Counting 70 years of experience, Iskratel is the leading European provider of infocommunications solutions, with its own R&D and manufacturing centres, 900 employees and local presence in more than 30 countries. Iskratel delivers integrated telecommunications solutions for telco, transportation, public safety, and energy industries.

Executive Whitepaper

Maximising In-house Wi-Fi Coverage and Performance

Powerline backhaul as the best way to boost indoor wireless

In just a few years, the availability and omnipresence of the wireless signal has become as natural as air. As users, we have come to believe that over-the-air internet services should always be available to us and that these services should be available anywhere and on many different devices such as smartphones, tablets and laptops. Even in our homes (which are likely to be equipped with a good wired internet connection) or offices, we rely on Wi-Fi and too often think of connectivity via wired internet as *so 20th century*.

At the same time, use of Wi-Fi in our homes allows us to avoid having to install cables all over the house or apartment, which is something most will welcome. On the other hand, this means that good Wi-Fi coverage and performance (throughput) need to be provided by Wi-Fi access points (APs) – or we will not be able to reap the benefits of wireless connectivity.

Summary

New Wi-Fi technologies bring the ability to provide more and more bandwidth to users. For example, 802.11ac operating at 5 GHz promises the throughput of up to 1.3 Gbps, which would enable a range of services on wireless clients. At higher frequencies, more spectrum can be used – but that comes with a price of poor coverage. Due to higher attenuation at 5 GHz, 802.11ac exhibits a shorter range compared to 802.11n at 2.4 GHz. The good performance and range of 802.11ac are only achievable in open areas without physical obstacles on the propagation path.

Inside buildings, concrete or brick walls practically prevent wireless transmission of 802.11ac at 5 GHz, causing 802.11ac to perform worse than 802.11n at 2.4 GHz. Even in wood-constructed homes, 802.11ac does not deliver on its promise.

In indoor environments, Wi-Fi mesh (with satellite APs) may bring some improvement in coverage, but fails to provide the performance. The only way to provide both Wi-Fi coverage and performance is to use wired backhaul to satellite APs, with powerline communications (PLC) being the most convenient way to connect the satellites which facilitate the use of bandwidth-hungry and delay-sensitive applications on wireless clients throughout the building.

The overstated promise of 802.11ac Wi-Fi

Despite the advanced technology it introduces, 802.11ac cannot always deliver due to several serious limitations.

In open, obstacle-free space, wireless signals are attenuated exponentially over distance, with the attenuation coefficient directly proportional to the frequency. In practice, this means that at the same distance, the signal of higher frequency is attenuated more. In other words, at double frequency (which is roughly the case for 2.4 GHz and 5 GHz), the same signal strength can be expected as early as at half the distance. The first aspect of 802.11ac (operating at 5 GHz) is, therefore, a shorter range compared to 802.11n (operating at 2.4 GHz). Furthermore, with 80 MHz channel bonding the power level drops, reducing the coverage area.

The presence of physical obstacles on the propagation path has an even more important impact on wireless signals. The attenuation of signals that travel through walls and other objects depends on the material and composition. Plaster and wooden interior walls are relatively easy to pass, for example, while materials like concrete, brick walls, tiles, mirrors, and even lead-based paints incur high signal attenuation. Worse yet, metal plates, chicken wire in walls (ferro-concrete), or water (e.g. fish tanks) are complete show stoppers.

The observable effect of all this is that 802.11ac does not pass through concrete and even 802.11n at 2.4 GHz performs better. Inside buildings with heavy concrete walls or a lot of iron and steel, 802.11ac's advanced modulation (256-QAM) is virtually unusable beyond five metres. When 256-QAM is not viable, 802.11ac downshifts to 64-QAM, matching the 802.11n. In this case, the bottom line is there is no benefit.

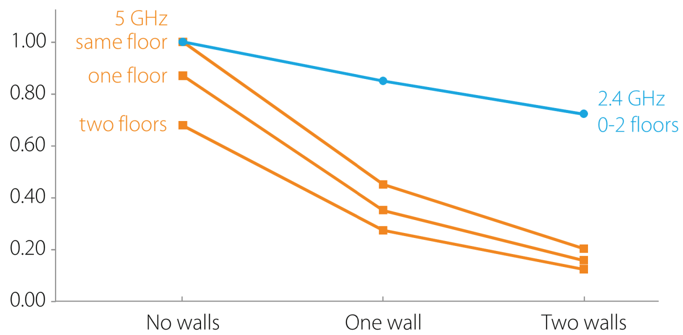
The bitter truth about in-house performance of 802.11ac Wi-Fi

To get the benefits of 802.11ac, APs should be placed in open areas with line of sight to clients. Cubicle office areas, hotel lobbies and outdoors are the best use cases. But the worst are buildings with heavy concrete or steel construction.

