The Plume Advantage: Putting the Adapt in Adaptive WiFi

Plume®

The Plume Advantage: Putting the Adapt in Adaptive WiFi

ABSTRACT

WiFi is the predominant way we connect to the internet and access our mobile and digital lives. Residential customer experience is directly proportional to the speed and reliability of the WiFi connection, and the mobility of devices we use to consume content requires WiFi to reach every corner of the home. Traditional centralized WiFi routers fail to provide adequate coverage for the whole home, and accompanying WiFi repeaters or extenders fail to reliably extend the WiFi connection. In order to completely solve the WiFi problem, a new architecture is required. This architecture requires a deeply distributed WiFi access network with a centralized, intelligent controller to manage the delivery of WiFi speed, reliability, and coverage. Each network must be able to adapt to each customer's home size, environment, and usage based on current client device usage and historical insights of customer patterns. The benefits of such an adaptive WiFi system are compared against traditional WiFi systems and also against newer mesh-based WiFi systems.

AUTHORS

Adam Hotchkiss
Co-Founder, VP Product

Bill McFarland
Chief Technology Officer

Table of contents

Introduction

Today, in their homes, people are consuming ever more content, interacting via richer communication mediums, and relying on various internet-delivered applications and services to make their lives more comfortable and safer.

Led by the emergence of HD and UHD video-on-demand and IoT connected devices, consumers are using the corresponding applications and devices in even more places in the home, and WiFi is becoming the standard way these devices and applications are connecting to the internet. The broadband internet connection available in most homes today is extremely reliable and consistent with 99.9% uptime. Moreover, the upstream infrastructure and resources–compute, storage, CDN, DNS, and other cloud platform services–are even more reliable, with a 99.99% uptime. However, today's consumer internet experience is often frustrating, with choppy video, dropped sessions, and inconsistent speed. This problem is largely due to the WiFi network inside the home, the last few meters of the connection. Some of the key factors of this inconsistent performance are wireless interference, congestion, coverage impairments, and device (mis)behavior.

Today, home WiFi works well only in some places, some of the time.

Current systems focus development and marketing efforts on performance in terms of single-application speeds and feeds without paying close attention to the requirements of a high-quality experience across many simultaneous applications through whole-home WiFi coverage. Bringing a high-performing, consistent, and reliable WiFi experience to every corner of the home requires a completely new architecture and delivery model, like the one Plume offers under the HomePass™ suite called Adapt™. This adaptive WiFi service adds the space and time dimension to high-performance WiFi, as illustrated in figure 1, by replacing or complementing the centralized home router with a set of distributed, cloud-controlled, simple-to-install WiFi nodes or pods1. These small, beautiful WiFi access points are placed at optimal locations around the house. While traditional WiFi is centralized and static, relying on local control, Adapt is deeply distributed throughout the home and delivered as a cloud service that continuously adapts to the needs of the home and its occupants.

1 The term "pods" is used to refer to the complete 'family' of Plume's WiFi access points including pods, PowerPods™ and SuperPods™.

