CASE STUDY:

OPEN SOURCED WI-FI HARDWARE

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Executive Summary

We believe that the networking industry is ready for “Open Sourced Wi-Fi Hardware,” a disaggregated approach to wireless networking in which fully interoperable hardware and software can be purchased from different vendors.

Proprietary hardware forces vendor lock-in, reduces customer choice, slows innovation, and inflates costs. Open standards foster increased competition and innovation, which directly lead to better products at lower prices. Customers have made it clear that they want the freedom to buy the best access point for their application, from anywhere, and manage it the way they want to, at fair costs.

A key milestone in this shift to a disaggregated model is marked by collaboration between vendors.

At the Open Compute Project U.S. Summit in March 2018, Mojo and Edgecore partnered to showcase the first “Open Wi-Fi” network based on Open Source Hardware, at the San Jose Convention Center. The interoperable network, comprised of Edgecore ECW5410 and Mojo C-130 Access Points, ran on Mojo’s NOS to provide high-performance secure Wi-Fi to the 3400 show attendees gathering to discuss the benefits of an open hardware ecosystem.

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1 Introduction

The journey to Open Sourced Hardware Wi-Fi platforms for enterprise Wi-Fi took a step forward when Edgecore Networks and Mojo Networks showcased the first, multi-vendor Wi-Fi network. Validating the open-compute model for enterprise wireless networking and employing Open Network Install Environment (ONIE), the Mojo Network Operating System (NOS) was loaded on nine Edgecore APs. Edgecore APs combined with Mojo APs to provide a homogenous Wi-Fi environment that provided high-speed Wi-Fi for the 3400 attendees who visited the OCP Summit 2018 show floor.

"We do massive Wi-Fi deployments every week at large scale events and we were pleased with how well this Open Wi-Fi network performed" - Networking Team, FNTech.

2 Deployment

QUICK FACTS

Event	Open Compute Project Summit 2018
Venue	San Jose Convention Center, San Jose, CA - Main Exhibit Hall
Dates	20th and 21st March 2018
Wi-Fi Coverage	40,000 sq. ft.
Visitors	Approx. 3400
20 APs	(9) EdgeCore Networks ECW5410 (11) Mojo Networks C-130

BACKGROUND

The data center industry has wholeheartedly embraced OCP's vision of hardware / software disaggregation. Open Source HW based Ethernet switches supported by multiple NOS vendors are now ubiquitous and bring tremendous benefits of choice, flexibility, cost savings, and innovation to end users.

A similar disaggregation model at the Edge was showcased by Mojo Networks and Edgecore networks for the enterprise Wi-Fi market, providing the same value to its customers. Leveraging the OCP disaggregation principles of utilizing ONIE (Open Network Install Environment) standard, Edgecore Networks and Mojo Networks demonstrated that access point disaggregation is ready for

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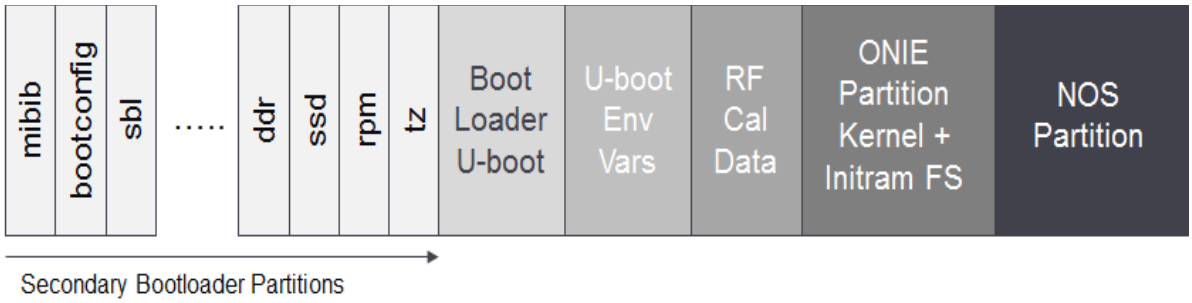
deployment by providing Wi-Fi access to the participants at the OCP Summit 2018. We covered the show floor with Wi-Fi coverage using “OCP Accepted” APs and the deployment went well.



Logical Flash Partition Layout on a Qualcomm ARM AP platform

Large conference halls are one of the most difficult venues to provide good Wi-Fi. To ensure an optimum Wi-Fi experience, we deployed twenty internal antenna access points (nine EdgeCore and eleven Mojo) throughout the 40,000 square foot exhibition space of OCP Summit 2018. The Wi-Fi network was designed to be able to provide ubiquitous, high-speed coverage in this very dynamic environment. The challenges were that the users were very mobile, and they tended to come into the exhibit hall all at the same time, between conference sessions, at lunch, and during cocktail hours.

Twenty APs were used to ensure consistently good coverage at high RSSIs and good Wi-Fi performance. This was coupled with a high-speed Internet connection to provide an good overall experience.

