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An Efficient Interoperability Analyzer for Seamless Multimedia Content Access

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Abstract

In home networks, multimedia content sharing has become commonplace. An open industry standard for seamless multimedia content access, called Digital Living Network Alliance (DLNA), provides guidelines designed to facilitate contents discovery, management, sharing, and distribution in consumer environment. Consumer experience with DLNA certified devices, however, has been rather poor and usability not up to speed. Despite the availability of DLNA interoperability guidelines, manufacturer customizations often lead to limited compatibility. Such compatibility issues lead to limited interoperability and are difficult to identify. In order to solve these problems, the design and implementation of an interoperability analyzer for DLNA devices is presented in this paper. The proposed analyzer monitors the home network, performs analysis of the underlying protocols used by DLNA, and identifies compatibility and interoperability issues between the devices. Especially, its Filter Component extracts only data relevant to DLNA in order to reduce the amount of analysis data and provide the user with only useful information. In addition, its Parser Component retrieves data from the database, parses the data, and performs conformance analysis.

Keywords: *Analyzer, DLNA, Home Network, Interoperability, Protocol.*

1 Introduction

Consumers today are acquiring, viewing, and managing an ever increasing amount of multimedia content, due to the advances in home networks and the proliferation of smart devices such as smartphones, tablets, and smart TVs. There is high consumer interest and demand for accessing multimedia content from one consumer device to another. Consumers want to enjoy digital entertainment content easily and conveniently across different devices, regardless of the location of the source. The Digital Living Network Alliance (DLNA) has been formed to address such consumer needs and to provide interoperability guidelines based on open industry standards for seamless multimedia content access [1]-[7]. DLNA enables streaming of multimedia content between devices connected to the same home network, using either wired or wireless connection, without having to store the content on both devices [8]. DLNA is one of the most popular ways of multimedia sharing in the home network, with many networked multimedia consumer electronic devices supporting it in one form or the other. Before being made commercially available, devices implementing DLNA guidelines are tested and certified for compatibility and interoperability. However, consumer experience with DLNA has been rather poor and usability not up to speed. First of all, DLNA is not easily identified. DLNA goes by many different commercial names such as AllShare, SmartShare, Simple Share, etc. Therefore, consumers often do not realize that the devices that use these different commercial names actually provide the same DLNA based technology and that they are supposed to interoperate. In addition, manufacturer customizations extend media compatibility to formats that aren't included in the guidelines. Hence, despite being DLNA certified products, there are cases when products from different manufacturers are unable to share multimedia content, leading to consumer confusion and frustration. Therefore, in this paper, an efficient interoperability analyzer for DLNA devices is presented. The proposed analyzer monitors the home network, identifies the connected DLNA devices, and examines the underlying protocols. It analyzes compatibility and interoperability issues between devices or problems in the network and provides troubleshooting guidelines to the user. In order to reduce the amount of analysis data and provide the user with useful information, it has a Filter Component which extracts all data irrelevant to DLNA. In addition, its Parser Component retrieves data from the database, parses the data, and performs conformance analysis. The remaining of this paper is organized as follows. A review of the DLNA guidelines is provided in Section 2. Section 3 discusses the interoperability problems identified with DLNA usage in the consumer scenario. In Section 4, the design and implementation of the proposed analyzer is detailed. In Section 5, Some experimental results are shown to evaluate the proposed interoperability analyzer. Concluding remarks along with future work and improvements are mentioned in Section 6.

