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THE POSSIBILITIES...



2020 Fall
Technical Forum

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LESSONS LEARNED FROM COVID-19 PANDEMIC

Managing the Coronavirus BW Surge: How to cope with the Spikes & Long-term Growth

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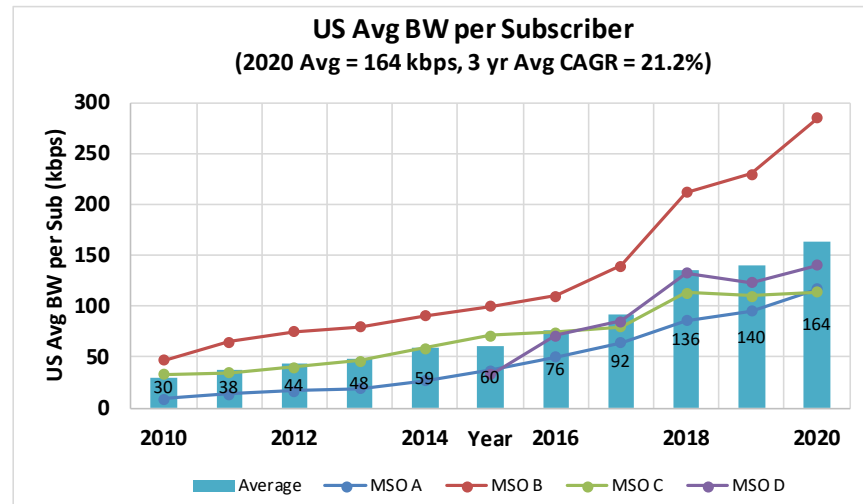
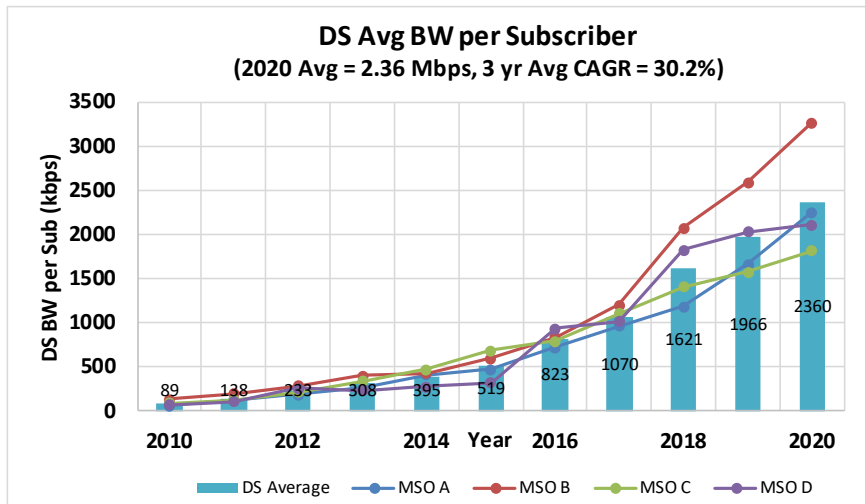
**“With all due respect, sir, I believe this will be our finest hour.”
From the movie: Apollo 13**

Broadband kept society & the economy running in these hard times...

- *ARGUABLY ITS MOST SIGNIFICANT CONTRIBUTION TO SOCIETY IN ITS SHORT LIFE-SPAN*
- To everyone who has created & made the Internet available to society.... *HATS OFF TO YOU!!!*

Be proud of the infrastructure we have created; **BUT...** **We have work to do** ...

- The COVID -19 BW Surge has **exposed cracks in the system** ...
- This should serve as **a wake -up call** ...
- We have improvements to make to the infrastructure...
- It's time to **start upgrading the network for the demands of the 2020s**



