// WhitePaper

Optimizing Guest Wi-Fi in the Video-First Era

As of January 2022, there were 4.95 billion Internet users globally, of whom 92.1% access the Internet via smartphones[1]. The "typical" global Internet user now spends almost seven hours per day on the Internet across all devices, spending more than 40 percent of their waking life online – a figure that is forecast to grow[2].

The average data traffic generated by a smartphone user has grown 50% during the pandemic and is projected to grow by a factor of four between 2022 and 2027 (25% per annum). The monthly global average data usage per smartphone reached 11.4GB in 2021 and is forecast to reach 47GB by the end of 2027 in Europe and North America.

A smartphone-savvy consumer base and video rich applications, in combination with expected very high 5G penetration, will drive traffic growth. Video traffic currently accounts for 69 percent of all smartphone data usage and is projected to hit 79 percent in 2027[3].

How can service providers keep their Guest Wi-Fi networks sustainable, while data usage doubles every three years and there never seems to be enough bandwidth?

[1] Kepios, Digital 2021 Global Overview Report, forecast
[2] GWI, Global Audiences Report, Q3 2021
[3] Ericsson Mobility Report, Nov 2021

Video-First Era

As regions reopen their economies, morning and evening commuting will resume as consumers return to their pre-pandemic lifestyles. Relationships are now being built and nurtured online, **predominantly through video**. It is, therefore, no surprise that video streaming continues to dominate the Internet. TikTok, YouTube, Facebook Watch, and Netflix reign supreme with tremendous growth in the past year. Their easy to watch, ever-changing content continues to capture the imagination. A Netflix report showed that 27 percent of viewers **binge watch while commuting** or waiting for other services, and 12% have even used Netflix in public restrooms.

Social sharing has been slowly evolving from a static to a dynamic medium. Dynamic content such as reels, video snaps, and stories help people feel connected. Facebook continues to be the main way that mature audiences keep connected. Instagram appeals to millennials, and Twitter and Reddit are all the rage for Gen Z. The increased reliance on social sharing to build and maintain relationships by sharing rich media and video content has made **high quality and reliable connections critical** to the success of wireless networks.

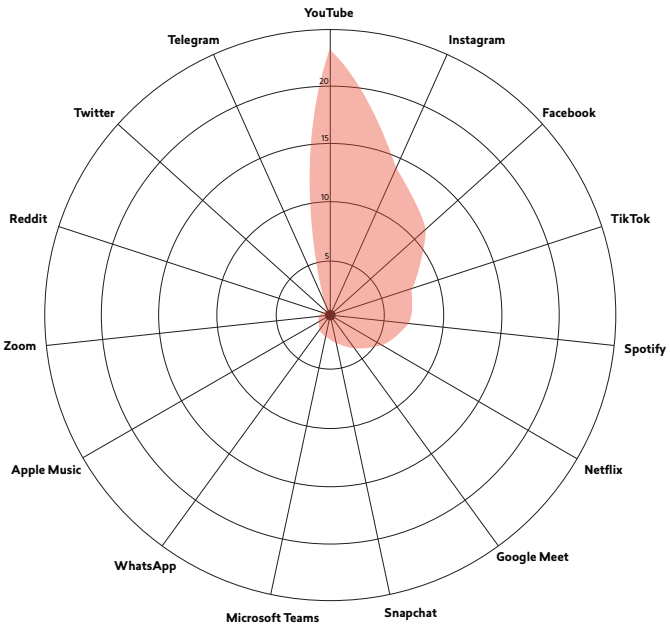
Performance of messaging applications has become another critical part of the wireless experience. WhatsApp continues to be the leading mobile messaging platform with **2 billion monthly active users**. Facebook Messenger, Snapchat, and Telegram come next in popularity as consumers switch between messaging platforms to stay connected with the world. Memes, voice and video messages, and reactions enrich the content we share via messaging.

Even as parts of the world begin to tentatively reopen in-person spaces, many people will continue working and learning remotely on a more permanent basis, often **working while commuting** and even combining leisure trips with work breaks. Learning and business applications Zoom, Teams, and Meet require a consistent upstream and downstream network connection. An analysis reveals that collective monthly active users of these three mobile apps in the first half of 2021 were more than 2.5 times higher than in the first half of 2020[4].

