Implementation Proposal of an IMS-Based IPTV System over an IPv6/MPLS Network Using Open Source Software

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Abstract: The continuous development of communication networks has allowed the emergence of IPTV as an innovative service which together with IMS, promises to change radically the TV experience for consumers. The main intention of this paper is to propose the design of an IMS-based IPTV system using open source software for its development and using an IPv6/MPLS core network to provide multimedia content transportation. For this purpose, we first study the related work in the area, and then we present the proposed design describing all the devices and software available for the implementation of the prototype. We have identified a lack of research in IPTV concerning IPv6 and we propose a prototypical implementation as a way to deepen into this subject and generate more research in the area.

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1. Introduction

Nowadays, packet switching networks based on Internet Protocol are being deployed worldwide; this has enabled the emergence of a new kind of services, ready to be offered to clients. One popular service, which is still under continuous development, is the so called IP Television. IPTV represents a set of multimedia services that are transported over IP networks and are managed so as to guarantee (up to a certain extent) quality of service, security, interactivity and reliability (ITU, 2014). IPTV has become a strong competitor against legacy television providers (like cable or satellite) in countries where this technology has been adopted, providing traditional Live TV service together with a set of supplementary services such as video on demand (VoD), private virtual record (PVR) and interactivity services, which have improved TV experiences for users.

Currently, there are several Telco providers who have implemented IPTV services over their already-deployed networks; normally IPv4-based networks. Given the increasing popularity of IPTV, the amount of users has rapidly grown, and Telco providers are now realizing that the IPv4 addressing scheme is falling short. IPv6 (Deering S and Hinden R, 2014) is the latest version of protocol IP and unlike IPv4 (Postel J, 2014), which has a 32 bit address space; IPv6 has an address space of 128 bits. Such an unimaginable amount of IP addresses permits getting rid of the NAT system; hence, it is important to start the migration from the current IPv4 networks to the new IPv6 model so as to be able to cope with the increasing customer demand. An example of this is NTT, a Japanese Internet service provider that has deployed a next generation- IPv6 network and has recently offered an IPTV service called Hikari TV, which runs completely over its own IPv6 infrastructure.

Convergence is another key point in the deployment of IPTV. Nowadays, there is the need to offer several services to users wherever they are regardless of the type of device they use (TV, smartphone, tablet, PC). The concept of ITU-T Next Generation Networks (NGN) (ITU, 2013) is intended to deal with this issue by providing a solid architecture to separate the Service Layer from the Transport Layer, allowing several services to be transported regardless of the network infrastructure. This will enable IPTV services to be delivered to several devices through different kinds of packet-based networks (fixed, wireless, mobile). NGN has adopted the IP Multimedia Subsystem (IMS) as a tool to provide a standard way of delivering signaling messages over networks, using Session Initiation Protocol (SIP) (Rosenberg J et al., 2014) in order to establish and control the multimedia session.

In this paper, we propose the implementation of an IMS based IPTV system using Open Source Software. The main idea is to design an IPv6/MPLS core network to provide the transport of multimedia content using both QoS mechanisms and TE. Subsequently, the traffic generated by the IPTV system over such core network is evaluated and its performance is compared with and IPTV system running over IPv4. The remainder of this paper is organized as follows: Related work is discussed in Section II. In Section III, our prototypical implementation is proposed. Section IV discusses the validity of the proposed implementation. Finally, conclusions are drawn in Section V.

2. Related Work

Many studies on IMS-based IPTV systems have been conducted recently; some of these studies have dealt with the complete IMS architecture proposed by ETSI/TISPAN (ETSI, 2006), as well as the standardization efforts made so far. Such studies were mainly intended to suggest a new architecture, specifically designed for IPTV systems and having the IMS Core component at its heart (Mikoczy E al., 2008). Additionally, the implementation of a prototype to evaluate such architecture has also been suggested (Mikoczy E et al., 2007). Other authors have investigated the convergence capabilities of IMS-based IPTV systems; provide services to both fixed and wireless networks (Al-Hezmi A et al., 2008) (Choi K et al., 2011) (Mikoczy E et al., 2011).

