Georgia Tech Smart Cities and Inclusive Innovation

#SMARTer Together

Webinar Series

Democratizing Connectivity

SMARTer Together Webinar Panel

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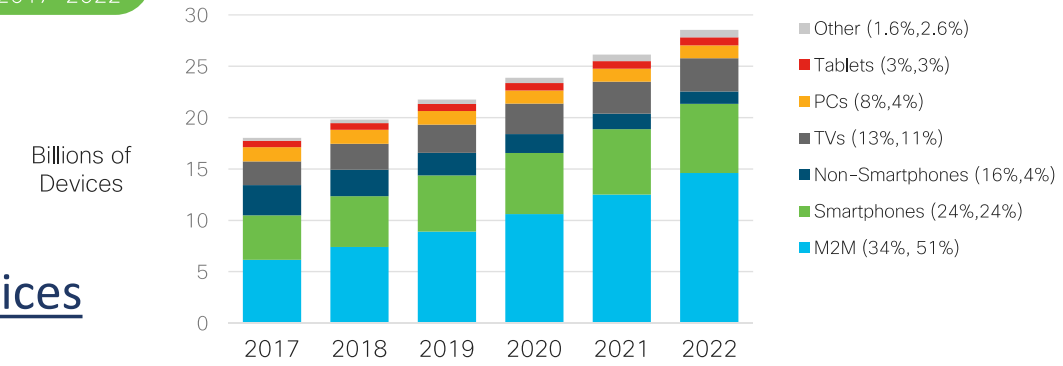
Growth and shifts in demand for connectivity

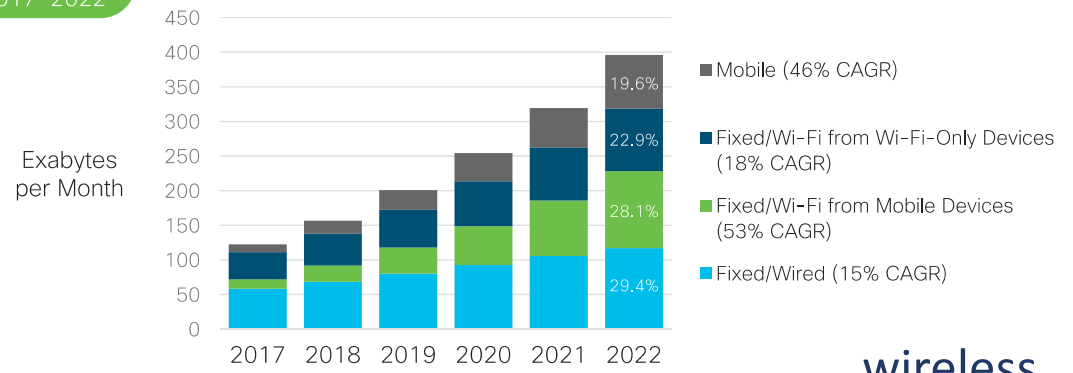
- Increase in traffic volume, number of devices, wireless

