Framework and Architecture for Programming Education Environment as a Cloud Computing Service

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ABSTRACT
A developing e-learning platform in both the present and the future of learning management systems is cloud computing. To enable e-Learning, numerous cloud computing models for e-learning have been proposed. However, using an e-Learning environment to teach computer programming necessitates a platform with specialized applications like a programming workbook, automatic plagiarism detection and marking software, a centrally located logbook for tracking students' progress, an online development environment, etc. Additionally, there are regulations for managing education in the e-learning cloud that need to be addressed, including managing instructional materials, courses, exams, performance, students, and instructors' workload. The suggested architecture for Programming Education Environment as Cloud Computing Services takes these factors into account.

I.   INTRODUCTION
The technology of cloud computing has begun to play a significant and active role as a middleman in the transport and exchange of information. This technology came into existence after the so-called Web 2.0 second wave of Internet computing development in the 2000s. The Web 2.0 technologies enable users to read and write using Internet apps, upload material to the web, and communicate with others using live video and audio.A recent development in information technology is cloud computing, which has significant implications for a variety of spheres of human existence, including education. The old way of delivering education must adapt in light of the development of information and communication technology (ICT). Online educational systems using cutting-edge technology like cloud computing are currently replacing the traditional methods of delivering education.

To draw students, educational institutions will keep improving their facilities and curricula. Typically, universities and colleges lack the funding necessary to establish and maintain cutting-edge ICT systems for learning environments that can assist faculty, staff, researchers, and developers. The budgets of institutions will continue to be under pressure due to the rapid advancement of ICT technology. The availability of more bandwidth has made cloud computing a viable option for lowering ICT costs and relieving businesses of the burden and price of maintaining hardware and software [15]. Cloud computing is an emerging new computing environment for delivering computing services which can be categorised as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Commercial implementations for IaaS and PaaS are already available such as Amazon's EC2 and S3,Microsoft's Azure, App Engine by Google, and IBM's Cloudburst. Cloud computing pay-as-you-go services were developed initially to target businesses. Recently, cloud computing has been adopted for economic reasons in schools and universities by turning old computers to fully functional virtual machines [14]. Cloud computing's potential to improve efficiency, cost and convenience for the educational sector has been recognised by US universities by moving course from locally owned infrastructure to the cloud [16]. Despite the challenging economic climate, some universities are able to expand their services to faculty and students rather than cut them back with the use of cloud computing facilities [12]. Several universities in UK have adopted Google Apps due to cost and unreliable in-house email systems [13]. Even universities and schools in poor countries in Africa are using cloud computing supported by Google and Microsoft [11,17].Cloud computing platform for computer science students to experiment on large-scale

distributed computing has been explored [10,16]. However such service for programming courses which is crucial for building strong foundation required for these students is non-existent. It requires platform equipped with special applications such as program automatic marking and plagiarism detection, centralised logbook for monitoring students' work and performance, online development environment, etc.

Laisheng and Zhengxia talk about the problems with e-learning cloud computing and how to fix them [7]. The introduction of e-learning cloud computing will result in a great deal of new issues due to the disparities between education received in a school or college and education received via the use of the internet. They specifically contend that education management regulations cannot be fully replaced by e-learning. Allowing teachers or instructors to take the lead and actively participate in the creation and use of the e-learning cloud as well as establishing a set of comprehensive management rules for the cloud-based e-learning mode, including management of teaching content, course management, examination management, performance management, student management, management of instructors' workload, and so on, are some potential solutions.

This essay follows this format. Section 2 reviews related works on cloud computing and e-learning, Section 3 discusses the specifications for developing educational cloud computing services, Section 4 describes the proposed framework and architecture, Section 5 discusses the system implementation, and Section 6 wraps up the paper with a discussion of future work.

II.   RELATED WORKS ON CLOUD COMPUTING AND E-LEARNING

The definition of Cloud Computing services varies according to the source of the definition. For example Red Hat/Amazon's EC2 [2] provides cloud computing as a collection of Linux machines with storage functionality [3], Google's platform for Cloud Computing hides locality and scalability issues from the programmer who writes programs to a custom programming API [4], Microsoft views it as a virtualization layer between the hardware and the OS and is releasing a developer toolkit for providing the user with "software plus service." [5]. It is to say that in Cloud Computing applications, a user does not need to run processes in terminal equipment such as user's personal computer, but in clusters of servers on a large scale on the Internet. Data in Cloud Computing is stored in the data center on the Internet while the user processes are not executed locally. The enterprise which provides Cloud Computing services is responsible of maintaining and managing the normal operation of these data centers. Users can use any devices to access cloud computing services via the Internet at any time and from any place.