2 Review of DLNA Guidelines

The DLNA guidelines are composed of several industry standards such as Hyper Text Markup Language (HTML), Extensible Markup Language (XML), General Event Notification Architecture (GENA), Simple Object Access Protocol (SOAP), Universal Plug and Play (UPnP), Internet Protocol (IP), etc. Future DLNA guidelines may broaden to cover new areas, as new technology and standards become available. UPnP shown in [9]-[11] is the most important protocol used in DLNA guidelines and is deeply involved in the overall operation of DLNA. The UPnP Device Control Protocol (DCP) framework is exploited for device/service discovery and control. It provides automatic network self-configuration, neighbor devices and capabilities discovery, and control functionality. The UPnP Audio/Video (AV) technology in [11] offers media management and control solution for DLNA and enables devices and applications to identify, manage, and distribute media content across the home network. Also, it defines the interaction model between UPnP AV devices and associated control point applications. The DLNA guidelines define three different types of device categories: Home Network Device (HND), Mobile Handheld Device (MHD), and Home Infrastructure Devices (HID). In the HID category, there are Digital Media Server (DMS), Digital Media Player (DMP), Digital Media Renderer (DMR), Digital Media Controller (DMC), and Digital Media Printer (DMPr). The DMS stores content and makes it available to network. The DMP finds content offered by a DMS or Mobile Digital Media Server (M-DMS). The DMP provides playback and rendering capabilities and is not visible to other devices like DMC or Mobile Digital Media Controllers (M-DMC). The DMR is similar to the DMP where it renders or plays content received from a DMS or M-DMS, whereas it is unable to find content on the network and has to be set up by a DMC or M-DMC. The DMC finds content offered by a DMS or M-DMS and matches it to the rendering capabilities of a DMR. The DMPr provides printing services to the home network. The MHD differs from the HND in terms of the supported interface and media format. The functionality of M-DMS, M-DMC, and Mobile Digital Media Player (M-DMP) are equivalent to DMS, DMC, and DMP, respectively. The Mobile Digital Uploader (M-DMU) sends content to an M-DMS or DMS with upload functionality. The Mobile Digital Media Downloader (M-DMD) finds and downloads content exposed by an M-DMS or DMS and plays the content on the M-DMD. The HID provides the interoperability between the HND and MHD. Mobile Network Connectivity Function (M-NCF) plays a role of the bridge between mobile device networks and home networks, and Media Interoperability Unit (MIU) provides content transformation between required media formats for home networks and mobile devices.

The DLNA media format in [12] is presented to accomplish an interoper-

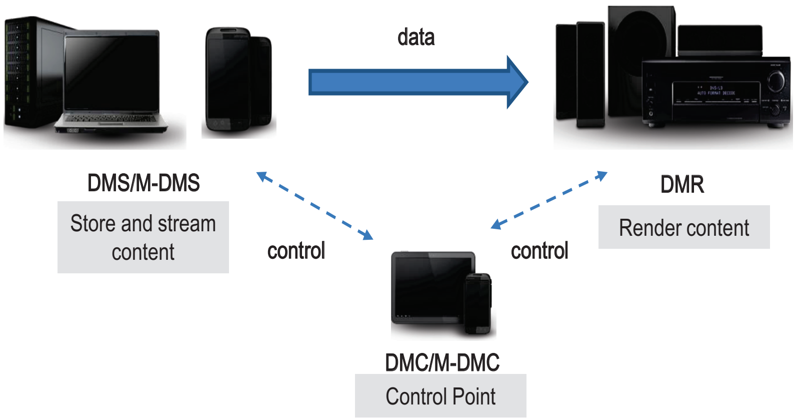

Figure 1: DLNA 3 box model.

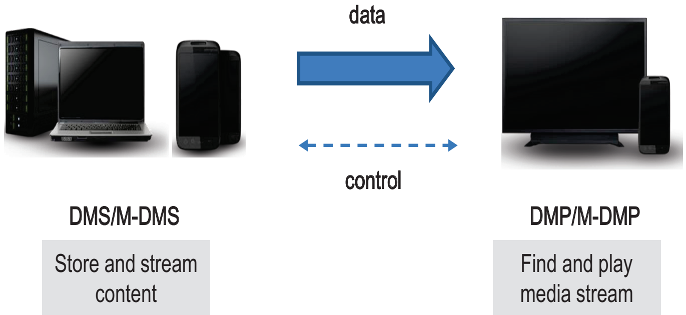

Figure 2: DLNA 2 box model.

ability baseline, which defines a set of required media formats and a set of optional media formats for image, audio, and video with audio for both MHD and HND device categories. Any DMP, M-DMP, DMR, M-DMD, and DMPr device should receive content from any DMS or M-DMS device by supporting the mandatory formats. A DMS or M-DMS device is able to stream content in its native format when the receiving device supports such native format. However, the DMS or M-DMS device has to transcode the native format to one of the applicable formats or to a format processed by the rendering device when the native format is not supported.

