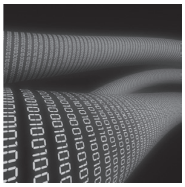


Archives of
Transport System
Telematics

Volume 11

Issue 2

May 2018

Remote Management and Monitoring of Computer Systems in Telematics

W. NOWAKOWSKI, T. CISZEWSKI, Z. ŁUKASIK
UNIVERSITY OF TECHNOLOGY AND HUMANITIES IN RADOM, Faculty of Transport and Electrical Engineering, Malczewskiego 29, 26-600 Radom, Poland
EMAIL: w.nowakowski@uthrad.pl

ABSTRACT

The development of transport systems is largely supported by telematic systems, therefore it is necessary to ensure their high availability and reliability of IT systems. The authors of the article, recognizing this important problem, have developed software for remote management and monitoring of the computer systems used in transport telematic systems. The software uses WMI (Windows Management Instrumentation) technology, which is the Microsoft implementation of Web-Based Enterprise Management (WBEM). The WMI service uses a Common Information Model (CIM) to represent managed network components (i.e. computers, printers, disks, memory, CPUs, processes). All these objects represent a set of information that could be described in a data model and can be stored in the WMI database - CIM repository. In the paper, the authors present the methodology of using this technology and its practical implementation in software. The conducted researches confirmed the great usefulness of this standard in the diagnostics of computer systems used in transport telematic systems.

KEYWORDS: telematics, computer systems management, WMI, diagnostics

1. Introduction

Nowadays the development of transport systems is largely supported by telematic systems. It is regarding both the logistics, i.e. planning, implementing and controlling the efficient flow of goods and people, as well as the freight forwarding, that is, the activity consisting of organizing transport. As the IT systems are the important part of the telematic systems and thus play a major role in transport systems it is necessary to ensure their high dependability [5, 6, 10]. By the system dependability, we mean the ability to provide system operation that can defensibly be trusted, in the tasks that this system executes. The dependability of the telematic system is characterized by following attributes:

- *reliability* – the ability to continuity of the operating within a certain time interval and in certain conditions of use,
- *availability* – the readiness to correct operation within a certain time interval and in certain conditions of use,
- *maintainability* – the system ability to self-maintenance or self-recovery under given conditions of the operation, in which it can perform the required functions assuming that the service is carried out under specified conditions, with pre-established procedures and measures,
- *integrity* – this attribute is related to confidentiality and in the broad sense it is a protection against improper changes leading to the incompatibility of the system with the original specification, e.g. as a result of unauthorized access to software or\and data,
- *safety* – this term means the absence of an unacceptable risk.

The occurrence of the telematic systems failures requires their renewal process, where the renewal process is the method of restoring of the system to the state of use. Restoration of this state is related to the system condition checking and it is a one of the tasks of technical diagnostics. In the case of computer systems, diagnostics can be carried out using various technologies [1, 4, 16].

The most commonly used standards for management and monitoring of devices in the networks are SNMP (Simple Network Management Protocol), mainly used in data networks and TMN (Telecommunications Management Network), which has traditionally been used in backbone telecommunications networks. The development of data networks and their convergence with voice networks mean that in some networks these two systems collide with each other, usually introducing SNMP management to the backbone networks. In that time, the DMI (Desktop Management Interface) standard was also often used to manage computers and devices on the network. In order to improve and standardize management methods, the Distributed Management Task Force organization (DTMF) proposed to define a new standard that would enable integrated management of the complex IT environments. As a result of DTMF's work, the Web Based Enterprise Management (WBEM) standard was developed. It includes both architecture and technologies for device, network and service management in desktop systems as well as in enterprise networks and infrastructure [18]. One of the components of the WBEM model is the formalized Common Interface Model (CIM), which is used to describe the aspects of the systems management. CIM also includes a number of standard models (schemes) for systems, applications, networks, devices and other common components, expressed in the Managed Object Format (MOF) language. This standardization allows software developers of various hardware platforms and systems to refer to management data in clearly defined and unified manner. The current version of the standard (CIM Schema version 2.50) is available at [18].

One of the best-documented and widely used implementations of the CIM model and the WBEM standard, which is used on the Windows platform, is Windows Management Instrumentation (WMI) [3, 12, 13, 15]. The authors decided to test this technology usefulness in monitoring of the telematic systems and they built their own software allowing to supervise the operation of the computer systems, which are used, among others, in telematic environments.

