APPROACH IN INSTALLING AND CONFIGURING GENERAL PROGRAM MONITORING CLIENT DEVICES FOR IPTV MONITORING OF A1 AND VIVACOM

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Abstract: In the article, we address the issue of automated initialization, installation, and configuration of the General Program Monitoring, version 3 application with minimal human involvement and manipulation. General Program Monitoring is Internet Protocol TV monitoring software built from scratch. It is used to monitor the viewing behavior of customers of the television operators A1 and Vivacom. The purpose of the article is to present an approach for an automated installation and configuration process. To achieve this goal, we review the design and implementation of the software as well as the client application. The novelty of the approach is realized in a fully automated integration of the monitoring software and the procedures for its installation and configuration on the client device and the network, in the conditions of independence from the architecture of the network infrastructure and other accompanying hardware and software limitations.

Key words: Software applications, configuring software, Internet Protocol television, TV monitoring, General Program Monitoring.

1. INTRODUCTION

The expansion of a company's network architecture brings with it an increase in administration. The most significant problem in expanding a network infrastructure turns out to be the issue of increasing its complexity. When maintaining a complex network environment, it often happens that even the most experienced specialists find it difficult to operate. When solving the same tasks different administrators come to implement different solutions. The problem is further complicated by the fact that when performing routine, common network tasks repeatedly, system administrators tend to make different types of mistakes. For example, when upgrading

or partially replacing an existing network infrastructure, when optimizing existing network solutions, when integrating a new software component, critical situations leading to complications in the maintenance of the network environment increase significantly. In practice, the unified solution to these problems is known as "automation of network operations" [1, 2]. In recent years, there has been a significant increase in the transmission of video and television streaming over the Internet infrastructure. Internet Protocol Television (IPTV) is a service for providing digital content over the Internet based on the Internet Protocol (IP) [3, 4]. IPTV service has become a key product for Internet Service Providers (ISP), offering several benefits both to ISP and end-users [5]. The mass usage of IPTV makes the service economically meaningful to TV providers as well as Internet providers and advertisers [6, 7]. For that reason, the sociological agencies perform monitoring and measuring of various parameters of IPTV usage. In order to implement IPTV monitoring, a specialized software solution is needed that meets hardware, network and software specifics.

General Program Monitoring, version 3, (GPM3) is an IPTV monitoring software developed from scratch. GPM3 is IPTV monitoring software built from scratch. It is used to monitor the viewing behavior of customers of the television operators A1 and VIVACOM and has been operating in the industry for more than two years. From every client device are collected records for program name, TV status (ON/OFF), current timestamp, actual program time, etc. As a new software product, there were a number of issues to resolve in the development and integration stages. In integrating the software, the main technical problem is related to the initial installation procedures of GPM3. In this article, we address the problem of automated configuration of GPM3 with minimal involvement and manipulations by the administrator. The purpose of the article is to present an approach of a unified automated process for installing and configuring GPM3. To achieve this goal, the following are considered: design and implementation of specific software, application deployment to customers, and analysis of application operation results. The novelty of the approach consists of automating software installation and configuration of software on client device. This ensures greater independence from the network infrastructure and other accompanying hardware and software limitations.

Section 2 reviews the scientific literature on the software problem and its solution approaches, and more specifically the issues of automated installation and configuration of IPTV and device for monitoring. Section 3 examines the setup in the integration module for automated installation and configuration of GPM3 application software, providing details for network infrastructure. A common scheme for a client device hardware installation. Next, we discuss hardware and software for the GPM3, requirements for initialization and configuration procedures, etc. Section 4 describes the problem solution using integration approach. Attention has been paid to what initial state the Finite State Machine of GPM3 should be brought to by executing automated procedures of network configuration and application configuration. Section 5 discusses the achieved results in technical and economic terms. The

conclusion summarizes the contributions of the development of a module for automated installation and configuration of GPM3 and the achieved benefits.

