eth0,]
```

```
net.if.in[eth0,errors]
```

```
proc.cpu.util[<name>,<user>,<type>,<cmdline>,<mode>,<zone>]
```

```
proc.cpu.util[zabbix_agentd]
```

```
proc.cpu.util[,root]
```

```
proc.cpu.util[,,,nginx]
```

Usage of quote marks:

Correct

```
net.if.in["eth0",errors]
```

```
log[/var/log/messages,"Error: [A-Za-z,.]"]
```

Wrong

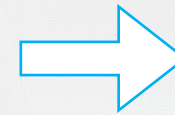
```
net.if.in["eth0,errors"]
```

```
log[/var/log/messages,Error: [A-Za-z,.]]
```

Host interface

- ⚡ An agent interface is default, preselected and used when creating a new item
- ⚡ This field is available when opening an item on the host level
- ⚡ Some item types do not use it, for example: Zabbix agent (active), Calculated, etc.
- ⚡ If multiple interfaces exist on a host, they will be available in the dropdown list

Type	IP address	DNS name	Connect to	Port
Agent	<input type="text"/>	student-XX	IP <input checked="" type="checkbox"/> DNS <input type="checkbox"/>	10050
Agent	1.2.3.4	<input type="text"/>	IP <input checked="" type="checkbox"/> DNS <input type="checkbox"/>	10050
SNMP	2.3.4.5	<input type="text"/>	IP <input checked="" type="checkbox"/> DNS <input type="checkbox"/>	161
IPMI	3.4.5.6	<input type="text"/>	IP <input checked="" type="checkbox"/> DNS <input type="checkbox"/>	623



* Host interface

student-XX : 10050

Agent

student-XX : 10050

1.2.3.4 : 10050

SNMP

2.3.4.5 : 161

IPMI

3.4.5.6 : 623

Type of the data as stored in the database

- ⚡ Numeric (unsigned) - 64bit unsigned integer
- ⚡ Numeric (float) - floating point number (Float64)
- ⚡ Character - short text data (255 characters)
- ⚡ Log - data with optional log related properties: timestamp, source, severity, eventid (64 KB)
- ⚡ Text - text data (64 KB)

If a wrong data type is selected, the item will become unsupported

- ⚡ Example: data 0.0125 (float) and type Numeric(unsigned)

Before being stored in the database, the text values get truncated to match the database value type limit.

 If upgrading from older versions, the "history" table must be manually upgraded to Float64

Units are used for the numeric data only (unsigned/float)

⚡ If set, K/M/G/T/P/E/Z/Y prefix will be added

- 5000 W -> 5 KW

⚡ Special processing to display B, Bps, unixtime, uptime, s

- 1024 B -> 1 KB
- 125 uptime -> 00:02:05
- 1589199730 unixtime -> 2020.05.11 12:22
- 61 s -> 1m 1s

⚡ Any unit can be prevented from being converted by using a <!> prefix

- 3500 !RPM -> 3500 RPM
- 10000 !W -> 10000 W
- 125 !uptime -> 125 uptime
- 61 !s -> 61 s



Units are processed by the frontend to display raw data in the human-readable format.

Retrieve a new value for this item every N seconds

- ⚡ Minimum update interval is 1 second
- ⚡ Maximum allowed update interval is 86400 seconds (1 day)
- ⚡ Time suffixes are supported, e.g. 30s, 1m, 2h, 1d
- ⚡ Defaults to seconds if a suffix is not used
- ⚡ Single user macro (variable) is supported
- ⚡ Can be set to 0 (never checked)

Update interval cannot be set for the following item types

- ⚡ Zabbix trapper
- ⚡ SNMP trapper
- ⚡ Dependent items

Passive item value can be collected immediately using the [Execute now] button.



