Schools receive over $4 billion per year for "high performance" broadband:
Do (we/they) know what that means?

James Deaton (Great Plains Network)
Mark Johnson (MCNC)

AIMS 2018

Background

- 1996 Telecommunications Act established foundation for E-Rate
- Administered by the Universal Service Administration Corporation (USAC)
- Reimburses a discounted portion of the total cost of Internet, WAN, and managed internal broadband services for schools and libraries
- Began distributing funding in 1998
- Often matched by state-based programs covering portions of the unreimbursed amounts

An open API for USAC E-rate data is finally available

Background

State Educational Technology Directors Association (SETDA) published a [report in 2012](#) establishing recommendations for **bandwidth per student**

FCC [E-Rate Modernization Orders of 2014](#) adopts SETDA numbers as a bandwidth target

Education Superhighway embraced and popularized this concept in [ESH's State of the States Report](#) with engagement directly with Governors

Background

FCC Bandwidth Goals

BROADBAND ACCESS FOR TEACHING, LEARNING AND SCHOOL OPERATIONS	2014-2015 SCHOOL YEAR TARGET	2017-2018 SCHOOL YEAR TARGET
An external Internet connection to the Internet Service Provider (ISP)	At least 100 kbps per student	At least 1 Mbps per student
Internal Wide Area Network (WAN) connections from the district to each school and among schools within the district	At least 1 Mbps student	At least 10 Mbps per student

https://upgrade.educationsuperhighway.org/types-of-fiber-services/k-12-bandwidth-targets/

Background

In September 2016, the State Educational Technology Directors Association (SETDA) released "[The Broadband Imperative II: Equitable Access for Learning.](#)"

- **Small School District (Fewer than 1,000 students)**
  - At least 1.5 Mbps per user (100 Mbps minimum for district) by 2017-18
  - At least 4.3 Mbps per user (300 Mbps minimum for district) by 2020-21
- **Medium School District (3,000 students)**
  - At least 1 Gbps per 1,000 users by 2017-18
  - At least 3 Gbps per 1,000 users by 2020-21
- **Large School District (More than 10,000 students)**
  - At least 0.7 Gbps per 1,000 users by 2017-18
 - At least 2.0 Gbps per 1,000 users by 2020-21

Current State

Broadband now critical to schools and used for administrative purposes, testing, course management, course content

Bandwidth per student, dollars per megabit, special construction, and managed wireless are directing funding practices but experience at the schools often falls short in being able to qualify what the schools are receiving

Spotty attempts to measure capacity with opaque methods and little, if any raw data

