The recent COVID-19 outbreak has put forward a huge challenge for colleges and universities all over the world in continuing teaching and learning process by keeping their students, staffs and faculty safe.

Distance education on the Internet unlike traditional learning in classrooms.

Minimum Requirements: A computer, Internet.

Advantages: Anytime, anywhere,

Design issues

Heterogeneity

one s/w many programming languages ma make support multiple different h/w support multiple different OS support different APIs, Standards, protocols

Scalability

Security

Online Learning

Problems students face

Self-Motivation

Compared to remote learning, there are no fellow colleagues

Time Management

Technical Issues

Adaptability Struggle

Advantages:

Keywords:

unprecedented and staggering

less effective than face-to-face

Design Issues:

Navigation must be easy. The simpler it is to explore through the platform, the better

Appearance must be appealing else it would be difficult for learners to comprehend on their roles and tasks. Complex and complicated design can discourage learners and lose their interest in the course preventing them from achieving the goal of the course.

Grouping information is necessary to grasp everything of a topic.

Usability: If all the links work properly in all environments.

Synchronous/Asynchronous communication

A teaching and learning(TL) system is a **system/ software-based platform** that offers a teaching and learning environment to its users by providing the facility of management, administration, support,reporting, documentation, delivery, tracking of programs. The programs can be educational content like courses, videos, documents. An online teaching and learning(OTL) system is a system designed to create a virtual environment for teaching and learning purposes where courses can be delivered and monitored. It applies technology to learning and teaching purposes, which couldn’t be done in on-site classroom. It is therefore, the use of technology to learning. It can also be referred to e-learning which supports hybrid online F2F courses. A large group of different organizations, from high schools to large corporations can be benefited from the online teaching learning system. With the current COVID-19 outbreak, there is a sudden rise of the number of educational institutes switching from face-to-face learning to virtual classroom learning. Universities, institutions has been forced to implement online teaching learning system.

The different components of Online Teaching and Learning System are user , catalog and curriculum, communication, media player, resource management, scheduler, report and analytics.

User Management: User Management is the process of maintaining the records of instructors as well as students by providing access to the system and keeping track of their activities. There are two types of users in e-learning system. First, teacher or instructor is the person who is responsible for enrolling and teaching students to the classroom. The instructor also monitors the class by identifying and solving problems with the course and students and, aims in the completion of the course. Second, students are the people who get enrolled in the class by the teacher. Their main aim is to learn from the class by attending lectures and be able to solve assignments, quizzes or any tasks provided by the instructor.

Communication: Communication between the instructor and the learners is key to successful learning. In OTL, instructors think and plan about timely and effective communication means to provide the students for support and enhancement of their learning experience. Communication is internet-based and it’s forms are synchronous and asynchronous.

Synchronous Communication is the relay of information in real time between two or more people. A message is sent; the recipient receives the message and responds quickly in synchronous communication. Live chat rooms, video conference calls are some examples.

Asynchronous Communication is the relay of information with time lag between sending and receiving the message between two or more people. The sender doesn’t expect an immediate response from the receiver in asynchronous communication. Email, discussion forums, blogs, message boards are some example.

Curriculum and Catalog: Curriculum and Catalog provides the information about the university or institution providing the course. Catalog consists of Catalog Rights Policy which provides the rules applied to the student throughout the curriculum. It includes enrollment to graduation requirements. Catalog Hour Policy includes the information about minimum number of hours to be invested for the course.

Curriculum refers to the program offered by the institution. It consists of the requirements and courses which is to be completed for obtaining the degree or certificate.

Resource: Any digital materials that support learning is called a resource for OTL. The digital materials like lecture slides, video lectures, assignments, links, e-books, websites, bibliography, webliography are the some of its examples. The instructor provides these resources to the students for the successful completion of the course.

