Hewlett Packard
Enterprise

techUK Spectrum Policy Forum (SPF)

Future Demand for Indoor Spectrum

Large Public Venues (LPVs)

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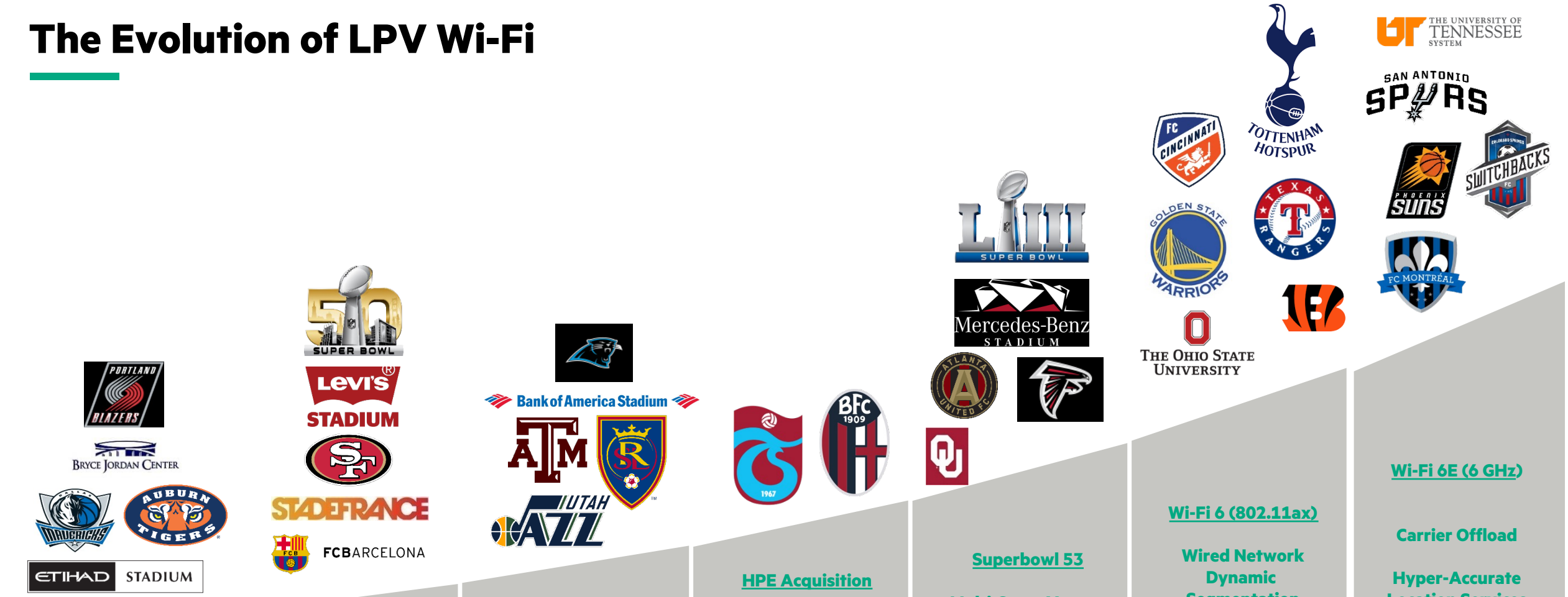
The Evolution of LPV Wi-Fi



Early Adopters

Air-Time Limited

Fan Experiences

Location Services

Scale – 100K Users

Setting Records

HPE Acquisition

Global Scale

Wired plus Wi-Fi

Superbowl 53

Multi-Sport Venues

World Records

Wi-Fi 6 (802.11ax)

Wired Network Dynamic Segmentation

Guest Experience Analytics

Wi-Fi 6E (6 GHz)