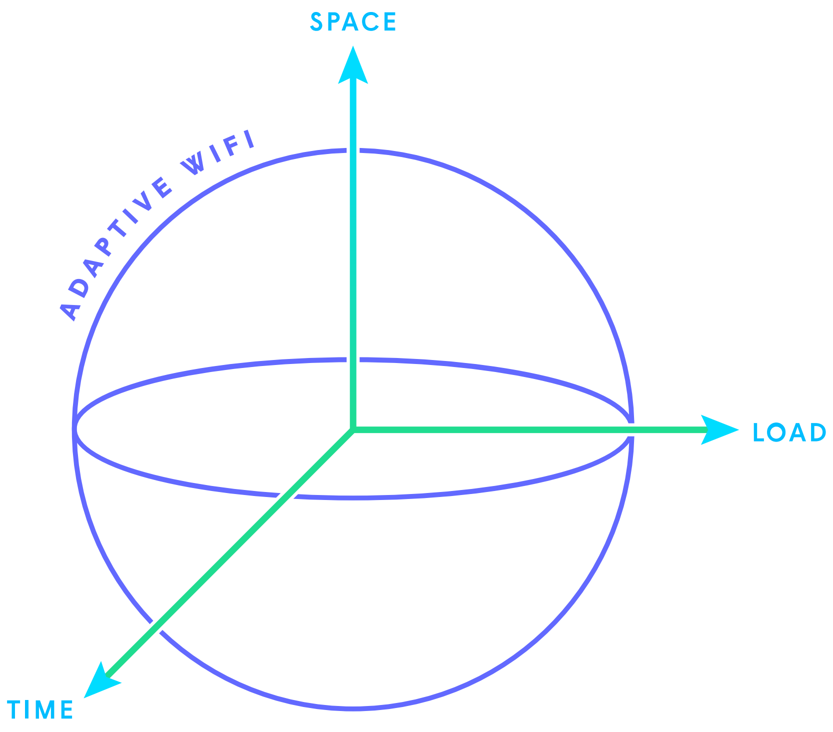


Figure 1: Adaptive WiFi dimensions

Beyond the consumer, there are many others with a vested interest in high-performing, consistent WiFi around the home:

OTT PROVIDERS

The over-the-top Service Provider (OTT-SP) ecosystem relies increasingly on consistent, high-performance WiFi for adequate delivery of their content, customer satisfaction, and retention.

COMMUNICATIONS SERVICE PROVIDERS

As the "last few meters" of their broadband access infrastructure, CSPs need managed, high-performance, and consistent home WiFi for delivery of video-over-wireless, data, and other services to a multitude of wireless devices.

IOT & SMART HOME DEVICE MAKERS

The rapidly emerging IoT and smart home category requires adaptive WiFi as a fundamental enabler to handle the growing number of connected devices consistently and reliably. The distributed nature of Plume's Adapt ensures that the distance (range) between IoT devices and the home infrastructure is always short. Such an architecture is critical for IoT devices which are small and low-powered, and cannot afford to transmit signals all the way across a home to a single Access Point (AP). Easy and secure onboarding, configuration of smart devices, and reliable connectivity for data collection are core elements of the Adapt service.

Design approach

Why is Plume's Adapt service distributed?

Wireless signals degrade with distance, more so when passing through walls made of common construction materials. This attenuation is particularly dramatic if the walls are brick or stone (common in Europe), contain wire mesh (traditional plaster), or metal foil (common in insulation in newer homes). The wireless signal corresponding to the WiFi 11ac and 11ax standard degrades even more rapidly with distance since it uses the 5GHz spectrum as compared to the 2.4GHz spectrum used by earlier, slower versions of the standard.

As the consumer is starting to use increasingly more bandwidth-hungry WiFi devices at more and more places in the home, the approach taken by the high-end routers is to use increasingly more powerful hardware in the router in the hopes of driving the WiFi signal to more places in the home. More powerful hardware means using more radio chains (antennas) with sophisticated signal processing (MIMO) and higher-power amplifiers to generate a stronger signal. This approach leads to higher cost, size, and consumption. In addition, very few devices are able to fully use the MIMO capabilities. In all cases, the increase in range that can be achieved this way is relatively incremental and reflects diminishing returns for larger increments in power and complexity. Figure 2 shows the resulting improvement in coverage achieved by such higher-end routers. As distance increases, the rate of performance of the WiFi signal is greatly diminished, and expensive increases in signal power and parallel transmissions provide only marginal WiFi performance at distance.

Figure 3 highlights a more sophisticated distributed WiFi approach, in which coverage is improved by sprinkling the smaller, lower power AP hardware (pods) across the home.

The WiFi signal is forwarded across the optimally placed pods around the home to reach all client devices. With a sufficient number of pods (depending on the size of the home), the WiFi signal never needs to travel very far between pods, or from the last pod to the final client device. By substantially shortening the distance that the WiFi transmissions need to travel, this solution dramatically reduces the degradation of the WiFi signal, allowing for substantially higher data rates throughout the entire home.

