Data Center Workload Analysis in Multi-Source RSMAD's Test Environment

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***Abstract*—The paper presents the system model of Radio System for Monitoring and Acquisition of Data from Traffic Enforcement Cameras, noting the used network connections and their effective throughput. The article presents the results of test verifying the performance of selected elements of designed system, in terms of image data transmission from multiple sources. Threats that could be caused by large amounts of data transmitted from multiple sources to the database server have been identified.**

Keywords-RSMAD; data center; workload; performance.

I. INTRODUCTION

Radio System for Monitoring and Acquisition of Data from Traffic Enforcement Cameras (RSMAD) provides innovative, integrated and extensive computerized system primarily used for transmission, archiving and exploration of data concerning traffic offenses. The RSMAD system is designed for the police and it is to cover the whole country with its range [1][2].

The research has been aimed at verifying the performance and capabilities of the one of the most important elements of the system – the Data Center (on the basis of the database server). It was very important to test workload of the database server in the multisource RSMAD's environment (presented in Section III).

There are many articles referring to database servers' workload. But it is difficult to find example related with testing database server workload, using many mobile sources of image data.

The paper contains system model and multi-source RSMAD's environment description, database server's performance measurments methods, and interpretation of results. The model of the system, detailing the tested elements and their parameters, will be discussed. The multi-source RSMAD's environment will be presented, including summarized possible throughput. The tests were conducted in variants presenting the actual conditions of the system performance and in variants allowing identification of the risks resulting from the larger amount of incoming data than the predicted one. Therefore, proposals to avoid such threat will be presented.

II. SYSTEM MODEL

The basic element of the RSMAD system is Traffic Enforcement Camera (TEC) enriched by Transmission Module (TM). The module's role is performed by a computer with parameters not worse than presented in Table I. The UMTS/GSM/TETRA modem (router) and dedicated application are also integral elements of the module. The application collects and processes image data from TEC and forms the transport block (compressed and cryptographically protected packet containing image data and included information (in XML format)). So, prepared data is sent by the application to the database server using FTP (*File Transfer Protocol* [3]). Transport block is transmitted using the secure VPN (*Virtual Private Network*) tunnel. The entire image data processing is also to partially relieve the Data Acquisition Center.

Database server performs several key functions in the system:

- Operates the FTP server software allowing recording the transport blocks by TM included in the RSMAD system,
- Processes the received transport blocks, providing decryption, decompression, verification and recording of image data, as well as adding the information included in transport block to database,
- Stores the image data for the application used to generate documentation of traffic tickets for traffic offenses.

The exact technical parameters of the database server are presented in Table I.

TABLE I. HARDWARE PARAMETERS OF SELECTED RSMAD'S ELEMENTS

	Transmission Module	Database Server
Processor	Intel Celeron M 1.00 GHz	Intel E7400 2.80 GHz
HDD	160 GB	250 GB
RAM	1024 MB	2048 MB
Operating system	Windows XP Home Edition x86	Windows Server 2008 Enterprise x86
Network Interface Card	Ethernet 10/100	Ethernet 10/100/1000

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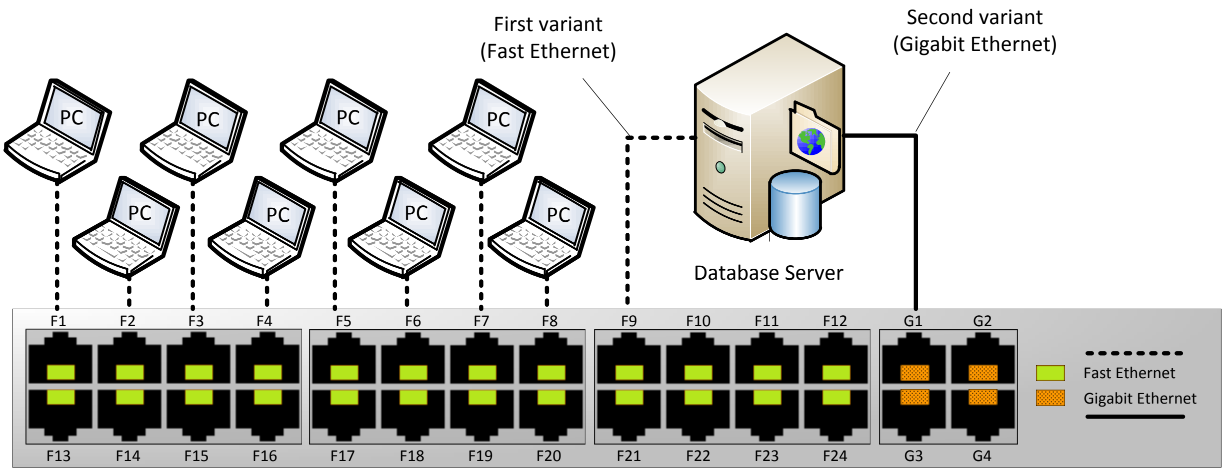

