State of Wi-Fi Reporting

DSA 2021 Global Summit

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Reliably Fast Broadband & Wi-Fi for the Home

Outline

- Introduction
  - ASSIA
  - Data Aggregation
- State of Wi-Fi Report Results: Parameters Evolution Over Time
  - Wi-Fi Traffic
  - Wi-Fi Latency
  - Wi-Fi Interference
  - Wi-Fi Congestion
- Overall Spectrum-Need Score
- Wi-Fi, Broadband, and infrastructure investment
- Conclusions

Introduction

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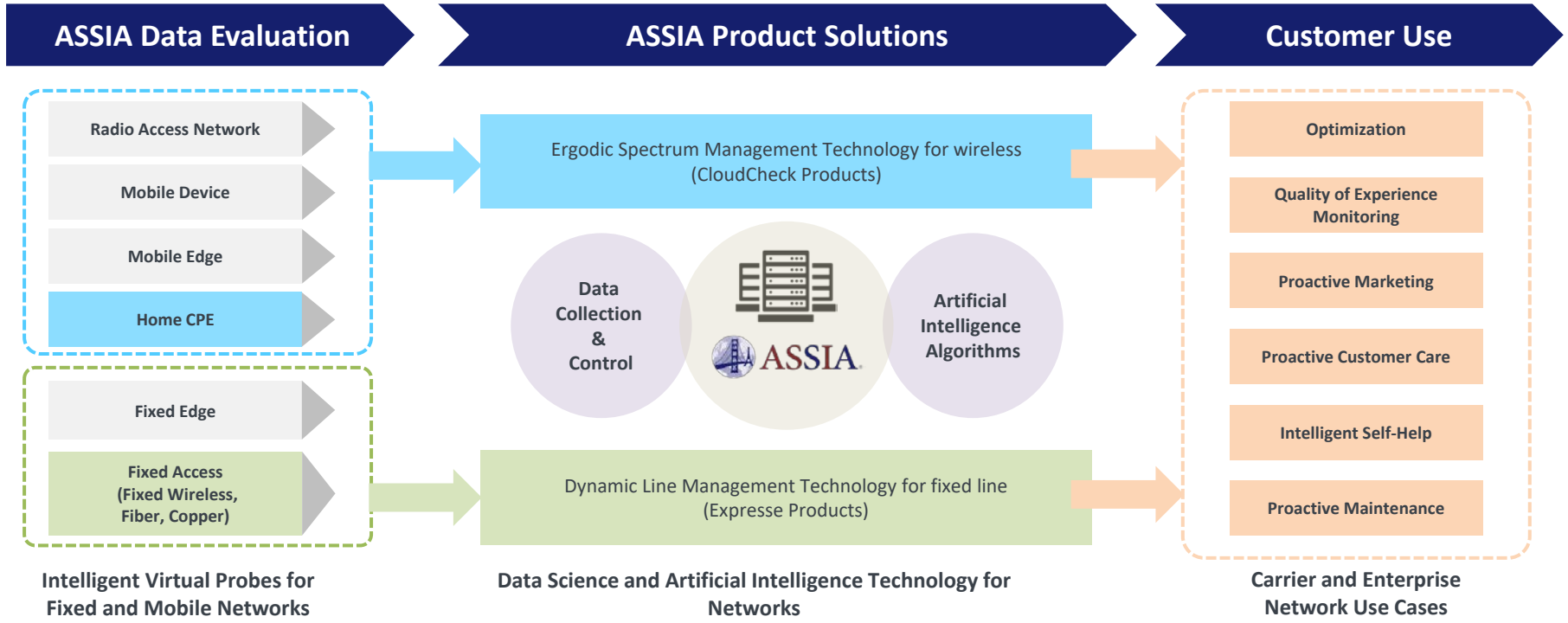
Wi-Fi and Broadband Data Aggregation

Reliably Fast Broadband & Wi-Fi for the Home

ASSIA AI-PLATFORM FOR CONNECTIVITY



ASSIA's AI optimizes fixed/wireless connections Quality of Experience through data-collection/analysis, all devices, equipment, middleware, and networks

per-customer, neighborhood or network-wide basis

reduces operating expenses related to service calls, dispatches, hardware replacements, or related to customer churn

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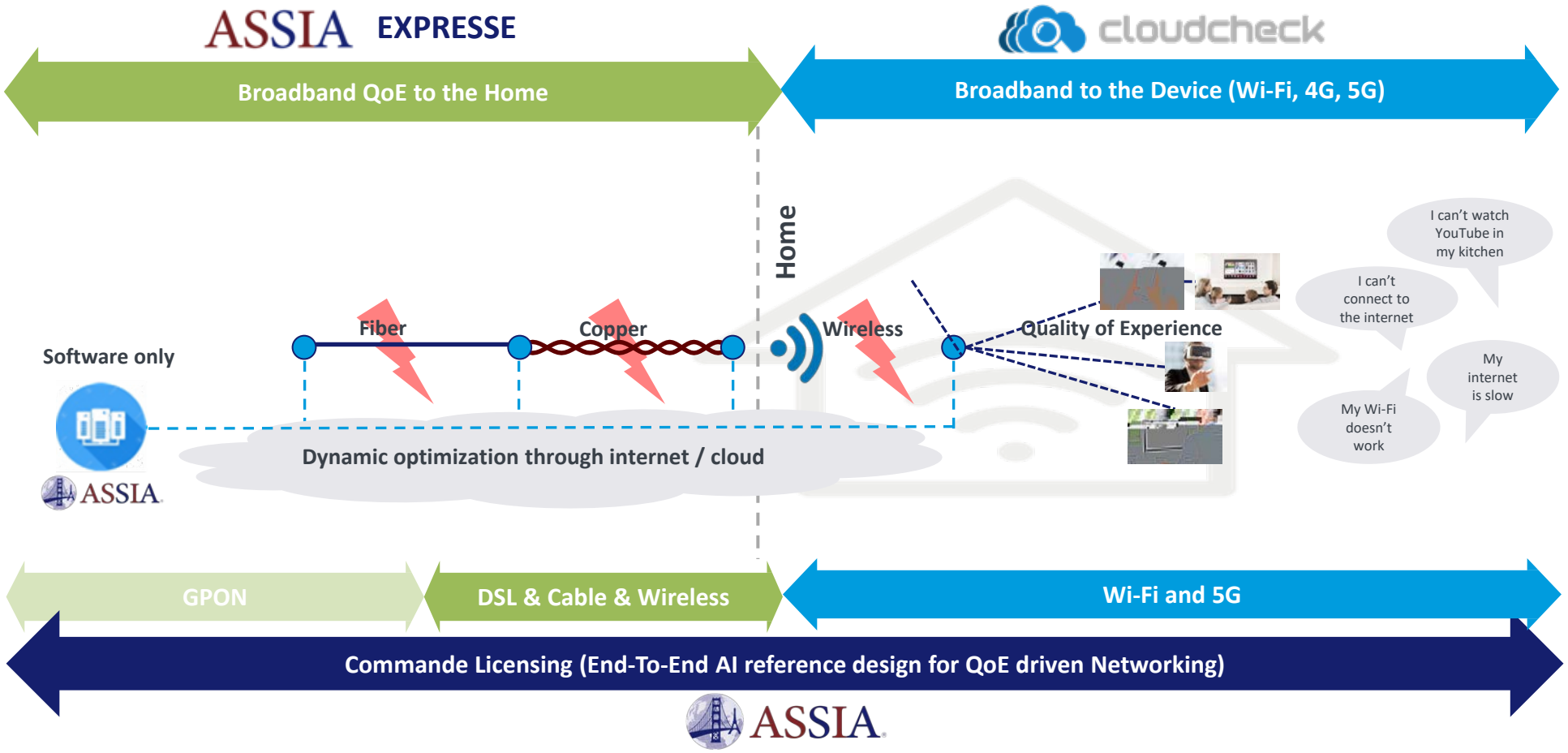
ASSIA and Software Products