2. Telematic systems management

Telematics plays an important role in the control and management systems in transport by improving the movement of goods and people. Taking into account the tasks carried out, among other things, the following areas of application of telematic systems can be distinguished:

- automatic free collections and access control,
- freight and fleet management,
- traffic and travel information,
- traffic management,
- route guidance and navigation.

All these systems are based on information and telecommunication technologies (ICT). The distributed structure of telematic systems enforces the need for remote management and monitoring their computer system. Currently, WBEM is the standard management of computer systems in heterogeneous networks, and the implementation of WBEM for the Windows environment is WMI. Therefore, the WMI technology was used by the authors of the article, to develop the concept of remote management and monitoring the telematic systems. The WMI service allows to control many important computers parameters, i.e. installed software, running processes, CPU load, or disk usage.

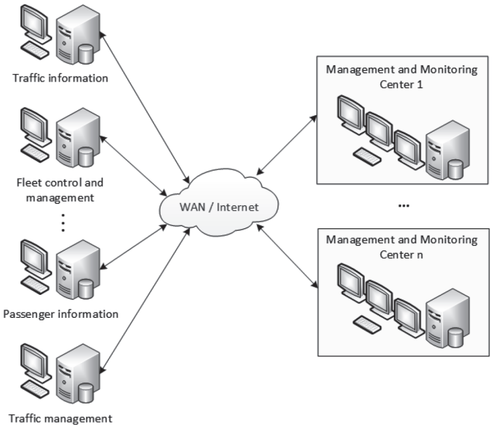

Traffic information
Fleet control and management
⋮
Passenger information
Traffic management
WAN / Internet
Management and Monitoring Center 1
...
Management and Monitoring Center n

Fig. 1. Telematic systems management and monitoring system architecture [own study]

The management and monitoring of computer systems in the case of telematic systems can be implemented remotely from local centers (Fig. 1). However, it is necessary to develop specialist software and activate the WMI service in managed computers.

3. Web-Based Enterprise Management architecture and system model

The purpose of the Web-Based Enterprise Management (WBEM) was to develop a general industry standard for computer systems management in heterogeneous networks. The assumptions provided for the possibility of unified management of various types of equipment and independence from any operating system and network architecture (Fig. 2).

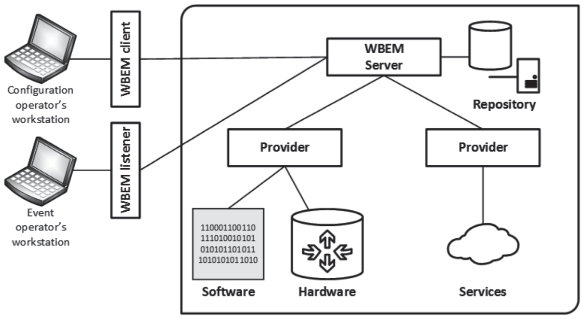


Fig. 2. The WBEM Components [own study based on 2]

The unified, common access to the managed units is carried out by using either HTTP or HTTPS protocol. To represent the managed objects and their characteristics, a Common Information Model (CIM and xmlCIM) is used.

In practice, the system operator uses the selected CLI (Command-Line Interface), GUI (Graphical User Interface) or BUI

(Browser User Interface) for management, which connects to the WBEM client API (Application Programming Interface), which in turn finds the selected WBEM server for the managed device and prepares a universal message (XML) containing the request. The server decodes the request, performs the appropriate authorization procedures, checks the defined management model and performs one of the request types related to the managed object. Usually, the operations carried out by the request can be included in the following management categories [2]: faults management, configuration management, accounting management, performance management or security management (Fig. 3).

The WBEM specification includes, among others, the following elements [18]:

1. Protocols:
   - CIM-XML (v.2.4),
   - WS-Management (v.1.0),
   - CIM-RS protocol (v.2.0).
2. Mappings:
   - WBEM URI (Universal Resource Identifier) Mapping Specification (v.1.01),
   - Representation of CIM in XML (CIM-XML, v.2.50.0),
   - WS-CIM Mapping Specification (v.1.1.0),
   - UML Profile for CIM (v.1.0).
3. Discovery:
   - WBEM discovery using the Service Location Protocol (v.1.0.1),
   - WBEM SLP Template (v.2.0.1).
4. Query languages:
   - CIM Query Language (CQL, v.1.0),
   - Filter Query Language (FQL, v.1.0.1).
5. Management profiles specifications.

