

Bandwidth Prediction in Zoom Meetings: A Mathematical Model Based on Feature Configuration Analysis

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Abstract

Video conferencing applications such as Zoom Meeting require sufficient and stable bandwidth to maintain communication quality. However, bandwidth needs often vary depending on user configurations, including video resolution, audio bitrate, and content-sharing activity. This study aims to develop a mathematical formula capable of accurately estimating bandwidth requirements for Zoom Meeting sessions. The methodology combines quantitative experiments and numerical simulations by collecting throughput data using Wireshark, analysing feature-based parameter variations, and validating the proposed formula through MATLAB simulation. Data were obtained from multiple Zoom sessions executed under controlled conditions with different feature combinations and replicated twenty times to ensure accuracy. The validation results show that the formula consistently provides realistic and stable estimations when compared with actual throughput measurements and simulation outcomes. The proposed model offers a simple yet effective tool for predicting bandwidth requirements, supporting efficient network capacity planning, and enhancing the overall performance of video conferencing environments.

Keywords : *Bandwidth, Formula, Video Conference, Wireshark, Zoom Meeting.*

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1. INTRODUCTION

The widespread adoption of video conferencing technologies, particularly Zoom Meeting, has highlighted the critical importance of sufficient bandwidth availability to maintain optimal communication quality [1], [2], [3]. The COVID-19 pandemic has further accelerated the use of Zoom Meeting as a primary medium for virtual meetings, distance education, and online conferences, owing to its intuitive interface and cross platform compatibility [4], [5], [6]. Nevertheless, the overall performance of Zoom Meeting is highly dependent on a stable and high speed internet connection, as inadequate bandwidth can lead to buffering, latency, and noticeable degradation in both audio and video quality [7], [8].

Bandwidth is a critical factor that determines the performance of a Zoom Meeting session [9]. Several variables, such as video resolution, the number of participants, audio quality, and content sharing activity, directly contribute to overall bandwidth consumption [10], [11], [12]. A comprehensive understanding of these parameters enables users to accurately estimate bandwidth requirements and optimize the network infrastructure being utilized [13], [14]. Accurate bandwidth prediction not only enhances user experience but also promotes efficient management of network resources [15].

A number of studies have been conducted to estimate bandwidth requirements in video conferencing applications [16]. Nurmaina et al. analyzed data packet transmission over GSM networks from various service providers to evaluate network quality based on the TYPHON standard [17]. Other studies have explored estimation approaches using machine learning or statistical modeling techniques

in streaming services [18], [19]. However, most of these studies have not provided a practical mathematical model that explicitly accounts for user-specific variables in Zoom, such as video resolution, audio bitrate, and the number of participants [20].

To address this research gap, the present study aims to formulate a mathematical model for estimating bandwidth requirements in Zoom Meeting by considering key factors such as video resolution, audio bitrate, and the number of participants [21], [22]. The proposed formula is designed to be simple, adaptive, and directly applicable for both end users and network administrators as a practical tool for planning and managing bandwidth capacity [23].

The proposed model is validated through simulations using MATLAB software by comparing the estimated results generated by the formula with the actual throughput data obtained under various configuration scenarios [24], [25], [26]. The validation process is conducted within a testing environment that reflects real-world conditions, including variations in the number of participants, video resolution levels, and fluctuating network conditions [27], [28]. Through this approach, the model is expected to demonstrate high reliability and relevance across diverse practical applications [29].

This study contributes to the optimization of network performance for video conferencing applications and serves as a reference for the development of adaptive bandwidth management systems and future improvements in Quality of Service (QoS) [30]. The findings are highly relevant to educational institutions, enterprises, and remote work environments where uninterrupted virtual communication is essential. By simplifying the bandwidth estimation process through an easily implementable model, this research bridges the gap between theoretical concepts and practical applications in modern network communication management.

2. METHOD

This study employs a quantitative experimental approach combined with simple numerical simulations to develop and evaluate a bandwidth estimation model for Zoom Meeting usage [19], [21]. The objective of this research is to derive a practical mathematical formula capable of predicting bandwidth requirements based on various user configuration combinations, such as camera activation, microphone usage, and screen-sharing features [17], [20].

