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Concept of Hybrid-Flexible Lecture using H.323 Protocol of Remote Conference System

Malayphone Sonephachanh[1*], Naoki Ohshima[2]

[1] Graduate School of Sciences and Technology for Innovation, Yamaguchi University, Ube, Yamaguchi, Japan
[2] Graduate School of Management of Innovation and Technology, Yamaguchi University, Ube, Yamaguchi, Japan

* Corresponding Author: b007wcv@yamaguchi-u.ac.jp , nohshima@yamaguchi-u.ac.jp

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Abstract: *This paper explores the innovative concept of Hybrid-Flexible (HyFlex) lectures, utilizing the H.323 protocol in remote conferencing systems, a timely response to the evolving educational landscape accelerated by the global pandemic. Yamaguchi University's multi-campus model adopted H.264 codec teleconferencing systems to facilitate remote lectures and conferences. However, the onset of COVID-19 and the subsequent surge in online learning necessitated a more versatile approach. This study delves into integrating on-premises conferencing systems with cloud-based services like Webex, showcasing a novel solution that marries traditional and online teaching methods. The paper details the technological underpinnings, particularly the H.264 codec and H.323 protocol, which are essential for high-quality, efficient multimedia communication. It then illustrates the practical application of these technologies in creating a HyFlex environment, demonstrating their effectiveness through a series of feasibility tests conducted at Yamaguchi University. These tests reveal how the Hybrid-Flexible model can overcome typical challenges such as cost, technology infrastructure, and student engagement, providing an equitable learning experience for remote and in-person participants. Conclusively, the paper presents an insightful case study of adapting to change in the educational sector, offering a scalable and efficient model for universities worldwide. It underscores the potential of leveraging existing technology in restructuring to bridge the gap between traditional and digital learning, heralding a new era in education that is more inclusive, flexible, and resilient to unforeseen challenges.*

Keywords: HyFlex Lecture, H.323 Protocol, on-premises conferencing system, Online Learning

1. Introduction

Yamaguchi University is a university with multiple campuses. Therefore, to reduce the cost of operating classes and conferences connecting multiple campuses, an H.264 codec teleconferencing system was introduced before the Corona disaster in 2019, and telelectures and teleconferences within the university have been conducted. On-campus remote lectures were relayed using on-premises conferencing systems (SONY PCS-XG77, PCS-XG100 in the case of Yamaguchi University) installed in specific classrooms on each campus. The on-premises conferencing system can simultaneously transmit and receive camera images (a full view of the classroom or a zoomed-in view of the lecturer) and computer screens. Each

classroom has two large screens, so the camera image and computer screen are projected onto each screen (Ohshima, 2021).

Since the coronavirus disaster of 2019, online classes using cloud-based online conferencing services such as ZOOM and Webex have quickly become famous as a non-contact teaching method to avoid the risk of coronavirus infection (Fitzpatrick). The coronavirus spread so rapidly that it caused some short-term confusion in the educational field, such as problems with the introduction of online classes. However, it has now established itself as an educational support tool that can be used without problems. Lifestyles are returning to the way they were before the Corona disaster. In conjunction with this, the teaching style at universities is also returning from online to face-to-face lectures (Weldy, 2018).

This study reports on a feasibility test conducted in 2020, when the introduction of online classes began, of a high-flex format in which online and face-to-face lectures are conducted simultaneously, in anticipation of the teaching style after the end of the Corona disaster.

2. Background

There have been many attempts at distance lectures. The following is a chronological summary of the evolution of distance lectures. In the 1960s-1970s, the era shifted from radio courses to TV-based distance education, providing an audio-visual classroom experience. Universities like the University of Houston pioneered broadcasting courses via television (Hart, 1990). In the 1970s-1980s, focus on increasing access to higher education was paramount, marked by establishing open universities and distance learning courses (Vivien, 2023). In the 1980s-1990s, the advent of the Internet in the 1980s-1990s revolutionized distance education. Institutions began offering online courses, enabling an interactive and flexible learning experience (An, 2021). The 1990s-2000s were characterized by the integration of digital technology into education, enhancing online courses' interactivity and multimedia content (Abdu, 2018). The 2000s saw the emergence of online learning platforms and virtual universities, offering a wide range of courses and degrees. The focus shifted to creating more engaging and interactive online learning environments (Beldarrain, 2006). Massive Open Online Courses (MOOCs) emerged in the 2010s to provide a structured online learning environment (Hajdukiewicz & Pera, 2020). With the expansion of online learning environments, the blended learning model, which integrates online learning with the traditional classroom, became a focus in education.