10% CAGR
2017–2022



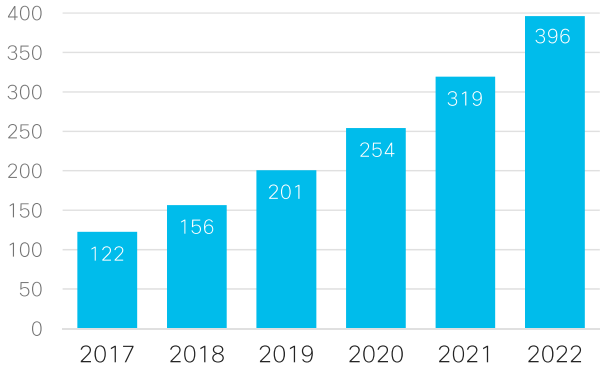
devices

26% CAGR
2017–2022



wireless bandwidth

26% CAGR
2017–2022



data

Source: Cisco Virtual Network Index

Growth and shifts in demand for connectivity

- New bandwidth-intensive and latency-sensitive workloads

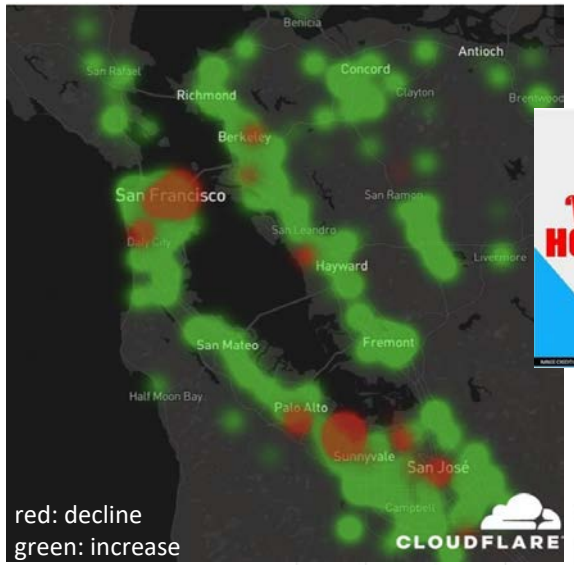
high definition video

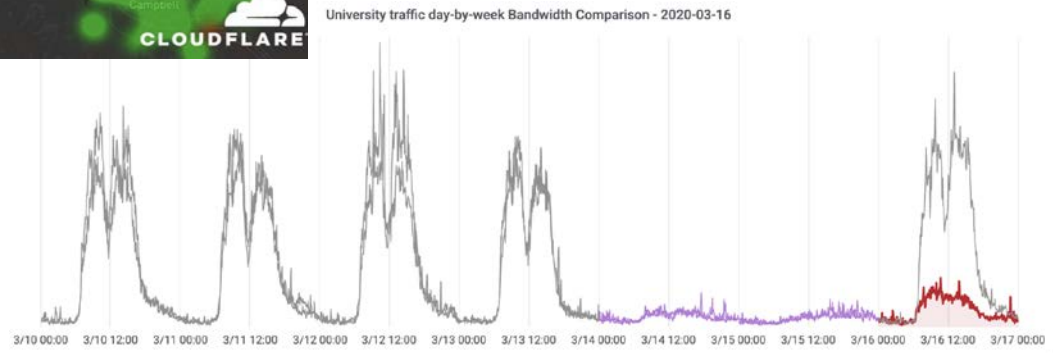
AR/VR

SmartCity, automation

Growth and shifts in demand for connectivity

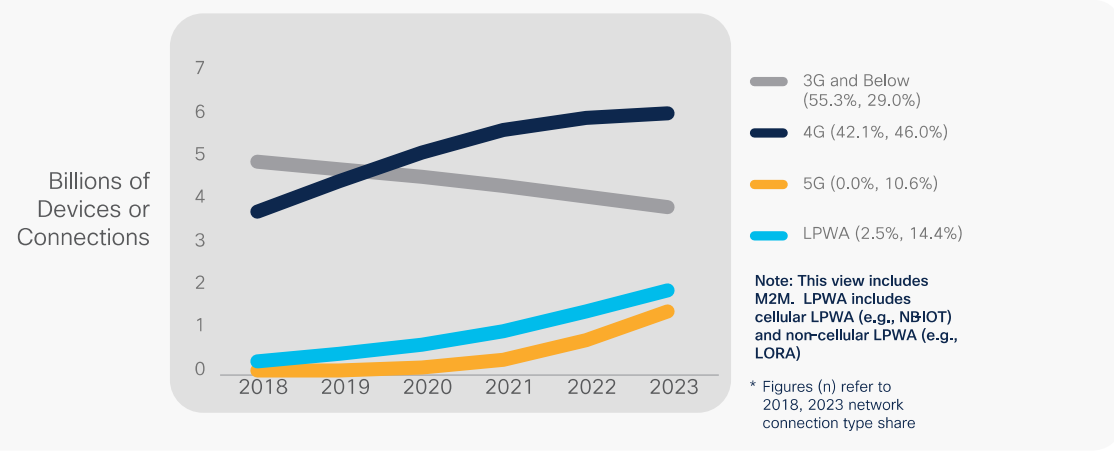
- Demand shifts due to new “normal”; connectivity == basic services



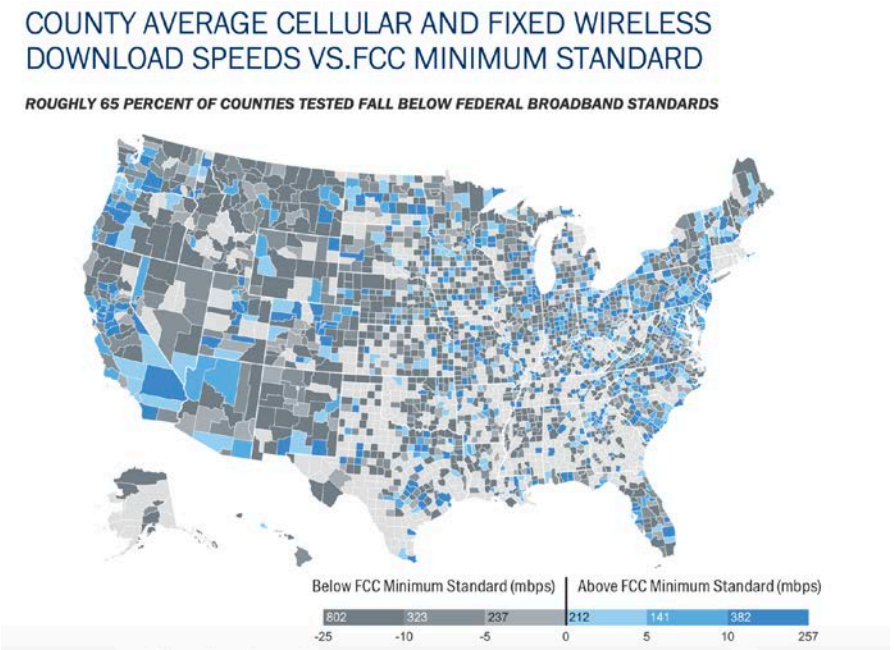


Close the gap with next-G technology

- 5G, but….



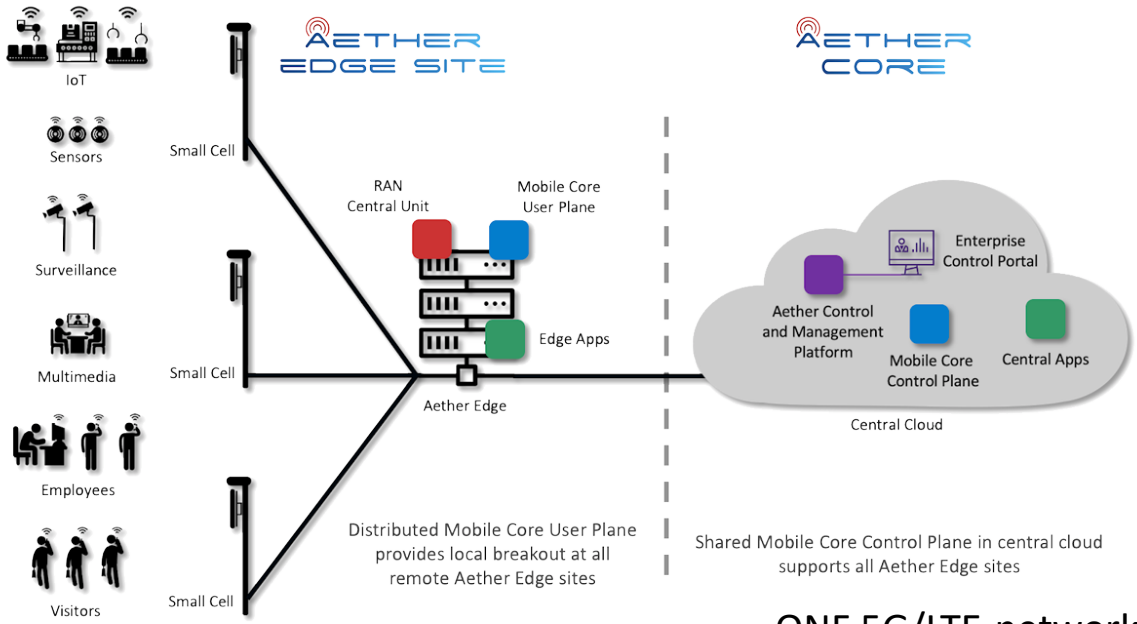
Source: Cisco Annual Internet Report, 2018–2023