The research process consists of several systematic stages that reflect the methodological sequence of activities, beginning with a literature review, direct data collection through Zoom Meeting sessions, formulation of an estimation model based on average throughput, and validation of the results using simulations and mathematical calculations [23], [24]. Each stage is designed to be interconnected and mutually supportive in achieving the main objective of this study, which is to provide an easy-to-implement yet accurate bandwidth prediction tool [25].

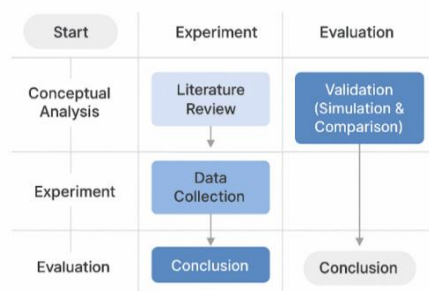


Figure 1. Research Flow

Figure 1 illustrates the overall research workflow, which begins with a literature review, followed by data collection using Wireshark, analysis and formulation of the bandwidth estimation model, validation of the results through MATLAB simulations, and finally, the formulation of conclusions.

2.1. Literature Review

The literature study was conducted to gain a comprehensive understanding of bandwidth utilization characteristics in Zoom Meeting applications and network throughput measurement methods [4], [10], [11]. The reviewed literature includes official Zoom documentation regarding bandwidth requirements for various usage scenarios, such as video, audio, and screen-sharing activities [30]. In addition, references related to packet sniffing techniques using Wireshark and the fundamental principles of throughput measurement were analysed to ensure the accuracy of data collection [19], [22]. Previous studies discussing bandwidth estimation in video conferencing applications were also reviewed to guide the experimental methodology and model development. This literature study serves as the foundation for formulating a systematic and valid research approach.

2.2. Experimental Environment and Tools

This research was conducted in a controlled environment using a personal device connected to a high-speed and stable Wi-Fi network. The experiments were performed locally to maintain consistency in network parameters and to facilitate real-time monitoring and data recording. All experimental procedures were carried out on a single laptop running the Windows operating system, equipped with sufficient hardware specifications to simultaneously operate Zoom Meeting, Wireshark, and MATLAB applications [24], [26].

The software utilized in this study includes Zoom Meeting for executing video conferencing scenarios, Wireshark as a network traffic monitoring tool (sniffer), and MATLAB for performing simple mathematical simulations based on the formulated estimation formula. Wireshark was employed to capture and record throughput parameters during active Zoom sessions, while MATLAB was used to simulate bandwidth estimation according to user configuration parameters. Table 1 summarizes the hardware and software specifications used in this study:

Table 1. Specifications of Hardware and Software Components

Component	Specification / Version
Hardware	Laptop, Intel Core i7-7700HQ, RAM 16 GB, SSD 512 GB
Operating System	Windows 10 Pro 64-bit
Video Conferencing Application	Zoom Meeting Version
Packet Sniffer	Wireshark 3.x
Simulation Tool	MATLAB R2021a

2.3. Data Collection

The data collected in this study consist of actual throughput values obtained from Zoom Meeting activities conducted under various feature combinations. Throughput is measured as the average data transfer rate during each session (in bits per second), representing the actual bandwidth requirement for each usage configuration. The experiments were performed using a single laptop, where Zoom Meeting was executed for each of the following feature configurations as shown in Table 2.

Table 2. Experimental Scenarios of Zoom Meeting Capture

No	Microphone	Camera	Share Screen	Scenario Description
1	Active	Active	Active	All Zoom features are active
2	Active	Inactive	Active	Camera is disabled, others remain active
3	Active	Active	Inactive	Screen sharing is disabled
4	Inactive	Active	Active	Only the microphone is disabled

Each scenario was executed for 10 minutes without any background processes that could interfere with network traffic. To ensure data reliability, each scenario was repeated 20 times, resulting in a total

of 80 Zoom Meeting sessions. During each session, the Wireshark application was run in parallel to capture network traffic on the Wi-Fi interface. The log data obtained from Wireshark were then collected and analysed to calculate the average throughput by dividing the total amount of transmitted data (in bytes) by the session duration (in seconds), which was subsequently converted into bits per second. The mean value from the 20 repetitions of each scenario was used as the baseline estimation for the formula developed in the next stage.