In this paper Cloud Computing is defined as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [1]. This definition describes that Cloud Computing has five essential characteristics namely:

i) On-demand self-service: usage of computing resources at anytime without the need to interact with the cloud service provider.
ii) Broad network access: computing resources can be accessed over a network through acceptable devices such as computer machines or mobile phones.
iii) Resources pooling: provides pool or resources that are shared by users.
iv) Rapid elasticity: user can acquire more resources from the cloud.
iv) Measure service: resource usage appropriate metrics such as bandwidth, monitoring storage.

Typical cloud computing services in academics organizations has been discussed in detail by [6]. The services characteristics are:
• It can be used as a personal workspace;
• A convenient tool to make teaching and learning interactive- has strong potential for social interactivity;
• Personal Learning Environments (PLEs) used by many people as an alternative to institutionally controlled Virtual Learning Environments (VLEs)/ LMS with different personalized tools to meet their own personal needs and preferences; as teachers we are always learning;
• Provides opportunity for ubiquitous computing;
• No need for backing up everything to a thumb drive and transferring it from one device to another;
• No need to copy all stuff from one PC to another when buying a new one. It also means you can create a repository of information that stays with you and keeps growing as long as you want them;
• Provides large amounts of processing power comparable to supercomputer level;

The e-learning has been defined as a set of definitions. Among these definitions that were

agreed upon is the following definition of e-Learning: "E-learning comprises all forms of electronically supported learning and teaching. The information and communication systems, whether networked learning or not, serve as specific media to implement the learning process [7]." Recently cloud computing has emerged as a platform which play an important role in the field of e-learning. Considering that learning is a large part of everybody's life activities, thus the use of cloud computing in e-learning will provide a new learning style and medium which is considered as the third generations of e-learning system. Its

features are able to address the problems and obstacles that were once a hindering factor that affect the spread of education through the electronic media. In e-learning cloud computing model, cloud provider is responsible for building and maintaining e-learning cloud, providing technical support to e-learning cloud. Cloud users request to cloud provider for services from e-learning cloud. E-Learning cloud will provide the services accessed based on users' demand. Fig. 1 summarized the model in which during the cycle, servers support the users.
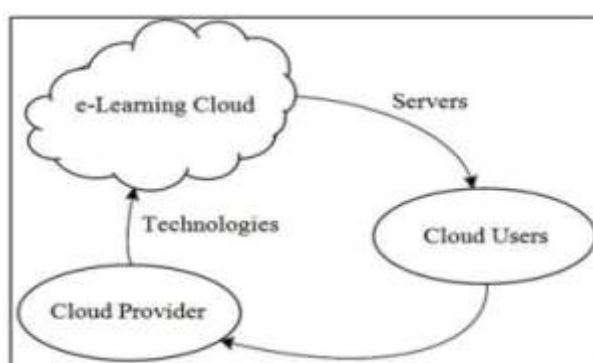

Fig.1.Modelofe-Learning cloud computing[8]

Table 1 shows the challenges faced by e-learning developers and the solutions to those challenges [9]. Through
application development they seek to find solutions

to these challenges and practicality in terms of performance [9].

Table 1. Challenges and solutions of e-Learning

Challenges	Solutions
User idea. E-learning cloud, as a cloud computing infrastructure and IT service delivery and usage patterns, subverts traditional idea of the use of computing resources, so the user's awareness and acceptance will profoundly affect future operation and development mode for e-learning cloud.	Build successful cases, and promote their applications as an opportunity.
Education management rules. Because of a difference between school education and e-learning cloud education, the introduction ofe-learning cloud computing will bring a lot of new problems.	Establish a suit of comprehensive management rules for e-learning mode based on cloud, including teaching content management, course management, examination management, performance management, student management, teacher workload management and so on.
Resource development. There will have a group of e-learning cloud materials of high quality, high-grade, for e-learning program, which requires investing a lot of human and material resources and using the intelligenceof educational experts, technical experts and art experts in cooperation to create a set of scientific, interesting and artistic learning resources.	A variety of experts are organized by e-learning providers to complete the work.