<https://www.zabbix.com/documentation/5.0/manual/appendix/suffixes>

Flexible intervals

- ⚡ Allows to override item update interval on a specific time period
- ⚡ If multiple flexible intervals overlap, the smallest time is used
- ⚡ Update interval of 0 can be used together with a flexible interval to emulate scheduling on a specific time of the day only

* Update interval

Custom intervals

Type	Interval	Period	Action
Flexible	Scheduling	10m	6-7,00:00-24:00 Remove

[Add](#)

⚠ Not supported for the C-based Zabbix agent active checks

ℹ https://.../5.0/manual/config/items/item/custom_intervals#Flexible%20intervals

Can be used to collect values at the specific time

⚡ A scheduling interval is defined as: md<filter>wd<filter>h<filter>m<filter>s<filter> where:

- md - month days
- wd - week days
- h - hours
- m - minutes
- s - seconds

Type	Interval	Period	Action
Flexible	wd1-5h9		Remove

Add

Examples:

⚡ wd1-5h9 - every Monday till Friday at 9:00

⚡ h9m/30;h10 - execute at 9:00, 9:30, 10:00

⚡ h9-10m10-40/30 - execute at 9:10, 9:40, 10:10, 10:40

⚡ md1wd1h9m30 - every 1st day of each month at 9:30 if it is Monday

Scheduled checks are executed in addition to the "Update interval" checks

⚠ Not supported for the C-based Zabbix agent active checks

ℹ https://...5.0/manual/config/items/item/custom_intervals#Scheduling_intervals

History and trends are two ways of storing collected data in Zabbix

- ⚡ History keeps each collected value
- ⚡ Trends keep averaged information on hourly basis and therefore are less resource-hungry

You can set for how many days history or trends will be kept

- ⚡ In the item properties form
- ⚡ When mass-updating items
- ⚡ When setting up housekeeper tasks

By default, the housekeeper removes older data once in an hour

If History is set to "Do not keep history"

- ⚡ The item will update only dependent items and inventory
- ⚡ Related triggers won't be evaluated

Used space on /	
Timestamp	Value
2020-04-21 18:59:02	3493412002
2020-04-21 18:58:02	3493322752
.....
2020-04-21 18:06:02	3492265206
2020-04-21 18:05:02	3492260286
2020-04-21 18:04:02	3492254730
2020-04-21 18:03:02	3492252312
2020-04-21 18:02:02	3492251478
2020-04-21 18:01:02	3492249912
2020-04-21 18:00:02	3492249600

Raw data
60 values
(60x90 bytes)
5400 bytes

Aggregated
1 x AVG
1 x MIN
1 x MAX
1 x COUNT
4 values
80 bytes



/dev/null



https://www.zabbix.com/documentation/5.0/manual/config/items/history_and_trends

Visualise or decode values in the human-readable format

- ⚡ Used almost everywhere in the frontend and in notifications
- ⚡ Matched numerical value can be represented as a string

Configuration > Hosts > {host} > Items > [Create New] or edit existing

Show value [show value mappings](#)

Example: Monitoring > Latest data

<u>net.cisco.c2911</u>	Fans (5 Items)		
<input type="checkbox"/>	Fan 1: Fan status	2018-05-21 17:39:04	normal (1)
<input type="checkbox"/>	Fan 2: Fan status	2018-05-21 17:39:04	normal (1)
<input type="checkbox"/>	Fan 3: Fan status	2018-05-21 17:39:04	shutdown (4)

