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A Video Streaming in WLANs Taxonomy (ViSWAT)

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Abstract: The Video Streaming in WLANs Taxonomy (ViSWAT) is a comprehensive framework designed to categorize and structure the diverse aspects of video streaming over Wireless Local Area Networks (WLANs). ViSWAT encompasses various dimensions, including content type, network architecture, quality of service, device and application, video resolution, content source, security, wireless standards, multicast, buffering, latency, content delivery, and user interaction. This taxonomy aids in the systematic analysis, organization, and understanding of video streaming in WLANs, allowing for informed decision-making and optimization of the video streaming experience across WLAN environments.

Keywords: Video, Streaming, Wireless Local Area Network (WLANs)

I. INTRODUCTION

Video streaming has become an integral part of modern digital communication and entertainment, with Wireless Local Area Networks (WLANs) serving as a crucial conduit for the delivery of video content to a wide range of devices. As the demand for high-quality video streaming experiences continues to grow, it becomes essential to comprehensively understand and categorize the myriad aspects that influence video streaming over WLANs. To address this need, the Video Streaming in WLANs Taxonomy (ViSWAT) is introduced, providing a structured framework for the systematic classification of video streaming scenarios, encompassing diverse factors such as content type, network architecture, quality of service, device and application, video resolution, content source, security, wireless standards, multicast, buffering, latency, content delivery, and user interaction.

In an age where video content is ubiquitous, ViSWAT offers a valuable tool for researchers, network administrators, content providers, and application developers to navigate the complex landscape of video streaming within WLANs. With the dynamic and evolving nature of video streaming technologies and consumer expectations, ViSWAT enables a deeper understanding of the key components that shape the video streaming experience, allowing for informed decision-making and strategic planning. The following sections provide a detailed exploration of each dimension within ViSWAT, offering insights into the myriad factors that influence video streaming in WLANs and their significance in delivering optimal user experiences.

The taxonomy is structured to address not only the technical and network-related aspects but also the user-centric elements that impact video streaming. As users increasingly turn to WLANs for video content consumption and interaction, the ViSWAT framework acknowledges the critical role of wireless networks in shaping the present and future of video streaming, making it a valuable resource for anyone involved in the dynamic and rapidly evolving field of digital media delivery.

This paper consists of seven sections. In Section II video streaming is introduced and its role inWLANs. Section III presents the Video Streaming in WLANs Taxonomy (ViSWAT). Each component of ViSWAT is described with relevant details. In Section IV a comparison of ViSWAT elements is given. Uses of ViSWAT are illustrated in Section V and a discussion in section VI. Finally, in Section VII the conclusion is given.

II. VIDEO STREAMING IN WLANS

Video streaming [1], [2], [3], [4] in wireless local area networks (WLANs) is a popular and integral aspect of today's digital landscape. It refers to the process of delivering video content over wireless networks to end-users, allowing them to watch videos on a wide range of devices, from smartphones and tablets to smart TVs and desktop computers. Video streaming has become a dominant form of content consumption, with platforms like YouTube, Netflix, Amazon Prime Video, and many others offering a vast array of video content accessible over WLANs.

One of the key challenges in video streaming over WLANs is delivering high-quality video content while ensuring a smooth and uninterrupted viewing experience. Several factors influence the quality of video streaming in WLANs:

Network Infrastructure: The WLAN infrastructure, including routers, access points, and wireless standards (e.g., 802.11a/b/g/n/ac/ax), plays a crucial role in determining the available bandwidth, coverage, and network stability. The choice of network hardware and standards affects the quality of the video streaming experience.

Content Resolution: Video content is often available in different resolutions, such as standard definition (SD), high definition (HD), and ultra-high definition (UHD/4K). The resolution impacts the image quality and the amount of data required for streaming. Viewers on WLANs may choose the appropriate resolution based on their device capabilities and network conditions.

Quality of Service (QoS): QoS mechanisms help prioritize video traffic and ensure a consistent streaming experience. QoS-guaranteed streaming prioritizes video content to maintain quality even during network congestion, while best-effort streaming provides no specific guarantees, and the quality may vary based on network conditions.

Buffering and Adaptive Streaming: To mitigate issues related to network fluctuations, video streaming often employs buffering and adaptive streaming techniques. Buffers preload and store video data for smoother playback, while adaptive streaming dynamically adjusts the video quality based on the viewer's network conditions to provide an optimal experience.

Latency: Latency, or the delay between video capture and playback, is a critical factor in video streaming. Low-latency streaming is crucial for real-time applications like live streaming and video conferencing, while high-latency streaming may be acceptable for on-demand content.

Security: Ensuring the security of video content and user data during transmission is essential. Secure streaming employs encryption and authentication measures to protect content, making it suitable for sensitive or private content.

The interaction between these factors, combined with the inherent limitations and capabilities of WLANs, creates a dynamic environment for video streaming. In this context, network optimization, security measures, and adaptive technologies are essential to deliver a seamless and high-quality video streaming experience over WLANs.

III. VIDEO STREAMING IN WLANS TAXONOMY (VISWAT)

The Video Streaming in WLANs Taxonomy, or ViSWAT, is a comprehensive framework designed to provide a systematic and structured approach to understanding the multifaceted landscape of video streaming over Wireless Local Area Networks (WLANs). With the proliferation of video content consumption across a wide array of devices, from smartphones and tablets to smart TVs and desktop computers, the need for a framework that organizes and categorizes the various aspects of video streaming within WLAN environments has become increasingly evident.

ViSWAT serves as a valuable resource for researchers, network administrators, content providers, and developers, offering a detailed and organized taxonomy that encompasses a wide range of dimensions. These dimensions include the type of content being streamed, the network architecture in use, the quality of service requirements, the devices and applications involved, the resolution of the video, the source of the content, security considerations, wireless standards, multicast or unicast streaming, buffering strategies, latency constraints, content delivery mechanisms, and the level of user interaction supported.

The taxonomy is a valuable tool for addressing the complex and dynamic challenges associated with video streaming in WLANs. By providing a structured framework, ViSWAT enables stakeholders to make informed decisions, optimize the user experience, and adapt to the evolving landscape of video streaming technologies and consumer expectations. In the following sections, we delve into the various dimensions of ViSWAT, shedding light on their significance and the role they play in shaping the video streaming experience in WLANs. Whether you are a network engineer, a content provider, or an end user, ViSWAT offers insights and guidance for navigating the complex world of video streaming in WLAN environments.

A taxonomy of video streaming in Wireless Local Area Networks (WLANs) can be structured based on several key factors and considerations. Here's a taxonomy that categorizes video streaming in WLANs:

1. Type of Content[5], [6], [7]:

Live Streaming: Real-time broadcasting of events or content, such as sports events, news, or live video conferencing.

On-Demand Streaming: Pre-recorded videos that can be accessed at any time, including movies, TV shows, or educational content.

Type of Content is a crucial dimension in the Video Streaming in WLANs Taxonomy (ViSWAT) as it categorizes video streaming scenarios based on the nature of the content being delivered. The two primary categories under this dimension are:

Live Streaming:
Description: Live streaming refers to the real-time broadcasting of events or content as they happen. This content is streamed to viewers as it is being captured, allowing them to watch and engage with events as they unfold. Examples of live streaming content include sports events, news broadcasts, live video conferencing, webinars, and live gaming broadcasts on platforms like Twitch.

Characteristics:
Real-time: Live streaming provides immediate access to events or content as it occurs, eliminating the delay associated with recording and editing.

Interactivity: Viewers often have the opportunity to engage with the content through live chats, comments, and real-time interaction with hosts or other viewers.

Dynamic: The content is subject to unpredictable events, making it exciting and unpredictable for the audience.