DS Tavg grows 20 % to 2.3 Mbps in 2020

- Fastest growing MSO (B) at 3.27 Mbps

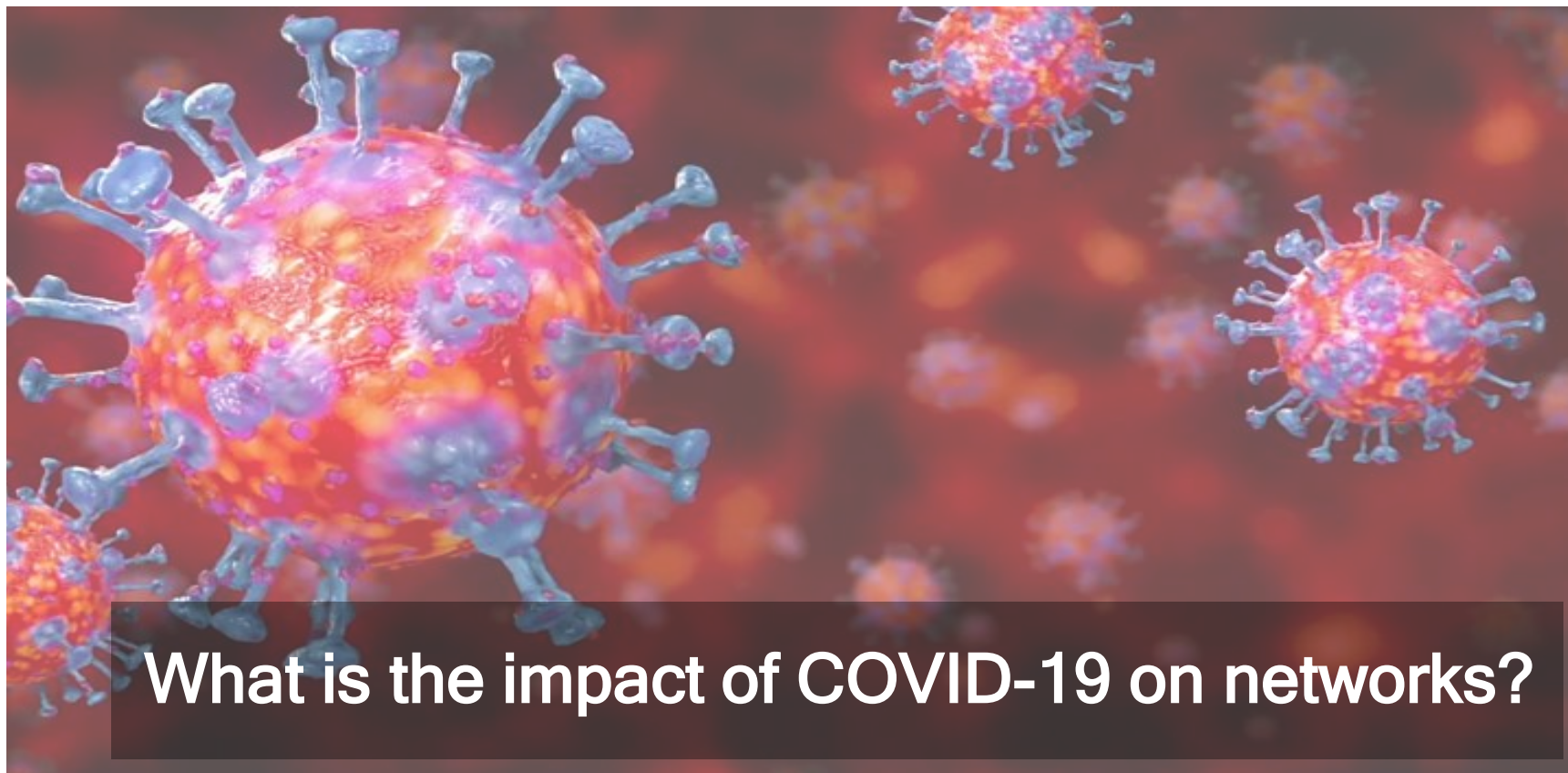
DS Tavg 3-yr CAGR **eases to ~30%**

- MSOs' 3-yr CAGRs range from ~18% to ~40%

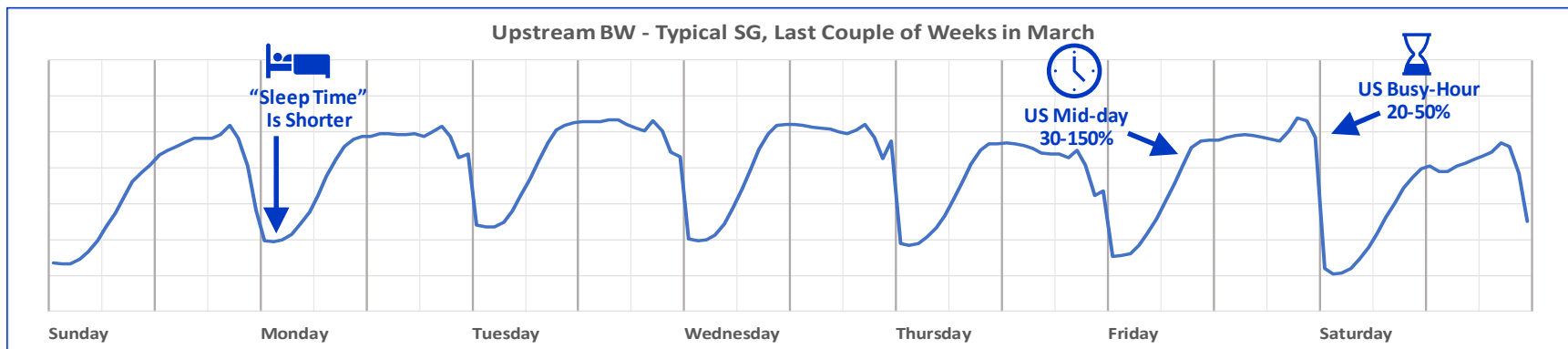
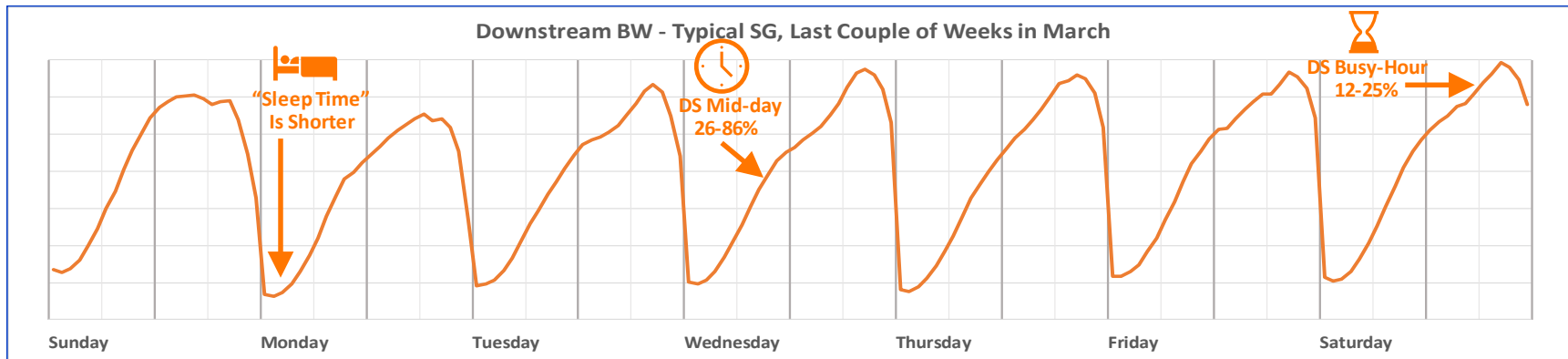
US Tavg bumps 16% to 164 Kbps in 2020

