Mobile World Congress 2014

Behind the Wi-Fi Network

White Paper

July 2014

Contents

Overview

The mobile industry and wireless network technologies continue to expand the reach and power of the Internet in ways that where unimagined just 10 years ago. There was no place on earth where this was more evident than at the GSMA's Mobile World Congress. With over 85,000 attendees, 4000 vendors representing 200 countries, this is the largest Mobile industry focused show on the planet. And thanks to partnerships between Cisco, Fira de Barcelona and GSMA, Wi-Fi has been a prominent component of this show since 2010. The show, previously known as 3GSM World Congress, has seen an increase from one attending Wi-Fi vendor in 2010 to a "who's who" list of Wi-Fi companies attending, regularly owing to the success of Wi-Fi and the display of capabilities presented year over year since moving the show from Cannes to Fira de Barcelona in 2006.

Figure 1. An Aerial View of Mobile World Congress 2014 at Fira Gran Via, Barcelona - a Massive 280,000 Meters^2 (Three Million Square Feet) Facility

The Fira de Barcelona arena is divided into eight grand halls, numerous conference rooms, multiple outdoor areas, and an elevated, continuous walkway that flows through the middle, connecting the entire venue. For Mobile World Congress 2014, Fira debuted a brand new, state-of-the-art carrier-grade network designed by Cisco. Coverage for the first time was extended to include both vendor spaces and all public spaces, including outdoor areas providing high-speed coverage end to end. Cisco delivered a flexible suite of solutions that allowed for policy enforcement while meeting multiple individual competing use cases without compromising function or stability of the network as a whole.

Solving Customer Problems

Treating Wi-Fi as a service to be offered to exhibitors and attendees requires some forethought and planning. It also requires a new way of looking at Wi-Fi deployment. Fira traditionally supplied vendors with wired Internet access as part of its space contract. However, in past years allowing uncoordinated Wi-Fi to prevail in the exhibition halls has led to complete or partial failure of both available bands. Fira took the bold step of offering Wi-Fi services as part of the Internet package and regulating strictly outside Wi-Fi in the exhibition spaces. The goal was to provide a coordinated spectrum that was usable by all, sharing the resource in the community.

As part of this service, Fira deployed a full, state-of-the-art Cisco® core network infrastructure to enable management of the resulting solution and granular customization to meet individual vendor's needs. Any outside wireless permitted in the halls was coordinated within the spectrum to ensure an interference-free operation.

Figure 2. Extensive Coverage Area View of Free Public Wi-Fi, Hotspot, and Exhibition Wi-Fi Networks

Free public Wi-Fi was provided for all attendees. Free Wi-Fi coverage was provided in 100 percent of non-exhibition space. It was possible for users to roam seamlessly throughout the entire public portion venue. Users could enjoy a high-performance Wi-Fi connection in over 50 restaurants and between every exhibition hall. Public Wi-Fi bandwidth was initially capped at two Mbps per user, but was opened up to 16 Mbps by the week's end to allow for capacity testing of the solution. In all, public Wi-Fi totaled of about one million square feet (93 square kilometers) of contiguous coverage.

This year GSMA, Fira, and Cisco, along with 10 roaming partners provided a fully operational Hot Spot 2.0 service on the same public network, enabling cellular subscribers to join and participate in the network using Passpoint. Users of this service enjoyed a zero-touch automatic authentication and seamless roaming across the entire public Wi-Fi network.

Fira de Barcelona offered superior wireless coverage with a carrier-class Wi-Fi experience for the GSMA, the exhibitors, the media, and all the attendees from around the globe.

Use Cases

Fira de Barcelona is a microcosm of Wi-Fi use cases. Everything from large, open, outdoor public access areas to highly dense theaters and auditoriums can be encountered in the same physical location week to week and show to show. The same physical hall accommodates vastly differing environmental conditions as each conference brings its own indoor cities to be constructed and torn down within a span of a few days. If you have ever been to a technical conference, then you've seen the amazing transformation from empty congress halls to a bustling city (Figure 3).

Figure 3. Transformation of Event Area from Empty Hall to Multi-Vendor Exhibition Booth Space

Critical to the operation and maintenance in this widely dynamic environment is Cisco Radio Resource Management, which provides for automatic channels and power adjustments to maintain efficient and pervasive wireless coverage. As needs change, so does network tuning and performance. Automating this saves countless IT staff hours on a monthly basis and provides for a consistent user experience show to show.

Productized Network Services

Fira de Barcelona is the service provider that delivers network services as a product to events held at its facility. Exhibitors contract for services from Fira as part of the lease agreement on exhibition space. Using the Cisco Wi-Fi to LAN service, on a high-availability Cisco switching architecture, Fira was able to serve more than 4000 vendors with individual policy-driven, private, secure, customized access. Service offerings allowed for selection of peak and individual bandwidth contracts, number of concurrent users, broadcast custom SSID's names, private VLANs, and regular Internet access. All of this was centrally monitored and managed against contract service-level agreements (SLAs). Exhibitors could securely access their resources from any Wi-Fi connection within the venue. That is carrier grade.

Special Design Criteria

The Fira de Barcelona congress center has many diverse physical RF architectures. For example, huge halls, auditoriums, artistically shaped entrance areas, large outdoor areas, and a central bridge connecting all halls were just a few of the challenges. Each unique area required a special Wi-Fi design criteria based on user density and expected activities. To accommodate all the design needs, many rigorous wireless site surveys were carried out (using Ekahau Site Survey tools) months before the event. The intent was to analyze access point placements, antenna designs required, and mounting solutions. Post-deployment site surveys were done after the network installation to characterize and tune the network.

Wireless Policy Enforcement

Wi-Fi operates in unlicensed spectrum. That means Cisco had to consider proliferation of all the wireless access points, personal hotspot devices, and interfering devices brought by visitors and exhibitors. The network operations team had to design the network robust and flexible enough to co-operate with rogue access points, and Wi-Fi and non-Wi-Fi interfering devices on premises. Cisco wireless rogue management, Cisco CleanAir™ spectrum analysis, and location engines actively provided actionable information and locations on rogue device issues within the network. Fira employed a team of individuals to coordinate the spectrum on the show floor.

Devices identified as out of policy were located and remediated to reduce the impact on the Wi-Fi network. Education was provided to the community and will be in the future as an ongoing effort. Assisting users with connection challenges and education is an effort that pays dividends for all in the community.