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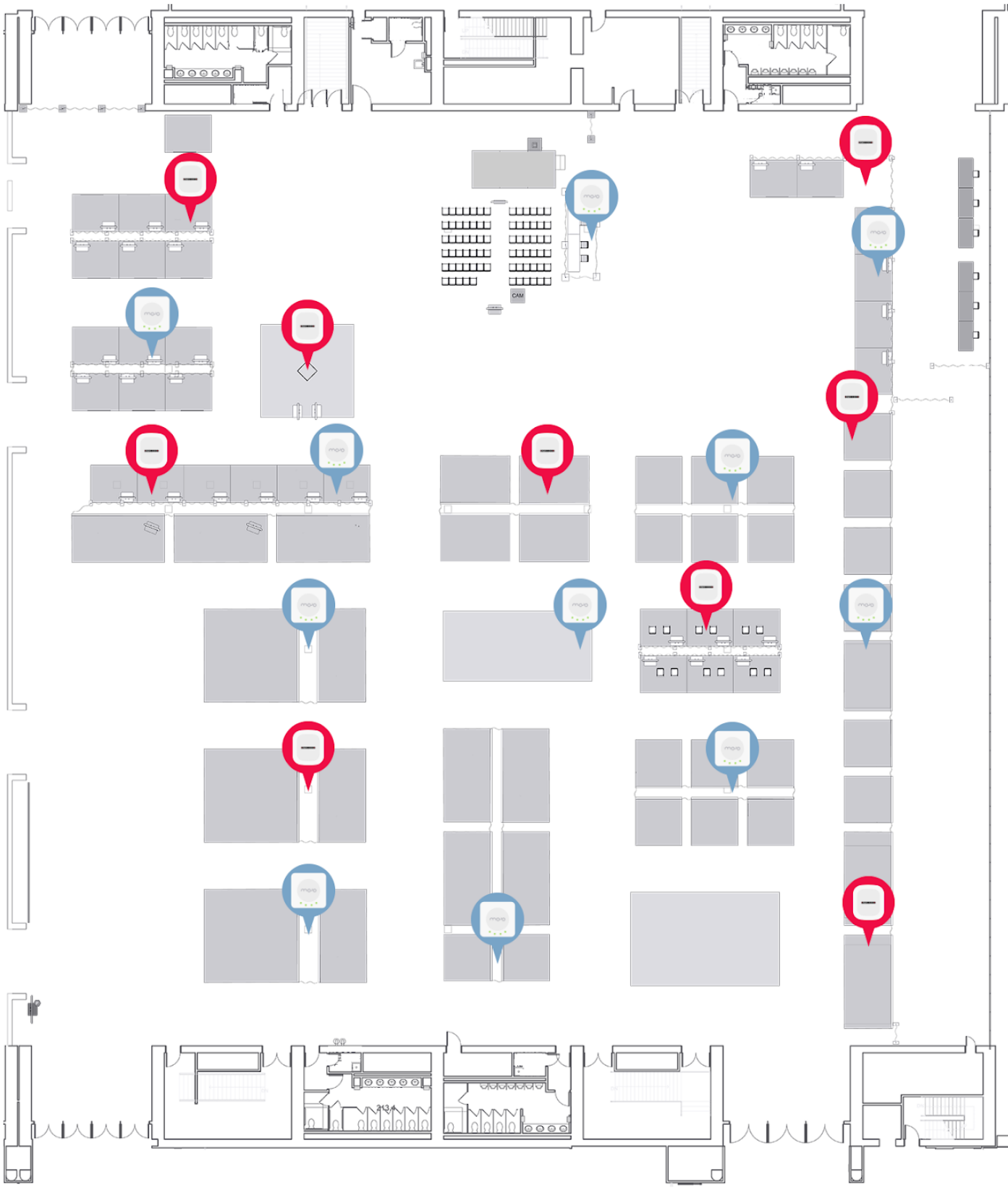
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Figure 1. Floor plan of San Jose Convention Center Exhibit Halls

The location of the access points is denoted by red (Edgecore) and blue (Mojo) icons above.

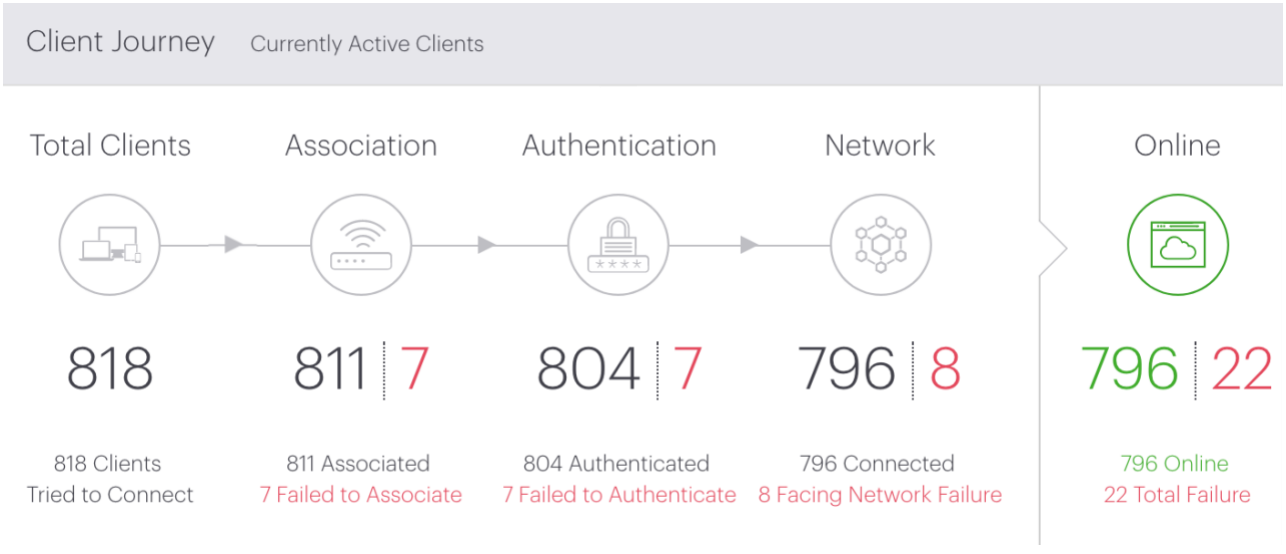
3 Operational and Performance Details

The most important measure of success of the open compute model for Wi-Fi access at the OCP Summit 2018 is that attendees used the Wi-Fi and had a good Quality of Experience. For this to happen, not only were the standard Wi-Fi criteria of the number of APs, their placement, and adequate signal coverage necessary, the additional complication of multi-vendor hardware was a factor. All systems needed to work properly on each AP as did the communication between APs. It was critical that the NOS work properly with the underlying AP hardware. The AP hardware, NOS, and cloud management platform all performed flawlessly providing an good Wi-Fi experience for the attendees.