With new features like spatial music and lossless audio, streaming audio sounds great. Leading music streaming services Spotify, Apple Music, and YouTube music require **increasing amounts of bandwidth**. And they all serve video content nowadays.

Streaming activity in the Video-First Era aligns with the natural movements of consumers throughout the day with peaks before work, mid-day, and especially **during the late afternoon commute**.

The fifteen platforms and services mentioned above are collectively responsible for **80% of the total smartphone data traffic** volume and bandwidth consumption in mobile and Guest Wi-Fi networks[5].



/// Data traffic volume share among the fifteen leading smartphone applications in mobile and Guest Wi-Fi networks, 2021

[4] SensorTower, Store Intelligence, July 2021
[5] Sandvine, The Mobile Internet Phenomena Report, May 2021 and RebelRoam, Dec 2021

Application	Monthly active users	Share of total data traffic volume[5]	Average time spent in the app[6]
YouTube and YouTube Music	2562 M[7]	23 %	23.7 h / month
Instagram	1478 M[7]	14 %	11.2 h / month
Facebook, Messenger, and Watch	2910 M[8]	11 %	19.6 h / month
TikTok	1000 M[8]	7.3 %	19.6 h / month
Spotify	381 M[9]	6.8 %	25.0 h / month
Netflix	222 M[5]	5.0 %	12.8 h / month[10]
Google Meet	100 M[11]	3.4 %	15.0 h / month[12]
Snapchat	557 M[7]	2.3 %	3.0 h / month
Microsoft Teams	80 M[13]	1.8 %	15.0 h / month[12]
WhatsApp	2000 M[8]	1.3 %	18.6 h / month
Apple Music	98 M[14]	1.0 %	25.0 h / month
Zoom	300 M[15]	0.9 %	15.0 h / month[12]
Reddit	430 M[7]	0.4 %	4.0 h / month
Twitter	436 M[7]	0.4 %	5.1 h / month
Telegram	550 M[8]	0.4 %	3.0 h / month

Table 1: Monthly active users (global), data traffic volume share, and average time spent on the fifteen leading smartphone applications in the mobile and Guest Wi-Fi networks, 2021

[6] App Annie, State of Mobile 2022
[7] Platform self-service advertising resources
[8] Company announcements of MAU
[9] Statista, 2022
[10] RebelRoam assumption, 20% of viewing occurs in the mobile and Guest Wi-Fi networks
[11] Alphabet, 2020 Q1 Earnings Call
[12] RebelRoam assumption, on average 40min per workday
[13] Microsoft, Investor Call, Apr 29th, 2020
[14] Business of Apps, Apple Music Revenue and Usage Statistics, Jan 2022
[15] Business Insider, daily meeting participants, Apr 2020

State of Guest Wi-Fi

By all accounts, today's Guest Wi-Fi networks are not moving data as well as they could. Most of the world's Guest Wi-Fi users experience **slower than desired** web services and video stream load times whether they are in airports, conference venues, sporting venues, or onboard planes, ships, trains, or buses. Guest Wi-Fi performance suffers from the compounding of multiple factors including:

1. Service quality degradation resulting from the interference and signal propagation issues that are native to wireless networks (Wi-Fi, mobile, satellite), especially in the case of mobile Guest Wi-Fi networks.

2. The organic 25% annual increase in the average Guest Wi-Fi user's per minute data traffic consumption, fueled by the growing share of video content, contributes to congestion where/when there is insufficient Internet or Wi-Fi network bandwidth.

3. The common Guest Wi-Fi operator practice of limiting the per-user Wi-Fi connection speed in an effort to contain bandwidth costs and reduce overall network congestion by discouraging the usage of bandwidth heavy (i.e. video streaming) applications. Unfortunately, this practice actively exacerbates the poor user experience by increasing web page load times (time-to-content or TTC) and video content load time (time-to-play or TTP).

4. In edge cases, Guest Wi-Fi operators actively block some video streaming content (i.e., YouTube, Netflix, etc.), which users find offensive given the popularity of the Net Neutrality movement.