Media Player : Media players are the application software that provides animations, visuals, narration allowing instructor to showcase complex ideas to easily understandable form. A smartphone or a laptop with a media player is key to make the learning process effective and enjoyable. Instructors need video or media player to create lecture slides, videos and other resources. Students need media player to play, pause, replay the video lectures, slides and other resources of the course. Multimedia in an OTL system deals with the file size, file format, animations, compression format for audio.

Scheduler: Scheduler deals with the developing, editing and managing courses’ schedule. It also manages assignment deadline, test, quizzes and exam timetables. It keeps track of all the timing and deadlines in the course with a view of successfully completing the course in time.

Analytics and Report: It deals with improving the learning experience in the OTL system. It measures individual student and whole class performance. It also keeps track of the attendance, test scores, course completion status and generates course completion reports. It analyzes the participation, engagement and involvement with the help of time spent by each student in viewing a slide, submitting an assignment, watching the video lectures and number of times the system was visited. Based on the analytical data and reports, instructor can find the weak areas of the course content and impose new ideas and techniques which was very tedious in traditional learning.

The fast growing field of technology has paved path for its integration in other fields. There has been a significant growth in the number of OTL platforms over the last decade as it has many advantages.

Flexible and Deliverable: The availability of just a device connected to internet, people from any geographical location can learn online at anytime based on their convenience. Unlike traditional learning where a learner need to physically attend the classroom,OTL is so flexible that it can be fit in busy schedule or hectic personal lives. There is no compulsion of investing many hours of the day totally on a course because of which multiple courses can be taken unlike traditional learning. Since, the pace of learning is different among each learner, OTL is deliverable enough that it allows learner of different nature to cope up with the progress of the course.

Interactive Learning: The implementation of visuals, animations, graphics results better understanding of the course content. Video lectures can be paused, repeated and played in loop allowing the learner to grasp the content by taking enough time.

Learning Sequence: An online course contains a repeated sequence of lectures, quizzes and assignments which allows learners to experience active learning. With quizzes and assignments immediately after lectures, course content can be better understood and course content retention definitely increased.

Minimum physical infrastructures: Traditional learning requires large number of physical resources like chair, desk, board, classroom to accommodate students. But, online learning decreases this demand as classes are run online and not much physical resources are required.

Peer Learning: The availability of discussion forums increases the interaction between students and teachers. A student can interact with fellow colleagues and share respective views, understanding of the content. Students and teachers can post related resources or questions and have discussion on it.

Mass Accommodation: Top universities around the world have democratized the learning by making their courses accessible for everyone via online. In comparison to physical learning, the number of students who can enroll in an course(online) range from hundreds to thousands as online learning can be conducted with minimum physical infrastructure.

Learning Sequence: Video Quiz Assignment in sequence. So active learning.

Instant Feedback: Grading of test results immediately.

Rewatch, revisit resources: Pause, rewind, speed up that allows flexibility in learning.  
Game like learning: 3D visualization, animations and visuals.

Peer Learning: Discussion forums

Transport Cost:

Anytime, Anyplace

The different types of online teaching learning are blended learning, active learning, engaged learning, personalized learning etc.

Blended Learning:

A teaching learning practice that blends traditional face-to-face teaching and online learning. Both teacher and student are physically present in the classroom, and educational materials are provided online to the students for further interaction online. It is called hybrid learning as it combines synchronous and asynchronous learning. It is also called reverse teaching, flip teaching, backwards classroom, or reverse instruction. It offers flexibility and learner convenience by allowing learners to control their remote learning and on-site learning pace. The lecture and study materials are provided online while team/ project based works are done in the classroom.

Active Learning

A teaching learning practice where instructor aims to actively involve learners with course material and class activities while learning is called active learning. Unlike traditional learning where students passively involve in learning by just listening to the teacher, active learning involves activities like class discussion, brainstorming, problem solving, case studies, collaboration etc. These activities make students think, discuss, investigate, interpret, innovate. It helps build skills like critical thinking, decision making and boosts learners’ motivation, performance and knowledge retention.