Network Considerations: Live streaming demands a robust and low-latency network to ensure that viewers receive the content in real time without interruptions or significant delays.

On-Demand Streaming:
Description: On-demand streaming involves pre-recorded videos that can be accessed by viewers at any time they choose. This category encompasses a wide range of content, including movies, TV shows, educational videos, and user-generated content on platforms like YouTube and Netflix.

Characteristics:
Convenience: Viewers have the flexibility to choose when and where to watch content, pausing, rewinding, or fast-forwarding as needed.

Consistency: The quality of on-demand streaming is typically consistent since the content is pre-recorded and often undergoes post-production.

Archive: On-demand content can be cataloged and made available for extended periods, creating an archive of video resources.

Network Considerations: While on-demand streaming may be more forgiving in terms of network latency, it still requires sufficient bandwidth to deliver high-quality video without buffering.

The choice between live streaming and on-demand streaming depends on the nature of the content and the viewer's preferences. Live streaming is ideal for events that require immediate viewer engagement and interaction, while on-demand streaming is suitable for content that can be pre-produced and accessed at the viewer's convenience. Both types of content have their unique characteristics, network requirements, and use cases, making it important to distinguish between them within ViSWAT for effective video streaming management and optimization.

2. Network Architecture[8]:
Single-Hop WLAN: Video streaming within a single WLAN, where devices communicate directly with an access point.

Multi-Hop WLAN: Video streaming across multiple WLANs or wireless mesh networks, where data may traverse multiple hops before reaching its destination.

Network Architecture is an important dimension within the Video Streaming in WLANs Taxonomy (ViSWAT). It defines the structure and organization of the network over which video content is streamed. In this dimension, we distinguish between two primary network architectures:

Single-Hop WLAN:
Description: Single-Hop WLAN refers to the network architecture where video streaming occurs within a single Wireless Local Area Network. In this setup, devices, such as smartphones, laptops, or smart TVs, communicate directly with a single access point or wireless router to access video content. The video data is

transmitted from the content source (e.g., a media server or streaming platform) to the access point, and then it is distributed directly to the connected devices.

Characteristics:
Simplicity: Single-Hop WLANs are straightforward and easy to set up, making them suitable for home networks, small businesses, and small-scale deployments.

Limited Range: The range of a single access point is limited, and devices need to be in close proximity to the access point for optimal signal strength and video streaming performance.

Lower Complexity: Since the data primarily flows between devices and a single access point, the network has lower complexity compared to multi-hop networks.

Network Considerations: Single-Hop WLANs are well-suited for scenarios where the coverage area is relatively small and devices are in close proximity to the access point. They require reliable signal strength for uninterrupted video streaming.

Multi-Hop WLAN:
Description: Multi-Hop WLAN, also known as a wireless mesh network, is an architecture where video streaming occurs across multiple WLANs or network nodes. Data, including video content, can traverse multiple hops before reaching its final destination. This architecture is often used in larger-scale deployments, such as public Wi-Fi networks, outdoor venues, and smart city applications.

Characteristics:
Extended Coverage: Multi-Hop WLANs can cover larger areas by allowing data to hop from one access point or node to another, extending the network's reach.

Redundancy: Multi-hop networks often provide redundancy, so if one path becomes congested or fails, data can be rerouted through alternative paths, enhancing network reliability.

Scalability: Multi-hop networks can be scaled to accommodate a higher number of devices and users, making them suitable for crowded environments.

Network Considerations: Multi-Hop WLANs are more complex to design and manage than single-hop networks due to the need for coordination between multiple access points or nodes. However, they offer advantages in terms of coverage, redundancy, and scalability, which can be essential for ensuring consistent video streaming performance in challenging environments.

The choice between single-hop and multi-hop WLAN architectures depends on the specific requirements of the video streaming application. Single-hop WLANs are often sufficient for small-scale, home, or small business networks, while multi-hop WLANs are preferred for larger coverage areas, outdoor venues, and scenarios where scalability and redundancy are essential for maintaining video streaming quality and reliability.

3. Quality of Service (QoS) [9], [10]:
Best-Effort Streaming: No specific QoS guarantees, where video quality may vary depending on network conditions.

QoS-Guaranteed Streaming: Prioritizes video traffic to ensure consistent and high-quality streaming, often through Quality of Service mechanisms.

Quality of Service (QoS) is a critical dimension within the Video Streaming in WLANs Taxonomy (ViSWAT) that addresses how video streaming traffic is managed and prioritized within wireless networks. It aims to ensure a certain level of service quality for video content delivery. In this dimension, we differentiate between two primary approaches:

Best-Effort Streaming:
Description: Best-Effort Streaming refers to a video streaming scenario where there are no specific Quality of Service guarantees. In this approach, video content is delivered over the network without any dedicated

prioritization or resource allocation. The video quality may vary depending on network conditions, such as congestion, interference, or fluctuations in available bandwidth.

Characteristics:
Non-Prioritized: Video traffic is treated the same as other data on the network, and there is no special treatment or preference given to video streaming traffic.

Variable Quality: Video quality can fluctuate based on the current state of the network, leading to potential buffering, pixelation, or reduced resolution during adverse network conditions.

Simple Network Management: Best-Effort Streaming is often easier to implement, as it does not require complex Quality of Service mechanisms.

Network Considerations: Best-Effort Streaming is suitable for scenarios where network resources are not constrained, and fluctuations in video quality are acceptable. However, it may result in a less predictable and potentially suboptimal video streaming experience in network-congested situations.

QoS-Guaranteed Streaming:
Description: QoS-Guaranteed Streaming, on the other hand, prioritizes video traffic to ensure consistent and high-quality streaming. This approach employs Quality of Service mechanisms to allocate network resources specifically for video content, guaranteeing a certain level of service quality.

Characteristics:
Prioritization: Video traffic is given higher priority over other data types to ensure minimal interruption and consistent quality, even during network congestion.

Resource Reservation: Network resources, including bandwidth and low-latency pathways, may be reserved exclusively for video streaming traffic.

Enhanced User Experience: QoS-guaranteed streaming results in a more predictable and reliable video streaming experience, with reduced buffering and improved video quality.

Network Considerations: QoS-Guaranteed Streaming is essential for scenarios where maintaining high-quality video is critical, such as video conferencing, telemedicine, or live sports broadcasting. Quality of Service mechanisms, like traffic prioritization and resource allocation, are employed to ensure a reliable and uninterrupted video streaming experience.

The choice between best-effort and QoS-guaranteed streaming depends on the specific requirements of the video streaming application and the available network resources. While best-effort streaming may suffice for non-critical or non-demanding video content, QoS-guaranteed streaming is crucial for applications where maintaining a consistent and high-quality video experience is paramount. It involves the implementation of network mechanisms that prioritize and reserve resources for video traffic to guarantee a superior streaming quality.

4. Device and Application[11]:
Smartphone/Tablet Streaming: Video streaming on mobile devices through dedicated apps or web browsers.

Smart TV/Streaming Device: Streaming video on smart TVs or devices like Roku, Apple TV, or Amazon Fire TV.

Desktop/Laptop Streaming: Viewing video content on computers using web browsers or dedicated applications.

Device and Application is a fundamental dimension in the Video Streaming in WLANs Taxonomy (ViSWAT) that focuses on the specific types of devices and the associated applications used for streaming video content. This dimension encompasses a variety of devices and platforms, each with unique characteristics. The primary categories under this dimension are:

Smartphone/Tablet Streaming:

Description: Smartphone and Tablet Streaming involves the consumption of video content on mobile devices such as smartphones and tablets. Users access video streams through dedicated mobile apps or web browsers, allowing them to watch videos on the go, anytime and anywhere.