Technical challenges

Video streaming accounts for the majority of global Internet traffic and content delivery has naturally been an area of intense focus for providers. **Compression techniques and adaptive mechanisms** are highly effective at lowering the time-to-play and at adapting playback resolution to changing network conditions.

Google states that YouTube videos can be streamed in low definition at a sustained speed of 500+ Kbps[16]. However, a good playback quality requires **at least 1 Mbps**.

Video resolution	Bandwidth requirement	Data traffic volume
LD 240p (poor)	0.5 Mbps	3.75 MB/min
SD 360p (fair)	0.7 Mbps	5.25 MB/min
SD 480p (good)	1.1 Mbps	8.25 MB/min
HD 720p (excellent)	2.5 Mbps	18.75 MB/min
HD 1080p (excellent)	4.0 Mbps	30.00 MB/min

Table 2: Bandwidth requirements and data traffic volume of YouTube at different video resolutions

[16] YouTube system requirements https://support.google.com/youtube/answer/78358

Technical challenges - continued

Viewing a five-minute video requires the Guest Wi-Fi to provide between 1 Mbps to 4 Mbps of bandwidth and to carry 26 MB to 150 MB of data. It is apparent that limiting the per-user Wi-Fi connection speed to 1 Mbps yields a potential saving of 3 Mbps of bandwidth and 124 MB of traffic in the case of a 5min video. But while streaming this way, at a moderate video quality and without video stalling, web services still **place high demands** on network performance as they require instant speed.

Web pages consist of many objects that are fetched to form a complete page. Moreover, web services are usually interactive with content leading to **more user requests** – each with its own time-to-content delay. This is unlike video streaming behavior, which is characterized by a request followed by a length of video played out. Interactivity on non-video sites and time-to-content for video services demand instant bandwidth.

The 2022 Ericsson Mobility Report includes results from a study run in the Ericsson Smartphone Lab in which fifty popular websites were accessed using the Google Chrome web browser on a recently launched flagship mobile device. Google's "Largest Contentful Paint" (LCP) metric was used to determine how fast the main content of a page was rendered on the device display.

The results indicate a strong relationship between available **downlink throughput and the TTC**. It is worthwhile to understand that the average download size of the fifty most popular websites is just 2 MB and this does not change at different download speeds.

Allocated bandwidth	time-to-content (TTC)	User experience grade
1 Mbps	12 sec	very poor
2 Mbps	8 sec	poor
3 Mbps	6 sec	poor
5 Mbps	4 sec	fair
7 Mbps	3 sec	fair
10 Mbps	2.5 sec	good
20 Mbps	1.5 sec	excellent

Table 2: The 75th percentile time-to-content metric at different bandwidth speeds

//// Considering the results reported in Table 2 and Table 3, it becomes apparent that throttling streaming services is desirable on a well optimized Guest Wi-Fi network while throttling other web services is not.

Streaming CDN

To simplify the optimization of Guest Wi-Fi networks for the contrasting characteristics of streaming and non-streaming websites, RebelRoam developed Streaming CDN – a cloud-based software-as-a-service offering. Streaming CDN provides Guest Wi-Fi operators with bandwidth optimized video and audio streaming. All of the top fifteen streaming centric applications listed in Table 1, as well as many others, are supported.

Streaming CDN delivers video at 240-480p resolution and audio in low quality mode. For the smartphone users in the Guest WiFi network, it provides sufficient video and audio quality without buffering.