Participatory Learning

A learning practice where learners actively participate in the learning process is called participatory learning. It imparts new knowledge and skills to the learners and allow them to test out those skills in the workplace. It is also called experiential learning. It is different from active learning by the fact that active learning is learning by involving in activities like reading, writing and discussing while it is learning by actually carrying out tasks in real life environment and observing the results. It is believed to provide the best retention.

Engaged Learning

Design Issues:

There are many issues that need to be dealt while designing an OTL system. Some of them

Heterogeneity, Concurrency, Usability, Error and Exception Handling, Fault Tolerance, Control and Handling of events, Interaction, Security

Heterogeneity: An OTL system should address heterogeneous i.e. able to operate on different operating systems, multiple web browsers, devices coping up with multiple standards and protocols. It needs heterogeneity for system components like frontend, backend, database, APIs. Not all users have high specs device so, the system should be developed to run even in the low specifications devices and needs to function normally with different versions of the above components.

Concurrency: The system should be able to decompose into parts that can run independent to each other. Several processes operate at the same time on separate computers running on the system. For example, many users may access the resources at the same time. These processes should be able to communicate with each other. Multiple servers are placed to handle this process so, system should be designed to run multiple jobs simultaneously. Timing overhead, latency and complexity can increase when data is transmitted between the devices. The system should be able to deal with these issues and other related issues of efficiency, atomicity, synchronization, and scheduling.

Usability: The system should be designed to improve the ease-of-use. Only those features and functionalities need to be included in the system that could be effortlessly learned by the users. The system should be efficient to use and not irritate or confuse the users so they can have high level of productivity. Repeated errors can get the users frustrated so, design needs to focus on making users subjectively satisfied. It should be easy to remember, so that casual users can return to the system and use it without having to learn everything all over again. Every action a user takes should achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

Data Persistence: The system should maintain a database containing all the data from the system.

Error and Exception Handling:Various errors can occur in the OTL system. User generated errors are the errors that can occur in account creation, accessing data, etc. The system should decrease the risk of such errors by ensuring access from only authorized users. While designing the system, low error rate should be the target so that users make few errors while in the system and they can easily recover from it. The system should operate without any glitches or bugs and every click should bring user closer to their objectives. Even the error occurred in the system should be displayed with user-friendly and readable error message.

While developing the system, developers should run different test cases to systematically uncover different class of errors. A successful test is the one that uncovers an as-yet undiscovered error.[Pressman, Software Practitioner].

Fault Tolerance:

The need of fault tolerance arises when the system encounter different faults that is happening or has already happened in the system. The system must continue to its normal operation even after the faults are detected. Fault tolerance greatly impact the reliability of the system. Software faults are considered as design faults so, while designing the system, fault tolerance should be considered with huge importance.

Security

System should be designed to ensure security, safety and privacy. It needs to address vulnerability, threat issues to minimize future opportunities for intruders. Different security protocols need to be placed to tackle these issues.

The user’s roles and permissions needs to be defined with registration and authentication options. Users should be granted permission to access only those information for which they are authenticated. Only authorized users should be permitted to modify data and information in the system. The developers should be aware and concerned with how to tolerate security-related attacks and threats that might occur.

Challenges:

Accessibility: Accessibility can be a barrier in OTL system design. Accessibility issues can exist for the people with wide range of disabilities. A possible way of solving the issue is including “assistive technology”. As blind or visually impaired users cannot access the system, transcription feature should be available. The system should incorporate TTS(Text-to-speech) .i.e conversion of a text into speech which supports handicapped communication and is accessible for a wide range of users. For users who learn better visually, accessibility can be ensured by providing video. Text alternatives needs to be included for non-text based content like captions and transcriptions for videos along with SST(Speech-to-text) i.e conversion of speech into text for hearing impaired users.

The system should address color-blind people with color-blind mode. The system should be responsive for varieties of users using just a mouse or a keyboard to navigate and those using screen readers too.