However, the coronavirus pandemic in 2019 caused restrictions such as the inability to conduct face-to-face classes to avoid the risk of contracting the coronavirus. To avoid the risk of coronavirus transmission while ensuring the quality of education, online format lecture methods rapidly became popular. This section summarizes the changes in distance education issues after the coronavirus pandemic. Technology Access and the Digital Divide: The pandemic accelerated efforts to bridge the digital divide, such as some students having unstable Internet access. Many educational institutions and governments have invested in providing equipment and Internet access to students. As a result, a more inclusive environment for distance learning has been created than before the pandemic, but the challenge remains that only some have satisfactory online connections (Rooney, 2011; Schegloff, 2013).

About "quality of education," before the pandemic, online education was often considered inferior to face-to-face learning. There were concerns about the quality and accreditation of online courses. The effectiveness of online learning compared to traditional face-to-face

instruction was one of the subjects of debate. Perceptions of online education improved after the pandemic as more resources were devoted to developing quality courses (Lytras et al., 2022). Many institutions adopted online education, increasing its credibility and acceptability. Before the pandemic, the general drawback of online courses (distance learning) was limited student interaction and collaboration. The only way to share information was through electronic bulletin boards (Hirlehei, 2019). After the pandemic, tools and environments such as breakout rooms, chat functions, collaborative projects, and virtual collaboration became widespread. Both professors (instructors) and trainees (students) have a better understanding of how to facilitate interaction in an online environment (Dede, 1996; Hobson & Jurkuhn, 2020).

On the other hand, moving all educational curricula online quickly and cheaply for classes involving practical skills such as training and practical training took much work. Therefore, a new format was devised in which half of the students take the practical training in the classroom, and the other half take the course online. Interest in the Hybrid-Flexible (HyFlex) format, which combines face-to-face and online learning by relaying online classroom instruction, increased.

However, the HyFlex format had several problems and challenges.

i. Technological infrastructure and resources: Implementing the HyFlex model requires a significant investment in technology. The equipment needed for face-to-face and online environments (e.g., cameras, microphones, stable Internet connections) is costly.
ii. Student participation: Engaging online and face-to-face students equally is challenging. Relaying the dynamism of a classroom lecture (e.g., writing on the whiteboard, conversations between the instructor and students, demonstrations by the instructor, etc.) involves technical difficulties. This difficulty can result in a situation where the same quality of learning content cannot be provided to both students. As a result, online students may feel isolated and less engaged than face-to-face students. Ensuring equitable participation and interaction between both groups is a critical problem.

This study addresses these HyFlex format issues by integrating an existing on-premises conferencing system with the Webex online conferencing service. The on-premises conferencing system that Yamaguchi University had been working to implement early on was a video conferencing system based on the H.264 codec. This on-premises conferencing system supports the H.323 protocol. Webex, provided by Cisco, supports the H.323 protocol, allowing on-premises conferencing systems to participate in Webex conferences (Hirlehei, 2019). Yamaguchi University licensed Webex as the official online conferencing system for the Corona Disaster. Therefore, it was easy to coordinate the intra-Internet gateway required for SIP connectivity. Since Yamaguchi University has an environment for connecting an on-premises conferencing system and a Webex online conferencing system, this study connected them and built the HyFlex environment on a trial basis. We then tested the feasibility of solving the issues of hybrid flexible connections (cost issues and broadcast of class dynamics) (Detyna et al., 2023).

3. H.264 Codec and H.323 Protocol

3.1 H.264 Codec

The H.264 codec, officially named Advanced Video Coding (AVC), is widely adopted as a standard for video compression. It is recognized for efficiently compressing video data, enabling high-quality video transmission while maintaining low bit rates. This compression standard is essential in various digital video applications, ranging from streaming over the

Internet to high-definition television broadcasts. H.264 is a technical standard for connecting on-premises equipment for high-quality remote conferencing (Ohshima, 2018).

3.2 H.323 Protocol

The H.323 protocol is a set of established standards for multimedia communications over packet-based networks, particularly those not utilizing the traditional Public Switched Telephone Network (PSTN). H.323 encompasses protocols that manage the initiation, conduct, and termination of real-time audio, video, and data transmissions. H.323 is instrumental in providing a framework for interoperability, facilitating seamless communication between diverse network devices and applications. This paper used this protocol to connect an on-premises conferencing system to the Webex online service.