Infrastructure

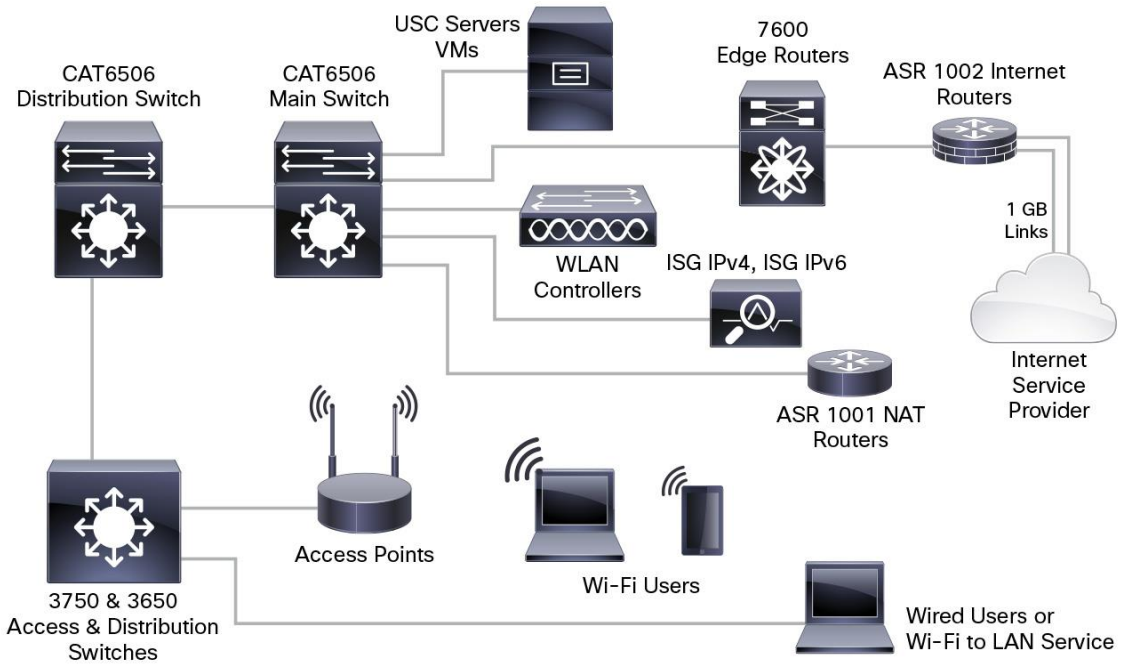
When planning a network to meet the needs for 85,000 users, the network must allow for maximum redundancy with minimum bottlenecks. Sizing is important, but it was also critical to estimate how many of the 85,000 users will actually take advantage of the Wi-Fi simultaneously at a time. History revealed that between 2011 and 2014, when the public network was limited to hotspot service only, there were between 55,000 to 70,000 visitors and a peak of 7500 concurrent Wi-Fi connections. However, the design needed to cover the new services and complete coverage of the facility with wireless, so staff included the total number of wired connections from the year before and came up with a target of 12,000 –15,000 peak concurrent Wi-Fi users. Overbuilding is always a good idea; in this environment it is required since year-over-year growth has tracked at 300 percent.

Figure 4. Cisco Wired and Wireless LAN Equipment Deployed for the MWC 2014 Network

Network Layout

The entire network was designed taking high availability into consideration. Power redundancy and geographical distribution has been used across two data centers with a dual-Internet connection from two different Internet service providers (ISPs). Figure 5 outlines a simplified wireless network model of the actual network architecture.

Figure 5. Wireless Network Model for MWC 2014



Cisco Wireless LAN Controllers (WLCs) were configured with access point Stateful-Switch-Over (SSO) to provide access point and SSID resiliency. At the RF level, Cisco HDX features were implemented including RRM, CleanAir technology, ClientLink, BandSelect, and RX-SOP to improve the availability and management for the coverage & quality of service.

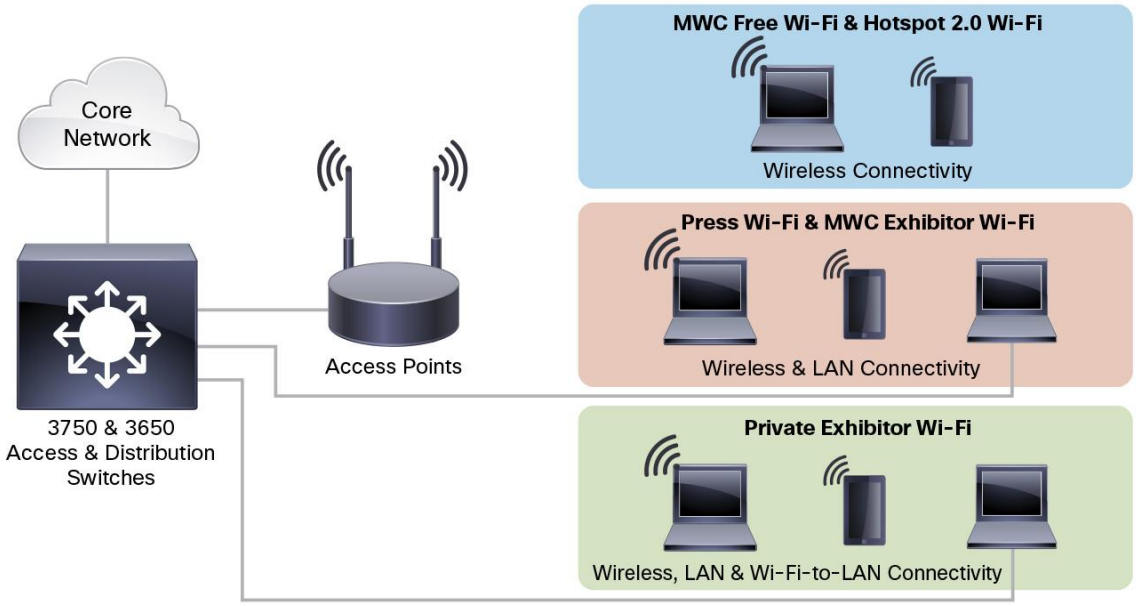
Cisco UCS® servers ran multiple instances of the critical platform management solutions, including:

- Cisco Prime™ Infrastructure to manage, control, and assess the entire wired-wireless network
- Cisco Mobility Services Engine (MSE) for location, rogue detection, and analytics
- DHCP servers
- DNS servers

The exhibitor network offered networking services, including Internet connectivity and private Wi-Fi-to-LAN service managed by a RADIUS server. Exhibitors were offered tiered bandwidth purchase choices of one to 200 Mbps to the Internet, along with per-connection policies from one to eight Mbps. This was accessible over wired or wireless connections. Access to the exhibitor's private VLAN and was available from any point in the facility through the exhibitor network.

Cisco Wi-Fi-to-LAN service seamlessly integrated the access over Wi-Fi or wired ports through a central access policy. Users were correctly mapped to their corresponding resources based on authentication, regardless of edge access method.

Figure 6. Wireless Networks Segregation to Offer Three Separate Wi-Fi Services



The Wi-Fi-to-LAN service opened doors for the booth vendors for more exclusive demos and customer presentations where there was a requirement for a wired device (laptop) and a wireless device (iPad or Apple TV) to be on the same virtual LAN (VLAN).

In addition to regular services, exhibitor services included:

- One custom SSID with a number of private users: from 20 (for 10 Mbps contracts) to 200 (for 200 Mbps contracts) and also premium option with unlimited users.
- Active alerts on 80 percent bandwidth usage
- Services online tracking (from 25 Mbps and up)
- Network consultancy (from 50 Mbps and up)

Wi-Fi Design and Planning

Fira de Barcelona is a massive facility. In order to adequately cover the facility a high density design model was used. High density design in an open space requires isolation of the individual Wi-Fi channels. Access points must also be placed so as to not interfere with operations, and strict ceiling height restrictions exist to accommodate exhibitions.

Special Antenna Designs

Selecting the right combination of hardware is critical while planning and deploying high density networks. High-gain directional antenna plays an important role in focusing signal power in smaller areas rather than spreading signal everywhere with internal, omnidirectional access points. Table 1 lists the types of antennas used at MWC 2014.