Sold to ISPs Globally (5 continents)

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Data Aggregation

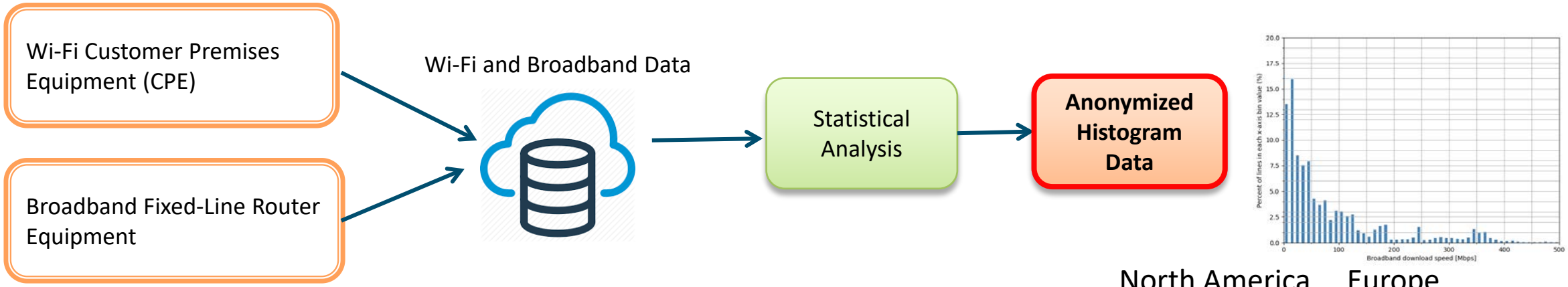
ASSIA footprint for collection globally > 50M access connections
Serving 100's of millions of Wi-Fi –Connected Devices

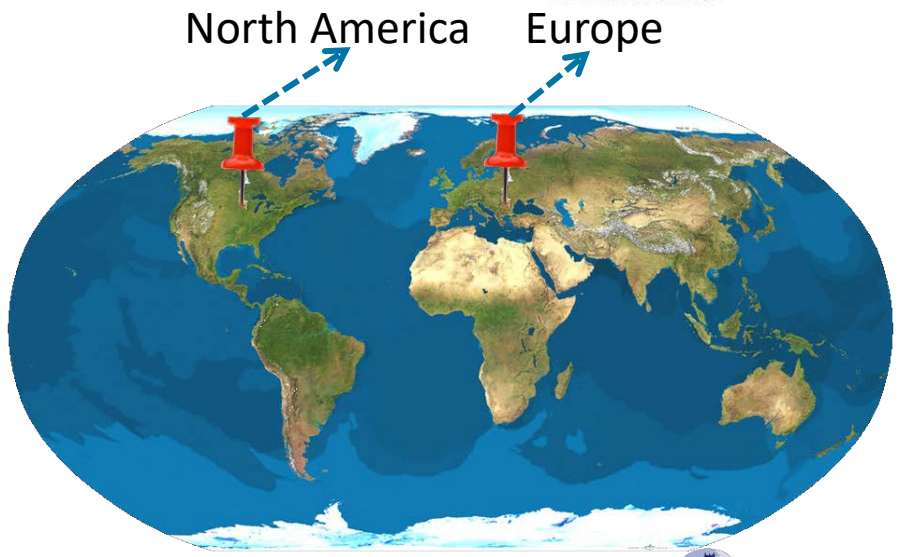
Reliably Fast Broadband & Wi-Fi for the Home

ASSIA Data Collection and Aggregation

ASSIA Data Collection

- Performance metrics
- Diagnostic parameters
- Network status & test





- Millions of lines in North America and Europe
  - ~40 Global ISP's (most have >1M links)
  - ISP operational-expense reduction is main use

ISPs invest in Wi-Fi because their customers' QoE is significantly impacted. Consumers fault the ISP for poor Wi-Fi!

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Some metrics that ASSIA's customers desire

All correlate well to field QoE for Wi-Fi in live ISP service & cost ISPs and Application Providers $ when poor

- **Wi-Fi Traffic**

  Wi-Fi traffic at each Wi-Fi router, sum of all stations' traffic, daily and hourly

- **Wi-Fi Latency**

  Average daily round-trip delay (ms) between the Wi-Fi router and all its clients

  This is not the server to client delay measured, e.g., by Opensignal (it is less)

- **Interference**

  Time percentage that a channel is unavailable because **other routers** (and unassociated stations) occupy that same channel

- **Congestion**

  QoE-extrapolated measure of end-customer frustration as a function connection-bandwidth use by **stations associated to this router;** i.e., how active is the router?

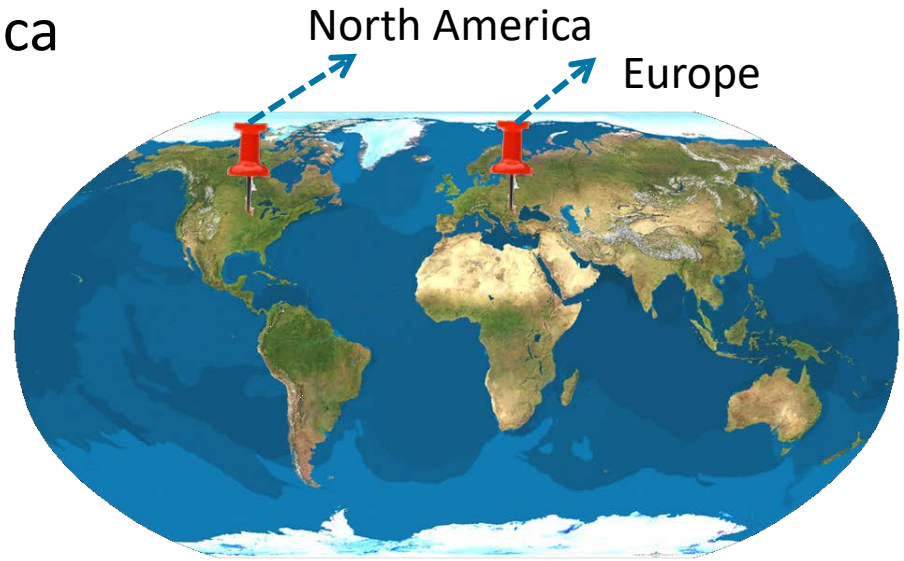
- **Wi-Fi throughput to transmit rate ratio**

