Next generation IPTV solution for educational purposes

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***Abstract* - The aim of this work is to design an appropriate concept of IPTV for the needs of academic institutions. Based on the analysis, selected existing technologies of the components of internet television in cooperation with newly created components are transforming into a multifunctional next-generation IPTV solution with educational abilities. The result is a concentration of these functionalities into a single complex structure in the form of portal with web interface, which allows upload of high definition video content, categorization, distribution, play and assign to playlist of scheduled broadcast.**

***Keywords* – IPTV, VOD, Streaming, Wowza**

I. INTRODUCTION

The issue of streaming technology and IPTV is quite extensive and thus more and more widespread in commercial television services and also in the educational field. IPTV is a means of information delivery to the recipient in the form of video, audio or web content. This type of broadcast is transported through the network using internet protocols. Usage of IPTV is polyfunctional, but it has the largest representation in the replacement of analogue television broadcasting. Other usage includes the possibility of remote education, which is unlike video conferencing, technologically simpler option of providing one video stream to large number of recipients, but at the expense of losing interactivity from side of recipients. This fact creates a new dimension in looking at education, where barriers of distance are broken down and there is opportunity to participate in full training process through the network anywhere in the world.

IPTV adapted to educational purposes appears to be a means, which could be in the future as one of the primary sources of education, therefore, is appropriate to propose an IPTV system in the form, which meets all the requirements of learners, and it is suitable for mass usage. The aim of this work is to contribute new concept of IPTV solution for the academic environment using popular technologies in the field, with proper connection and adding newly created components.

Analysis of this work deals with mapping of existing technologies, such as: streaming, video conversion tools, web players, flash technology, HTML5 and other support tools. Work continues with creation of concept showing interconnection between selected technologies and new components necessary for the functionality required by academic institution. Implementation of the idea consists of the configuration of existing components and creation new program parts for supporting interconnection. The final part of the work evaluates the results generated by solution and the functionality of the resulting IPTV portal of new generation.

II. GOALS

The goal is to design a complex IPTV solution enabling the management, distribution, reception of video content and creation of scheduled broadcast. Work should end with the implementation of IPTV portal with user friendly interface.

III. ANALYSIS

A. Streaming

Streaming is a technology, which ensures the transfer of multimedia content over a network. It allows transmission of audio, video or even other multimedia content from sender to recipients. This technology can be used to real-time broadcasting, but also for receiving video on demand (VOD). Traditional broadcasting operates in a way where videos are broadcasted in real time in accordance with pre-planned schedule or ongoing live events from the cameras. Receiving video on demand allows recipient to choose the video content that will be transmitted at that moment.

Streaming media formats compared with conventional media formats brings many advantages. These benefits include: media content protection against piracy, controlling the flow of content, selection of allowed recipients or easy content management. For this reason, especially due to affordability, these technologies are largely appearing as an appropriate means for providing educational services through the Internet. This all brings a new dimensions and more effective teaching methods then static text and images.

Delivering of streaming media content is provided without the need to download entire files. As soon as computer starts playing the media, it also starts downloading content from the next sections from streaming server. This process is called buffering, which means that downloading content and playing the parts are going at the same time. Streaming is mostly without affecting the transmission quality, in addition to the initial buffer initialization. The aim is to provide services with streaming technologies in accordance with the limitations of network bandwidth. It is necessary to use such technology, which ensures that the recipient is receiving the data smoothly and without delay. Describing method, however, affects the quality of video playback. The

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quality of transmitted media streaming is often subject to criticism. People often compare the quality of streaming media with the quality of conventional media files and they seem inadequate. But the main and important feature of streaming media is not quality but access.

B. Resolution and codecs

Standard TV broadcast formats offer a resolution up to 720x576 pixels (SD), which means that the signal is drawn in 576 lines of 720 pixels. Minimum resolution referred to as high definition (HD) is defined as resolution of 1280x720 pixels. Maximum commonly used high-resolution live video ends on the value of 1920x1080, which is referred to as "Full HD". However there are higher resolutions for imaging and broadcasting video, which are not yet mass, because there are high costs of equipment. The more pixels can device draw, the more details can be received. Significant impact on the quality of high resolution has the way how the image is recorded and rendered on the screen. There are two types of image rendering: progressive and interlaced. Interlaced image is rendered on screen at any one time either odd or even lines. Rendering takes place so rapidly that the human eye is unable to normally capture. The smaller decline in the quality still occurs with rapid changes in the image and can cause impression of flashing. By contrast, in progressive mode, the entire area of the screen renders the image in one step for one change, so that allows tracking all the details together. The most common current formats are high definition 720p, 1080i and 1080p. This marking determines the number of lines in resolution and letter identifying way of rendering (i - interlaced, p - progressive).