2. LITERATURE REVIEW

2.1. Automated installation and configuration of IPTV

IPTV is a digital TV broadcasting technology that uses the Internet to deliver TV channels and on-demand content to viewers. Installing and configuring an IPTV system can be a time-consuming process, involving multiple steps such as network configuration, server setup, software installation, and channel customization [8]. Network changes are still being done manually, which means that operational expenses are 2 to 3 times greater than network cost [9]. However, with the help of automation tools, this process can be simplified and streamlined, saving time and effort [10]. One way to automate the installation and configuration of IPTV is to use a software tool such as Ansible, Puppet, or Chef [11]. These tools allow you to define the desired configuration of your IPTV system in code, which can be easily applied to multiple devices and servers. For example, you can create an Ansible playbook that installs the necessary software packages, configures network settings, and sets up the IPTV channels and Electronic Program Guide.

Another approach is to use specialized IPTV middleware solutions that provide a user-friendly interface for managing the IPTV system. These solutions often include pre-built templates and scripts for configuring the system, as well as tools for monitoring and troubleshooting. Examples of such middleware solutions are Xtream-UI, Stalker Portal, and IPTV Panel.

Overall, automated installation and configuration of IPTV can help simplify and speed up the process of deploying an IPTV system, allowing you to focus on delivering high-quality content to your viewers [12, 13].

2.2. Automated configuration of IPTV device for monitoring

The role of sociological media agencies in the chain “television provider - end user”, is to measure different viewership parameters such as: when certain program is watch, for how long, to collect statistical data for the programs in a certain time slot, to compare programs among different TV channels and other types of data. This information is analysed and sold to interested companies.

The media agencies find it difficult to collect data for monitoring via client devices which are owned of Internet provider for a number of reasons. The main two are that IPTV provider, being the owner of the client devices, is not willing to share responsibility with the media agency and data protection requires that each instance of database access must be controlled by ensuring that only authorized access takes place [14]. For development of GPM3 IPTV monitoring we use approach with adding network bridge (see Fig. 1) [15]. This approach is preferred by media agencies because it allows for defining the legal positions of the user and agency irrespective of the IPTV partner or any other third party.

Once you have installed and configured your IPTV system, the next step is to configure the individual devices that will be used to access the IPTV channels. This can include IPTV set-top boxes, smart TVs, mobile devices, and web browsers [16]. Configuring each device manually can be time-consuming and error-prone, especially if you have a large number of devices [17, 18].

To automate the configuration of IPTV devices, you can use various tools and techniques. For example, some IPTV middleware solutions provide a device management feature that allows you to remotely configure the devices from a central location. This can include setting up the network connection, selecting the channel list, and customizing the user interface [19].

Another approach is to use device provisioning tools such as Zero Touch Provisioning (ZTP) or Simple Network Management Protocol (SNMP). These tools allow you to define the device configuration in advance and then automatically apply it to the devices when they are connected to the network. For example, you can use ZTP to automatically configure the network settings, firmware updates, and security policies on a set-top box as soon as it is plugged in [20, 21].

Overall, automating the configuration of IPTV devices can help save time and reduce errors, allowing you to provide a seamless and consistent user experience across all devices [22, 23]. However, these solutions are not directly applicable to the installation and configuration of IPTV devices monitored with GPM3. According to the [24] network traffic is very diverse and stochastic in nature, is divided into two categories: functional (transactional) traffic and background, which are two basic approaches for its monitoring. In the case of GPM3, the second approach is used.

GPM3 is a software application that has been developed for the purpose of monitoring viewing behaviour of customers of the television operators. One of its main features is that it will be independent of the technology and devices of the providers. For this reason, GPM3 is installed on an additional device with the expressed consent of users of the service (See Figure 1). Infrastructure, technology, and software are covered in detail in a separate publication [15]

3. SETUP

3.1. Infrastructure

The TV providers offer their service in form of package consisting of subscribed channels, hardware device (set-top box) and distribution network. Subscription packages are standardized and the client the one best suited for his needs. Set-top boxes are usually android based devices which function as endpoint for IPTV. They receive the channel in form of Transmission Control Protocol (TCP) or User Datagram Protocol (UDP) stream, decode the packets and provide High-Definition Multimedia Interface (HDMI) output to subscriber TV. They are operated by a remote control which for IP TV provides much more options than the regular aerial or cable TV. Rewind backwards, rewind forward, pause, go back to point in time just to name

a few. According to the head end equipment and the TV provider the set top box varies as hardware and capabilities.