- Fastest growing MSO (B) hits ~285 Kbps,
 - Double the US Tavg of the other 3 MSOs
- 2020 DS growth close to 2020 US growth

US Tavg 3-yr CAGR **steady at ~21%**



The BW Surge Effect on Bandwidth (US & DS) Some 7-Day Examples



The Effect on Bandwidth – as seen by NCTA

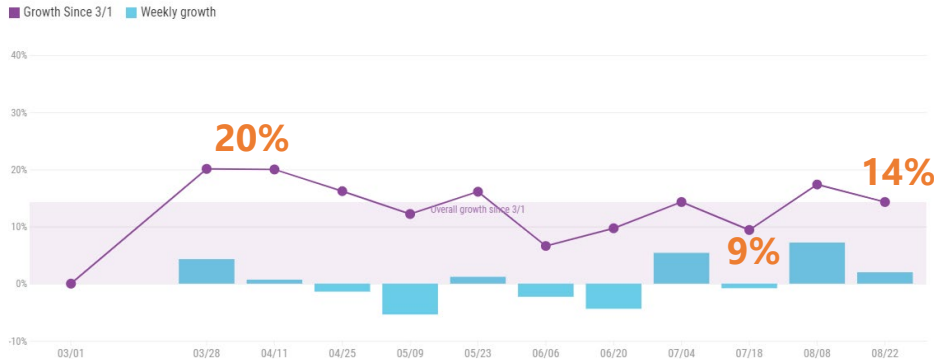
NCTA members: AlticeUSA, CableOne, Cox, Charter, Comcast, GCI, Mediacom, Midco, ...

- 94% of all USA subs represented
- Provider backbone networks have significant capacity

National Downstream Peak Growth

Observed Increase in Peak Consumer Usage

Overall Change in Pre-COVID Internet Usage Since Early March Compared to the Weekly Usage Change

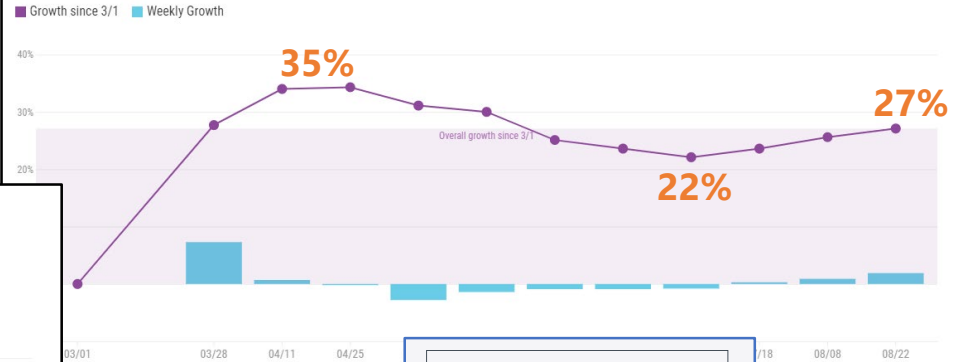


Source: Data from NCTA member companies • Data is updated on a bi-weekly basis

National Upstream Peak Growth

Observed Increase in Peak Consumer Usage

Overall Change in Pre-COVID Internet Usage Since Early March Compared to the Weekly Usage Change



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National

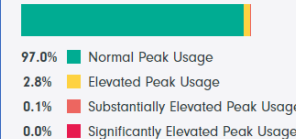
Downstream Growth (% of usage)

14.1% OVERALL SINCE 3/1 1.7% WEEKLY 5/9 - 5/16

Upstream Growth (% of usage)

31.5% OVERALL SINCE 3/1 0.3% WEEKLY 5/9 - 5/16

Network Performance (% of network)