Even though the quality is not the primary feature of streaming technology, it is the way, how can affect quality. When it comes to multimedia transmission through lines with high bandwidth, then can be used appropriate encoding, which ensures higher quality. When it comes to the transmission through lines with lower bandwidth, then it is possible to use the encoding, which will primarily ensures smooth playback, and then solves the issue of quality. Encoding is provided by codecs. Codec is compression algorithm, which is used to reduce the file size. Reducing of file size appears in process of transformation from conventional format to streaming media format. Programs that provide assistance for encoding with codecs are called encoders. Some encoders can encode the same source for multiple uses (depending on bandwidth). In terms of streaming technologies, here are important mainly video codecs and audio codecs. The best known are MPEG-1, MPEG-1, MPEG-2, MPEG-4, DivX, Vorbis, H.263, H.264. Each codec has ability to stream with specific amount bits per second (bit rate), which depends on the level of compression, on the resolution of the video, on the information contained in the transmission or on the number of audio channels. These codecs provide encapsulation of video content in video file format. The most common video file formats are AVI, OGG, MPG, MOV, ASF, WMV, FLV and MP4. Different codecs can be used to create various file formats, this means that file formats should not be linked only to a codec, but nevertheless there are some exceptions. The most widely used and most popular codec for HD is now H.264. This codec combines the best video quality in combination with the least requirements for the data stream. This means that it is possible to impose better and sharper video into a file on relatively small size. It has a large impact on cost savings for bandwidth and storage in the archive, unlike the previous generation's codecs. For comparison, H.264 uses the same quality recording and up to 4 times less storage capacity than standard codecs. Codec provides highly efficient use of the various kinds of applications, such as: Live TV, VOD, video conferencing, streaming and storage. It is designed to provide excellent quality in wide use (as 3G networks and mobile streaming).

C. IPTV Components

In terms of the concept of IPTV, there are several essential components needed to build IPTV solution, which provide services to end customers via the Internet. Distribution of video content to multiple packets, compression and transmission to hosts are provided by video streaming server. Conversion of media formats into a format suitable for transmission is provided by encoder. Camera is source for providing live broadcasts. The source of video on demand consists of data storage in combination with supporting tools such as web-based system for management and receiving of content (Fig. 1).

D. Expected functionality of proposed IPTV system

After introducing basics of IPTV technologies, it is appropriate to define the expected capabilities and functionality of the proposed IPTV solution for educational purposes. To make solution suitable for use in academic environment to provide educational multimedia content, it should meet the following requirements:

- Provide high definition for all services working with video content.
- Enable broadcast reception according to the schedule via a web interface.
- Realization of streaming broadcasts based on schedule.
- Include the possibility of schedule broadcast through a Web interface.
- Provide information about scheduled broadcast in the form of daily and weekly program or offer information about the current broadcast.
- Integrate environment to receive messages within broadcast in real time.
- Enable the reception from live cameras.
- Implement a live broadcast via from cameras.
- Provide reception of video on demand (VOD).
- Allow categorization of video content in VOD service.
- Allow the association name, description or other text fields for video content.
- Implement a web interface to upload new videos.
- Include automated creation of thumbnails from video.
- Include automated tool to obtain the video length.
- Allow searching for content in the VOD service.
- Offer the ability to share and spread links to the video content through social networks.

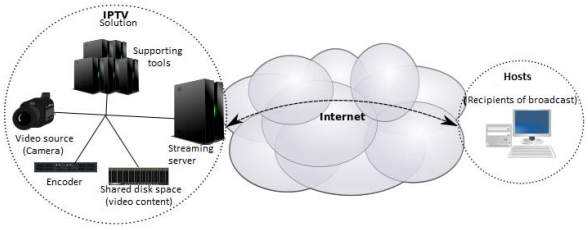

Figure 1. Concept of interconnection between mentioned IPTV components

Based on analysis of existing technologies for the needs of IPTV, it is shown that following components are suitable for use in this solution: Wowza Media Server, Stream Class Scheduler Module, Flash media encoder, FFmpeg, VLC and JWplayer.