In order to collect data for watched TV programs the monitoring company has two options. The first option is to install monitoring software in the set-top box which will collect the data and send it to a server for processing later. However, this approach has several drawbacks. First the monitoring entity must obtain the permission of the TV provider to install applications on the set top box. And the TV providers are numerous and set top boxes are of several flavours this task soon becomes unmanageable. Besides, the operating system updates have to be accounted for and monitoring application may not be written in programing language supported by it, and the monitoring server has to be collocated in TV providers network, etc. Technical drawbacks are numerous. The second option is to use an independent device. It avoids all complications mentioned above and also takes into account other specific requirements. The household members in the monitored family should always register with their name when watching TV. Same applies for guests and visitors. That's why we chose the second option, shown of Figure 1. It ensures independence for TV provides and their equipment and by a separate remote control satisfies user registration requirement.

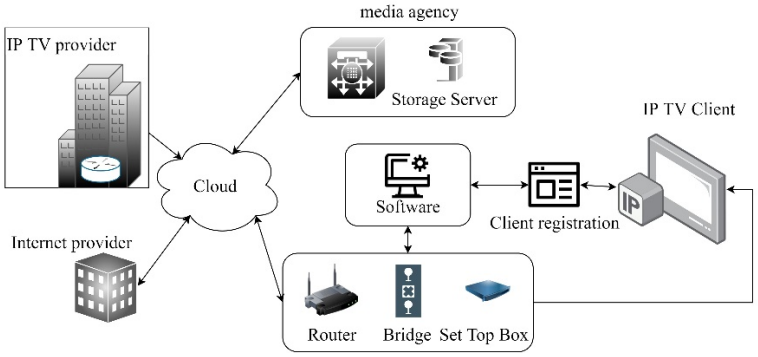

Figure 1. Architecture for network in IPTV monitoring via GPM3

3.2. Hardware and software selection

The TV monitoring device should be small in size, preferably cheap, with several Network Interface Cards (NICs), display and infrared capabilities. Our choice was Raspberry Pi 4. It has 40 pin industrial bus for connecting external devices, 4 Universal Serial Bus (USB) ports, built-in Ethernet, Wi-Fi interfaces. As an operating system (OS) we chose Ubuntu server because it has all needed components. The monitoring application is written in Python and mainly using Scapy network library. It is transparent for the user and acts as a network bridge between TV provider's network and the set-top box. While relaying traffic it sniffs the TV stream and collects necessary information. It also is the point of user registration, monitor data processing and dispatch. As of current it is called General Program Monitor, version 3.

3.3. Initialization procedure requirements

Every new device installation is unique. There has to be followed numerous steps and input to be provided. The technician must first ensure that the monitoring software is the most recent version, if not it must be downloaded from the deployment server and installed. All configuration information must be provided in correct order and be verified. The name of household members, map the names to remote control buttons for registration, register the new household with unique number, register the device with unique id, configure collection server, configure Ethernet interface, configure Wi-Fi interface, if necessary, configure Internet provider, configure IPTV provider, configure collection server and so on, and so forth. The list is lengthy. And at the end test are made to make sure everything functions as expected. The procedure is not simple and quite tricky.

In order to prevent common errors during configuration and testing we decided to create an initialization module. The module cuts the time for the initialization procedure many folds. It also provides standardization and errors diminished more 10 times.