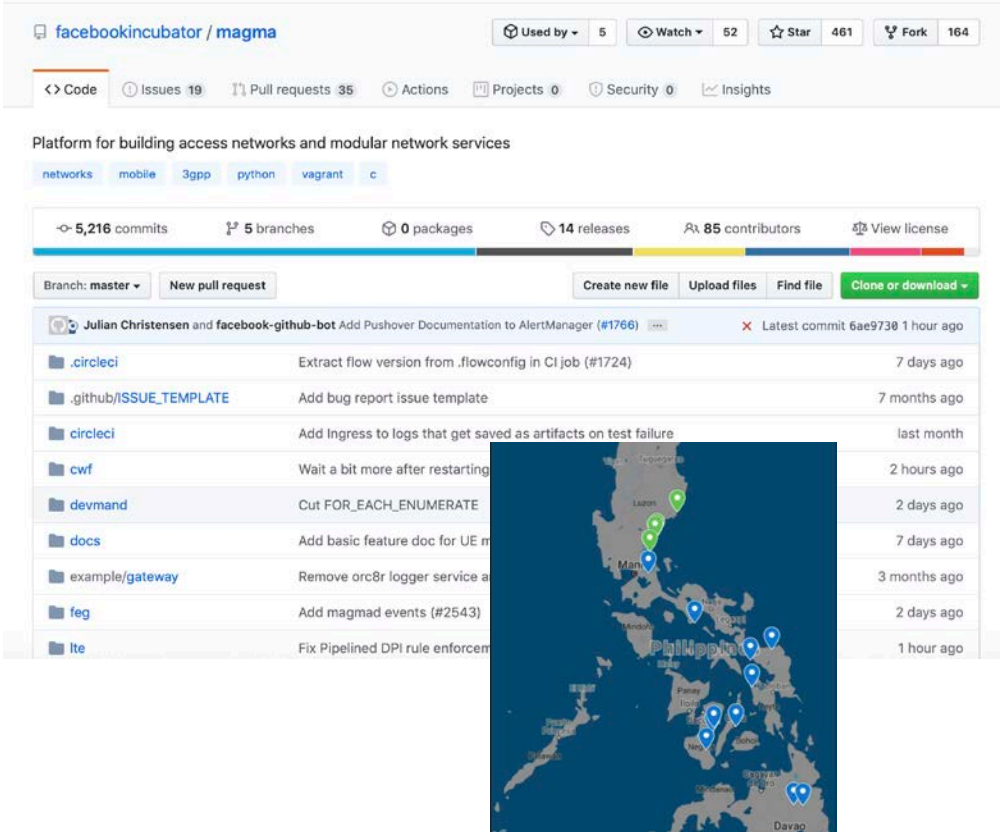
… more from Ellen

Close the gap with commoditization

- Trend toward open source software stacks and commodity hardware



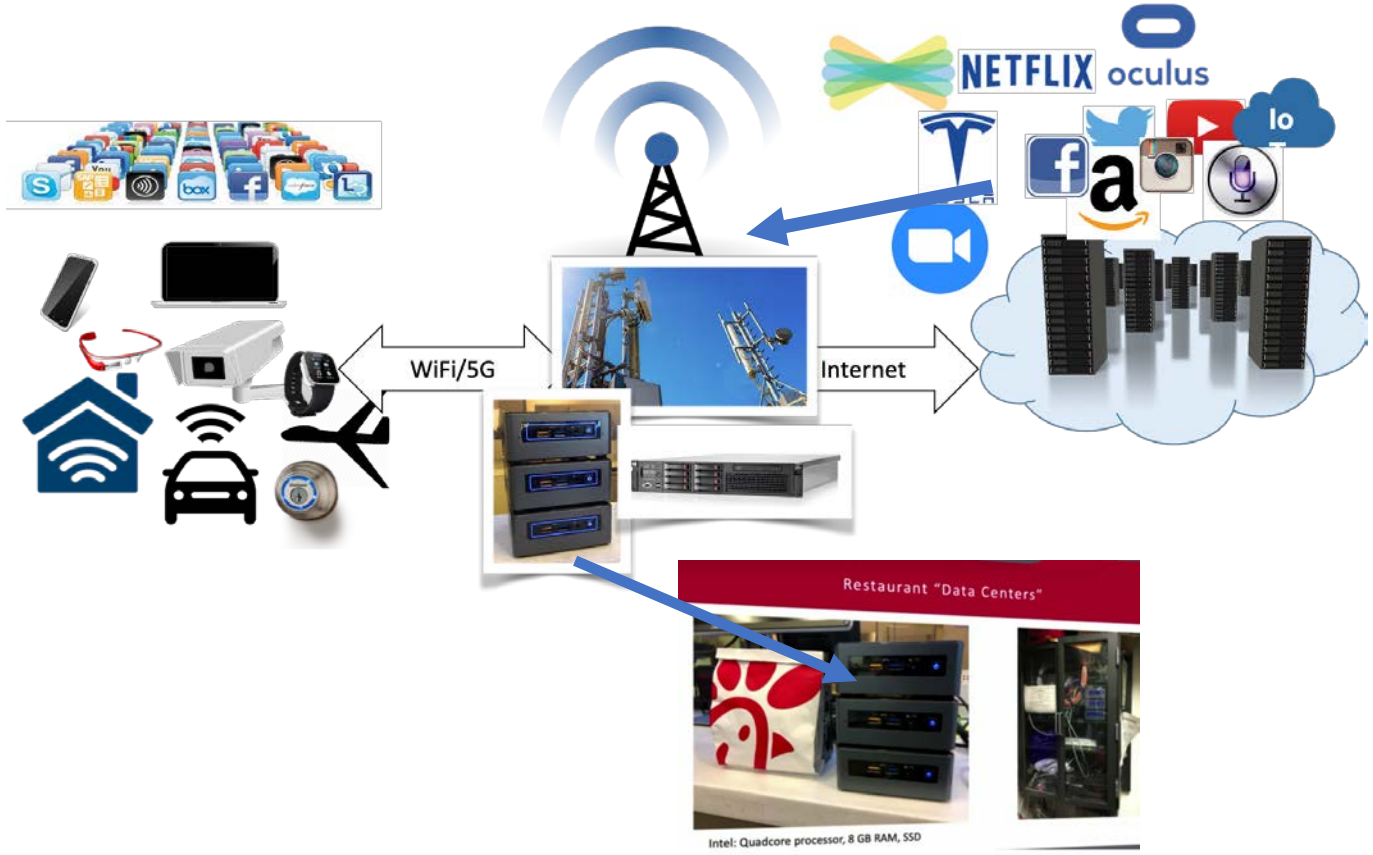
ONF 5G/LTE-network-aaS

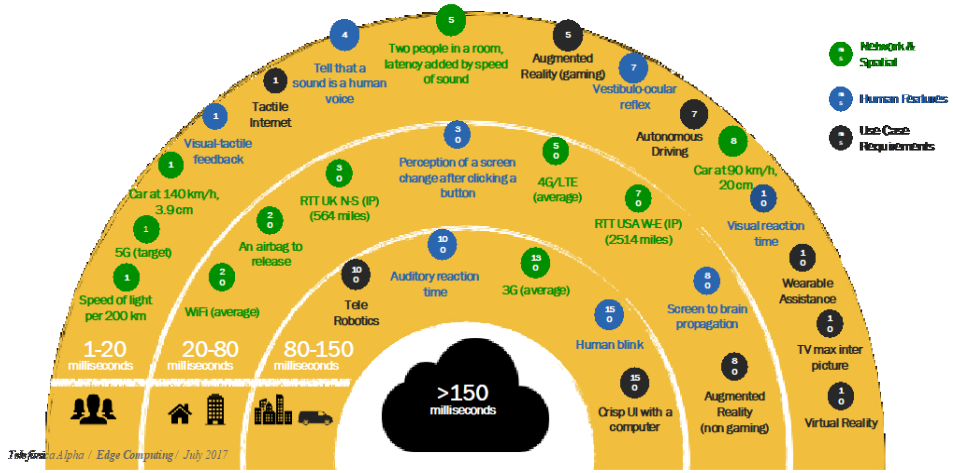