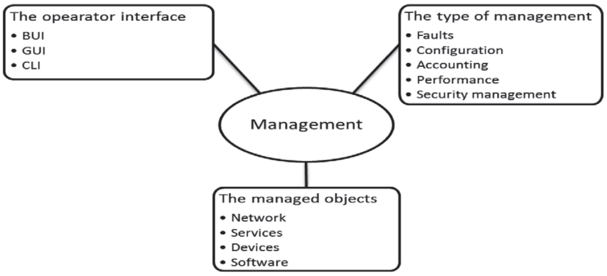


Fig. 3. Management categories [own study]

The WBEM specification should therefore be understood as a set of standards defining an environment-independent abstract layers of access to management information.

4. Windows Management Interface

The WMI, Microsoft's WBEM-compliant implementation, is a complete management infrastructure for the Windows operating systems. It integrates WBEM's concept of a common information model for management information into the Windows management framework [14]. WMI provides an interface for management data, which contains [17]:

- coherent model of the operating system state, configuration and behaviour,
- COM API that provides a single access point to all management information,
- interoperability with other Windows management services,
- flexible architecture that allows to expand the information model to include new devices, applications and services,
- WQL language and script tools that allow to supervise local and remote systems.

4.1. WMI architecture

The WMI three-tier architecture (Fig. 4) defines the following categories of elements: Management Applications, WMI Infrastructure, Providers.

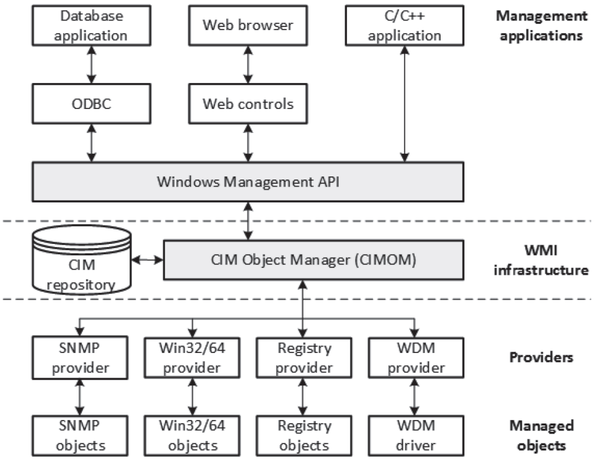


Fig. 4. WMI architecture [own study based on 14, 19]

Management Applications (called consumers) provide the operator tools for querying, enumerating data, running providers methods as well as events monitoring. There are two types of consumers: permanent consumers and temporary consumers. The permanent consumers are registered in the CIM repository and receive event notifications regardless of whether they are running. The temporary consumers receive notifications only when they are running.

The WMI infrastructure is composed of two main components: the WMI service (winmgmt), also known as Common Information Model Object Manager (CIMOM) and the WMI repository. The WMI service operates as an intermediary between the providers, management applications and the WMI repository, providing static data about objects and implementing customer requests in the form of dynamic queries of providers.

WMI providers are COM objects that monitor for WMI the logical or physical components of a managed system. The WMI providers are installed with the operating system installation (built-in WMI providers) or with any installed application that provides its own WMI providers (application-specific WMI providers).

4.2. Common Information Model

As it was mentioned above, one of the key elements of a universal management system is to have common representation of objects from the real world. This means the need for a unified data model, in which each of the objects is described by a set of its properties. Management data are acquired, stored and analysed using a common format.

The CIM standard consists of two parts: the CIM specification and the CIM schema. The CIM specification defines a data model and describes the methods of its encoding by using Managed Object Format (MOF) files or an Extensible Markup Language (xmlCIM). At the same time, the specification defines naming conventions and mapping methods, i.e. the elements necessary for cooperation with other management systems, such as: SNMP [9], DMI or CMIP. The CIM schema using classes, subclasses, instances, properties and relations represents in UML notation the data model (set of data diagrams and the relations between individual components), which is the necessary for managing systems.