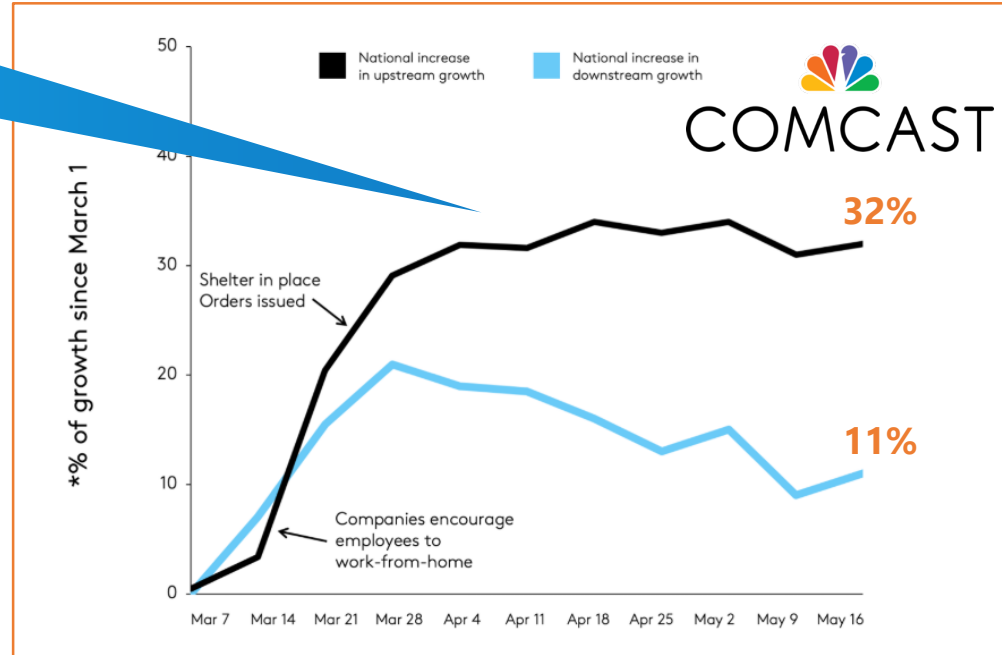


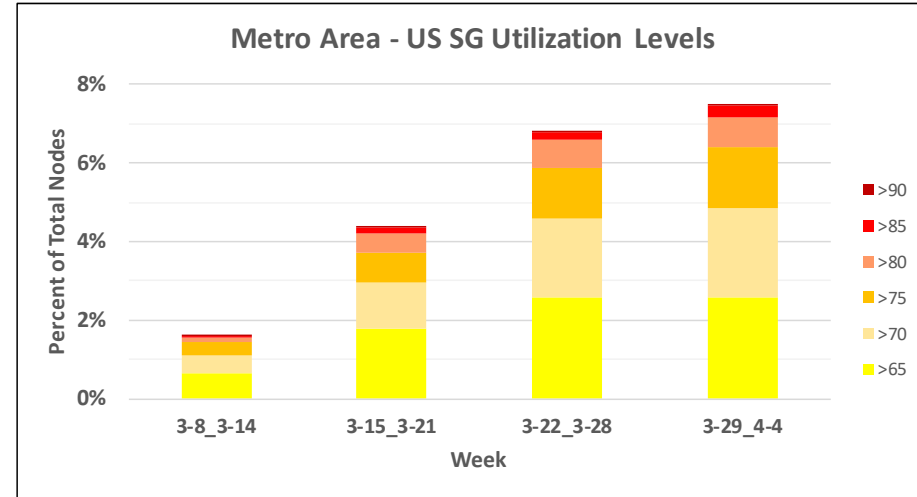
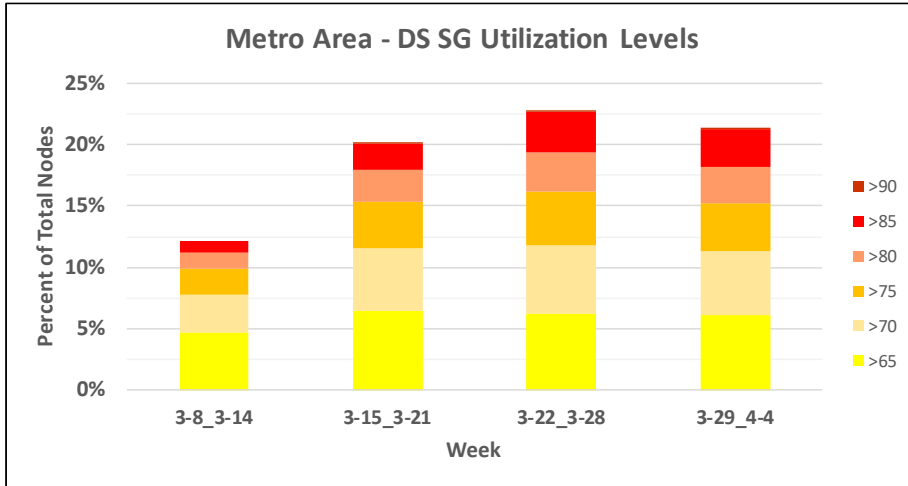
“We engineer the network to handle spikes and shifts in usage, and what we have seen so far with COVID-19 is within our capacity.”