E.g., Scaling Community Cellular Networks with Community Cellular Manager, Shaddi Hasan et al., NSDI'19

Close the gap by trading one resource for another

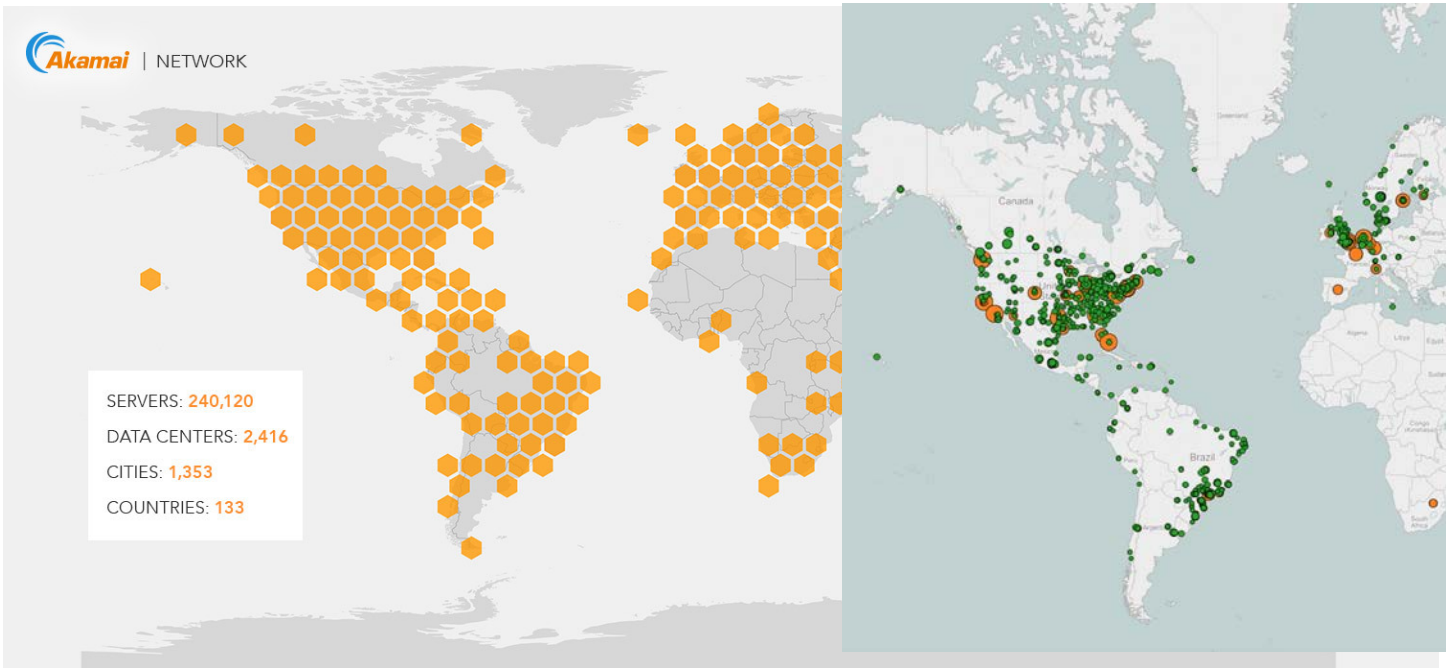
- Edge Computing, Mobile/Multi-access Edge Computing (MEC)
- use compute at the network edge to deliver latency, bandwidth, privacy, …