It can be observed that in most of these proposals very few authors worked over IPv6 networks; their main focus was on the study of the IMS platform itself, rather than analyzing the effects of IPv6 on their implementations. Other related works focused on the transport layer instead of the service layer. Murcia, et al., proposed and implemented a video transmission platform over IPv4 networks using MPLS-TE and other management mechanisms to guarantee some level of end-to-end QoS to video traffic (Murcia V, 2011). Some researchers studied the re-convergence techniques on MPLS networks and analyzed ways of improving QoS, whereas others preferred to implement VPLS networks over IPv4 for a content-delivery network due to its capabilities in dealing with different classes of services and its fast restoration procedures (Pompei S et al., 2010) (Wang Y et al., 2010). For the purposes of this paper, it is also interesting to study related works about IPTV traffic measurement. Young J. Won, et al., measured commercial IPTV traffic on four different residential broadband access networks and presented gathered traffic statistics of the IPTV service. These authors also provide a mathematical description of traffic behavior and bandwidth demand for IPTV VoD services (Won Y et al., 2008).

Another particular study focused on measuring multicast traffic collected from an Italian IPTV service provider. Different kinds of IPTV flows were encountered, characterized, and measurements of QoS factors were made according to variables such as jitter, packet loss rate and delay (Mellia M and Meo M, 2010). Other authors explored several aspects that helped model IPTV services and presented a synthetic video trace generator that accurately resembles IPTV streaming itself (Reaz A et al., 2011).As related work was being explored, we realized that there were very few IPTV implementations that cover the study of IPv6 networks over MPLS (Rosen E, 2014) and that implement the IMS architecture for controlling the service layer.

3. Materials and Methods

In this section, we describe the devices, tools and design employed to implement a prototype of an IMS-based IPTV system at Universidad Distrital Francisco José de Caldas (U.D.F.J.C).

3.1 CECAD

CECAD is an acronym in Spanish that stands for High Performance Computer Center. It is a computing laboratory created by U.D.F.J.C to promote research and innovation in several areas, providing high performance computational tools for undergraduate, graduate and PhD students (Openimscore, 2012).

3.2 The Devices

DELL HPCC Server: CECAD has a powerful Dell High-Performance Computing Cluster that is utilized to promote research in the campus. This platform will support different kinds of servers that are used in the IPTV prototype.

Cisco 2911: The 2911 is an integrated-services router that offers voice-and-video-capable digital signal processor slots, embedded hardware encryption acceleration, and other new characteristics that support a wide range of connectivity options and communication protocols; including IPv6, MPLS, OSPF, EIGRP, Multicast protocols, etc.

Cisco 2821: The 2821 is an integrated-services router that has been optimized for the secure and wire-speed delivery of concurrent data, voice, video, and wireless services. The 2800 series provides IPv6 support as well as MPLS routing and multicast capabilities.

Cisco 3750G: This is a Layer-3 Gigabit Ethernet switch, with smart multicast capabilities and IPv6 compatibility.

Raspberry Pi: It is a credit card size computer powered by a 700 Mhz microprocessor and a 512 Mb RAM, this computer has a HDMI port and works using a Debian based distribution.

3.3 Open Source Software

Open IMS Core: The Open IMS Core is an Open Source implementation (made by Fraunhofer FOKUS) of IMS Call Session Control Functions (CSCFs) together with a Home Subscriber Server (HSS). These two systems form the core elements of all IMS/NGN architectures, as currently specified by 3GPP and ETSI/TISPAN (Openimscore, 2014). The IMS Core is the main component within the IMS architecture and it transports all the signaling traffic (SIP, SDP, Diameter) of the network.

UCT Advanced IPTV: The UCT Advanced IPTV software is an attempt at a standards-compliant implementation of an IMS based IPTV service, created by the Communications Research Group at University of Cape Town. This software provides a SIP-based Application Server specifically designed for IPTV (Openimscore, 2014).

VLC Server: VideoLAN is a complete software solution for video streaming and playback, developed by students at Ecole Centrale Paris under the GNU GPL. VLC can stream MPEG-2 and MPEG-4 files, DVDs, digital satellite channels, digital terrestrial television channels and live videos on the network in a unicast or multicast fashion and has full support for IPv6 (videolan, 2014).