  Router's available throughput divided by the maximum transmit rate (MCS data rate)

  Interference and congestion *decrease* this measure and so indicate spectrum need

More Specifics on ASSIA's Wi-Fi and Broadband Collections

- ASSIA collects and anonymizes many data parameters
  - Currently, across millions of lines in North America and Europe, All data 28-05-2020 to 28-02-2021
- This report currently aggregates & analyzes:



Wi-Fi Data

Wi-Fi Throughput (speed)	Daily, 2.4 and 5 GHz bands
Wi-Fi Transmit Rate	Daily, 2.4 and 5 GHz bands
Wi-Fi throughput to transmit rate ratio	Daily, 2.4 and 5 GHz bands
Wi-Fi Congestion	Daily and max hour, 2.4 and 5 GHz bands
Wi-Fi Interference	Daily and hourly, 2.4 and 5 GHz bands
Wi-Fi Traffic	Daily and hourly, upstream and downstream, 2.4 and 5 GHz bands
Wi-Fi Latency	Daily, 2.4 and 5 GHz bands

Broadband Data

Broadband Traffic	Daily and hourly, upstream and downstream
Broadband Throughput (speed)	Daily, upstream and downstream
Broadband Latency	Daily

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State of Wi-Fi Report

ASSIA's business depends profits from the ISP's commercial value attributable to Wi-Fi.

ASSIA realizes regulators and application providers also care (or soon will) about Wi-Fi QoE

This DSA Report thus provides unique insights about Wi-Fi spectrum, its use, its limitations.

Reliably Fast Broadband & Wi-Fi for the Home

Wi-Fi already needs the 6 GHz spectrum in North America

- **to avoid QoE limitations on:**
  - **Video for work from home**
  - **Remote health care**
  - **Video entertainment**
- **to justify any fiber-to-home infrastructure investment**

Europe follows roughly 6 to 12 months later

State of Wi-Fi Report

- Report Objectives
  - Track Wi-Fi traffic evolution
  - Monitor & analyze spectrum use
  - Improve spectrum use to reduce interference & congestion
- Wi-Fi QoE degrades from spectrum limitations
  - Steady Wi-Fi-use growth (with pandemic bump, of course)
  - Clear shift from 2.4 GHz to 5 GHz, occurred first in North American, now Europe
  - Track periodically (quarterly to annually)
- Relate to Market trends to leverage best Wi-Fi bands
  - Very little 6 GHz data yet (expect in 18 months, annual Wi-Fi replacement 10%)
- Report Link: http://dynamicspectrumalliance.org/global-summit/

Annualized Percent Change in Wi-Fi Data: Summary

	2.4 GHz	5 GHz
North America		
Wi-Fi traffic, downstream	4.4%	30.2%
Wi-Fi traffic, upstream	5.5%	22.5%
Wi-Fi interference*	7.1%	18.3%
Wi-Fi congestion in busy hour	-3.6%	760.9%
Wi-Fi latency	13.4%	21.7%
Wi-Fi throughput / transmit rate	-7.3%	-18.8%
Europe		
Wi-Fi traffic, downstream	42.0%	42.0%
Wi-Fi traffic, upstream	14.4%	21.8%
Wi-Fi interference	3.7%	5.4%
Wi-Fi congestion in busy hour	64.0%	28.6%
Wi-Fi latency**	29.9%	5.7%
Wi-Fi throughput / transmit rate	-8.7%	-8.4%

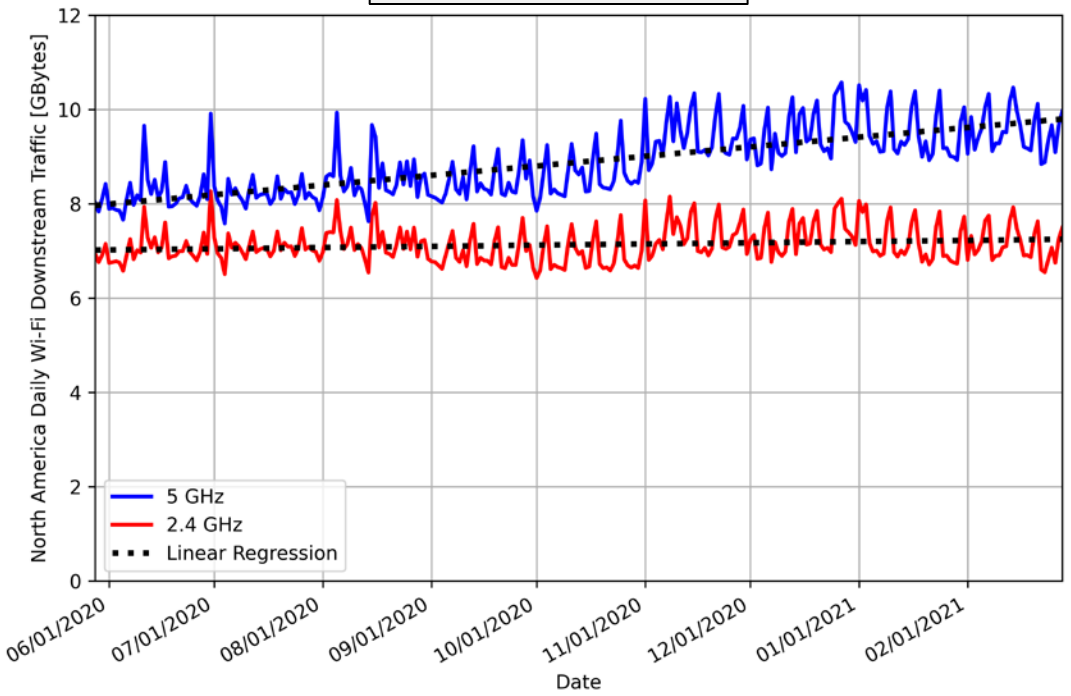
Wi-Fi **growth is rapid**,
Maintenance of good QoE
is increasingly challenging