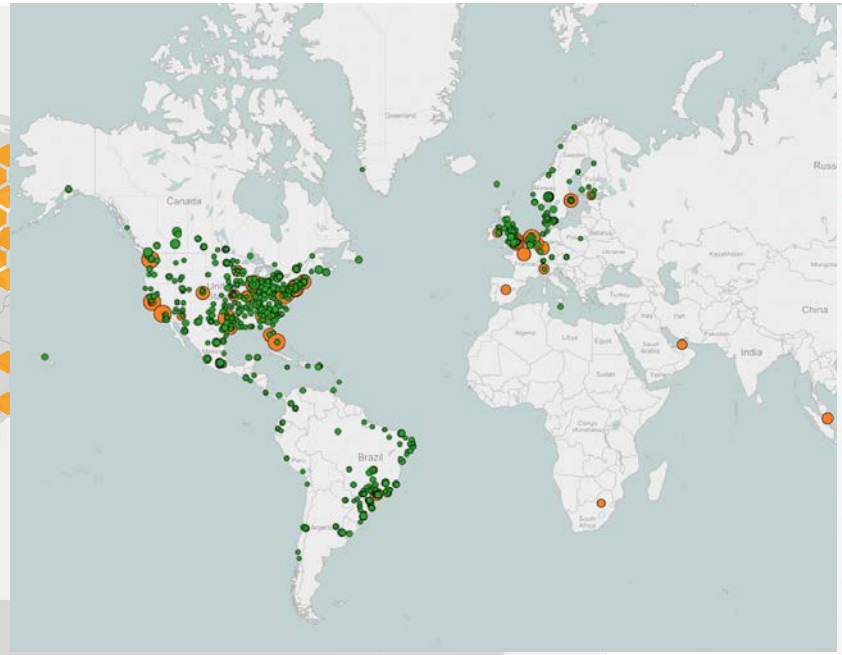


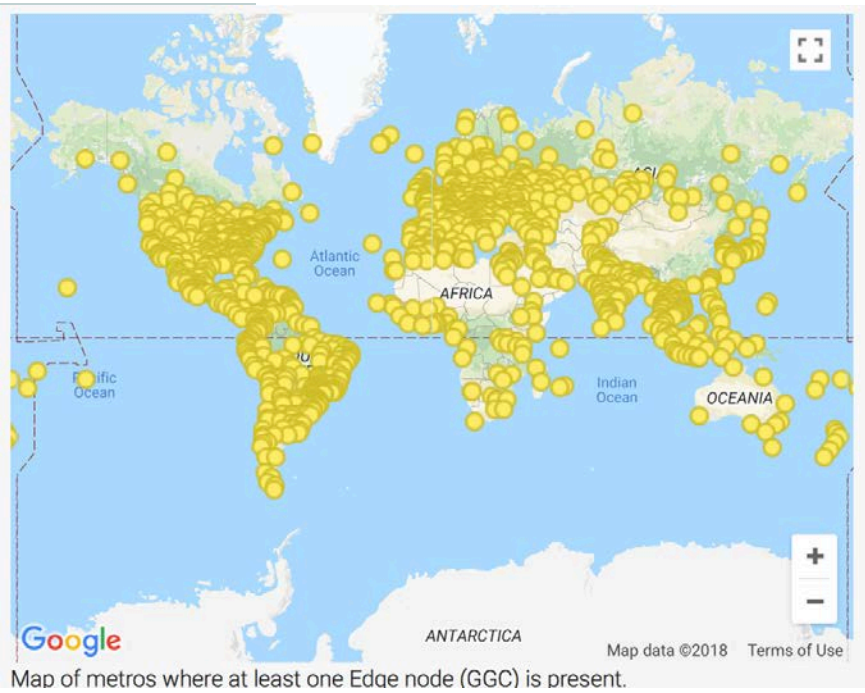


Source: Pablo Rodriguez, Telefonica Alpha, SEC'17

Is it new? Isn't there an "edge" today?







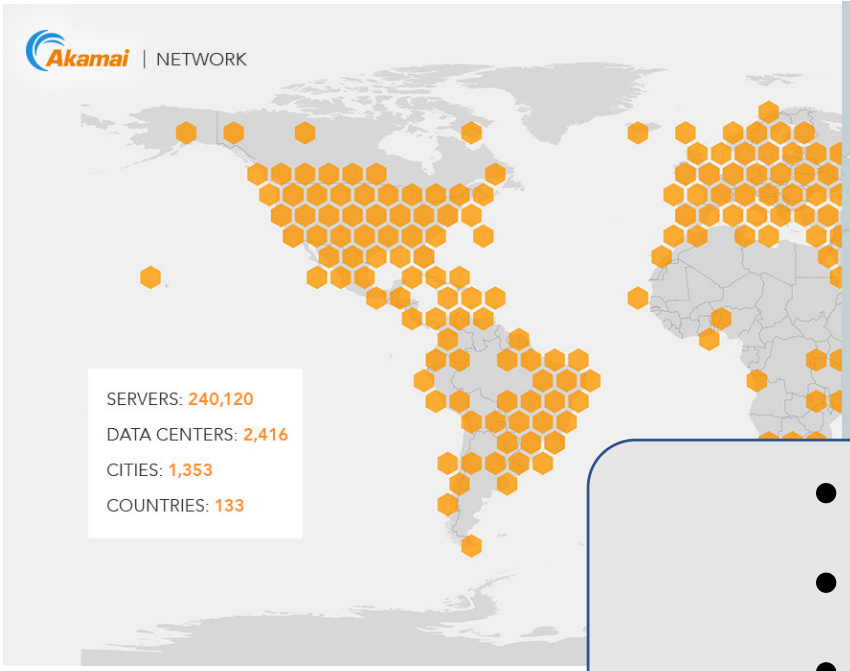
Map of metros where at least one Edge node (GGC) is present.