4. H.264 Codec-based Teleconferencing System

Yamaguchi University has been using an H.264 codec-based teleconferencing system for distance lectures within the university and distance training on multiple campuses. The H.264 codec-based teleconferencing system can deliver clear lecturer images, audio, and PC video. The system can be connected to any location in Japan or overseas if an Internet communication environment is available. In addition, the H.264 codec-based teleconferencing system is installed with dedicated hardware so that connections can be quickly established simply by turning on the receiver and calling the other station. Even faculty members and students who do not have expert knowledge of telecommunications can efficiently and stably communicate with each other.

Since the H.264 codec-based teleconferencing system is designed for teleconferencing, it assumes a mode in which both parties face each other face-to-face in an equal position. This mode is called "meeting mode" (Ohshima, 2021).

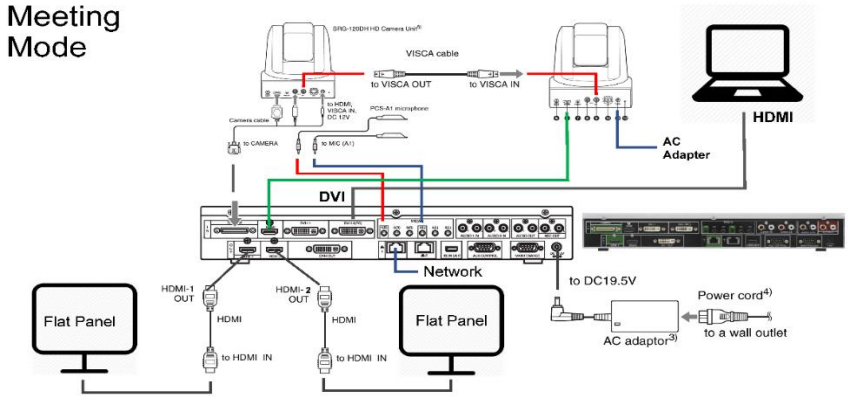

Figure 1: Meeting mode setting

Figure 1 shows the connection diagram of the devices that support the meeting mode. The connected devices consist of two remote video cameras, two flat panels (about 60 inches), a codec, and a PC.

The dedicated video cameras are connected separately for the video signal (HDMI cable) and control (VISCA cable), and the camels' angle and zoom (wide: tele) are adjusted by the remote controller.

It has primary and secondary ports as Network ports. Generally, the primary port has a private IP address (intranet environment), and the secondary port has a global IP address (Internet environment). In this feasibility test, a global IP address was configured to connect the on-premises conferencing system to the Webex online conferencing service (cloud service) (Mohan, 2013).

5. Hybrid-Flexible Connection

5.1 Feasibility Test 1

Figure 2: Hybrid-Flexible demonstration connection

In the strict sense of the term, hybrid-flexible refers to a teaching method in which lectures given in a face-to-face format are relayed to an online meeting room to simultaneously realize two types of attendance: onsite and online attendance (Beatty, 2019). It has proven challenging to convey a realistic classroom atmosphere when relaying face-to-face classroom lectures to online students. The reason for this difficulty stems from the position of the camera. In general, the basic principle of relaying the realistic feeling of an event is to send the relayed video from the same viewpoint as the audience (Marriott, 2007). This fundamental matter is easily understood if one associates it with television broadcasts. For example, in sports (baseball, soccer, tennis, etc.) broadcasts, the video camera is always placed in the same position as the audience. Applying this relationship to the classroom it is evident that the role corresponding to the "audience" is that of the students. Then, the item corresponding to the "relay camera" is usually a built-in video camera built into the teacher's notebook PC. This laptop computer provides the video from the teacher's point of view. The camera image on the screen of a student taking an online course is always from the teacher's viewpoint, not the students. Although trivial, this difference in camera view is one of the most significant reasons lectures cannot be relayed realistically (Liu et al., 2001).

This study proposes a new solution connecting an on-premises TV MEETING system (H.323 protocol) to the Webex service. The following hypotheses are made as one assumption in the proposal of this study (Morgan & Ball, 2015; Ohshima, 2021).

Hypothesis: If two-way communication is established between teacher and students while facing each other, it can be said to be a face-to-face class.

This hypothesis asserts that the class can be considered face-to-face if two-way communication can be secured with the teacher and students facing each other. The characteristics of on-

premises conferencing systems can be used to ensure two-way communication with students in the classroom, even if the instructor is not physically present in the classroom. This mechanism can be realized by relaying lectures given by the instructor from a Webex terminal to the on-premises conferencing system. This mechanism will be referred to as DX face-to-face teaching in this study.