The experimental topology in this study was designed to represent the actual flow of data communication during Zoom Meeting sessions. This strategy was developed to ensure that the throughput acquisition process took place within a controlled environment without interfering with the natural behaviour of the network system. The experiments were conducted using a single laptop that simultaneously operated two primary applications: Zoom Meeting, which generated network traffic, and Wireshark, which served as a packet-sniffing tool for monitoring the traffic flow. With this configuration, the entire data collection process could be performed locally within a single workstation. The experimental system topology during the data collection process is illustrated in Figure 2, which depicts a simplified scheme of interactions between the host device, the wireless network, and the external internet connection.

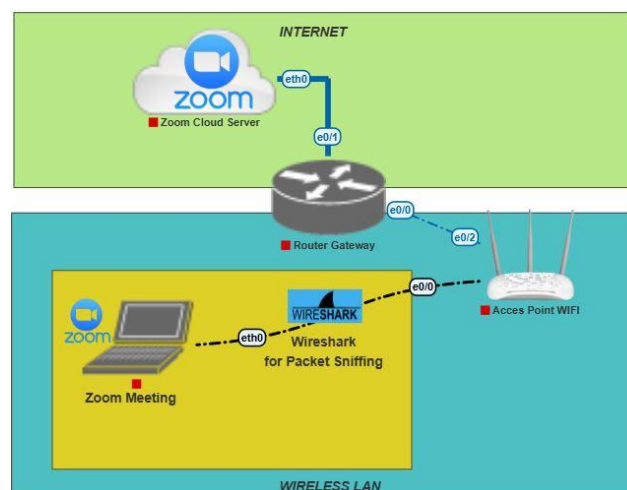


Figure 2. Network topology used in the Zoom Meeting simulation

As illustrated in Figure 2, the experiment was conducted in a controlled environment using a single laptop running two main applications, namely Zoom Meeting and Wireshark. This device served as the central component of the entire data collection process while representing a typical Zoom Meeting usage scenario in real-world conditions. The Zoom application was used to generate network traffic corresponding to video conferencing sessions with various feature combinations, such as microphone, camera, and screen sharing. Meanwhile, Wireshark functioned as a packet-sniffing tool to record the data traffic produced by Zoom activities in real time.

During the data collection process, the test laptop was configured to run only one application utilizing the internet connection Zoom Meeting. All background applications that could potentially access the network, such as system updates, cloud synchronization, or other notification services, were disabled to prevent interference with Zoom traffic. By ensuring that Zoom Meeting was the sole active network process, the throughput captured by Wireshark accurately represented the actual bandwidth consumption of the application without distortion from external sources.

Wireshark was configured to capture packets through the wireless network interface (Wi-Fi interface), focusing primarily on the protocols and ports utilized by Zoom Meeting. By default, Zoom uses UDP ports 8801–8810 for video and audio transmission; however, in fallback conditions, it may

also operate using the TCP protocol. The packet capture process was directed to monitor data flows passing through these ports, ensuring that all network activities related to Zoom sessions were comprehensively and accurately recorded.

The analysis was conducted by calculating the total amount of data transmitted during each experimental session and dividing it by the session duration to obtain the throughput value in bits per second (bps). This calculation was performed for each predefined scenario using an averaging approach across multiple session repetitions. Through this method, each scenario yielded a single value representing the actual bandwidth estimation, which was then used to assess the accuracy of the developed estimation formula. Furthermore, all measurements were conducted under uniform duration and parameter settings to facilitate a fair comparison across scenarios.

The topology and approach employed in this study are non-intrusive, meaning that no structural modifications or manipulations were made to the network during the experiment. All procedures were conducted using a passive observation method, ensuring that the collected data accurately reflected the actual conditions of Zoom Meeting usage. The main advantage of this approach lies in its ease of replication and applicability in different environments, enabling both researchers and network practitioners to perform similar performance evaluations effectively.

2.4. Formulation of the Bandwidth Estimation Formula

The formulation of bandwidth requirement estimation in this study was based on throughput data obtained through the data collection process using Wireshark. Each scenario, involving different combinations of Zoom Meeting features microphone, camera, and screen sharing was executed for a specified duration and repeated 20 times to obtain a representative average throughput value. This average value was then used as a reference to calculate the bandwidth consumption associated with each active feature during a Zoom session.

The first step in the formulation process was to observe the variations in throughput values across different Zoom Meeting scenario combinations. Although Wireshark cannot explicitly identify traffic types based on the specific Zoom features in use (such as microphone or camera), the experiment was designed in a controlled manner, allowing the observed differences in throughput values to be associated with the contribution of each feature. Consequently, the bandwidth consumption of features such as the camera, microphone, and screen sharing could be estimated based on significant throughput changes that occurred when these features were activated or deactivated.