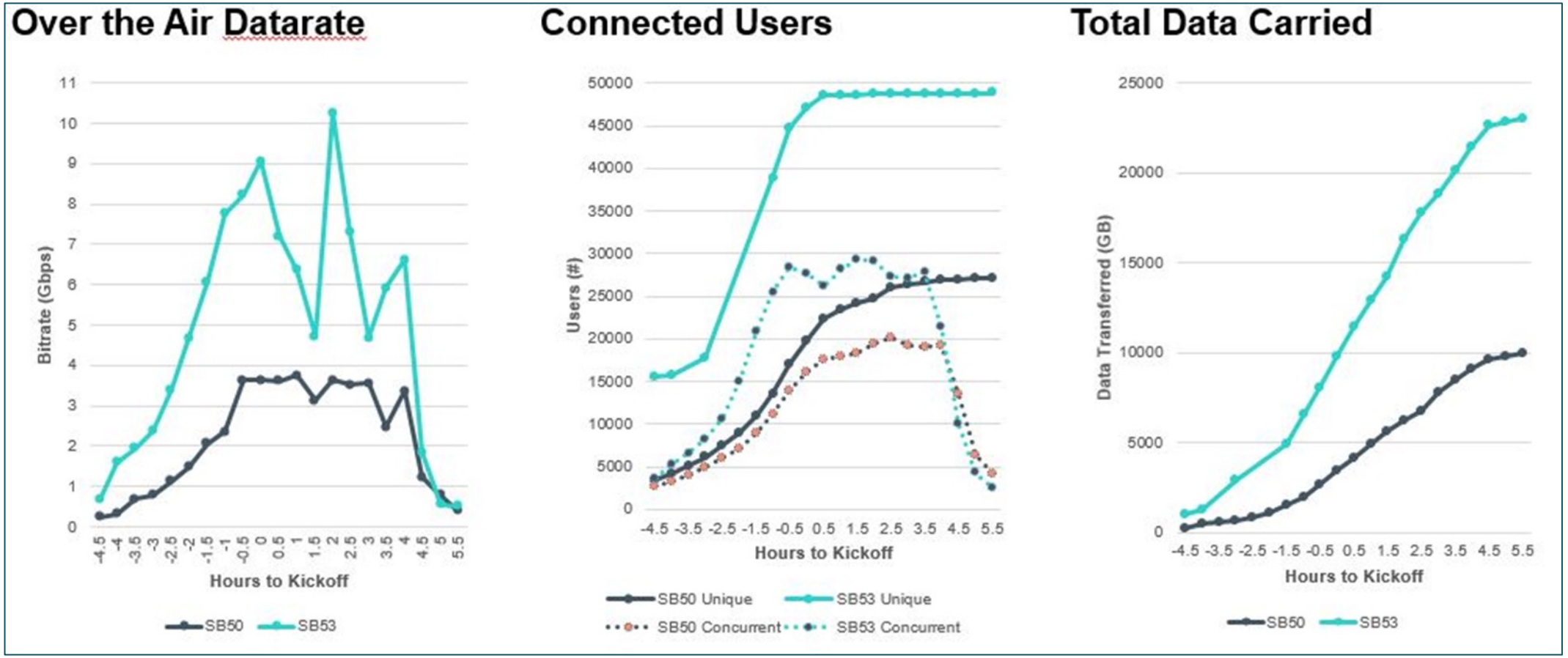
Carrier Offload

Hyper-Accurate Location Services

Private 5G

2002 → 2023 +

The Superbowl as a LPV “Benchmark”



SB50 – Levi’s Stadium (Feb. 2016) and SB53 - Mercedes Benz Stadium (Feb. 2019)

2023 – Setting NFL Records at Paycor Stadium

https://www.bengals.com/news/paycor-stadium-wi-fi-record-ravens-bengals-playoff-game

Cincinnati Bengals – Paycor Stadium

- *"Wi-Fi data consumption at Paycor Stadium reached new heights during Sunday's playoff game as fans connected to the state-of-the art network in record numbers."*
- The Wi-Fi network processed data at a higher rate than the Super Bowl as traffic soared to 22.3Gbps.
- The previous high for an NFL game was 20.7 Gbps recorded at Super Bowl LVI.
- Key areas of growth include:
  - 76% increase in unique device connections per game
  - 436% increase in maximum data rate with average peak data rates reaching 10.7Gbps
  - 230% increase in data volume per game averaging 8.5TB transferred per game with 12.8TB transferred during the playoff game.

2023 – Setting World Records at Ohio State University

Stadium Tech Report March 16, 2023

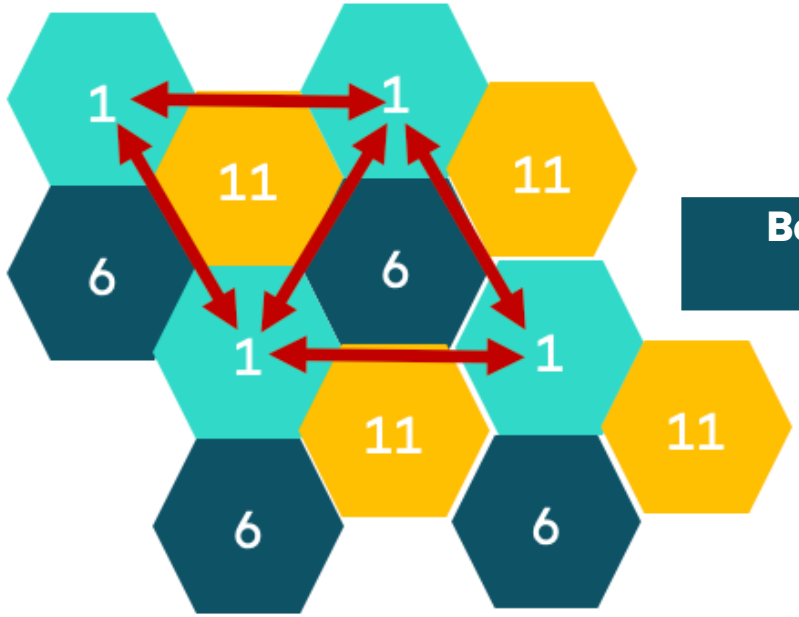
Ohio State sets new top Wi-Fi mark, 34.8 TB, at Michigan game

- Ohio Stadium, home of the Ohio State Football team and one of the largest public venues anywhere, is now the unofficial leader in single-day Wi-Fi data used, with 34.8 terabytes used at the venue on Nov. 26, 2022, during Ohio State's rivalry matchup with Michigan, according to statistics provided by the school.
- With sellout crowds that often top 105,000 in attendance (for Michigan the attendance this season was 106,787, according to the school), Ohio Stadium quickly became one of the top spots for single-day Wi-Fi performance after installing an Aruba Wi-Fi 6 network ahead of the 2019 season.