The cloud computing infrastructure for e-learning in the current period and in the future, relative to those provided by cloud computing hardware, software and sources of support e-learning are shown in Fig. 2. Looking at the components of the architecture of e-learning cloud computing infrastructure, the components are divided into five logical layers, namely he hardware resource layer, software resource layer, resource management layer, service layer and application layer.

- Hard resource layer: This layer represents the

lowest layer in the sequence of layers of e-learning, which include all the hardware used in e-learning such as physical memory and CPU. Its emphasis is placed on the construction for the infrastructure. Through the use of virtualization technology, physical server, storage and network form a virtualization group which is called by the upper software platform. The pool of physical host is dynamic. A new physical host can be added in order to increase physical computing power.

Fig. 2. Architecture of e-Learning cloud [7]

- Software resource layer: This layer mainly is consists of operating system and middleware. Through middleware technology, a variety of software resources are integrated to provide a unified application programming interface (API) for software developers, so they can easily develop a lot of applications using the software resources and include them available through cloud computing service.
- Resource management layer: This layer is representing the key to achieve loose coupling between software resources and hardware resources. Through integration of virtualization and cloud computing scheduling strategy, on-demand free flow and distribution of software over various hardware resources can be achieved.
- Service layer: This layer contains three levels of cloud computing services defined in the service model, which are, SaaS (Software as a service), PaaS (Platform as a Service) and IaaS (Infrastructure as a service).
- Application layer: This layer mainly consists of e-learning applications which include

content production, educational objectives, content delivery technology, assessment and management component [7].

The elements in the application layer can be customized by application developer to support specific cloud service such as programming education service. Our work only focus on the application layer because we are providing programming education applications as cloud computing services. C++ Workbook application and database will be hosted by Google's cloud platform. We highlight the roles of instructors, students and administrator or the key person in charge of managing and conducting a programming course in a specific education institution. Content production and educational objectives are the responsibilities of instructors. Instructors can upload course objectives and learning outcomes for a specific course. Instructors can develop the content and publish them. They can also use content developed by experts. Instructors also decide which content delivery technology will be used for each content. For example video streaming

is provided for accessing learning materials. Instructors are also responsible for creating classrooms, allocating students to classrooms, creating programming problem sets, assigning selected problem sets to classrooms and setting assessment criteria. Administrator is responsible for handling instructor and student registration, creating classrooms and allocating new instructors to existing classrooms, updating question banks and handling management of changes in application. The system can also provide automatic marking for multiple choice problems. In the future automatic marking for programs will also be included.

