Adapted IPTV Service within novel IMS Architecture

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ABSTRACT
The paper introduces a novel architecture to be used in IMS (IP Multimedia Sub-system) context. Thanks to the use of a MCMS (Multimedia Content Management System) along with interoperable components, the proposed solution enables an efficient adaptation of services according to the Perceived Quality of Service degradation at the end-user side.

Keywords
IMS, PQoS, Adaptation, IPTV.

1. INTRODUCTION
The IP Multimedia subsystem (IMS) is an overlay system that is serving the convergence of mobile, wireless and fixed broadband data networks into a common network architecture where all types of data communications are hosted in all IP environments. As recent public trials have shown, IMS technology still suffers a number of confining factors; amongst them is the perceived quality of service (PQoS). The existing IMS infrastructure does not provide any PQoS aware management mechanism within its service provisioning control system.

It is expected that the success of multimedia services within the IMS infrastructure will depend on how end users perceive the quality of the services provided. Therefore, novel IMS compatible user centric network management solutions that employ cross layer adaptive techniques are inevitable.

In this paper, we focus on the integration of such PQoS aware management in the IMS architecture delivering IPTV services and more specifically on the media session control between the user's terminal, IMS elements and the PQoS aware management mechanism. Any multimedia streaming services would use the same architecture. This architecture is currently being developed in the ADAMANTIUM European project [1].

In the following section, the proposed architecture is overviewed and all the elements are introduced. The third section describes the realization of the adaptation process in the IPTV scenario. Section 4 concludes the paper.

2. ARCHITECTURE OVERVIEW
Current IMS architectures are unable to provide any PQoS aware management mechanism within its service provisioning control system. The paper proposes a novel IMS-compatible user-centric network management solution that employs cross-layer adaptive techniques for IPTV services in order to (a) compensate network impairments (Network QoS - NQoS) according to the time varying conditions of the network delivery chain, (b) perform a content dependent optimization of the encoding and/or streaming parameters, and to (c) improve the end user experience/satisfaction by maximizing the delivered PQoS level. This will provide an efficient solution/approach for future networked multimedia making it possible to maintain the quality of the media at every step of the media lifecycle from creation to consumption.

The essential component of the proposed solution is the MCMS (Multimedia Content Management System), which is in charge of interfering in the media delivery process when PQoS (Perceived Quality of Service) [2] degradation occurs at the end user side, by performing real time cross layer adaptation across the media delivery chain. Based on the monitoring data, the adaptation logic initiates a dynamic cross layer adaptation procedure, which extends from the service generation entity to the user terminals. The MCMS, along with its modules, is implemented on a real IMS platform comprising an UMTS access network where IPTV over IMS services are integrated. An overview of the proposed PQoS-aware MCMS-based architecture is depicted in Figure 1 and comprises the following elements.

1. The MCMS modules, which are the main management entities. They focus on monitoring the network statistics (i.e. core, access, terminal), the service delivery i.e.Media Server Resource Function (MSRF) and the service perceptual level at the end-user terminal in order to define and apply an optimal cross layer adaptation action across the delivery network chain and media lifecycle i.e. service generation node, core network, access network and end-user terminal. The final objective is to maximize the user satisfaction. As shown in Figure 1, MCMS modules are located in the Application Server (AS) Layer of the IMS architecture. MCMS modules can extend the IPTV AS with real-time monitoring important information, including impairment information from source (e.g. content dynamics), core/access network (e.g. network/link QoS) and terminal (e.g. delivered PQoS). IPTV AS is mainly responsible for Service Control Function as defined in TiSPAN v2 standardization [3], IPTV Service Provisioning, IPTV Service Personalization and other IPTV specifics services such as voting or advertisement functionalities. The Service Control Function has a threefold responsibility:

- Service Authorization during session initiation and session modification, which includes checking IPTV users' profiles through the 'Sh' interface in order to allow or deny access to the service;
- Credit control and limit;
- Selection of the relevant IPTV media functions.