Let's investigate further some of these …

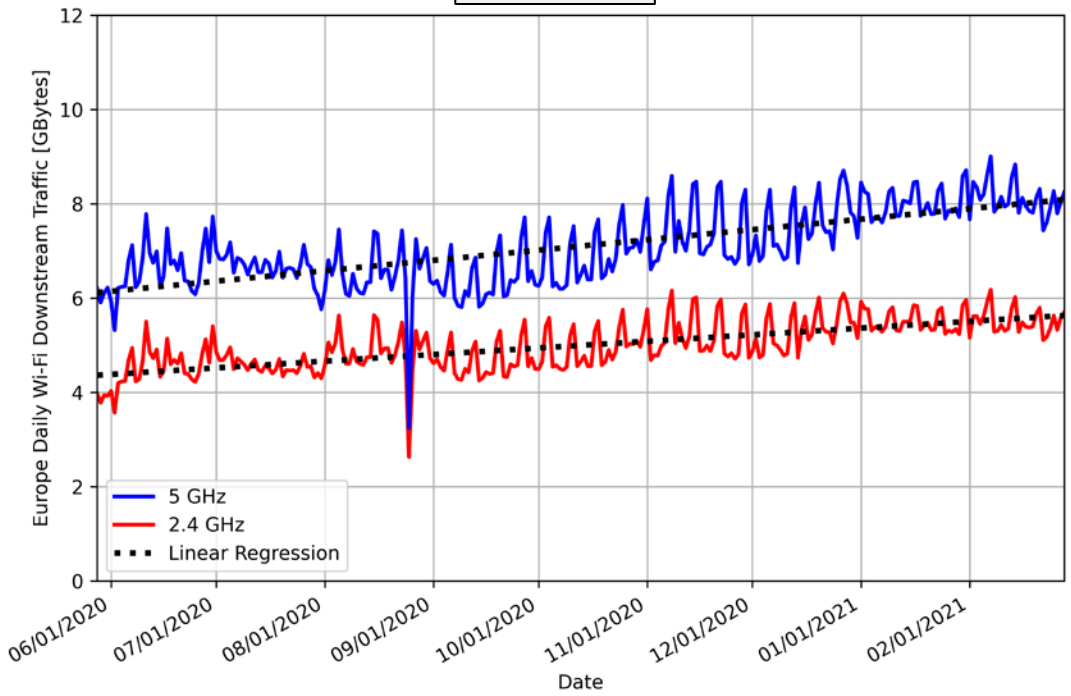
Wi-Fi Traffic

- Wi-Fi traffic **doubles every 3 years.**

NORTH AMERICA



EUROPE



2.4 GHz | 5 GHz
4 | 30 %

Wi-Fi traffic is growing in both 5 GHz and 2.4 GHz

2.4 GHz | 5 GHz
42 | 42 %

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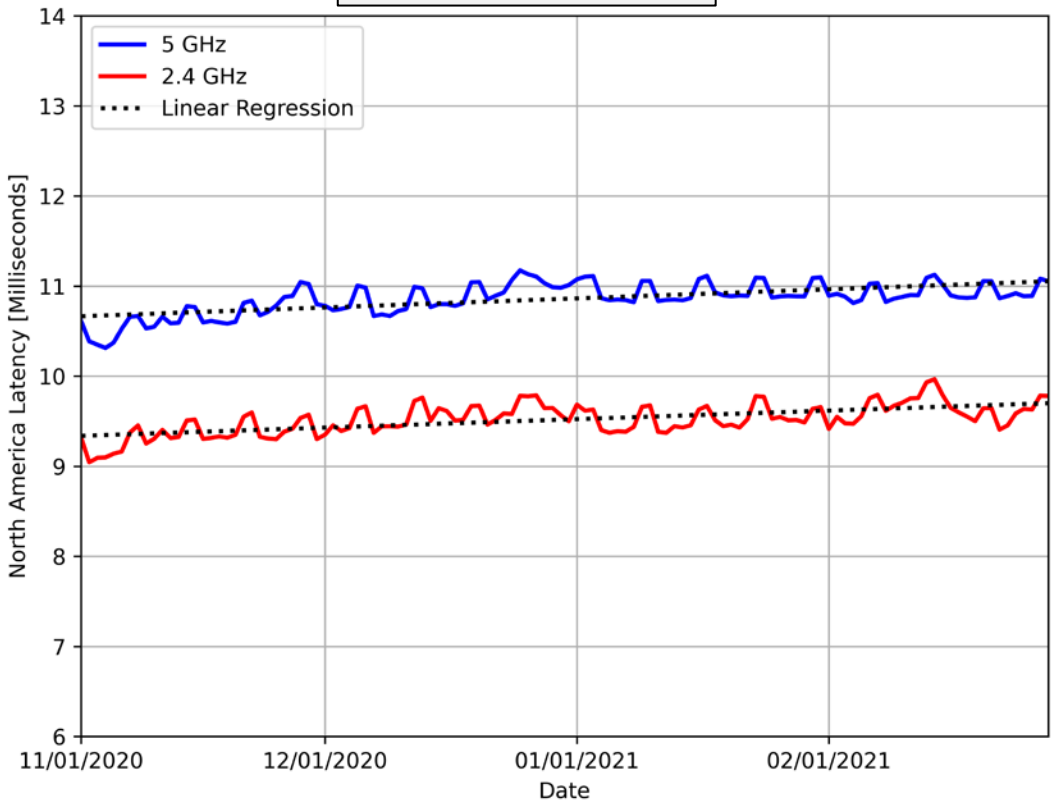
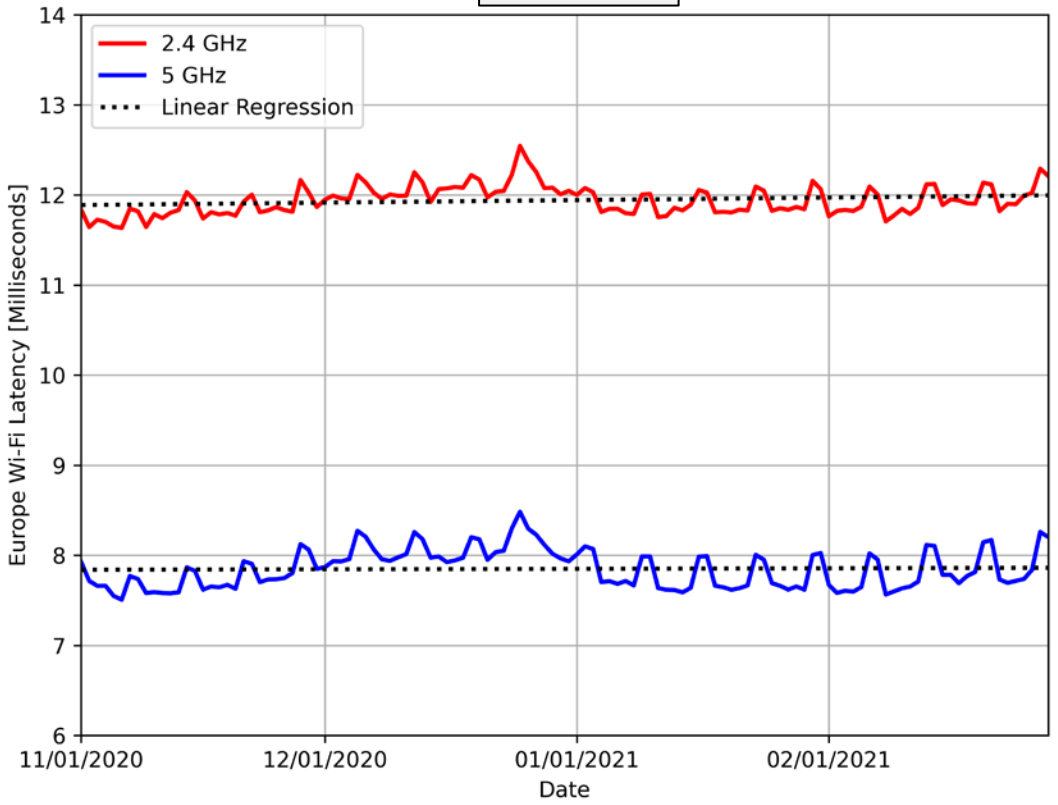
Wi-Fi Latency evolution (ms)