After the baseline values were obtained from the average throughput of each feature, the next step was to integrate a tolerance margin to account for network overhead, traffic fluctuations, and reserve capacity requirements. This margin was set at 10% of the total value and was directly added to the summation result as a compensatory component for potential real-time bandwidth spikes. This approach acknowledges that video conferencing activities do not always operate under constant conditions, particularly when dynamic factors such as automatic video resolution adjustments or sudden participant increases occur.

The resulting estimation formula was structured by grouping components according to the active features during a Zoom Meeting session, such as microphone, camera, and screen sharing. The output of this formula provides an estimate of the average bandwidth requirement per user, expressed in megabits per second (Mbps), depending on the combination of features utilized. Furthermore, the total estimated bandwidth requirement for multiple users can be obtained by multiplying the individual calculation result by the number of participants in the Zoom session. This formula was designed to be flexible and applicable across various scenarios, including individual use, educational institutions, corporate settings, and large-scale network capacity planning.

This model was developed not only based on theoretical assumptions but also on empirical observations of network traffic systematically collected during the experiments. The purpose of this process was to produce a practical and comprehensible bandwidth estimation formula that remains relevant for planning Zoom Meeting connection requirements under various usage configurations.

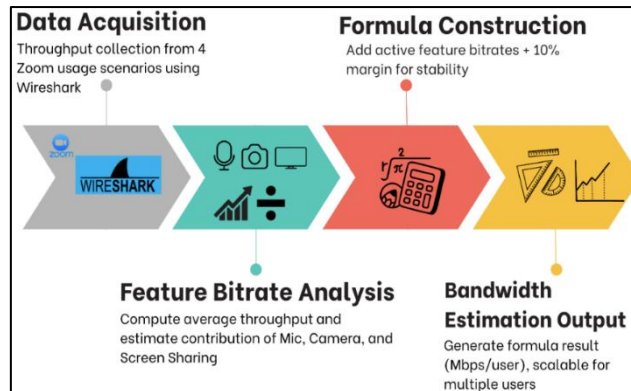


Figure 3. Flow of bandwidth estimation formula development

Figure 3 presents the development process of the bandwidth estimation formula in the form of a horizontal pipeline consisting of four main stages. The process begins with the collection of throughput data using Wireshark based on four feature combination scenarios in Zoom Meeting usage. This is followed by a feature contribution analysis, which estimates the extent to which each feature (microphone, camera, and screen sharing) influences total bandwidth utilization. Based on the results of this analysis, an estimation formula is constructed by summing the bitrates of all active features and adding a 10% margin to account for potential network fluctuations. The final stage produces a per-user bandwidth formula (in Mbps) that is flexible and scalable according to the number of participants.

2.5. Simulation and Validation

After the bandwidth estimation formula was derived based on the average throughput results from four Zoom Meeting feature configuration scenarios, simulations were conducted to observe the logical consistency of the estimated results when applied to conditions involving a larger number of users (hosts). The four configuration scenarios used in this study included combinations of active and inactive features such as microphone, camera, and screen sharing. The simulation was performed using a simple calculative approach without employing any network toolbox or dynamic traffic modelling in MATLAB. The estimated bandwidth values for each feature were obtained from the official Zoom documentation and summed according to the configuration of each scenario. Subsequently, the total estimated bandwidth per user for each scenario was multiplied by the number of hosts to determine the overall bandwidth requirement. The reference bitrate values for each Zoom feature used in the simulation are presented in the Table 3.

Table 3. Bitrate Ranges for Zoom Meeting Features

Type	Value
Video Bitrate	0 – 1200
Audio Bitrate	0 – 80
Share Screen	0 - 600

This simulation was not intended for direct empirical validation but rather as an initial effort to evaluate the logical consistency and scalability of the developed formula. The approach is deterministic in nature and still provides a valuable contribution as a foundational reference for bandwidth capacity

planning across various multi-host Zoom Meeting scenarios. Validation through real network testbed experiments is recommended as a follow up in future research.

3. RESULT

Data collection was performed using Wireshark during a 10-minute Zoom Meeting session under four different feature configurations. Each configuration was designed to evaluate the effect of enabling or disabling the camera, microphone, and screen sharing on the total transmitted data. The experiment was repeated 20 times for each configuration category, and the average value was taken as the final result to ensure measurement consistency and accuracy.

