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A Content Oriented Smart Education System based on Cloud Computing

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Abstract

Cloud computing has attracted a great deal of attention in the education sector as a way of delivering more economical, securable, and reliable education services. This paper proposes and introduces a cloud-based smart education system for e-learning content services with a view to delivering and sharing various enhanced forms of educational content, including text, pictures, images, videos, 3-dimensional (3D) objects, and scenes of virtual reality (VR) and augmented reality (AR). The proposed system consists of six main features that are required for deploying cloud-based educational content services: 1) a cloud platform that provides an infrastructure for the realization of a cloud-based educational media service environment, 2) a compatible file format that enables it to provide media content through various types of devices, 3) an authoring tool that enables teachers to create various types of media content, 4) a content viewer that displays different types of media on multiple platforms, 5) an inference engine that provides students with individualized learning content, and 6) a security system that manages privileged user access and data encryption in the cloud for dependable educational content services. We believe that the proposed system should provide a new and innovative solution for cloud-based educational media services by supporting a cloud-based service environment with a totally integrated system.

Keywords: *Cloud-based education system, Content oriented education system, Cloud-based educational content service, E-learning content service, Smart media service*

1. Introduction

Cloud computing has become a major point of interest in many fields, with its potential for providing enhanced service environments along with the advantages of scalability, flexibility, accessibility, reliability, and high performance while reducing IT-related operating costs [1, 2]. As a consequence, many enterprises are leveraging cloud computing technologies to conduct their business in a more cost efficient way. We are generally familiar with the concept of cloud computing and use several cloud services in our everyday lives, such as Gmail, Docs, and Calendar from Google, iCloud from Apple, SCloud from Samsung, SkyDrive from Microsoft, and Dropbox from

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Dropbox. Cloud computing can be seen as a new IT service model for delivering and provisioning computing resources, such as networks, servers, storage, and applications, as a service over the Internet, anytime and anywhere [3-5]. Cloud computing was first mentioned by Christophe Bisciglia at Google in 2006, though more attention was paid to it after Google launched “Google Apps” in 2007 [2], and it became more popular still after Apple launched iCloud in 2011.

Cloud computing has also attracted a great deal of attention in the field of education with its potential for delivering economical, securable, reliable, and sharable education services [6]. An increasing number of universities and educational institutions in the USA and UK are adopting cloud computing not only for increased cost savings but also for improving the efficiency and convenience of educational services [7]. Several companies, including Cisco, Microsoft, NEC, Amazon, and Google, are accelerating delivery of cloud-based education systems to educational institutes as a way of generating new business. Several learning management systems, including Moodle and Blackboard, are also supporting cloud-based educational services [8]. A number of studies have been conducted investigating the benefits of cloud computing for e-learning systems [8 - 10] and have suggested solutions for cloud computing based e-learning systems [6, 10, 11]. However, most of the current cloud-based education systems focus on delivering and sharing learning materials rather than supporting and establishing an integrated, total cloud-based educational service environment.

In this paper, we propose a content-oriented, smart education system using cloud computing that integrates a number of features; these features are required to implement a cloud-based educational media service environment. The proposed system enables a school to deliver and share a variety of enhanced forms of educational content, including texts, pictures, images, videos, 3-dimensional (3D) objects, and virtual scenes of virtual reality (VR) and augmented reality (AR). The proposed system consists of six main features required for the deployment of cloud-based educational content services. In other words, we developed six main features for the realization of a content-oriented smart education system based on cloud computing technologies. These technologies are: a cloud platform, a compatible file format, an authoring tool, a content viewer, an inference engine, and a security system. The intended implementation is for a small-scale, private cloud, rather than a large-scale, public cloud. The concept of the proposed approach was partially introduced in previous works [12-15].

The remainder of this paper is organized as follows. Section 2 describes the definition and characteristics of cloud computing, including cloud-based education systems. Section 3 presents the proposed cloud-based education system for smart media content services with the six main features. Section 4 summarizes the paper and outlines directions for future research.