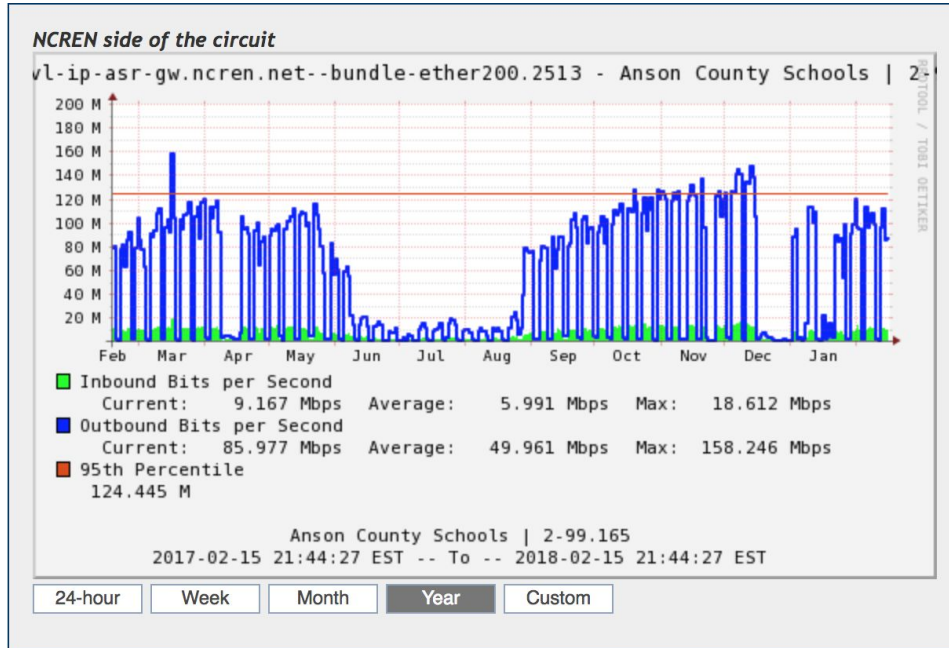# Infrastructure Influenced By FCC Modernization Order
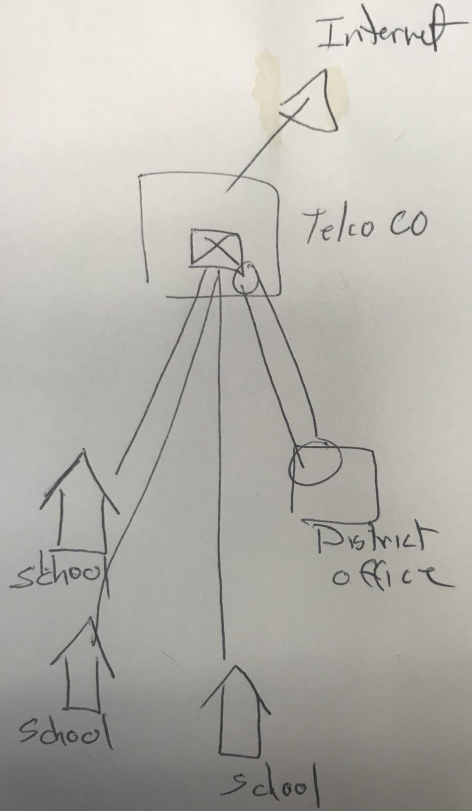
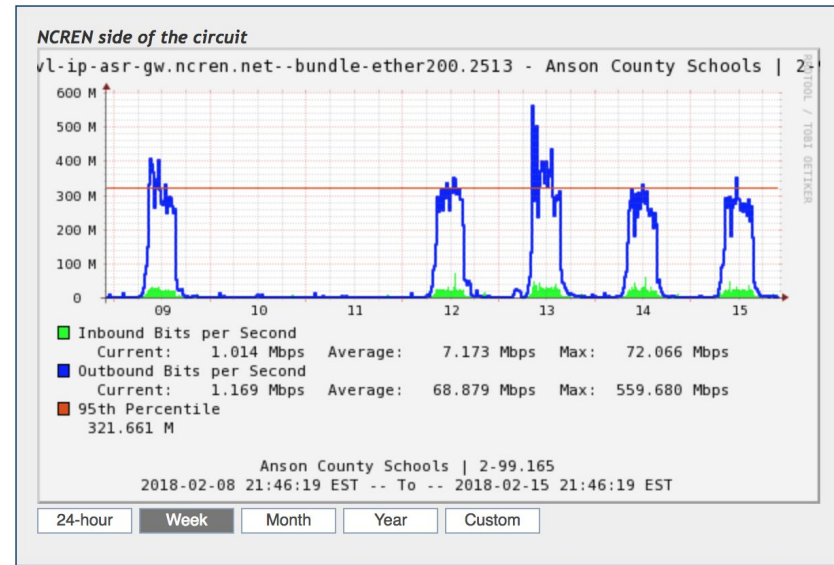Typical district connection architecture
(outside of building)
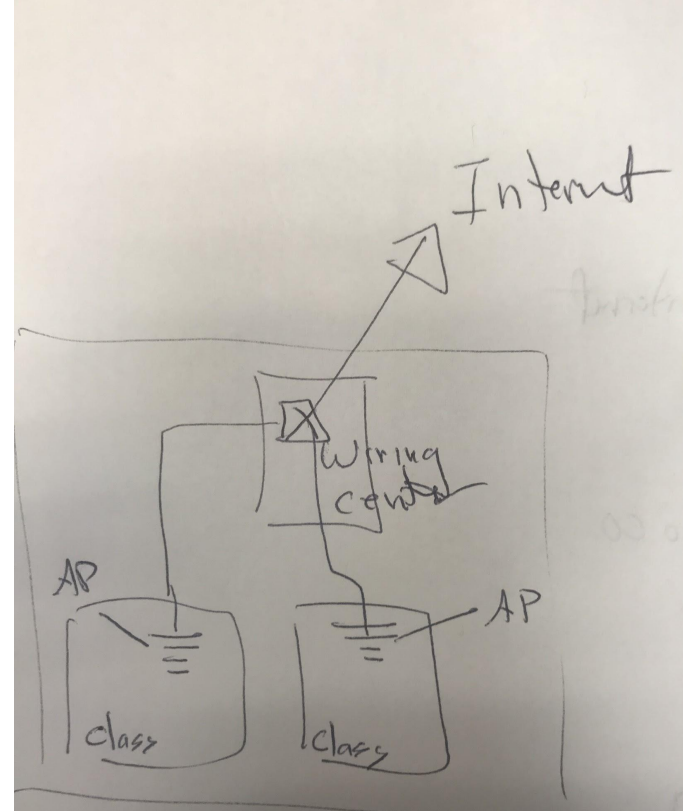
Typical building architecture:
Wired to building, wireless to users