Fig. 2 shows a feasibility test of the hybrid flexible connection using a conference room with an on-premises conferencing system as a classroom. The instructor's online lecture (Webex) is simultaneously relayed to the online PCs (students) connected from the Internet and to the on-premises conferencing system connected from the classroom. Online students view the lecturer's video and lecture materials on their PCs (O'Callaghan et al., 2017). On the other hand, students in the classroom view the lecturer's video and lecture materials projected on a large screen installed in the classroom. These displays convey essentially the same quality of information, with the only difference being the size of the display devices (laptop and classroom screens). The results of the feasibility test show that the Hybrid-Flexible connection between the on-premises conferencing system and Webex has sufficient practical potential.

5.2 Feasibility Test 2

Yamaguchi University established the Graduate School of Frontier Sciences in 2016 by reorganizing and integrating all science and engineering graduate schools (Graduate School of Engineering, Graduate School of Science, and Graduate School of Agricultural Science) and started integrated science graduate education. As an interdisciplinary educational program that fosters interdisciplinary human resources capable of driving ever-evolving technology and rapidly changing business, the Graduate School of Science and Technology opened the Advanced Course of Research and Development Strategy for all graduate students. The number of students enrolled in this course is 400. The authors are in charge of this course (Yamaguchi).

The Graduate School of Frontier Sciences consists of the School of Engineering, the School of Science, and the School of Agricultural Sciences. Since the Graduate School of Engineering is located on the Tokiwa Campus of Yamaguchi University, students attend lectures in this course on the Tokiwa Campus. The Graduate School of Science and Agricultural Science is on the Yoshida Campus. Therefore, the lectures of this course are taken on the Yoshida Campus. Before the coronavirus disaster, classes were held by relaying lecture rooms on these two campuses via a remote lecture system.

In 2020, the lecture method was shifted to online lectures to avoid the effects of the coronary disaster and the risk of infection with coronavirus. In anticipation of the end of the coronary disaster, we conducted a feasibility test of the Hybrid-Flexible method, which is more practical, by conducting classroom and online lectures simultaneously (MacKevett & Feubli, 2022; Sakib, 2022).

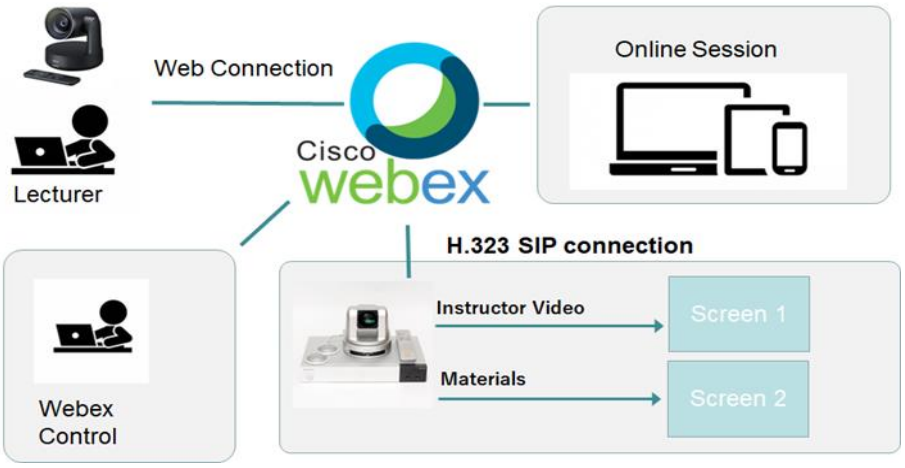

Figure 3: System diagram for feasibility test in an actual classroom

Fig. 3 shows a system diagram of a feasibility test in an actual class. In Fig. 2 and Fig. 3, the number of players in the class differs. In Figure 2, the procedure assumes that the teacher conducts the class and sends out the delivery.

On the other hand, since the lectures in R&D Strategies are structured in an omnibus format, the lectures are delivered by a different instructor each time. Figure 3 shows the system diagram when there are three players: the organizer (Webex Control), the lecturer (Lecture), and the student (Student).