To create a new or modify an existing value map, go to Administration > General > Value mapping

Value mapping ▼ Create value map Import

<input type="checkbox"/> Name ▲	Value map	Used in items
<input type="checkbox"/> Alarm state	0 ⇒ Ok 1 ⇒ Alarm	Yes
<input type="checkbox"/> APC Battery Replacement Status	1 ⇒ unknown 2 ⇒ notInstalled	

Click [Create value map]

* Name

* Mappings

Value	Mapped to	Action
<input type="text" value="123"/>	⇒ <input type="text" value="One Two Three"/>	Remove
<input type="text" value="45"/>	⇒ <input type="text" value="Four Five"/>	Remove

[Add](#)

Add Cancel



<https://www.zabbix.com/documentation/5.0/manual/config/items/mapping>

Applications are used for logical sorting and grouping of items

🔌 Configuration > Hosts > {host} > Applications

<input type="checkbox"/>	Name ▾	Applications
<input type="checkbox"/>	Example host - Applications	Applications 2

Applications

Create application

All hosts / [Example host - Applications](#) Enabled ZBX SNMP JMX IPMI [Applications 2](#) [Items 6](#) [Triggers](#) [Graphs](#) [Discovery rules](#) [Web scenarios](#)

Filter

Host groups

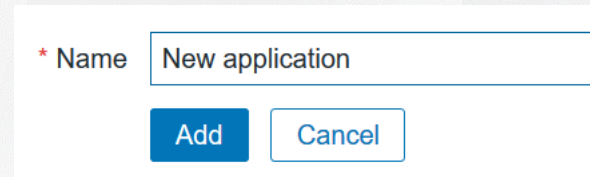
Hosts

<input type="checkbox"/>	Application ▲	Items	Info
<input checked="" type="checkbox"/>	CPU	Items 1	
<input type="checkbox"/>	Network	Items 2	

Displaying 2 of 2 found

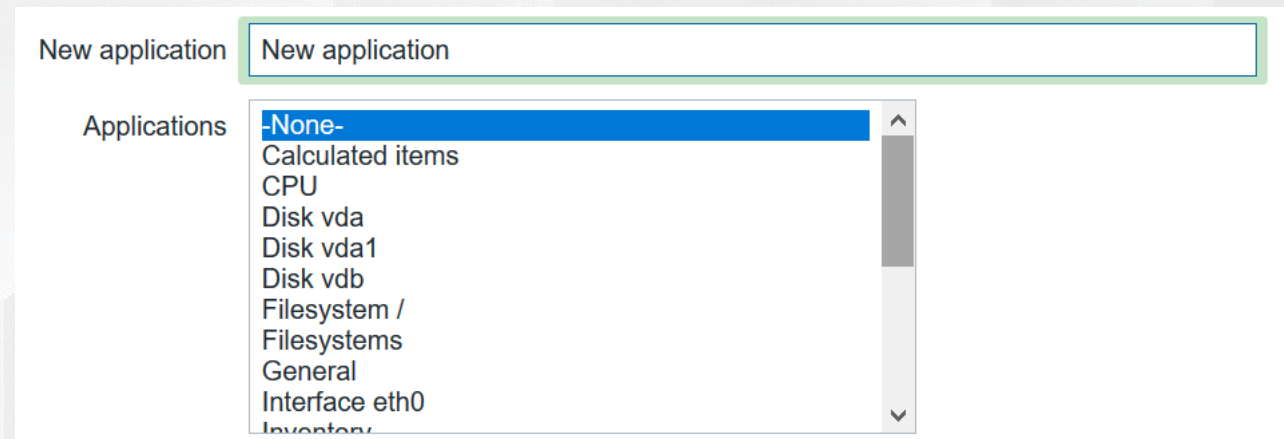
1 selected

Configuration > Hosts > {host} > Applications > [Create new application]



* Name

The same can be done during creating/modifying an item



New application

Applications

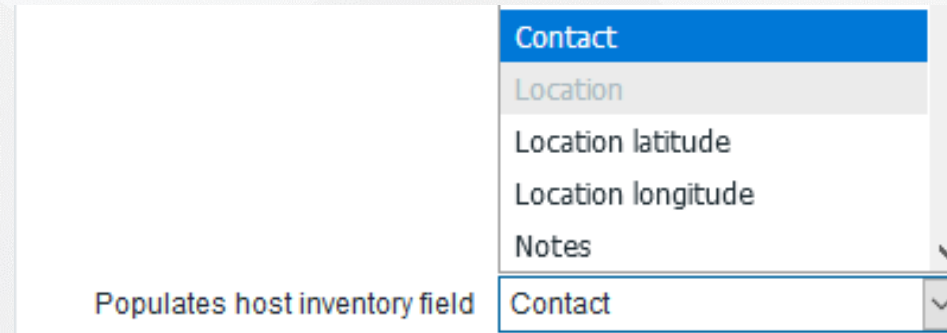
- None-
- Calculated items
- CPU
- Disk vda
- Disk vda1
- Disk vdb
- Filesystem /
- Filesystems
- General
- Interface eth0
- Inventory



<https://www.zabbix.com/documentation/5.0/manual/config/items/applications>

Select a host inventory field that the item value will populate

⚡ Grayed out if another item on the host/template is using the field



The screenshot shows a configuration form with a dropdown menu. The dropdown is open, displaying a list of host inventory fields: Contact, Location, Location latitude, Location longitude, and Notes. The 'Contact' field is selected and highlighted in blue. Below the dropdown, the text 'Populates host inventory field' is visible, followed by a smaller dropdown menu that also has 'Contact' selected.

⚡ This will work if an automatic inventory population is enabled for the host

⚡ This field is not available if the Type of information is set to "Log"



<https://www.zabbix.com/documentation/5.0/manual/config/hosts/inventory>

It is possible to test the item while creating/modifying it

- ⚡ Item key and connection parameters must be set properly
- ⚡ In the item configuration form, press the [Test] button
- ⚡ Values are processed by the frontend and not saved to the database

If unselected allows manual input

Test item

Get value from host

Host address Port

Proxy


Value **raw value**

Time

Previous value Prev. time

End of line sequence LF CRLF

Result **value as it will be stored in database** 0.57

 Available only for passive items!