Working with Limited Resources:

Not all students in OTL system have high bandwidth or strong internet connection. This can cause video buffering, high latency and packet loss. Lower quality devices with outdated device drivers will tackle problems using the system so, the system should be designed to address limited resources.

Scalability

With the evolving technology, the user requirements change frequently. This arises the challenge of scalability for the system i.e. coping up with this evolving requirements. The system needs to smoothly and quickly meet growing number of learners. The system might challenge handling the huge traffic of users using the system, allowing these users to connect and use the system without any delay, organizing these users into different branches and managing a large amount of data. The system should therefore adapt to these changing needs.

Ensuring Security

The system will be challenged by security threats like compromised-key attack, network denial-of-service attack, eavesdropping, identity spoofing, man-in-the middle attack, RTP replay attack, spim, viruses and worms. Other threats that the system might encounter are confidentiality violation, integrity violation, denial of service, illegitimate use, malicious program, repudiation, masquerade, brute-force attack, information leak etc.

These threats cause challenge for security and it can be tackled by imposing tactics to provide solutions for enforcing the necessary authentication, authorization, confidentiality, data integrity, privacy, accountability, availability, safety and non-repudiation requirements, even when the system is under attack. Security can be maintained by end-to-end encryption of the chats, audio/video calls and information. Data encryption assures that the data is safe and secure, it can be maintained with SSL protocols. Secure Socket Layer(SSL) is a encryption based Internet security protocol that establishes an encrypted link between a server and a client.

Similarly, SSO can be used to maintain authentication. Single Sign-On(SSO) is a user authentication service that enables the users in accessing multiple applications and services using same user information or credentials for quick and safe login to the system. Security of the system can be strengthened by enabling SSL between SSO severs and database.

Performance:

In a real-time video session, all the devices like headsets, webcams used by the participants can largely impact audio and video quality. The network connectivity issues like latency, packet loss and jitter can largely decrease the quality and performance of the meeting. While,addition of features like noise filtering, echo cancellation will increase the performance of the meetings.

Different type of servers may be required to be maintained at same or different data centers for different tasks. Servers like proxy server, mail server, FTP server need to maintained to do different jobs. Multiple servers help maintain high server traffic, server overloading, slow loading and system crashes. Different algorithms are to be applied to handle the server load and to improve the response time. Port utilization and optimization should be increased on the servers.

User Support

Although the whole word is becoming more and more tech savvy, not all users in the OTL system might be technology literate. Even the frequent users may encounter many issues while using the system. So, there need to be support services to tackle those problems. Imposing 24/7 assistance rather than business hours support, email support etc can be helpful to address questions or concerns. Online FAQ and training tutorial should be kept well updated in the system. Live Chat feature will allow to speak directly to a customer service/support representative to solve basic issues. A community of the users can be created where discussion on the common issues, software updates, patch notes can be discussed and solved without even the need of support representatives.

Integrations

An OTL system supporting integration with other well known systems can help user in improving their experience. Integration also assist in delivering learning content more and providing personalized online learning. Other notable benefits of integration includes reduction in redundant data, reduction in the risk of incorrect user data, tracking of user analytics. The system if integrated with social media sites like Facebook, Twitter, LinkedIn can help sell courses, find potential clients and even promote the courses. Similarly, on integration with reliable payment gateways can help users pay for the course easily and safely. The system should be able to integrate to different API, plugins, SSO, webhooks for this purpose.

Maintaining User Engagement: One of the challenges of an OTL system is maintaining user engagement. Users can be engaged by maintaining seamless transition between operations so they would enjoy using in the system and not get frustrated at all. The availability of visual simulation, graphics on the content of the course will increase knowledge retention, thus users will most likely use the system in future. Chat features helps increase engagement by allowing users to communicate with the teachers, system administrators and even developers. It will decrease the number of emails souring in the system. Surveys, blogs, FAQs, discussion forums, feedback forms can engage users in the system.