Figure 1. The test environment (2nd and 3rd variant)

Database server is just one of many elements included in the Data Acquisition Center which description exceeds the theme of this article. The detailed architecture of the RSMAD system is presented in [1][2][4].

To create the earlier mentioned VPN tunnels, the Security Gateways (ZyXEL ZyWALL 2 Plus) were used. This solution fundamentally improves the level of security of data transmitted over Internet. [5]

The transmission module, sending transport blocks from TEC, uses the selected subsystems of UMTS/GSM/TETRA for transmission of data. Selection of particular solution, as well as transmission rate offered, depends on specification of particular modem used in the system, configuration of used network and its instantaneous load. RSMAD does not limit technology of transmission which can be chosen by the operator of the system.

The target implementation of the RSMAD system should be characterized by a throughput of the database server link much greater than the throughput rate of transmission module of TEC. Such solution would significantly improve the capacity of the system and would make its work faster and more efficient [6].

III. The Multi-Source RSMAD's Environment

Traffic enforcement camera (mobile or stationary) can take 2 new photos and TM can generate 2 new transport blocks every 5 seconds. Maximum size of one transport block is 2 MB. According to these assumptions, maximum throughputs generated by 100 TMs has been presented in Table II.

TABLE II. MAXIMUM THROUGHPUT GENERATED BY 1 AND 100 TRANSMISSION MODULES

Transmission type used	Maximum throughput (1 TM)	Maximum throughput (100 TMs)
n.a. (maximum value)	6.4 Mbps	640 Mbps
HSUPA (release 6)	5.76 Mbps	576 Mbps
UMTS	384 kbps	37.5 Mbps

Maximum values (in the 1st row in Table II) were calculated on the basis of assumptions presented in the previous paragraph. Other maximum throughputs are dependent on transmission type used.

It is necessary to mention that average transport block size is much lower than 2 MB, real throughputs are lower than theoretical. In addition, mostly TECs do not take maximum number of photos, and not every localization allows for the best transmission type support. Generally, real throughputs are much lower that maximum value.

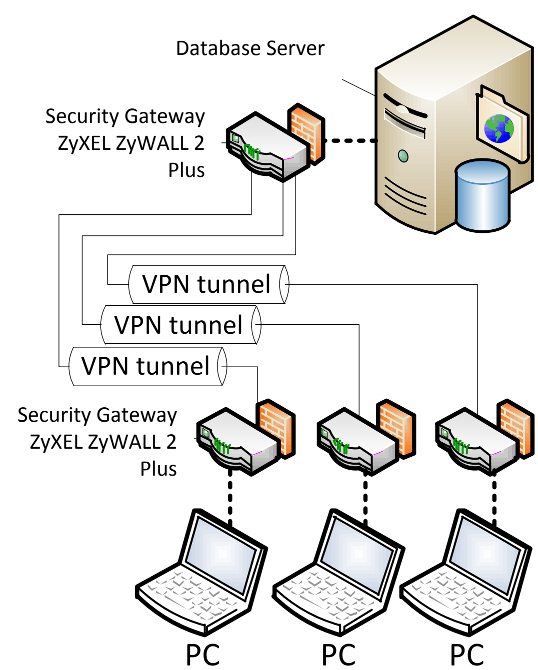

Figure 2. The test environment – the first variant.

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IV. DATABASE SERVER'S PREFORMANCE MEASUREMENTS

Due to the expected large number of supported devices, as well as a large amount of incoming image data, the database server was subjected to various performance tests. These tests checked the efficiency of the database server under the various load of its Network Interface Card (NIC), and under load of the database itself. Following the preformed tests, it was decided to further investigate the performance of the hard drive used in the test server. All tests were carried out independently to each other. Analysis of tests' results is presented in Section V.