Why use it

Whether in a huge stadium or on an intercity bus, optimizing the Guest Wi-Fi network should be done for multiple reasons. Key among them are:

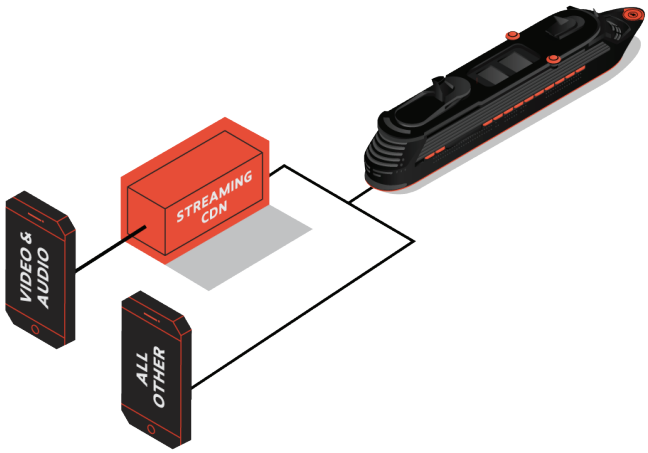
//// Optimization reduces bandwidth requirements by downscaling video and audio streaming bitrates

//// Optimization improves Wi-Fi user satisfaction with the service by improving web services time-to-content speed

In addition to improved user experiences, lower bandwidth consumption per user expands network capacity and extends the useful life of Wi-Fi hardware.

How it works

In simple terms, a client application issues a DNS query for a particular domain. This query is intercepted by the Streaming CDN nameserver and verified against its datasets. If it passes all controls, the DNS query is resolved and traffic for streaming applications (i.e., YouTube, Netflix, Instagram, Snapchat, Facebook, etc.) is delivered via the nearest Streaming CDN servers in the cloud.



Why RebelRoam

RebelRoam has been improving Guest Wi-Fi performance since 2015. Companies across Europe and North America trust RebelRoam to optimize the performance of their Wi-Fi networks aboard thousands of coaches, cruise ships, riverboats, ferries, and trains carrying millions of passengers monthly.

Free up bandwidth by up to 40%

Increase user satisfaction with the core service

Create a competitive advantage with the awesome Wi-Fi experience.

Proof of Concept Study

The following proof of concept study illustrates the ability of Streaming CDN Guest Wi-Fi Optimization to **reduce the overall data traffic** from a video streaming services. While YouTube was used for this illustration, comparable results have been shown for TikTok and video embedded in social media such as Facebook.

All four tests were run using iPhone 11 Pro with native iOS YouTube app. The YouTube video (https://www.youtube.com/watch?v=Fe-GrSOrg1o) was started from the beginning and stopped at 60 seconds. This was done to simulate the behavior of users who typically watch for 20-40 seconds before jumping to different content.

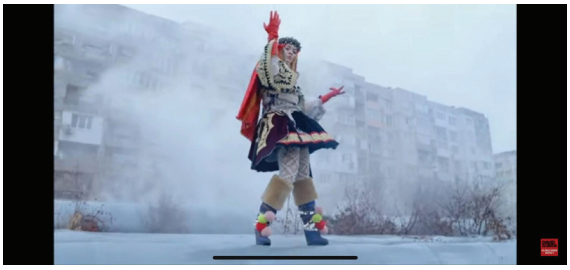
The following test settings were used:

Test 1 – All settings on auto, no Wi-Fi throttling
Test 2 – Download speed of the Wi-Fi client throttled at 1 Mbps, which is typical for public Wi-Fi networks
Test 3 – YouTube client set to Data Saver mode, no WI-Fi throttling
Test 4 – All settings on auto, RebelRocket Streaming CDN traffic optimization used in the WI-Fi network.

As the table shows, Streaming CDN kept **87% of the traffic** off the unoptimized network and achieved a **58% reduction** in data traffic compared to the typical Guest Wi-Fi network where user download speed is throttled to 1 Mbps.

Test	Shaping	Quality	Traffic in MB	Test 1	Test 2	Test 3	Test 4
#1	None	1080p	26.6		+230%	+303%	+686%
#2	Wi-Fi client throttled to 1 Mbps	480p	8.0	-70%		+21%	+135%
#3	YouTube client in Data Saver mode	360p	6.6	-75%	-18%		+94%
#4	**Streaming CDN**	240p	3.4	**-87%**	**-58%**	**-29%**	

1. Un-optimized,
Quality: auto (1080p)



3. YouTube client in Data Saver mode,
Quality: auto (360p)

2. Wi-Fi client throttled to 1 Mbps,
Quality: auto (480p)

4. Streaming CDN,
Quality: auto (240p)

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