District-level measurements

NCREN side of the circuit
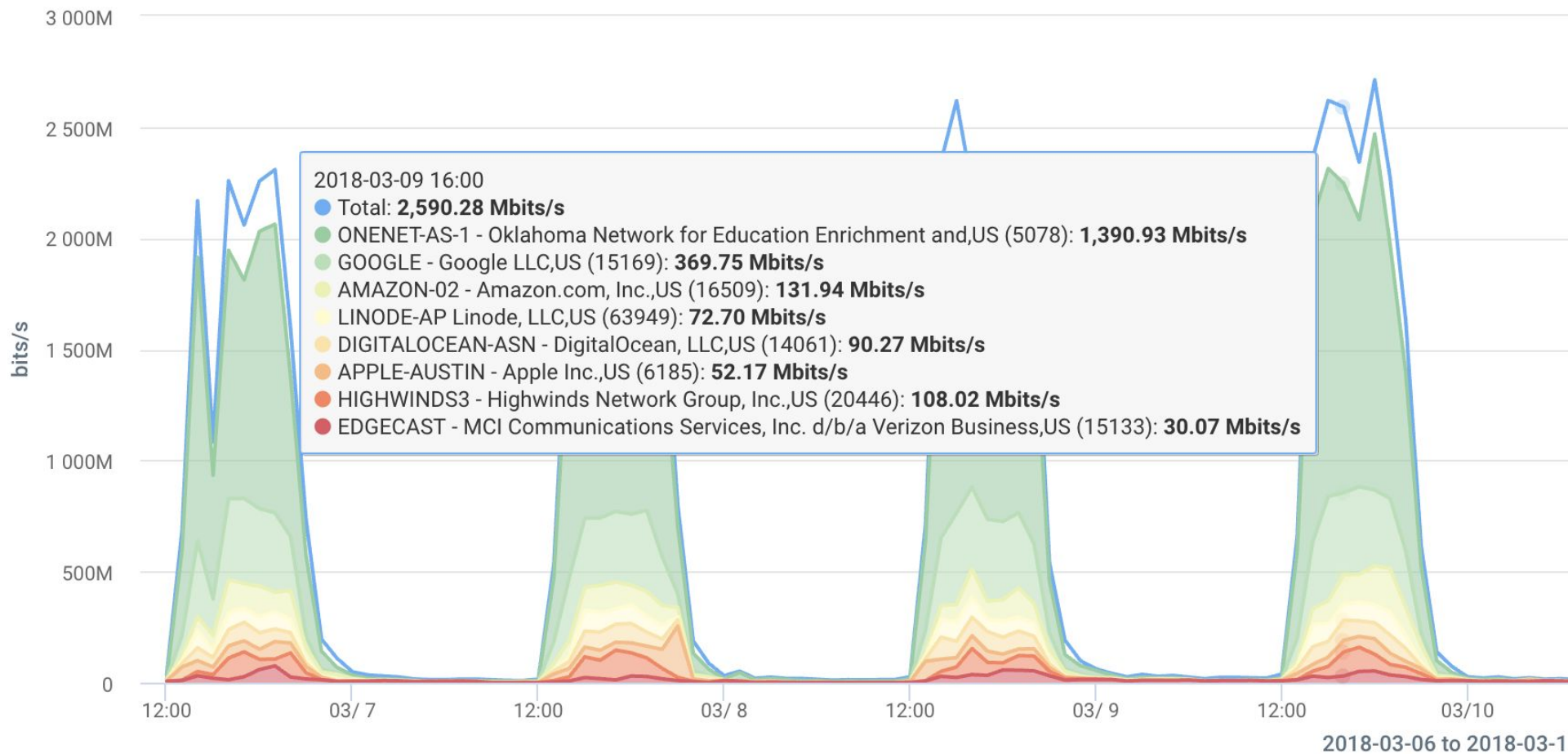
vl-ip-asr-gw.ncren.net--bundle-ether200.2513 - Anson County Schools | 2-