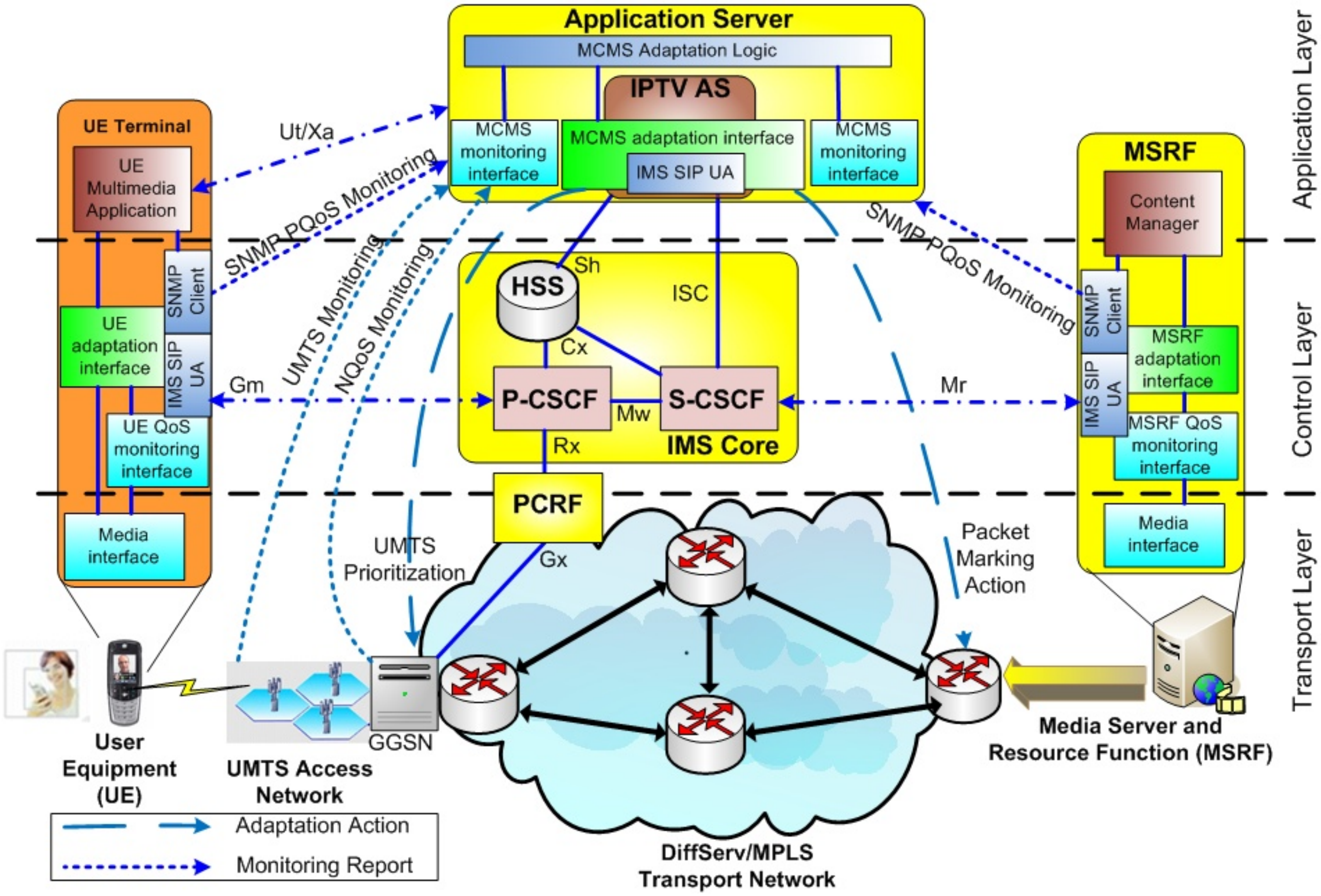

Figure 1: The Overall Architecture

The Service Control Function is then managing the IPTV session management constantly knowing the UE status. Therefore, IPTV AS can also be extended with the MCMS Adaptation Interface in order to trigger cross-layer adaptation including service layer adaptation (e.g. source/terminal coding parameters and FEC), network layer adaptation (e.g. traffic policies) and link layer adaptation (e.g. service classification). This MCMS Adaptation Module is controlled by some intelligent decision logic called MCMS Adaptation Logic within the MCMS system. The integration of the MCMS modules in the Application Layer makes the PQoS aware management available for any kind of access or transport network. Figure 1 only shows UMTS Access network, but this solution can also work for Fixed Access, WLAN or even Cable Access with corresponding Policy and Rule Functions.