Various usage interaction models are defined in the guidelines to illustrate the architecture and interaction between device classes. To illustrate device interaction for content delivery, two specific models are defined: 3 box and 2 box models. Fig. 1 illustrates the DLNA 3 box model. In the 3 box model, a user uses the DMC/M-DMC to discover DLNA devices on a home network. The DMC provides the control interface for finding, browsing, and selecting content. After selecting the content, the user uses the DMC/M-DMC to select where the content will be played (rendered). The content data is then transferred from the selected DMS/M-DMS to DMR. The DLNA 2 box model is illustrated in Fig. 2. The 2 box model is a special case of the 3 box implementation. In this use scenario, a DMP/M-DMP provides a user with an interface to find, browse, select and eventually view digital media. A DMP can be thought of as a combination of a DMC and DMR with a few additional characteristics. The DMC part of the DMP always selects the local DMR as the target renderer for all content.

3 Some Problems with DLNA Devices

There are some problems with DLNA devices such as DLNA product identification, additional media formats, interoperability, etc. DLNA product identification is difficult since the use of DLNA-certified logo is not mandatory. Even if DLNA functionality is implemented in the product, it may have different names according to its manufacturer such as Sony's HomeShare, Philips' Simple Share, Samsung's AllShare, LG's SmartShare, etc. Additional media formats to satisfy incessant demands of customers is another problem. Generally, DLNA has restricted media formats to increase compatibility, but customers have been constantly demanding additional popular formats like Audio Video Interleave (AVI), Digital Theater System (DTS), etc. This problem may persist as new and popular media formats emerge in the market.

Interoperability between DLNA-certified devices made by different manufacturers is the most serious problem. Through a few key devices with required functionalities and mandatory media formats, DLNA certification is carefully performed. All types of DLNA-certified devices on the market are supposed to interoperate even if they are produced by different manufacturers. In real world, however, they cannot work together since some manufactures want to support popular media formats and use different implementation skills and media codecs for their product competitiveness. In other words, only DLNA devices produced by the same manufacturer can have the interoperability. Also, usability is a common problem since customers usually don't have technical knowledge on DLNA devices. Sometimes, customers face diverse challenges such as client and server set-up, enabling subtitles, abrupt network disconnections during streaming play, album images not being displayed properly, inability to connect or find devices, and long delays associated with initial streaming, if no feedback or information is given from DLNA devices.