4. SOLUTION

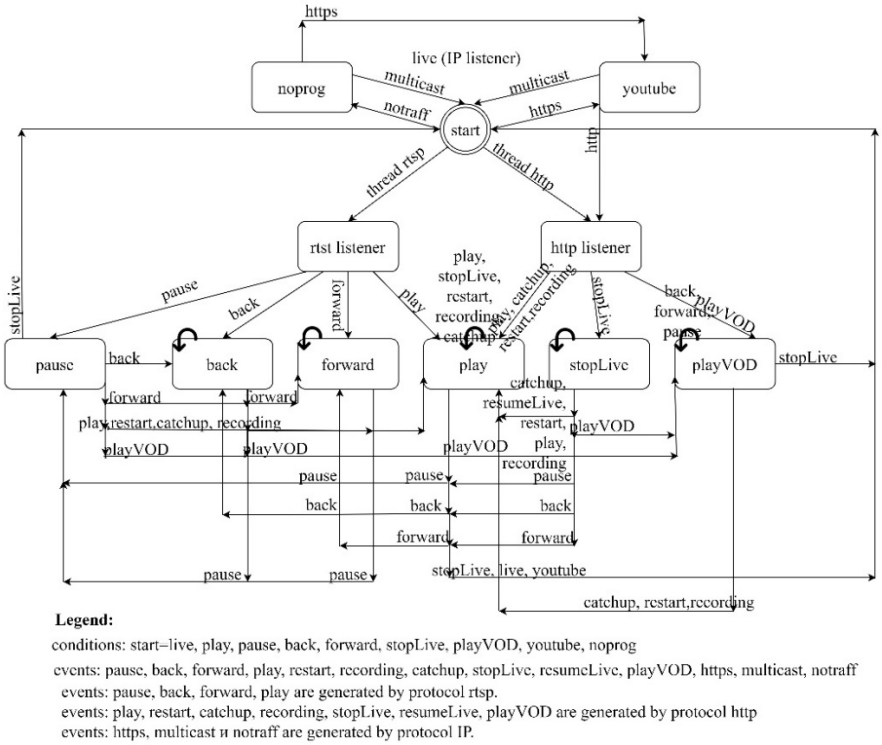

Figure 2. Finite-state machine of the GPM3 states

The core of the GPM3 monitoring process is a software implementation of a Finite State Machine (FSM), shown in Figure 2. The automated installation and configuration approach under consideration is a network integration of software on a client device that is compatible and functional with the client network infrastructure, but is depending on its architecture, technology and software. This means in practice that after the technical assembly of the physical device and wiring, the installation and configuration approach should bring the FSM to the "start" initialization ready state, shown in Figure 2.

Since this process involves several procedures, we will give a schematic view in three separate figures accompanied by relevant explanations. As we can notice, Figure 3 is divided into three parts: Network configuration, Application configuration and Final configuration, which represent three separate flows of automation and interpretation of the procedures. Network configuration and Application configuration reveal the two main flows of initialization procedures, while Final configuration shows the parallel flow of the process.

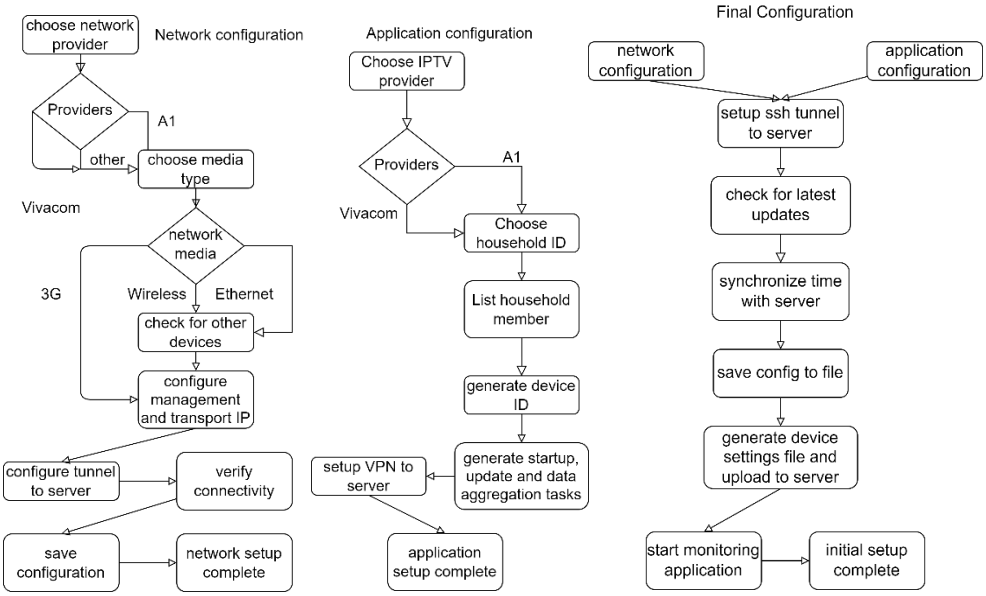

Figure 3. Network configuration, Application configuration and Final configuration.