Competitions highly motivate students to engage in gamification tasks[] and help students exploit their talents and capabilities. The system will definitely be challenged in attracting, retaining and engaging its users. Therefore, features that support gamification .i.e game-based learning should we able to be deployed in the system as it effects the motivation and performance of students.[Why gamification]

Learning Content Quality

Every e-learning system needs content support as users can tackle content issues at any point in the learning process thus, the course delivered on the OTL system should meet user satisfaction without any content issues. One of the e-learning content challenge for the system is supporting standards-compliant content or standards-certified content. To tackle this challenge, the system should be approved by an authorizing tool or need to follow some standards. There are many technical e-learning standards like SCORM (Sharable Content Object Reference Model), Tin Can API, xAPI, AICC(Aviation Industry Computer-Based Training Committee) which enables effective, efficient online courses and even allows content authors to distribute their content to other OTL system.

Cost and Pricing

The OTL system is designed to address as many students and teachers all around the globe. If the cost of implementing the system is expensive then no one will use the system. Different expenses that a commercial OTL system can have are implementation cost, training cost, support cost, maintenance charge, content creation cost while open source OTL system are free of cost. All these costs depend upon the development and maintenance cost of the system so, it is one of the greatest challenge to put the cost and pricing required to implement the system as low as possible. For commercial OTL system, usefulness of system, sustainability to the user needs, total cost of ownership, return on investment should be

*Host and co-host in meetings*

*Host should be allowed to control various aspects of a meeting like managing the participants, starting/stopping record, muting the participants, allowing participants to screen share. Host should be provided with a permission to share the privileges to co-host who can manage administrative side of the meeting.*

*This helps the host to fully control the meetings and prevent participants from misbehaving.*

Safety security reliability resilience robustness understandability testability adaptability modularity complexity portability usability: efficiency learnability scalability supporting multimedia types (text/ sound/ video, etc.) heterogeneity availability privacy affordability/ cost QoS

## **Zoom**

**Safety**

**security**: low

**reliability**: no crashes, no disconnects, notifies users for every action

**Resilience** SYSTEM

**Robustness** SYSTEM

**understandability**: easy to understand

**testability**: i/o checking, detailed stats, a/v test, network stats

**adaptability**: network adaptation, adjusts fps and resolution, In screen share(custom FPS, audio share)

**modularity**: high(pop ups), chat, participants

**complexity**: low

**portability**: yes, all platforms

**usability**: easy to use, easy to join meeting, easy to create

**efficiency**: low cpu and memory usage

**learnability**: easy to learn

**scalability**: 2 to 1000 people, unlimited storage

**supporting multimedia types** (text/ sound/ video, etc.): upto 512 mb file size each time

**Heterogeneity:** of course, can switch servers

**availability**: everywhere, most devices

**privacy**: low, no end-to-end encryption

**affordability/ cost:** high/ low

**QoS:** pretty high, pretty high cause google and facebook authentication sys to login

### **GOOGLE MEET**

**Safety:**

**security**: vulnerabilities of being run on a browser

**reliability**: browser dependent

**Resilience** SYSTEM

**Robustness** SYSTEM

**understandability**: easy to understand

**testability**: a/v test

**adaptability**: doesn’t adjust fps, adjusts resolution

**Modularity**: low due to browser

**complexity**: low

**portability**: yes, all platforms

**usability**: easy to use, easy to join meeting, easy to create, sound effects

**efficiency**: low cpu and memory usage

**learnability**: easy to learn

**Scalability**:250 participants, unlimited storage

**supporting multimedia types** (text/ sound/ video, etc.): upto only video and audio no files

**Heterogeneity:** yes

**availability**: everywhere, most devices

**privacy**: high personal data collection

**affordability/ cost:** high/ low

**QoS:** high, because google and everyone has google, reporting and stuff

**Error Handling:** lets you close browser

### **CISCO WEBEX**

**Safety:**

**security**:  insufficient validation, two high severity vulnerabilities, CVE-2020-3127, CVE-2020-3128

**Reliability**: video and audio keeps getting cut

**Resilience** SYSTEM

**Robustness** SYSTEM

**understandability**: easy to understand, slightly confusing due to spinners when connecting issues, no notifications for admission, sound effects when participants join