TONY WERNER, President – Technology, Product, Xperience

Comcast Key Takeaways:

- VoIP & Video Conferencing is up 210 -285%
- Gaming downloads are up 20 -35% generally, up to 80 % during new releases
- Linear video consumption increased +2 hours per day per household
- Video OnDemand (VoD) hitting record highs, up 50 % YOY
- Xfinity Mobile sees a 36% increase in mobile data usage over Wi-Fi
 - But a 17% decline in LTE Data usage





- DS SG in the **Green** – dropped from ~90% to ~80%
- DS SG in the **Red** – tripled from 1% to 3%
 - Immediate attention required
- SG in the **Yellow** – almost doubled from 11% to 18%
 - Need attention in 6-12 months or less

- US SG in the **Green** – dropped from ~98% to ~91%
- US SG in the **Red** – quadrupled from ~0.25% to 1%
 - Immediate attention required
- US SG in the **Yellow** – quadrupled from 1.5% to 6%
 - Need attention in 6-12 months or less

The Cause of the Surge – the Usual Suspects



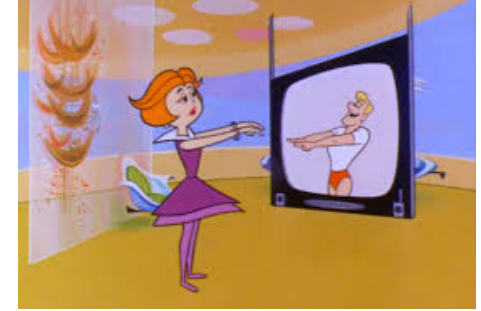
Work @ Home



Telemedicine



Video Conferencing,
Social Networking



Remote Learning



Gaming



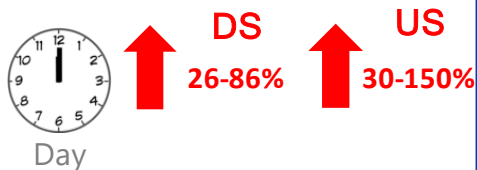
Video Streaming

We will focus more on **Upstream**, because the MSO Upstream is more Capacity-constrained... It becomes the **Achilles Heel of Cable...**

- 20-42 MHz US
 - ~87 Mbps w ATDMA
- 20-65 MHz US
 - ~175 Mbps w ATDMA

The Ugly

a Year's worth of traffic growth in 1-2 weeks!



High Usage: **8am to 2am**
Sleep time: **Only 4-6h**

The Bad

QoE ↓

Negative QoE effects:

- **Packet delays for gamers** from higher latencies & buffer-bloat
- **Video tiling in streaming & video conferencing** from packet delays & drops
- **File Download & Upload times increased** (a little bit)

Subscribers are **hitting their data caps** much more rapidly

- for MSOs with data caps

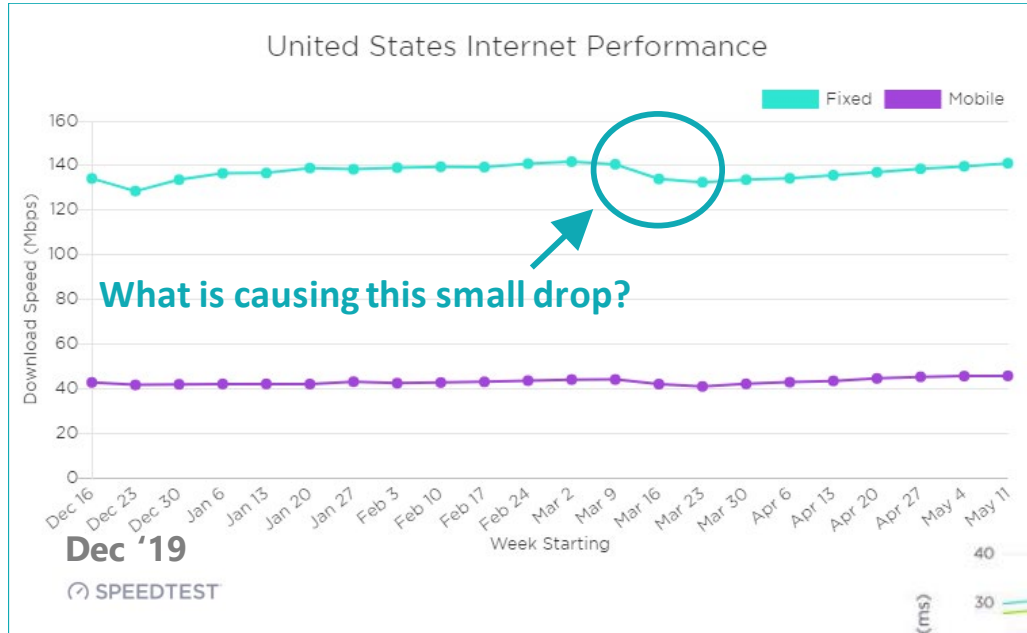
The Good

Bad QoE effects have been relatively minimal to date

- (unless Service Groups are over-subscribed)