2. Related Works

2.1. Cloud Computing

Cloud computing can be seen as a natural evolution of grid and utility computing [16]. Grid computing delivers a high-performance computing system by combining and virtualizing a number of computing resources, distributed in multiple locations over the Internet, to solve very large computational problems. Utility computing involves the renting of computing resources on demand [17, 18]. The key concepts of cloud computing were adopted not only from grid and utility computing but also from existing IT technologies; for example, service-centered architecture from SOA (Service

Oriented Architecture), scalable and elastic IT resource delivery from virtualization models, and platform services from Web 2.0 [2]. More importantly, cloud computing can deploy many other additional features, such as scalability, flexibility, accessibility, reliability, and high performance, while reducing IT-related operating costs and implementing a green IT environment [1, 2, 17]. It is a new IT service model for delivering and provisioning IT resources, such as networks, servers, storage, software, applications, and documents. These resources are available on-demand, in a scalable, elastic, and real-time virtual way, anytime and anywhere, from multiple remote locations over the Internet [3-5]. Cloud computing allows users to access and use any IT resource by paying for what they need in a more enhanced, service-oriented platform environment, rather than directly purchasing the required IT resources [18].

The National Institute of Standards and Technology (NIST), in its definition of cloud computing, has identified five essential characteristics, four deployment models, and three service models of cloud computing [19]. The five essential characteristics include on-demand self-service, rapid elasticity, measured service, broad network access, and resource pooling. The four deployment models are public, private, community, and hybrid cloud. Finally, the three service models include Infrastructure as a Service (IaaS), Platform as Service (PaaS), and Software as a Service (SaaS). In the IaaS service model, the vendor provides to clients hardware resources, such as servers, storage, networks, and other fundamental computing resources, allowing consumers to run software and applications. In the PaaS service model, the provider provides clients with a cloud infrastructure for deploying clients' applications, created with programming languages and tools supported by the provider. In the SaaS service model, the vendor provides clients with the vendor's applications running on a cloud infrastructure, including various business models and standardized application processes, through a variety of client devices [19]. For example, S3 from Amazon and hosted hardware services from Cisco, IBM, and HP are based on the IaaS model; EC2 from Amazon, Force.com from Salesforce.com, and Google Apps Engine from Google are the basis of the PaaS model; and Web Services from Amazon.com, CRM from Salesforce.com, and Google Apps and Gmail from Google are based on the SaaS model [2].

More recently, the concept of cloud computing evolved from delivering, sharing, accessing, and storing applications to providing access to a variety of files, such as text documents, photos, videos, and music. These files are stored in the cloud on remote computer servers with file syncing solutions, as seen in the cloud-based document management of Dropbox and iCloud. Dropbox [20] is a free cloud service from Dropbox Inc. that allows users to share documents, photos, and videos anywhere by offering storage and file synchronization in the cloud. iCloud is also a cloud-based storage service from Apple Inc. that allows users to store music and iOS applications; these files can be downloaded to different devices via remote servers [21].

Through such services, a user can store documents and applications in cloud storage, accessible from multiple remote locations via the Internet, but not necessarily stored on the user's computers. In cloud storage, the user's data is kept in shared data centers (servers) and managed in a highly secure, robust, and reliable way. The user can download the stored applications and documents to multiple devices and platforms via an optimized interface for each device, such as smartphones, tablets, netbooks, and PCs. The downloaded resources will always be updated with latest versions through file synchronization.

2.2. Cloud-based Education Systems

As the adoption of cloud computing increases, many academic institutions are introducing cloud computing technologies into their education systems, promising and delivering more scalable and reliable education services. Many universities have acknowledged the potential benefits of leveraging cloud computing for economic reasons, as well as for more advanced teaching and data sharing [22]. A number of studies were conducted to investigate the benefits of using cloud computing for e-learning systems [8 - 10] and to suggest solutions for cloud computing-based e-learning systems [6, 10, 11]. Pocatilu *et al.*, [9] presented cloud computing advantages for e-learning as being low cost with higher data security, virtualization, centralized data storage, and the possibility of monitoring data access. They also specified cloud computing benefits for e-learning in terms of the characteristics of the three cloud service models: infrastructure (e-learning systems can be run on the provider's infrastructure), platform (e-learning systems can be implemented based on the provider's development interface), and service (e-learning systems can use provider-developed solutions). Bora and Ahmed [10] examined the benefits of adopting cloud computing for e-learning and found it is low cost, offers improved performance, provides instant software updates and improved document format compatibility and data security. Additionally, it provided many benefits for students and teachers, such as online courses, exams, assignments, projects, feedback, forums, and e-learning content and resource management.

The University of California (UC) at Berkeley is operating its courses on a cloud supported by Amazon Web Services, based on the SaaS service model [7]. The University of Washington is adopting cloud computing to provide state-of-the-art productivity and collaboration tools to staff and students, supported by Microsoft (Windows Live including Email and Calendaring, Messenger, SkyDrive, Spaces, and Photos) and Google (Google Apps including Google Email, Calendar, Docs, Sites, and Talk) [23]. The University of Texas at Austin and the North Carolina State University achieved a substantial decrease in IT-related expenditures [24]. Universities are leveraging cloud computing for economic reasons as well as for more advanced teaching, instruction, and data sharing.