E. Wowza Media Server

It is fully interactive server for streaming multimedia content with full support for H.264. It is Java server platform, which is also suitable for high deployment with a large number of clients in the network and with continuous operation. Wowza has wide ranging possibilities, not only as a means for streaming stored files (VOD) or live broadcast, but as a means to secure video conferencing, shared screens or games. There is also the possibility of using modules that provide control of dynamic content such as advertising or playlist. Since Wowza is based on JAVA, there is a possibility to create own modules that can be fully customized. These modules are created using an integrated environment Wowza IDE, which also offers the ability to configure and manage server activity.

Concerning security, the server provides it at a high level. It includes protection against unwanted intrusions and even restriction to capture streaming content. These features are provided through an encrypted transfer with RTMP / RTMPS protocol and special security token, which generates a strong protection against applications for recording broadcast content.

Usage of server is extensive and it is not depend of type of recipient's device. Broadcast reception is possible via the web interface, custom software applications, mobile devices or set-top box. Wowza is able to stream to all of these devices in parallel and selects the correct protocol and data flow depending on the client.

In this solution it will be utilized as the primary server for broadcasting.

F. Stream Class Scheduler Module

Additional Wowza's module provides control of streaming channels. Schedules are defined in the input file in the SMIL language. With appropriate modifications and additions, offers the following functionality: Establishment of multiple broadcast streams (channels). Possibility of creation for each channel a broadcasting schedule (playlists). For each playlist is defined date and time of playing and path to video files. For each video can be defined playback position and playback time. It also has possibility to live streaming channel in HD on the schedule in real time.

This module in combination with the Wowza server appears to be a suitable component for building new custom automated systems for creating broadcast as part of a new generation IPTV solution.

G. Flash Media Encoder

This software is built to stream live video in real time and simultaneously convert to Flash. It supports codecs H.264 and On2 VP6. The program can simultaneously live broadcast and save the broadcast to file in FLV format. This feature is useful for creating video archives in IPTV solution. Encoder has various features influencing quality of streaming beginning from selecting the encoding resolution, ending with the choice of filters to determine the bitrate. The restriction appears to be his platform compatibility, which is defined for Windows and Mac OS, but there is lack of support for control over the command line interface. The program could be controlled only through a graphical interface, which eliminates the possibility of automation.

In this solution it will be utilized for providing live broadcasts from the cameras.

H. FFmpeg

Complete multiplatform solution for recording, converting and streaming video. It can quickly convert media files between different formats. Control is provided by using the command line, but the commands are intuitive and parameters are automatically filled. It can even convert video directly from a source that is currently streamed live. It also provides additional features as resize the video using high quality filters and also directly to the live broadcast.

It will be utilized in current solution as tool for video conversion, for determination the length of video and for the creation of video thumbnails.

I. VLC

A combination of server and client designated to delivery or receive streaming media formats. VLC is built in a modular way. It means that it is possible to choose from a variety of different modules providing control of video. It has possibility of direct conversion input to the output container formats suitable for streaming. There is support for managing playlists and another advantage is the existence of extensions for Web browsers in form of VLC player which can play stream directly in browser. VLC can operate with filters in the streaming video directly like showing logo or inserting RSS. Best advantage of this tool is possibility to control every feature via the command line interface. The potential can be seen in creating automated scripts for broadcast.

In this solution it will be utilized as secondary server for broadcasting outside of the web portal (e.g. STB).

J. JWplayer

JWplayer is web based flash player with support of RTMP protocol and HTML5. It brings feature called "dynamic bitrate switching", which set the bitrate of video

dynamically according the information from user about bandwidth. This feature decides what bitrate has to be provided to best ensure the continuity and quality of play. Playback can also stop and delay live streaming, then store streaming in temporary memory and then re-launched from memory for next watching. Player supports various extensions such as publish videos directly on social networks with one control or adding information directly to the video.

JWplayer will be utilized to play broadcast and video on demand in web interface of current IPTV solution.