Characteristics:

Mobility: Mobile devices provide the flexibility to watch video content while on the move, making them ideal for commuters and travelers.

Touchscreen Interaction: Touchscreens enable intuitive user interaction, including swiping, tapping, and pinch-to-zoom gestures.

App Ecosystem: Smartphones and tablets have access to a vast ecosystem of video streaming apps, offering a wide range of content.

Network Considerations: Streaming on mobile devices requires consideration of factors like cellular data usage, network coverage, and the need for adaptive streaming to accommodate varying network conditions.

Smart TV/Streaming Device:

Description: Smart TV and Streaming Device streaming involve viewing video content on television screens using smart TVs or dedicated streaming devices like Roku, Apple TV, Amazon Fire TV, and Google Chromecast. These devices offer access to various streaming platforms and apps.

Characteristics:

Large Screen Experience: Smart TVs and streaming devices provide a cinematic and immersive viewing experience on larger screens.

Remote Control: Dedicated remote controls or smartphone apps are often used to navigate and interact with content.

App Integration: These devices offer seamless integration with popular streaming platforms, making it easy to access a wide array of content.

Network Considerations: Smart TVs and streaming devices rely on Wi-Fi or wired connections to access video content, so network stability and sufficient bandwidth are essential for uninterrupted streaming.

Desktop/Laptop Streaming:

Description: Desktop and Laptop Streaming involves watching video content on personal computers or laptops using web browsers or dedicated desktop applications. This is a common choice for work-related video conferencing, online education, and general content consumption.

Characteristics:

Productivity and Multitasking: Desktop and laptop devices enable users to multitask, combining work or other activities with video streaming.

Larger Display: While not as large as TV screens, computer monitors offer a more spacious viewing area compared to mobile devices.

Keyboard and Mouse Interaction: Users interact with video content using a keyboard and mouse, providing precision and control.

Network Considerations: Desktop and laptop devices typically rely on wired or Wi-Fi connections. Network stability is important to ensure smooth streaming, particularly for high-resolution content.

The choice of device and application for video streaming depends on user preferences, the context of usage, and the desired viewing experience. Smartphone and tablet streaming offers mobility, while smart TVs and streaming devices provide a home theater experience. Desktop and laptop streaming caters to productivity and multitasking scenarios. Each category presents unique characteristics and network considerations that need to be taken into account for an optimal video streaming experience.

5. Video Resolution[12]:

Standard Definition (SD): Lower-resolution video suitable for smaller screens or low-bandwidth connections.

High Definition (HD): Higher-resolution video with improved image quality for larger screens.

Ultra High Definition (UHD/4K): The highest video quality with very high resolution for large screens.

Video Resolution is a key dimension in the Video Streaming in WLANs Taxonomy (ViSWAT) that describes the quality and clarity of the video content being streamed. Video resolution is typically expressed in terms of pixel dimensions, where a higher resolution indicates a greater number of pixels, resulting in a sharper and more detailed image. This dimension encompasses different video resolution categories:

Standard Definition (SD):

Description: Standard Definition (SD) video offers a relatively lower resolution compared to higher-definition formats. It is characterized by its pixel dimensions, typically at or below 720x480 pixels. SD video is well-suited for smaller screens and devices, and it's often used in scenarios where bandwidth is limited or when the content's visual fidelity is not the primary focus.

Characteristics:

Lower Bandwidth Requirements: SD video consumes less data, making it suitable for low-bandwidth connections, which can be important for stable streaming over WLANs with limited throughput.

Compatibility: SD video is compatible with a wide range of devices, including older smartphones, tablets, and legacy television sets.

Smaller File Sizes: The smaller file sizes associated with SD video make it quicker to load and easier to store and transmit.

Network Considerations: SD video is suitable for scenarios with restricted bandwidth, such as rural areas or older WLAN networks. It provides an efficient compromise between quality and data consumption.

High Definition (HD):

Description: High Definition (HD) video offers improved image quality and clarity compared to SD. Common HD resolutions include 1280x720 pixels (720p) or 1920x1080 pixels (1080p). HD video is designed for larger screens and provides a more immersive viewing experience, especially on modern HDTVs and computer monitors.

Characteristics:

Enhanced Image Quality: HD video delivers sharper and more detailed images, making it ideal for content where visual fidelity is crucial.

Widescreen Aspect Ratio: HD video typically uses a 16:9 aspect ratio, providing a cinematic widescreen experience.

Increased Bandwidth Requirements: HD video requires more bandwidth compared to SD, so a stable and higher-speed WLAN connection is important for uninterrupted streaming.

Network Considerations: HD video streaming demands a more robust WLAN connection to maintain video quality. It is commonly used for entertainment content like movies, TV shows, and high-quality streaming services.

Ultra High Definition (UHD/4K):

Description: Ultra High Definition (UHD), often referred to as 4K, represents the highest video quality with very high resolution. It typically has a resolution of 3840x2160 pixels. UHD offers unparalleled clarity, detail, and color accuracy, making it suitable for large screens and premium viewing experiences.

Characteristics:
Exceptional Clarity: UHD/4K provides an exceptional level of image clarity and detail, allowing viewers to see even the finest nuances in the content.

Large Screen Compatibility: UHD is designed for large-screen displays, such as 4K TVs and home theater setups.

Substantial Bandwidth Demands: Streaming UHD content requires a substantial amount of bandwidth to ensure consistent video quality, making it suitable for high-speed WLAN connections.

Network Considerations: UHD/4K streaming necessitates a high-speed WLAN with significant bandwidth capacity to handle the data-intensive content. It is commonly used for premium video services, high-quality content, and large-screen displays.

The choice of video resolution depends on several factors, including the viewer's device, screen size, available bandwidth, and the nature of the content being streamed. SD is suitable for small screens and lower bandwidth, while HD and UHD/4K provide superior quality for larger screens and a more immersive viewing experience, requiring a more robust WLAN connection to maintain video quality.

6. Content Source[13]:
Online Streaming Platforms: Content from online services like Netflix, YouTube, Hulu, and Amazon Prime.

Local Streaming: Video files stored on a local server or device, such as media servers or network-attached storage (NAS) devices.

Content Source is a dimension within the Video Streaming in WLANs Taxonomy (ViSWAT) that focuses on the origin or location of the video content that is being streamed. It distinguishes between two primary categories:

Online Streaming Platforms:
Description: Online Streaming Platforms are services that deliver video content over the internet. These platforms offer a wide range of content, including movies, TV shows, user-generated videos, and live broadcasts. Popular examples of online streaming platforms include Netflix, YouTube, Hulu, Amazon Prime Video, Disney+, and many others.

Characteristics:
Extensive Content Libraries: Online streaming platforms provide vast libraries of video content, covering various genres and interests.

On-Demand Access: Users can select and stream content at their convenience, pausing, rewinding, and resuming playback as needed.

Streaming Apps: Many platforms offer dedicated applications for smartphones, tablets, smart TVs, and other devices, making it easy for users to access content.

Network Considerations: Streaming from online platforms requires a stable and reasonably fast WLAN connection to ensure smooth playback. Factors like bandwidth, latency, and network reliability impact the viewing experience.

Local Streaming:
Description: Local Streaming involves video files stored on a local server or device within a WLAN. These local sources may include media servers, network-attached storage (NAS) devices, or even the storage of video content on personal computers or dedicated local servers.

Characteristics:
User Control: Local streaming gives users control over their content libraries and allows them to organize and manage their video collections.

Reduced Dependence on the Internet: Local streaming is not reliant on external internet services, making it suitable for scenarios with limited or unreliable internet access.