Densification: More Channels Improve Performance & Reduce Interference

A minimum of 7-9 channels are required for typical enterprise Wi-Fi deployment. Dense **large-public-venues (LPVs) can require 23 or more discrete channels** to support 10s and 100s of thousands of devices.

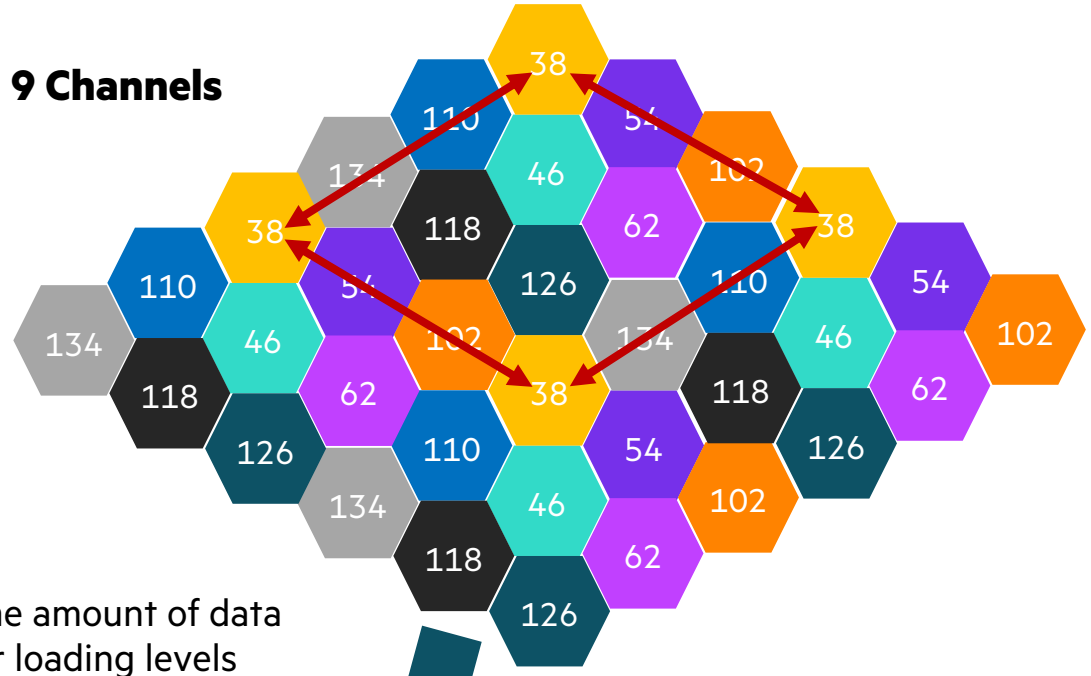
3 Channels



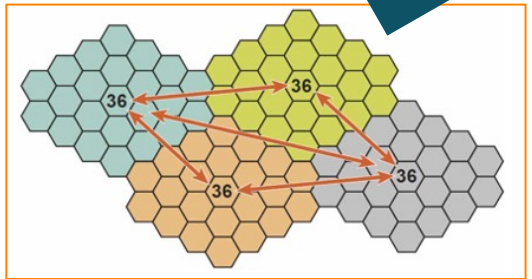
Benefits of Larger Number of Channels

- Lower interference probability
- Lower noise floor
- Higher data rates
  - Less airtime to transmit same amount of data
- Capable of absorbing much higher loading levels by distributing demand