It is obvious, that in a real system there are new objects for which the model has not been defined yet. We may also need to manage the features and methods of objects that are not included in the standard definitions or add new links between them. For these cases, the possibility of extending the schema definition using text files in human and machine-readable MOF format has been defined.

For the purposes of information exchange between CIM systems HTTP or HTTPS protocol, which is available in each computer, is used, and data are transferred in an universal XML format. For such needs, the standard defines cimXML - methods of transforming CIM objects into XML and their encapsulation in the HTTP protocol.

4.3. WMI Query Language

In addition to possibility of simple information browsing, WMI also provides advanced methods for retrieving information from the CIM repository. For this purpose, a specific query language, called WMI Query Language (WQL), was developed. WQL is a subset of the ANSI SQL (American National Standards Institute Structured Query Language). However, the WQL language, in order to fit the needs of WMI, has some semantic changes compared to SQL. The main difference is that you cannot modify the CIM repository information - only repository reading is allowed. WQL is mainly used to perform the following [7]:

- data queries,
- schema queries,
- event queries.

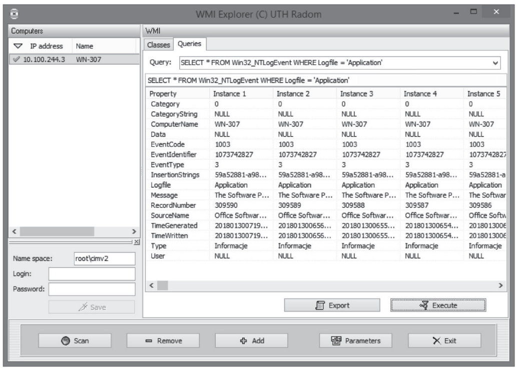
Data queries are used to retrieve class instances and data associations. They are the most commonly used type of query in WMI scripts and applications. For example, a query:

```
SELECT * FROM Win32_NTLogEvent WHERE Logfile
= 'Application'
```

requests the event log file named *'Application'* from all instances of *Win32_NTLogEvent*. In this query following WQL statements are used:

- *SELECT* - is statement to perform a data query,
- *FROM* – in this example retrieves all instances of the *Win32_NTLogEvent* class,
- *WHERE* – narrows the scope of a data, by enforcing fulfilment of the condition *Logfile = 'Application'*.

The result of this query obtained in the WMI Explorer application is shown in Fig 5.



Query: SELECT * FROM Win32_NTLogEvent WHERE Logfile = 'Application'

SELECT * FROM Win32_NTLogEvent WHERE Logfile = 'Application'

Property	Instance 1	Instance 2	Instance 3	Instance 4	Instance 5
Category	0	0	0	0	0
CategoryString	NULL	NULL	NULL	NULL	NULL
ComputerName	WN-307	WN-307	WN-307	WN-307	WN-307
Data	NULL	NULL	NULL	NULL	NULL
EventCode	1003	1003	1003	1003	1003
EventIdentifier	1073742827	1073742827	1073742827	1073742827	1073742827
EventType	3	3	3	3	3
InsertionStrings	59a52881-a98...	59a52881-a98...	59a52881-a98...	59a52881-a98...	59a52881-a
Logfile	Application	Application	Application	Application	Application
Message	The Software P...	The Software P...	The Software P...	The Software P...	The Softwar
RecordNumber	309590	309589	309588	309587	309586
SourceName	Office Softwar...	Office Softwar...	Office Softwar...	Office Softwar...	Office Softw
TimeGenerated	201801300719...	201801300656...	201801300655...	201801300654...	2018013006
TimeWritten	201801300719...	201801300656...	201801300655...	201801300654...	2018013006
Type	Informacje	Informacje	Informacje	Informacje	Informacje
User	NULL	NULL	NULL	NULL	NULL

Fig. 5. WQL sample of data query [own study]

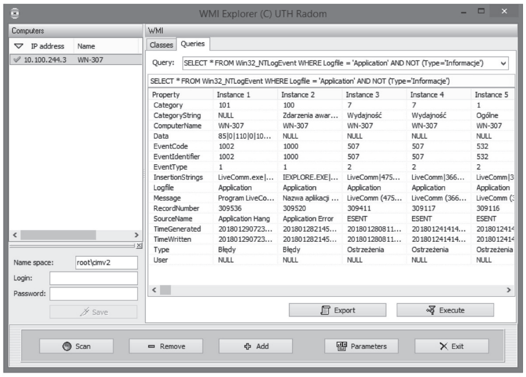
Multiple groups of properties, operators, and constants can be combined in a *WHERE* clause using logical operators (*AND*, *OR*, or *NOT*), as is shown in the following query:

```
SELECT * FROM Win32_NTLogEvent
WHERE Logfile = 'Application' AND NOT
(Type='Informacje')
```

The result of this query is shown in Fig. 6.