There are several choices for network setup: 3G modem connection, Wi-Fi connection, Ethernet connection. If the connection is 3G then we must choose provider (A1/VIVACOM) to apply appropriate configuration and 3G model type to install and load kernel driver. If Wi-Fi connection is chosen, then the technician provides Service Set Identifier (SSID) and password to connect to access point (AP). A second interface for administration purposes is also configured and a network scan is carried

out to find any device in the administration subnet. Many households have more than one TV and monitoring devices. We must make sure no IP address conflicts happen. If Ethernet interface is also selected, then similar steps are performing for Ethernet network too. Then a tunnel is setup to the monitoring server. The tunnel is needed for administration and troubleshooting. After successful setup the network configuration is saved to device. Afterward a unique id for the device is generated for bookkeeping purposes and the hostname is changed to it. A household id is generated according to company policy, all member names are provided and mapped to digit for remote control register. An IPTV provider and version is chosen to start the corresponding monitoring script. At last, Secure Socket Shell (SSH) tunnel with public key authentication is configured with a remote server for data collection. A cron table entry is added to the device for software updates check and Network Time Protocol (NTP) synchronization. If new software version is available, the it is downloaded and started. All relevant configuration information is saved and uploaded to the server for later reference.

5. RESULTS AND DISCUSSION

GPM3 is a commercial software application that was developed based on the economic principle of return on investment. As such, some important economic results have been achieved through the development of an automated installation and configuration module. Figure 4 shows the automatic installation and configuration, which does not require highly specialized technical knowledge of software, network, protocols, etc. With the development of a module for automated installation and configuration of GPM3, the requirements for the qualification of the technical specialist are significantly reduced. In addition, the time spent for device configuration decreased many times. Instead of consuming hours of highly trained staff to configure each individual monitoring device, now configuration is trivial. Time spent is minutes instead of hours and employees can spend their efforts more productively. However, these results are a direct consequence of the technical merits of the automated installation and configuration module.

In the network infrastructure of IPTV service providers, different generations of devices, different software and its versions coexist, which are not always compatible both internally and with external devices. The installation of a new type of software, at different points in the network, creates different types of conflicts that cannot be predicted. Creating a unified installation and configuration procedure is a labor-intensive task, but once programmed, the benefits are numerous. One of the benefits of installation automation is process unification. The process is divided into manageable steps with strictly defined order. At each step the technician is asked a single question, the input is checked, and the result is immediately available. At every step tests are performed to verify success or failure and if necessary the process is terminated until errors corrected. All output is saved in consistent manner and uploaded to server for reference. Another benefit is a tremendous drop in configuration errors.

Before installation automation each household usually required several visits of a qualified person. This was due to errors or skipping configuration steps. Although we do not have statistical data, we can confidently say that after putting the deployment script into action the error rate dropped tenfold both as number and discovery time.

For the software module for unified initialization, no metric was applied to evaluate the speed and memory of the installation and configuration of the client network and GPM3, since the process takes several seconds when working with Raspberry Pi 4 and the OS Ubuntu Server 64 bit for ARM architecture. No such measurements have been observed in the scientific literature, however, a comparison of the performance of the GPM3 module on different operating systems may be of interest in future research. Why this question is not relevant at this stage is discussed in a separate publication [15].