Direct Access: Content is accessed directly from the local storage device, reducing reliance on external servers or third-party platforms.

Network Considerations: Local streaming typically places less demand on internet bandwidth since the content is served locally within the WLAN. It can be a good choice for conserving internet resources or for private content collections.

The choice between online streaming platforms and local streaming depends on various factors, including user preferences, the nature of the content, and the network environment:

Online streaming platforms offer convenience and access to a vast library of content, making them suitable for those who prefer a wide variety of content and on-demand access.

Local streaming provides more control over content and is advantageous in scenarios with limited internet access or when users want to maintain private video collections. It reduces the need for external internet resources, making it a good choice for conserving bandwidth.

The network considerations for each option differ, with online streaming platforms relying on internet resources and local streaming drawing from locally stored content. Users and organizations choose between these sources based on their specific requirements and the available network infrastructure.

7. Security[14], [15]:

Secure Streaming: Utilizing encryption and authentication to protect video content and user data during transmission.

Unsecured Streaming: Streaming without encryption or security measures, typically not suitable for sensitive content.

Security is an essential dimension within the Video Streaming in WLANs Taxonomy (ViSWAT) that pertains to the measures taken to protect video content and user data during transmission. This dimension is crucial, especially when dealing with sensitive or confidential content. It encompasses two primary categories:

Secure Streaming:

Description: Secure Streaming involves the use of encryption and authentication mechanisms to safeguard video content and user data as it is transmitted over a network. Encryption ensures that the data is scrambled and can only be decrypted by authorized parties, while authentication verifies the identity of the parties involved in the communication.

Characteristics:

Data Encryption: Video content and related data are encrypted to prevent unauthorized access or interception during transmission.

Authentication: Secure streaming may require user authentication to ensure that only authorized users can access and view the content.

Privacy and Confidentiality: This approach is crucial for protecting sensitive or confidential content, such as corporate video conferences, medical teleconsultations, or secure video communication.

Network Considerations: Secure streaming typically requires additional processing overhead for encryption and decryption, which may impact network latency and bandwidth usage. However, the benefits in terms of data security and privacy are paramount in many scenarios.

Unsecured Streaming:

Description: Unsecured Streaming involves the transmission of video content without the use of encryption or robust security measures. In unsecured streaming, video data is sent in plain text, making it susceptible to eavesdropping, interception, and unauthorized access.

Characteristics:
No Encryption: Video data is transmitted without encryption, which can expose it to potential breaches or data leaks.

Accessibility: Unsecured streaming is often used for public content that does not require protection or for scenarios where security is not a primary concern.

Lower Processing Overhead: Unsecured streaming is generally more resource-efficient in terms of processing, as it does not require encryption and complex authentication processes.

Network Considerations: Unsecured streaming may be suitable for public content or scenarios where privacy and security concerns are minimal. However, it poses a risk of data interception and unauthorized access.

The choice between secure streaming and unsecured streaming is heavily dependent on the sensitivity of the content and the security requirements of the specific use case:

Secure Streaming: This is vital for scenarios involving confidential, proprietary, or sensitive content, such as telemedicine consultations, legal depositions, corporate meetings, and government communications. The encryption and authentication mechanisms employed provide a high level of data security, but they may introduce some network overhead.

Unsecured Streaming: This is more suitable for public content, live broadcasts, or scenarios where data privacy is not a primary concern. It is often used for streaming content that is intended for open consumption and doesn't require protection against unauthorized access.

The choice of security measures should align with the content's sensitivity and the need to protect user data and privacy, considering that secure streaming provides enhanced data protection and confidentiality but may require more network resources.

8. Wireless Standards[16]:
802.11a/b/g/n/ac/ax: The specific IEEE 802.11 standard used for WLAN connectivity, which affects the available bandwidth and range.

Wireless Standards refer to the specific IEEE (Institute of Electrical and Electronics Engineers) 802.11 standards used for Wireless Local Area Network (WLAN) connectivity. These standards define the specifications for wireless communication, including the modulation techniques, frequency bands, data rates, and features. Different standards offer varying levels of performance in terms of available bandwidth and range. In the context of the Video Streaming in WLANs Taxonomy (ViSWAT), the primary focus is on the following wireless standards:

802.11a:
Description: IEEE 802.11a was one of the early WLAN standards. It operates in the 5 GHz frequency band and supports data rates of up to 54 Mbps. However, it has a shorter range compared to some later standards.

Characteristics:
Higher Frequency: Operating in the 5 GHz band, 802.11a is less susceptible to interference from common household devices operating in the 2.4 GHz band.

Limited Range: The higher frequency results in shorter signal range, making 802.11a suitable for smaller WLAN environments.

802.11b:
Description: IEEE 802.11b was one of the first widely adopted WLAN standards. It operates in the 2.4 GHz band and offers data rates of up to 11 Mbps.

Characteristics:
2.4 GHz Band: The use of the 2.4 GHz band allows for better signal range and wall penetration but may face more interference from other devices.

Slower Data Rates: 802.11b has relatively slower data rates, making it suitable for basic internet browsing and light streaming.

802.11g:
Description: IEEE 802.11g is an improvement over 802.11b, offering data rates of up to 54 Mbps in the 2.4 GHz band.

Characteristics:
Backward Compatibility: 802.11g is backward compatible with 802.11b, allowing for a smooth transition from older standards.

Improved Data Rates: It provides higher data rates compared to 802.11b, making it more suitable for video streaming and data-intensive applications.

802.11n:
Description: IEEE 802.11n, also known as Wi-Fi 4, offers significant advancements over earlier standards. It operates in both the 2.4 GHz and 5 GHz bands, supporting data rates of up to 600 Mbps or more through the use of multiple antennas and MIMO (Multiple Input, Multiple Output) technology.

Characteristics:
Enhanced Data Rates: 802.11n delivers substantially higher data rates, making it ideal for HD video streaming and more demanding applications.

Dual-Band Support: It operates in both the 2.4 GHz and 5 GHz bands, providing greater flexibility and reduced interference.

802.11ac:
Description: IEEE 802.11ac, or Wi-Fi 5, is a high-performance standard that operates exclusively in the 5 GHz band. It offers data rates of up to several gigabits per second, making it suitable for 4K video streaming, online gaming, and other bandwidth-intensive activities.

Characteristics:
Gigabit Data Rates: 802.11ac provides gigabit-level data rates, making it well-suited for high-definition and ultra-high-definition video streaming.

Beamforming: Beamforming technology helps direct signals to specific devices, improving signal strength and reducing interference.

802.11ax:
Description: IEEE 802.11ax, also known as Wi-Fi 6, is the latest standard as of my last knowledge update in January 2022. It operates in both 2.4 GHz and 5 GHz bands and is designed to provide even higher data rates, improved network efficiency, and better performance in crowded environments.

Characteristics:
Increased Capacity: 802.11ax supports more simultaneous connections and enhances network efficiency through technologies like Orthogonal Frequency Division Multiple Access (OFDMA).

Improved Range and Performance: It offers better performance and range, making it suitable for demanding applications, including 4K and 8K video streaming.

The choice of the 802.11 standard depends on the specific requirements of the WLAN environment and the demands of video streaming. For example:

802.11n and beyond are ideal for high-definition and ultra-high-definition video streaming, especially in larger and more demanding network scenarios.

802.11g is suitable for basic video streaming and general internet usage.

802.11a is appropriate for smaller WLAN environments where high data rates are not a priority.

Selecting the right standard is critical to ensuring a stable and high-quality video streaming experience over a WLAN. Advancements in Wi-Fi standards, such as 802.11ac and 802.11ax, have significantly improved network performance, making them well-suited for the demands of modern video streaming applications.

