Binge On Under the Microscope: Understanding T-Mobile’s Zero-Rating Implementation

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Northeastern University

University of Southern California
Evolution of Mobile Networks
Evolution of Mobile Networks

0G
Pre cellular

1G
Analog telecommunication 5.6KBps

2G
1990s. GSM, CDMA, GPRS, EDGE. 236Kbps

3G
2000s. 382Kbps-2Mbps

4G
Up to 100Mbps for mobile.

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YouTube
Netflix
Pokémon Go
Hulu
WhatsApp
Instagram

?!!
Mobile Data Growth

Mobile Data Growth

Traffic Management Techniques
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Rate limiting
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Rate limiting

Data caps

You’ve reached your data cap!
Traffic Management Techniques

Rate limiting

Transcoding

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Zero-rating
Binge On
Binge On

INTRODUCING BINGE ON™

Video now streams FREE without using your data, only from T-Mobile.

SHOP PLANS

Order now! Call 1-877-413-5903

Game of Thrones available on HBO NOW. 3rd party subscription charges may apply.

Now you can stream all you want for FREE without using your data.

With Binge On, Simple Choice users on a qualifying plan are FREE to stream unlimited video on your favorite services like YouTube, Netflix, HBO NOW, and many more without using a drop of your high-speed data. Nothing to configure – all automatically applied to your qualifying plan. Streamers, go ahead and Binge On.

See list of all streaming services ➤

Request a video streaming service to Binge On ➤
Binge On

• Data from a *selected* list of video providers is *zero-rated*
Binge On

- Data from a *selected* list of video providers is **zero-rated**

- *All* detectable video is **optimized** for mobile devices (promises **480p or better**)

---

**INTRODUCING BINGE ON**

Video now streams **FREE** without using your data, only from T-Mobile.

**SHOP PLANS**

Order now! Call 1-877-413-0993

Now you can stream all you want for **FREE** without using your data.

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Request a video streaming service to Binge On.
Binge On

- Data from a selected list of video providers is zero-rated
- All detectable video is optimized for mobile devices (promises 480p or better)
- Every user is opt-in by default
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- **All** detectable video is **optimized** for mobile devices (promises **480p or better**)
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- **No provider** has opt-out as of today
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Conduct a study of T-Mobile’s zero-rating *policy* and *implementation*
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i. How Binge On impacts performance?
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Methodology
(at 10,000 feet)

Record&Replay (IMC 2015)
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Record & Replay (IMC 2015)

Record:

- End user

Tunnel

VPN proxy
Methodology
(at 10,000 feet)

Record&Replay (IMC 2015)

Record:
end user → Tunnel → VPN proxy → Netflix

Replay:
end user ← Tunnel ← Replay server
Methodology
(at 10,000 feet)

Record & Replay (IMC 2015)

Record:
- End user
- Tunnel
- VPN proxy
- Classifier

Replay:
- End user
- VPN tunnel
- Replay server

Diagram showing the flow of data from the end user through a tunnel, captured by the classifier, and replayed through the same tunnel back to the end user, with a focus on the VPN proxy and the classifier.
Methodology
(at 10,000 feet)

Record&Replay (IMC 2015)

Record:
- end user
- Tunnel
- VPN proxy
- Netflix

Replay:
- end user
- Tunnel
- Replay server
- Analyzer
Binge On’s Performance Impact
Binge On’s Performance Impact

Binge On disabled

CDF

Throughput (Mbps)

Netflix

Exposed

VPN
Binge On’s Performance Impact

Throughput (Mbps)

Exposed
VPN

Exposed
VPN

Binge On disabled

Binge On Enabled
Binge On’s Performance Impact

- Binge On polices all video to avg. throughput of 1.5Mbps
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- Binge On polices *all* video to avg. throughput of **1.5Mbps**
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Binge On’s Performance Impact