III. REQUIREMENTS OF PROGRAMMING EDUCATION CLOUD SERVICES

Cloud computing services for providing programming education includes C++ Workbook which has various user centric provision and administration functions. The requirement for students includes request for class registration, access content, access exercises from the designated problem set, submit exercises, check for marks/results and check for correct answers. The requirements for Instructors include create classroom, creates problem set, choose the questions for each problem set, allocating exercises or problem sets to specific classroom, setting criteria for assessment and assign students to classrooms. Instructors can also monitor students' progress. The requirements for administrator include creating and managing accounts for instructors and students, creating classrooms and allocating new instructors to existing classrooms, updating question banks and handling management of changes in application. Fig. 3 summarizes the features for each designated role.
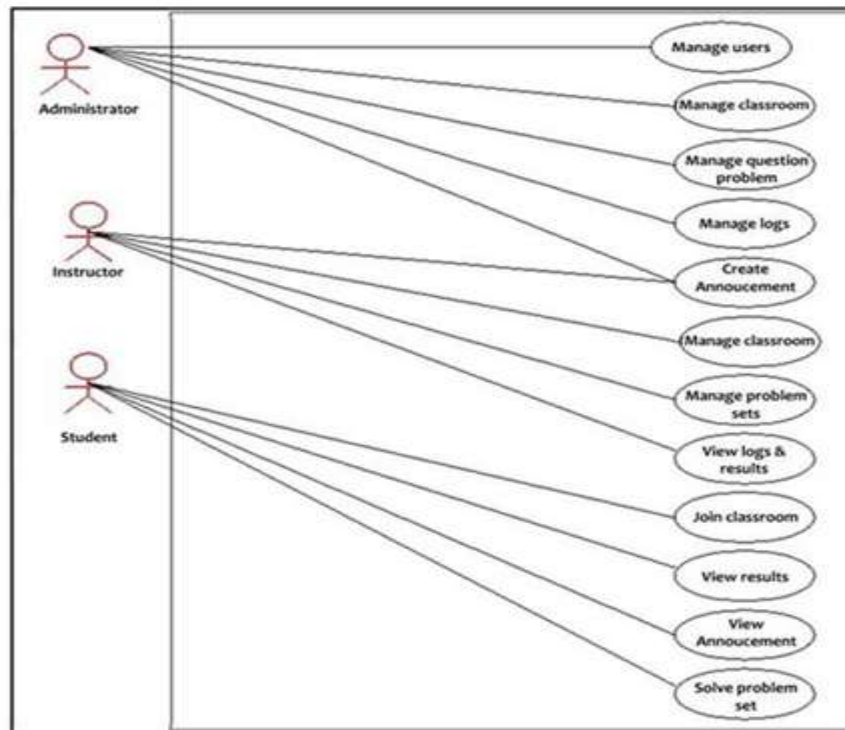

Fig. 3. Roles for users of programming education cloud service

IV. FRAMEWORK AND ARCHITECTURE OF PROGRAMMING EDUCATION CLOUD SERVICE

For developing the architecture of Cloud C++ Workbook, we have studied the previous technologies and practices that have been used in providing online learning programming environment. E-Workbook is a web application that is sometimes provided as supplementary materials to support text book provided by publishers. Instructors from institutions are given access to exercises and solutions to help them in teaching programming. E- Learning is online learning management system which has gone through three generation of revisions. The 1st

generation of e-learning uses the Internet and web-based technology to deliver conventional educational products and services such as textbooks, articles, training courses, lessons and workshops; on the other hand the 2nd generation of e-learning approach is to provide a network interconnected learning opportunities rather than a library of separate online texts and courses. Cloud computing which recently has been adopted by many educators worldwide provides platform, infrastructures and software as services to support learning. In the proposed framework, we selected suitable elements from e-Workbook, e-Learning system and cloud computing technologies to form the architecture for programming education as a cloud service as illustrated in Fig.4.

The services offered in the Programming Education Environment include logging of programming activities, program plagiarism detection, programming workbook and automatic marking. Specifically this work focuses on the development of the system architecture for programming workbook application. To demonstrate the working mechanism of the framework C++ Workbook is designed and developed as a Software as a Service (SAAS).
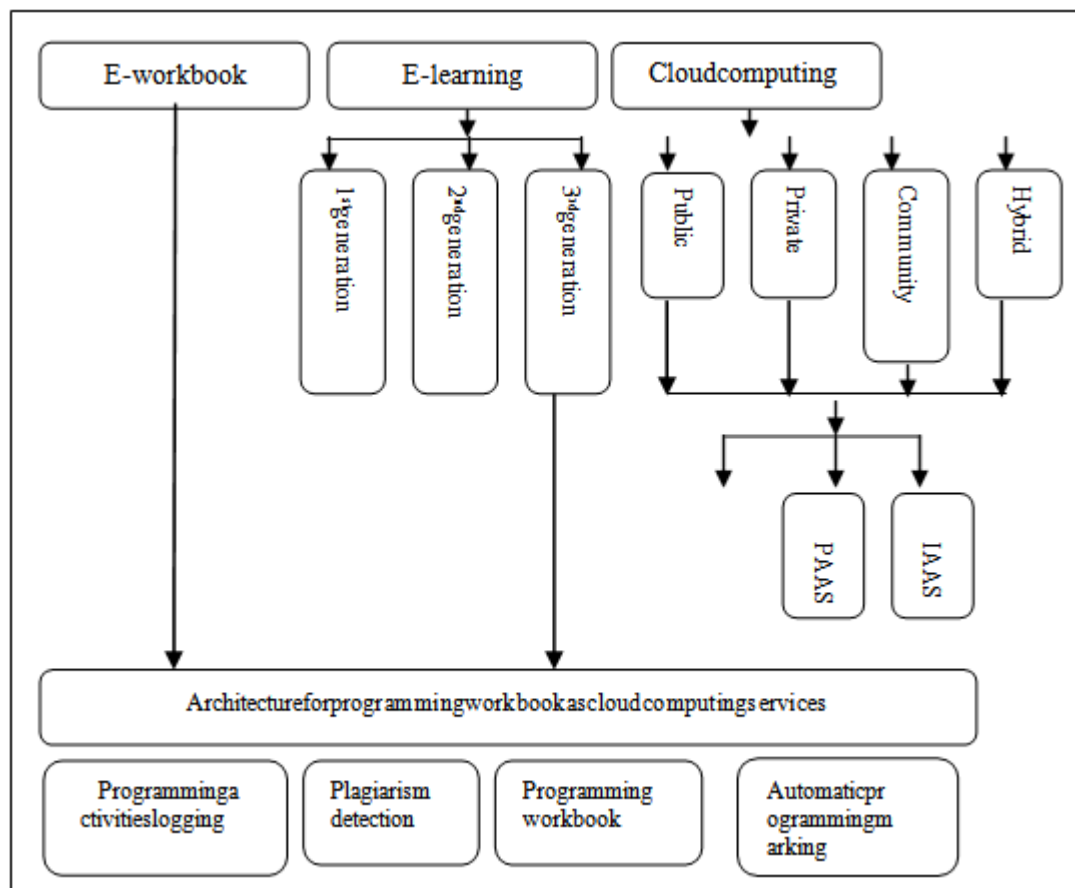
Fig. 4. Framework for programming education as a cloud service