Next type of queries are schema queries used to retrieve class definitions and schema associations. Schema data queries use the SELECT statement with a syntax similar to that for data queries. The difference is the use of a special class called meta_class, which identifies the query as a schema query. Another difference is that only schema queries support "*" [2]. To narrow the scope of the definitions returned, a provider can add a WHERE clause that specifies a particular class, as is shown in a following query:

```
SELECT * FROM meta_class WHERE __Dynasty =
'Win32_CurrentTime'
```



Query: SELECT * FROM Win32_NTLogEvent WHERE Logfile = 'Application' AND NOT (Type='Informacje')

SELECT * FROM Win32_NTLogEvent WHERE Logfile = 'Application' AND NOT (Type='Informacje')

Property	Instance 1	Instance 2	Instance 3	Instance 4	Instance 5
Category	101	100	7	7	1
CategoryString	NULL	Zdarzenia awar...	Wydajność	Wydajność	Ogólne
ComputerName	WN-307	WN-307	WN-307	WN-307	WN-307
Data	85|0|110|0|10...	NULL	NULL	NULL	NULL
EventCode	1002	1000	507	507	532
EventIdentifier	1002	1000	507	507	532
EventType	1	1	2	2	2
InsertionStrings	LiveComm.exe|...	IEXPLORE.EXE|...	LiveComm|475...	LiveComm|366...	LiveComm|3
Logfile	Application	Application	Application	Application	Application
Message	Program LiveCo...	Nazwa aplikacji ...	LiveComm (475...	LiveComm (366...	LiveComm (3
RecordNumber	309536	309520	309411	309117	309116
SourceName	Application Hang	Application Error	ESENT	ESENT	ESENT
TimeGenerated	201801290723...	201801282145...	201801280811...	201801241414...	20180124141
TimeWritten	201801290723...	201801282145...	201801280811...	201801241414...	20180124141
Type	Błędy	Błędy	Ostrzeżenia	Ostrzeżenia	Ostrzeżenia
User	NULL	NULL	NULL	NULL	NULL

Fig. 6. WQL sample of data query with extended logical condition [own study]

Last type of queries are event queries which are used to filter events that WMI can return to an application. To discuss these queries the example of a reporting an instance modification event called __InstanceModificationEvent was used. This event is reported when an instance of a class changes in the examined namespace.

For example, for instance Win32_Service, the event reported can be due to the modification of the default startup mode of a Windows service. The query we used to filter the event was:

```
SELECT * FROM __InstanceModificationEvent
WITHIN 10
WHERE TargetInstance ISA 'Win32_Service'
```

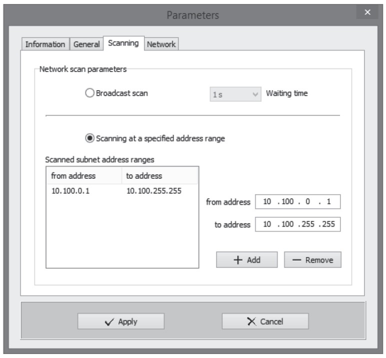
In this case, instead of performing the query on an instance (such as a data query) or on a class (such as a schema query), the query is made on the instance modification event represented by the *__InstanceModificationEvent* system class.

5. WMI Explorer

Our software the WMI Explorer has been developed to facilitate remote diagnostics of computer systems included in telematic systems. It allows:

- browse WMI classes, view instances and their properties,
- execute WQL query and view the result.

WMI Explorer is used to monitor the parameters of computers with an active WMI service. The application allows to build such a list of computers as a result of network scanning. Scanning can be performed in broadcast mode or in a specific range of IP addresses (Fig. 7).