So, how can the 5 GHz signal pass from room to room in homes with concrete walls? Well, it cannot. The rooms have doors and/or other openings that wireless signals can pass through – although with very low throughput efficiency and no further than a room or two away. Unfortunately, it will barely pass from floor to floor – if at all.

Surprisingly, even wood-constructed homes don't perform any better. The measurements performed in typical wood-constructed, three-storey family houses, with Wi-Fi clients throughout each house, explored the impact of construction elements on the efficiency of Wi-Fi operating at 2.4 GHz and at 5 GHz.

Throughput efficiency at 2.4 GHz and 5 GHz



The results for coverage at 2.4 GHz and at 5 GHz vary significantly: the 2.4 GHz signal handles (wooden) walls and floors much better than the 5 GHz signal. On average, 85% throughput efficiency (i.e. a factor of 0.85) can be expected when crossing a single wooden wall at 2.4 GHz, and only 45% throughput efficiency (a factor of 0.45) at 5 GHz (yielding 72% and 20% for two walls at 2.4 GHz and at 5 GHz, respectively).

For floor crossing, no effect on throughput efficiency is observable for 2.4 GHz signal. On the other hand, the 5 GHz signal is notably affected when passing from floor to floor – only 87% throughput efficiency (a factor of 0.87) per floor should be accounted for (yielding 76% for two floors).

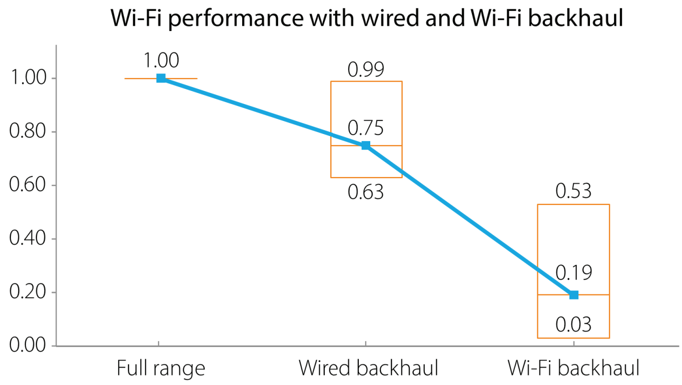
[1] In the context of this paper, the notion of 'throughput efficiency' is used as a ratio between the actually achieved throughput (in bits per second), and the achievable open-space, obstacle-free throughput (in bits per second).

Wired backhaul for maximum wireless performance

Regardless of specific materials and construction of the building, the Wi-Fi signal has to be brought to all parts of it – or the users will not be able to make use of wireless connectivity. A single AP at the home gateway will not be sufficient to connect all clients in all locations efficiently. Remote APs (satellites) need to be installed and connected to the home gateway (HGW) via a wired or wireless backhauling method.

Recently, MoCA conducted tests to determine whether Wi-Fi mesh is a viable alternative for whole-home coverage, compared to a Wi-Fi network using (existing) in-house coax cabling as backhaul to the satellites. The tests were performed in a number of typical wood-constructed, three-storey family houses, with the main 802.11ac AP located at the lower level, and Wi-Fi clients at all three levels. For testing the backhaul (Wi-Fi and cable-based), one satellite was located at the main level and one at the top level.

The results showed a dramatic improvement in Wi-Fi performance when using wired backhaul, compared to Wi-Fi backhaul. Specifically, wired backhaul provided 75% throughput efficiency on average (ranging from 63% to 99%, depending on client location). Compared to wired backhaul, Wi-Fi backhaul performed surprisingly (about four times) poorer: it only achieved 19% throughput efficiency on average (ranging wildly from 3% to 53%, depending on client location).



Whole-home coverage and high performance can be difficult to achieve without a wired backhaul. Although Wi-Fi mesh may somewhat improve the coverage, a wire is still critical for both coverage and performance.