- Binge On polices all video to avg. throughput of 1.5Mbps
- Only participating providers are zero-rated
- Rate limit is cumulative for all flows from a single SIM
- Binge On’s infrastructure does not “optimize” video
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QoE impact
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YouTube iFrame Player API

- A large variety of video qualities
- HTTPS (prevents in-network caching/transcoding)
- A rich API for gathering QoE metrics.
QoE impact

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Average over 10 runs

<table>
<thead>
<tr>
<th>Quality</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD1080</td>
<td></td>
</tr>
<tr>
<td>HD720</td>
<td></td>
</tr>
<tr>
<td>480p</td>
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QoE impact

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<table>
<thead>
<tr>
<th>Resolution</th>
<th>Time to start (seconds)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>enable</td>
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<tr>
<td>HD1080</td>
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</tr>
<tr>
<td>HD720</td>
<td>2.8</td>
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<table>
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<tr>
<th>Resolution</th>
<th>Time to start (sec)</th>
<th>%Video loaded</th>
</tr>
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<tbody>
<tr>
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<th>Quality</th>
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<th>#Rebuffers</th>
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<tr>
<td></td>
<td>enable/disable</td>
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<tr>
<td>HD1080</td>
<td>4.6/2.6</td>
<td>1/3</td>
<td>7.2/0.1</td>
</tr>
<tr>
<td>HD720</td>
<td>2.8/1.6</td>
<td>2/5</td>
<td>2.5/0</td>
</tr>
<tr>
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<td>1.8/1.3</td>
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Binge On’s classifier
Binge On’s classifier

Diagram showing the connection between an end user, a Record & Replay server, and the end user.
Binge On’s classifier

Record&Replay

end user

Replay server

Rate limited?
Binge On’s classifier

Record&Replay

end user

Replay server

Rate limited?

No

Classified as non-video
Binge On’s classifier

Zero rated?

Rate limited?

Yes

No

Classified as non-video
Binge On’s classifier

Record&Replay

end user

Replay server

Zero rated?

Rate limited?

Yes

No

No

No

Classified as non-BingeOn video

Classified as non-video
Binge On’s classifier

Record&Replay

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Classified as BingeOn video

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HBOGO, ShowTime, Hulu, Amazon Video, YouTube (HTTP)

Netflix

YouTube (HTTPS)
Binge On’s classifier

Detection criteria

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Free-riding Binge On
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Get /
Host: foo.com

Local proxy

Get /

http://foo.com
Free-riding Binge On
Free-riding Binge On

Get /
Host: foo.com

Local proxy

Get /
X-Host: foo.com
Host: hbogo.com
Free-riding Binge On

Diagram:

- A computer with a browser open to `http://foo.com`
- A local proxy
- T-Mobile's network
- GET request to `http://foo.com` with Host: `foo.com`
- GET request to `hbogo.com` with X-Host: `foo.com` and Host: `hbogo.com`
Free-riding Binge On

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Local proxy

T-Mobile’s network

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http://foo.com

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Free-riding Binge On
Free-riding Binge On

T-Mobile’s network

Get / Host: foo.com

Local proxy

External proxy

Get / X-Host: foo.com
Host: hbogo.com

Get / X-Host: foo.com
Host: hbogo.com

T-Mobile’s network

http://foo.com

Get /
Host: foo.com

X-Host: foo.com

Host: hbogo.com
Free-riding Binge On

Get / Host: foo.com

Local proxy

Get / X-Host: foo.com
Host: hbogo.com

foo servers

External proxy

T-Mobile’s network

Get / Host: foo.com

External proxy

Get / X-Host: foo.com
Host: hbogo.com
Summary

Provided a detailed look at zero-rating in a popular US carrier

Characterized Binge On’s impact on traffic:

• Rate limits all video traffic
• Charges for video from non-participating services
• No evidence of optimization
• Can have a negative impact on video QoE metrics.

Identified how T-Mobile classified traffic

Showed implementation admit vulnerabilities
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