○ Broadcast scan — 1 s — Waiting time

● Scanning at a specified address range

from address	to address
10.100.0.1	10.100.255.255

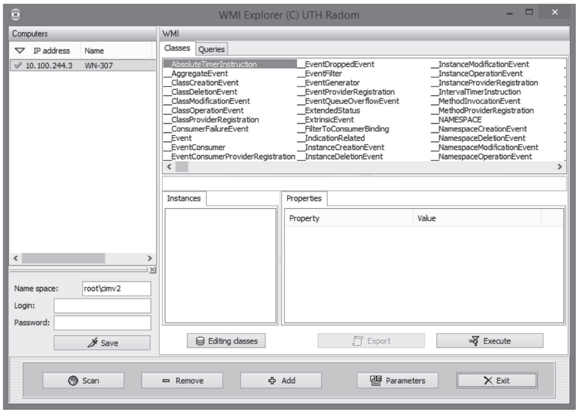
from address: 10 . 100 . 0 . 1

to address: 10 . 100 . 255 . 255

Fig. 7. WMI Explorer – network scanning parameters [own study]

After scanning all found as a result of network scanning computers are added to the list displayed in the WMI Explorer main window (Fig. 8).

Another important convenience is possibility of local\remote user authentication (user login and password) on diagnosed computer as well as possibility of changing the name space associated with the repository containing the object definitions. The application includes, by default, the namespace "root\cimv2", in which 958 classes are defined (Fig. 8). The user has the ability to edit the list of displayed classes, and thus can block the display of those classes that are not important to him (Fig. 9).



IP address	Name
✓ 10.100.244.3	WN-307

Name space: root\cimv2

Login:

Password:

Fig. 8. WMI Explorer main window [own study]

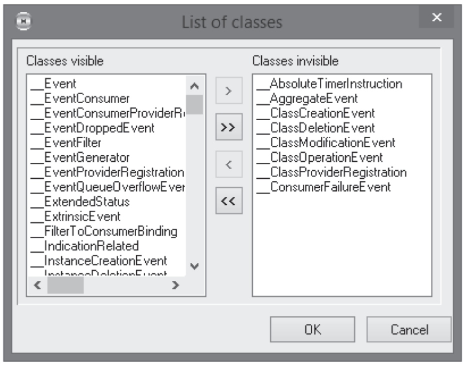
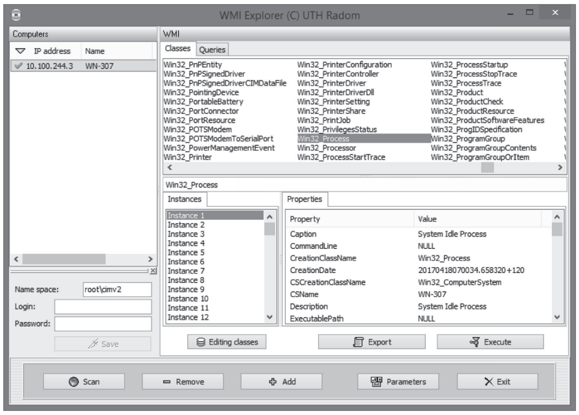


Fig. 9. Edition the class list in WMI Explorer [own study]

The basic functionality of the WMI Explorer application is to select the diagnosed computer, then to indicate the given class and view instances and their properties. The result of checking the "Win32_Process" class, which displays a list of running processes was shown in Fig. 10.



IP address	Name
✓ 10.100.244.3	WN-307

Name space: root\cimv2

Login:

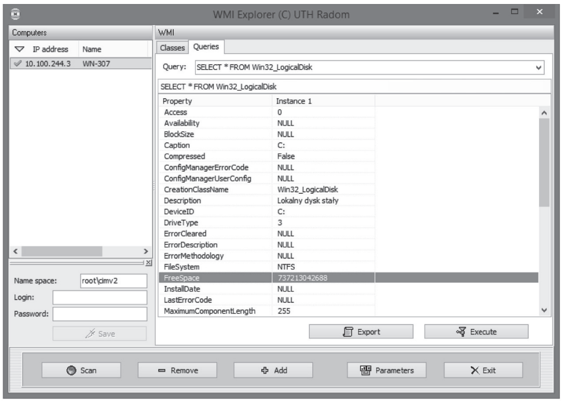
Password:

Property	Value
Caption	System Idle Process
CommandLine	NULL
CreationClassName	Win32_Process
CreationDate	20170418070034.658320+120
CSCreationClassName	Win32_ComputerSystem
CSName	WN-307
Description	System Idle Process
ExecutablePath	NULL

Fig. 10. Browse WMI classes, view instances and their properties [own study]

WMI Explorer also includes the ability to create queries using WMI Query language. In order to do this, the user should select the "Queries" tab, and then enter the query (Fig. 11). WMI

Explorer remembers the last entered commands, and thus they can be also re-selected them from the pop-up list in combo box.