2. The Multimedia Server and Resource Function (MSRF), which is an IMS based MRF module with an additional twofold responsibility:

- The monitoring of the spatial and/or temporal content dynamics along with the selected encoding/streaming parameters
- The adaptation, according to the MCMS commands, of the IPTV encoding parameters and/or the respective FEC value.

The first contact point within the IMS infrastructure is the Proxy-CSCF (P-CSCF) module, which relays the services session towards the Serving-CSCF (S-CSCF) in charge of handling the session management. In addition, Home Subscriber Server (HSS) contains the subset of Home Location Register and Authentication Center functionality required by the Access Network. It can also be extended to IPTV users' profile. The P-CSCF also performs the interaction between Session Control and Policy Control. It inspects the Session Description Protocol (SDP) parameters within each new SIP offer/answer transaction and, if required by QoS preconditions, extracts the media descriptions and communicates with PCRF to inform the need for QoS reservation. Regarding policy control, the Policy Control and Charging Rules Function (PCRF) performs the logic for QoS authorization and for binding application-level sessions to network resources. PCRF communicates with P-CSCF via Rx interface for authorization responses or re-authorization requests triggered by network events. A PPC Rule is made up of a service data flow template, jointly with the related charging and QoS information. Provided that resource reservation results on a successful QoS level, destination endpoint accepts the multimedia session by sending a 200 OK in response to the Invite command.

3. An IP Core – DiffServ/MPLS Compatible Transport Network. Our architecture considers a DiffServ/MPLS-enabled core network for the delivery of the requested multimedia service. We develop IMS and MCMS compatible modules and interfaces for the packet marking and traffic monitoring at the edges of the DiffServ/MPLS traffic network. All the core network nodes (i.e. routers) are considered as inter-cooperated and capable of treating appropriately marked traffic by the corresponding DiffServ/MPLS mechanisms, without any additional reconfiguration by the IMS or MCMS modules.

4. The UMTS Access Network. At the access side, a UMTS access network is considered, which provides service/bearer classification mechanisms for providing QoS constraints on the delivered service type (e.g. video, voice, data, etc). the classification mechanisms of the GGSN are exploited by the sophisticated PQoS-aware cross layer adaptation procedure with scope the perceptual optimization of the delivered service. Towards this, the Policy Decision Function (PDF @Release 6) or the Policy Control Rule Function (PCRF @Release 7) of the IMS will be exploited and further enhanced.

5. The User Equipment (UE). At the PQoS-enabled user terminals (e.g. 3G mobile handset, SIP voice/video phone, PDA), a Terminal Adaptation Module (TAM) is integrated, enabling the terminal's interaction with the appropriate interfaces/modules of the MCMS.

The overall architecture, incorporting all the described components enables novel capabilities of IMS systems in terms of services, notably adaptation. The architecture is fully implemented, at a large scale, within the framework of the European Project ADAMANTIUM [1].

3. IPTV Adaptation Mechanism in IMS

3.1 IMS Media Session Management

The Figure 2 describes sequence diagram of the messages that are exchanged when an IPTV session is established and torn down between a User Equipment and the MSRF through IMS. An example of adaptation mechanism with SDP re-negociation is also shown. For sake of simplicity in the diagram, we do not represent messages flowing through the Call Session Control Function CSCF and neither the Rx interface between P-CSCF and PCRF. The Ut/Xa reference points for the purpose of service profile configuration are also not shown.

The successfully registered UE initiates the IPTV service sending a SIP INVITE request with a SDP body, which describes the media session (Codec, Video to play, Framesize, Framerate, Bitrate) as depicted in Figure 3. The first SIP contact entry point for the UE is the Proxy-CSCF. Proxy-CSCF forwards the INVITE+SDP request to S-CSCF. The latter detects an IPTV service initiation thanks to the service-triggering information presented in the form of initial filter criteria (iFC) downloaded from HSS during the UE's Registration process. S-CSCF forwards the request to a specific IPTV AS through the IMS Service Control (ISC) interface. IPTV AS treats the request by parsing the SDP in order to retrieve the media file to play. The IPTV AS may also use the IPTV user profile to customize the user experience according to the user preferences. Then, the IPTV AS forwards the INVITE request to a corresponding MSRF which terminates the SIP dialog. The MSRF sends back a 200 OK message with the final negotiated SDP body and the CSCF forwards it back to the UE. Then, the MCMS adaptation interface is informed about the active service sessions since it belongs to IPTV AS. This idle mode of the MCMS modules is essential for its scalability abilities, because during this operating mode, resources are not consumed. The MCMS modules simply wait for the reception of a PQoS-degradation alarm from the end-user terminal, indicating poor perceptual quality and therefore bad user experience.