Following are operational and performance details from the OCP Summit 2018 Wi-Fi deployment.

Live Connection

Attendance on the show floor ebbed and flowed throughout the day with the highest number of concurrent Wi-Fi users occurring during the lunch rush. The image below shows the number of active clients attempting to and successfully connecting to the Wi-Fi and wired network and the users who were having connection issues and the connection phase where they were experiencing a problem.



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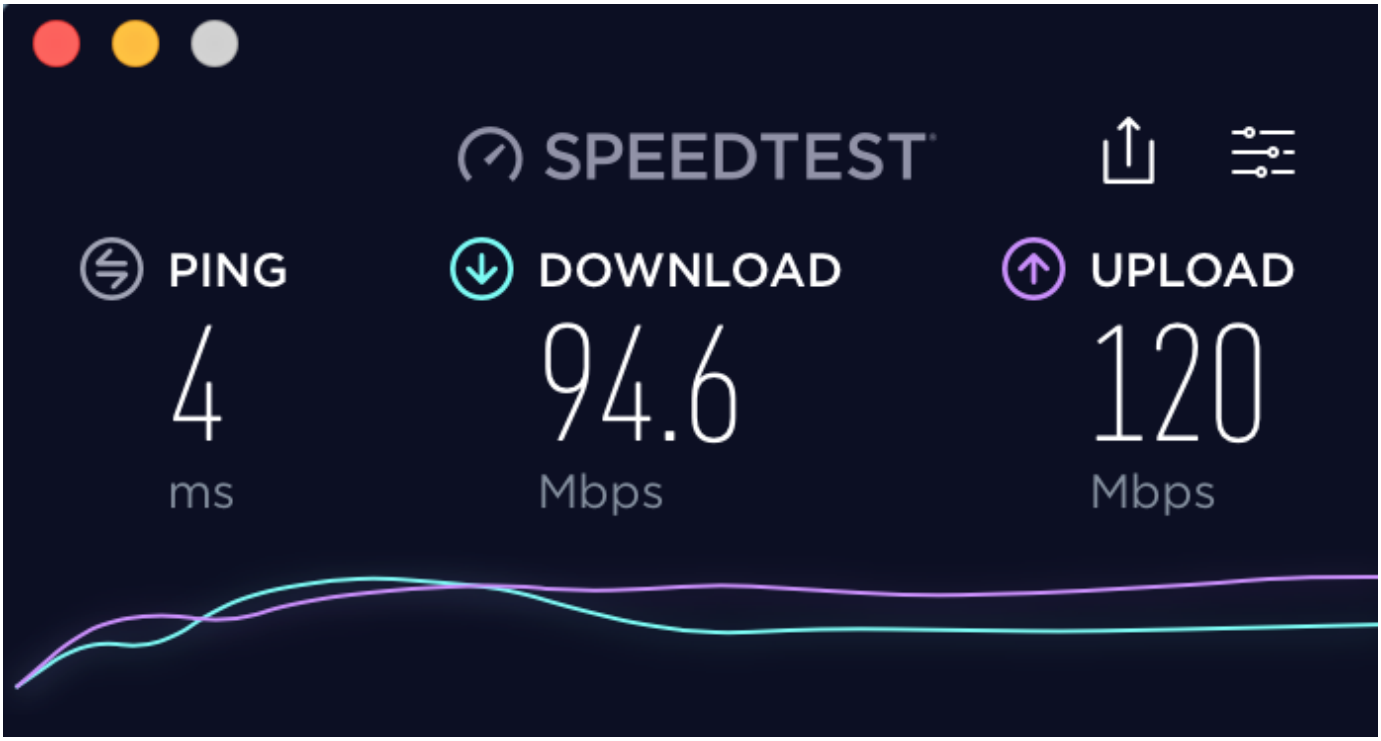
Speed Test

There was no bandwidth rate limiting policies installed for users. Hence, sporadic speed tests showed that devices were able to soak up all the available backhaul capacity during non busy periods as captured in the speed test screen shot below.



Channel and Client Distribution

A key component for optimal performance is if the channels selected for use by the APs are distributed. Having too many APs on the same channel severely impacts the RF performance and user experience. The chart below shows that the channels selected by the APs is fairly dispersed.

User experience is optimized by distributing clients so that not all clients are on a few APs while other APs have few clients. Ideally all APs would have approximately the same number of clients. This is a balancing act because clients need to have a good signal for good performance while being load balanced between APs. The chart below shows a good distribution across APs. Note the top two APs in the list are at the entrance and are the first APs attendees connect to when they enter the show flow and the last APs as they leave the show floor.

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Name	Model	Ch.	Clients	RF Utilization(%)
AP-18-Mojo_86:...	C-130	56	74	10.06
AP-04-EC-Mojo_...	ECW5410	36	71	28.47
AP-13-Mojo_23:...	C-130	44	39	6.77
AP-16-Mojo_88:...	C-130	52	33	4.04
AP-02-EC-Mojo_...	ECW5410	149	31	5.38
AP-24-Mojo_86:...	C-130	153	31	9.11
AP-19-Mojo_86:...	C-130	64	26	5.67
AP-11-Mojo_22:...	C-130	52	26	47.83
AP-17-EC-Mojo_...	ECW5410	157	25	5.04
AP-08-EC-Mojo_...	ECW5410	48	23	7.61
aAP05-EC-Mojo_...	ECW5410	153	19	3.79
AP-03-Mojo_22:...	C-130	40	19	3.49
AP-15-EC-Mojo_...	ECW5410	153	17	4.33
AP-09-Mojo_23:...	C-130	165	17	5.41
AP-06-EC-Mojo_...	ECW5410	149	12	6.31

Wi-Fi Signal Strength

Adequate signal strength is essential to good Wi-Fi performance and high data throughput. It is not practical to cover every nook and cranny with good signal strength, the OCP Summit 2018 show floor was served quite well with 78% of the coverage being Good or Great.