IP address	Name
10.100.244.3	WN-307

Name space: root\cimv2
Login:
Password:

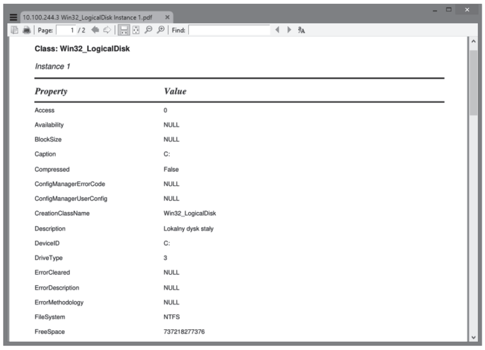
Query: SELECT * FROM Win32_LogicalDisk

SELECT * FROM Win32_LogicalDisk

Property	Instance 1
Access	0
Availability	NULL
BlockSize	NULL
Caption	C:
Compressed	False
ConfigManagerErrorCode	NULL
ConfigManagerUserConfig	NULL
CreationClassName	Win32_LogicalDisk
Description	Lokalny dysk stały
DeviceID	C:
DriveType	3
ErrorCleared	NULL
ErrorDescription	NULL
ErrorMethodology	NULL
FileSystem	NTFS
FreeSpace	737213042688
InstallDate	NULL
LastErrorCode	NULL
MaximumComponentLength	255

Fig. 11. Execute sample WQL query and view the result [own study]

An interesting feature is the ability to export the results obtained by browsing classes or through WQL queries. WMI Explorer provides reports in PDF, XLS or XML format (Fig. 12).



10.100.244.3 Win32_LogicalDisk Instance 1.pdf

Class: Win32_LogicalDisk

Instance 1

Property	*Value*
Access	0
Availability	NULL
BlockSize	NULL
Caption	C:
Compressed	False
ConfigManagerErrorCode	NULL
ConfigManagerUserConfig	NULL
CreationClassName	Win32_LogicalDisk
Description	Lokalny dysk stały
DeviceID	C:
DriveType	3
ErrorCleared	NULL
ErrorDescription	NULL
ErrorMethodology	NULL
FileSystem	NTFS
FreeSpace	737218277376

Fig. 12. WMI Explorer - sample report in PDF format [own study]

6. Conclusion

The development of IT makes them applicable in various areas of economic and social life. It also contributes to the rapid technological development of telematic systems. Progress which is undoubtedly noted must go hand in hand with maintaining high quality standards by these systems. This can be achieved by integrating work related to system testing and diagnostics as well as system reliability and safety, and thus by striving to obtain system dependability.

The various technologies used in the diagnosis of computer systems were discussed in this paper. Most of the considerations apply to the WMI standard, which is a set of Windows protocols and extensions for management and access to computer resources. The authors of the paper have checked the usefulness of this technology in the monitoring of telematic systems. The WMI Explorer software, built for this purpose, enables remote supervising and monitoring of computer systems. A large number of objects defined in the WMI repository allows for comprehensive monitoring of computers working under the supervision of the Windows operating system and the components cooperating with them. The conducted studies and tests carried out by the authors allow to confirm the high usefulness of WMI technology in the monitoring of computers used in telematic systems.

Acknowledgment

This material is based upon work supported by Polish National Center for Research and Development under Grant No. PBS3/A6/29/2015.