NORTH AMERICA



2.4 GHz | 5 GHz
13 | 22 %

EUROPE



2.4 GHz | 5 GHz
30 | 6 %

Latency is degrading over time as traffic increases

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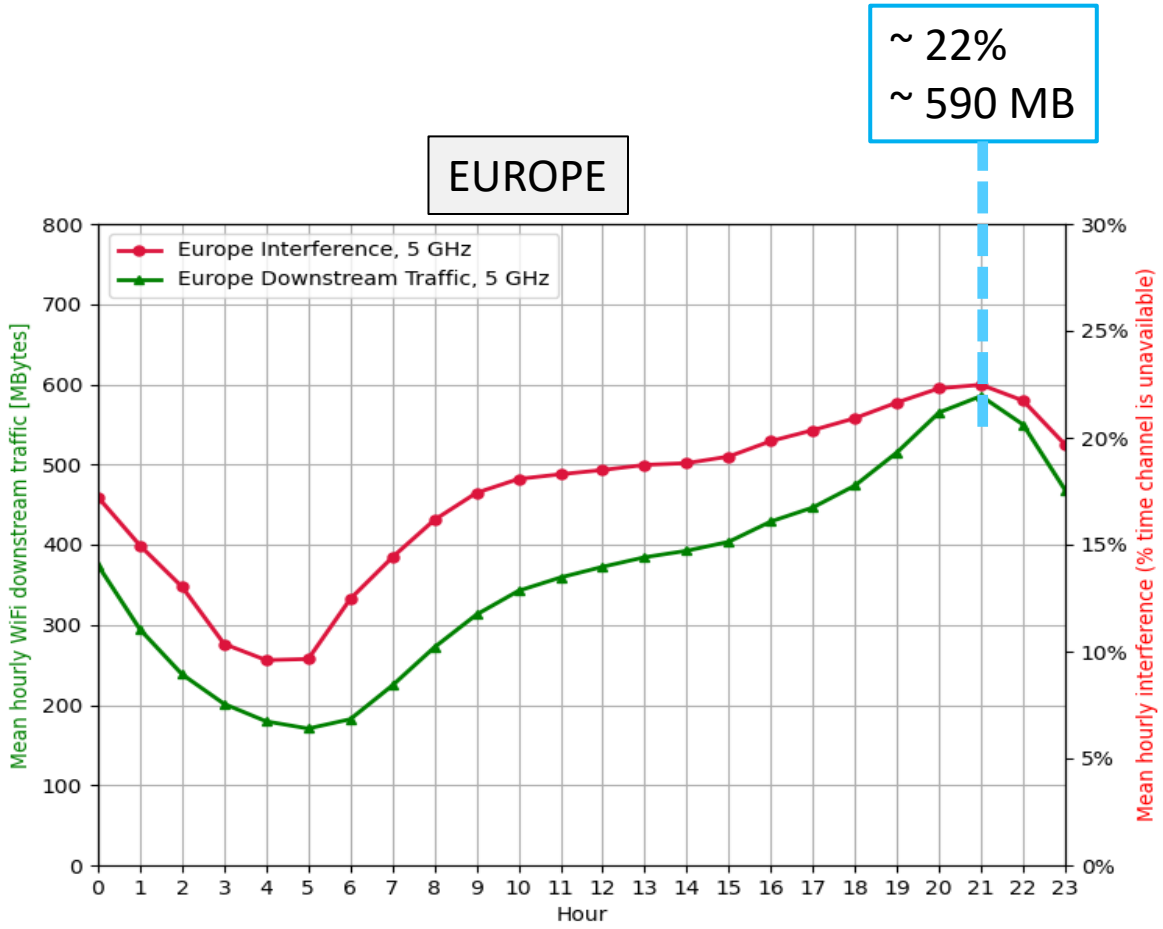
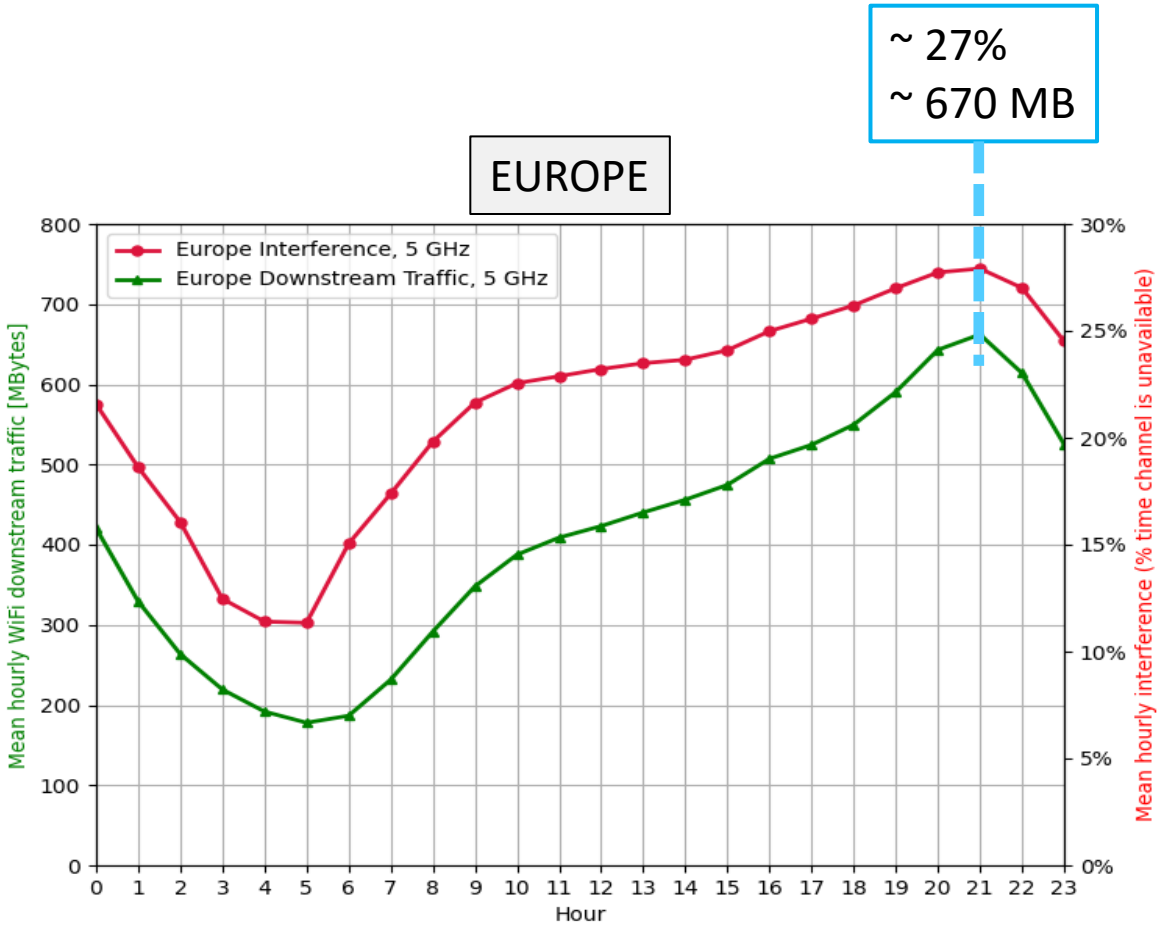
European Hourly Wi-Fi Interference