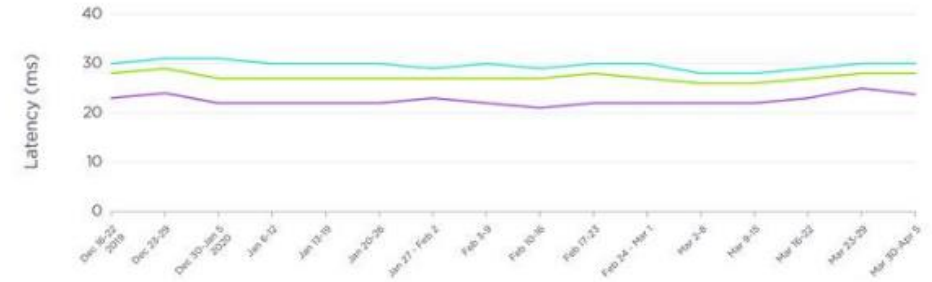
In general, the **DOCSIS networks** are holding up to this sudden, stressful packet load... Why? Several reasons:

- Network Capacity planning added **plenty of Head-room**
 - e.g. 1.2*Tmax Headroom to absorb SLA bursts
- Despite **heavily congested US** causing delays & drops:
 - **CMTS Scheduling algorithms are AI Engines, excellent at adapting** to congestion, with fair BW distribution
 - **Most internet applications are elastic and forgiving...** TCP & ABR recover from throughput reductions & pkt loss
 - **Subs are more tolerant about small lapses** when they are more worried about the virus et. al.

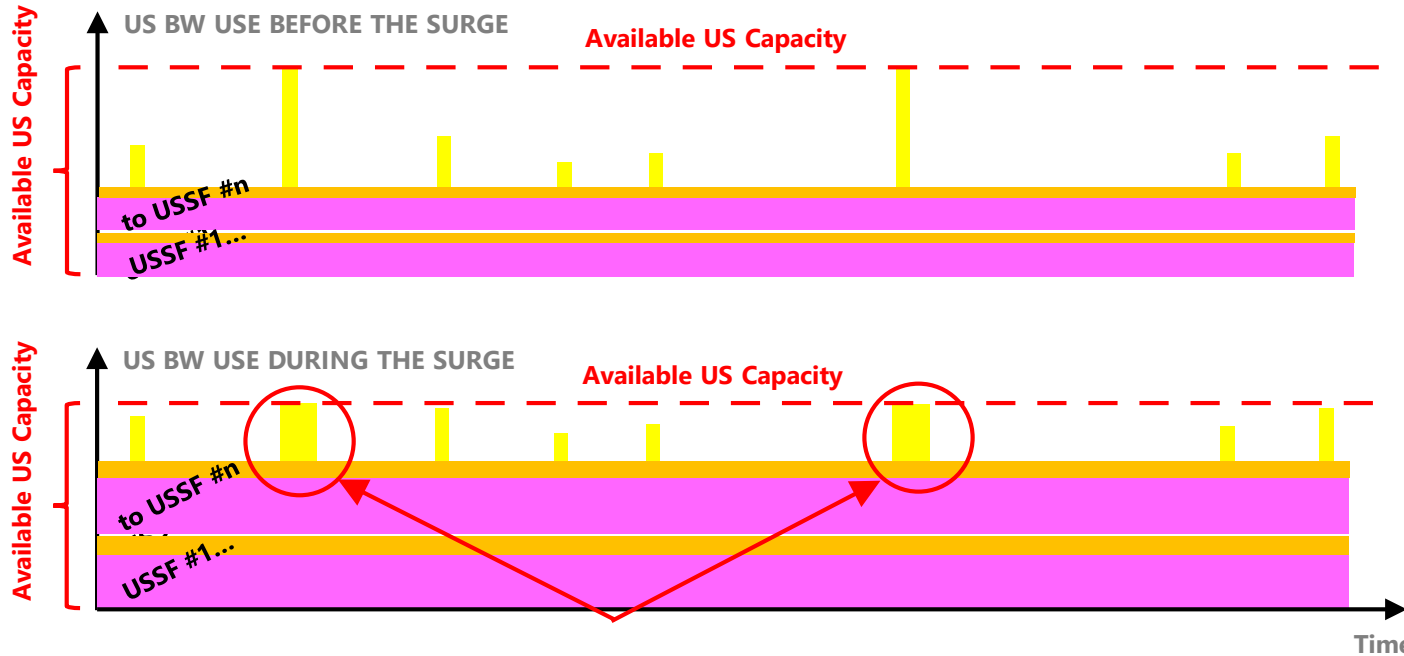


USA initially saw ~9% drop in Mean Download Speed, but by May recovered to ~1% down since March 2

- Less than the drop seen during the Holiday week of Dec 23-29
- Latencies are relatively unchanged from previous 12-week range



<https://www.speedtest.net/insights/blog/tracking-covid-19-impact-global-internet-performance/>



Beauty of Stat-Muxing Traffic & Intelligent US Scheduling During COVID-19 BW Surge:

- Great CMTS schedulers will throttle down these high bursts (delaying packets and perhaps dropping packets when needed)..but predom inantly within highest-BW streams using a large % of their T_{max} value

Simple CMTS Related Changes

Add additional **DOCSIS channels** – if spectrum available

- **Add OFDM to DS roll-off** (e.g. above top of 750/870 MHz plant)
 - OFDM bit-loading could enable extra 100-200MHz of ‘Bonus’ bandwidth, **potentially 1 Gbps**
- **Add OFDMA** below 15MHz, and in diplexer roll-off (e.g. 42-45)
 - Run US with lower QAM bit-loading as needed
 - OFDMA: below 20 MHz; &/or into roll-off (42/65MHz)
 - SC-QAM : below 20 MHz &/or into roll-off (42/65MHz)
 - perhaps using Int. US Agility to auto-adjust QAM levels