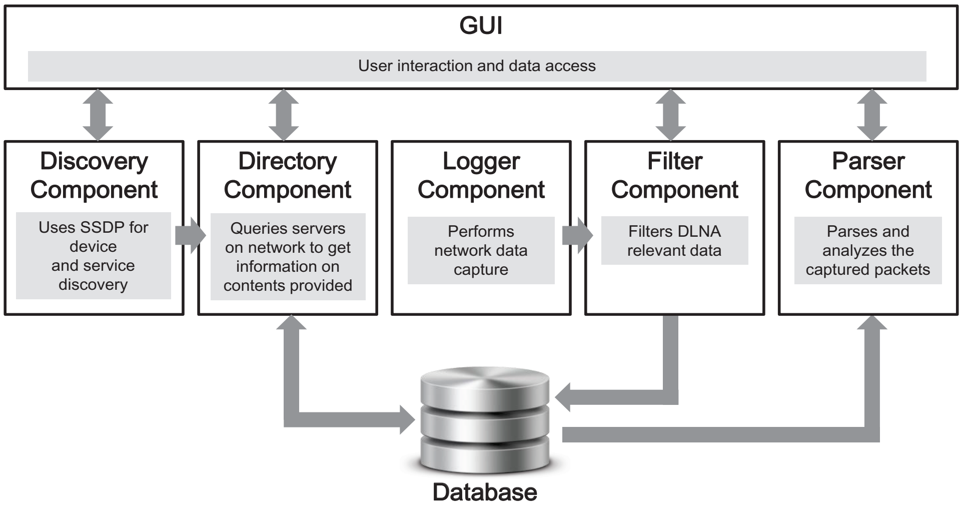

Figure 3: Functional design of the proposed interoperability analyzer.

4 Proposed Interoperability Analyzer

The functional design of the proposed interoperability analyzer is illustrated in Fig. 3, which is designed to provide useful information about DLNA devices, media formats as well as errors and incorrect operation in a home network. The proposed analyzer consists of five components: Discovery, Directory, Logger, Filter, and Parser Components.

First, Discovery Component discovers the DLNA devices on the home network by using Simple Service Discovery Protocol (SSDP) with M-SEARCH messages (device/service search) and NOTIFY messages (presence announcements). Second, Directory Component receives the information on the discovered DLNA devices from Discovery Component and queries the servers on the home network to return information on the provided contents, protocols and media formats. In addition, it queries the renders to return transfer protocols and media formats. After that, it matches the protocols and formats from servers and renderers and stores the information in the database. Third, Logger Component executes network data capture for storing network traffic data, which will be used for error detection and analysis, in the database. Because the client and server use out-of-band transfer protocol to directly transmit content, it is required to observe and analyze content transfer data as well. Fourth, Filter Component obtains data from the Logger Component and extracts all data that is irrelevant to DLNA. This is done in order to reduce the amount of data to analyze and provide the user with useful information. It stores the filtered network traffic data in the database. Fifth, Parser Component retrieves data from the database, parses the data, and performs conformance analysis.

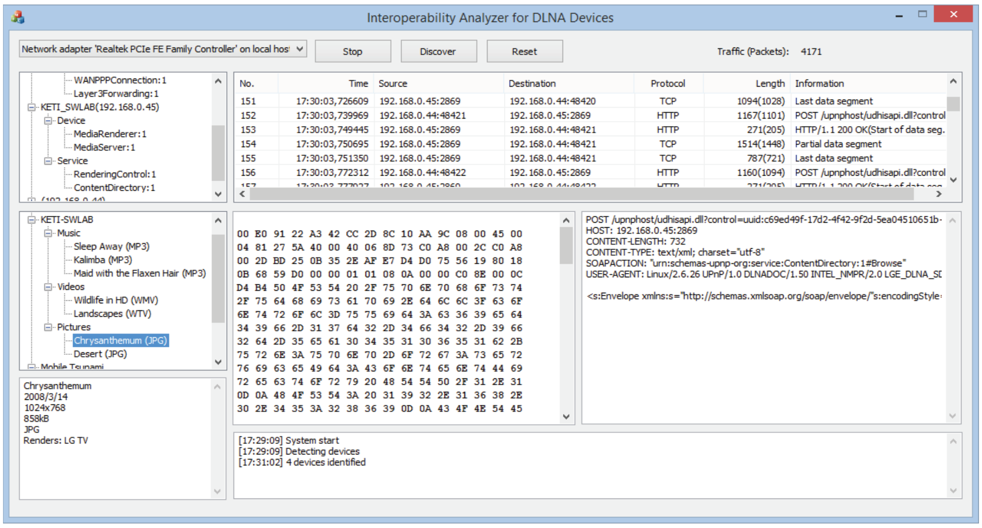

Figure 4: GUI implementation of the proposed interoperability analyzer.

It verifies that the protocol attributes are within valid range and identifies any errors found. A high-level Graphical User Interface (GUI) provides the convenient user interaction and access to data.