Several companies including are accelerating delivery of cloud-based education systems to educational institutes as a way of generating future business, and several learning management systems are also now supporting cloud-based educational services [8]. Although much work has been done to date with regard to adopting cloud computing for educational systems, further studies need to be conducted to develop more diverse forms of cloud-based education systems, in more innovative and efficient ways. Meanwhile, most of the current cloud-based education systems are concentrating on delivering and sharing learning materials and teaching activities, rather than constructing and supporting an integrated, total cloud-based educational environment.

3. Content Oriented Smart Education System based on Cloud Computing

3.1. Overview of the Proposed System

Figure 1 presents the proposed cloud-based education system for smart media content services [12, 14]. The proposed system enables delivery and sharing of a variety of enhanced educational content by integrating a number of features required for the deployment of a cloud-based educational media service environment. Figure 2 shows the proposed system with its six main features required for deploying cloud-based educational content service.

Teachers in schools are able to create various forms of learning content, including text, images, video, 3-dimensional (3D) objects, and virtual scenes based on virtual reality (VR) and augmented reality (AR), using an authoring tool provided by the system. The content is managed in the cloud in a compatible common file format. The system supports various platforms, such as personal computers (PCs), notebooks, tablets, smart TVs, and smartphones. The system also provides a content viewer for displaying learning content and an inference engine to support content customized to each individual student, based on their preferences and knowledge. An inference engine is included to provide students with personalized learning content by analyzing their preferences, learning styles, and content usage patterns. In addition, a security system is provided for controlling data access and encryption in the cloud.

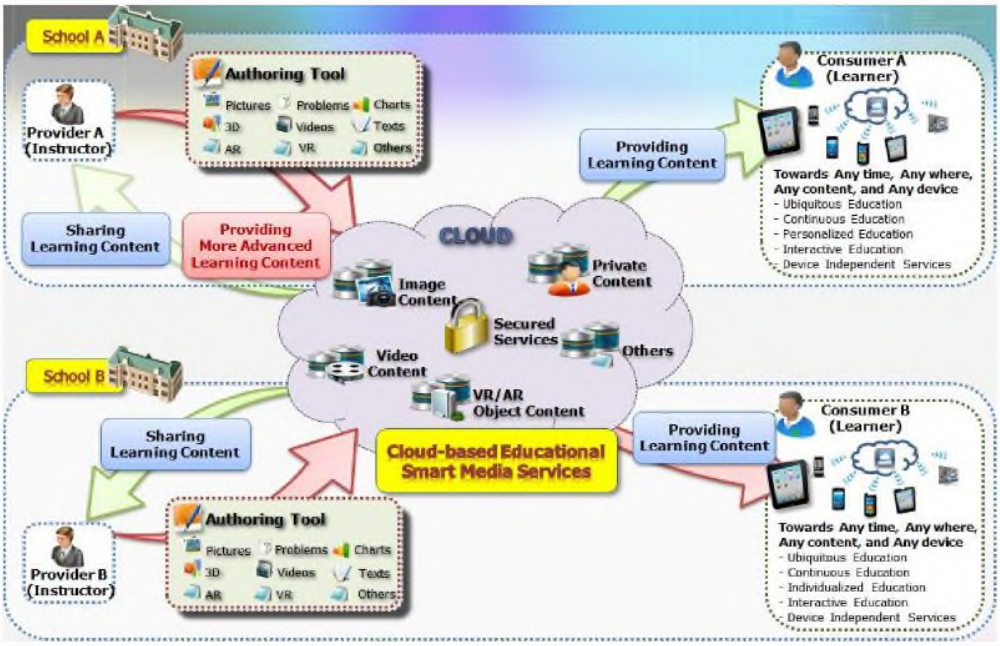

Figure 1. Architecture of the proposed cloud-based education system for smart content services