Bibliography

[1] CHAN K., et al.: A model-oriented framework for runtime monitoring of nonfunctional properties. 1st International Conference on the Quality of Software Architectures (QoSA 2005)/2nd International Workshop on Software Quality (SOQUA 2005), Erfurt, Germany, 2005, Quality of Software Architectures and Software Quality, Lecture Notes in Computer Science, Volume 3712, 2005, pp. 38-52

[2] HOBBS C.: A Practical Approach to WBEM/CIM Management. CRC Press, 2004

[3] ISMAIL A., HAJJAR M., EL-SAYED M.: A New Management Tools For Remote-Access Through Lan (P2P) Using Wmi Technology. World Conference on Business, Economics and Management (BEM), Antalya, Turkey, 2012, Procedia Social and Behavioral Sciences, Volume 62, 2012, pp. 824-831

[4] JAYAPUTERA J., POERNOMO I., SCHMIDT H.: Runtime verification of timing and probabilistic properties using WMI and .NET, Proceedings of the 30th EUROMICRO conference, 2004, pp. 100-106

[5] KORNASZEWSKI M., CHRZAN M., OLCZYKOWSKI Z.: Implementation of new solutions of intellignet transport systems in railway transport in Poland. Smart Solutions in Mikulski J. (ed) Smart Solutions in Today's Transport, Springer Verlag, Berlin Heidelberg, CCIS 715 (2017), pp. 282–292

[6] KUMAR R., KHAN S.A., KHAN R.A.: Revisiting Software Security: Durability Perspective. International Journal of Hybrid Information Technology (SERSC), Vol.8, No.2, 2015, pp. 311-322

[7] LISSOIR A.: Understanding WMI Scripting, Digital Press, 2003

[8] ŁUKASIK Z., PERZYŃSKI T.: Telematic Systems to Aid in Safety in Inland Water Tourism, in Mikulski J. (ed) Activities of Transport Telematics, Springer Verlag, Berlin Heidelberg, CCIS 395 2013

[9] NOWAKOWSKI W., CISZEWSKI T., ŁUKASIK Z.: The Concept of Railway Traffic Control Systems Remote Diagnostic, in Mikulski J. (ed) Smart Solutions in Today's Transport, Springer Verlag, Berlin Heidelberg, CCIS 715 (2017), pp. 471-481

[10] PERZYŃSKI T., LEWIŃSKI A.: New Telematic Solutions for Improving Safety in Inland Navigation, in Mikulski J. (ed) Smart Solutions in Today's Transport, Springer Verlag, Berlin Heidelberg, CCIS 715 (2017)

[11] PNIEWSKI R., KORNASZEWSKI M.: Global safety of Traffic Control Systems in anthropotechnical aspects. 17th International Scientific Conference Globalization and Its Socio-Economic Consequences. Proceedings, Part IV. University of Zilina, The Faculty of Operation and Economics of Transport and Communications, Department of Economics, Rajecke Teplice, Slovak Republic, 2017, pp. 2012-2017

[12] RAY D., BRADFORD P.: An integrated system for insider threat detection. 3rd International Conference on Digital Forensics, Orlando, FL, 2007, Advances in Digital Forensic III, International Federation for Information Processing, Volume 242, pp. 75-86, 2007

[13] STOEGERER C., KASTNER W.: Distributed Monitoring for Component-based Traffic Management Systems. 15th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), Bilbao, Spain, 2010, IEEE International Conference on Emerging Technologies and Factory Automation-ETFA, 2010.

[14] TUNSTALL C., COLE G.: Developing WMI Solutions: A Guide to Windows Management Instrumentation. Addison-Wesley, 2003

[15] VARELA F.: Centralized Monitoring of the Microsoft Windows-based computers of the LHC Experiment Control Systems. International Conference on Computing in High Energy and Nuclear Physics (CHEP), Taipei, Taiwan, 2010, Journal of Physics Conference Series, Volume 331, Article Number 022029, 2011.

[16] YEH M.H., LAI Y.C., LIN J.W.: An Extendable Web-based System of Managing Distributed Servers Using Ipmi and Wmi Techniques. Pakistan Journal of Statistics, Volume 28, Issue 5, Special Issue SI, 2012, pp. 551-564

[17] Microsoft Docs - Windows Management Instrumentation (WMI) https://technet.microsoft.com/en-us/library/dn265977

[18] Web-Based Enterprise Management - Distributed Management Task Force specification https://www.dmtf.org/standards/wbem

[19] WMI Architecture Basics - Microsoft TechNet Blogs https://blogs.technet.microsoft.com