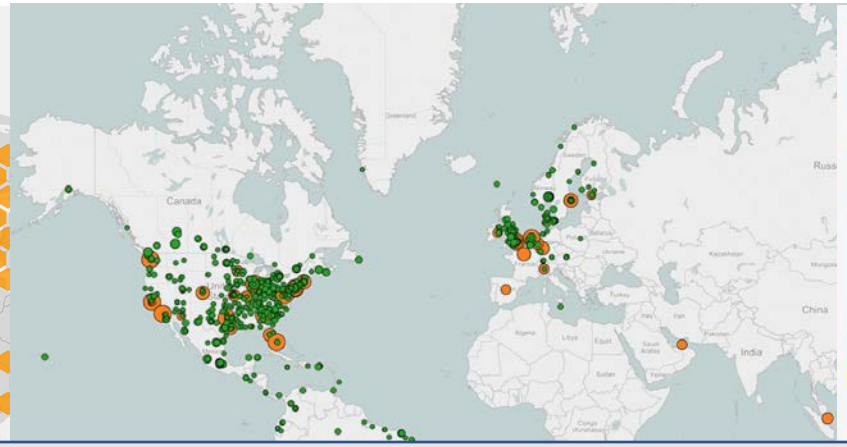
Akamai CDN

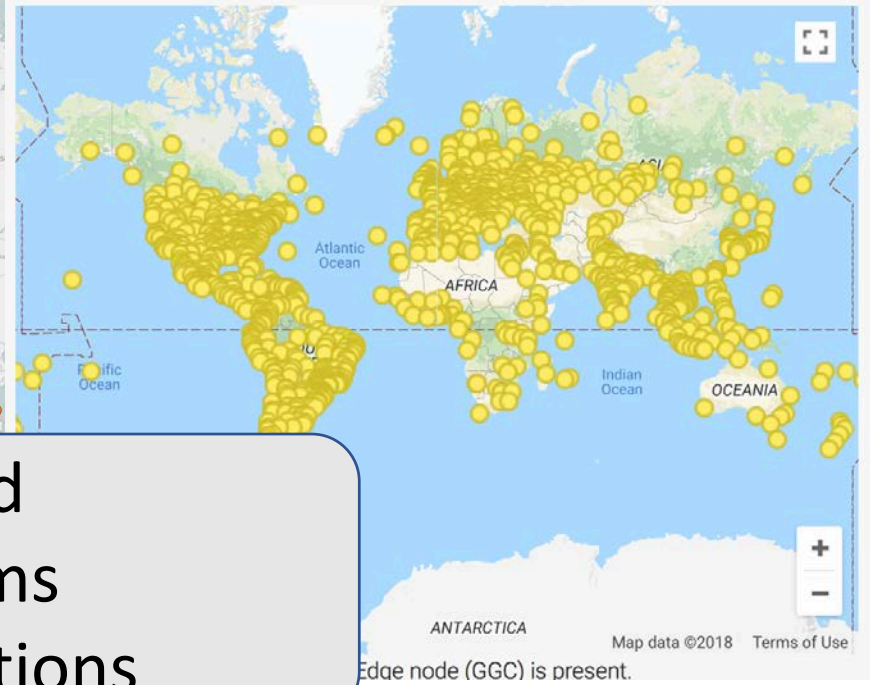
Netflix Open Connect

Google Global Cache

Is it new? Isn't there an "edge" today?







- Reduce backhaul demand
- Several 10s to few 100s ms
- O(few 1000s) global locations

Akamai CDN

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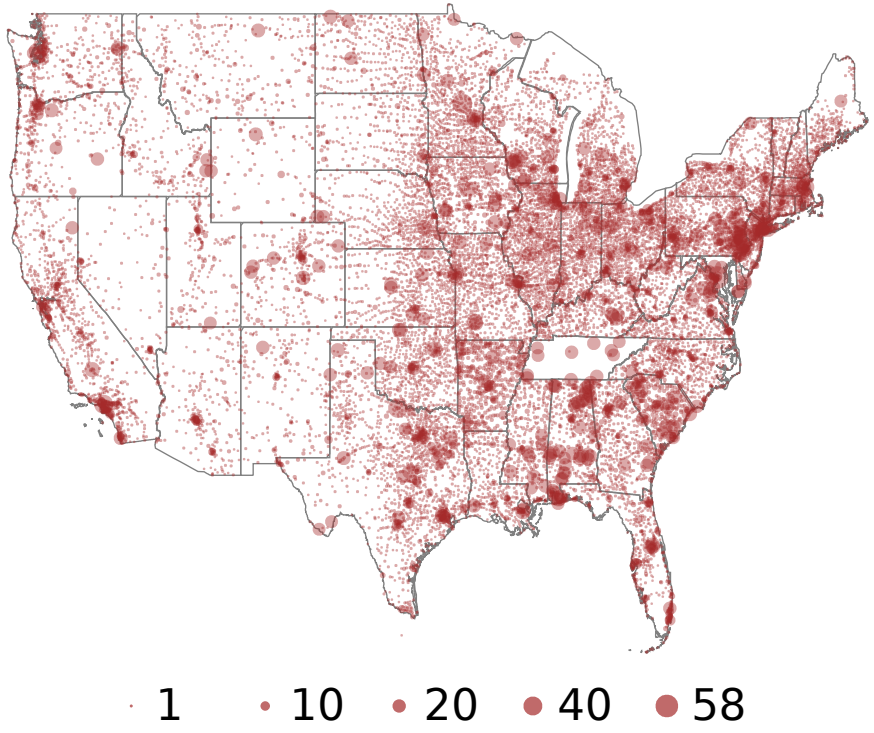
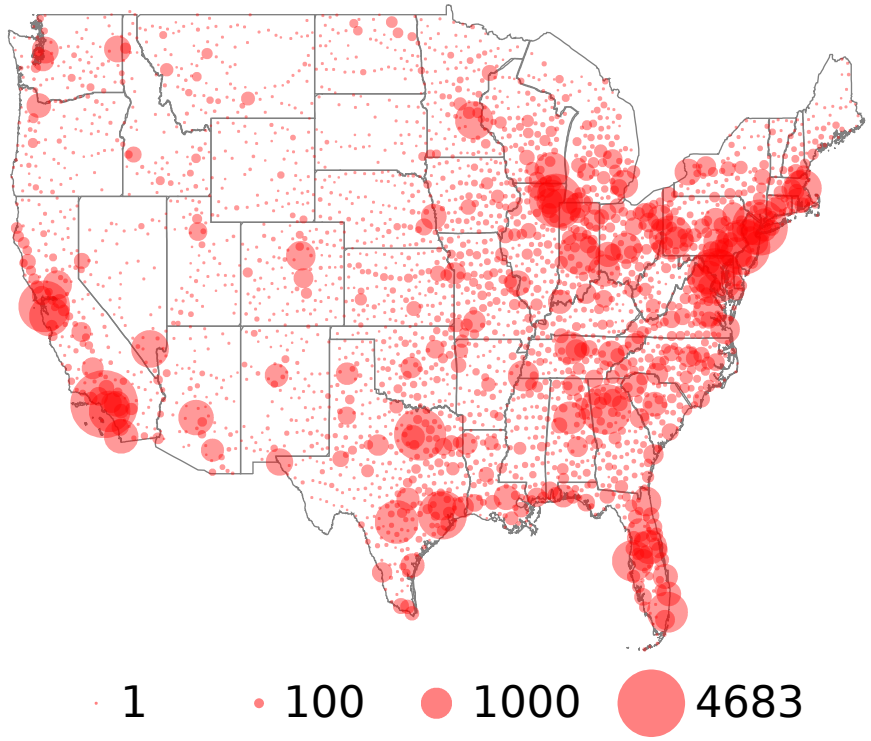
New “deeper”/“leafier” edge is emerging