UCT IMS Client: The UCT IMS Client has been developed by the Communications Research Group at University of Cape Town in order to be used with the FOKUS Open IMS Core. The client supports AKA authentication and emulates IMS signaling. The current version supports voice and video calls as well as session-based instant messaging, Presence, IPTV viewers, and an XCAP client; however, it works with IPv4 only (Waiting D et al., 2008).

myMONSTER TCS: The Telco Communicator Suite is a Java-based framework that delivers a unified communication experience for all forms of IP-based telecommunication, ranging from Multimedia Telephony to other types like rich Presence, Group List Management, and IPTV applications. It is extremely powerful, yet lightweight enough to run on both fixed and mobile devices; it also includes IPv6 support (Monster, 2014).

3.4 Design

Our intention is to design an IMS-based IPTV prototype, in order to perform this design, we have decided to use the international UIT-T model known as TMN (Telecommunications Management Network) (CCITT, 1996); which is consistent whit all the factors (physical and logical) of this work; and using also the FLOSS (Free, Libre, Open Source Software) approach obtaining all of its technical and economic advantages. As a first stage the TMN model considers the configuration administration, which involves all the activities of planning and designing network architecture and/or services; this stage also takes into consideration the hardware administration and supply; as well as, the administration and setting up of all the software involved.

Our first attempt to design the IPTV system considers that, at present, few IPv6/MPLS-capable routing devices are available. Figure 1 depicts the physical layout (interconnection) of the devices that compose the IPTV prototype.

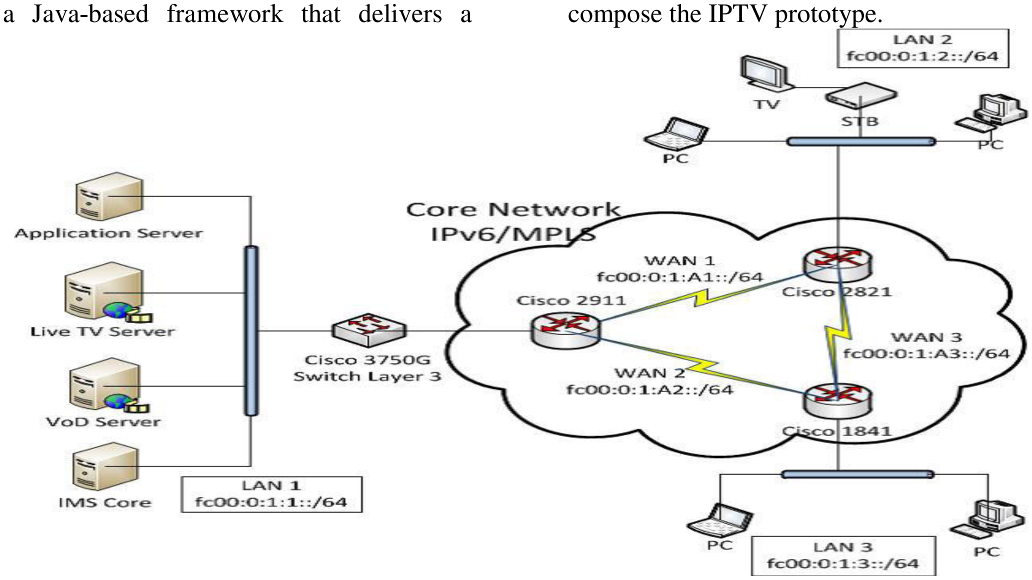

Figure 1. Physical Interconnection of the Proposed IPTV Prototype

The Live TV and VoD Servers will be located on the content production side of this layout; both servers use VLC. There will also be a SIP Application Server using UCT Advanced IPTV, which may be located at the same server as the VoD service. Finally, there will be a server for implementing the IMS core (using Open IMS Core), which will be the key point in the IPTV platform session establishment. The HPCC Server, which will contain the servers already mentioned, is currently installed and interconnected through a Cisco 3750 layer-3-capable Switch, located at CECAD. We have available three routing devices, namely a Cisco 2911 router, a Cisco 2821 router and a Cisco 18411 router.

Our proposal is to construct a private network using this two devices and take advantage of their IPv6 and MPLS capabilities in order to design a robust core network for the IPTV prototype. Attached to the 2821 and 1841 Routers, several LAN networks will be placed; these networks will serve the clients of the IPTV system.