9 Channels

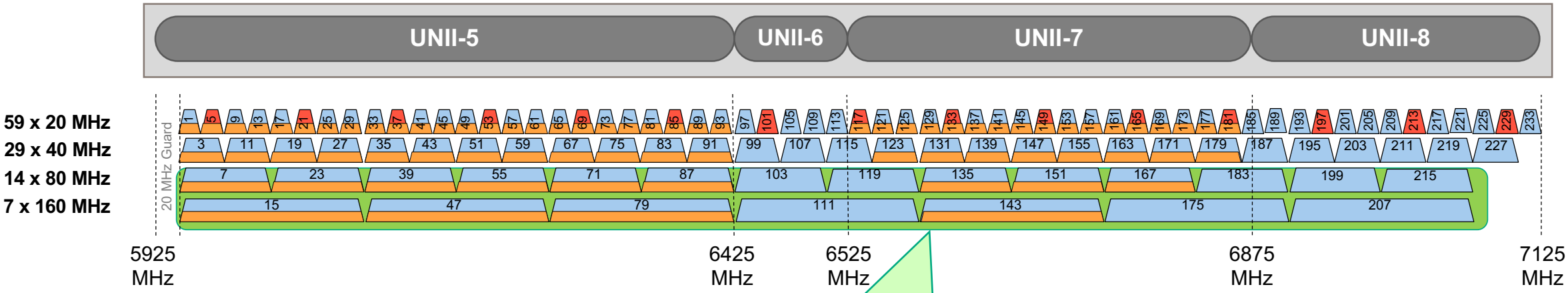


23 Channels



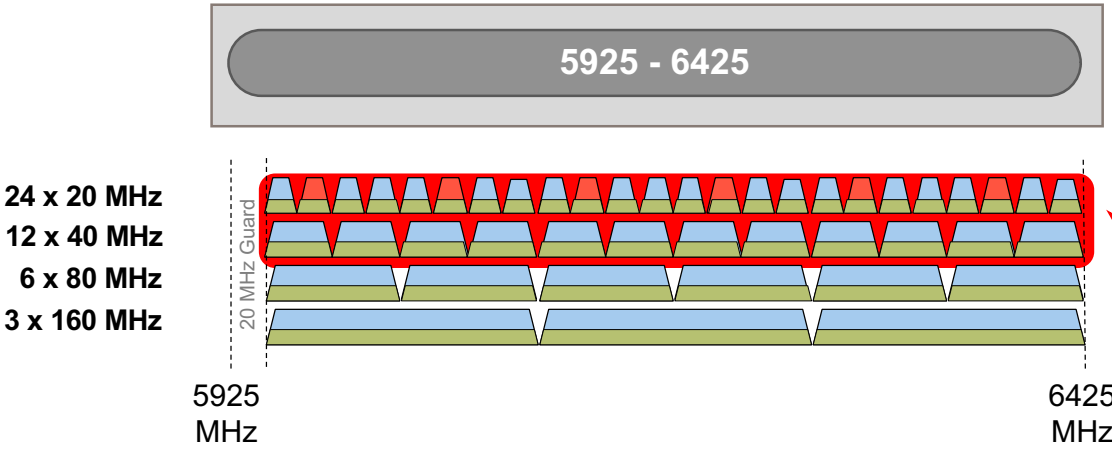
Co-channel Interference

Comparing 1200 MHz vs 500 MHz Channels



80 and 160 MHz channels will be the default for 1200 MHz countries

2x2 Client 160 MHz 1024 QAM = **2.4 Gbps**



20 and 40 MHz channels will continue to be default for 500 MHz countries

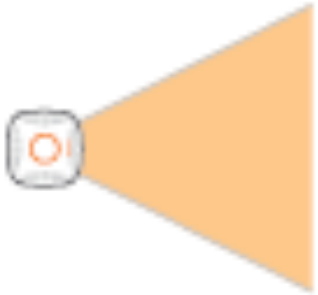
2x2 Client 40 MHz 1024 QAM = **574 Mbps**

Channel Availability		
	1200 MHz	500 MHz
20 MHz	59 (58)	24
40 MHz	29	12
80 MHz	14	6
160 MHz	7	3

RF Coverage Options for LPVs

Overhead Coverage

- APs are placed on a ceiling, catwalk, roof, or other mounting surface directly above the users to be served.
- Depending on the height difference, one can use APs with integrated antennas or connectorized APs with specially chosen external antennas.
- In either case, the direction of maximum gain is oriented downward.
- Generally, APs are placed no more than 4 m (13 ft) above the heads of the crowd to be served.



Side Coverage

- APs are mounted to walls, beams, columns, or other structural supports like hand-rails that exist in the space to be covered.
- Either directional or omnidirectional antennas can be used, with the direction of maximum gain aimed sideways with a shallow down-angle.