K. *Interconnection of components*

For the interconnection (Fig. 2) of these components is necessary to design custom components such as: web portal for access and manipulation of video content, web interface for creating the schedule, a database of videos and schedule, script for creating SMIL playlist for Wowza server, script for creating a playlist for VLC, storage of video files, live video source (video camera).

The overall solution is designed for availability all services for all roles from anywhere via the Internet. Services for administration of broadcast or VOD not depend on special programs running only at servers however, solution allows administration and configuration via the web interface in the browser. This brings consistency of solution, where almost all functions are controlled from a single comprehensive environment. Environment takes the form of a web portal with a friendly and intuitive user interface.

Overall design allows for five types (roles) of access the system: creator of live broadcasts, administrator of video content, recipient of video content via web, administrator of broadcast schedule, recipient of broadcast via software.

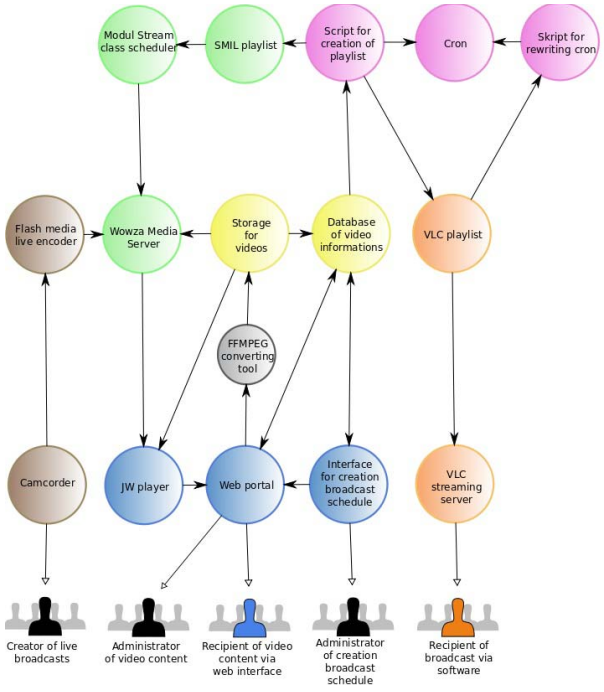

Figure 2. Design of interconnection all components in IPTV solution.

L. *The creator of live broadcasts*

This role uses live video from the camera as a source for live streaming intended recipients. He also manages encoding tool for live broadcast and through this tool also keeps a record of live broadcast to archive for next integration to VOD service.

M. *The administrator of video content*

He manages VOD section, which includes: uploading new video contents, classification to categories, nomenclature, association of textual information and thumbnail selection. He can add, edit and delete video content related to VOD section.

N. *Recipient of video content via web interface*

He has allowed watching of scheduled broadcast, live broadcasts and video on demand (VOD). He can view the schedule, search video content and share via social networks.

O. *The administrator of broadcast schedule*

This role creates and manages broadcasting schedule created from existing database of video content, where the video is assigned to the day of the week and exact time, when start to broadcast. He can also assign video from VOD section to schedule.

P. *Recipient of broadcast via software (VLC)*

He can receive scheduled broadcast outside the web interface through protocols supporting VLC streaming technology. It can be done by external software players installed in operation system in computer or set-top box.

IV. Solution And Results

Entire solution was based on an operating system of Linux (Ubuntu 10.10, Kernel 6.2.32) with installed LAMP server (a combination of Apache, MySQL and PHP). It was necessary to create a shared folder for cooperation of individual tools. In this folder are located files related to portal, configuration files and files related to creating schedule. Each section of the web portal is based on interconnection of technologies HTML, PHP and jQuery. The HTML files define placing objects on page, location of static text, dependencies to external JavaScript files or styles. JavaScript files define the characteristics and behavior of objects from the jQuery UI library. Files written in PHP furthermore ensure connection to the database and manage dynamic objects in the page. Code of Flash player (JWplayer) is located in HTML files and for improving the player look it was used modified skin.