A. Test of database server performance under Network Interface Card load – the first variant

Tests have been conducted to verify the impact of the amounts of incoming image data on the database server performance. Methods for loading of the NIC were used. Tests were carried out using the FTP server software, running on the database server, and FTP clients, running on other computers (elements of the test environment). Each FTP client was able to establish up to ten simultaneous connections.

During testing the following options backgrounds, a load on the NIC was increased – files were sent from single computer, and then gradually the number of computers sending files was successively increased. Computers and servers were equipped with Gigabit Ethernet. Server performance was measured by registering on Database Server's NIC download rate. Also the percentage usage of CPU was recorded.

In the first variant of the test environment, it was taken into account a combination of 3 FTP clients (10 connections per client) with the server using a secure VPN tunnel (the set up by Security Gateways). The first variant of the test environment is presented in Figure 2.

The maximum rate was limited to only about 20 Mbps (as presented in Table III). This was due to a high degree of transmission security, low productivity and applied Security Gateways. Such a low rate has had a negligible impact on server load – CPU usage has increased by no more than 2 - 3% in comparison to CPU load without using NIC.

TABLE III. DOWNLOAD RATES IN TUNNEL MODE – THE FIRST VARIANT OF THE TEST ENVIRONMENT

Type of IPsec	Type of hash algorithm	Type of cipher	Average data transfer rate in [Mbps]	
			Test I	Test II
ESP	**SHA-1**	**3DES**	*17,12*	*19,36*
		AES-128	*18,48*	*20,64*
		AES-256	*18,00*	*20,32*

B. Test of database server performance under Network Interface Card load – the second variant

In subsequent versions of the test environment (presented in Figure 1), the use of Security Gateways and VPN tunnel was abandoned (for tests only) to check the server performance in a much larger influx of imaging data. In target implementation of RSMAD, security gateways' performance will not influence significantly on efficiency of system work.

The only network device that mediated the transfer was a switch equipped with Fast Ethernet and Gigabit Ethernet interfaces (such solution provided the least possible impact of other devices on the effective transmission rate). Computers – clients' NICs were connected to the Fast Ethernet interfaces, and server's NIC was connected to Fast Ethernet interface of the switch.

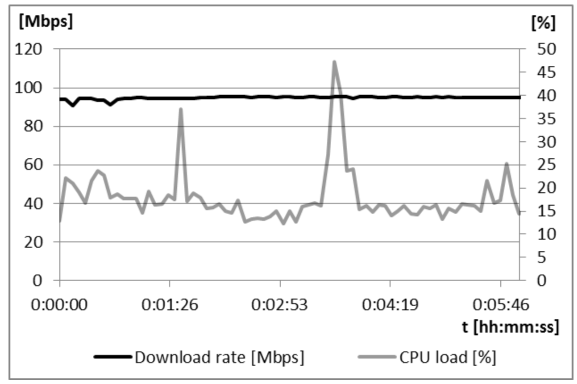

Figure 3. CPU load and NIC load (download rate) of Database Server – the second variant of the test environment.

The Database Server's NIC transmission rate at the limit standard Fast Ethernet was recorded – aggregate file transfer rate reached 96 Mbps (Figure 3). The CPU load of Database Server was in this case was about 15 – 20 %.

C. Test of database server performance under Network Interface Card load – the third variant

In the third scenario of the test environment, similar measurement methods as in the second variant were used.

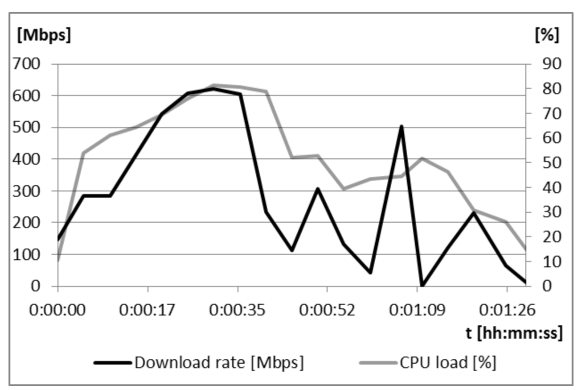

Figure 4. CPU load and NIC load (download rate) of Database Server – the third variant of the test environment.