Inbound Bits per Second
Current: 9.167 Mbps Average: 5.991 Mbps Max: 18.612 Mbps
Outbound Bits per Second
Current: 85.977 Mbps Average: 49.961 Mbps Max: 158.246 Mbps
95th Percentile
124.445 M

Anson County Schools | 2-99.165
2017-02-15 21:44:27 EST -- To -- 2018-02-15 21:44:27 EST

[24-hour] [Week] [Month] [Year] [Custom]

Yearly utilization cycle

Summer, Christmas, spring breaks visible
Typical growth from spring to fall

NCREN side of the circuit

vl-ip-asr-gw.ncren.net--bundle-ether200.2513 - Anson County Schools | 2-

Inbound Bits per Second
Current: 1.014 Mbps Average: 7.173 Mbps Max: 72.066 Mbps
Outbound Bits per Second
Current: 1.169 Mbps Average: 68.879 Mbps Max: 559.680 Mbps
95th Percentile
321.661 M

Anson County Schools | 2-99.165
2018-02-08 21:46:19 EST -- To -- 2018-02-15 21:46:19 EST

[24-hour] [Week] [Month] [Year] [Custom]

Weekly utilization cycle

Weekends visible
Consuming vs providing
workday-only

Top Source AS Number by Average bits/s

2018-03-09 16:00
- ● Total: **2,590.28 Mbits/s**
- ● ONENET-AS-1 - Oklahoma Network for Education Enrichment and,US (5078): **1,390.93 Mbits/s**
- ● GOOGLE - Google LLC,US (15169): **369.75 Mbits/s**
- ● AMAZON-02 - Amazon.com, Inc.,US (16509): **131.94 Mbits/s**
- ● LINODE-AP Linode, LLC,US (63949): **72.70 Mbits/s**
- ● DIGITALOCEAN-ASN - DigitalOcean, LLC,US (14061): **90.27 Mbits/s**
- ● APPLE-AUSTIN - Apple Inc.,US (6185): **52.17 Mbits/s**
- ● HIGHWINDS3 - Highwinds Network Group, Inc.,US (20446): **108.02 Mbits/s**
- ● EDGECAST - MCI Communications Services, Inc. d/b/a Verizon Business,US (15133): **30.07 Mbits/s**

2018-03-06 to 2018-03-1

NCREN UTILIZATION MAP - K-12

February 2018 ▲▼

<= 31.35 kbps	31.36 - 69.12 kbps	69.13 - 106.88 kbps	106.89 - 144.66 kbps	144.67 - 182.43 kbps	>= 182.44 kbps