3.1. Throughput Measurement Results Using Wireshark

Data collection was carried out using Wireshark during a 10-minute Zoom Meeting session with four different feature configurations. Each configuration was designed to test the effect of activating or deactivating the camera, microphone, and screen sharing on the total amount of transmitted data. The results can be seen in Table 4.

Table 4 Measured Throughput Values Captured Using Wireshark

Scenario	Packet Size (Bytes)	Transmission Time (Seconds)	Throughput (Kbps)
Camera On, Mic On, Share Screen On	899,556	602.358	1493.39
Camera On, Mic Off, Share Screen On	735,525	604.012	1217.73
Camera On, Mic On, Share Screen Off	673,279	608.248	1106.91
Camera Off, Mic On, Share Screen On	797,806	603.012	1323.03

Based on Table 3, the obtained throughput is highly influenced by the number of active Zoom features. The highest throughput value (1493.39 Kbps) occurred when all three features camera, microphone, and screen sharing were activated simultaneously. This result is logical, as the combination of video and screen sharing leads to an increased data transmission rate, where the continuous video frame stream consumes high bandwidth, while screen sharing adds additional load due to real-time screen encoding.

Conversely, the lowest throughput (1106.91 Kbps) was observed when the screen sharing feature was disabled, indicating that this feature contributes significantly to overall bandwidth consumption. Interestingly, when the camera was turned off but screen sharing remained active, the throughput value was still relatively high (1323.03 Kbps), suggesting that screen sharing alone can generate a data traffic volume comparable to that of standard video transmission.

The measurement results show that the increase in the number of activated features in Zoom Meeting is directly proportional to the rise in bandwidth demand. The activation of the camera and screen sharing produces the most significant throughput surge, as both generate dense and continuous video data streams. Meanwhile, disabling one of the main features, such as screen sharing or the camera, significantly reduces the network load. These findings confirm that the more complex the user activities are, the greater the bandwidth consumption required to maintain stable communication quality.

3.2. Bandwidth Requirement Formulation Results

The bandwidth requirement formulation was derived based on the throughput values obtained from packet sniffing on the Zoom Meeting application. The throughput value represents the amount of data transmitted within a specific time interval, as shown in the following equation (1).

$$Throughput = \frac{\text{Amount of data sent (bit)}}{\text{Transmission Time (Second)}} \quad (1)$$

The obtained throughput values were then used to construct a bandwidth requirement model. To maintain a stable connection during Zoom Meeting sessions, a 10% margin was added to the actual throughput value. This margin serves as a buffer to accommodate network fluctuations and packet bursts that may occur during the conference session.

$$B_{Reg} = T + (T \times 0.1) \quad (2)$$

Where:

B_{Reg} : bandwidth requirements (Kbps)

T : throughput value of measurement results (Kbps)

0.1 : adjustment margin of 10% of actual throughput

For multi device usage, the total bandwidth requirement can be calculated by multiplying the per-device bandwidth value by the number of participants (n) :

$$B_{total} = n \times B_{req} \quad (3)$$

The formulation process followed the stages described in Figure 1 of the methodology section, which include throughput data collection, application of a safety margin, and validation of the results through MATLAB simulation. Using the throughput measurement values presented in Table 3, a bandwidth requirement model was obtained for the four Zoom Meeting configurations, as shown in Equations (4) to (11).

a. Scenario 1 (Camera On, Mic On, Screen Sharing On) :

$$B_{req} = 1493.39 + (1493.39 \times 0.1) = 1642.73 \quad (4)$$

$$B_{total} = n \times 1642.73 \quad (5)$$

b. Scenario 2 (Camera On, Mic Off, Screen Sharing On) :

$$B_{req} = 1217.73 + (1217.73 \times 0.1) = 1339.50 \quad (6)$$

$$B_{total} = n \times 1339.50 \quad (7)$$

c. Scenario 3 (Camera On, Mic On, Screen Sharing Off) :

$$B_{req} = 1106.91 + (1106.91 \times 0.1) = 1217.60 \quad (8)$$

$$B_{total} = n \times 1217.66 \quad (9)$$

d. Scenario 4 (Camera Off, Mic On, Screen Sharing On) :