Figure 2: Coverage Improvement With Single WiFi Router HW Improvement

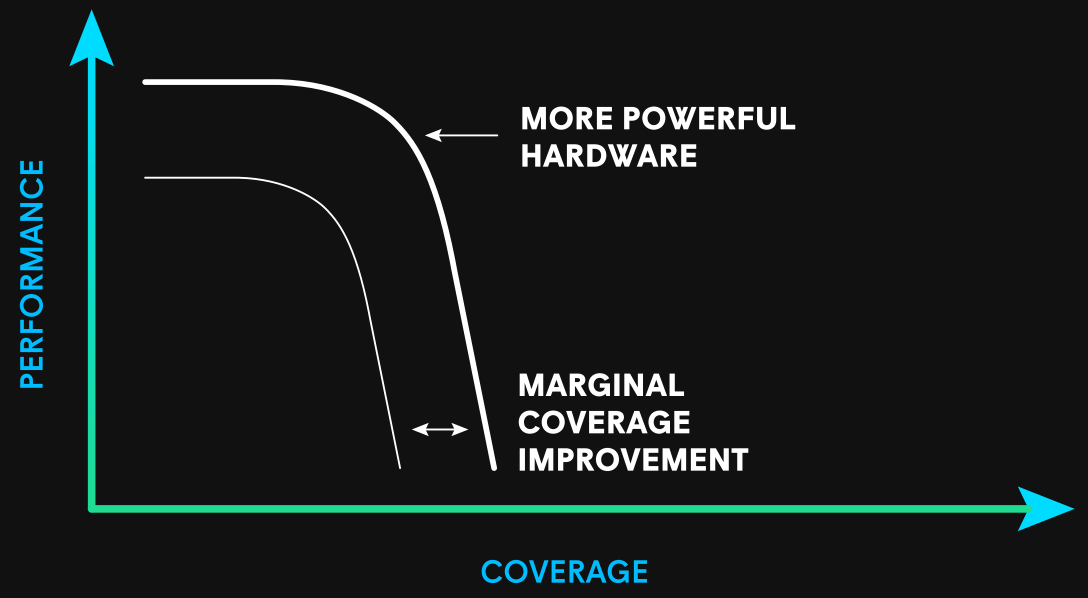
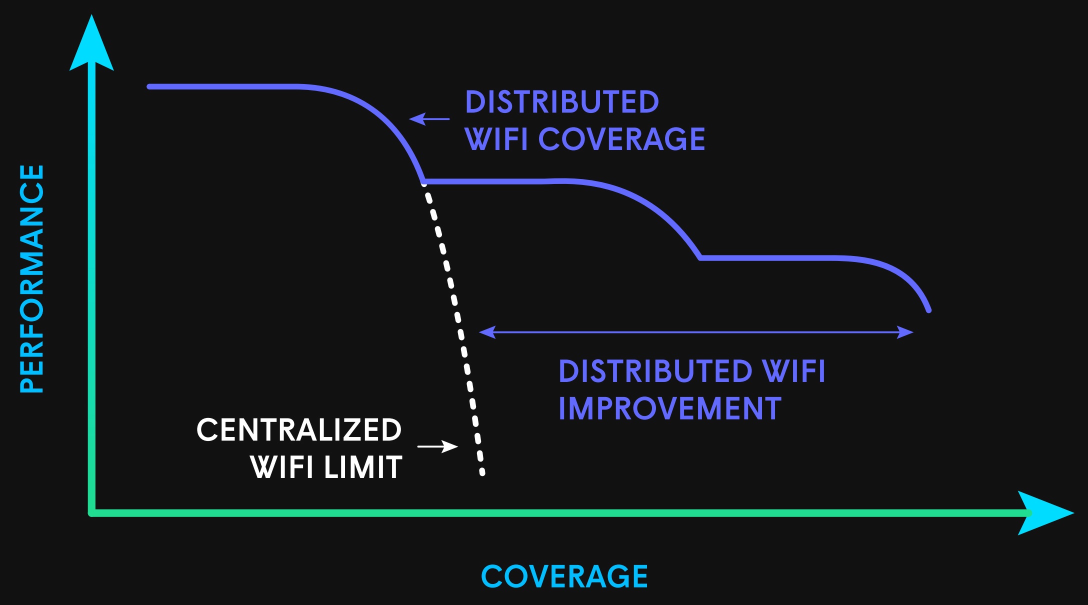


Figure 3: Coverage Improvement With Distributed WiFi System



A distributed WiFi system has several advantages over a single router:

With a single router, the WiFi performance at different places in the home will vary based on the placement of the router since there is only one way for the signal to get from the router to a given device. With a distributed WiFi system, the signal can take several paths to get to the client device, and therefore the system can be optimized to choose the most effective path.