◉ Per-Student Utilization
○ Per-Student Utilization (Peak Day)
○ Total Utilization
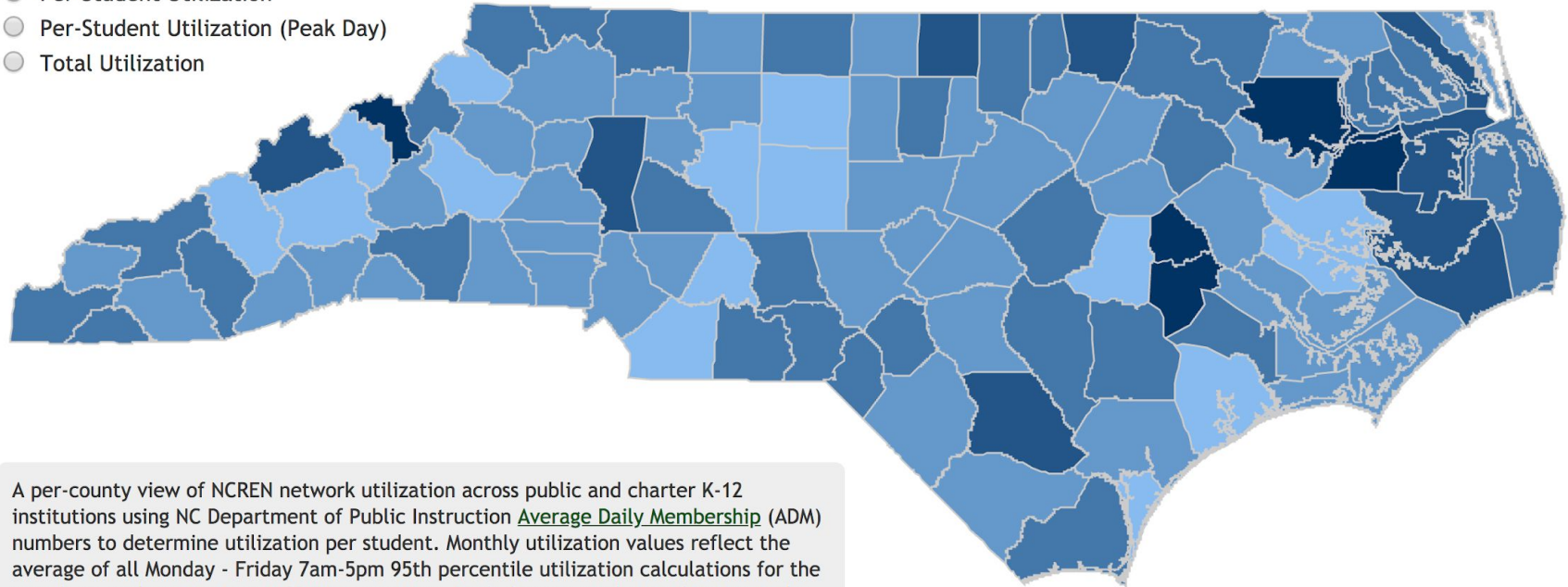
A per-county view of NCREN network utilization across public and charter K-12 institutions using NC Department of Public Instruction Average Daily Membership (ADM) numbers to determine utilization per student. Monthly utilization values reflect the average of all Monday - Friday 7am-5pm 95th