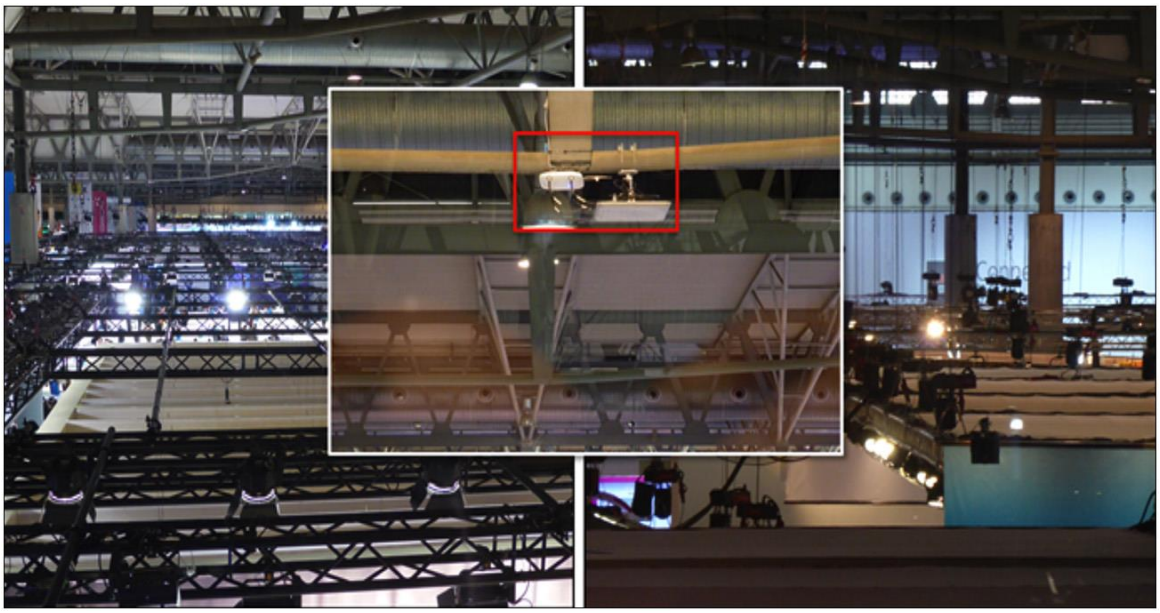
Table 1. Antenna Types and Specifications

Name	Type	Specifications		Antenna
AIR-ANT2513P4M-N	Dual-band polarization diverse antenna	Gain	2.4 and 5 GHz 13 dBi	
		Polarization	Vertical/horizontal	
		Azimuth plane 3 dB Beamwidth	2.4 and 5 GHz 30°	
		Elevation plane 3 dB Beamwidth	2.4 and 5 GHz 30°	
AIR-ANT2566P4W-R	Dual-band MIMO 4-element patch antenna	Gain	2.4 and 5 GHz 6 dBi	
		Polarization	Linear vertical	
		Azimuth plane 3 dB Beamwidth	2.4 GHz 105°	
			5 GHz 125°	
		Elevation plane 3 dB Beamwidth	2.4 GHz 70°	
			5 GHz 60°	
AIR-ANT2460NP-R	2.4 GHz MIMO 6 dBi 3-element patch antenna	Gain	6 dBi	
		Frequency	2400 - 2484 MHz	
		Polarization	Linear vertical	
		Azimuth plane 3 dB Beamwidth	80°	
		Elevation plane 3 dB Beamwidth	75°	
AIR-ANT5160NP-R	5 GHz MIMO 6 dBi 3-element patch antenna	Gain	6 dBi	
		Polarization	Linear vertical	
		Azimuth plane 3 dB Beamwidth	65°	
		Elevation plane 3 dB Beamwidth	65°	

The high-gain AIR-ANT2513P4M-N antenna was deployed in all open halls. This antenna provides very tight 3 dB Beamwidth (31x31 degrees 2.4 and 5 GHz) with a very sharp 6 dB Beamwidth of 42 degrees. This is essential for cell isolation and managing co-channel interference. The antennas allowed optimal reuse of channels and produced on average 3000 square feet (280 square meters) cell size. Cisco RRM using over the air metrics tuned the resulting network to optimize cell size, power, and co-channel interference and resulted in 30 dB isolation between cell centers with a nominal 15 percent overlap. During the show, with 10 dB attenuation added between the floor and the ceiling, signal at the floor level was even at -60 dBm for 5 GHz and -57 dBm for 2.4 GHz. Antenna height in the halls was at an average 12 meters (Figure 7) with a direct line-of-sight view of the floor below.

Many challenges to Wi-Fi exist in a conference center environment, not the least of which is the construction and rigging for exhibitions changing the equation. Attenuation values between the empty and a full hall can swing from 5 to up to 10 dB in places to the floor.

Figure 7. Cisco Access Points Attached with Dual-Band Antenna Mounted on the Ceiling



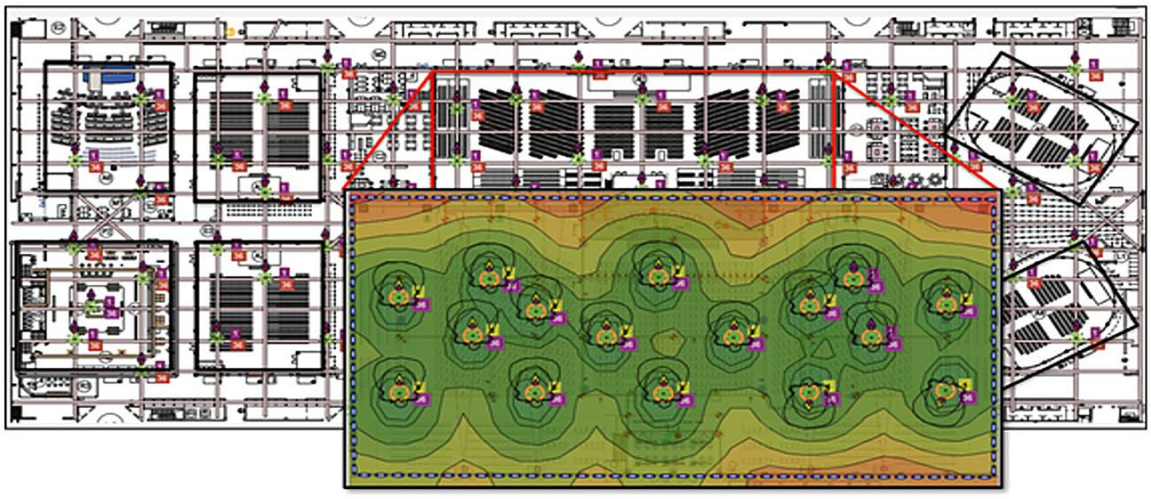
To accommodate the levels of attenuation, Cisco designed the network for high tolerances and used its High Density Experience (HDX) feature set to manage the changes and provide automated granular client control and coverage.

Not all halls can easily accommodate grand exhibitions. For Mobile World Congress, the GSMA gold hall was configured with seven high-density auditoriums, supporting a capacity range from 300 - 2000 persons. Additional coverage was placed in these theaters to accommodate the high density of users. Ceiling-mounted access points were converted to monitor mode. RRM tuned the resulting coverage automatically, with RF profiles created for each individual theater.