Computers – clients' NICs were also connected to the Fast Ethernet interfaces but server's NIC was connected to Gigabit Ethernet interface of the switch. The third variant of the test environment is presented in Figure 1.

A significant load of the CPU, reaching up to 80% was observed (as presented in Figure 4). With the achievement

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rate exceeding the level of 500 Mbps, the FTP server application has stopped responding and the performance of the operating system has also been disrupted.

D. Testing of the efficiency of the database server in conditions of database load and testing of the database server's hard drive performance

During testing, the local connection to the database took place. Also, neither of the available physical NICs was used. Database environment Microsoft SQL Server 2008 was used with AES-128 database encryption. To check the performance of the database server, toughest test conditions were prepared. Each query to the database began with the forging of a new connection.

The procedure was 8 times repeated, beginning with the 1st query, each time increasing the number of requests tenfold. Additionally, all tests were 3 times repeated, and the results averaged [7].

Data saving in the database took place in a continuous manner, taking 50% of the CPU power (continuous operation of one core). Average number of queries per second (with 50% CPU load) is presented in Table IV.

TABLE IV. RESULTS OF TESTING OF THE EFFICIENCYOF THE DATABASE SERVER IN CONDITIONS OF TABABASE LOAD

Number of queries	Processing time [s]	Average number of queries per second
1	0.0170	58.82
10	0.0180	555.56
100	0.0230	4347.83
1000	0.0727	13755.16
10000	0.4773	20951.18
100000	3.9303	25443.35
1000000	35.1163	28476.80
10000000	353.4117	28295.61

In real conditions of the system operations, a database query will not be done continuously. Between queries there will be made a decryption and a decompression of the transport block. Therefore database server's load caused database work will be much lower.

Hard drive performance was tested using a dedicated application. Testing software checked maximum possible speed of data saving to hard drive. With the greatest load write speeds on the hard drive have achieved 85 MBps (680 Mbps). It should be noted that the total load of hard disk with recording generated by one application or one process may prevent the stable operation of the operating system.

V. INTERPRETATION OF RESULTS

Tests conducted in the first scenario of the test environment shows that the transmission and processing of data sent with the maximum allowed rate (for this variant) do not interfere with the work of the database server.

Second, an intermediate variant of the test environment also allows the stable operation of the database server. However, it should be noted that throughput disrupting the work rate of the device (Environmental Test - variant 3), are also feasible to achieve. This is possible by using a sufficiently large number of sources of image data (TECs) using a high-speed links (eg. HSUPA or later subsystems).

After a thorough research of the third variant of the test environment, it was found that the recorded throughput, distorting the FTP server application performance and system application, can be close to the maximum possible data read / write speed to the hard disk of the database server. A disk performance test, has confirmed the hypothesis that the system stability problems really arise when achieving a comparable throughput with a maximum speed of read / write data to the hard drive.

The work of the database server is not only limited to receiving files from multiple image data sources and its processing (e.g., image data information adding to the database). The image data or information about a specific traffic offenses stored in the data base will be used by applications for conduct the process issuing the ticket. All of these processes will load the CPU, RAM, hard drive and the Database Server's NIC.

There is a possibility of increasing the efficiency of application server through:

- The use of a hard drive with higher read/write rate,
- The use of multiple hard drives connected in the matrix increasing read/write speed in comparison to a single hard drive,
- Replacement or installation of new CPUs,
- Installation of larger amount of memory.

In case of absence of a sufficient capacity to process incoming transport blocks this task can also be differentiated between the database server and an FTP server on two physically separate servers. This solution due to the design and architecture of the RSMAD system should not create problems other than a more complex configuration of the software currently drafted.

In order to become independent on hardware, the stability of their servers should be taken care of, through its appropriate configuration on the application layer. The maximum rate allowed on the FTP server should be also limited to the level which does not cause destabilization of the server operating system's work.

VI. CONCLUSION AND FUTURE WORK

The paper identified the risks resulting from the provision of large amounts of data from multiple sources to the database server. Modifications to hardware in order to prevent overloading of RSMAD system's servers were also proposed. Moreover, the need to control system's performance, not only carried out on the hardware level but primarily at the application layer, was pointed.

With the current state of implementation of subsystems for data transmission in mobile networks, the occurrence of described risks is not expected. But they should not be

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ignored as in view of the rapid development of the 4G cellular networks, the risk of overloading the equipment with too large number of incoming data is becoming more real.

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