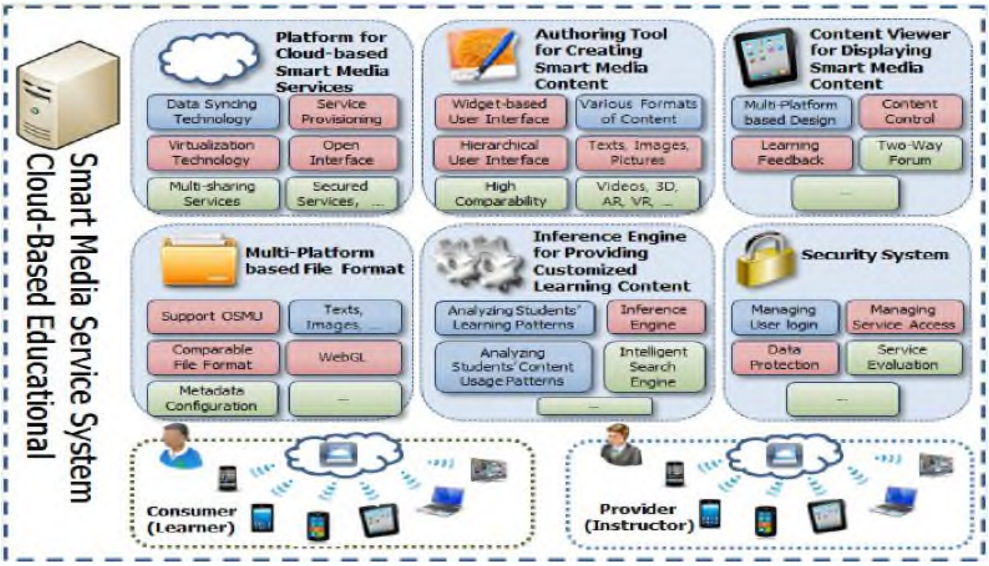

Figure 2. Infrastructure of the proposed system with its six main

features **3.2. Six Main Features**

3.2.1. Cloud Platform: The proposed system established a private cloud platform to provide an infrastructure for the implementation of a cloud-based educational media service environment by applying several IT and cloud computing technologies, such as data synchronization, virtualization, service provisioning, and multi-sharing services. In other words, we configured a private cloud platform to install and operate a cloud-based educational media service environment by leveraging IT and cloud computing technologies. In addition, we identified software and applications required for the proposed cloud-based education service and allocated them to the three cloud service models (IaaS, PaaS, and SaaS) as shown in Figure 3.

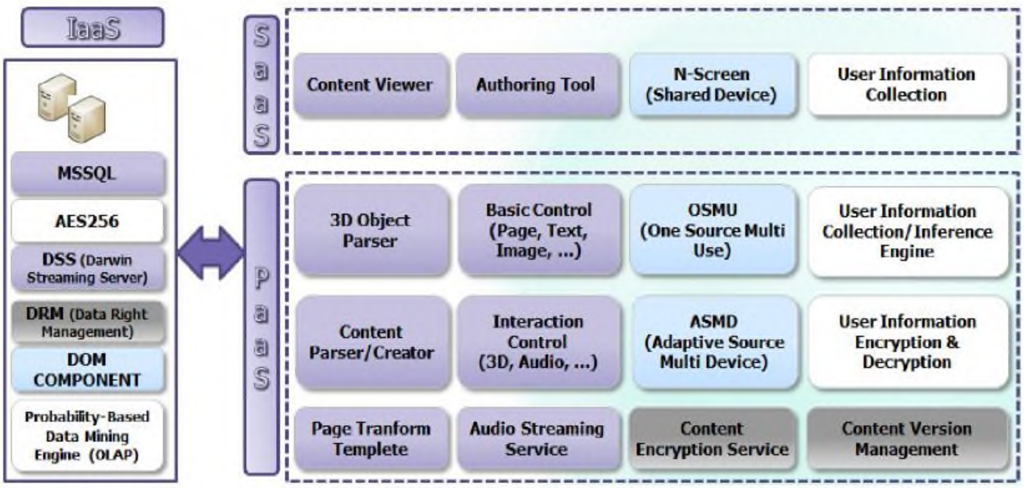

Figure 3. Cloud-based educational media service environment

3.2.2. Common File Format: We developed a common file format to be able to manipulate various types of media content on multiple device platforms based on an XML document format with HTML5, eXtensible 3-Dimensional (X3D), and JavaScript.