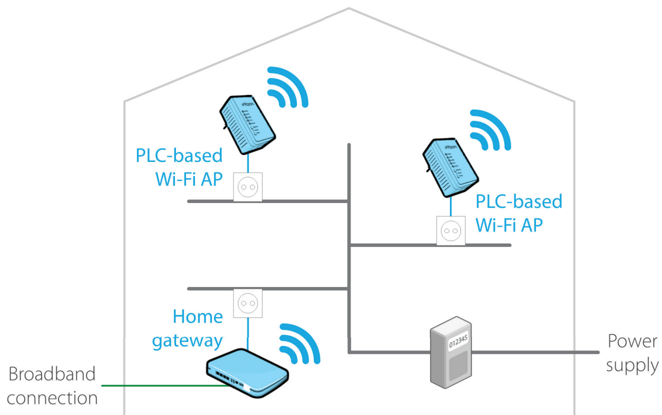
Another point to consider is the effect of additional latency, introduced by the multi-segment Wi-Fi network, on TCP throughput. For TCP performance, satellite APs using wired backhaul provide the best balance between throughput and latency. The additional latency of wired backhaul is small in comparison to Wi-Fi backhaul: the latter doubles or even triples the latency, drastically reducing TCP throughput.

Powerline communications: ubiquitous and discreet

For the best reach and performance, all the APs evidently need to be connected to the HGW using wired backhaul. The options include Ethernet cabling, coax cables, copper pairs and powerlines, with Ethernet cabling as the best option. Alas, most homes were not built with Ethernet installations and installing them later on is not an option in most cases.

On the other hand, powerlines are inherently present and widespread in all buildings. Therefore, using PLC as a means to connect satellite APs to the HGW is the least intrusive and hassle-free method, since it requires no dedicated cabling or additional installations.

PLC adapters plug directly into power sockets and contain integrated 802.11n Wi-Fi APs, effectively converting any power socket into a network-connection point. The PLC adapters, compliant to standard PLC technologies (like HomePlug AV or IEEE 1901), connect over distances of up to 300 metres and provide effective bandwidth of up to 95 Mbps – which serves demanding multimedia services like high-definition television, video on demand, cloud-based services, online gaming or video surveillance.



About Iskratel's solution

Iskratel provides fibre- and copper-based broadband solutions, suitable for all types of end users (residential and enterprise) and all types of services, from high-speed internet or premium high-definition TV to business VPNs or services and apps from the cloud. Along with the SI3000 Lumia, a scalable multi-service broadband access and aggregation product at the central office, Iskratel provides a family of Innbox CPE products. The Innbox CPE family includes universal home gateways, home gateways for fibre and copper access, and fibre-termination units. Innbox CPE devices span from low-end fibre termination to full-fledged, high-end home gateways.

Innbox G69 is a standards-compliant (ITU-T G.984) GPON HGW that gives operators control over the services and provides customers with superior Wi-Fi performance and coverage. Innbox G69 supports 802.11n (2x2, at 2.4 GHz and 5 GHz) and 802.11ac (3x3, at 5 GHz) Wi-Fi concurrently and automatically selects the optimum channel(s). It integrates power amplifiers that allow transmission with maximum allowed power. In addition, Innbox G69 allows additional, managed remote APs to be added to the HGW, increasing the number of accessible Wi-Fi channels. Use of PLC for backhauling to satellite APs allows Wi-Fi coverage in places that the wireless signal cannot effectively reach otherwise.

Using built-in monitoring and diagnostics, operators can remotely optimise and improve Wi-Fi settings, such as transmission speeds and transmit power. This allows them to launch new services, which depend on superior Wi-Fi performance, including connected- and smart-home applications. The whole in-house Wi-Fi network can be managed via TR-069.

Innbox PLC500W is a standards-compliant (HomePlug AV and IEEE 1901) powerline adapter and satellite AP that supports PLC data rates up to 95 Mbps, along with 150 Mbps over 802.11n Wi-Fi and 100 Mbps RJ-45 Ethernet ports. It is suitable for a wide range of residential and commercial uses. With high PLC throughput and low PLC latency, Innbox PLC500W enables efficient delivery of a range of services and applications to every corner in the house.

For more information on Iskratel's solutions, please contact marketing@iskratel.si.

ISKRATEL

Iskratel, d. o. o., Kranj

Ljubljanska cesta 24a
SI 4000 Kranj, Slovenia
Phone +386 4 207 20 00
Fax +386 4 202 26 06

info@iskratel.si
www.iskratel.si

About the author

Tomo Bogataj is responsible for strategic marketing of Iskratel's Telco solutions, and has twenty years of experience in telecommunications. He co-created Iskratel's software-defined access, and contributed to Iskratel being the first vendor to provide SDN-based broadband in 2010.

Contact him at t.bogataj@iskratel.si.

May 2017