9. Multicast vs. Unicast:

Multicast Streaming: Broadcasting video to multiple devices simultaneously to reduce network load.

Unicast Streaming: Sending individual video streams to each viewer, which can be more bandwidth-intensive.

Multicast Streaming and Unicast Streaming are two different approaches to delivering video content over a network, each with its own advantages and use cases. Let's explore these two methods in detail:

Multicast Streaming:

Description: Multicast streaming involves sending a single video stream to multiple recipients simultaneously. Instead of creating separate streams for each viewer, the video source sends one copy of the content, and network infrastructure replicates and distributes it to multiple receiving devices that have expressed interest in the content. Multicast streaming is an efficient way to deliver content to a large audience, as it reduces the overall network load and conserves bandwidth.

Characteristics:

Bandwidth Efficiency: Multicast optimizes bandwidth usage because it doesn't create a unique stream for each viewer. Instead, it replicates the data as needed.

Scalability: Multicast is well-suited for scenarios where a single video stream needs to reach a large number of viewers, such as live broadcasts, webinars, or IPTV (Internet Protocol Television).

Low Latency: It can offer lower latency than unicast streaming because the content source only needs to transmit a single stream.

Network Considerations: Multicast requires network infrastructure support, including multicast-capable routers and switches, making it more suitable for managed or enterprise networks rather than consumer-grade or residential networks.

Unicast Streaming:

Description: Unicast streaming involves sending individual video streams to each viewer. In this approach, the content source creates a unique stream for each recipient. This method is used in most on-demand video streaming services and some live streaming scenarios. Unicast is more bandwidth-intensive than multicast but offers greater control over individual viewing experiences.

Characteristics:

Personalization: Unicast allows for personalized experiences, enabling viewers to start, pause, rewind, and customize their video streams.

Wider Applicability: It is widely used for on-demand video streaming platforms (e.g., YouTube, Netflix) and for live streaming that requires interactive features (e.g., gaming streams, video conferencing).

Higher Bandwidth Usage: Unicast consumes more bandwidth as each viewer receives a dedicated video stream.

Network Considerations: Unicast streaming is suitable for a broad range of network environments, from home networks to enterprise setups. It is more accessible and doesn't rely on specialized network infrastructure.

The choice between multicast and unicast streaming depends on the specific requirements of the video streaming scenario:

Multicast Streaming is ideal for efficiently distributing live content to a large audience, especially in situations where bandwidth conservation and low latency are crucial. It is commonly used for live events and broadcasting.

Unicast Streaming is versatile and provides personalized experiences. It's suitable for on-demand content and interactive live streaming, where viewers may have different preferences and control requirements. It's the typical approach for online video platforms.

In practice, a combination of both methods may be used to balance the advantages of bandwidth efficiency and personalization in complex network environments.

10. Buffering and Adaptive Streaming:

Buffering: The use of buffers to preload and store video data for smoother playback, especially in cases of network fluctuations.

Adaptive Streaming: Adjusting video quality dynamically based on network conditions to provide the best viewing experience.

Buffering and Adaptive Streaming are two critical techniques used in the world of online video streaming to ensure a smooth and uninterrupted viewing experience, particularly when dealing with variable network conditions. Let's dive into the details of each:

Buffering:

Description: Buffering refers to the process of preloading and storing video data before it's displayed to the viewer. This technique is used to ensure continuous playback even in scenarios where the network may experience fluctuations in data delivery speed. During buffering, a portion of the video is temporarily downloaded and stored in a buffer, which acts as a reservoir. The video player then plays the content from this buffer, which allows for a smoother and uninterrupted viewing experience.

Characteristics:

Latency: Buffering introduces a slight delay between initiating playback and actual viewing, as it involves downloading a portion of the video before starting playback.

Buffer Size: The size of the buffer can vary, and a larger buffer can compensate for more significant network disruptions.

Stability: Buffering helps maintain video playback stability by providing a continuous stream of video data, even if the network's speed fluctuates.

Network Considerations: Buffering is particularly helpful in situations with unreliable or fluctuating network conditions. It helps mitigate the effects of buffering pauses or stuttering, providing a smoother viewing experience. However, excessive buffering can lead to longer initial load times.

Adaptive Streaming:

Description: Adaptive Streaming is a dynamic video streaming technique that adjusts the quality of the video being played based on real-time network conditions. It involves encoding the same content at multiple quality levels (e.g., different resolutions and bitrates) and continuously monitoring the viewer's network speed and device capabilities. The video player then selects the appropriate quality level in real-time to provide the best possible viewing experience.

Characteristics:

Quality Adjustment: Adaptive streaming ensures that viewers receive the highest video quality their network connection and device can handle at any given moment.

Seamless Transition: It allows for seamless quality transitions during playback. If network conditions improve, the quality can be increased without interrupting playback.

Optimized Viewing: Adaptive streaming optimizes the viewing experience by preventing buffering pauses and maintaining consistent playback.

Network Considerations: Adaptive streaming is highly beneficial in today's diverse network environments, where viewers use various devices and network speeds. It helps deliver a consistent and high-quality experience by adapting to the viewer's specific situation.

In practice, buffering and adaptive streaming often work together to ensure a high-quality and uninterrupted video streaming experience:

Buffering: The initial buffering helps preload enough video data to start playback smoothly while providing a buffer for network fluctuations. It's particularly useful when starting a video stream or when network conditions are poor.

Adaptive Streaming: Once playback has begun, adaptive streaming continuously monitors network conditions and device capabilities. It ensures that the viewer receives the best possible quality without buffering pauses or stutters throughout the video.

Together, these techniques help overcome network challenges and provide viewers with a consistent and high-quality video streaming experience, even in situations where network conditions are less than ideal.

11. Latency[17], [18], [19]:

Low-Latency Streaming: Reducing the delay between video capture and playback, important for live streaming and video conferencing.

High-Latency Streaming: Tolerating higher delays, which may be acceptable for on-demand content.

Latency, in the context of streaming media and online communications, refers to the delay or lag between the moment data is captured or transmitted and the moment it is received and experienced by the end user. Low-latency and high-latency streaming have significant implications for various applications, including live streaming, video conferencing, and on-demand content delivery. Let's explore these two concepts in detail:

Low-Latency Streaming:

Low-latency streaming focuses on minimizing the delay between the time content is captured and the time it is presented to the viewer or participant. This is especially critical for real-time applications, such as live streaming and video conferencing, where immediate interaction and engagement are essential.

Key components and considerations for low-latency streaming:

a. Encoding and Compression: To reduce latency, it's important to use efficient video and audio encoding techniques. These codecs should balance between maintaining good quality and minimizing the time it takes to encode and decode content.
b. Delivery Protocol: Low-latency streaming typically requires the use of specific streaming protocols designed to reduce delays. For example, WebRTC (Web Real-Time Communication) is commonly used for interactive applications like video conferencing.
c. Network Optimization: A stable and fast internet connection is crucial to minimize latency. Reducing packet loss and optimizing routing can significantly improve the overall streaming experience.
d. Edge Computing: Distributing processing and storage closer to the end-users, often via edge computing infrastructure, can further reduce latency by minimizing the distance data needs to travel.
e. Real-Time Feedback: In low-latency streaming, real-time feedback mechanisms allow for immediate adjustments based on user interactions. For example, in live streaming, chat messages or audience polls can be integrated, and the presenter can respond in real time.
f. Adaptive Bitrate Streaming: While minimizing latency, it's also important to ensure a smooth viewing experience by adjusting video quality based on the viewer's network conditions, device capabilities, and screen size.

High-Latency Streaming:

High-latency streaming, in contrast, tolerates longer delays between content capture and playback. This approach is often used for on-demand content delivery, such as streaming movies and pre-recorded videos, where real-time interaction isn't a primary concern.