Solution includes two files written in Bash language, which are added in system Cron. These scripts are designed to automate the operations related to create broadcast schedule. For automation it was necessary to implement two types of commands calling FFmpeg server: getting video length and getting video thumbnail. Wowza Media Server was used as the primary server for the broadcast schedule. Streaming is working through RMTP protocol by transmitting the video content from a specific application of Wowza server built for live

streaming. As a complement to server extension, it was installed Wowza Collection Module, which contains the Stream Class Scheduler module. It was important to add the server configuration component called ServerListener, which arranges loading SMIL file for organization and schedule of broadcast.

The solution includes the usage of complementary tools such as VLC and Flash Media Encoder. VLC server was used only as a secondary server operating along the Wowza Media Server for streaming to end-customers with a specific software or set-top box. Flash Media Encoder was used for live broadcasts such as software, which supports video transmission from the camera. This encoder has to run from another windows compatible hardware with connection to cameras.

Result of work is the complex web portal containing four basic sections for watching video content, management video content, upload new videos and for creating schedule of broadcast. All services are available from one web interface for all kind of roles.

A. Watching section

The first, introductory section of the portal (Fig. 3) is designed to receive scheduled broadcast. It allows to watch broadcast via web player, to show current information about ongoing stream or to appear panel for live text messages. Live text messages can be dynamically updated by administrator and are shown below video window without need for refresh page in browser. There is also a daily and weekly program schedule viewable from scrolling toolbar. Information such as name of currently streamed video is displayed in information panel above the video window.

B. Video on demand section

The second section (Fig. 4) offers video on demand (VOD) services. Content are divided in categories located at the top menu and subcategories, which showing like visual icons. After clicking on the icon pops up a list of videos belonging to that subcategory. After initialization of video playback by clicking at thumbnail, it appears window with video player containing information about video. VOD Section also contains blocks showing 5 most viewed videos and 5 latest videos. At the top of section is the search window, which is able to search video content in database after specification one or more letters. Search system automatically complete words and selects the appropriate records. Every video can be shared through an integrated link to social network (Facebook) and there is also ability to switch to full screen view.

C. Upload section

To add a new video content is specified the next section of portal called "Upload". It consists of two parts (steps). The first step is for uploading video file from the file system of currently connected user. Upon successful completion of data transfer will automatically display the second part - a step for selection thumbnail and assignment information for video (Fig. 5). In this step, thumbnail is created by changing position of slider, which updates actual thumbnail at display.

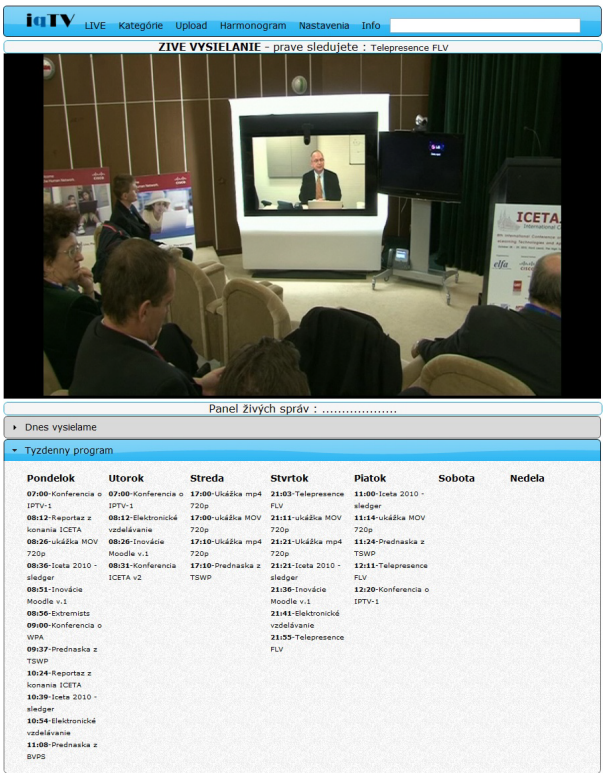

Figure 3. Screenshot of portal section for watching live broadcast and weekly program schedule.