Cell sizes in the theaters where around 1500 square feet (140 square meters). At its peak, in the Hall 4 auditorium (Figures 8 and 9) bearing a 2000-person capacity, there were 1924 concurrently connected devices during Mark Zuckerberg's Facebook keynote on February 24, with a peak load of 530 Mbps flowing from this single 23,000-square-foot location within the venue, powered by 16 Cisco access points.

Figure 8. View of Inside the Hall-4 Keynote Auditorium before the Facebook Keynote Session

Figure 9. Site Survey Analysis Used to Measure the RF Coverage in Hall-4 Keynote Auditorium



Precise AP Groups and RF Profiles were used on the wireless LAN controllers (WLC) to accommodate the entire venue allowing for highly granular assignment of SSIDs and tuning parameters for individual access points. A total of 216 access point groups were configured to manage 865 access points, which included everything from broadcast SSIDs (exhibitors subscribed for vanity SSIDs), to access point power levels, channels, data rates, and HDX thresholds.

This granular control over the network allowed the operations to successfully host all exhibitors and attendees. Along with the three main SSIDs, hundreds of additional exhibitor and vendor SSIDs were individually applied only to one or two access points each within the venue.

Characterization of the network was done post-installation, and again once most of the facility was occupied before the show. After the start of the show, attenuation slightly exceeded best estimates (coming in at 10 dB with crowds) and a slight power adjustment (3 dB) was applied venue-wide through transmit power control thresholds and templates. The result was pervasive coverage to every booth, restaurant, classroom, lecture hall, and outdoor networking lounge. Knowing the venue's coverage capabilities at minimum and peak capacities allowed Fira to effectively anticipate requirements for future events and apply stored configurations through profiles to accommodate any changes.

HDX Features and Configurations

Cisco HDX was the driving technology used to enhance the end-user experience in challenging RF environments. The Cisco wireless LAN Controller (WLC) is designed to sustain and scale in such deployments and offers many flexible configuration and tuning options in order to accommodate different environments, providing automatic adjustments in widely dynamic environments.

Radio Resource Management

RRM's Dynamic Channel Assignment (DCA) algorithm assigns channels for each radio in the network, reducing co-channel interference and proper cell balance. There were areas under Fira's control, and areas that were outside of direct control where private Wi-Fi was permitted. DCA managed all of this and maintained an interference-free operation during the show.

Table 2. DCA Channel Configurations Were Applied through RF Profiles Using These Channels

Band	Channels	Use
2.4 GHz	1, 6, 11	2.4 GHz spectrum
5 GHz	36, 52, 56, 60	Reserved for exhibitors and demos
	40, 44, 48, 64, 100, 104, 108, 112, 116, 132, 136, 140	Usable 5 GHz channels
	149 - 165	Invalid channels in Europe

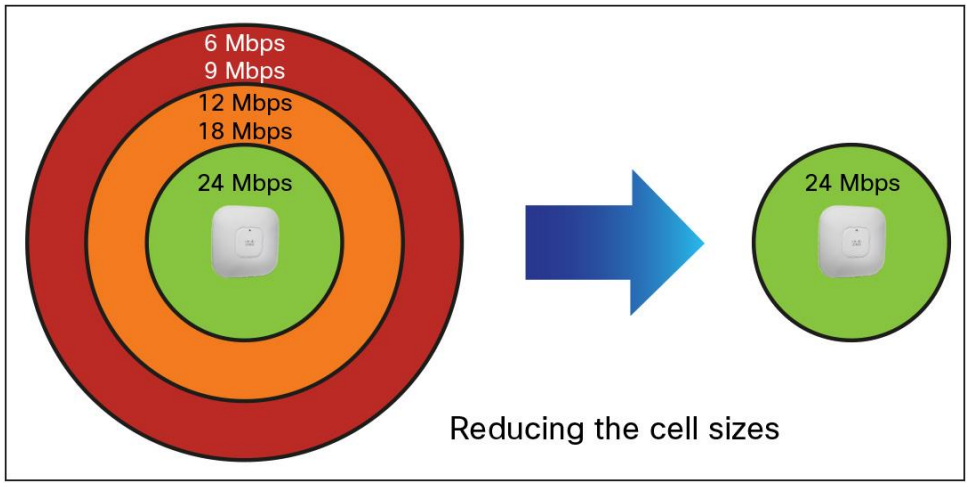
Channels 36, 52, 56, and 60 where reserved for use by non Fira Wi-Fi. However, several vendors' equipment were reporting radar interference in the assigned DFS channels of 52, 56, and 60. Ultimately, the network operations team re-assigned a non-DFS channel block of 36, 40, 44, and 48 to accommodate the vendors' equipment.

Cisco access points did not detect any above-normal instance of radar signatures and were able to use all of the available DFS channels. This re-configuration happened in real time and while the show was operating. This kind of control is what sets Cisco apart and defines carrier-grade technology. Unforeseen events happen; having a plan that deals with them makes it manageable.

Data Rate Selection

Disabling lower data rates is very important to enforce a high data rate to the connected clients (efficiency) as well as smooth roaming and load balancing in dense networks. By disabling the lower data rates the network operations team also reduced the physical boundary of each access point's cell size. Data rates were applied through RF profiles to modify specific groups of access points based on use, density, and desired capacity. Understanding the cells' designed coverage and allowing for the erosion of signal-to-noise ratio (SNR) at the client level when users gather in density determines the lower boundary of a data rate. Because of its design, the access point always has the best view and the highest sensitivity in the venue, as it sits directly above. User devices tend to be shielded from one another as they are close together and separated by the users themselves. Minimum mandatory data rates ranged from 12 Mbps, to 36 Mbps in the highest density areas.

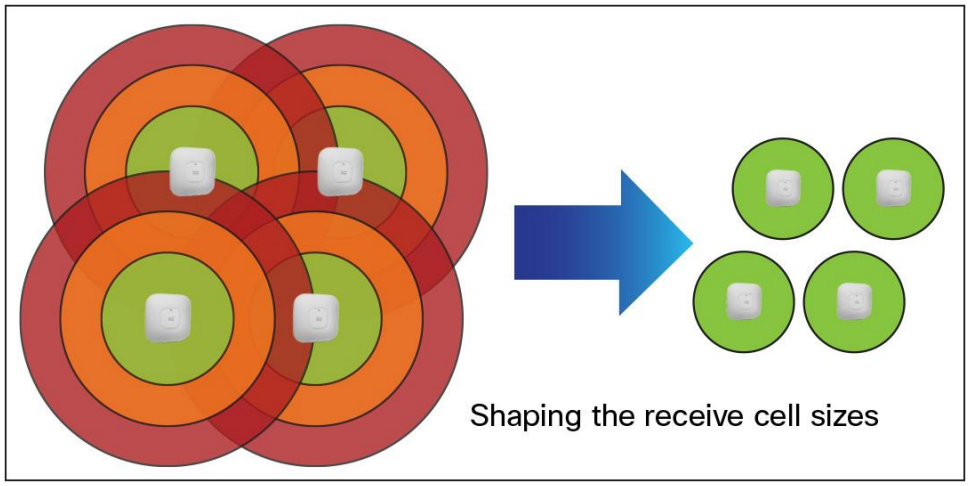
No 802.11b data rates (1, 2, 5.5, and 11) were permitted. The overall protocol spread is captured below in network statistics. Setting data rate policy on the network encourages good client roaming behavior and provides natural load balancing between cells.