Figure 2, shows the logical connections between the components described above. The connection process for IMS clients is well known, namely the IMS clients send SIP-based messages to the IMS Core and request the IPTV service; the IMS Core authorizes and authenticates users and connects them to the Application Server (AS), which keeps all information about contents and the media servers.

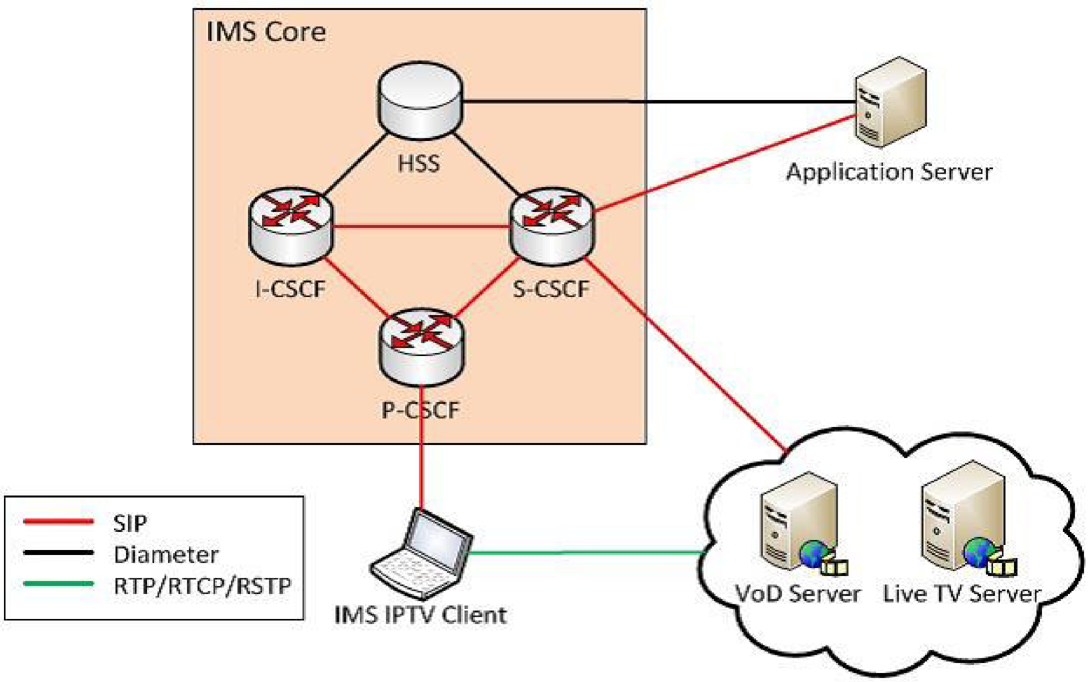

Figure 2. Logical Connections of the Proposed IPTV Prototype

The IMS Core was implemented using the OpenIMSCore package running over Debian Squeeze, which needs a DNS server for communication purposes. This package is flexible, being able to work in several environments and supporting Dual Stack, so as we can use it for IPv4 and IPv6 IPTV networks.

The AS communicates with the IMS Core's HSS to obtain information about the user profile; it also presents a personalized content guide to the client. From this content guide, the client choses a channel and sends a request to start receiving the channel's content. The IMS Core transfers this request to the AS, and then returns an appropriate multicast/unicast IPv6 address to the client so as to start listening to that specific address and receive the content as requested.

The AS was implemented using UCT IPTV Advanced software which has the limitation of working only over IPv4 systems, which is a big problem for the successful implementation of our IPv6 platform. Dealing this problem was complex, but fortunately some researchers from Warsaw's National Institute of Telecommunications, has developed an alternate version (Janikowski S et al., 2012) of UCT's Software capable of working on IPv6 systems, so we finally turn out using this AS package.

The multimedia servers were implemented using VLC software, Open Source software which works perfectly for both IPv6 and IPv4 environments. Both servers (VoD and Live TV) were implemented over a Debian Squeeze environment and version 2.0.3. Two flowers were used taking into consideration all its codification possibilities.

The clients will be implemented using several devices such as Personal Computers and Set Top Boxes in order to install on them the IMS client software. Our first intention was to use commercial Set Top Boxes in order to implement several clients, but such devices were incompatible with the current IMS Client software; so as to be able to emulate a STB we are going to use the Raspberry Pi to create our own STB IMS compatible which thanks to its capabilities is available to connect to any HD TV.