5/28/20 to 11/27/20



5/28/20 to 2/28/21

Interference growing as traffic grows
Interference increased 5% in 3 months

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Wi-Fi Congestion vs Traffic

- Congestion grows much faster than traffic

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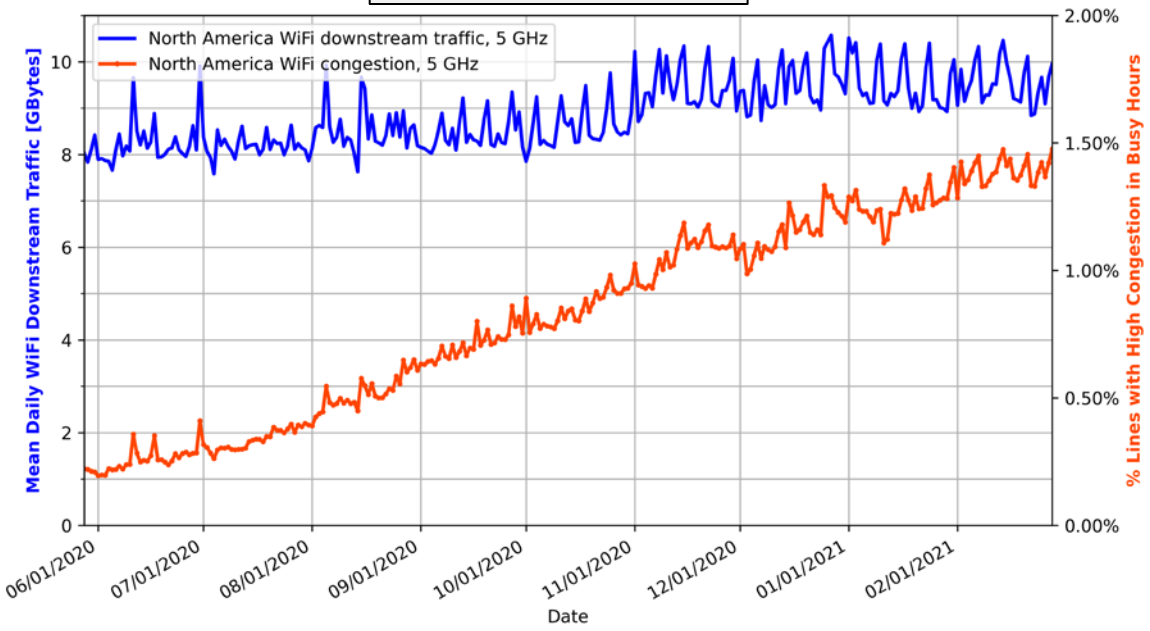

- Congestion still grows linearly with traffic

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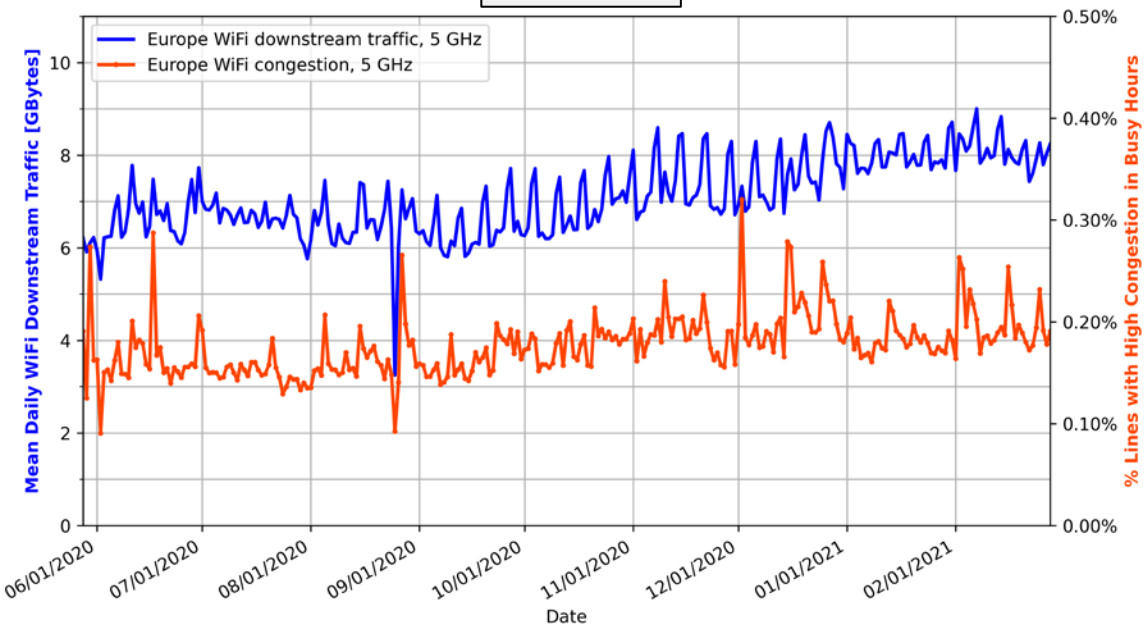

1% congestion typically means
users complain because QoE is unacceptable

Operational costs become unacceptable

Wi-Fi congestion growing nonlinearly as Wi-Fi traffic grows
North America already faces congestion issues
Europe will in 6 months