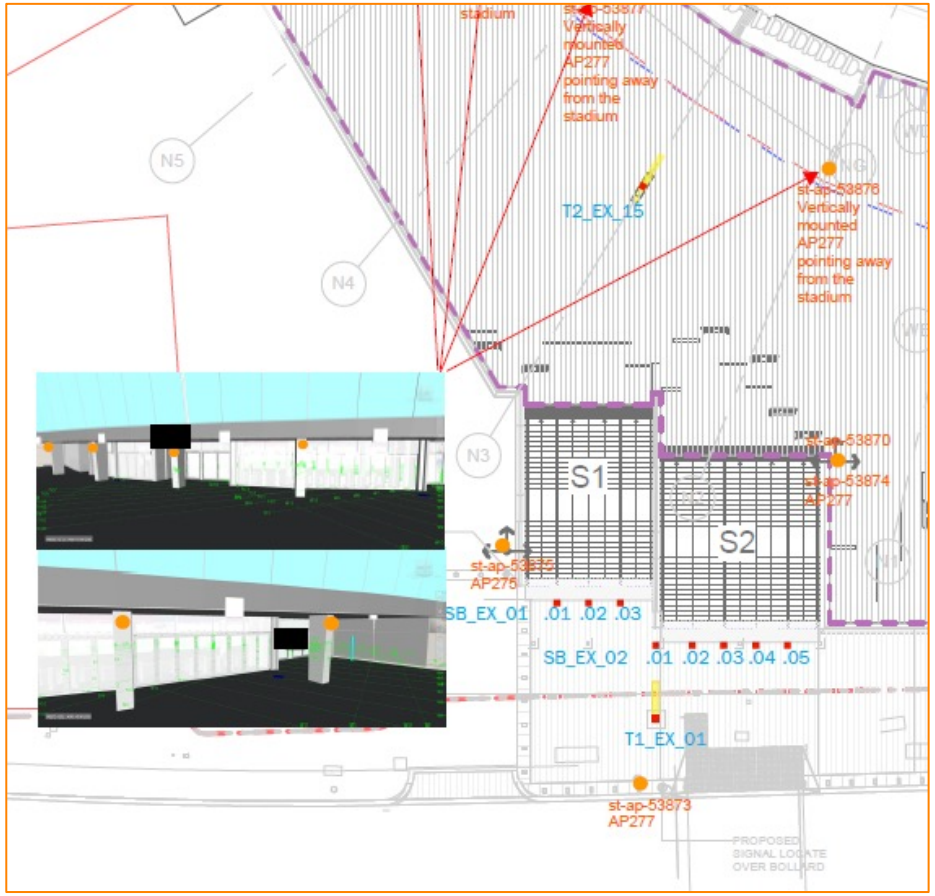
Floor Coverage

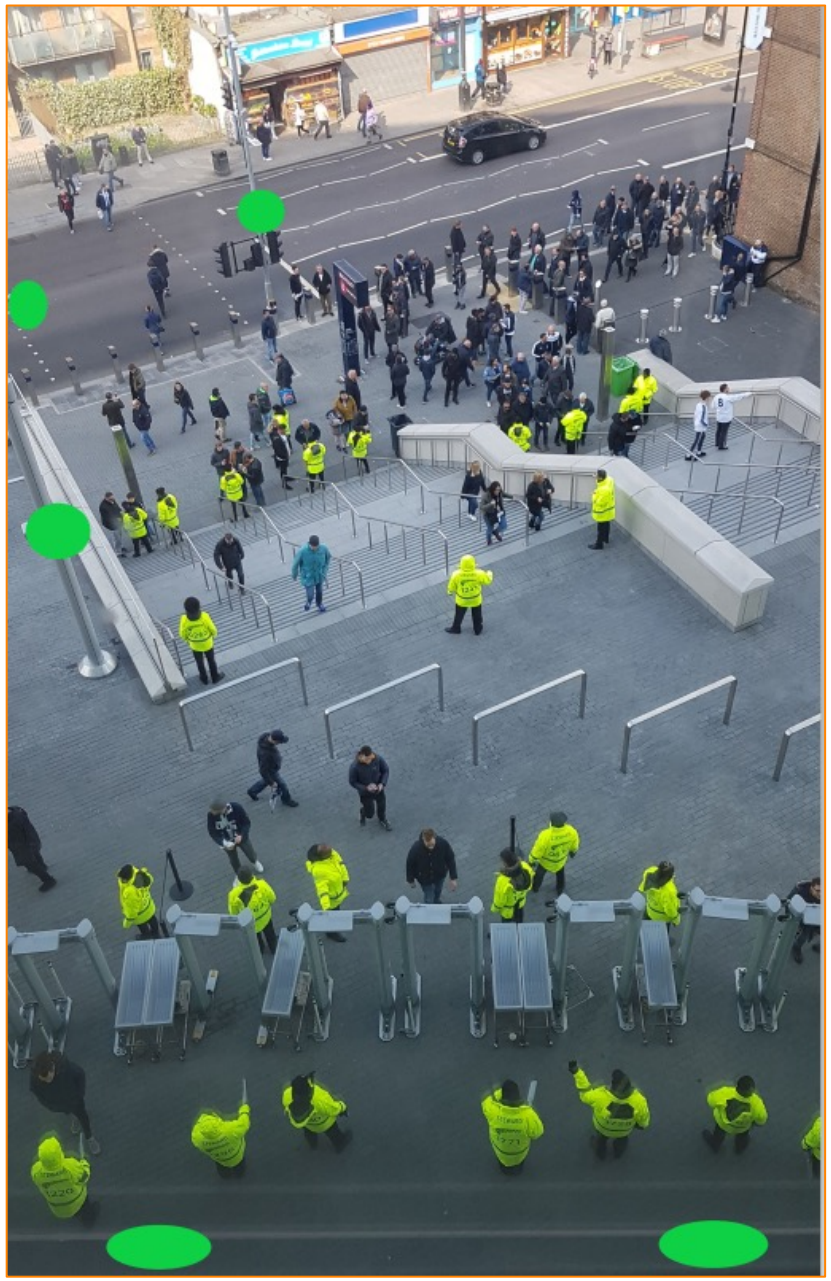
- This design creates picocells using APs mounted in, under, or just above the floor of the coverage area.
- This strategy is the only one that can allow for spatial reuse of channels inside a room of 1,000 m2 (10,700 ft2) or less.
- In general, picocells use APs with integrated antennas to minimize the required space under the seat.