XML has been used in many areas as a means of representing data and meta-data. It consists of two components: the Document Type Definition (DTD) that defines the schema for the XML document structure and the eXtensible Style sheet Language (XSL) that describes styles for representing XML data. That is, XML separately represents content and style, so that the same content can be viewed on multiple devices by defining only the styles appropriate to each device. XML is also designed to make it easy not only to describe many different kinds of data but also to send and receive data between computer systems connected to the Internet, such as data transmission in smartphones [13]. For these reasons, we adopted XML as the basic representation language for developing a common file format for various types of contents. Table 1 summarizes the content types defined in the common file format [13]. These content types are inserted and handled in a document file as a control. We divided the content types into two categories: basic controls that are displayed in a 2D screen and interactive controls that can play 3D video and objects or respond to user actions. Each of these controls is defined with a number of properties and each property is specified with its own data type, such as numeric, character, or multiple choice. Table 2 shows the properties and provides brief explanations of each control defined in the common file format.

Table 1. Content types defined in the common file format

Category	Control Type	Definition
Basic Control	Page	Control for each page layout
	Text	Control for page content
	Image	Image file control (*.png, *.jpg, and *.gif)
	Table	Table control
	Math	Formula control
	2D Objects	2D object control (Line, Circle, Polyline, Polygon, and others)
Interactive Control	Video	Video control (*.mp4)
	Audio	Audio control (*.mp3)
	3D Object Loader	3D object control (*.3ds)
	AR	AR control
	Annotation	Annotation data control (memo, underline, textbox, highlight)
	Animation	Animation control that responds to user actions
	Quiz	Quiz control

Table 2. Properties of each control defined in the common file format

Category	Property
Common properties for all controls	width (of a control area), height (of a control area), x, y (x- and y-axis of control area), block (range of a control area), id (identification of a control area)
Page	screen (direction, userPage), chapter (totalNum, pageStyle, pageUse, pageIndex, title)
Text	font-backcolor, font-backimage, item-valign (vertical alignment), text-halign (horizontal alignment), textItem (URL)
Image	class (using styles defined in css), item-valign, item-halign, caption (caption information), imageItem (URL, tooltip)
Table	border, tr: align, valign, td: align, valign
2D Objects: circle	cx (x-axis of the center of the circle) , cy, r (radius), fill (color to fill the circle)
rectangle	width, height
line	x1, x2, y1, y2, style (color and thickness of the line)
ellipse	cx, cy, rx (horizontal radius of the ellipse), ry (vertical radius of the ellipse), fill
polygon	points (coordinates of each polygon vertex), fill
polyline	points, fill
Video	class, controls, item-valign, item-halign, caption, start-time (default: 0)
Playlist	item_num (the number of videos played on the video control), playing_index (the index of the currently playing video)
Source	src (video's location information), type, video_index (the video index in the playlist)
Audio	class, controls, item-valign, item-halign, caption, start-time (default: 0)
Source	src, type
3D Object Loader	class, item-valign, item-halign, caption
Space	left, right, bottom, top, near (minimum value of the z-axis), far (maximum value of the z)
Camera	startposition, endposition
Object	id, pointIndexSet, texture (information about the location of texture mapping)
PointItem	coord (vertex information: x, y, z), color, texturecoord (mapping information)
AR	class, item-valign, item-halign, caption
Bound	left, right, bottom, top, near, far
Marker	type (marker-based or marker-less), data (for image recognition if marker-less: moments), URL (image of marker information when marker-based)
Object	id, pointIndexSet, texture
PointItem	coord, color, texturecoord
Memo	class, userid, bookid, target, target-index, contents, page
Animation	class, item-valign, item-halign, caption, active-event (animation start properties), audio-url (audio source location, audio-active-event (audio playback properties)
AnimationImages	url, name
AnimationGroups	unit (unit that an animation is played)
AnimatinItems	img-name, keyframe-time (animation changing time), width, height, x, y
Quiz: Answer	type (multiple choice or short answer), itemnum (the number of multiple choice)
Example/User	exindex, collect (answers)

HTML5 supports the <video> and <audio> tags to enable users to manipulate them in a very simply and easy way. Thus, we handle the video and audio controls based on HTML5 with JavaScript. For the AR control, we use X3D with JavaScript because X3D can encode a scene file using the XML format. X3D is runtime architecture that represents 3D computer graphics, including VR and AR, in an XML-based file format [25]. For basic shape control, such as circles, rectangles, lines, ellipses, and polygons, we used the Scalable Vector Graphics (SVG) format. Table 3, 4, and 5 show the XML source codes for the audio, 2D objects, and AR controls, respectively.