FCC registered central offices
Total 30,669, as of Mar. 2017



FCC registered cellular towers **locations** (Crown Castle, …)
Total 217,346, as of Mar. 2017

Source: FCC, not guaranteed to be fully inclusive

New “deeper”/“leafier” edge is emerging

Deutsche Telekom Embarks on Edge Computing for IoT

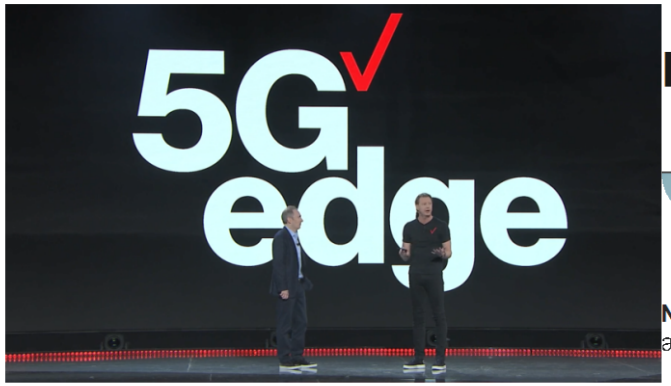
Matt Kapko | Editor
December 3, 2019 12:22 PM

T-Systems, a subsidiary of global operator Deutsch computing platform that delivers low latency for Io facilities. The EdgAir platform is designed to operat security and transmit data in less than 10 milliseco and consulting company.

The platform is based on OpenStack and allows en virtual machines (VM) or in Docker containers as microservices that operate independent of the underlying infrastructure. The containers are also coordinated via Kubernetes and EdgAir equipment can be installed as a pole mount, ruggedized rack, or a standard rack.

Verizon partners with AWS to bring more power to its 5G edge

by Sue Marek | Dec 3, 2019 4:33pm



Verizon CEO Hans Vestberg made an appearance at AWS re:Invent conference in Las Vegas to talk about how Verizon plans to incc AWS cloud compute and storage at the network edge. (AWS)

Verizon is bringing cloud computing closer to its 5G network edge by teaming with Amazon Web Services (AWS). Verizon will use AWS Wavelength, Amazon's new cloud platform designed for edge computing, to make it easier for developers to create and deploy low latency applications.

AT&T and Microsoft announce early result of their 5G-cloud partnership

CNN

LIVE TV

Updated 5:47 PM ET, Tue November 26, 2019

New York (CNN Business) —AT&T and Microsoft have announced the next phase of a partnership that's aimed at advancing development in two of the buzziest areas of tech: 5G and cloud computing.

The companies inked an agreement in July to work together on innovations in 5G and cloud. 5G is next generatio network technology that's expected to change the way people live and work. And the cloud is distributed data storage and computing power that doesn't rely on traditional on-site data centers. AT&T (T) (CNN's parent company) also agreed to migrate its data and workflows to the Microsoft Azure cloud, in what was reportedly a more than $2 billion deal for Microsoft (MSFT), according to Reuters.

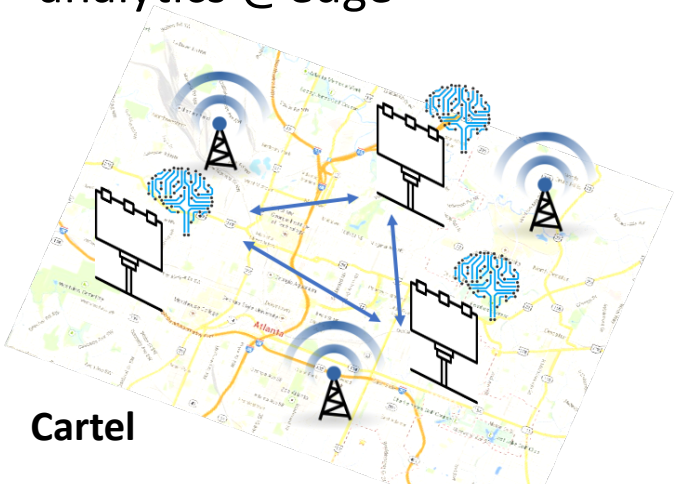
On Tuesday, Microsoft and AT&T's business unit announced the pilot launch of their so-called "network edge compute" technology, an early outcome of the partnership. The advancement is expected to help both companie enterprise customers take advantage of the benefits of 5G, as AT&T works to roll out 5G across the US by mid-2020.

Source: FCC, not guaranteed to be fully inclusive

Our research: systems software for MEC

Edge-native technologies

- Edge ≠ Cloud
  - Systems software for a multi-tenant edge with latency-centric SLOs
  - Security and privacy
  - Application frameworks for edge-cloud and distributed analytics @edge



Cartel

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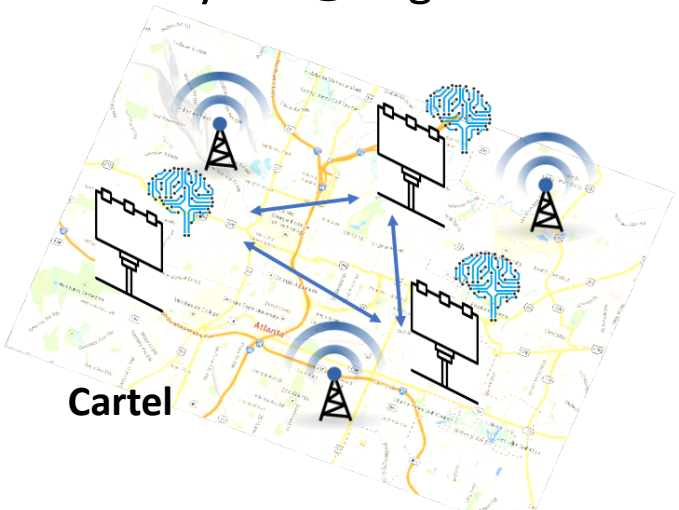