Configuration > Hosts > Items

- Find items from multiple hosts, host groups
- Find unsupported items
- Further drill down by sub-filters

Items
Create item

All hosts / Zabbix server
Enabled
ZBX
SNMP
JMX
IPMI
Applications 18
Items 124
Triggers 58
Graphs 25
Discovery rules 3
Web scenarios
Filter

Host groups

Hosts
type here to search

Application

Name

Key

Type

Update interval

Type of information

History

Trends

State

Status

Triggers

Template

Discovery

Configuration > Hosts > Items

⚡ Select multiple items in the list and press [Mass update]

<input type="checkbox"/>	Wizard	Name ▼	Triggers	Key	Interval	History	Trends	Type
<input type="checkbox"/>	...	Total memory	Triggers 1	vm.memory.size[total]	1m	7d	365d	Zabbix agent
<input checked="" type="checkbox"/>	...	System uptime	Triggers 1	system.uptime	30s	2w	0d	Zabbix agent
<input checked="" type="checkbox"/>	...	System name	Triggers 1	system.hostname	1h	2w		Zabbix agent
<input checked="" type="checkbox"/>	...	Available memory	Triggers 1	vm.memory.size[available]	1m	7		

3 selected

Item Preprocessing

- Type Original
- Host interface Original
- JMX endpoint Original
- URL Original
- Request body type Original
- Request body Original

To execute a passive check immediately, press [Execute now]

- 🔊 In an existing item (or a discovery rule) configuration form
- 🔊 For selected items/rules in the list of items/discovery rules

<input type="checkbox"/>	Wizard	Name ▼	Triggers	Key	Interval	History	Trends	Type
<input checked="" type="checkbox"/>	...	Total memory	Triggers 1	vm.memory.size[total]	1m	7d	365d	Zabbix agent
<input checked="" type="checkbox"/>	...	System uptime	Triggers 1	system.uptime	30s	2w	0d	Zabbix agent

2 selected

Successful execution will return a green message

Red message - something is wrong (check the Details)

✓
Request sent successfully

⚠

[Details ▼](#)
Cannot send request

⚠ This functionality is supported for passive checks only.

📄 https://www.zabbix.com/documentation/5.0/manual/config/items/check_now


Configuration > Hosts > {host} > Items

- Single item deletion from an item configuration form
- Multiple items deletion by selecting many items

The screenshot shows the Zabbix configuration interface for a host. Three items are selected, highlighted in yellow:

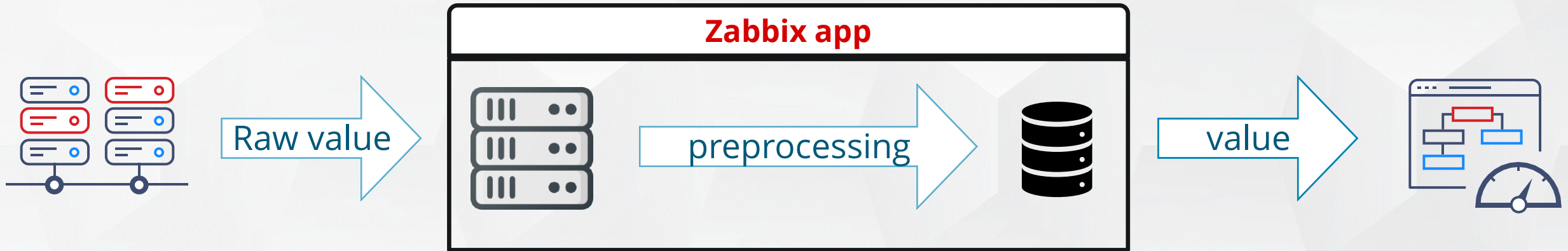
<input checked="" type="checkbox"/>	...	Template Module Zabbix agent: Zabbix agent availability	Triggers 1	zabbix[host,agent,available]	1m
<input checked="" type="checkbox"/>	...	Template Module Zabbix agent: Zabbix agent ping		agent.ping	1m
<input checked="" type="checkbox"/>	...	Template App Zabbix Server: Zabbix configuration cache, % used	Triggers 1	zabbix[r-cache,buffer,pused]	1m

Below the table, a toolbar shows "3 selected" and buttons for "Enable", "Disable", "Execute now", and "Clear history". A modal dialog box is open, asking "Delete history of selected items?" with "OK" and "Cancel" buttons. The dialog also shows a pagination control with "2", "3", and a right arrow.

 The history clean up starts immediately and might take a long time!



Preprocessing