The GUI implementation of the proposed analyzer working on a portable personal computer based on Windows is represented in Fig. 4, where Win-Pcap is used for capturing network traffic and analyzing DLNA data, which provides a network interface Application Program Interface (API) in [13]-[15]. Network packets are captured from the network card set to operate in promiscuous mode and saved to a database. SQLite, which can be embedded into the program, is used as the database for its simplicity of use. The captured IP traffic is displayed in the right-top window of the GUI. The IP stream is filtered to reduce computation and processing burden, and only packets relevant to DLNA are saved to the database. If a particular data is selected, the captured data is taken back from the database, and its raw hexadecimal data and payload information are displayed. The DLNA device information is shown in the three windows on the left side of the GUI. The device and service information for each discovered DLNA device is shown in the top first window, which can be obtained by analyzing SSDP traffic data. The discovered media files are shown in the middle window. In the last window, additional information about the selected device, service, or content is displayed. Also, information about compatible devices is provided for media files. An information log window is located at the bottom, which provides useful information to the user such as current program status, available devices, actions performed, or events detected. In summary, the proposed analyzer detects DLNA devices, lists the available multimedia contents, and identifies compatibility in media

Figure 5: Laboratory test environment.

formats. Furthermore, it analyzes network or protocol relevant problems by tracing the captured data traffic.

5 Experimental Results

The setup for laboratory testing is as illustrated in Fig. 5. A wireless access point router assigns local IP addresses to all DLNA devices on the home network through its Dynamic Host Configuration Protocol (DHCP) server and manages the connection of wireless DLNA devices. Through a single Ethernet cable, a dummy hub is connected to the wireless access point router. The proposed analyzer and all wired DLNA devices are connected to the dummy hub used to facilitate network packet capture. In the experimental setup, all packets are forwarded to the proposed analyzer by connecting it to the dummy hub. Then, the proposed analyzer operating in promiscuous mode will be able to see and capture all packets in the home network.

The processing time to verify the performance of the proposed analyzer is shown in Fig. 6 where a laptop consisting of Intel Core i7-2637M CPU @ 1.70 GHz and 4.00 GB of RAM was considered for the proposed analyzer. The traffic segment was captured during JPEG image of 860 kb streaming from DMS to DMP. The maximum size of the data ranges up to 1,514 bytes. This is the maximum length of an Ethernet packet. The processing of events and commands takes approximately 23.04 ms. Processing times close to 0 ms represent that the packet has been dropped since it does not the DLNA relevant data. Processing of bulk multimedia traffic, which indicates actual payload data of the image, takes approximately 19.53 ms shown starting around at