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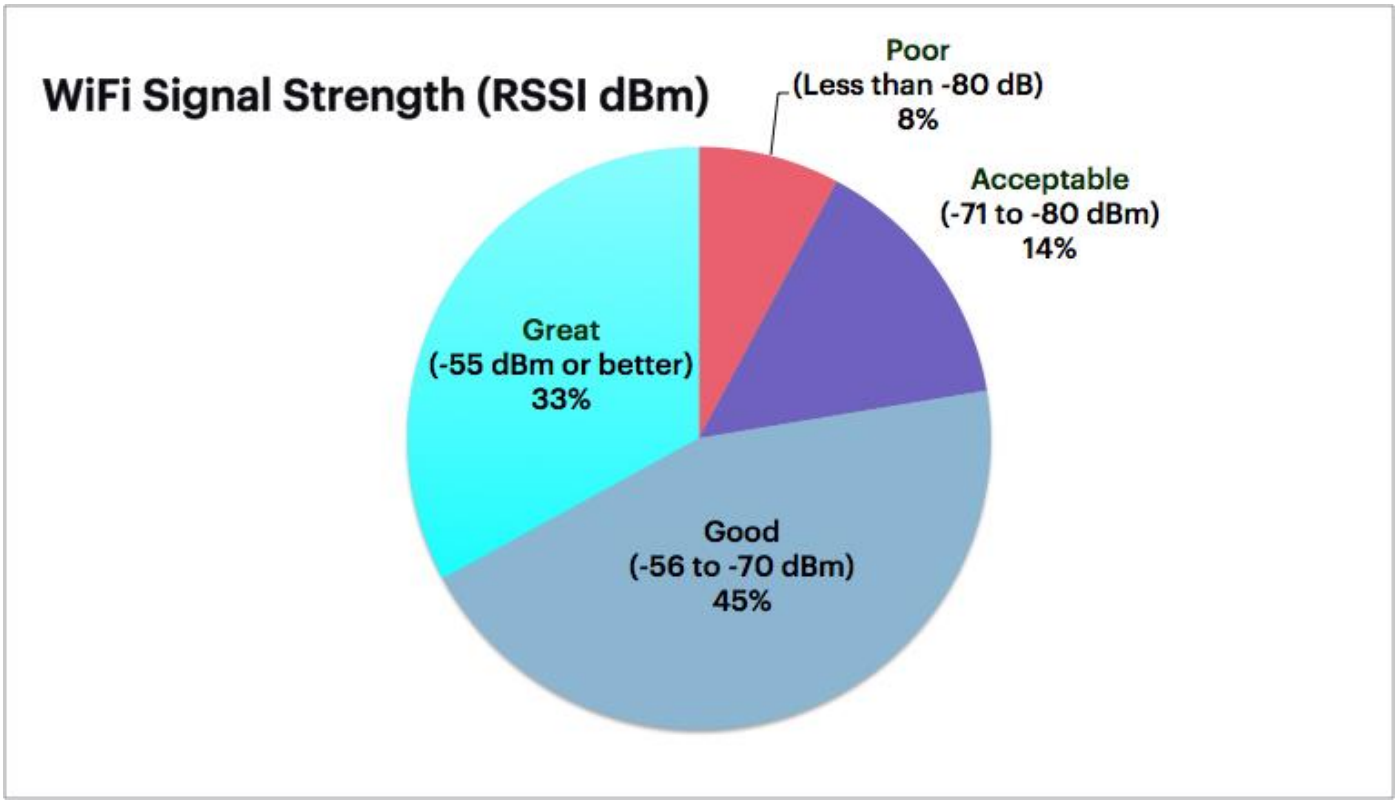

Conversions

The OCP Summit 2018 consisted of conference sessions and vendor displays on the show floor. The OCP Accepted APs were deployed throughout the vendor area on the show floor. The conference areas were served by a different Wi-Fi solution.

The graphs below show the number of attendees that were seen by OCP Accepted APs both inside and outside of the vendor show floor area. On March 20th approximately 3700 attendees were seen by the system, with 82% of them visiting the show floor. While there were fewer attendees seen on the 21st, more of them (85%) visited the show floor on March 21st.