Key components and considerations for high-latency streaming:

a. Video Quality and Compression: In high-latency scenarios, there's more flexibility to prioritize video quality. More time can be allocated to encoding and compressing the content to deliver higher resolution and fidelity.

b. Content Delivery Network (CDN): Content can be efficiently distributed to a global audience through CDNs, which replicate content on multiple servers worldwide, reducing the latency experienced by viewers.
c. Content Preparation: Content can be preprocessed, segmented, and optimized before distribution to reduce the time required for on-the-fly processing during playback.
d. Buffering: High-latency streaming can afford larger buffering periods, allowing for smoother playback even with slower or less stable internet connections.
e. Offline Viewing: Some high-latency streaming platforms offer the ability to download content for offline viewing, allowing users to watch content without any streaming delays.

In summary, low-latency streaming prioritizes minimizing delays to provide real-time interaction and engagement, making it suitable for applications like live streaming and video conferencing. In contrast, high-latency streaming tolerates longer delays and focuses on maximizing video quality and stability, which is ideal for on-demand content. The choice between low and high-latency streaming depends on the specific use case and user expectations for a particular application or service.

12. Content Delivery and Caching[20], [21], [22]:

Content delivery and caching are crucial concepts in the world of online content distribution, particularly for video streaming and other media services. These approaches play a vital role in optimizing the delivery of content to end-users, ensuring faster access, lower latency, and a better overall user experience. Let's delve into these concepts in detail:

Direct from Source:

Fetching video content directly from the content provider's server is a straightforward approach where the user's device or application contacts the original server where the content is hosted. This method has both advantages and limitations:

Advantages:

Freshness of Content: Content is always up-to-date since it's directly pulled from the source, ensuring the latest version is delivered.

Real-time Updates: Changes or updates to the content are reflected immediately.

Limitations:

Latency: Direct access can introduce higher latency, especially if the user's location is far from the content server. It can result in slower loading times and reduced user experience for users located at a distance.

Scalability Challenges: If the content provider experiences high traffic, their servers may become overwhelmed, leading to slower loading times or even outages during peak periods.

Cache-assisted Streaming:

Cache-assisted streaming leverages the use of content delivery networks (CDNs) or local caching servers to reduce latency and improve content availability. CDNs are a network of geographically distributed servers that store cached copies of content, reducing the need to retrieve content from the original source server. Here's how this approach works:

Advantages:

Lower Latency: CDNs place content closer to the end-users, reducing the time it takes for content to reach the viewer. This results in faster loading times and smoother streaming experiences.

Scalability: CDNs are built to handle high traffic loads, distributing the load across multiple servers to ensure content remains accessible during traffic spikes.

Load Balancing: CDNs can distribute requests to the nearest server with available capacity, ensuring efficient and balanced content delivery.

Limitations:

Caching Period: Cached content may not always be the most up-to-date version, as there might be a delay in updating cached copies with the latest changes.

Cost: Using a CDN or caching servers involves additional infrastructure and operational costs, which may be a concern for some content providers.

Cache-assisted streaming can use different caching mechanisms, such as content caching, edge caching, and proxy caching. These methods can be adapted to suit various types of content and user interactions.

In summary, direct content delivery from the source ensures content freshness but may introduce latency and scalability challenges. Cache-assisted streaming, facilitated by CDNs and caching servers, reduces latency, improves scalability, and offers a smoother user experience by distributing content closer to end-users. The choice between these methods depends on factors like the type of content, the user's location, and the importance of low-latency delivery. Content providers often use a combination of these approaches to balance content freshness and efficient delivery.

Direct from Source: Fetching video content directly from the content provider's server.

Cache-assisted Streaming: Utilizing content delivery networks (CDNs) or local caching servers to reduce latency and improve content availability.

13. User Interaction[23], [24], [25]:

Passive Streaming: Viewers simply watch the content without interaction.

Interactive Streaming: Content with interactive elements, such as live chat, polls, or user-generated content.

User interaction plays a significant role in shaping the viewer's experience when consuming digital content, particularly in the context of online streaming. There are two primary modes of user interaction: passive streaming and interactive streaming. Let's explore each of these in detail:

Passive Streaming:

Passive streaming is the traditional mode of content consumption where viewers simply watch or consume content without any active participation or interaction with the content itself or with other viewers. In this mode, the viewers are essentially "passive" observers, and the content is delivered in a linear, one-way fashion from the content provider to the viewer. Key characteristics of passive streaming include:

Linear Viewing: Viewers follow a predetermined path set by the content provider, and they have limited control over the content's progression. For example, when watching a movie or a pre-recorded video, viewers have no influence on the storyline or events.

No Real-Time Interaction: Passive streaming does not involve real-time interaction with the content or with other viewers. There is typically no live chat, polling, or user-generated content that viewers can contribute to while watching.

Examples: Traditional TV broadcasts, on-demand video platforms like Netflix (for content that doesn't incorporate interactive features), and live streaming without any interactive elements are examples of passive streaming.

Passive streaming is ideal for scenarios where the primary goal is to provide a straightforward viewing experience, and viewer engagement or interactivity is not a primary concern.

Interactive Streaming:

Interactive streaming, on the other hand, introduces various interactive elements and opportunities for viewers to actively engage with the content, content creators, and other viewers. This mode enhances the viewer's role from being a passive observer to an active participant. Key characteristics of interactive streaming include:

Real-Time Interaction: Interactive streaming allows viewers to engage in real-time conversations through live chat, participate in polls, ask questions, or even influence the direction of the content. For example, in a live gaming stream, viewers can chat with the streamer, request specific gameplay, or make in-game decisions.

User-Generated Content: Some interactive streaming platforms enable viewers to submit their own content, such as comments, reactions, or even contribute directly to the stream's content. This can foster a sense of community and collaboration among viewers.

Viewer Influence: In certain cases, the actions or decisions of the viewers can impact the content itself. For instance, in a live interactive story or game show, viewer votes or choices might determine the outcome.

Examples: Live gaming streams on platforms like Twitch, interactive live shows or Q&A sessions on YouTube, and webinars with real-time audience engagement features are examples of interactive streaming.

Interactive streaming is well-suited for content creators and platforms that aim to foster a sense of community, engage viewers actively, and provide unique, personalized experiences. It is particularly popular for live events, gaming, educational content, and interactive storytelling.

In summary, passive streaming involves one-way content consumption with limited viewer interaction, while interactive streaming introduces real-time interaction, user-generated content, and opportunities for viewers to actively participate and shape the content experience. The choice between these modes depends on the content type, audience engagement goals, and the platform's capabilities and features.

This taxonomy provides a structured way to categorize and analyze the various dimensions of video streaming within WLANs. Different applications and use cases may prioritize different aspects of this taxonomy to ensure an optimal video streaming experience.

IV. TAXONOMY ELEMENTS AND RELATIONSHIPS

ViSWAT appears to be a classification framework or a way to organize and categorize various elements related to video streaming within WLANs. Each of the components listed in the ViSWAT framework plays a role in understanding and analyzing different aspects of video streaming in wireless networks. Here's how the elements are related within the ViSWAT framework:

Type of Content: This element classifies video content into live streaming and on-demand streaming. The choice of content type affects many aspects of the streaming experience, including latency, security, and network architecture.

Network Architecture: ViSWAT distinguishes between single-hop WLAN and multi-hop WLAN. The network architecture chosen can have a significant impact on the quality of service (QoS) and the delivery of video content, especially in scenarios involving multi-hop communication.

Quality of Service (QoS): QoS is categorized into best-effort streaming and QoS-guaranteed streaming. The QoS level selected influences the viewer's experience and the network requirements for smooth video streaming.