HDX RX-SOP Threshold

In addition to the use of HDX antennas, the receive-start-of-packet (RX-SOP) threshold adjustment is used to further shape the receive cell size in HDX environments. This allows tuning of the physical cell to more closely match the desired cell size.

The radios are extremely sensitive, and in a high-density environment such as a wide open convention center floor, signals travel a long way. To reduce the receive cell size of each access point and avoid interference from co-channels, a medium RX-SOP threshold value of -75 dBm was applied to both 2.4 and 5 GHz radios universally. This aligns the receive cell size with the designed transmitter cell size. Signals below -75 dBm are filtered by the radio. This encourages and enforces roaming behavior in clients and load balancing on the system. It also reduces overall channel utilization in high-density environments.



Cisco ClientLink (Beamforming)

In high-density Wi-Fi, signal levels are all high as the connected users are located quite close in a condensed area (hence, high density). Cisco ClientLink features assist individual stations by detecting when the station is adjusting data rates to maintain a connection and placing the packets for that station in the transmitter Beamforming queue. ClientLink can provide up to 6 dB additional Received Signal Strength Indicator (RSSI) to a specific station, overcoming temporary loss of SNR due to interference.

Figure 10. ClientLink Optimizes Overall System Performance

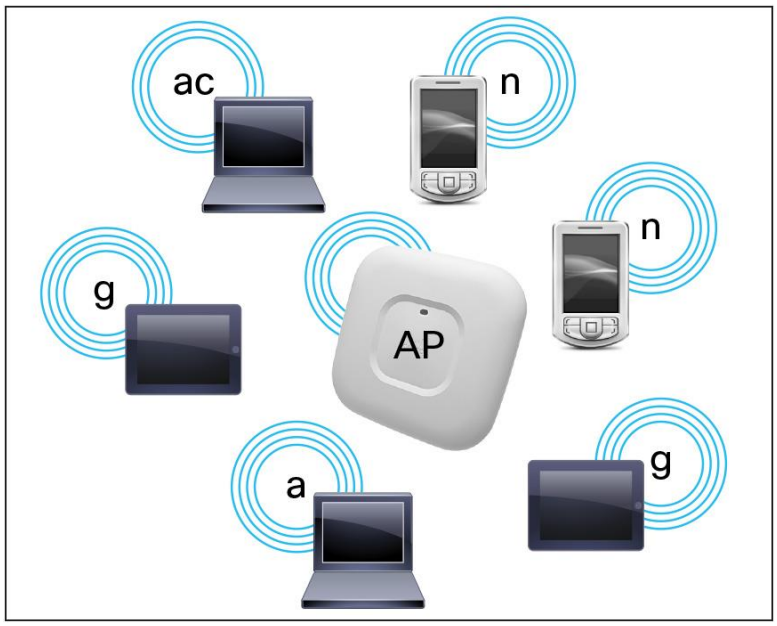
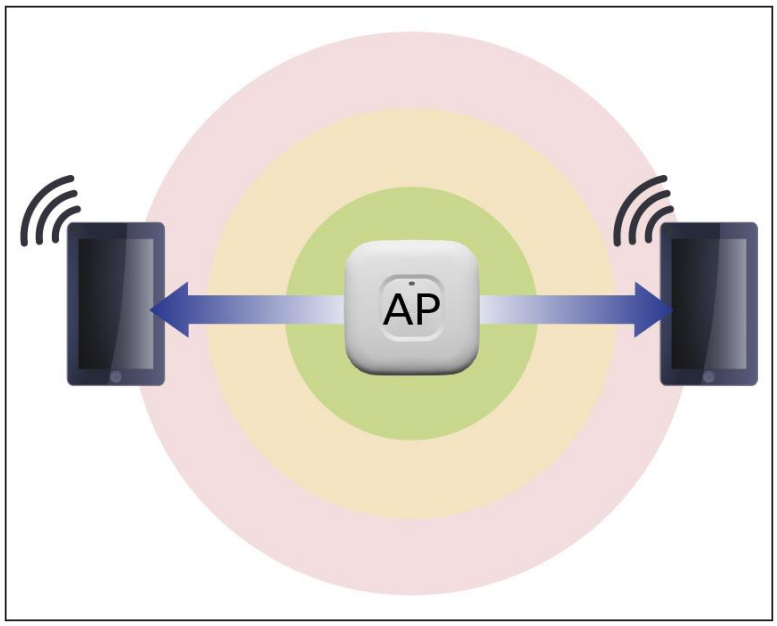


Figure 11. Clients at the Edge Get the Most Benefit from ClientLink Performance Optimizations



ClientLink effectively maintains device speeds to further enhance the efficiency of the network. This conserves airtime and allows more users to share the spectrum simultaneously. The third generation of this technology has proven itself in the most adverse conditions and remains independent of client-side technology, providing benefits for every 802.11 a/b/g/n/ac client in the cell.

Advanced Services

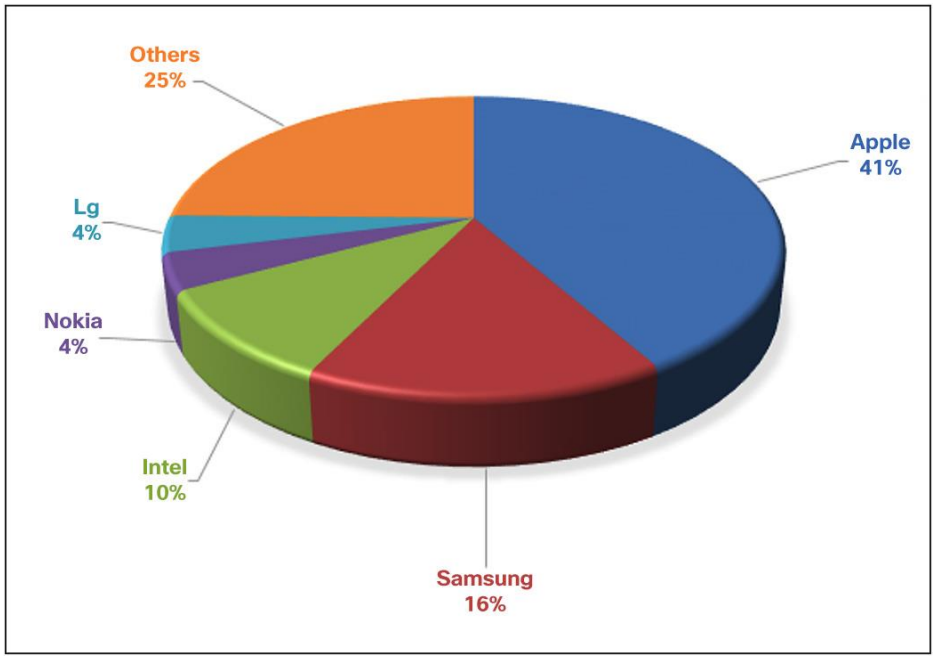
Hotspot 2.0 Passpoint Network Description

A successful demonstration for the next-generation hotspot (NGH) demonstrated the viability of the Passpoint Release 1 devices in the marketplace today at the GSM Association Mobile World Congress 2014. The program for the MWC 2014 demonstrated the interoperation and roaming of 18 operators who loaned their SIM cards and Tunneled Transport Layer Security (TTLS) credentials to prove the seamless roaming, accounting, and NGH experience for end users. BYOD Passpoint-capable devices successfully pre-associated and automatically authenticated utilizing 802.11u, 802.1x and NGH technology.