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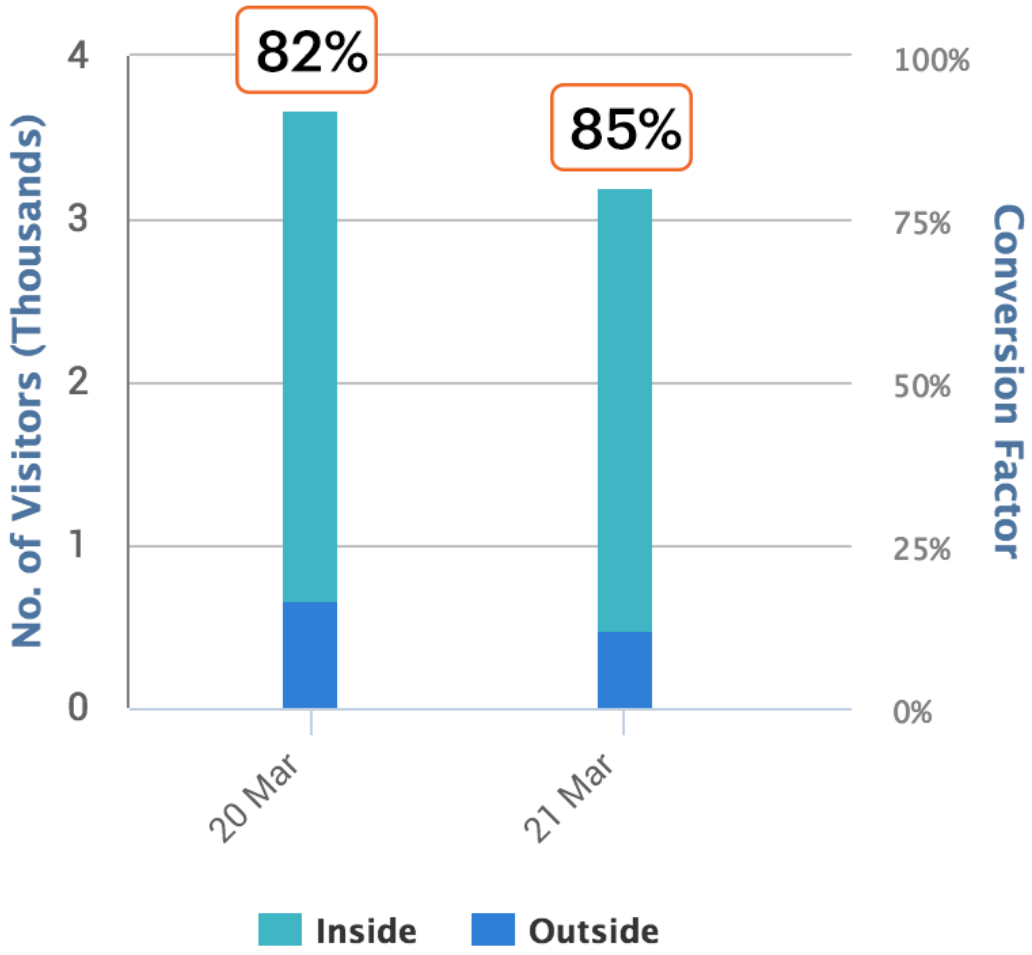

Attendance / Usage

Mojo's Network Operating System (NOS) collected a wide range of information during the show and setup. On the first day of the show, March 20th, there were just under 4000 unique visitors that connected to the OCP Wi-Fi network on the show floor. Some attendee's visited the show multiple times during the day bringing the total number of visitors to just over 6000 with most of the visits occurred in the 1pm to 4pm time slot.

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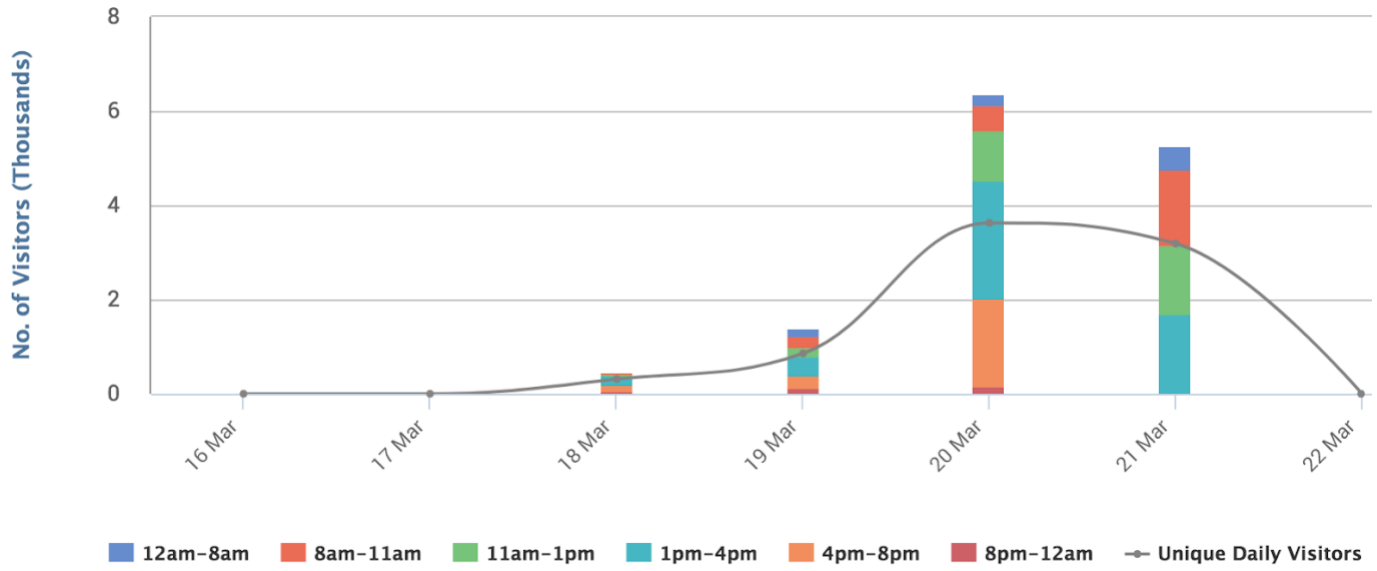
Show floor attendance dropped a bit on March 21st to just over 5000, with the visits fairly equally distributed between the morning, noon, and early afternoon time slots.



Over the course of the two days the exhibit hall was open, a total of 258 GB of data volume observed across the Wi-Fi network with 66% of it being delivered from the AP to the client (download).