MAXIMIZE CONFIGURATION

Most WiFi client devices (e.g. phones, PCs, TV boxes, IoT devices) use one or two antennas and do not benefit from the >4 radio chains built into the most powerful routers. A distributed WiFi system can use a similar radio configuration as supported by the devices to avail a significant cost advantage without losing performance on the client connection speed.

MULTIPLE PODS, ANY NUMBER OF CHANNELS

A centralized WiFi router can only use a limited number of channels, and those channels have to bear the load for all the clients on the home network. The multiple pods of a distributed WiFi network like Adapt’s can operate over any number of channels, thereby spreading the radio spectral load without causing interference. The distributed network also benefits from load balancing, allowing devices to be distributed among the multiple APs in the home, relieving congestion in the AP to client links.

MU-MIMO TECHNOLOGY IS LIMITED

Some of the recently launched 11ac wave2 routers use MU-MIMO technology to allow a single router to send traffic to multiple client devices in parallel by using different subsets of its multiple radio chains. Similarly, upcoming 11ax routers will use OFDMA technology to communicate with multiple devices in parallel. However, the resulting capacity increase is modest due to operating in the same channel from the same radio when compared to the significant capacity gain achieved from separating the multiple radios of a distributed WiFi network in frequency and space. MU-MIMO gains are further limited by the fundamentally fragile nature of the nulling based technology.

LEVERAGE SOFTWARE TO MANAGE COMPLEXITY

The proliferation of WiFi nodes, or pods, throughout the home provides large degrees of freedom for traffic routing between the end-device and internet gateway connection. The number of potential connections between nodes increases by N(N-1), greatly increasing the ability to deliver a reliable, high-performance WiFi service.

Distributed WiFi networks are more complex to configure and manage, specifically to deliver the optimal performance commensurate with their capability. This complexity is best handled with a centralized software entity with knowledge across the entire network. In essence, a distributed WiFi approach achieves a superior wireless system by shifting the complexity from hardware to software.

What are the pitfalls of WiFi repeaters or mesh?

WiFi repeaters can be used to extend coverage in a way that may seem similar to the distributed WiFi approach, but repeaters act as independent nodes and do not coordinate with the central router or other repeaters (nodes) in the system. Therefore, unintelligent repeaters cannot adapt to the changing needs of wireless networks and can only be used to boost (repeat) the signal from the central router. Some WiFi repeaters repeat the signal on the same channel, thereby reducing the overall capacity of the network by introducing self-interference. Even in the case where a repeater attempts to repeat the WiFi signal onto a different frequency channel, it requires sophisticated management by the user to optimize performance. Any configuration created by the user will be a single static configuration, unresponsive to changing conditions or interference from neighboring networks. Moreover, in traditional repeater-enhanced WiFi networks, the selection of the connecting WiFi node per client device is completely controlled by the device.

Devices operating on their own will often not choose the path of maximum performance. For example, customers can experience extremely poor performance when their devices “stick” to a distant repeater rather than connecting to the nearby router. Finally, coordination of changes in the WiFi network, such as channel or SSID changes, are hampered by the lack of a centralized authority. Typically, consumers changing their WiFi network name or password end up in a tangle of reboots, disconnected devices, and partially connected networks. In sum, the use of WiFi repeaters or extenders to increase range often leads to inconsistent results and often lessens the performance of the network as a whole.