The original UCT Client software has the limitation of working only for IPv4 systems, so as well as with the AS, we decided to use a modified version (Janikowski S et al., 2012). The original UCT client needs the previous installation of VLC software for clients too, so in order to use the modified version of UCT's client we had to use an alternate version of VLC live555 plugin for IPv6 RTSP support. This alternate live555 version runs only on VLC package version previous to version 2.0; so we decided to use version 1.1.9 "The Luggage" for VLC software. Table 1, describes the server configuration environment used for implementing all the servers described above.

Table 1. Prototype's Server configurations

Server Name	IMS core	IPTV_AS	Servidorlivetv	Servidorvod
Description	IMS Core Functions	IPTV Application Server	Real Time IPTV transmission	Video on Demand Server.
CPU's	3	3	5	5
RAM	4 GB	4 GB	4 GB	4 GB
ROM	22 GB	22 GB	22 GB	22 GB
OS	Debian Squeeze v6.0 amd64	Debian Squeeze v6.0 i386	Debian Squeeze v6.0 amd64	Debian Squeeze v6.0 amd64
Software	OpenIMSCore	UCT Advanced IPTV	VLC Server	VLC Server
IP Address	fc00:0:1:1::4/64	fc00:0:1:1::5/64	fc00:0:1:1::3/64	fc00:0:1:1::2/64

4. Method

It results necessary to test the developed framework using several parameters such as, jitter, delay, and packet losses; so as we can compare the IPv6 performance against IPv4 platforms. In order to accomplish this objective the prototype presented was implemented using in first instance IPv6 to take the proper measures. The prototype implemented is able to work using IPv4 as well as IPv6 and this can be done by configuring another AS that works on IPv4, as well as, another Multimedia Server, by doing this we could take measures using IPv4 so we can compare boths scenarios.

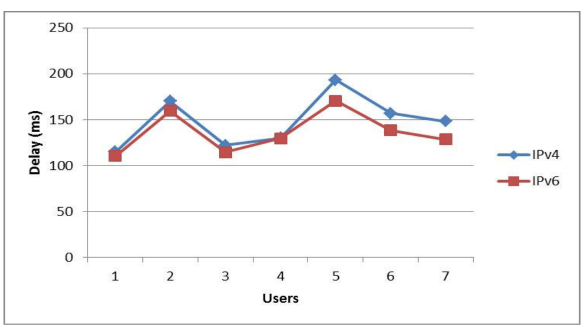

Figure 3. Jitter Comparation for IPTV on IPV4 and IPV6

ms; having an improvement of 24.11% for IPv6.

To measure the chosen parameters we had made transmissions of 45 minutes in both IPv6 and IPv4 scenarios. First we tested the platform over an IPv6 network with high load and the users varying from 1 to 7; the measures were done by testing the same framework using the IPv4 servers. In figure 3 we show the average jitter measured for the IPv4 scenario, as well as, the measures for the IPv6 scenario.

From this figure we can appreciate that the measured jitter is considerably better for the IPv6 network, where that average jitter for IPv6 is 27.42 ms, while for IPv4 the average jitter is about 36.14

Figure 4 displays the measured end-to-end delay values and figure 5 shows the measured packet losses.

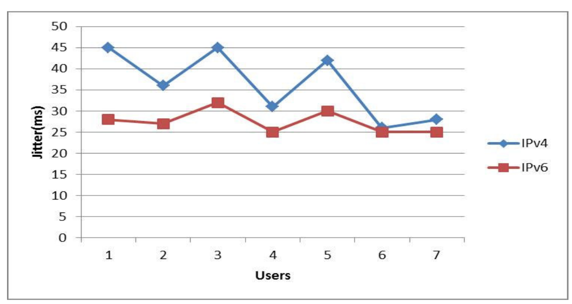

Figure 4. Delay Comparation for IPTV on IPV4 and IPV6

In terms of latency, IPv6 is more efficient compared to IPv4 for IPTV as shown in figure 4. The average delay for IPv4 is about 147.85 ms, but in IPv6 this value is 135.91 ms; showing an improvement of 8.07%. In terms of packet loss percentage, performance is again better over IPv6 compared to IPv4 in most cases. Noticeably improved performance results are for low traffic load when the number of users is low. The average loss percentage for IPv4 is 2.5%, in contrast, for IPv6 there is an improvement of 16.77% having an average loss percentage of 2.08%.