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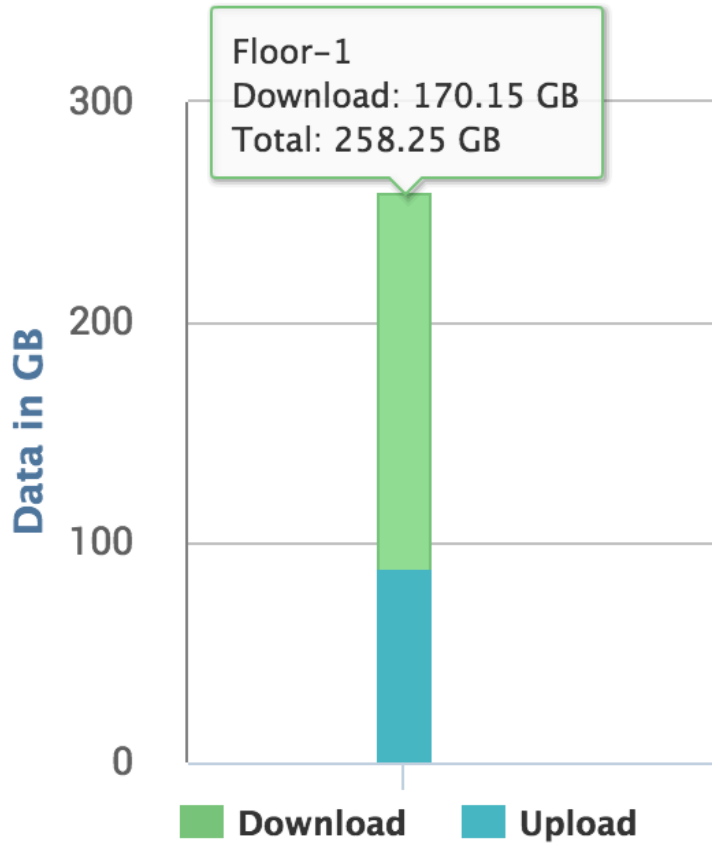

Mojo's AP NOS includes an application visibility engine which looks at the network traffic passing through the AP and categorizes it by application. This snapshot of the Application Visibility dashboard show that the three application users of Wi-Fi are TCP, SSL, and HTTP.

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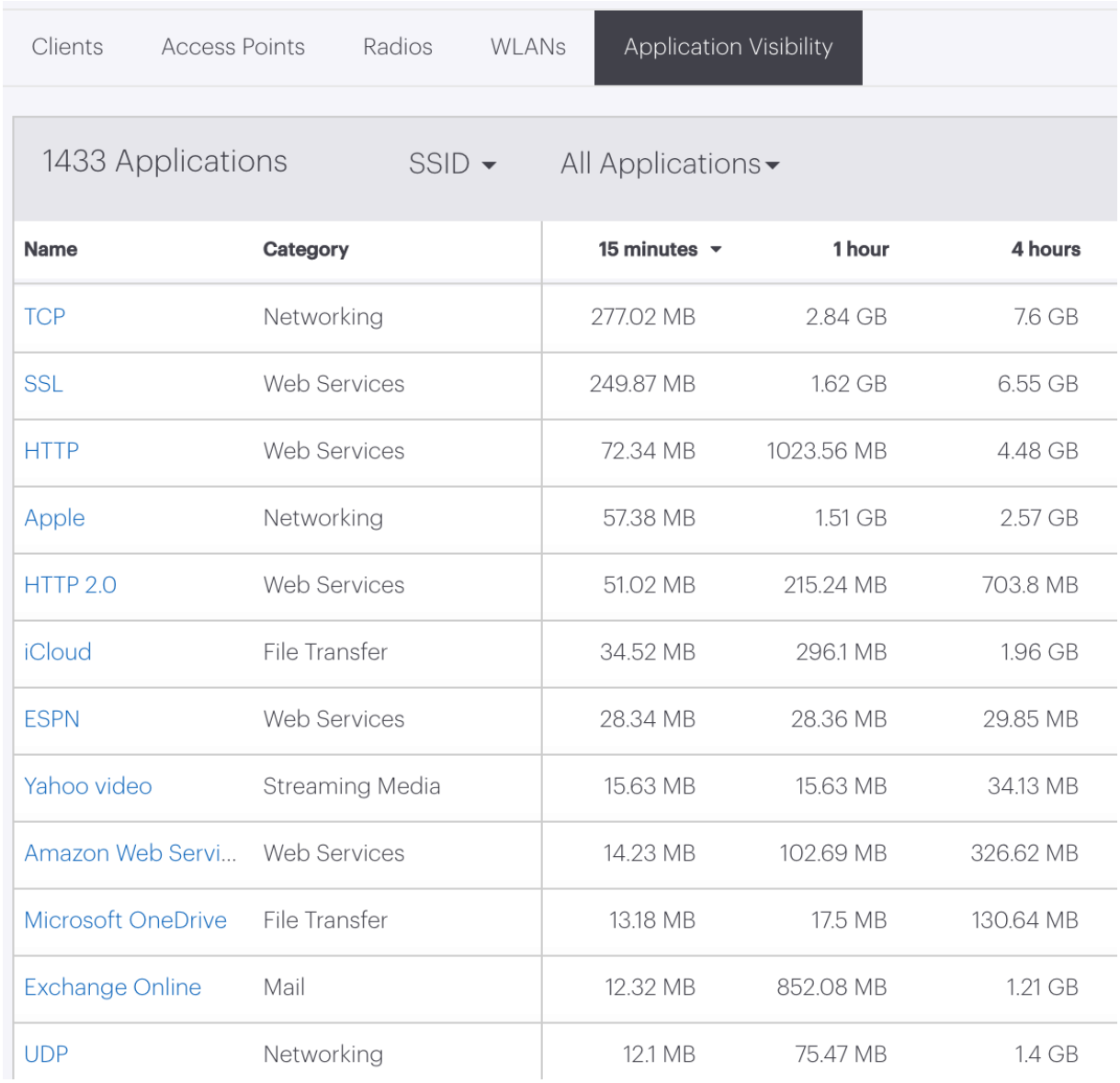