Table 3. XML source code for an audio control

```
<Audio width="320px" height="240px" x="10px" y="10px" block= "{true |
        false}" id= "audio01" class="audioplayer" controls="{true | false}" item-
        valign="{top | middle | false}" item-halign="{left | center | right}"
        caption="first audio" start-time="0">
        <PlayList><source src="audio.mp3" type="audio/mp3" /></PlayList>
</Audio>
```

Table 4. XML source code for 2D object controls

```
<svg id="svgelem" height="600" xmlns="http://www.w3.org/2000/svg">
    <circle id="redcircle" cx="150" cy="150" r="150" fill="cyan" />
    <rect id="redrect" x="100" y="100" width="300" height="100" fill="red" />
    <line x1="0" y1="0" x2="200" y2="400" style="stroke:blue;stroke-width:2" />
    <ellipse cx="150" cy="350" rx="100" ry="50" fill="brown" />
    <polygon points="20,10 300,20, 170,50" fill="greenv />
    <polyline points="0,0 0,20 20,20 20,40 40,40 40,60" fill="pink" />
    <defs>
        <radialGradient id="gradient" cx="50%"cy="50%" r="50%" fx="50%"fy="50%">
        <stop offset="0%" style="stop-color:rgb(200,200,200); stop-opacity:0"/> <stop
        offset="100%" style="stop-color:rgb(0,0,255); stop-opacity:1"/> </radialGradient>
    </defs>
    <ellipse  cx="200"  cy="250"  rx="100"  ry="50"  style="fill:url(#gradient)"  />
</svg>
```

Table 5. XML source code for an AR control

```
<AR width="100px" height="100px" x="10px" y="10px"
    block= "{true | false}" id= "AR01" class="AR"
    item-valign="{top | middle | false}"
    item-halign="{left | center | right}"
    caption="first VR">
    <Marker type="" data="" URL="" />
    <Object id="obj01" pointIndexSet="0 1 2 3 4 ..." texture="">
        <PointSet>
            <PointItem coord="100 20 30" color="255 255 255 255" texturecoord="0.2 0.5" />
            <PointItem coord="100 20 30" color="255 255 255 255" texturecoord="0.2 0.5" />
        </PointSet>
    </Object>
    <Object id="obj02" pointIndexSet="0 1 2 3 4 ..." texture="">
        <PointSet>
            <PointItem coord="100 20 30" color="255 255 255 255" />
            <PointItem coord="100 20 30" color="255 255 255 255" />
        </PointSet>
    </Object>
    <Bound left="" right="" bottom="" top="" near="" far="" />
</AR>
```

3.2.3. Authoring Tool: The system provides an authoring tool to allow teachers to create various types of smart media content including text, images, video, sounds, widgets, and 3D, VR, and AR objects and scenes. Figure 4 shows the content creation processes of the authoring tool system. The content creation process is divided into three phases: control creation, file configuration and editing, and distribution. In Phase 1, users can perform operations to create controls (content) to be inserted in documents. In Phase 2, users can set the layout of a document and then insert controls into the document. In Phase 3, the authoring system converts the newly-created document to the common file format then uploads the file to the server for distribution to client devices. The document structure of the authoring tool system follows the structure of the Flow Document of WPF (Windows Presentation Foundation). Figure 5 shows examples of a document creation process (Phase 2) using text and image controls (contents).