The service provider mobile operator participation through mobility was for EAP-SIM in the Hotspot 2.0 network at large. This network consisted of 331 access points set up in the public areas, the walking hallways, entrance areas, Hall 8, and the registration desk at the venue. The 10 operators all ran EAP-SIM with roaming agreements on device platforms of Galaxy S4 Samsung, iPhone 5, 5c, 5s, and compatible tablets and devices.

The pre-show contacts for the 10 operators involved had been emailed instructions and IOS mobile configuration files so that users could pre-load and turn on Passpoint on their mobile devices to attend the MWC 2014 conference. For those users of the 10-operator community who missed the instructions and the profile download files, an onboarding SSID was advertised on the 331 HS2.0 access points, called MWC HS2 Setup. Once a client's WPA2 session was complete they would automatically associate to the MWC Hotspot2 Passpoint network. Figure 12 outlines the hotspot device distribution.

Figure 12. Hotspot User Device Distribution



*Note: A lower ratio for Apple devices is shown as Murata is an Asian iPhone variant and there were a heavy presence of Korean users (SKT, CMCC, PCCW, etc.)

Key MWC Hotspot2 Network Statistics

First, the show only allowed for the listed 10 operators to participate in the HS2.0 network at the MWC2014. These 10 operators were a small subset of the 80,000 users who showed up. Second, the numerous RADIUS server rejects for countless other operators' clients who had Passpoint-compatible devices were not allowed on the HS2.0 network and were forced to the MWC Free Wi-Fi SSID. The advantage for HS2.0 clients in the group of 10 operators was unlimited bandwidth for their devices (sometimes 70 plus Mbps data rates).

Hotspot 2.0 users by protocol shows a higher tendency for 5-GHz operation. The success of this HS2.0 event was excellent and many lessons were learned from this large-scale deployment, in which the network operations team had to set filter constraints and test the roaming and admissions capabilities of the network.

Location, Applications and Network Analytics

Thousands of NetFlow entrees and session information entrees were collected in real time from multiple boxes like Cisco Integrated Services Routers (ISRs), Mobility Services Engines (MSEs), and WLAN controllers to analyze the type of applications being used, their usage according to coverage areas, user activities, social media activities, trends, and more.

A farm of multiple MSE servers were employed to collect massive location information from all the WLAN controllers. All the numbers were analyzed using a Cisco Prime platform. MSE played important role aggregating all the data. Figure 13 shows a Cisco Connected Mobile Experience appliance revealing the number of active devices in the Hall 2 exhibition area.

Figure 13. Cisco Connected Mobile Experience (CMX)

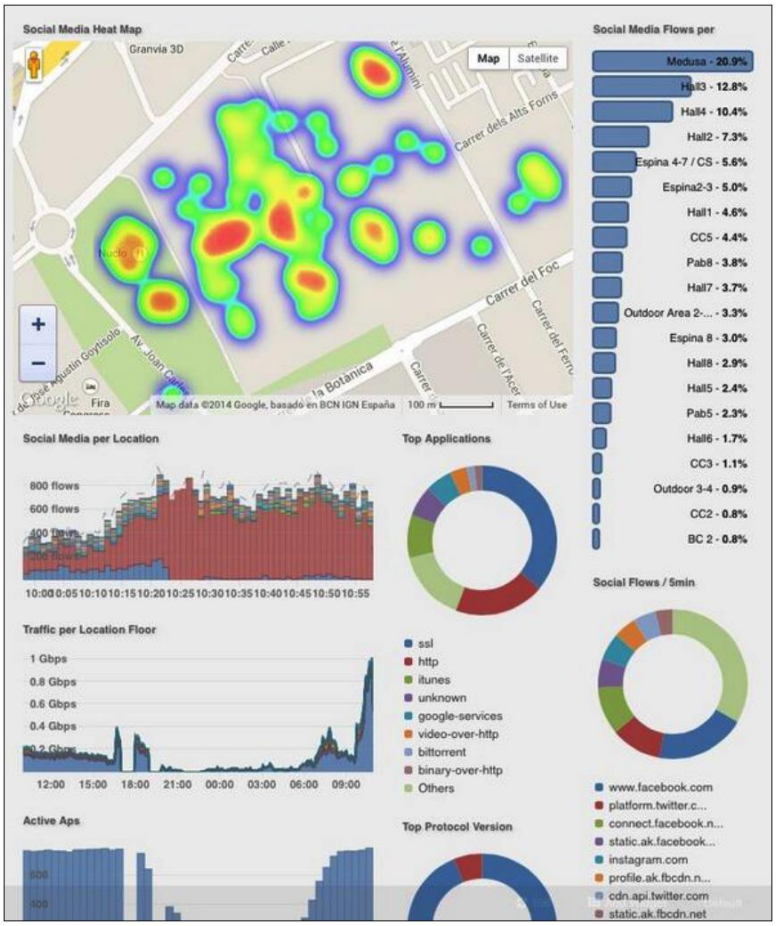
Location information included generating reports on a daily basis, which comprised of the following parameters:

- Venue location reports (MSE)
- Device counts per hall or venue
- Device dwell time per zone

- Hourly visits and dwell times per zone
- Preferred paths per hall

Implementing Cisco infrastructure with a third-party application engine, location-based heatmaps (Figure 14) were generated to individually point out areas of interest based on client activities, associations, distribution, and connectivity information.

Figure 14. Heatmaps and Analytics Information of Current Statistics of App Traffic and Locations



Application reports generated from the collected analytics provided with a wide range on information on the user application trends and areas with the highest footfall using these applications.

Application reports included:

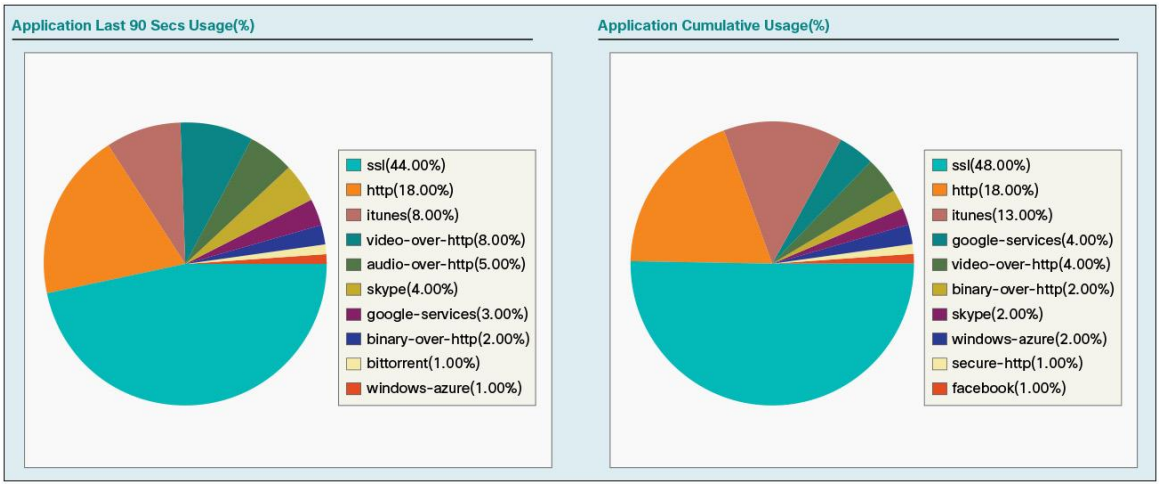
- Top 10 URLs by visitors and by traffic
- Heatmaps for top 10 URLs per hall and event
- Top 10 applications
- Top 10 destination countries for traffic
- Social analytics

Network Statistics

MWC 2014 turned out to be one of the biggest wireless networks deployed at a single venue for the tradeshow. Besides gathering client and user information from Cisco Prime Infrastructure, the network operations team used information from Cisco Intelligent Services Gateways (ISGs) and session flows to understand how much the network was actually being used.