Clients | Access Points | Radios | WLANs | Application Visibility

1433 Applications SSID All Applications

Name	Category	15 minutes	1 hour	4 hours
TCP	Networking	277.02 MB	2.84 GB	7.6 GB
SSL	Web Services	249.87 MB	1.62 GB	6.55 GB
HTTP	Web Services	72.34 MB	1023.56 MB	4.48 GB
Apple	Networking	57.38 MB	1.51 GB	2.57 GB
HTTP 2.0	Web Services	51.02 MB	215.24 MB	703.8 MB
iCloud	File Transfer	34.52 MB	296.1 MB	1.96 GB
ESPN	Web Services	28.34 MB	28.36 MB	29.85 MB
Yahoo video	Streaming Media	15.63 MB	15.63 MB	34.13 MB
Amazon Web Servi...	Web Services	14.23 MB	102.69 MB	326.62 MB
Microsoft OneDrive	File Transfer	13.18 MB	17.5 MB	130.64 MB
Exchange Online	Mail	12.32 MB	852.08 MB	1.21 GB
UDP	Networking	12.1 MB	75.47 MB	1.4 GB

Presence Information

The Mojo system monitors the Wi-Fi environment for any devices that can be seen. The table below show the number of device instances see by the system as well as the number of unique devices. A device may be seen multiple times as it comes near and retreats from the monitoring APs.

Note: Devices that probe the Wi-Fi network (visible to Wi-Fi network) are considered *present ;* Once users connect to the Wi-Fi network, the devices are considered *associated*.

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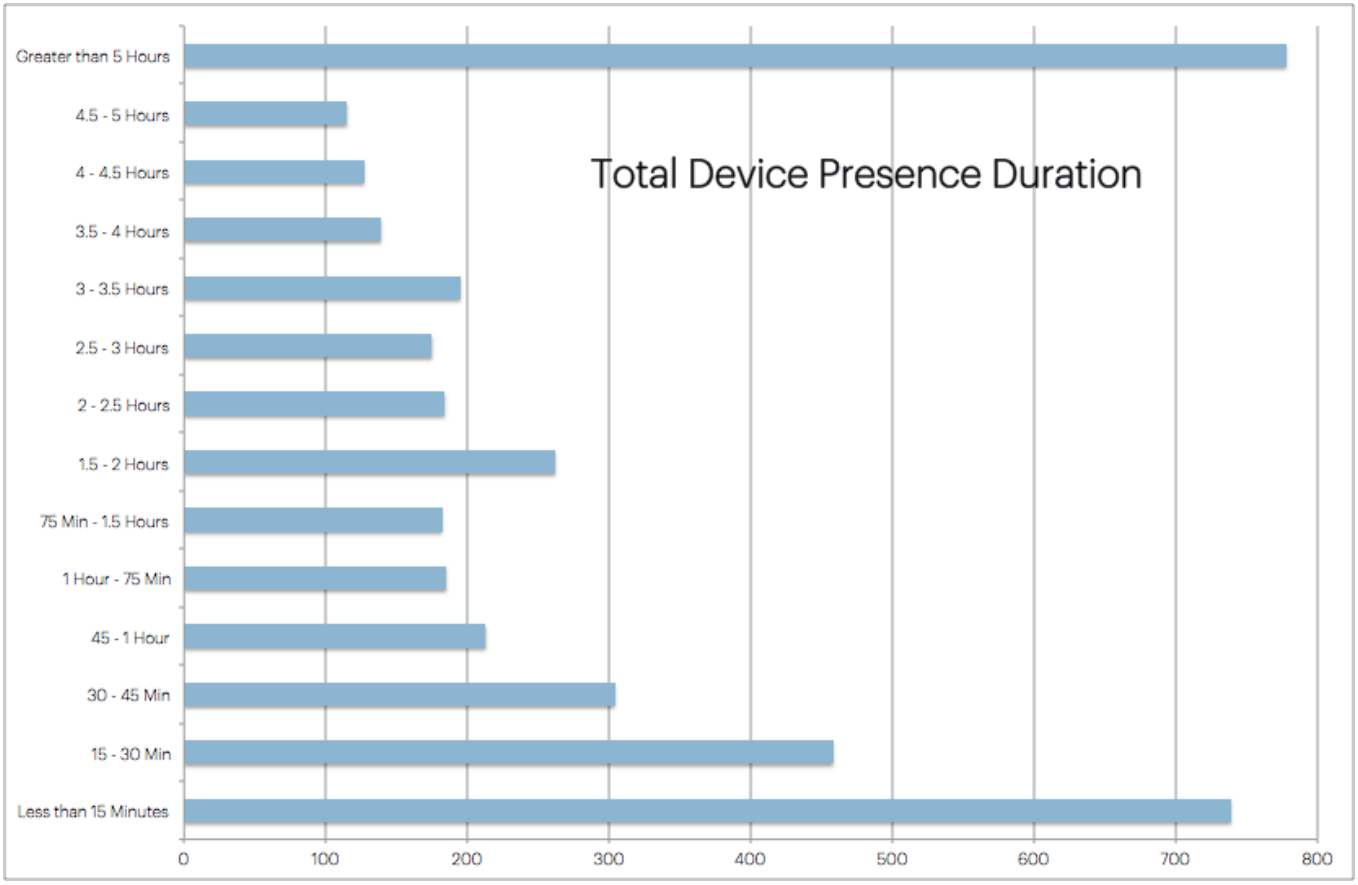
Devices at OCP Summit 2018	Total	20th	21st
Number of Devices Seen	22232	12638	9594
Number of Unique Devices	4057	3168	2924
Average visits per device	5.48	3.99	3.28

Presence Duration

The chart below breaks down the amount of time the device spent in the show area. The high number of devices with a duration of “Less than 15 Minutes” is likely due to people walking by the APs near the entrance.



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Client Associations

The platform tracks the number of client associations which can be broken down by frequency band and day. An Association is counted anytime a client goes off and comes back on the Wi-Fi network. It is not counted as an association when the client roams between APs. The table below shows the number of total associations for March 20th and 21st.

Date	2.4GHz	5GHz	Total
March 20th	141	4301	4442
March 21st	143	6254	6397
Total	284	10555	10839

Associations by Device Type

The system further tracks clients by the client type.