```
{"CPU":  
{"load": {  
  "value": 11.95  
}}}
```

- 1) JSON path: `$.CPU.load.value`
- 2) Multiply: `100`

1195

Transformation rules for received values

Item Preprocessing

Preprocessing steps	Name	Parameters	Custom on fail	Actions
1:	Regular expression	<input type="text" value="^[a-zA-Z\s]+(ld+)"/> <input type="text" value="11"/>	<input checked="" type="checkbox"/>	Test Remove
	Custom on fail	<input type="text" value="Discard value"/> <input type="text" value="Set value to"/> <input type="text" value="Set error to"/>		
2:	Custom multiplier	<input type="text" value="0.125"/>	<input checked="" type="checkbox"/>	Test Remove
	Custom on fail	<input type="text" value="Discard value"/> <input type="text" value="Set value to"/> <input type="text" value="Set error to"/> <input type="text" value="0"/>		
3:	Discard unchanged		<input type="checkbox"/>	Test Remove
				Test all steps

[Add](#)

- ⚡ Multiple transformations are possible
- ⚡ Each type has its own set of parameters
- ⚡ Custom on fail allows to discard/override value or an error
- ⚡ Testing for all steps or a single step

Testing multiple steps

Test item ✕

Get value from host

Value ✎ Time

Previous value ✎ Prev. time

End of line sequence LF CRLF

Preprocessing steps	Name	Result
	1: Change per second	1122
	2: Custom multiplier	8976
Result	Result converted to Numeric (unsigned)	8976

⚡ If some step fails - an error will give a clue about what's wrong

Preprocessing steps	Name	Result
	1: Regular expression Custom on fail	❗
	2: Custom multiplier	
	3: Discard unchanged	

cannot perform regular expression "[a-zA-Zs]+(d+)" match for value of type "string": pattern does not match ✕

- ⚡ Transformations are executed in the order in which they are defined
- ⚡ The order can be changed by dragging and dropping
- ⚡ All preprocessing is done by Zabbix server and proxies
- ⚡ An item will become unsupported if any of the preprocessing steps fails
- ⚡ It is possible to react on errors and introduce recovery options

Don't change stored data	[!] Change stored data
Units	Data type (different history table)
Value mapping	Preprocessing



<https://www.zabbix.com/documentation/5.0/manual/config/items/preprocessing>

Text	Regular expression	Match regex pattern and customize output	
		Threads_cached 0 Threads_connected 39	Threads_connected.(\\d*) 39
	Replace	Find the search string and replace it with another (or nothing).	
		UP	Search string: Up; Replacement: 1 1
	Trim	Removes provided symbols on both sides (right/left)	
		C 36 C	Parameters: C 36
	Right trim	Removes provided symbols on the right side	
		C 36 C	Parameters: C C 36
		Left trim	Removes provided symbols on left side
		C 36 C	Parameters: C 36 C
Arithmetic	Custom multiplier	Value * multiplier	
		88	Parameters: 0.125 11
Change	Simple change	Value - previous value (used for counters)	
		21	Prev_value: 11 10
	Change per second	Value - previous value / time - previous time	
		Value: now=21, prev=11 Time: now=1582207687,prev=1582207682	(21-11)/(1582207687-1582207682) 2 vps

Numeral systems	Boolean to decimal	Convert the value from boolean format to decimal. Textual representation is translated into either 0 or 1
	TRUE/FALSE, up/down	=> 1/0
	Octal to decimal	
	2322	=> 1234
	Hexadecimal to decimal	
	4D2	=> 1234
Structured data	XML Xpath	Extract value or fragment from XML data using XPath functionality.
	<pre><book category="cooking"> <title>Zabbix manual</title> <price>30.00</price></book></pre>	number(/book/price) 30
	JSON Path	
	<pre>{"store": {"bicycle": { "color": "red", "price": 19.95}}}</pre>	\$.store.bicycle.price 19.95
CSV to JSON	Convert CSV file data into JSON format	
"parameter", "value"	,	[{"parameter": "diameter", "value": "12"}]
diameter, 12		

Custom scripts	JavaScript	JavaScript function with a single parameter 'value' and user provided function body. Example: to perform Fahrenheit to Celsius conversion
	68	return (value - 32) * 5 / 9 20
Validation	In range Matches regular expression Does not match regex Check for error in JSON Check for error in XML Check for error using regular expression	Multiple ways how to check received value. + <i>Custom on fail</i> => override value/error
	20	min=10, max=21 20
Throttling	Discard unchanged Discard unchanged with heartbeat	Discard a value if it's same as previous one. Received one is not saved in the database.
	v1=0, v2=0, v3=0	v2 and v3 => discarded v1=0

Prometheus

Prometheus pattern

Extract required data from Prometheus metrics.

`cpu1{cpu="cpu-u",host="host1"} 1.19``cpu1{cpu="cpu-u"}`

0.19

Prometheus to JSON

Convert required Prometheus metrics to JSON.

`cpu1{cpu="cpu-u",host="host1"} 1.19`