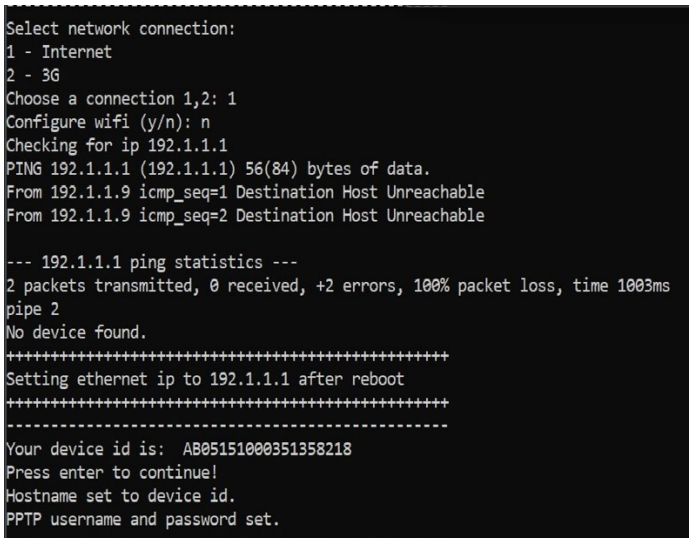

Figure 4. Automated installation and configuration of GPM3

6. CONCLUSION

GMP3 is a software application for monitoring IPTV on end-user devices. The application has been in use for two years and has proven effective over this period in monitoring A1 and VIVACOM customers. The application is not dependent on the web network and architecture, which is why it can be successfully used in other companies as well. It runs on Raspberry Pi 4 with the OS Ubuntu Server 64 bit for ARM architecture but is platform independent of OS and hardware configuration. The software is designed to function independently of the Internet provider, the IPTV provider, and the client hardware.

In the article, we presented the development of a GPM3 module for unified initialization and its application as an approach for automated installation and configuration of client software and network. The development of the GPM3 unified initialization module leads to direct economic effects, as the time for hardware and software installation is reduced many times. The main contribution of approach integration is in improving the quality of service for the end user. Before the development of the module, as discussed, all configuration information must be provided in correct order and be verified, which includes the name of household members, map the names to remote control buttons for registration, register the new household with unique number, register the device with unique id, configure collection server, configure Ethernet interface, configure Wi-Fi interface, if necessary, configure Internet provider, etc. After the development of the module, in practice, the software installation takes a few seconds, while the hardware wiring from 15 minutes to half an hour for each customer. The most significant benefit of the integration of the approach is in the avoidance of errors due to the unified and automated process.

The future development of the research is related to the realization of the functionality for monitoring multiple user devices in the same household.

REFERENCES

[1] Hämäläinen, S., Sanneck, H., Sartori, C. *LTE Self-Organising Networks (SON): Network Management Automation for Operational Efficiency*, John Wiley & Sons, January, UK, 2012.

[2] Mihăilă, P., Bălan, T., Curpen, R., Sandu, F. Network automation and abstraction using Python programming methods. *MACRo 2017 - Proceedings of the 6th International Conference on Recent Achievements in Mechatronics, Automation, Computer Sciences and Robotics.* Volume 2: Issue 1, 2017, p.95–103, DOI: https://doi.org/10.1515/macro-2017-0011

[3] Chen, Z., Yin, Y., Lu, X., Yang, J., Wang, Y. Overview of IPTV development in China. In book *Signal and Information Processing, Networking and Computers. Lecture Notes in Electrical Engineering*, (eds. Wang, Y., Xu, L., Yan, Y., Zou, J.), vol 677, Springer, Singapore, 2021, pp 799-807, https://doi.org/10.1007/978-981-33-4102-9_96

[4] Zeadally, S., Moustafa, H., Siddiqui, F. Internet Protocol Television (IPTV): Architecture, trends, and challenges. *IEEE Systems Journal*, vol. 5, no. 4, 2011, pp. 518-527, doi: 10.1109/JSYST.2011.2165601.

[5] Frnda, J., Nedoma, J., Vanus, J., Martinek, R. A Hybrid QoS-QoE estimation system for IPTV service. *Electronics,* vol. 8, no. 5, 2019, p. 585, https://doi.org/10.3390/electronics8050585

[6] Kim, M., Kim, J., Park S. Understanding IPTV churning behaviors: Focus on users in South Korea. *Asia Pacific Journal of Innovation and Entrepreneurship*, vol. 11, No. 2, 2017, pp. 190-213, doi:10.1108/apjie-08-2017-026.

[7] Mu, M. et al., Quality evaluation in peer-to-peer IPTV services. In book *Data Traffic Monitoring and Analysis. Lecture Notes in Computer Science*, (eds. Biersack, E., Callegari, C., Matijasevic, M.) vol. 7754. Springer, Berlin, Heidelberg, 2013, pp. 302-319 https://doi.org/10.1007/978-3-642-36784-7_12

[8] Barry, M., Tamgno J., Lishou, C., Cisse, M., QoS impact on multimedia traffic load (IPTV, RoIP, VoIP) in best effort mode. *2018 20th International Conference on Advanced Communication Technology (ICACT)*, Chuncheon, Korea (South), 2018, pp. 694-700, doi: 10.23919/ICACT.2018.8323886.