Edge use cases

- Services and applications
  - CDN, AR/VR, …
  - Mobile app delivery and updates
  - IoT analytics
  - Visual computing

Our research: systems software for MEC

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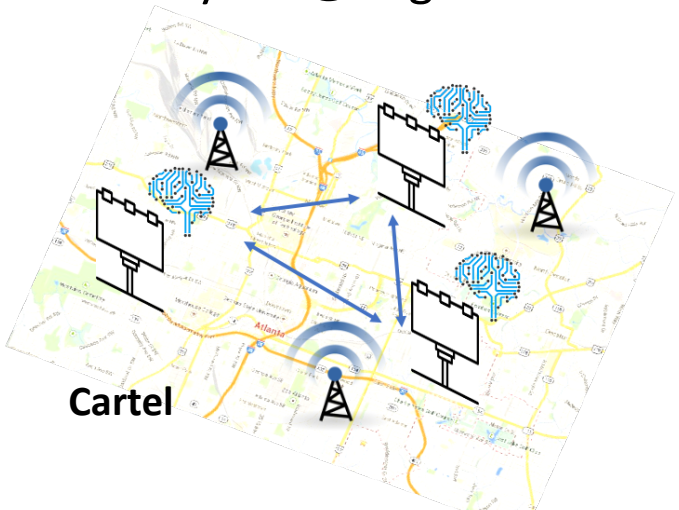

Edge use cases

- Services and applications
  - CDN, AR/VR, …
  - Mobile app delivery and updates
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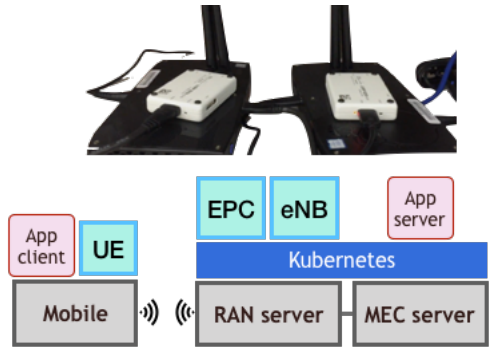
  - Visual computing

MEC-in-a-Box

- Turn-key deployment
  - Containerized mobile networks and MEC stack
  - Commodity x86 servers and USRPs
  - Containerized edge-ready applications



Demo at: https://tinyurl.com/mec-in-a-box

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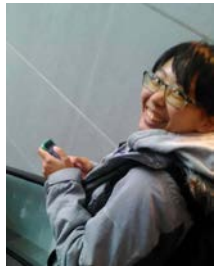

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Applications Driving Architectures

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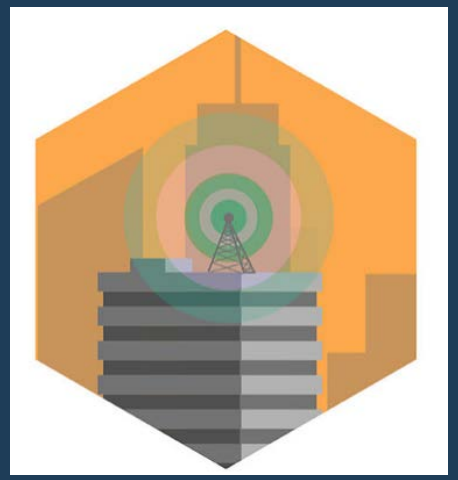
TECH BOOTCAMP 2019

TV WHITE SPACE: OVER-THE-AIR BROADBAND FOR RURAL LIBRARIES

WHAT IS TV WHITESPACE?



OVER THE AIR

White Spaces are unused spectrum. Typical TVWS installations use UHF and VHF broadcast spectrum.

HARDWARE

TVWS requires a base radio and client radios. In flat areas with no interference, range can be up to 6 miles.

SPEEDS

We have averaged 15mbps (symmetrical) in our area, even given moderate interference from Atlanta TV stations.

BENEFITS FOR PUBLIC LIBRARIES

LEVERAGE EXISTING FIBER CONNECTION

Existing speeds at all Georgia Public Libraries are sufficient to add TVWS.

REACH NEW PATRONS

Because we can't build libraries in every neighborhood, TVWS allows libraries to reach new areas and patrons, often underserved.

PROVIDE BACKUP FOR EMERGENCY SERVICES

TVWS has been used during emergencies when cell networks were inoperable.

ADD VALUE TO PUBLIC RESOURCES

By installing equipment in public parks and pools, libraries can add value to these public spaces, making taxpayers and funding agencies happy.

TVWS Deployment at Twin Lakes

A Journey

APRIL 2017

Applied for Beyond the Walls grant, as recommended by State Librarian.

MAY 2017

TLLS announced as a winner of grant, vendor selected, contract with vendor signed.

EARTH TWICE ORBITS THE SUN

APRIL 2019

Equipment installed by vendor.

MAY 2019

Local installer and IT business configure equipment and finalize installation. We're live!

Base Station Unit, atop Mary Vinson Memorial Library

Client Radio Unit, atop lightpole at Oconee Greenway

Future

- TWIN LAKES

Additional grant for development of a mobile TVWS device.

- HARDWARE VENDORS

Improvements to hardware increasing bandwidth and noise rejection have begun arriving.

- GOVERNMENT AND PRIVATE INVESTMENT

State and local governments, Microsoft, and other interested organization are pursuing developments of TVWS technology to address the digital divide.

ADDITIONAL READING

BEYOND THE WALLS

http://giglibraries.net/BTW-About

MICROSOFT TVWS ARTICLE

https://news.microsoft.com/on-the-issues/2019/06/25/airband-white-space/

Libraries WhiteSpace Project

Overview video (2 min.)

https://www.youtube.com/watch?v=SofOEsh3BNU

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