```
[
  {
    "name": "cpu1",
    "value": "0.19",
    "line_raw": "cpu1{cpu=\"cpu-u\",host=\"host1\"} 0.19",
    "labels": {
      "cpu": "cpu-u",
      "host": "host1"
    },
    "type": "untyped"
  }
]
```

PREPROCESSING - THROTTLING

mm:ss	Values	Discard unchanged	Discard unchanged with heartbeat 30s	
00:00	0	0	0	
00:05	0			No value because same as previous
00:10	0			
00:15	1	1	1	Received different value
00:20	1			
00:25	1			
00:30	1			
00:35	1			
00:40	0	0	0	Received different value
00:45	0			
00:50	0			
00:55	0			
01:00	0			
01:05	0			
01:10	0		0	Value written because of heartbeat 30s
01:15	0			
01:20	1	1	1	Received different value
01:25	1			
01:30	0	0	0	Received different value
01:35	0			
01:40	0			
01:45	0			
01:50	0			
01:55	0			
02:00	0		0	Value written because of heartbeat 30s
02:05	0			

Most common reasons, why an item becomes "Not supported"

- ⚡ Item key is not found
- ⚡ Item key does not allow parameters
- ⚡ Timeout during metric collection
- ⚡ Value is not available | wrong value type | too small or too large
- ⚡ No permissions | wrong credentials
- ⚡ Failed preprocessing steps

Not supported items are rechecked

- ⚡ Every 10 minutes by default
- ⚡ By pressing [Execute now]

Administration > General > Other

- ⚡ Define a refresh rate of the "Not supported" item checks

Other configuration parameters ▾

* Refresh unsupported items



Not supported items will negatively affect performance of Zabbix server



Data collection



Agent-less monitoring

Availability and performance of remote services

⚡ Syntax

- `net.tcp.service[service,<ip>,<port>]`
- `net.udp.service[service,<ip>,<port>]`
- `net.tcp.service.perf[service,<ip>,<port>]`

⚡ Examples

- `net.tcp.service[ftp]`
- `net.tcp.service[ssh,,1022]`
- `net.tcp.service.perf[http,,8080]`

Creates a TCP connection and expects specific response for

⚡ `sftp, imap, ldap, nntp, pop, smtp, ssh, telnet`

Creates a TCP connection without expecting and sending anything

⚡ `http, tcp`

Host accessibility by ICMP

Uses fping

- ⚡ Full path in the server configuration file
- ⚡ Correct suid/permission settings
- ⚡ SELinux can prevent Zabbix from running fping
- ⚡ Uses fping defaults (depends on the platform)

Source IP settings (the first default interface)

IPv6 supported by fping6 in most distributions

Supported item keys:

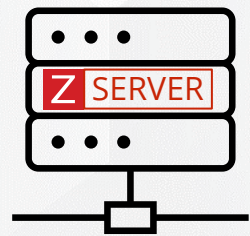
```
icmpping[<target>,<packets>,<interval>,<size>,<timeout>]
```