From this point, we distinguish two main use cases:

1. The MCMS adaptation interface triggers an adaptation that requires a renegotiation of the SIP session. In that case, the MCMS adaptation interface will send a SIP Message to the MSRF. The latter will renegotiate the session with the user terminal, in order to inform it of the new video parameters. For example: changing the video codec. A Re-Invite is used to renegotiate the SDP parameters because the INVITE process (request, response, acknowledgment) helps for RTSP/RTP/RTCP management as shown in Figure 4.

2. The MCMS adapts the required parameter without informing the user terminal. The user terminal adapts itself to the changed video and audio streams. For example: changing the bitrate of the video. A simple SIP UPDATE is sent from IPTV AS on the behalf of the UE.

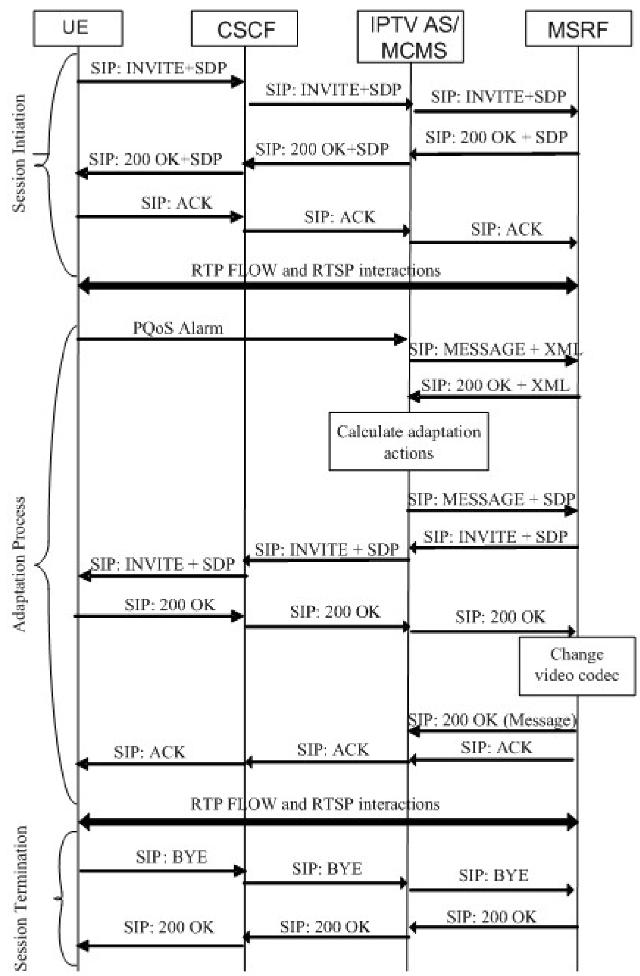

Figure 2: IPTV Session Handling for adaptation with SDP re-negociation

```
v=0
o=aude 13460 13460 IN IP4 192.168.1.153
s=ADAMANTIUM streaming session
t=0 0
a=tool:GStreamer
a=type:broadcast
a=media:a.avi
m=video 5000 RTP/AVP 96 34 32
c=IN IP4 192.168.1.153
a=rtpmap:96 H264/90000
a=rtpmap:34 H263/90000
a=rtpmap:32 MPV/90000
a=framerate:25.0
a=framesize:CIF
m=audio 5002 RTP/AVP 8
c=IN IP4 192.168.1.153
a=rtpmap:8 PCMA/8000
```

Figure 3: SDP example

3.2 MSRF Adaptation Process

The MSRF is driven by an IMS SIP UA. It instantiates a streaming session when it receives a SIP INVITE message from the IPTV AS which is forwarding the end user request for a media resource according to [3-9]. Each streaming session is composed of:

- A Media Streamer which streams media resources to the requesting client;
- An RTSP Session Controller which controls the Media Streamer with respect to the commands received from the client;
- A MSRF/MCMS InterFace (MMIF), which sends monitoring data to the MCMS monitoring interface and receive adaptation commands from the IPTV AS and the MCMS.