percentile utilization calculations for the month on each institution's NCREN connection. Peak day per-student utilization is the 95th percentile for the busiest single day.
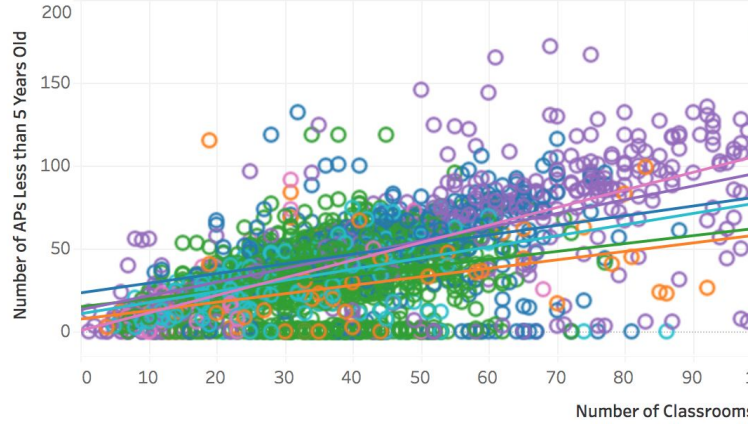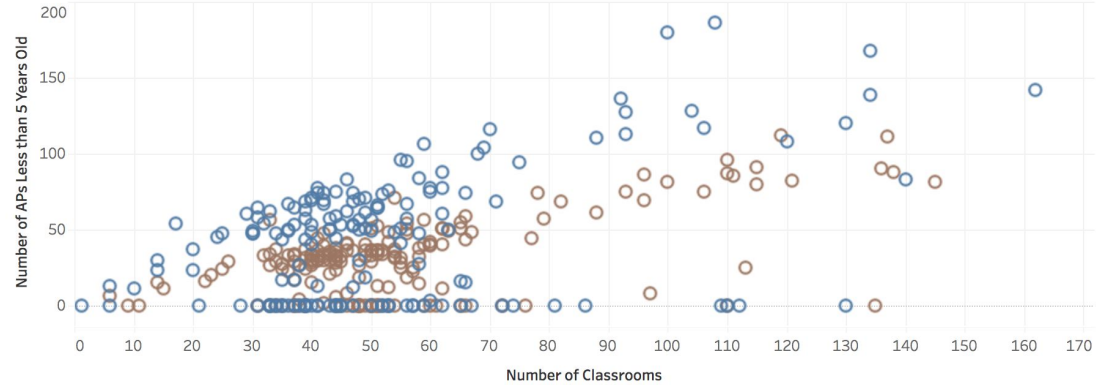
NC K12 traffic growth
2011–2017
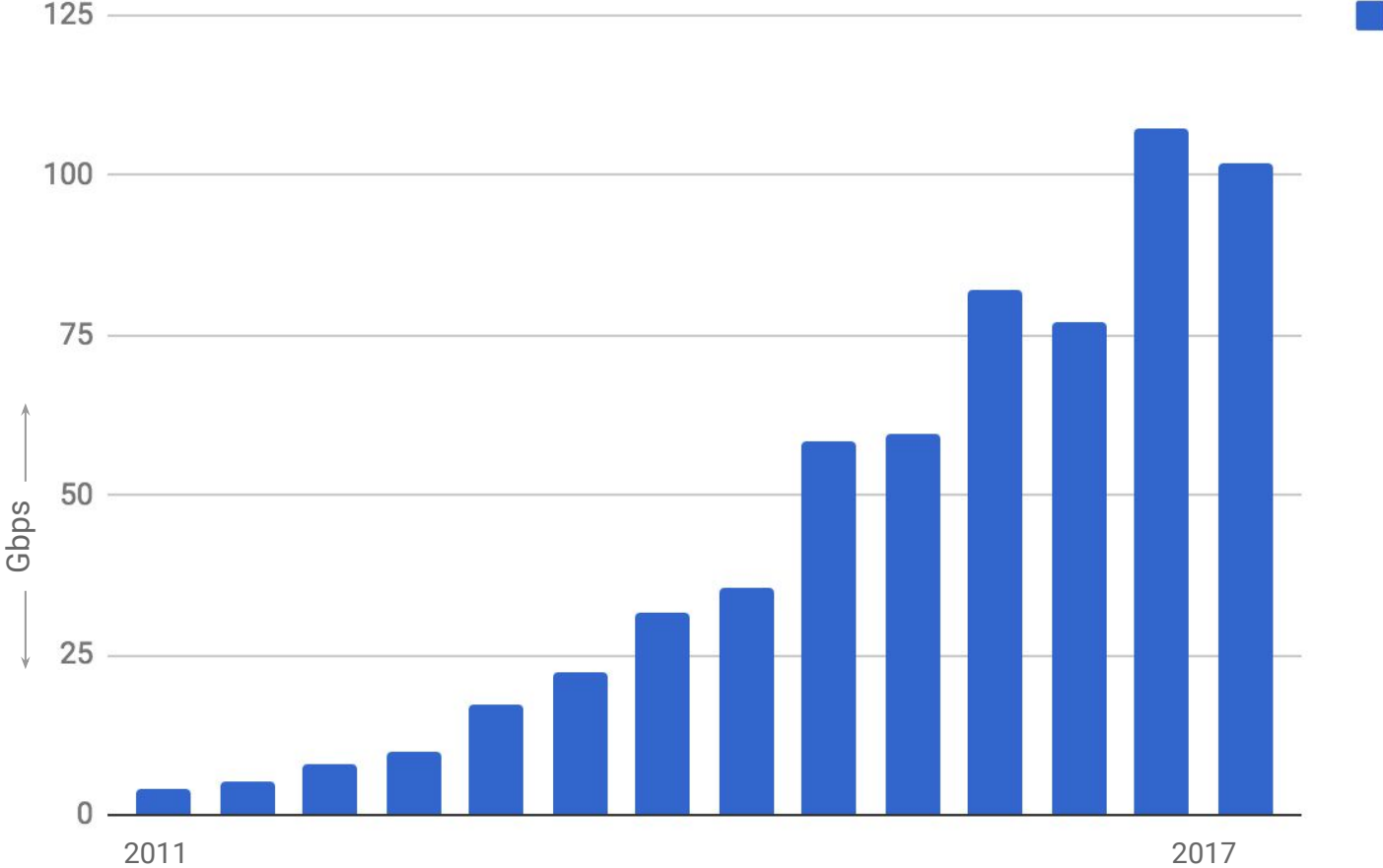
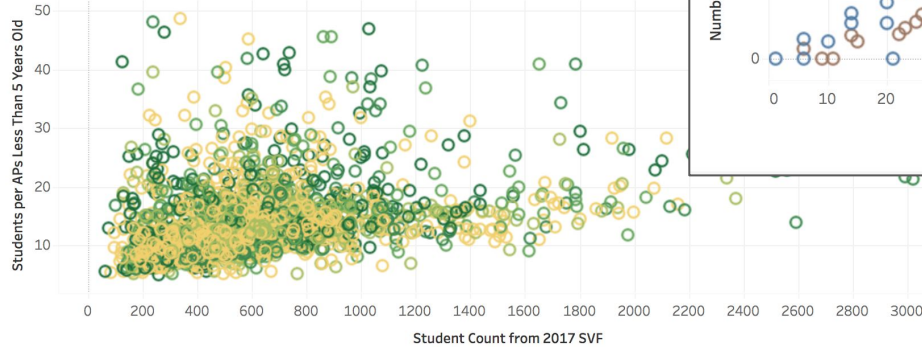# Sample data on WiFi deployment in North Carolina