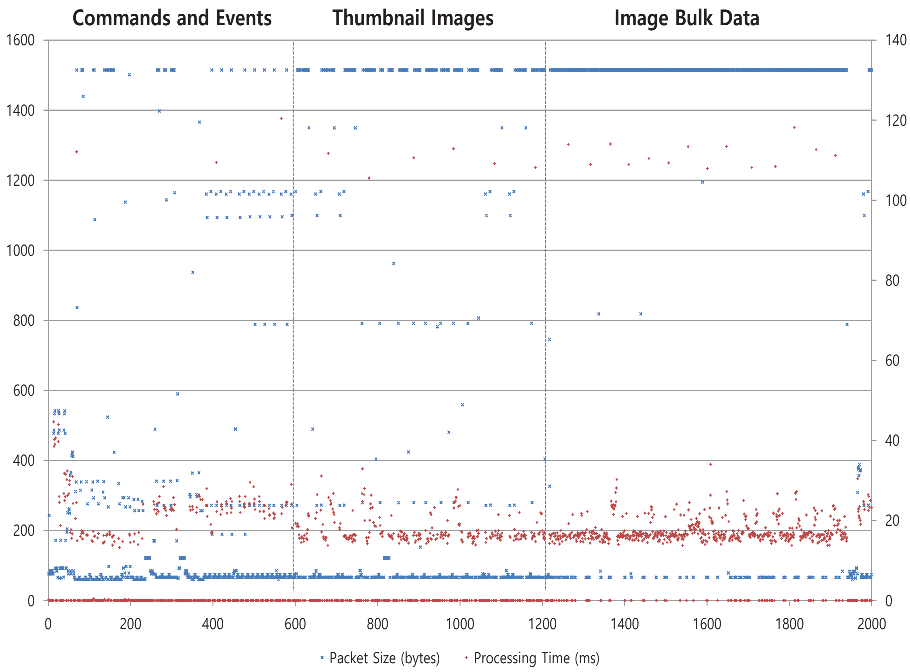

Figure 6: Processing time of the proposed analyzer with full database access.

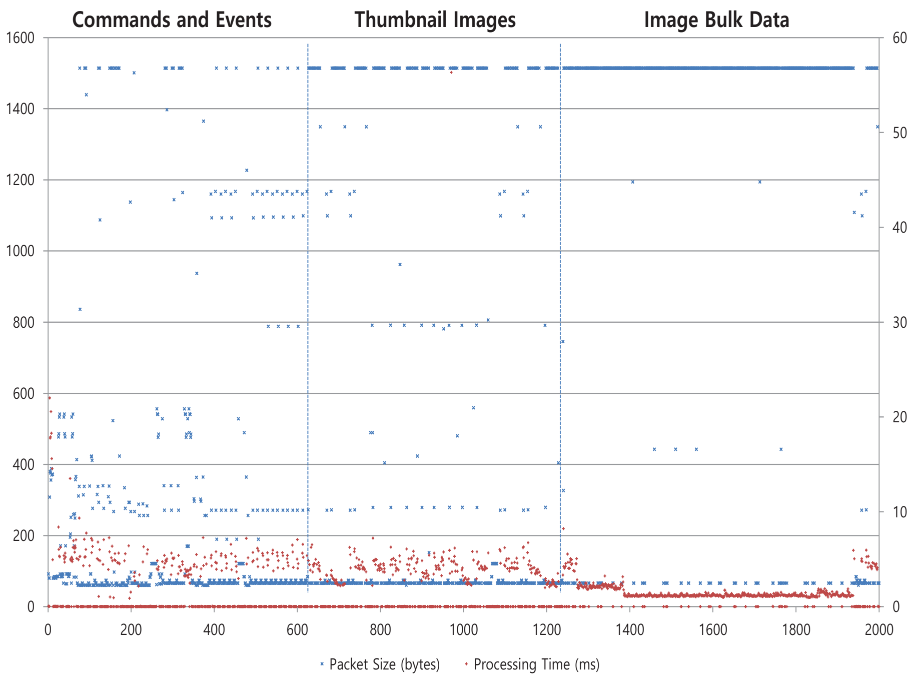

Figure 7: Processing time of the proposed analyzer without database access.

1,200 sample. Most of the processing time is used for database write operation. The processing time reaches over 100 ms at certain points related to database access and management. Since the accumulation of such processing time may cause the IP packet loss, internal buffer management should be performed. The processing time of the proposed analyzer without database access is shown in Fig. 7 to investigate the effects of database access and processing. The data processing time for commands and events decreases to an average of approximately 4.46 ms compared with 23.04 ms in Fig. 6 (i.e. the full database access). The processing of bulk multimedia data takes approximately 1.55 ms shown in the latter half of the graph starting at 1,243 sample, which denotes that processing of bulk multimedia takes less time, since data parsing or processing does not occur, and the packet analysis is skipped once identified as multimedia data.

6 Conclusion

In this paper, an efficient interoperability analyzer for seamless multimedia content access between DLNA devices was designed and implemented in a home network. It could monitor the home network, capture DLNA relevant traffic, and perform protocol examination, especially through its Filter and Parser Components. Based on the media classification information given by the proposed analyzer, the user could identify compatibility issues and determine device interoperability. Some experimental results showed the practicality of the proposed analyzer in terms of the processing time.

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