$$B_{req} = 1323.03 + (1323.03 \times 0.1) = 1455.33 \quad (10)$$

$$B_{total} = n \times 1455.33 \quad (12)$$

The calculation results indicate that the bandwidth requirement increases proportionally with the number of active features in the Zoom Meeting application. In the first scenario, where the camera, microphone, and screen sharing were all active simultaneously, the highest value approximately 1.64 Mbps per device was obtained. This value represents the maximum network load condition caused by

three simultaneous data streams: video, audio, and screen content. Meanwhile, in Scenario 3, where screen sharing was disabled, the bandwidth requirement decreased to around 1.22 Mbps per device, as only two primary data components video and audio were active. A similar reduction was also observed in Scenario 2 when the microphone was deactivated, indicating that although audio contributes a smaller portion, it still has a significant impact on the total data traffic.

Interestingly, in Scenario 4 (camera off, screen sharing on), the bandwidth requirement remained relatively high at approximately 1.45 Mbps per device. This finding indicates that screen sharing alone can produce a bitrate comparable to medium resolution video, as the real time screen encoding process requires continuous frame transmission. When applied in an environment with 30 active participants, the total bandwidth demand could reach approximately 49 Mbps for the scenario with all features enabled. This value represents the ideal network requirement to ensure stable video communication without delay or packet loss.

The addition of a 10% margin in the formulation has been proven to provide more realistic and reliable estimation values. Without this margin, the estimated results would be lower than the actual conditions, especially during throughput fluctuations caused by changes in connection quality or dynamic video movements.

3.3. MATLAB Simulation Results.

A simple simulation was conducted using MATLAB to estimate the required bandwidth based on the sum of the bitrate values from the video, audio, and screen sharing features, as described in the methodology section. The purpose of this simulation was to provide a comparison with the formula-based calculation results under various Zoom Meeting configurations. The simulation results present the estimated bandwidth requirements for both single-device and thirty-device scenarios operating simultaneously, as shown in Table 5.

Table 5 Simulated Bandwidth Estimation Results Obtained from MATLAB

Scheme	Bandwidth for 1 Device (Kbps)	Bandwidth for 30 Device (Kbps)
Camera on, mic on, share screen on	2068	62040
Camera on, mic off, share screen on	1980	59400
Camera on, mic on, share screen off	1414.66	42440
Camera off, mic on, share screen on	748	22440

In general, the simulation results indicate that the total bandwidth requirement increases with the number of activated features. The combination of camera and screen sharing produced the highest values, while configurations without the camera resulted in the lowest bandwidth demand. These simulation results were subsequently compared with the formula-based calculation outcomes in the following subsection to evaluate the consistency and accuracy of the developed estimation model.

3.4. Comparison Between Formula and Simulation Results.

A comparison was conducted between the estimated bandwidth results obtained from the developed formula and the MATLAB simulation outcomes across four Zoom Meeting configurations. The purpose of this comparison was to evaluate the pattern consistency and accuracy of the mathematical model in representing actual bandwidth requirements under real-world conditions.

a. Scenario 1 (Camera On, Mic On, Screen Sharing On) :

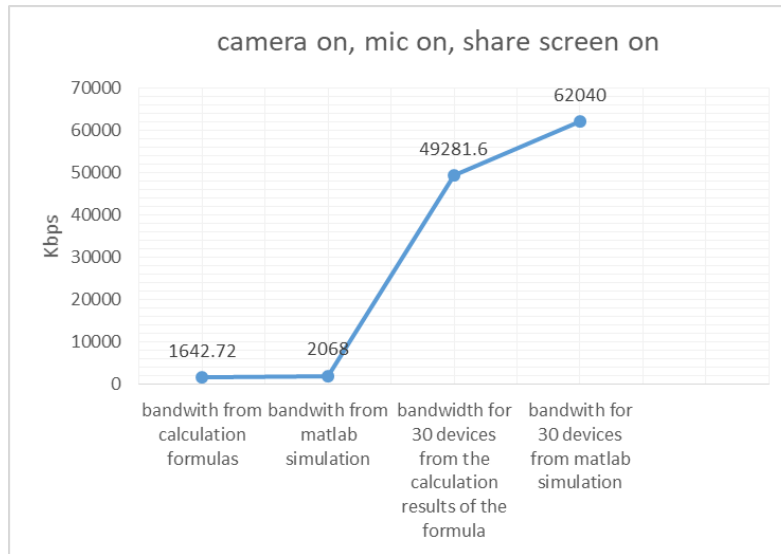


Figure 4 Bandwidth estimation comparison for Scenario (Camera On, Mic On, Screen Sharing On)