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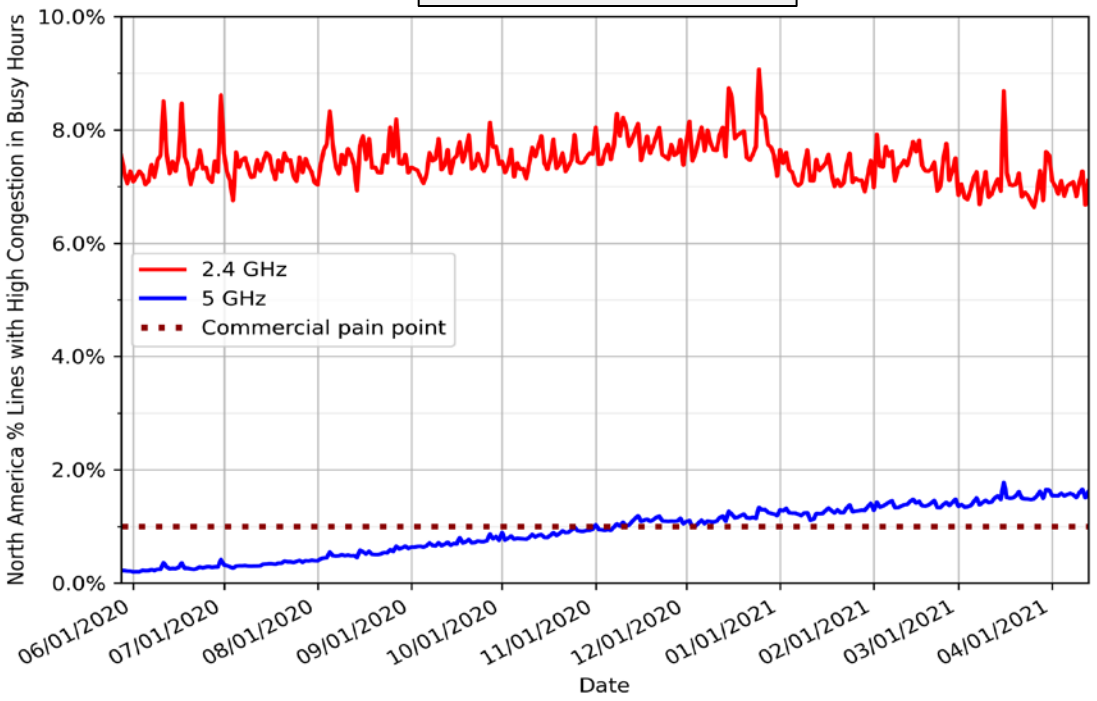
Busy Hour Wi-Fi Congestion

- busy hour has the maximum congestion over 24 hours for each service (% of links)

NORTH AMERICA



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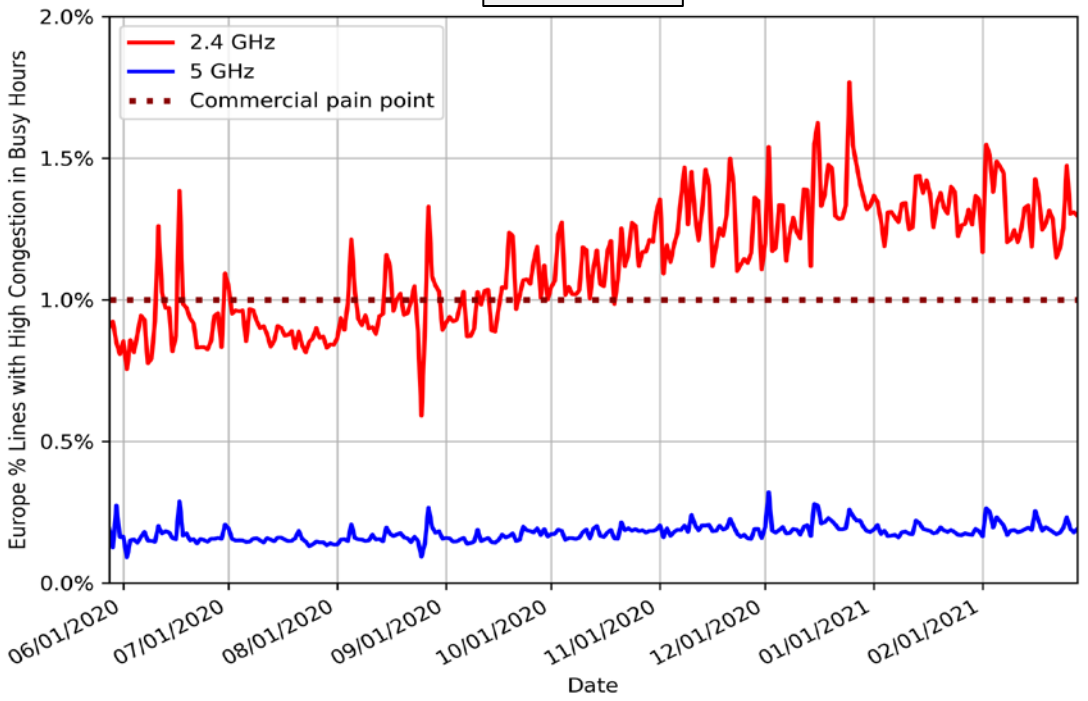

The problem is even more acute during busy hour
Users are reaching the limits of Wi-Fi @ 5GHz.
Wi-Fi 6E additional channels are designed to address this issue

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Overall Spectrum-Need Score (SNS)

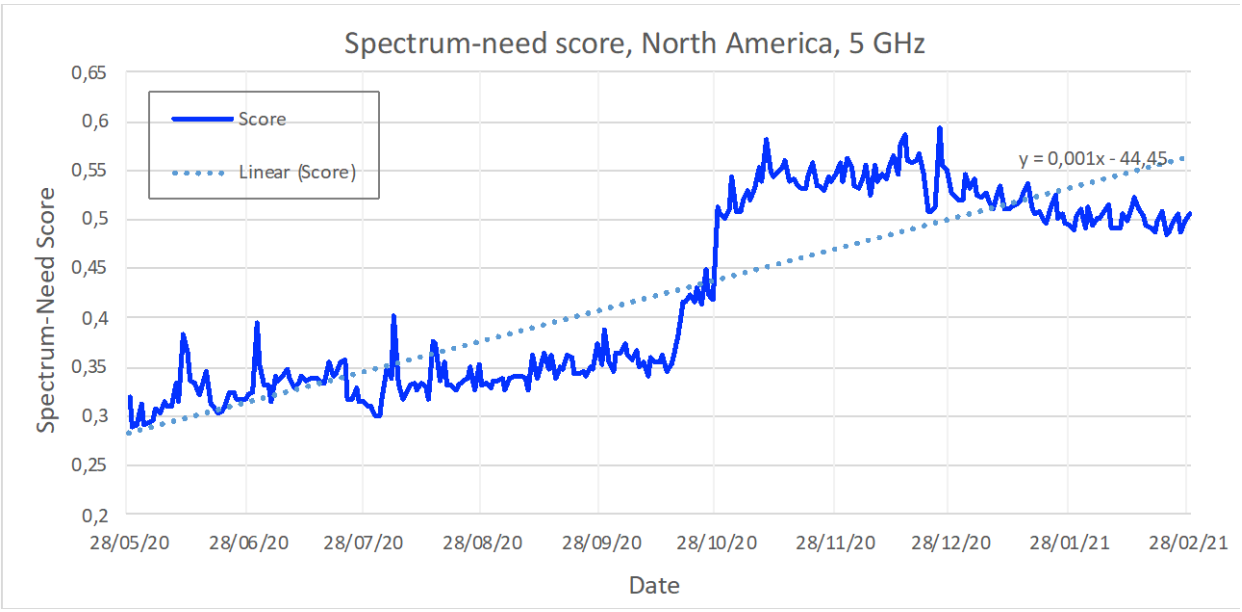
- ***Why***
  - ISPs care about all P's (traffic, latency, etc)
  - Regulator and consumers need simpler metric
  - **Great 0** < SNS < **1 Awful - need it now.**
  - Single agreed measure to measure spectrum scarcity

- ***Spectrum-need score*** combines salient Wi-Fi parameters (P's)
- Predicts spectrum need using:
  - *Wi-Fi traffic, downstream and upstream (P1,P2):* Traffic *increase* → more spectrum.
  - *Wi-Fi interference (P3):* Interference increase → more spectrum.
  - *Wi-Fi latency (P4):* Latency increase → more spectrum.
  - *Throughput to transmit rate ratio (P5):* This parameter's decrease (so subtract) → more spectrum

- Each parameter uses a 5% worst-case threshold, because the stress points are of interest.
  - SNS linearly combines the 5 P's with equal weight.