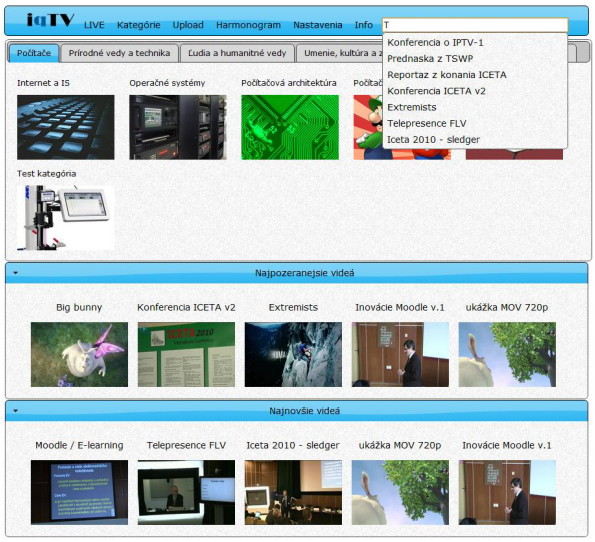

Figure 4. VOD section of portal designed for watching categorized videos.

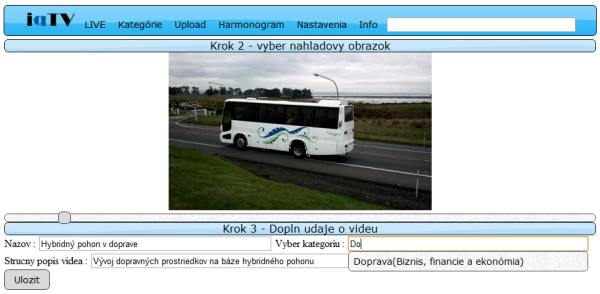

Figure 5. Choosing of thumbnail and adding information about new video.

D. Schedule section

Environment for creating broadcast schedule is implemented in a separate section (Fig. 6). It is divided into bookmarks by day of the week, where each day has the ability to add or remove blocks of the video content in exact time. Adding video is not only possible at the end or beginning of the schedule, but also in areas between existing records or it can edit the beginning of broadcasting.

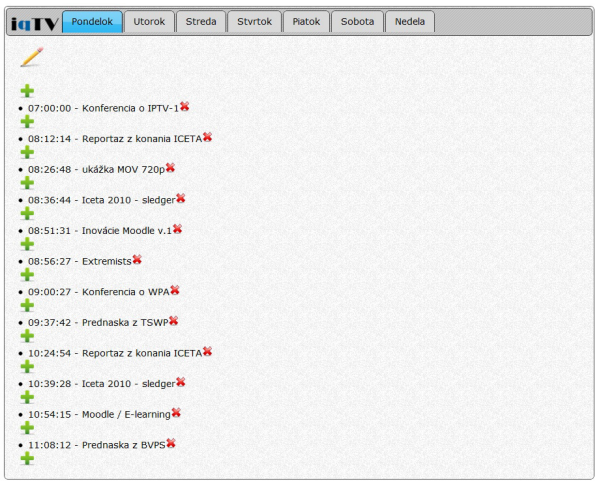

Figure 6. Environment for management broadcast schedule divided in days of week.

CONCLUSION

This work is dealing with design and implementation of comprehensive next-generation IPTV solution with the possibility to use in educational process. The design of concept was created based on an analysis of existing technologies in combination with creation custom components. Result of the work has been transformed into comprehensive and centralized system in the form of web portal with user friendly interface. The portal was built on HTML, PHP and JavaScript libraries in combination with jQuery UI. Wowza Media Server in cooperation with Flash technology was used as the primary technological solution for video broadcast. Reception of video content was provided by JWplayer, which is web based Flash player. As support tools programs like FFmpeg and Flash Media Live Encoder are used. The final result is a system which allow the reception, transmission, creation and management of video content in high definition.

From the perspective of the end recipient of services resulting web portal is designed to receive broadcast according to predefined schedule or watching video content on demand (VOD). In terms of administration of IPTV services, system carries out operations through the portal, such as adding new videos on server and creating broadcast schedule. Solution has the capability to integrate live broadcast from the videocameras encoded in real time.

In terms of functionality of the overall solution can be concluded that the system is suitable for use in the academic field as a means of education, but it is not impossible his wider usage in projects offering IPTV services outside the academic environment.

Future development of the presented system is aimed to its integration into content management system. The goal should be improvement of source codes of system in the form of modules related to CMS Drupal 7, because both systems are developed in the same programming languages. This integration will extend system functionality and usability and it will provide a central security solution covered by existing modules.

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