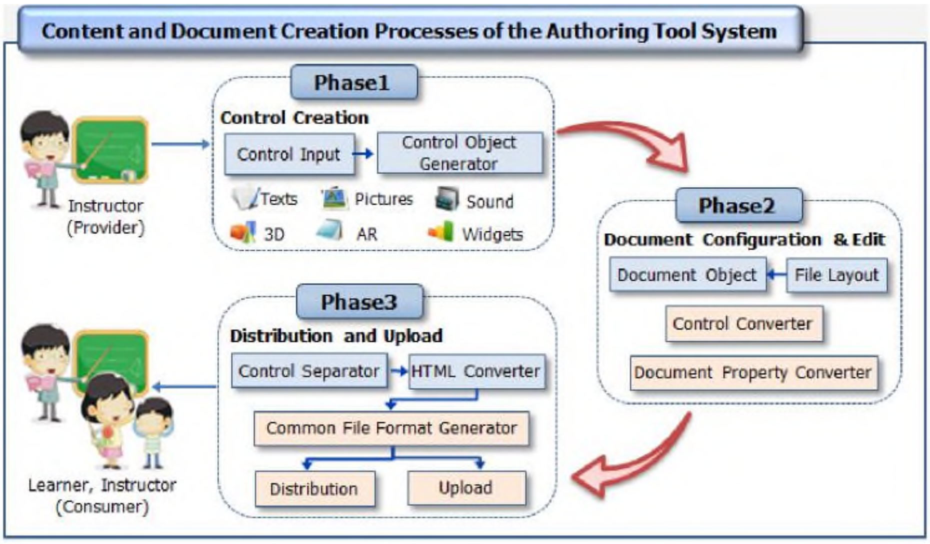

Figure 4. The processes of content and document creation

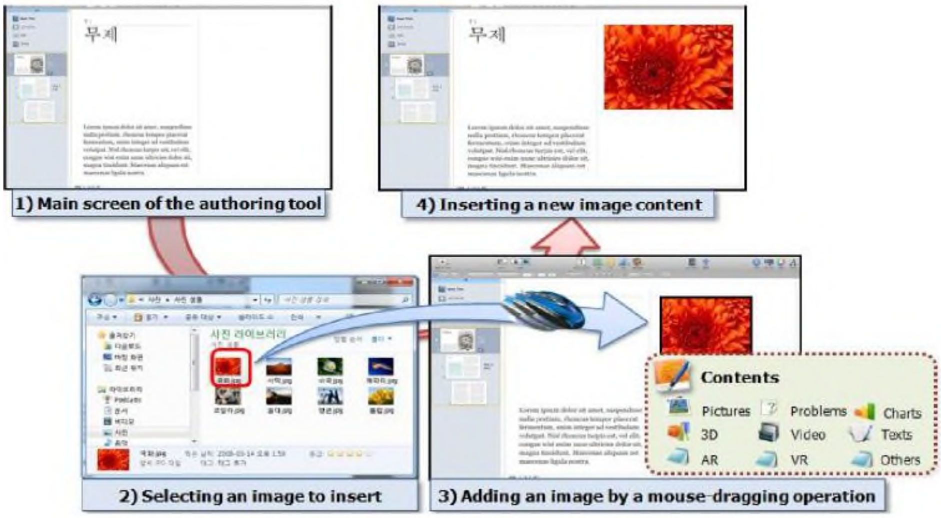

Figure 5. A document creation process using text and image controls

3.2.4. Content Viewer: We developed a content viewer to display media on multiple platforms. Figure 6 shows a number of devices supported by the content viewer. The contents created by the authoring tool are saved in the XML-based common file format described in Section 3.2.2. The viewer displays content on each device by converting the XML data to HTML, appropriate to each device. We used XSLT (Extensible Style sheet Language Transformations) for the file format conversion. XSLT is a language for transforming XML documents into other file formats. The content of the basic controls specified in Table 1 can be easily converted to HTML format via XSLT. However, it is difficult to covert the XML data of the interactive control content (i.e., audio, animations, 3D objects) to HTML format with XSLT. To solve this problem, we create an HTML area for displaying an interactive control, and then display the corresponding content on the HTML area through another content viewer we developed for visualizing interactive controls [13]. Figure 7 shows an example of learning content displayed on an iOS-based smartphone [13].

Figure 6. Various types of devices supported by the content viewer

Figure 7. Examples of learning content displayed on an iOS-based smartphone

3.2.5. Inference Engine: The proposed system includes an inference engine to provide students with personalized learning content by analyzing their preferences, learning styles, and content usage patterns. To achieve personalized learning services appropriate to each student's characteristics, the system saves the learning content, learning patterns, and learning achievements of each student in databases and analyzes them to infer learning elements associated with each student's characteristics. Then, the inference engine derives and builds individualized learning content for each student based on the inferred learning elements. Learning content is presented to students in order of interest and difficulty. Figure 8 presents the managed user information for estimating the students' learning characteristics. To determine the extent of the association between students and learning content, we used a number of data mining techniques including the Proportional Reporting Ration (PRR), Reporting Odds Ratio (ROR), Bayesian Statistics, and Information Component (IC) methods. Figure 9 shows examples of the analysis results for the students' learning characteristics.

3.2.6. Security System: A security system is included in the proposed system not only to encrypt data and control privileged user access but also to protect and solve network problems in the cloud. For the security of content, we encrypted all media content managed in the cloud using the Advanced Encryption Standard (AES) [26], which is the electronic data encryption standard established by the NIST. We have not yet fully developed the security system. We need to develop mechanisms to encrypt the learning context of students, as well as to retain backup data of all media content, and establish a security policy that accommodates cloud security components, such as data preservation, service availability, reliability, and resiliency. The security policy will provide dependable smart-media content services by reducing damage from cloud attacks, accidents, or unexpected fault-loads.