Overall SNS (Spectrum-Need Score)

NORTH AMERICA



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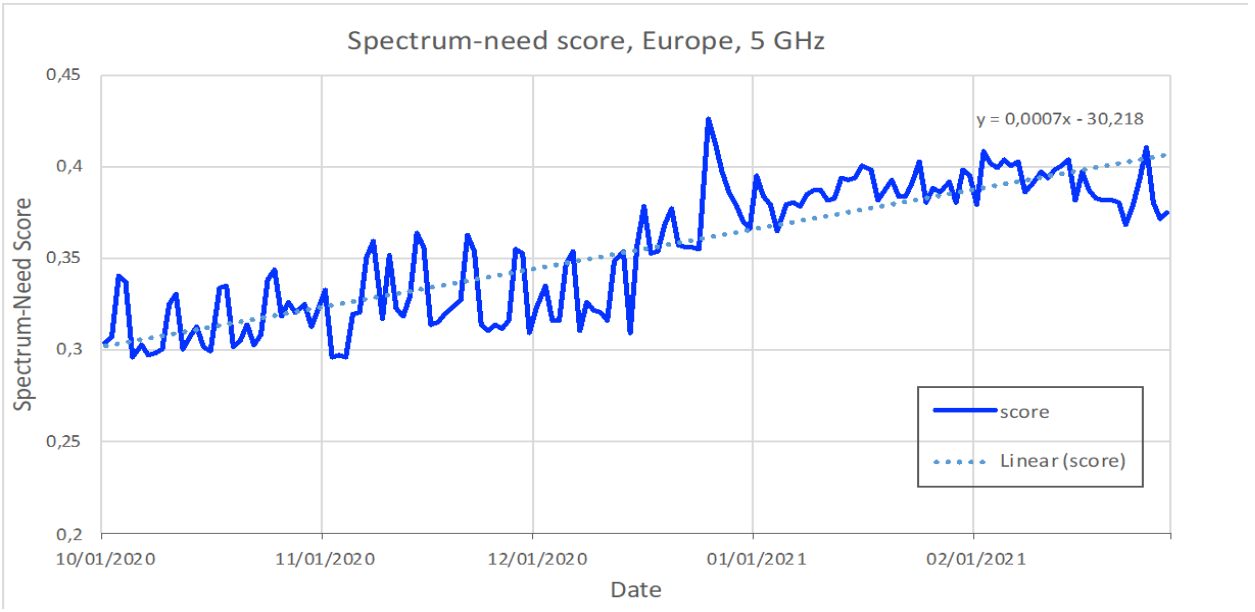

Spectrum-need score = 0.2 P1 + 0.2 P2 + 0.2 P3 + 0.2 P4 - 0.2 P5

Wi-Fi-related productivity negatively impacted in 1 year *(SNS rises 25-40% annually)*
→ 6 GHz will help

Continent, Wi-Fi Band	% Annual increase in spectrum-need score (linear regression)
North America, 2.4 GHz	13.2%
North America, 5 GHz	37.1%
Europe, 2.4 GHz	24.8%
Europe, 5 GHz	25.3%

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Wi-Fi versus Broadband Access Connection

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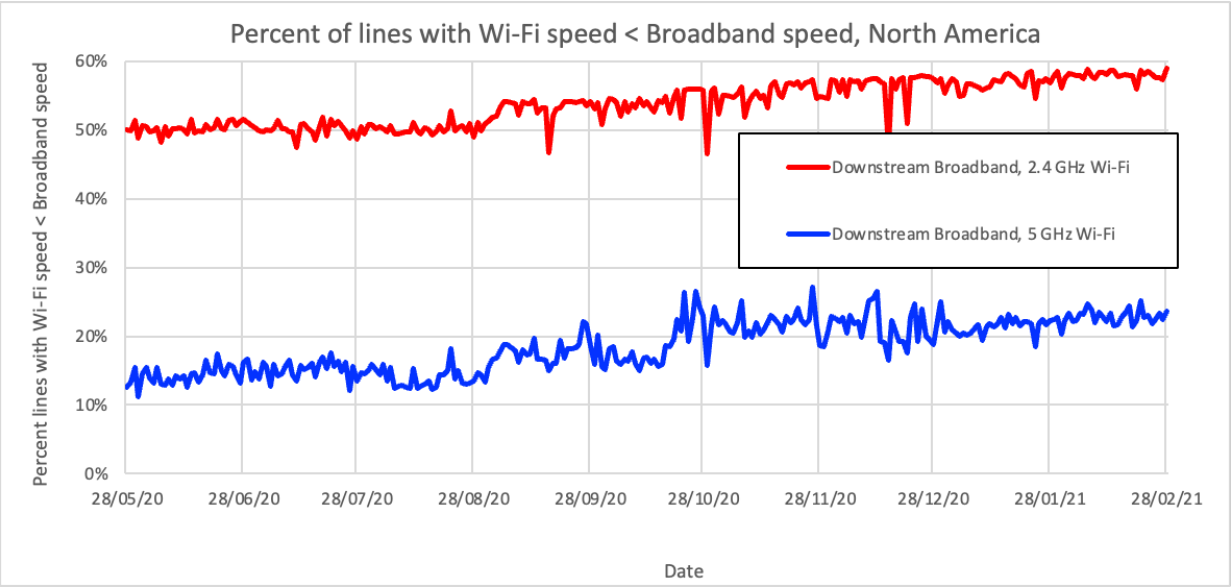
Wi-Fi vs Broadband Access Throughput

The **connectivity QoS is increasingly limited by Wi-Fi** rather than broadband

ISP investment might better be to Wi-Fi than FTTH, or FTTH investment return reduces



This is already a big problem in the US, and the problem is becoming more acute.

Wi-Fi slower than broadband (North Am)	Increase over one year
Downstream Broadband, 2.4 GHz Wi-Fi	13.0%
Downstream Broadband, 5 GHz Wi-Fi	14.4%

The curves tend to be higher in the plot as broadband speed increases or Wi-Fi speed decreases, i.e., Pr (Wi-Fi speed < Broadband speed) increases.

User-perceived performance is yet worse with increasing stations on same router.

State of Wi-Fi Report Conclusions

- Both 2.4 GHz and 5 GHz bands at or headed to saturation
  - annual increase in 5 GHz band is higher than 2.4 GHz band in North America and Europe.
- Increasing traffic exacerbates this trend (more work-at-home, remote anything).

- Wider Wi-Fi channels also encourage more traffic, so then
  - Wider channels → more congestion
  - Wider channels → more interference
  - Higher SNS

- The next generation of applications will require very low latency, which is sensitive to spectrum “quality”.

Thank You

End of Presentation

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