Figure 4 illustrates the comparison between the formula-based estimation and the MATLAB simulation under the configuration where all features were active. The graph shows that the simulated values are slightly higher than the formula calculation results. This difference occurs because the simulation process sums the bitrate based on the maximum value of each feature, whereas the formula uses the average throughput with a 10% adjustment margin. Nevertheless, the overall trend remains similar, indicating that the formula-based model consistently represents the bandwidth consumption pattern.

b. Scenario 2 (Camera On, Mic Off, Screen Sharing On) :

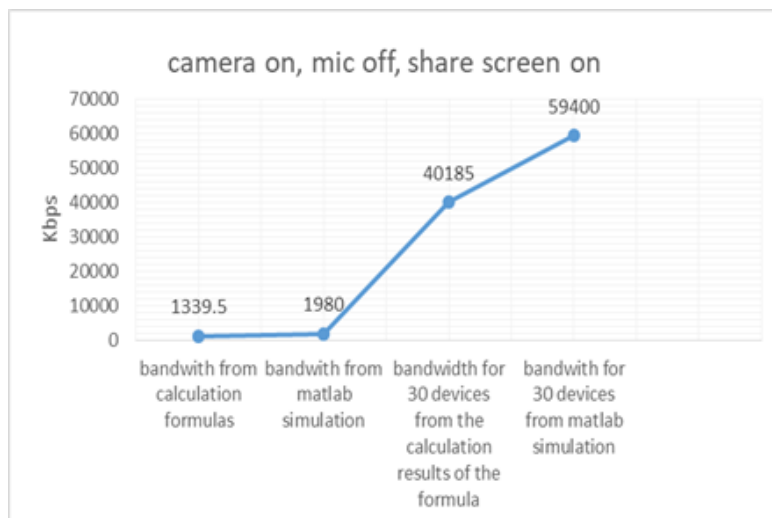


Figure 5 Bandwidth estimation comparison for Scenario (Camera On, Mic Off, Screen Sharing On)

The comparison results for the second scenario are presented in Figure 5. A larger gap can be observed between the simulated values and the formula-based results. This condition occurs because screen sharing continues to generate high data traffic even when the audio feature is disabled. This finding reinforces that visual components particularly screen sharing are the most dominant factors contributing to the total bandwidth requirement.

c. Scenario 3 (Camera On, Mic On, Screen Sharing Off) :

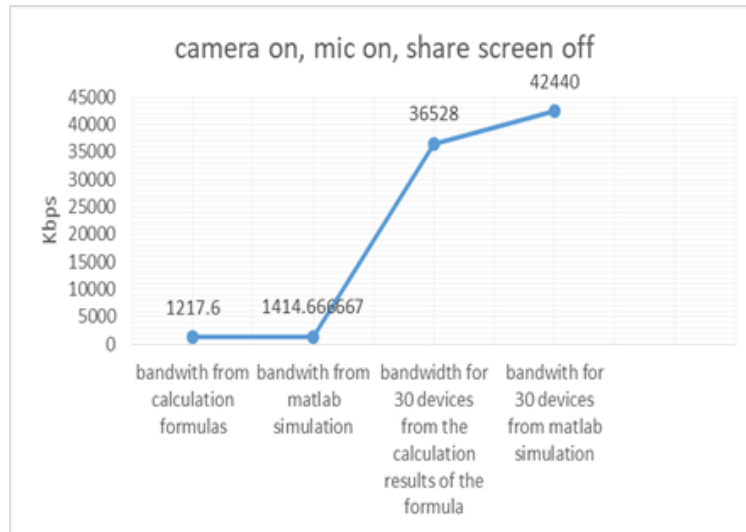


Figure 6 Bandwidth estimation comparison for Scenario (Camera On, Mic On, Screen Sharing Off)

In Figure 6, which presents the comparison results for the third scenario, the difference between the formula-based and simulated results appears smaller than in the previous two scenarios. This indicates that when only the two primary features—video and audio—are active, the calculation model produces results that are closely aligned with the simulation. This condition reflects a more stable network situation, as the bitrate variation is not as significant as in configurations that include screen sharing.