Tottenham Hotspur Football Club

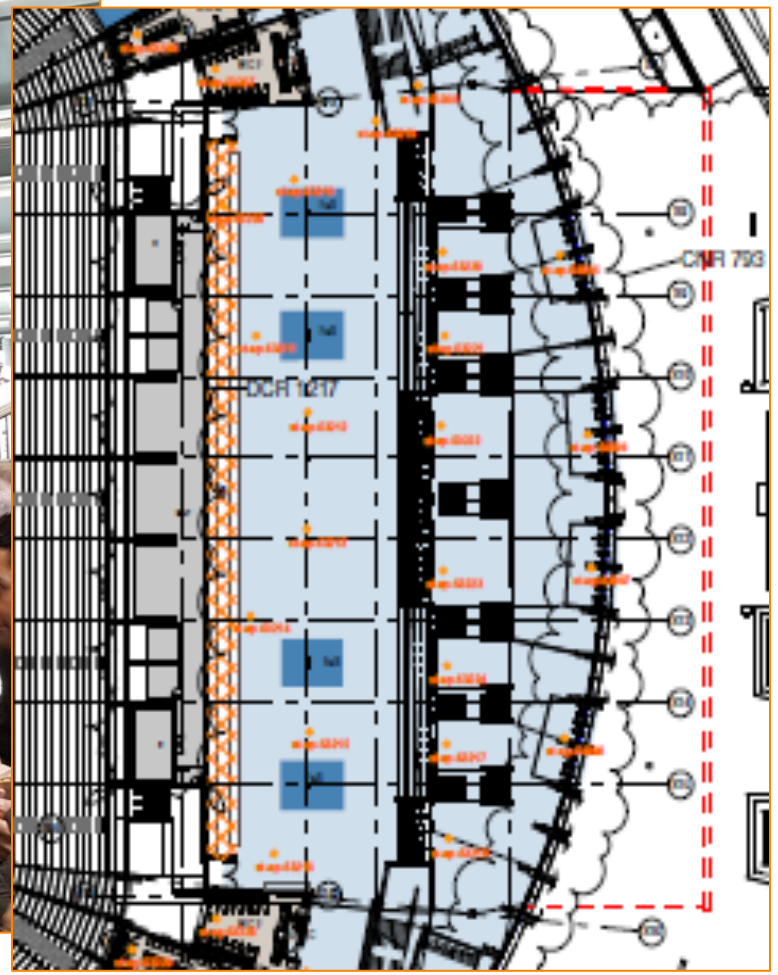
THFC: Perimeter Onboarding/Coverage

Over 100 directional AP's used to onboard users as they approach the stadium

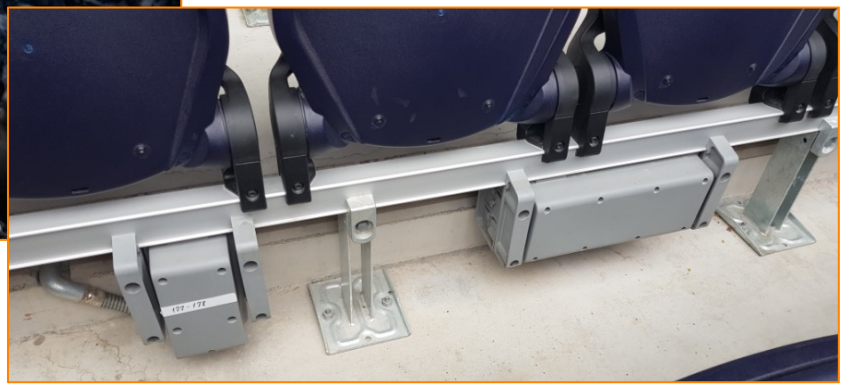




THFC: Concourse Wi-Fi

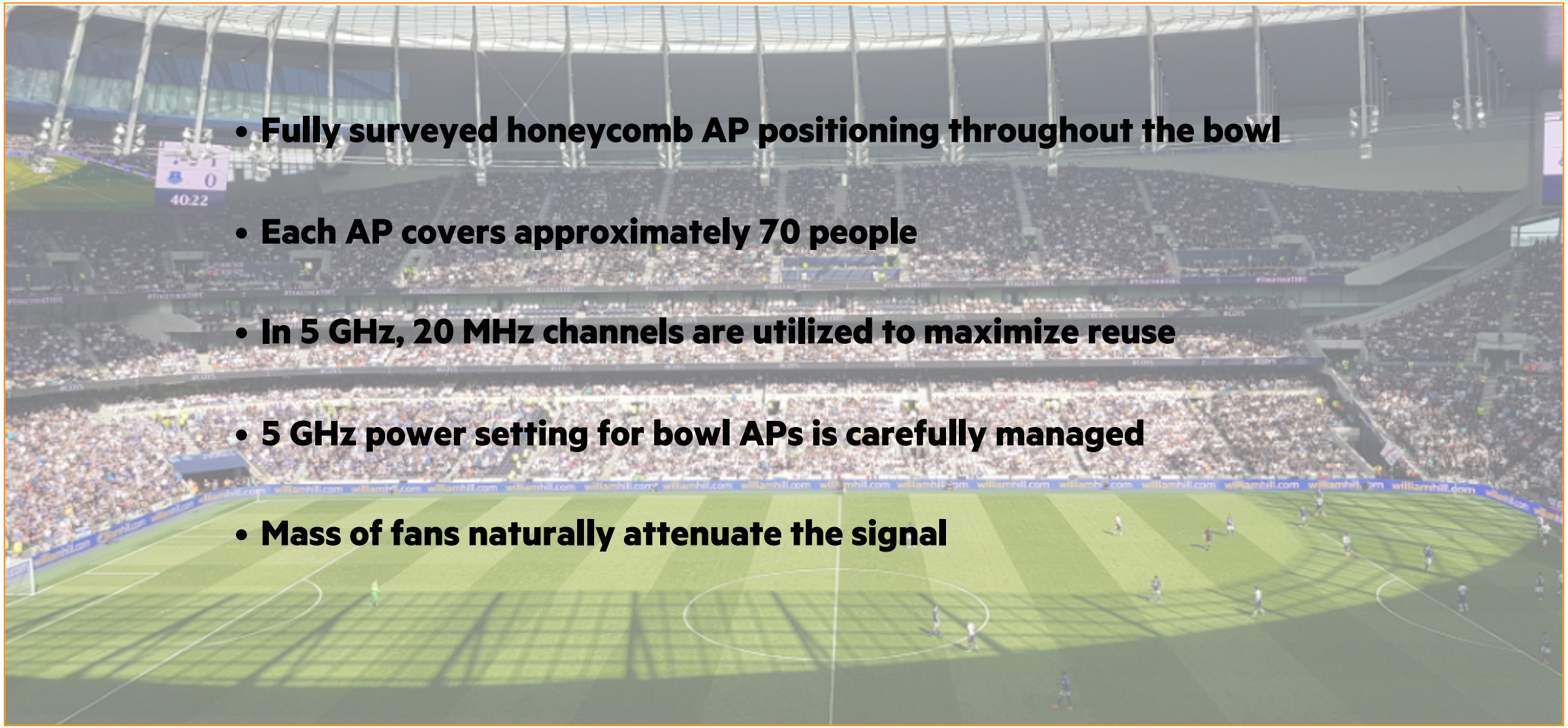


THFC: Wi-Fi in the Bowl



Over 800 APs in protective enclosures fitted to seat rail with separate power termination box