A new class of WiFi products form a mesh network to coordinate with each other to increase the WiFi range. Current mesh routing protocols are designed to provide reachability of traffic between mesh nodes, only ensuring that the traffic makes it to the internet gateway in some way. This focus of mesh routing on the survivability of the backhaul traffic between mesh nodes largely ignores the routing demands of the connected devices. These unsophisticated routing protocols do not address application performance or wireless network capacity to achieve the desired customer QoE. In fact, most mesh systems available today operate on a single channel backbone thereby significantly limiting the overall capacity while being prone to self-generated interference. Additionally, the locally managed, traditionally distributed control plane mesh routing architecture increases the complexity of each individual node, making it difficult to continue to add capabilities by adding additional nodes and routes to the mesh system.

The use of WiFi repeaters or extenders to increase range often leads to inconsistent results and often lessens the performance of the network.

How is Adapt different?

Plume’s adaptive WiFi system continuously adapts to the environment and user behavior to optimize the overall network capacity and application performance.

Some of the differentiating aspects of Plume’s Adapt system compared to repeater or mesh systems are:

- Continuous monitoring and avoidance of interference from neighboring networks
- Leveraging multiple, non-interfering channels to operate the network routing paths thereby increasing capacity
- Routing algorithms designed to balance the network load, maximize the network capacity, and optimize end-application performance based on client device requirements
- Traffic shaping/prioritization for application-level performance
- Ability to optimize network performance by steering clients to different pods in the system consistent with the optimized route topology
- Fast client hand-off across nodes for application survivability and quality of experience

Why is Adapt cloud-controlled?

WiFi network controllers first emerged in the enterprise environment to handle coordination among multiple Access Points. Enterprise vendors have been steadily migrating towards virtualized controllers (controllers deployed as software in the cloud).

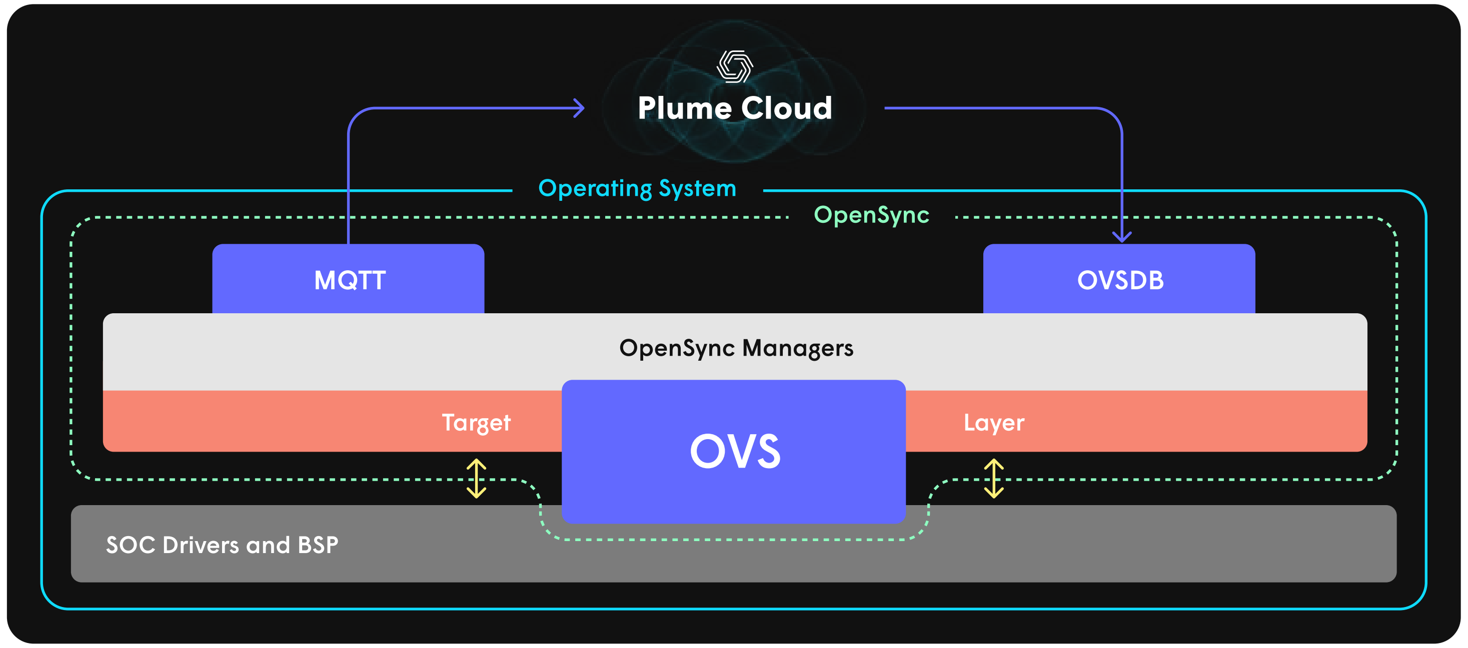
Leveraging a similar architecture to manage a distributed WiFi home network offers several advantages:

- Centralized management simplifies coordination among distributed nodes, and can more readily apply global optimizations across multiple customers. These optimizations can span large apartment complexes, or even entire regions of cities.
- Similar to channel frequency and bandwidth assignment, the assigning of client devices to pods (client steering) can be done more effectively with a centralized global view of the network including all client devices.
- Roll-out of new features and services is simpler, faster, cheaper, and less risky by updating the centralized cloud controller, without having to update the firmware on the in-home devices themselves.
- Network stability issues are eliminated with a centrally controlled network. Optimization is performed in the cloud, the result is configured in the network, and the network will remain in that state until the cloud decides to modify the configuration. This alleviates the problems experienced with distributed mesh systems in which each of the nodes are running independent algorithms, making localized decisions with arbitrary timing, thereby creating inconsistent and unpredictable network behavior.
- A cloud-based management system is able to aggregate data from many homes for analysis and learning. Improved methods for network optimization, client behaviors and bugs, and typical device/user patterns and behaviors can be extracted from such a cloud-based centralized database.
- The compute, storage, and memory complexity of each individual node is reduced, making the nodes smaller, less power-hungry and easier to develop and deploy. The cloud, with virtually unlimited compute power and memory, can run arbitrarily complex algorithms to learn and optimize.

Cloud-controlled advantage

- Network operations & customer support
- Inventory & billing systems
- Data analytics & insights with scalable realtime control
- Service onboarding & provisioning
- Device & firmware management
- Network performance control

OPEN-SOURCE PLATFORM BUILT FOR SCALE



What are the key attributes of our user-focused design?