```
icmppingloss[<target>,<packets>,<interval>,<size>,<timeout>]
```

```
icmppingsec[<target>,<packets>,<interval>,<size>,<timeout>,<mode>]
```

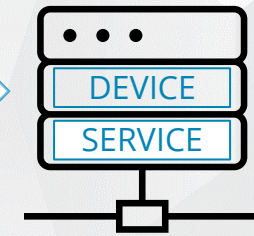
Example key: icmping[,5,10]

How it works (under the hood):



```
fping -C5 -i10 DEVICE
```

```
DEVICE: [0], 84 bytes, 0.06 ms (0.06 avg, 0% loss)  
DEVICE: [1], 84 bytes, 0.08 ms (0.07 avg, 0% loss)  
DEVICE: [2], 84 bytes, 0.06 ms (0.06 avg, 0% loss)  
DEVICE: [3], 84 bytes, 0.06 ms (0.07 avg, 0% loss)  
DEVICE: [4], 84 bytes, 0.06 ms (0.06 avg, 0% loss)
```



 fping

- -C n count of pings to send, report results in the verbose format
- -i n interval between sending ping packets (in milliseconds)



https://www.zabbix.com/documentation/5.0/manual/config/items/itemtypes/simple_checks

PRACTICAL SETUP

1. Create new:

1) Host: training.lan

- Visible name: Training Resources

- Add to group: Training/Servers

- Interface: DNS name training.lan

2) Applications:

- Simple check, Service

3) Items:

- ICMP ping

- Service Web performance

- Service NTP availability

4) Add/assign new items to the corresponding applications

2. Make sure that the items are receiving data and the results are displayed in a human-readable format

 Advanced task: Introduce throttling for the NTP item with 1h heartbeat. Why?!



QUESTIONS?



Time for a break :)