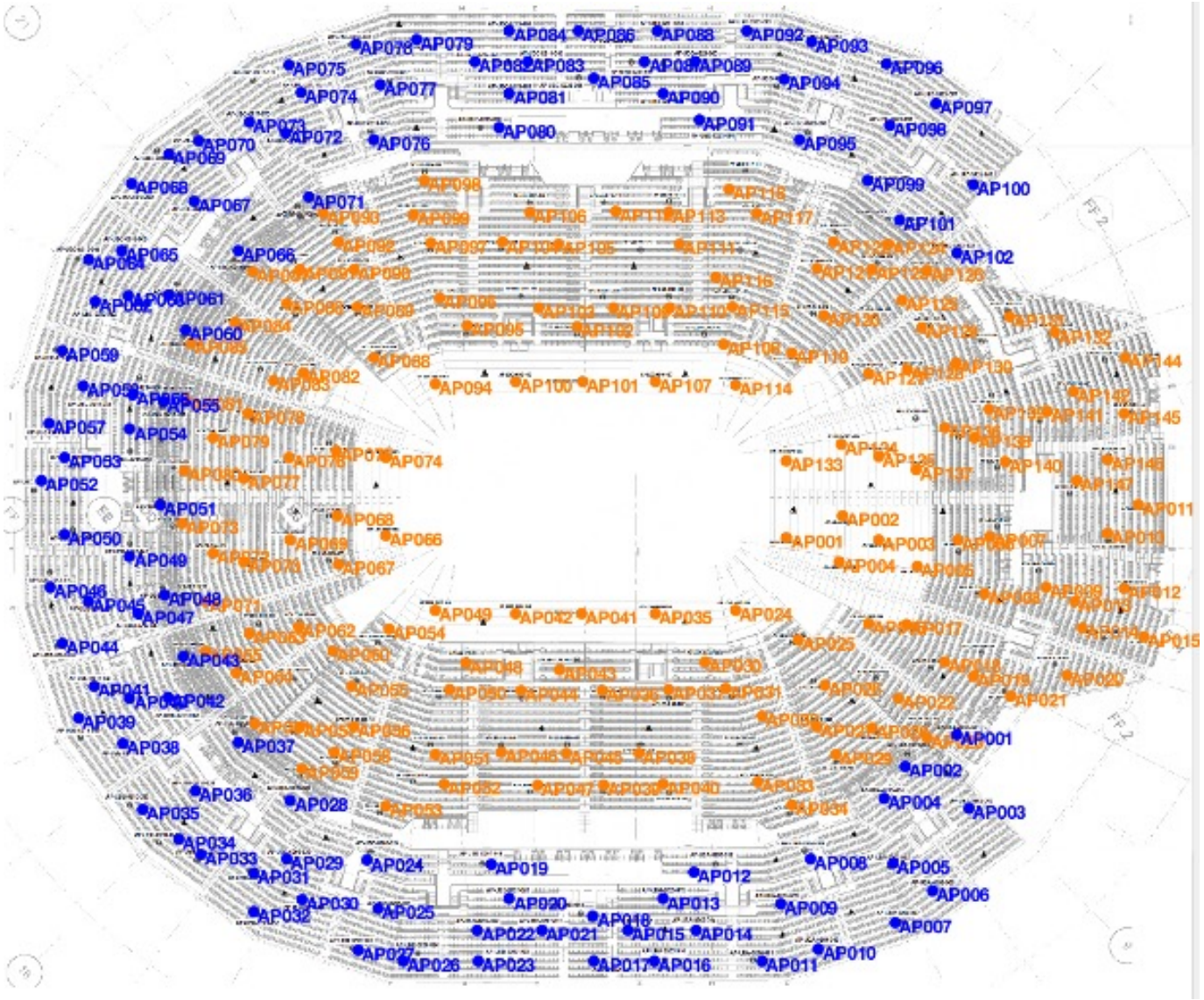
THFC: Bowl AP Configuration



- Fully surveyed honeycomb AP positioning throughout the bowl
- Each AP covers approximately 70 people
- In 5 GHz, 20 MHz channels are utilized to maximize reuse
- 5 GHz power setting for bowl APs is carefully managed
- Mass of fans naturally attenuate the signal