d. Scenario 4 (Camera Off, Mic On, Screen Sharing On) :

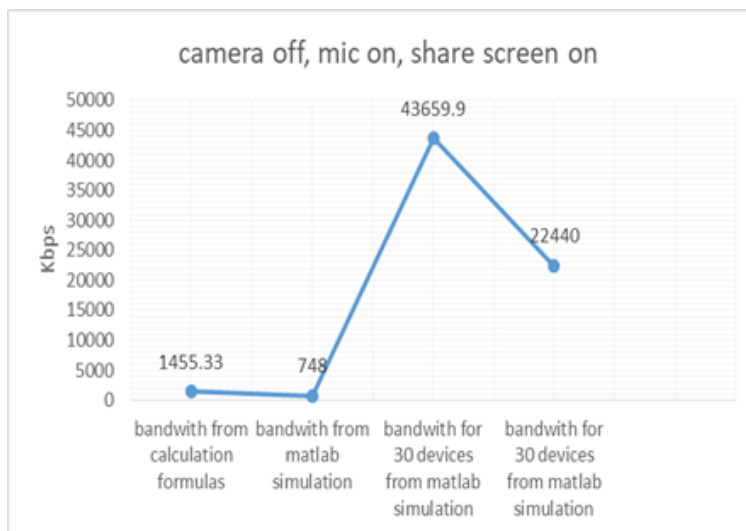


Figure 7 Bandwidth estimation comparison for Scenario (Camera Off, Mic On, Screen Sharing On)

The comparison results for the fourth scenario are shown in Figure 7. In this configuration, the difference between the formula-based and simulated results appears to be the largest, approaching nearly twice the value. This condition occurs because, in the simulation, the absence of video data flow causes the Zoom system to automatically reduce the bitrate to a much lower level. In contrast, in the formula calculation, the 10% adjustment margin was applied consistently without distinguishing between video activity conditions.

As a result, the mathematical model produced higher estimation values compared to the actual simulation outcomes. Nevertheless, the relationship pattern among features remained consistent the fewer visual components were active, the lower the required bandwidth. This considerable difference confirms that the calculation model operates conservatively, providing a safe estimation that can be used for network capacity planning to prevent bandwidth shortages during sudden increases in user load.

4. DISCUSSIONS

The research results demonstrate that the developed mathematical model can provide consistent bandwidth requirement estimations across various Zoom Meeting configurations. The comparison pattern between the calculated and simulated results exhibits a similar trend namely, the more features such as the camera, microphone, and screen sharing are activated, the greater the required bandwidth. This condition confirms that the proposed throughput-based formulation effectively represents the proportional relationship between the complexity level of user activities and the resulting network load.

The difference in values between the formula-based results and the MATLAB simulation outcomes is attributed to the distinct characteristics of the two approaches. The developed formula employs the average throughput value with a fixed adjustment margin, making it static in nature. In contrast, the MATLAB simulation dynamically aggregates bitrate values based on the active feature conditions. This leads to a noticeable deviation, particularly in scenarios without the camera, where the Zoom system reduces the bitrate to a minimal level while the formula continues to apply a constant margin. Nevertheless, the direction of value changes between the two remains consistent. The resulting mathematical model is conservative, producing safe estimations that are useful for network capacity planning to prevent bandwidth shortages during peak usage conditions.

From an implementation perspective, this model provides a practical and efficient approach to estimating bandwidth requirements without relying on complex simulation methods. It can assist network administrators in educational institutions, government agencies, and corporate environments in designing optimal video conferencing network capacities. Although its accuracy is sufficient for preliminary planning, the model still has limitations, as it does not account for variations in network quality or real-time bitrate adaptation mechanisms. Future research can be directed toward developing a dynamic formula or integrating machine learning algorithms to improve prediction accuracy for adaptive video conferencing systems.

5. CONCLUSION

This study successfully developed a mathematical model to estimate bandwidth requirements in the Zoom Meeting application based on throughput measurements and MATLAB simulation validation. The results show that the proposed model exhibits a consistent estimation pattern with the simulation outcomes, with an average deviation of approximately 34.6%. This indicates that the model can realistically represent bandwidth requirements across various usage configurations. The developed formula is simple yet sufficient to serve as an initial reference for video conferencing network capacity planning, particularly in educational and organizational environments. These findings provide a foundation for developing more adaptive bandwidth prediction systems in future research.

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