Cisco Application Visibility and Control (AVC) was enabled on the wireless and wired networks to control and monitor overall bandwidth utilization across the entire network (Figure 15).

Figure 15. AVC Dashboard Displaying Accumulative Applications Statistics



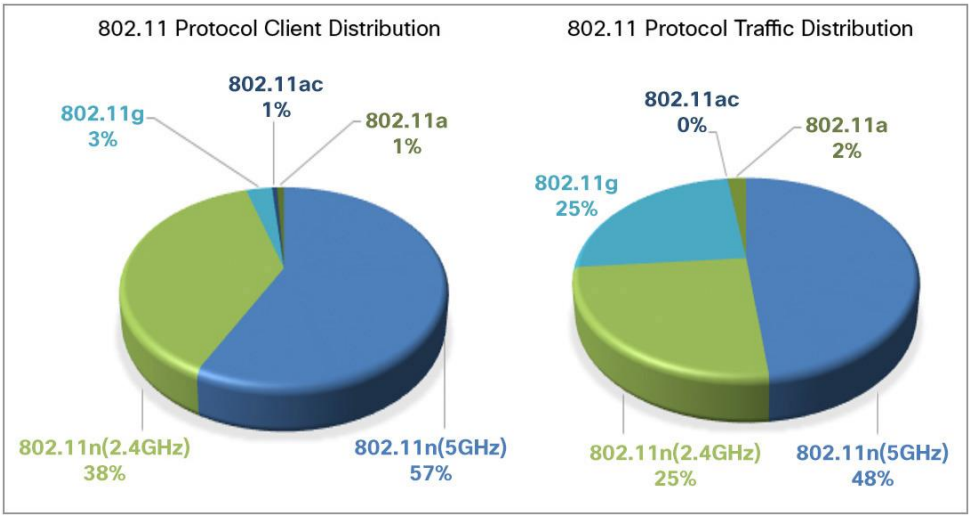
Using daily data traffic reports organized by Cisco Prime Infrastructure management, analysis of the total data traffic exchange was generated (Table 4).

Table 3. Daily and Total Network Statistics for Data Traffic, Devices, Protocols, and Peak Output

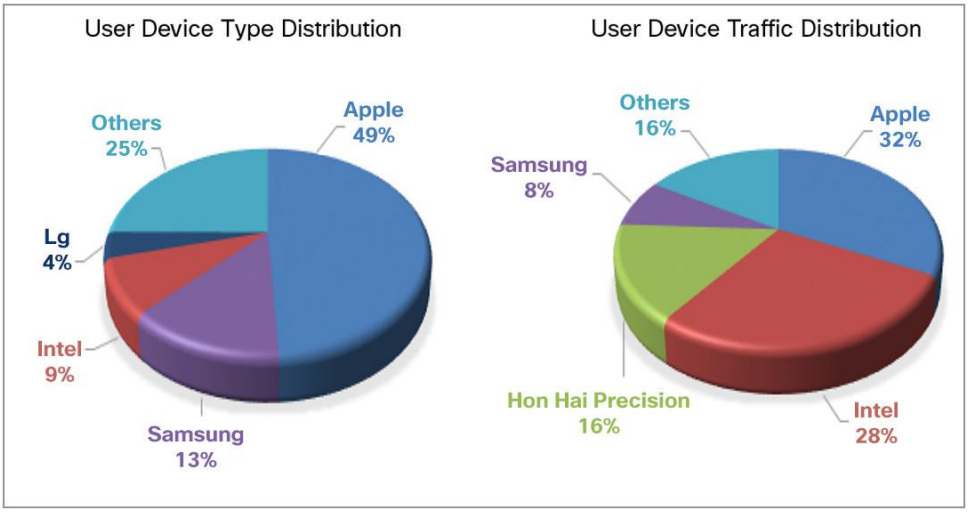
	Monday 24th February	Tuesday 25th February	Wednesday 26th February	Thursday 27th February	Overall
Data Exchanged	4.7 TB	6.5 TB	5.4 TB	2.5 TB	19.1 TB
Total devices	53175	60013	54255	32102	80880
Peak devices	19144	22126	20346	13178	22129
5 GHz vs 2.4 GHz	60% vs 40%	53% vs 47%	53% vs 47%	59% vs 41%	58% vs 42%
IPv4 vs IPv6 (traffic)	86% vs 14%	87% vs 13%	87% vs 13%	85% vs 15%	86% vs 14%
Peak Internet traffic	0.65 Gbps	1.0 Gbps	1.2 Gbps	0.6 Gbps	1.2 Gbps

*The data refers to the following opening hours: 7am to 7.30pm

Client and traffic distribution according to protocol type:



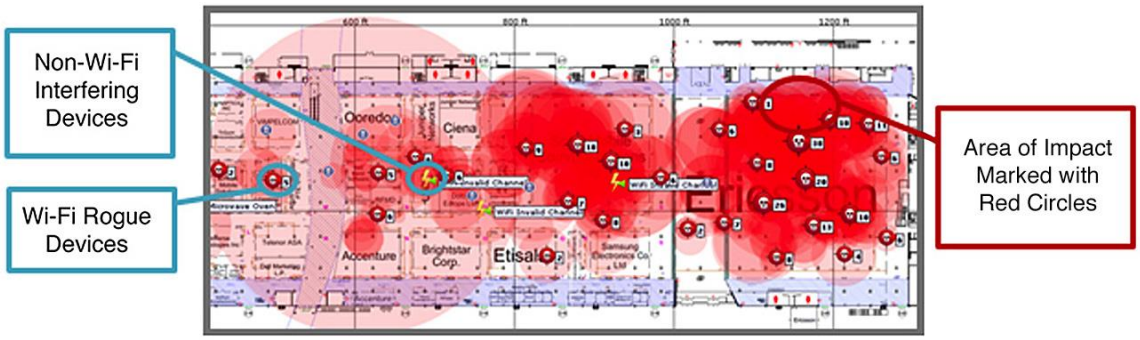
Client and traffic distribution according to device manufacturer:



Challenges

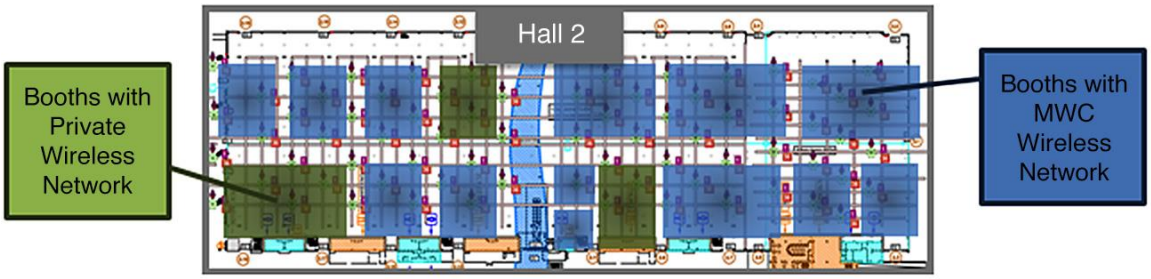
Rogues Devices, Personal Hotspots, Mi-Fi Devices

Cisco access points continuously monitor wireless rogue activities. In order to further enhance this capability, 25 Cisco Aironet Access Point Modules for Wireless Security and Spectrum Intelligence (WSSI) were deployed as an add-on to the existing access points to provide dedicated monitoring and resolution enhancement in this highly complex environment. Monitored rogue devices included many personal hotspot and Mi-Fi devices, such as unauthorized access points brought in by exhibitors, and smartphones running Wi-Fi data tethering over the cellular network. On average, over 2500 rogue devices were reported each day, spread across both 2.4 GHz and 5 GHz spectrum. Below is an example.



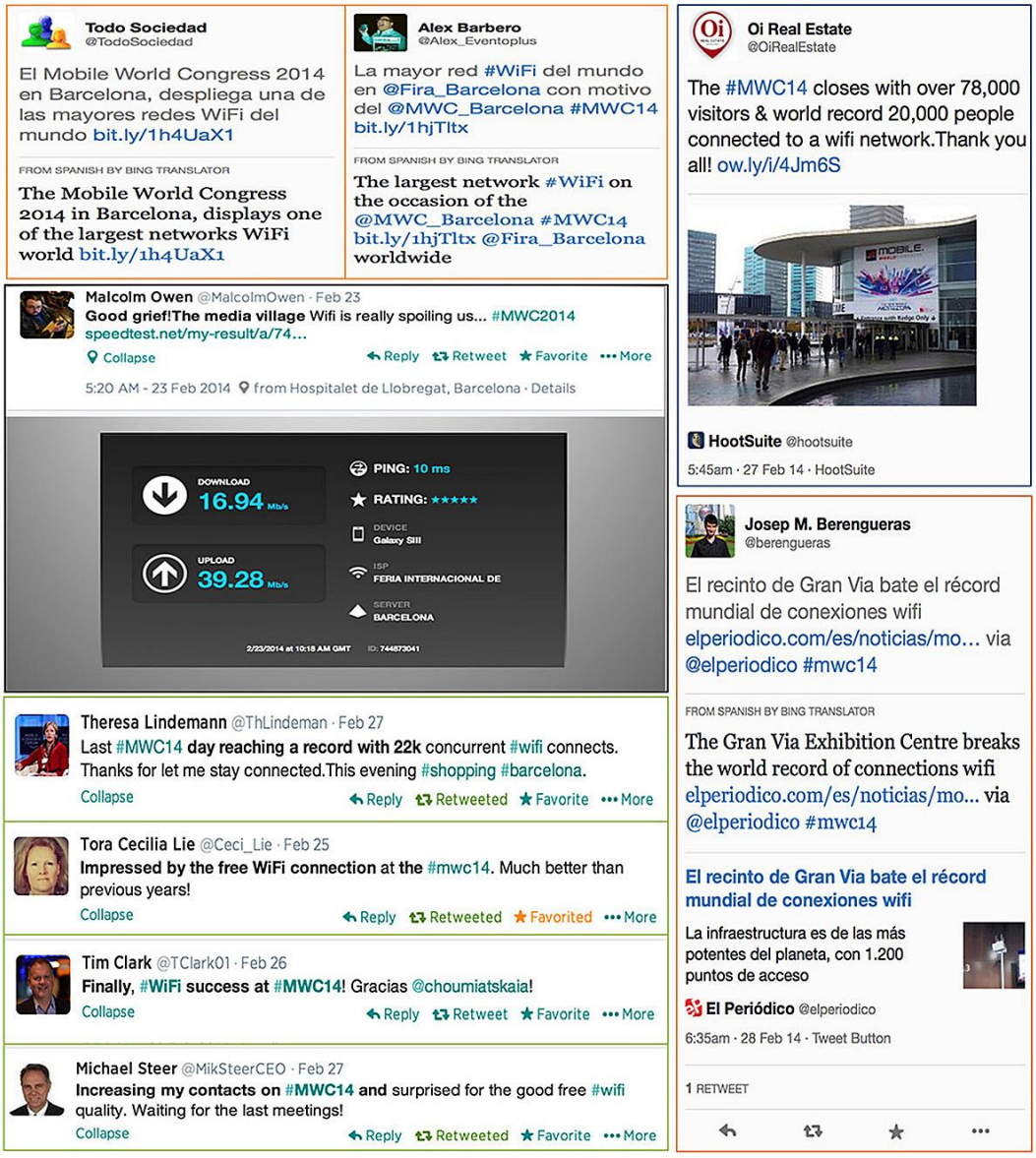
Wi-Fi Co-existence

Wi-Fi operates in a non-licensed spectrum and it has to adapt to the surrounding RF environment by co-existing with other Wi-Fi and non-Wi-Fi devices. Few specific vendors were allowed to use their own Wi-Fi equipment to enable their self-managed wireless network. Initially, only limited channels (36, 52, 54, and 60) were assigned to the private Wi-Fi network, but due to limitations of some vendors' devices which were unable to use the DFS spectrum band, Fira accommodated them by dynamically changing the spectrum plan without interruption to existing services.



In this ever-changing, challenging environment, the Cisco network utilized its robust RRM algorithms to quickly adjust channels and power levels to avoid co-channel interference, and at the same time provide quality service to existing users.

Social Media Feedback



What's Next?

Mobile World Congress has been implementing Wi-Fi services in the public areas for quite a few years, but taking on the big challenge of bringing the Wi-Fi network into the exhibition hall areas has allowed the organization to establish new ground and set MWC 2014 a class apart.

Large convention and exhibition hall construction, along with the existence of numerous Wi-Fi-enabled devices in the same arena, makes it an extremely inhospitable environment to deploy a pervasive Wi-Fi network. Cisco High Density wireless designs and infrastructure enabled the presence of a blanket Wi-Fi coverage across all eight exhibition halls, offering wireless and wireless-to-LAN services to the exhibitors and vendors.

Cisco delivered on the agreed service level agreement for an optimal Wi-Fi experience, sustaining over 20,000 simultaneously connected devices on the wireless network. While the free public Wi-Fi bandwidth was gradually raised from 2 Mbps to 4 Mbps, then 8, and finally to 16 Mbps per user to encourage and accommodate more user data transfer, the network operations team was happy to see a press representative enjoying the uncapped press Wi-Fi to upload more than 280 GB of data in one day from a single access point - a record by its own.

As we head toward the next generation of incoming mobile devices, Cisco is teaming up once again with FIRA and GSMA to catapult the Mobile World Congress 2015 Wi-Fi network to the next level with a full Cisco 3700 Series Access Point upgrade deployment. Together, we welcome the future technology adoption and newer challenges in high-density Wi-Fi, IPv6, 802.11ac, and Hotspot 2.0.

See you in MWC 2015.

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