Chase Center: World's Flagship Wi-Fi 6E Stadium

Chase Center: Bowl Coverage



249 Wi-Fi 6E APs to cover the bowl:

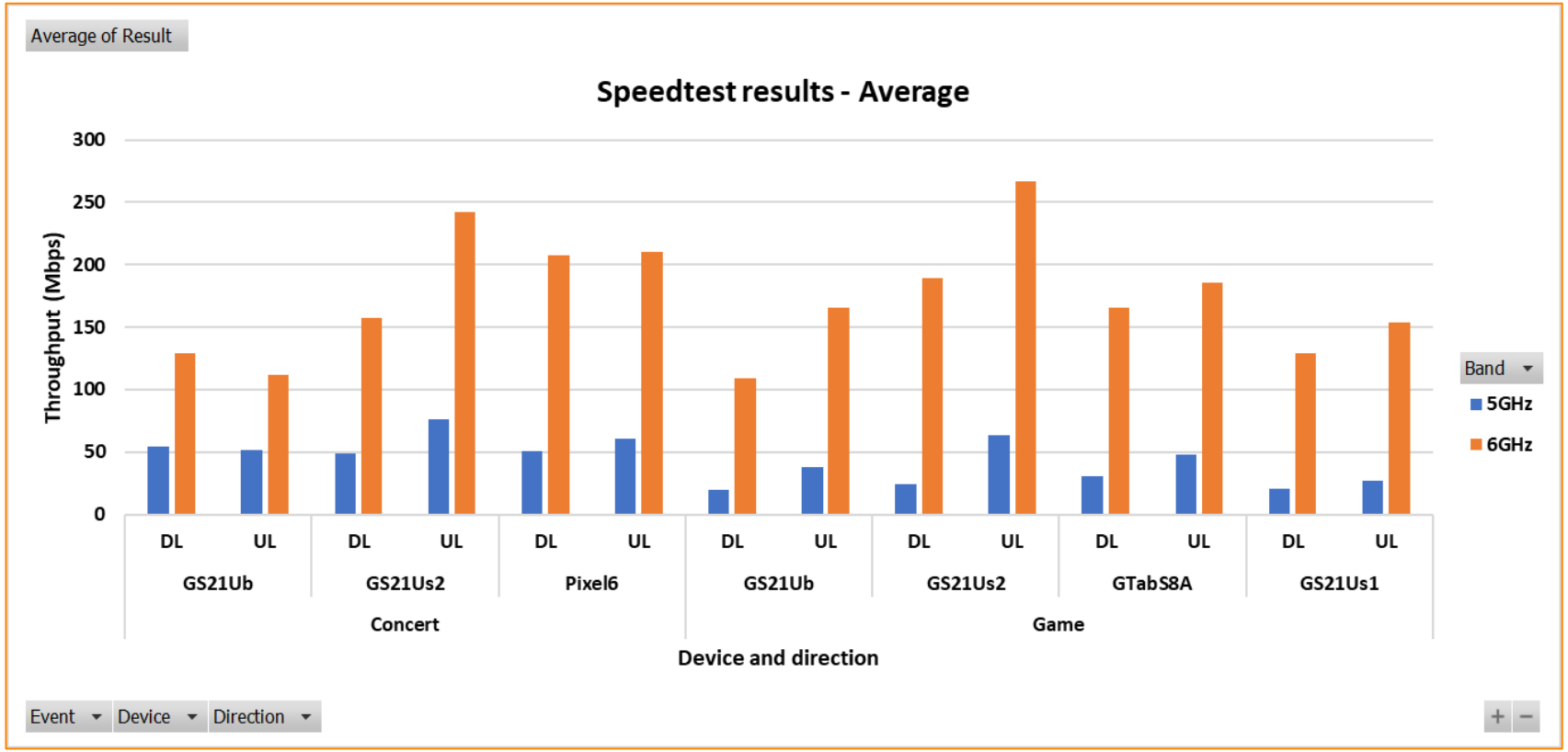
- Lower Bowl = 147 x AP-635
- Upper Bowl = 102 x AP-635

Approximately **1** 6E AP per 60 seats

Proximity of APs requires 23+ discrete (non-overlapping) channels to avoid co-channel interference issues.

An additional **603** AP-5xx are deployed in the concourses, back-of-house, offices & plaza.

Chase Center: Speedtest Results 6 GHz vs 5 GHz (Average Values)



- 5 GHz: 20 MHz
- 6 GHz: 80 MHz

- 80 MHz channel plan not viable in 5 GHz
- Fewer users/devices on 6 GHz due to maturity of client ecosystems.
- However, it does give us a sense of the client experience based on pathloss in a full stadium.

Thank you!

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