Device and Application: Different types of devices and applications are used for video streaming, including smartphones/tablets, smart TVs/streaming devices, and desktop/laptop computers. The choice of device and application can impact the user experience and the resolution of the video being streamed.

Video Resolution: The video resolution refers to the quality of the video being streamed, categorized into standard definition (SD), high definition (HD), and ultra-high definition (UHD/4K). The video resolution affects the viewing experience and network bandwidth requirements.

Content Source: This element classifies content sources as online streaming platforms or local streaming. The source of content can impact the security, content delivery, and the way viewers interact with the content.

Security: Security is categorized as secure streaming or unsecured streaming. The choice of security measures can affect the protection of video content and user data during transmission.

Wireless Standards: The specific IEEE 802.11 wireless standards used (such as 802.11a, 802.11n, etc.) influence the available bandwidth and range in WLANs, which can impact the quality of video streaming.

Multicast vs. Unicast: This element distinguishes between multicast and unicast streaming. The choice between these two approaches can affect network load and scalability.

Buffering and Adaptive Streaming: The use of buffering and adaptive streaming techniques impacts the smoothness of playback and the ability to handle network fluctuations. It's closely related to the QoS and video resolution.

Latency: ViSWAT classifies latency into low-latency streaming and high-latency streaming. The level of latency chosen has a direct impact on the viewer's experience, with low-latency being critical for live streaming and video conferencing.

Content Delivery and Caching: The choice of content delivery method, whether direct from the source or cache-assisted streaming, influences content availability, network efficiency, and latency.

User Interaction: ViSWAT classifies user interaction into passive streaming and interactive streaming. The level of user interaction impacts viewer engagement, the use of real-time features like chat and polls, and the design of the user interface.

By categorizing and considering these elements, ViSWAT provides a structured approach for analyzing and optimizing video streaming within WLANs. The relationships among these elements are crucial for understanding the various factors that contribute to the overall quality of the video streaming experience. Depending on the specific use case and objectives, different elements within ViSWAT may be prioritized or tailored to achieve the desired outcome.

V. USES FOR CVST

ViSWAT can be valuable in a variety of use cases related to analyzing and optimizing video streaming within wireless local area networks (WLANs). Here are several use cases for ViSWAT:

Quality Assurance and Testing:
Scenario: A video streaming service provider wants to ensure the quality of their content delivery to end-users.

Use of ViSWAT: ViSWAT can be employed to analyze and visualize the video streaming process, assessing aspects like video resolution, latency, and buffering. This helps in identifying any issues that may affect the quality of service and allows for the optimization of the streaming infrastructure.

Network Optimization:
Scenario: An organization has a WLAN in place and wants to improve the performance of video streaming across the network.

Use of ViSWAT: ViSWAT can analyze the network architecture (single-hop or multi-hop), wireless standards in use, and QoS settings to identify bottlenecks or areas for improvement. This information can be used to optimize the network for better video streaming.

Security Assessment:
Scenario: A content provider needs to ensure the security of their video content during transmission.

Use of ViSWAT: ViSWAT can help assess the security measures in place for video streaming, differentiating between secure and unsecured streaming. It can identify vulnerabilities and suggest improvements to protect video content and user data.

Device and Application Compatibility:
Scenario: A streaming service wants to ensure that their content is accessible across various devices and applications.

Use of ViSWAT: ViSWAT can analyze the compatibility of the content with different devices and applications, helping to optimize the delivery of video content to smartphones, tablets, smart TVs, desktops, and more.

User Experience Enhancement:
Scenario: A streaming platform seeks to enhance the user experience for their viewers.

Use of ViSWAT: ViSWAT can help in assessing user interaction and feedback. Interactive streaming elements, such as polls and live chat, can be analyzed to understand viewer engagement and preferences, allowing for user experience improvements.

Content Delivery Strategy:
Scenario: A content provider wants to optimize their content delivery approach, whether direct from the source or cache-assisted.

Use of ViSWAT: ViSWAT can help evaluate the advantages and disadvantages of content delivery methods. For example, it can determine when cache-assisted streaming through CDNs is more suitable and when direct streaming is preferred.

Latency Reduction:
Scenario: A live streaming service requires low-latency streaming for real-time interaction, such as live sports or gaming events.

Use of ViSWAT: ViSWAT can be used to fine-tune the streaming process to reduce latency, ensuring a seamless, real-time experience for viewers, which is crucial for live events.

Adaptive Streaming Optimization:
Scenario: A video streaming platform wants to optimize adaptive streaming for a better user experience.

Use of ViSWAT: ViSWAT can assess adaptive streaming techniques to dynamically adjust video quality based on network conditions. It helps ensure that viewers experience the best possible video quality without buffering issues.

Content Source Management:
Scenario: A media company delivers content from both online platforms and local servers.

Use of ViSWAT: ViSWAT can help manage content from different sources by assessing the benefits and trade-offs of each approach. It can help optimize content delivery strategies for each source.

In these use cases, ViSWAT serves as a valuable tool to analyze and optimize various aspects of video streaming within WLANs, allowing organizations to enhance the quality, security, and user experience of their video content delivery services. The specific use case for ViSWAT will depend on the goals and challenges of the organization or service provider.

VI. DISCUSSION

ViSWAT is a comprehensive framework designed to categorize and analyze the various dimensions and elements related to video streaming within wireless local area networks (WLANs). It serves as a valuable tool for understanding, optimizing, and enhancing the quality of video streaming experiences. Here is a final discussion of ViSWAT:

Structured Analysis: ViSWAT provides a structured and organized approach for dissecting the complex ecosystem of video streaming. By breaking down the various elements, it allows for a systematic examination of the factors that influence the quality of video content delivery.

Customization: One of the strengths of ViSWAT is its flexibility. Users can adapt the framework to prioritize specific elements and aspects that align with their objectives. This makes it a versatile tool that can be tailored to different use cases.

Problem Identification and Resolution: ViSWAT helps identify issues and challenges within the video streaming process. Whether it's related to latency, security, network architecture, or user interaction, ViSWAT offers insights that can lead to practical solutions for optimizing video streaming.

Quality Assurance: For video streaming service providers and content creators, ViSWAT aids in quality assurance. By using ViSWAT to assess the quality of service (QoS), video resolution, and other metrics, providers can ensure that viewers enjoy a reliable and high-quality streaming experience.

User Experience Enhancement: ViSWAT's categorization of user interaction and content delivery methods enables service providers to focus on user experience. The ability to analyze and optimize interactive elements and content delivery strategies contributes to viewer satisfaction and engagement.

Security Assessment: With the distinction between secure and unsecured streaming, ViSWAT helps ensure that video content is delivered in a secure manner, protecting both the content and user data. This is particularly important in today's digital landscape.

Network Optimization: ViSWAT can be a valuable resource for network administrators and IT professionals. It aids in network optimization by providing insights into network architecture and the impact of different wireless standards on video streaming performance.

Adaptive Streaming: Adaptive streaming optimization, a critical factor for delivering a smooth viewing experience, benefits from ViSWAT's analysis of buffering and adaptive streaming techniques. It allows for dynamic adjustments based on network conditions.

Content Delivery Strategy: ViSWAT's distinction between direct and cache-assisted content delivery methods assists content providers in making informed decisions about the most efficient way to deliver their content.

Continuous Improvement: ViSWAT can be used in an iterative manner. By continually monitoring and assessing the video streaming process using the framework, organizations can implement improvements and enhance the overall quality of their services.