**testability**: a/v test, health checker to check network quality

**adaptability**: doesn’t adjust fps, adjusts resolution

**Modularity**: yes

**complexity**: low

**portability**: yes, all platforms

**usability**: easy to use, easy to join meeting, easy to create, sound effects on chat,Private message

**efficiency**: low, high network usage

**learnability**: easy to learn

**Scalability**:200 participants

**supporting multimedia types** (text/ sound/ video, etc.): upto only video and audio no files

**Heterogeneity:** yes (shows server too)

**availability**: everywhere, most devices

**privacy**: high personal data collection

**affordability/ cost:** high/ low

**QoS:** high, reporting and stuff (More clear than others), no noise cancellation

**Error Handling:** asks you before close browser

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Services/ Features**  (Very High, High, Average, Low, Very Low) | ZOOM | Google Meet | Cisco Webex | Microsoft Teams  more chat then video calls (slack enemy) |
| Security | 10-11 digit meeting IDs  Claims to be end-to-end encrypted  No encryption(past)  Very Low | 25 characters meeting IDs  Encrypted (not end to end)  High | 9 digit meeting IDs  End-to-end  High | 910484337  Encrypted in transit and at rest. No end-to-end |
| Reliability | Very High | High (browser dependent) | High |  |
| Understandability | Easy to understand  No sound alerts | Very Easy | Easy |  |
| Testability | Very High | Average | Average |  |
| Adaptability | Very High | High | High |  |
| Supporting Multimedia Types | Up to 512 MB file each time | Only audio and video | Only audio and video |  |
| Modularity | Very High | Average | Very High |  |
| Portability | Supports all platform | Yes | Yes | Yes |
| Usability | Very High | High | High |  |
| Efficiency | Very High | High | Low | Very High |
| Learnability | High | High | High |  |
| Scalability | Very High | Average | Average | 250 participants |
| Heterogeneity | Yes | Yes | Yes |  |
| Availability | Fairy High | High | High |  |
| Privacy | Low(Past) | High | High |  |
| Affordability | High  Free (100 40 mins)  $15/month (100 24 hrs) | High  Free (100 60mins)  $6/month(25)  $12/month(50)  $25/month (100) | High  Free(100 Unlimited)  $13.5/month(50)  $19.95/month(100) | High  Free(50)  $4/month |
| Quality of Service | High | Very High (Google) | High |  |
| Error Handling | High | Average (doesn’t warn before closing) | High |  |

Security

Security refers to the protection of the user data and system against malicious attack, hackers. ZOOM faced serious security issues in 2020. Zoom didn’t have encryption so, Zoombombing .i.e an unwanted attack in the video conference calls by intruder was reported by many users because of which lawsuit was filed against it. But, Zoom recently encrypted all its data. Zoom also supports two factor authentication for user accounts. Likewise, Google Meet imposes transport encryption while Cisco Webex imposes end-to-end encryption on all its videos, audios, messaging and all other data.

All these platforms are secure as they allow users to report abusers with written details or added attachements.

Privacy:

Privacy refers to the how the users personal information are used and controlled. Zoom was accused of leaking user information to Facebook. Google Meet and Cisco Webex have protected the privacy of users.

Reliability

Reliability refers to the ability of the system to consistency perform as intended with very low crash and disconnect rate. Zoom has been handling huge surge in new users without crashes and much downtime. The calls do not disconnect and it notifies users incase of any network related issues. Google Meet runs on the browser and hence its reliability issues are browser dependent. Cisco Webex’s calls with medium bandwidth internet are not smooth as audio and video keeps disconnected so, it is less reliable than Google Meet and Zoom.