The architectural components of the application have been divided into three sections so that each section includes a set of functions for three specific user roles which are Administrator, Instructor and Student. This is illustrated by Fig.5.
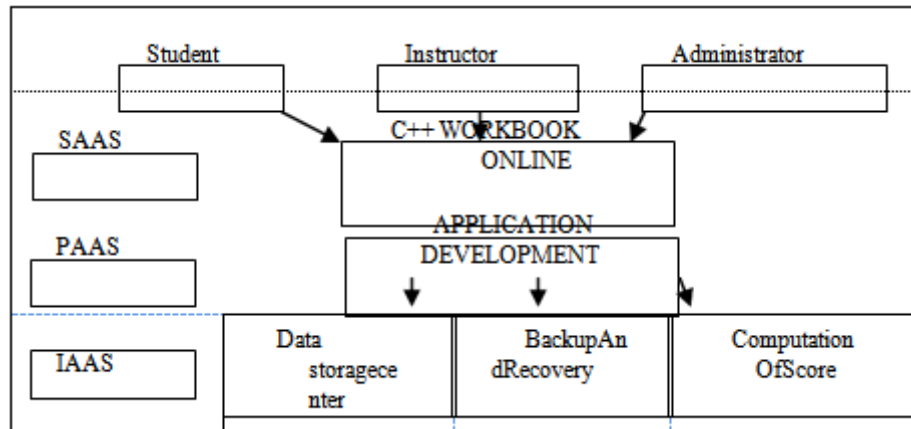
Fig. 5Architecture of C++ workbook as cloud service

V. IMPLEMENTATION OF CLOUD C++ WORKBOOK

C++ WORKBOOK uses Google App Engine for the platform and infrastructure services. The application is developed in Java. The following subsection describes the outline of its main characteristics and features. The target users are divided into three categories representing the administration, instructor and student in Fig. 6.

Fig. 6. A Screenshot of the C++WORKBOOK main page

5.1. Administrator features

The administrator is responsible for managing accounts for instructors and students, creating classrooms and allocating new instructors to existing classrooms, updating question banks and handling management of changes in application. These features are shown in Fig. 7(a) and Fig.7(b).

Fig. 7(a). Administrator main page Fig. 7(b). Setting questions for the question bank

5.2. Instructor features

Lecturer who teaches programming subject through the system is able to create classroom, assign his teaching assistant to be instructor for his class, assign students to selected classroom, create a problem set of exercise/quiz/exam and select questions from the question bank for the problem set. An instructor can supervise students assigned to him by giving advices in terms of solving questions. He can also monitor students' progress and follow-up on their exercise results and overall marks. Fig. 8(a), 8(b) and 9 depict screenshots of instructor's user interface for the said functions.