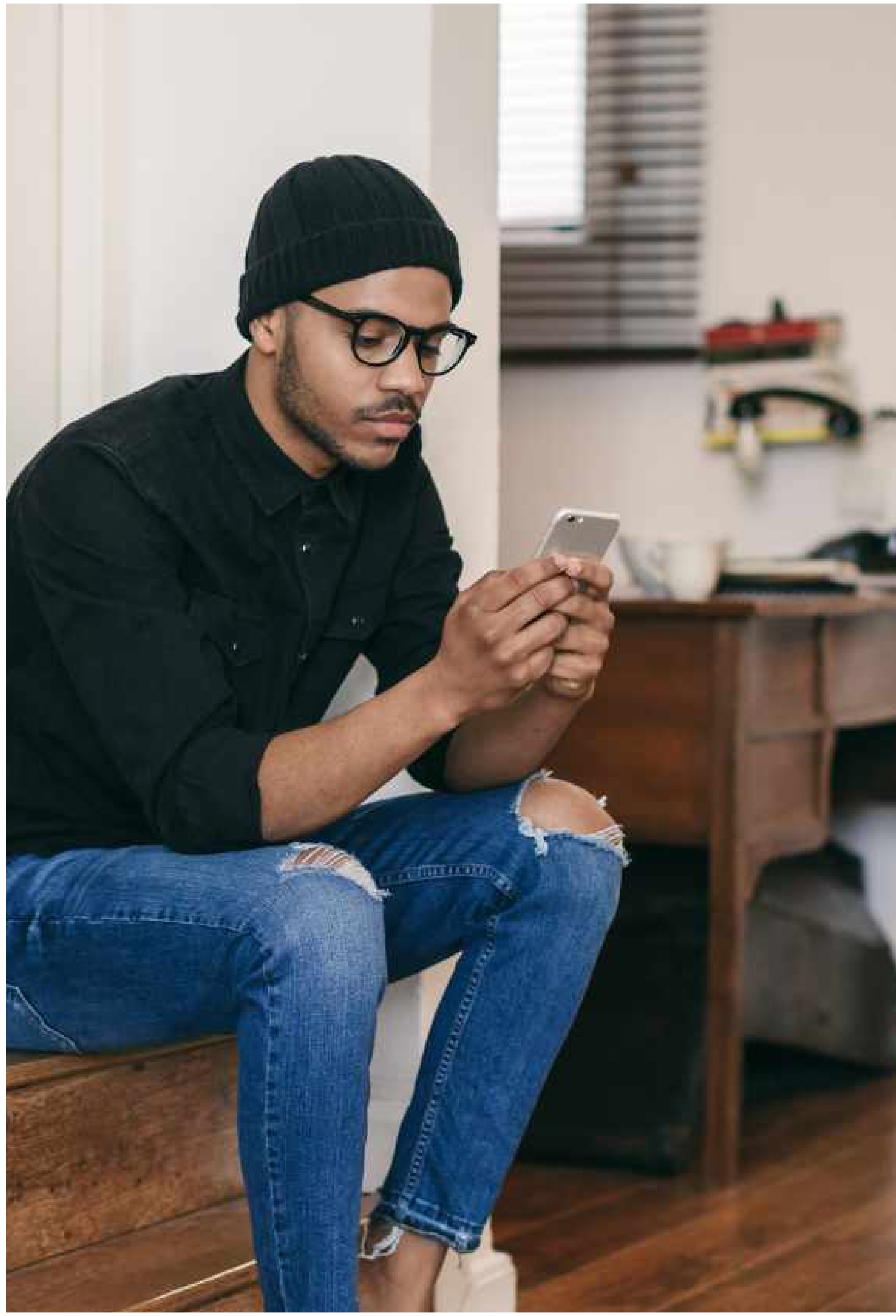
End-user experience is the most important aspect of our service design. An easy and intuitive installation process including the onboarding of nodes is critical. Plume's Adapt solution is mobile-first, enabling customer action through iOS and Android apps.

In designing the application and flows, we focused on consumer activity rather than packaging the system mechanisms. For the first time in consumer WiFi, customers are in control of the performance of, and access to, their home WiFi. Cloud-enabled features such as one-touch guest network access, remote performance monitoring and troubleshooting, IoT device auto onboarding, parental controls, advanced AI security, and whole-home motion awareness are features which can be continuously rolled out via the cloud platform over the life of the product without having to compromise due to legacy local controllers or hardware.

Adapt shifts the focus of wireless performance from the prevalent speed and feeds paradigm to one focused on the quality of the user experience. As such, attention is paid to whether the consumer can get the internet performance he/she requires everywhere in the home. Adapt ensures application performance, reliability, and coverage through cloud-controlled network optimization on a continuous basis.

Visibility and support is the third key attribute of a great consumer WiFi system. The consumer is provided beneficial performance metrics, status indicators, and data insights for each client device—and the internet connection—with in-app troubleshooting to assist with inquiries when things are not working well. For example, "is it your internet, or is it your WiFi?" Additionally, online or call support is provided by the Communications Service Provider (CSP) with the ability to visualize the customer network and related WiFi and CSP KPIs from the cloud fed operations center.

Adapt shifts the focus of wireless performance from the prevalent speed and feeds paradigm to one focused on the quality of the user experience.



Conclusion

The unique capabilities of Plume's Adapt service, a distributed, dynamic WiFi system with cloud-based control, provides the best quality of customer experience when compared to other available WiFi architectures.

The advantages can be seen in the network topologies themselves, including the use of multiple frequency channels in the backhaul, optimized selection of the number of hops, and channel frequency assignments planned across entire apartment complexes. It can also be seen in the management of the client devices in the networks, including simple onboarding, and coordinated client steering. Finally, the approach brings network management advantages including superior visibility and support, and the ability to easily upgrade and enhance capabilities, changing cloud software rather than code on an in-home device.

Learn more at plume.com