Associations	Unique	Total	Average
Android	398	2115	5.3
iOS	763	3821	5.0
iPad	32	105	3.3
iPhone	349	1396	4.0
Unknown	1293	3402	2.6

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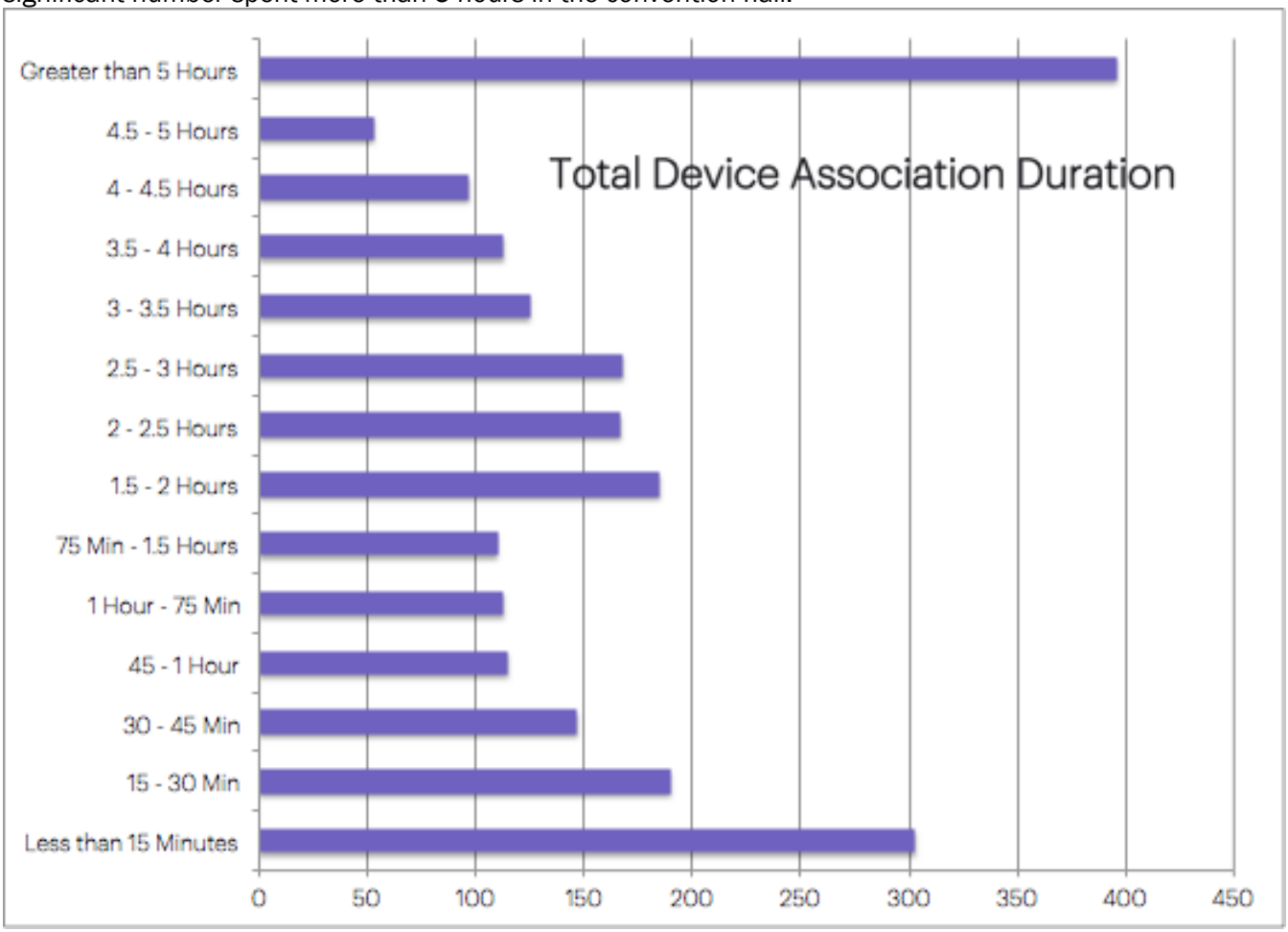
Total	2281	10839	4.8

Associated Device Duration

The system tracks the amount of time Wi-Fi clients are associated. The chart below shows that a significant number spent more than 5 hours in the convention hall.



4 Conclusion

Open Compute for Enterprise Wi-Fi came to fruition with the deployment of the first mixed vendor, “Open Wi-Fi” deployment at OCP Summit 2018. APs from Edgecore Networks and Mojo Networks running the Mojo NOS provided a good Quality of Wi-Fi experience to the 4300 conference attendees.

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5 Appendix “OCP Accepted” AP Details

The “OCP Accepted” APs from Edgecore Networks were ECW5410s.

Hardware

- Qualcomm 802.11ac WAVE-2 4x4 Dual Band Dual Radio
- Internal antenna
- Submitted to OCP in Mar 2017
- Available @ OCP Marketplace http://www.opencompute.org/products

Software

- U-Boot : Version 2012.07
- ONIE partition : ONIE version 2017.02-rc1
- NOS partition : Mojo NOS Ver. 8.6.1; Linux kernel 3.14.77 based on Qualcomm SDK SPF 5.0.2

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EdgeCore Networks ECW5410

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6 About Open Compute Foundation

The Open Compute Project Foundation is a 501(c)(6) organization which was founded in 2011 by Facebook, Intel, and Rackspace. Our mission is to apply the benefits of open source to hardware and rapidly increase the pace of innovation in, near and around the data center and beyond. The Open Compute Project (OCP) is a collaborative community focused on redesigning hardware technology to efficiently support the growing demands on compute infrastructure. For more information about OCP, please visit us at http://www.opencompute.org

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