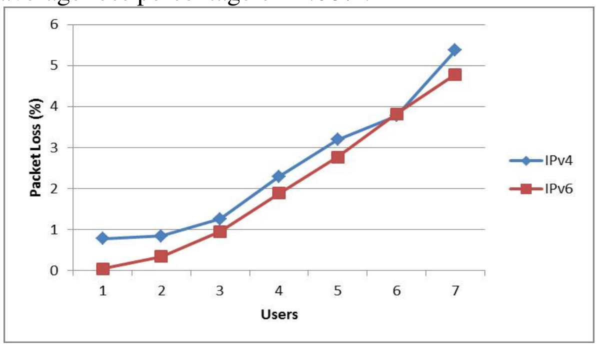

Figure 5. Packet Loss Comparation for IPTV on IPV4 and IPV6

5. Discussions

In this paper, we have proposed a prototypical design for an IMS-based IPTV service over an IPv6/MPLS network. The main purpose is to implement such design with real equipment so as to assemble a first platform intended for researchers (U.D.F.J.C students and members) to work on subjects like IPTV6 and Next Generation Networks using as a reference the UIT-T model known as TMN.

Nowadays, all communication systems converge on networking, and IP-based networks are the key in this new convergent architecture. NGN and

IMS emerge as a potential solution that provides service-and-network convergence through the use of IP networks and SIP communication.

Through this investigation, we have realized that there is a lack of research on IPv6/MPLS core-networks implementation over IMS-based IPTV systems. In the IMS implementations mentioned, there was a marked trend towards IPv4, and few studies were intended to study the effects of IPv6. Moreover, most of such studies carried out their implementation avoiding the use of proper core networks, and focused their attention on the session establishment process rather than on the effects of the core network on the IMS system.

The main intention of our proposal is having implemented the framework presented in figure 1, focusing in the core network so as to be optimized to work in an IMS IPTV environment; task that will be accomplished by using several tools such as MultiProtocol Label Switching (MPLS); diverse queuing techniques; and resource reservation techniques such as Resource Reservation Protocol (RSVP). Several tests were done using IPv6 implemented platform, and measures were taken in order to contrast the average performance between the IPv6 prototype and the UCT IPv4 Original proposal. By doing this tests, we have realized that there's a general performance improvement for the IPv6 framework.

As we wrote this paper, the design was being implemented with the available equipment, but the ultimate goal is to obtain another IPv6/MPLS routing device so as to implement the design shown in figure. 1. By including another routing device, we can build a more complex network and study the effects of the IPTV multicast traffic on IPv6/MPLS core networks in a more precise way. There are several advantages of using Open Source Software in this design; mainly the costs involved get reduced greatly and also the availability of the source code and the right to modify it brings flexibility working with the software.

6. Conclusion and Future Work

IPTV has emerged as a novel technology that allows the transmission of Live and VoD contents over IP-based Networks, bringing additional interactive and personalized services to users, which renovates users' experience of television. The growing amount of users demanding IP-based services is forcing providers to migrate towards IPv6 networks, allowing a major number of users to be accepted in a particular network. Additionally, with the implementation of NGN IMS, networks are converging to form a unique big network that can provide several services to several kinds of users and devices. During this investigation we realized that there is an important lack of research in IPTV concerning IPv6 and there is no much information in this subject available.

We have proposed an IMS-based IPTV service implementation, which represents the first step towards further extend research on IPTV platforms and networks. From this intended prototype there emerge comprehensive research studies on IPTV systems will be conducted. This paper claims to be a first approach in the implementation of an IPTV system.

In this paper, comparative performance test results over IPv6 versus IPv4 were presented for an IPTV network prototype. The presented results show that performances over IPv6 in general exceed performances over IPv4 considering the observed metrics, that is jitter, average latency and packet loss percentage.

Future work will attempt to analyze traffic behavior on the IPTV system running over the IPv6/MPLS core network. A model for predicting the future IPTV traffic using ARIMA Time Series will be proposed. We are also considering future implementations of additional services (such as VoIP, Presence and IM) provided by the IMS system.

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