5.3. Student features

A student who has been registered by the system administrator has the right to request to join any classroom available and then complete exercise/quiz/exam that has been assigned for the selected classroom. Following the completion of the exercise/quiz/exam, student can find the right answers and marks from the response to the exercise/quiz/exam, since the system automatically calculates marks. Fig. 10 shows the implementation of this feature.
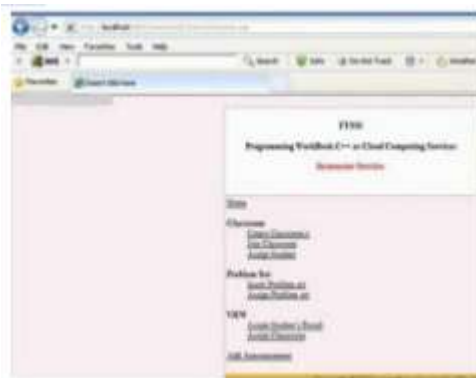

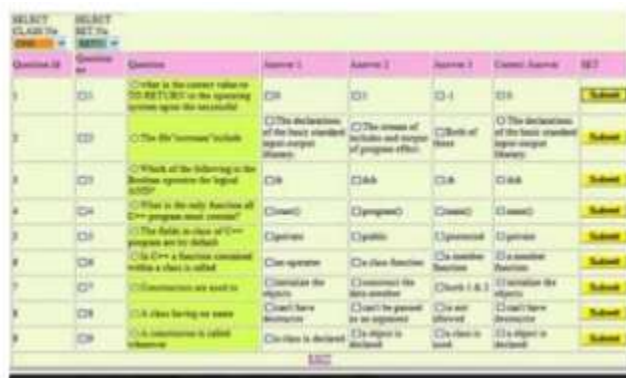Fig. 8(a). Instructor main service
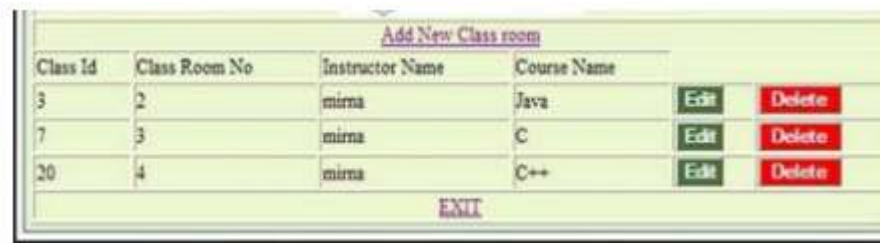

Fig.8(b) Instructor page for creating problem set

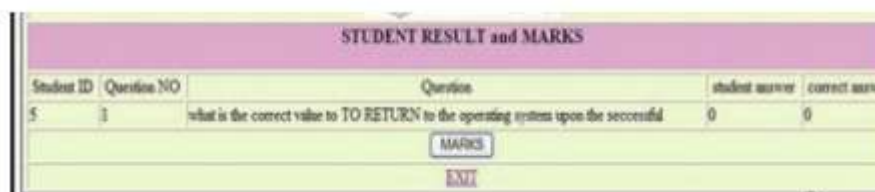
Fig. 9. Announcement module interface

Fig. 10. A student screenshot for result and marks

VI.   CONCLUSION AND FUTURE WORK

In this paper, I have discussed the challenges of e-learning and the potential of cloud computing to improve management of e-learning system from administration, technical and economical point of view. I have proposed a framework for programming education as a cloud service which combines the elements from current practices of e- Workbook, e-Learning and cloud computing technologies. The framework consists of several cloud services which includes programming workbook, automatic exercise and program marking, programming activities logging

and program plagiarism detection. I have designed the architecture and implemented one of the application services specifically the C++ Workbook as cloud service to verify the proposed framework. I will include other mentioned services in my future work. In conclusion, the concept of e-learning environment through the use of a new technique such as cloud computing technology can be materialized in educational institutions in various stages. Academic institutions can benefit economically using cloud computing environment because of minimal cost for administration, and maintenance, high uptime and ease of usage.

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