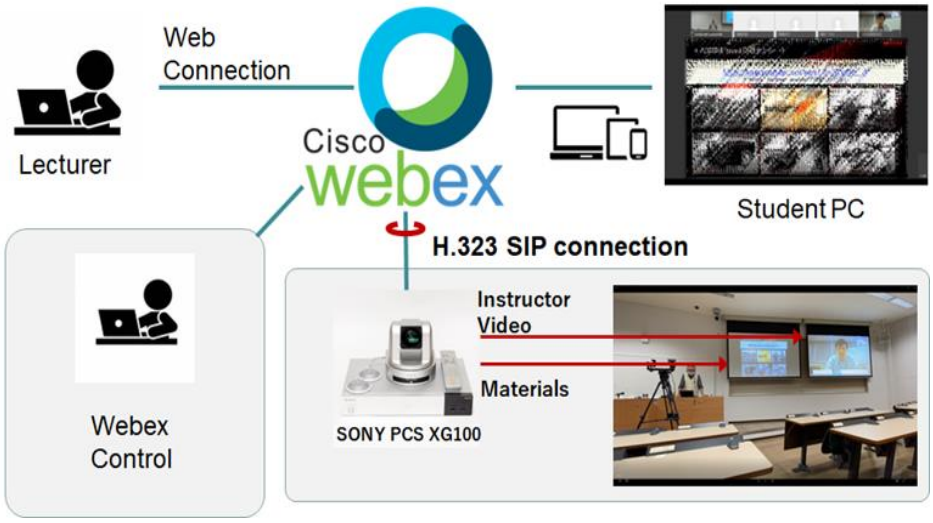

Figure 4: Feasibility Test in a Real Classroom

Fig. 4 shows the feasibility test of the hybrid flexible system in an actual class, connecting the instructor (delivering the class from off-campus), the lecture room, and the students (online). Students in the classroom could view the lecturer's video and lecture materials projected on a large screen installed in the classroom. This result indicates that the practical feasibility of the Hybrid-Flexible method is sufficiently high. However, as a result of feasibility test 2, we confirmed that a phenomenon not identified in feasibility test 1 occurs. In Feasibility Test 2, students who attended the lecture in the classroom also connected their notebook PCs to the lecture online. A laptop connection is essential since all lecture materials are distributed as electronic handouts. In this case, conflicts occurred between the sound system of the on-premises conferencing system and the audio signals of the laptops, resulting in poor acoustics due to feedback and loopback. Although we were able to eliminate this problem by deactivating

the speakers on the laptops of the students taking the course in the classroom, we recognized the need for further countermeasures.

5.3 Summary of Feasibility Tests

In this study, feasibility tests were conducted to address the two problems faced by the conventional HyFlex system described in the background: (1) cost and (2) delivery of dynamics.

The problem faced by the HyFlex system is the cost of the equipment purchased to prepare the hardware necessary to achieve HyFlex-style delivery. There are two constraints in delivering a lecture in a classroom: a single teacher must explain the lecture and deliver the lecture (operating the camera and audio microphone). A compromise that has been made in many cases to alleviate this constraint is to relay the lecture using a camera and microphone installed in the personal computer for the lecture. In this case, it becomes challenging to convey the dynamism of the lecture. If multiple cameras and microphones are provided, it is relatively easy to convey the dynamism of the lecture. However, the cost increases and the burden on the instructor (one person must play several roles) becomes more significant. Thus, it is likely that (1) cost and (2) delivery of dynamics are trade-off issues.

In Test1 and Test2 attempted in this study, the on-premises conferencing system is also connected to the online system as one node, so the online content delivered by the faculty member is also played in the classroom. Therefore, students taking the course online and students taking the course onsite (in the classroom) will receive the same content. In the case of this study, the existing on-premises conferencing system installed in the lecture room was used to create an environment by simply switching the connection method. Therefore, since no new equipment was added, there was no new burden regarding (1) cost. In addition, since the same content was received online and onsite, students could receive the same lessons regardless of which method they used. In other words, regarding (2) delivery of dynamics, the transmission gap was eliminated because onsite and online participants enjoyed almost the same degree of dynamics. The results suggest that the HyFlex system's problems can be solved using an on-premises conferencing system.

6. Conclusion

Yamaguchi University is a university with multiple campuses. After the coronavirus disaster in 2019, the university introduced a remote connection system using H.264 codecs to conduct remote lectures and teleconferences to avoid coronavirus infection risks. Since the coronavirus outbreak in 2019, online classes using cloud-based online conferencing services such as ZOOM and Webex have quickly become famous as a non-contact teaching method to avoid the risk of coronavirus infection. This study conducted a feasibility test of conducting online and face-to-face lectures simultaneously using a hybrid-flexible connection between an on-premises conferencing system and Webex. The results showed that the practical feasibility of the Hybrid-Flexible connection by linking an on-premises conferencing system and Webex was sufficiently high.

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