In summary, ViSWAT is a valuable tool for anyone involved in the planning, development, or management of video streaming services within WLANs. It offers a structured and holistic approach to analyzing and optimizing various aspects of video streaming, ensuring better quality, security, and user experience. As the landscape of video streaming continues to evolve, ViSWAT can be a key resource for staying competitive and delivering high-quality content to viewers.

VII. CONCLUSION

In conclusion, the Video Streaming in WLANs Taxonomy (ViSWAT) is a comprehensive framework designed to systematically categorize and analyze the diverse facets of video streaming within wireless local area networks (WLANs). ViSWAT provides a structured taxonomy encompassing elements such as content type, network architecture, quality of service, device and application, video resolution, content source, security, wireless standards, multicast vs. unicast, buffering and adaptive streaming, latency, and content delivery and caching. These elements are interconnected and pivotal for understanding, optimizing, and enhancing the quality, security, and user experience of video streaming services within WLANs.

ViSWAT is adaptable and serves a wide array of use cases, ranging from quality assurance and network optimization to security assessment and user experience enhancement. It empowers organizations and service providers to pinpoint and resolve issues, refine their video streaming procedures, and continuously enhance their services. With its flexibility and customizable nature, ViSWAT can be tailored to specific objectives and challenges, making it an invaluable tool for stakeholders in the video streaming ecosystem, including content providers, network administrators, and quality assurance teams.

In an era where video streaming plays an increasingly significant role in the digital landscape, ViSWAT offers valuable insights and methodologies to ensure that viewers receive dependable, high-quality, and secure video streaming experiences. By leveraging ViSWAT, organizations can stay competitive, adapt to evolving technologies, and meet the mounting expectations of users for exceptional video content delivery.

REFERENCES

[1] Khan K, Goodridge W. Future DASH applications: *A survey. International Journal of Advanced Networking and Applications.* 2018 Sep 1;10(2):3758-64.

[2] Khan, K. and Goodridge, W., *Markov Decision Processes for bitrate harmony in adaptive video streaming.* In 2017 Future Technologies Conference (FTC), Vancouver, Canada, unpublished.

[3] Koffka, K. and Wayne, G., 2018. *A DASH Survey: the ON-OFF Traffic Problem and Contemporary Solutions.* Computer Sciences and Telecommunications, (1), pp.3-20.

[4] Khan K, Goodridge W. *QoE evaluation of dynamic adaptive streaming over HTTP (DASH) with promising transport layer protocols: Transport layer protocol performance over HTTP/2 DASH.* CCF Transactions on Networking. 2020 Dec;3(3-4):245-60.

[5] Park YD, Jeon S, Jeong JP, Suh YJ. FlexVi: PHY aided flexible multicast for video streaming over IEEE 802.11 WLANs. IEEE Transactions on Mobile Computing. 2019 Jun 20;19(10):2299-315.

[6] Pasandi HB, Nadeem T, Amirpour H, Timmerer C. A cross-layer approach for supporting real-time multi-user video streaming over WLANs. In Proceedings of the 27th Annual International Conference on Mobile Computing and Networking 2021 Oct 25 (pp. 849-851).

[7] Yang W, Wu F, Tian K. High performance adaptive video streaming using NDN WLAN multicast. In Proceedings of the 8th ACM Conference on Information-Centric Networking 2021 Sep 22 (pp. 42-51).

[8] Wu F, Yang W, Ren J, Lyu F, Ding X, Zhang Y. Adaptive video streaming using dynamic NDN multicast in WLAN. In IEEE INFOCOM 2020-IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS) 2020 Jul 6 (pp. 97-102). IEEE.

[9] Nosheen S, Khan JY. Quality of service-and fairness-aware resource allocation techniques for ieee802. 11ac WLAN. IEEE Access. 2021 Jan 18;9:25579-93.

[10] Nosheen S, Khan JY. An adaptive QoS based video packet transmission technique for IEEE802. 11ac WLAN. In2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring) 2019 Apr 28 (pp. 1-5). IEEE.

[11] Park YD, Jeon S, Jeong JP, Suh YJ. FlexVi: PHY aided flexible multicast for video streaming over IEEE 802.11 WLANs. IEEE Transactions on Mobile Computing. 2019 Jun 20;19(10):2299-315.

[12] Wu F, Yang W, Ren J, Lyu F, Ding X, Zhang Y. Adaptive video streaming using dynamic NDN multicast in WLAN. InIEEE INFOCOM 2020-IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS) 2020 Jul 6 (pp. 97-102). IEEE.

[13] Patidar T, Pasca ST, Tamma BR. OASIS: A Framework for Enhanced Live Video Streaming over Integrated LTE Wi-Fi Networks. In2019 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS) 2019 Dec 16 (pp. 1-6). IEEE.

[14] Khan K, Goodridge W. A survey of network-based security attacks. International Journal of Advanced Networking and Applications. 2019 Mar 1;10(5):3981-9.

[15] Memon SK, Nishar K, Hanafi Ahmad Hijazi M, Chowdhry BS, Sodhro AH, Pirbhulal S, Rodrigues JJ. A survey on 802.11 MAC protocols industrial standards, architecture elements for providing QoS guarantee, supporting emergency traffic, and security: Future directions. Journal of Industrial Information Integration. 2021;24(Dec 2021).

[16] Yamada R, Tomeba H, Nakamura O, Sato T, Hamaguchi Y. Multi-AP Coordinated Radio Resource Allocation using Requirements for Video Transmission in Wireless LAN system. In2023 IEEE 97th Vehicular Technology Conference (VTC2023-Spring) 2023 Jun 20 (pp. 1-5). IEEE.

[17] Kondo Y, Yomo H, Yokoyama H. Demonstration of Multi-Diversity WLAN Supporting Low-latency and Seamless Video Streaming. In2022 IEEE 19th Annual Consumer Communications & Networking Conference (CCNC) 2022 Jan 8 (pp. 937-938). IEEE.

[18] Xing Y, Xue K, Zhang Y, Han J, Li J, Liu J, Li R. A low-latency MPTCP scheduler for live video streaming in mobile networks. IEEE Transactions on Wireless Communications. 2021 May 25;20(11):7230-42.

[19] Pasandi HB, Nadeem T, Amirpour H, Timmerer C. A cross-layer approach for supporting real-time multi-user video streaming over WLANs. In Proceedings of the 27th Annual International Conference on Mobile Computing and Networking 2021 Oct 25 (pp. 849-851).

[20] Jedari B, Premsankar G, Illahi G, Di Francesco M, Mehrabi A, Ylä-Jääski A. Video caching, analytics, and delivery at the wireless edge: A survey and future directions. IEEE Communications Surveys & Tutorials. 2020 Nov 9;23(1):431-71.

[21] Zhang D, Zhou P, Han B, Pathak P. M5: Facilitating Multi-User Volumetric Content Delivery with Multi-Lobe Multicast over MmWave. In Proceedings of the 20th ACM Conference on Embedded Networked Sensor Systems 2022 Nov 6 (pp. 31-46).

[22] Wu H, Chen J, Xu W, Cheng N, Shi W, Wang L, Shen X. Delay-minimized edge caching in heterogeneous vehicular networks: A matching-based approach. IEEE Transactions on Wireless Communications. 2020 Jun 25;19(10):6409-24.

[23] Omar B, Dequan W. Watch, share or create: The influence of personality traits and user motivation on TikTok mobile video usage.

[24] Lu B, Chen Z. Live streaming commerce and consumers' purchase intention: An uncertainty reduction perspective. Information & Management. 2021 Nov 1;58(7):103509.

[25] Sun Y, Shao X, Li X, Guo Y, Nie K. How live streaming influences purchase intentions in social commerce: An IT affordance perspective. Electronic commerce research and applications. 2019 Sep 1;37:100886.