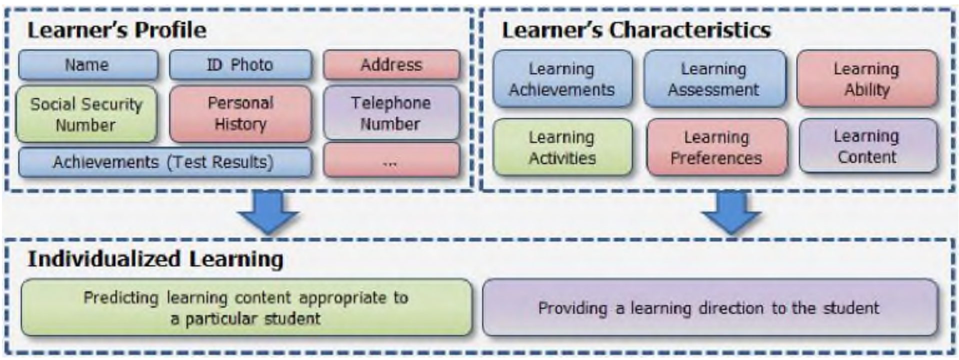

Figure 8. Information for analyzing the learning characteristics of students

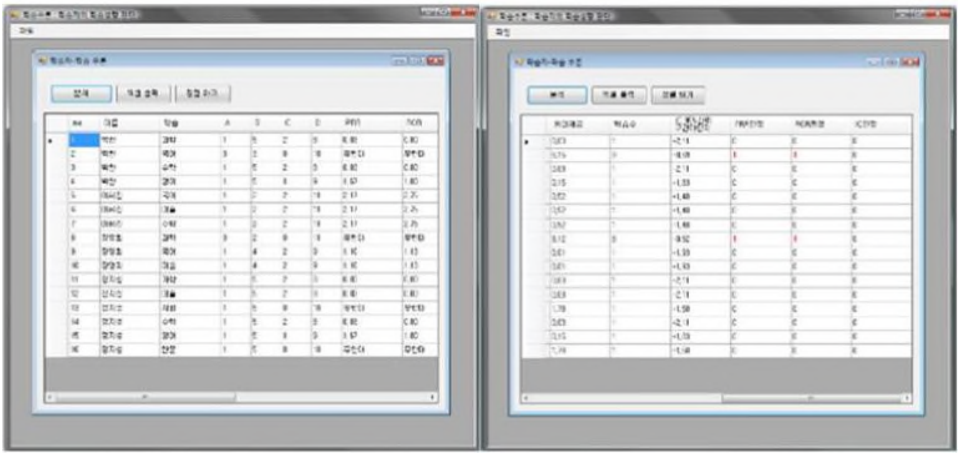

Figure 9. Examples of the analysis results for users' learning preferences

4. Conclusion

This paper proposed a content-oriented smart education system based on cloud computing that integrates a number of features required for implementing a cloud-based educational media service environment. The aim was to develop a total, integrated education content service system based on cloud computing to deliver and share a variety of enhanced forms of educational content, such as text, images, video, audio, animations, memos, quizzes, and 3D and AR objects. For the realization of a cloud-based content service system, we developed six main features. First, by leveraging several IT and cloud computing technologies, we established a private cloud platform to install and operate a cloud-based educational media service environment. In addition, we identified the software and applications required for the proposed cloud-based education services. Second, we developed a common file format enabling manipulation of various forms of media content on multiple platforms using XML, WebGL, and HTML5. Third, we implemented an authoring tool, allowing teachers to create various types of smart media content, including text, images, pictures, videos, and 3D and AR objects. Fourth, we developed a content viewer to display media content on diverse types of devices, such as PCs, notebooks, netbooks, tablets, smart TVs, and smartphones, through a multi-platform based design. Fifth, we implemented an inference engine to provide students with customized individual learning content by analyzing their learning and content usage patterns. Sixth, a security system was included in the proposed system to encrypt data and to control user access for dependable smart media content services.

This paper developed a number of features for the deployment of cloud-based educational content services. However, we have not yet fully implemented and evaluated the proposed system. First, we need to develop a more robust algorithm that enables the seamless display of the interactive controls' XML data on different devices. Second, we need to develop a security mechanism for encrypting the learning context of students, in addition to establishing a security policy by accommodating cloud security components for dependable education content services. Third, the adoption of more advanced cloud computing features is also necessary to support a more robust cloud platform. Fourth, the inference engine should be improved to provide more accurate individualized learning content suitable for each student's learning characteristics. In addition, the development of more forms of media content is also required, as well as the continuous improvement of the system via practical case studies.

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