Reduce Tmax on only Top Tier Service Flows **or increase lower Tier’s Tmax** Service Flows

- Enable “Power-Boost”

More Complex CMTS changes:

- Enable Tmin; adjust SF priorities; tweak scheduler parms

CM Changes

- Enable **TCP ACK Suppression** on all modems
- Enable **Buffer Control TLVs** and **D3.1 AQM** to suppress buffer-bloat

In-Home Changes

- Encourage Subscribers to **Upgrade** to higher Service Tier
- **Improve Wi-Fi** – router location
- Enable **ISCA (Integrated Service Class Agility)**
 - Dynamically reduce Tmax for specific “bad actors”

Plant Clean-up Recommendations

- Cleaned up plants might enable improvements:
 - **US SC-QAM** channels from 32- to **64-QAM**
 - **US OFDMA** channels from 256 to 512-QAM or **1024-QAM**
 - **DS OFDM** channels from 1024- to **4096-QAM**
- For SC-QAM channels, **optimize FEC** settings
 - Up to 13% improvement over default
 - Use **Intelligent Channel Optimizer (ICO) tool**
- For OFDMA channels, **optimize bit-loading settings** in Modulation Profiles using PMA tools (while still maintaining adequate PER)
 - Use **Intelligent Channel Optimizer (ICO) tool**

CMTS Related Changes

- Add **additional DOCSIS channels** – using new spectrum from:
 - Reduced Legacy Video QAMs
 - 1218/85 MHz plant upgrade
 - Service Group segmentation in hubs and in nodes
- Turn on or increase **OFDM/OFDMA channels**
- Add **additional CCAP ports** to segment Service Groups (SG)

RF Plant Upgrades

- Perform **Service Group Segmentation** to create smaller SGs
 - De-combine nodes in Headend (i.e. 1:1 CCAP port to node)
 - Enable 2nd Digital Return – i.e. 1x1 to 1x2; or 2x2 to 2x4
 - Segment existing nodes (e.g. 1x1 to 2x2 to 4x4)
- Upgrade severely congested sites to **1218/85 MHz**
- Migrate long fiber runs to **R-PHY/R-MACPHY**

Legacy Video

Reduce Legacy Video QAM Spectrum:

- **Switched Digital Video (SDV)**
- Use **Better Compression**
- Both reduce Legacy Broadcast QAM usage to increase DOCSIS OFDM + SC-QAMs spectrum

CM and In-Home Changes

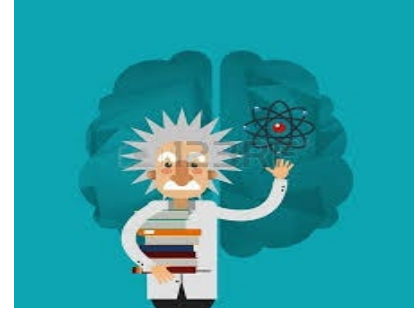
- Migrate all Top Tier subs to **D3.1 CMs**
- Add **more D3.1 CMs** to better utilize the available OFDMA spectrum
- Better use of higher spectral efficiencies
- **Upgrade to new Wi-Fi 6 router!!**

THE “2014” CommScope/ARRIS Basic TRAFFIC ENGINEERING FORMULA (BASED ON Tmax_max):

$$C \geq (N_{sub} * T_{avg}) + (K * T_{max_max})$$

**Peak Hour Avg Static Traffic Load
For Well-Behaved, Normal Traffic**

**Headroom for Good QoE for
Anomalous, High-BW Traffic**



Where:

- **C** is the required bandwidth capacity for the service group
- **Nsub** is the total number of subscribers within the service group
- **Tavg** is the average BW consumed per subscriber during busy-hour
- **Tmax_max** is the highest Service Tier Tmax offered by the MSO
- **K** is the QoE constant (larger values of K yield higher QoE levels)...

THE “2014” Basic TRAFFIC ENGINEERING FORMULA (BASED ON Tmax_max):

$$\text{Req'd Capacity} \geq (\text{Nsub} * \text{Tavg}) + (K * \text{Tmax_max})$$

Peak Hour Avg Static Traffic Load
Headroom for Bursts for Good QoE

K value:
 1.2 for great QoE...
 1.0-1.19 for good QoE...
 0.8-0.99 for fair QoE

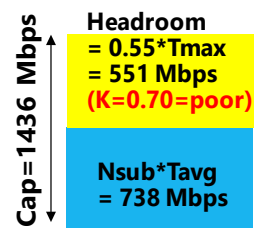
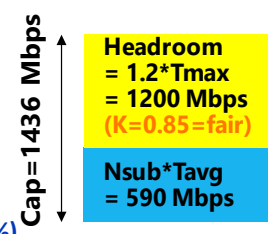
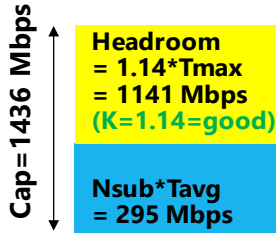
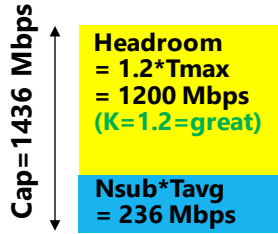
Downstream 3.0 + 3.1 Traffic Eng