3.2.1 MSRF Components

The different components of the MSRF are the following:

- The IMS SIP UA Component handles all initial requests to MSRF. On session initialization, it communicates with the Media Controller for media resource availability and the streaming session creation (Session Streamer instantiation to serve one User). Then, during the streaming, the IMS SIP UA listens for monitoring and adaptation requests and forwards them to the MMIF. It also forwards back the responses of the MMIF to the client which requested the adaptation. Finally, the IMS SIP UA also listens for session release by communicating with the Media Controller for the session teardown;
- The Media Streamer Component is responsible for streaming multimedia resources, using RTP (Real-Time Transfer Protocol) and RTCP (Real-Time Transfer Control Protocol) protocols. The MMIF component sends monitoring data to the MCMS monitoring interface and receives adaptation orders from the MCMS adaptation interface. As explained in the previous section, the MCMS adaptation interface will request monitoring data when the UE Terminal detects degradation in the PQoS. From this point, the MCMS adaptation interface will request monitoring data from the MMIF. After analysis, the MCMS will send adaptation actions to the MMIF through a SIP Message communication. With respect to the state of the RTSP session, the MMIF will then forward these orders to the Media Streamer. The Media Streamer will finally enforce the adaptation actions. The RTSP Session Controller is responsible for particular User session streaming control using the RTSP protocol. The session itself is initialized by the IMS SIP UA. The RTSP Server bloc listens to the RTSP request messages and forwards them to the given RTSP Session Controller, based on the request URL.
- The multimedia resources to be streamed are added to the MSRF by the Media Controller. In addition, it can propose an interface for content removing and manage the content accessibility. The Session Controller subcomponent is responsible for effective session streaming creation or removal based on IMS SIP UA request, respectively after successful SIP INVITE or SIP BYE methods.

3.2.2 Streaming and Adaptation Use Case Elementary Tasks

This section describes the use case for the media resource streaming and the adaptation with renegotiation focusing on the messages exchanges that take place in each elementary task. We distinguish five elementary tasks carried out by the MSRF in this use case chain as described in Figure 4:

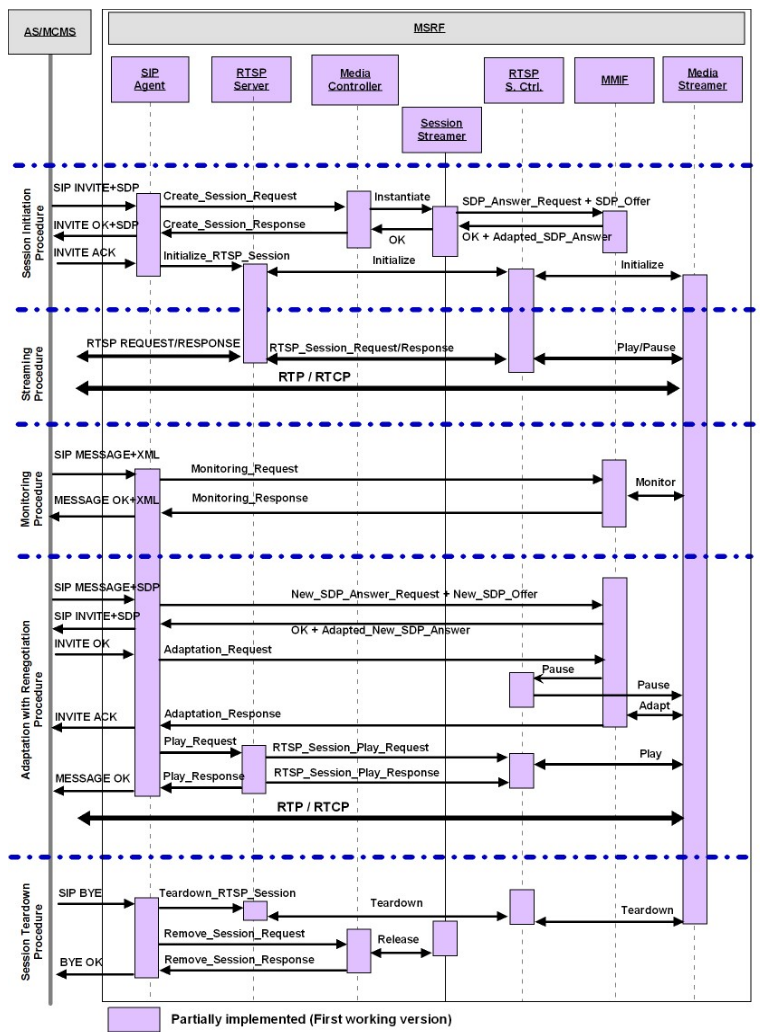

Figure 4: MSRF Adaptation Procedure

1. The ***IMS-SIP compliant session initiation phase***, started on the IPTV soft phone (terminal) request through the CSCF.

The INVITE message contains the terminal's SDP offer consisting of its capabilities (video size, codecs, etc.) and the name of the requested media resource. On reception of an INVITE + SDP message, the IMS SIP UA asks the Media Controller for the media resource availability and for new session creation. The Media Controller instantiates new session and, based on the terminal capabilities, the Adaptation subcomponent of the MMIF generates a SDP answer (new adapted SDP). Then, a response is reported back to the terminal using SIP OK + SDP message. If the terminal accepts the MSRF SDP answer, it acknowledges with a SIP ACK. Finally, the Media Streamer and the related RTSP session at the RTSP Server and the RTSP Session Controller are initialized.

2. The ***Media resource streaming phase***, based on RTP/RTCP/RTSP protocols. More specifically, only the PLAY and PAUSE RTSP methods are used to start and pause, respectively, the current media resource streaming. In fact, the terminal requests are received by the RTSP Server and forwarded to the RTSP Session Controller in order to play or pause the media resource at the Media Streamer. The responses are reported to the terminal through the reverse path. The media resource is streamed to the terminal using the classic RTP/RTCP protocol.
3. The ***Session monitoring phase***, triggered, using SIP signaling, by the MCMS on PQoS degradation detection at the terminal. The MSRF monitoring procedure uses the SIP MESSAGE + XML to and from the MSRF. On monitoring request, the IMS SIP UA contacts the monitoring subcomponent of the MMIF and this last one retrieves the monitoring data from the Media Streamer, aggregates them and sends back the results to be delivered to the MCMS.
4. The ***Session adaptation phase***, also triggered, using SIP signaling, by the MCMS to enforce the adaption decision based on the previous monitoring task. This adaptation phase is MCMS driven on PQoS degradation and after a successful monitoring procedure. It aims to adapt the media streaming parameters to the new network conditions for better media resource consuming at the terminal.

   In this task, the IMS SIP UA requests at the adaptation subcomponent of the MMIF for a new SDP offer based on the MCMS adaptation decision available in SIP MESSAGE + SDP request. The generated SDP offer by the MMIF is sent to the terminal using SIP INVITE + SDP. If the terminal accepts this new SDP offer, it replies with a SIP INVITE OK. Then, the MMIF stops (pauses) the streaming process through the RTSP Session Controller and adapts the streaming parameters at the Media Streamer. After a successful adaptation, the IMS SIP UA acknowledges to the terminal and requests the RTSP Session Controller to restart (play) the streaming process. Finally, a SIP MESSAGE OK is sent back to the MCMS.
5. The ***IMS-SIP compliant session teardown phase***, requested by the terminal to free resources allocated in the aforementioned phases. This session clean-up procedure is started by the terminal which contacts through the CSCF and IPTV AS the MSRF using SIP BYE message. Then, the SIP Server requests the Media Controller to tear down the RTSP session at the RTSP Server, the RTSP Session Controller, and the Media Streamer and to release the session. Finally, the SIP BYE OK is reported back to the terminal.

4. Conclusion

In this paper, we have introduced a dynamic cross layer adaptation mechanism complying with IMS architecture for PQoS improvement of the entire IPTV content delivery chain. This is mainly achieved by the design of the MCMS modules in combination with cross-layer adaptation techniques. The overall architecture has been briefly described and the main adaptation use case has been introduced.

5. ACKNOWLEDGMENTS

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