Classrooms versus Access Points (less than 5 years old)

Compare Selected Districts (APs less than 5 years old only)

Students per New AP Ratio (APs less than 5 years old)

Can we correlate this to performance?

Measurement Issues

Collecting and maintaining reliable active measurements

- Software approaches have often defaulted to having some administrator run speed test software on desktop machine of unknown capability at unknown and inconsistent times
- Little effort has been made to measure at the wireless user or compare that to edge of building
- Passive measurement introduces privacy concerns. Very little data on application performance (QoE)

  A mix of application types with different user bases, requirements, expectations
  E.g. Business administration, course administration, course content, standardized testing

Possible approaches

Introduce hardware appliance
      http://projectbismark.net/ – focused on home use, reprogrammed home routers
      http://perfclub.org/ – university research use, Raspberry PI devices
      https://www.samknows.com/ – FCC sponsored home use measurement
      https://atlas.ripe.net/ – European measurement, purpose-built devices

Need to define methods (traffic type, frequency, location of appliance, etc)
Carefully choose test destination endpoints to ensure consistency
- Endpoint selection must consider that the majority of traffic for many schools are sourced from cloud providers like Google and Amazon

Backend data store, schema
Base level visualization

Important philosophy

All data and methods should be open

Unresolved Issues

What are appropriate QoE measurements?

When, Where and How should measurement occur?

How do we use the measurements to drive policy?

What is the best way to communicate measurement results?

Current experience suggests policy makers don't want much (any?) complexity or nuance