Understandability:

Understandability refers to how well user understand the system and its user guide. Both Zoom and Webex do not produce pop sounds or easily visible notifications when new participants want to join the meeting. Webex shows spinners when there is network issues while Zoom and Meet don’t. Despite these shortcomings, all the platforms are easy to understand.

Testability

Testability refers to ability of system to easily carry out tests on how its working. All the platforms offer audio/video test while joining a meeting and network health status bar throughout the meeting. Zoom offers wide range of diagnostic information like CPU clock speed with cores, total memory used and available, amount of data being transferred and current bandwidth, network type and proxy status. Users can also view the frequency of audio, latency, jitter, packet loss and resolution(fps). So, Zoom offers more testability than other platforms.

Adaptability:

Adaptability is the ability of how well the system adapts on different network status. All the platforms offer adjustment of resolution while Zoom lets user adjust their fps while sharing screen. So, Zoom has higher adaptability as compared to other platforms.

Modularity:

Modularity is the ability of system to decompose into smaller modules and operate without affecting the main module. All the platforms are modular as all its smaller modules like chat, participant details, settings, invitation works concurrently without affecting the conference call (main module). Zoom and Webex are highly modular as the smaller modules pop up from the main screen while they don’t in Google Meet due to its dependency on browser.

Portability: All the platforms are highly portable as they run on all desktop operating system like Windows, Mac, Linux and even on mobile operating system like Android, iOS.

Usability: Zoom provides cloud video conferencing, online meetings, and cross platform group chat. Users can enter a meeting with just a click and not even signing up while users need to sign up to attend a meeting in Google Meet and Cisco Webex. Therefore, Zoom is more usable than the other two platforms

Efficiency: Zoom calls run smoothly even on low bandwidth internet. It uses less number of CPU cores and low memory usage to operate than Meet. Likewise, Webex needs very good internet to operate so, Zoom is the most efficient and Cisco is the least efficient one among all the platforms.

Learnability:

All these platforms have been designed for maximum number of users and they provide visual cues, textual information so anyone can learn the system easily. The UI is simple with visible font, appropriate font size and icons. All these platforms provide feedback and explains to the user what the system is doing.

Scalability:

The maximum number of participants a Zoom, Meet and Webex meeting can handle is 1000, 250 and 200 respectively. Likewise, the number of viewers they can handle during a live-stream is 10K, 100K and 100K respectively. So, all these platforms are scalable and can address increasing number of users.

Heterogeneity:

All these platforms have multiple servers in different geographical location of the world. They also provide various integrations and APIs so, they are all heterogeneous.

Affordability:

The free version of Zoom, Meet and Webex provide up to 100 participants with 40, 60 and unlimited minutes on each conference call. So, they are all affordable. The paid versions provide many features to the host of the call.

Quality of Service

The QoS of Zoom is good with meetings that can run even in low bandwidth internet. Zoom calls are more smooth than the other platforms. Likewise, the delay, jitter, packet loss is low with good network availability, network accessibility and IP connectivity. Similarly, the overall QoS of Meet and Webex is also comparable. All these platforms have low service response time, loss, echo, interrupts and crosstalk.

Error Handling

Zoom warns users before leaving the meeting. Google Meet doesn’t warn users due to the browser dependency. But, Webex warns it user before closing the meeting on the browser inspite of the browser dependency.

Design Hierarchical Block Diagram to represent the categories of existing OTL systems

(Logically group and sub-group existing OTL systems based on like nature of the services, mode

of services, other perspectives like Open source OTL systems and Professional OTL systems

(Please do not copy existing (others’) diagram for it, you design the diagram with your logical

background (why you are proposing this diagram, basis?) Draw block diagram/component

diagram of each OTL and briefly explain them in terms of major features/functionalities they

support for teaching learning.

References:

# *Risks and Remedies in E-Learning System [Security Challenge]*

# Competition as an element of gamification for learning: an exploratory longitudinal investigation [Gamification]

# Gamification: The effect on student motivation and performance at the post-secondary level [Why gamification]