[9] Bwalya, B., Zimba, A. An SDN approach to mitigating network management challenges in traditional networks. *International Journal on Information Technologies and Security*, vol.13, no.4, 2021, pp. 3-14.

[10] Pelivani, E., Besimi, A., Cico, B., An empirical study of user interface testing tools. *International Journal on Information Technologies and Security*, vol.14, no.1, 2022, pp. 37-48.

[11] Hristov, Hr., Ignatov, A. Automated management of network infrastructure. *Mathematics and Informatics*, vol. 64, no. 6, 2019, pp. 602-615.

[12] *Example for Connecting to the CDN Server to the IPTV Network Through Two Switches That Form a Dual-Node Cluster on the Ring Network*, support.huawei.com, [Online]. Available: https://support.huawei.com/enterprise/en/doc/EDOC1000069520/d90411b7/example-for-connecting-to-the-cdn-server-to-the-iptv-network-through-two-switches-that-form-a-dual-node-cluster-on-the-ring-network. [Accessed: Mar. 25, 2023]

[13] Kalbandia, I., Pawar, M., Nikhilkumar, B., Bachate, R., IPTV software process and workflow. *Procedia Computer Science,* 50, 2015, pp. 128-134, https://doi.org/10.1016/j.procs.2015.04.074

[14] Norjihan Abdul Ghani, Harihodin Selamat, Zailani Mohamed Sidek. *Journal of Web Engineering*, Vol. 14, No.3&4, 2015, pp.346-360 https://journals.riverpublishers.com/index.php/JWE/article/view/3881

[15] Hristov, Hr., Cheresharov, S., Valkanov, V., Ignatov, A., IPTV monitoring via GPM3 for A1 and Vivacom, *2022 IEEE 11th International Conference on Intelligent Systems (IS)*, Warsaw, Poland, 2022, pp. 1-6, doi: 10.1109/IS57118.2022.10019660.

[16] Mahimkar, A., A., et al., Towards automated performance diagnosis in a large IPTV network. *ACM SIGCOMM Computer Communication Review*, vol. 39, no. 4, 2009, pp. 231–242, doi: https://doi.org/10.1145/1594977.1592596.

[17] Tsietsi, M., Musvibe, R., Terzoli, A., Wells, G. Towards IPTV service discovery and selection in an IMS environment. *International Congress on Ultra Modern Telecommunications and Control Systems,* 2010, pp. 195-201, doi: 10.1109/ICUMT.2010.5676637.

[18] Mingardi, C., Brunner, M., IPTV quality of service management in home networks. *2009 IEEE International Conference on Communications,* 2009, pp. 1-5, doi: 10.1109/ICC.2009.5199103.

[19] Park, C., Jeong, K., Kim, S., Lee, Y., NAT issues in the remote management of home network devices. *IEEE Network*, vol. 22, no. 5, 2008, pp. 48–55, doi: https://doi.org/10.1109/MNET.2008.4626232.

[20] Iniewski, K., *Internet Networks: Wired, Wireless, and Optical Technologies*. United States: CRC Press, 1st edition, 2018.

[21] Kesavan, S., Senthilkumar, J., Suresh Y., V. Mohanraj, IoT device onboarding monitoring and management: Approaches challenges and future. In book *Challenges and Opportunities for the Convergence of IoT Big Data and Cloud Computing,* (ed. S. Velayutham.), *IGI Global*, pp. 196-224, 2021, DOI: 10.4018/978-1-7998-3111-2.ch012

[22] Komosny, D., Ganeshanm K., Jelinekm M., Burget, R., Scalability issues with the hi erarchical feedback aggregation for large-scale IPTV systems. *Proc. Seventh Int'l Network Conf*., 2008. pp15-26

[23] Stavrev, S., Terzieva, T., Golev, A., Integrating third-party services using brokers in the serious games' domain, *TEM Journal*, vol. 7, no. 4, 2018, pp. 842-848, doi: 10.18421/TEM74-23

[24] Romansky, R. Evaluation of experimental data from monitoring and simulation of network communication parameters, *International Journal on Information Technologies and Security*, vol. 14, No. 2, 2022, pp. 75-86.

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