Before Surge:
 Nsub=100
 Tavg=2.36 Mbps
 Tmax=1000 Mbps

During Surge:
 Nsub=100
 Tavg=2.95 Mbps (+25%)
 Tmax=1000 Mbps

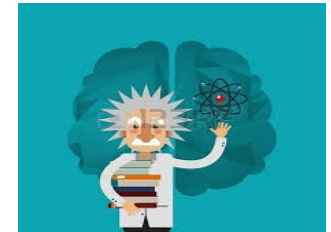
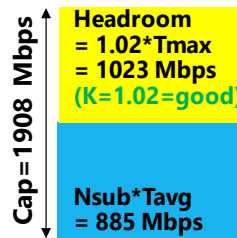
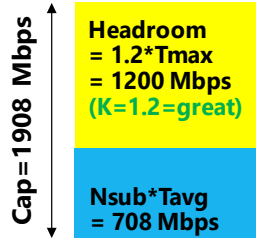
Before Surge:
 Nsub=250
 Tavg=2.36 Mbps
 Tmax=1000 Mbps

During Surge:
 Nsub=250
 Tavg=2.95 Mbps (+25%)
 Tmax=1000 Mbps



Before Surge:
 Nsub=300
 Tavg=2.36 Mbps
 Tmax=1000 Mbps

During Surge:
 Nsub=300
 Tavg=2.95 Mbps (+25%)
 Tmax=1000 Mbps



CMTS Related Changes

- Add **additional DOCSIS channels**
 - Using new spectrum, new SGs
- Increase **OFDM/OFDMA channels**
 - Reduce SC-QAM over time as 2.0/3.0 modems shrink
- Add **additional CCAP ports** to segment Service Groups

RF Plant Upgrades

- Push **Fiber Deeper** (e.g. N+0, N+1)
- Upgrade remaining plants to (at least) **1218/85 MHz**
- Migrate more nodes to **R-PHY/R-MACPHY** as part of long-term strategy

IP Video Migration

- Start migrating all Legacy Broadcast QAM subs to IPTV
 - With a goal to be mostly IPTV subs in a several years
- For IP Video migration, also consider:
 - Multicast ABR, Smart ABR

CM and In-Home Changes

- Migrate all Top Tier subs to **D3.1 CMs**
- Add even **more D3.1 CMs** to better utilize the available OFDMA spectrum
 - Better use of higher spectral efficiencies
- **Upgrade to new Wi-Fi 6E router!!**

What Does The Distant Future Hold?



1

Bandwidth usage may not snap back to its original pre-COVID levels when Coronavirus ends... Why?

- Because this novel social experiment may foster a new social paradigm
- Workers & companies may decide to explore more work-at-home activities
- Students & schools may decide to explore more on-line education activities

2

Bandwidth will obviously continue to grow into the 2020's...

- E.g. eSports is getting a boost now

Mid-Term Proposals for Mid-Term Needs (Upstream & Downstream)

- **Maximize D3.1 OFDM/OFDMA capacity**
 - **D3.1 is your biggest weapon** in the arsenal, definitely your biggest bang
 - **Upgrade to Gen-2 CMTS** (D3.1 US – OFDMA, more video, more SC-QAMs)
- **Perform Physical Node-Splits** (helps with Tav_g growth)

Long-Term Proposals for Long-Term Needs (Upstream & Downstream)

- **Perform 85MHz Mid-Splits** (helps with US Tav_g & T_{max} growth)
- **Perform 204MHz High-Splits** (helps with US Tav_g & T_{max} growth, enable 1G US Tier)
- **Turn on 1218MHz DS** (helps with DS Tav_g & T_{max} growth, uses existing taps)
- **Push Fiber Deeper** (helps with US + DS Tav_g growth)

Longer-Term Proposals for Longer-Term Needs (DOCSIS 4.0, 10G Initiative)

- Add **Ultra-High-Splits or FDX** (helps with Tav_g & T_{max} growth in the US)
- Add **Extended Spectrum DOCSIS** (helps with Tav_g & T_{max} growth in the DS)

Broadband kept society & the economy running in these hard times...

- *ARGUABLY ITS MOST SIGNIFICANT CONTRIBUTION TO SOCIETY IN ITS SHORT LIFE-SPAN*

DOCSIS still working very well, but some cracks that need filling...this is a wake-up call

- Many Quick Fixes are possible for fast relief
- Near-term solutions that can double or quadruple BW Capacity

BW will not snap back after COVID...it will continue to grow through the decade

- BW Capacity planning to withstand the future BW Surges
- Mid-term Solutions for coming years – Fiber Deep, Node-splits, 12/8/85 or 12/8/204 MHz upgrades
- Longer-term Solutions for next decade – Cable 10 G, DOCSIS 4.0 (FDX or ESD)

MSOs & Vendors need to begin working now to upgrade the HFC Plant to support the future Bandwidth Growth

Networks that have been designed with sufficient capacity have been resilient and handled the Coronavirus BW surge

Thank You!

John Ulm

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