Whitepaper: SyncMaster

An evaluation of the importance of running an efficient wireless network

This white paper explains the value of spectrum efficiency in unlicensed frequency bands and how Repeatit's SyncMaster solution works.

The Value of Spectrum Efficiency and Synchronization

To build a multipoint system is easy. To make it right and end up with a reliable, tolerant, high-performing multipoint system often proves to be more complex. Interference in the unlicensed bands is increasing all the time and to be able to provide a reliable service not only short-term but also in a longer perspective, the key is to be able to use the available spectrum as efficiently as possible. As many bits as possible has to be squeezed out on as little spectrum as possible.

The State of the Unlicensed 5GHz Frequency Band and Why Spectrum Efficiency is so Important

The wireless standards used for equipment in the 5GHz band have evolved drastically over the past years. This has mainly been fueled by the IEEE 802.11 evolution from 802.11n-2009 to 802.11ac wave 1 and wave 2 chipsets. The new standards promise very high peak rates to a lot of consumer-grade equipment like set-top boxes, residential routers, tablets, laptops etc. The same chipsets have also found their way into backhauling equipment.

There are three main ways that speeds are increased with new generation chipsets:
1) Higher-order modulation. This means more bits coded per symbol that are sent over a channel.

2) Spatial Multiplexing. When both the transmitter and the receiver are equipped with multiple antennas (commonly referred to as MIMO, Multiple Input Multiple Output) and each antenna in the receiver manages to see a signal that is uncorrelated with what is seen on the other antenna ports, it is possible to transmit data over multiple layers over the air. A 2x2 MIMO configuration could in theory give two times more throughput compared to when a single antenna is used.

3) Spectrum aggregation. If two 20MHz frequency blocks are used to transmit data, the achieved throughput is doubled compared to if only one 20MHz block is used. The latest chipsets supports 80MHz or even 160MHz channels.

As both spatial multiplexing and higher order modulation require very high Signal-to-Noise Ratio (SNR) to actually happen, as more transmitter/receiver antennas come with a higher cost (antennas, TRX

chains, filters etc.) and as the extra antennas in many cases will be used for Beamforming rather than Spatial Multiplexing, spectrum aggregation is the way a lot of new equipment will actually obtain higher throughput. The benefit of this is that significant throughput gain can be achieved also under fairly low SNR levels.

Unfortunately, the impact this has on the 5GHz band is in many cases very negative. Even if there is a lot of available 5GHz spectrum, it is a finite resource and just like any other natural resource it has to be treated with care and respect. Compared with very wide frequency channels, a MIMO configuration on a narrow channel is a much more spectrum efficient and reliable way to achieve a high performing link that does not degrade over time.

Relying solely on very wide channels to obtain high throughput also comes with several other negative side effects:

1) The receiver becomes much more sensitive to in/out-band interference, spurious emissions and noise from for example cellular base stations in the vicinity and therefore run a high risk to be blocked most of the time. As there are also two sides of every connection, the wide channel has to be interference-free on both sides to be useful. Many transceivers only check the own situation before starting to transmit. This works when the system range is some 10's of meters, but not for links operating over several kilometers.

2) Using wider spectrum means less output power per MHz. Equipment that transmits at 30dBm at 20MHz will only give 24dBm at 80MHz and 21dBm at 160MHz. This affects range, modulation schemes and link stability.

3) A wide channel pollutes the spectrum, meaning other operators, network owners and even residential users will have issues with their networks.
The value of synchronization

One of the main challenges when mounting a lot of equipment in the same site is the co-channel interference (equipment operating on the same channel). The more narrow channels that are used, the less of a problem this is. But in many cases there are not many channels to choose from in the first place and in some cases the amount of free spectrum decreases over time as concurrent systems are mounted in the same area. Consider the figure below where two transceivers are configured to operate at the same channel. This could be a typical point to point link or a PtF/PtMP BS unit.

In this example, if the upper unit transmits at 30dBm EIRP (Equivalent Isotropically Radiated Power) while the lower unit expects to receive a signal on some 120-140 dB lower strength at the same time on the same channel from a distant transmitter, a lot of things will go wrong. The receiver experiences vastly increased noise floor and in worst case it is blocked most of the time by the transmitter. Even with extremely good antenna isolation, the result is likely low throughput and lots of packet errors. Configuring the two units on separate channels does not necessarily solve the problem. This will provide some 40-50dB extra attenuation of noise, but links operating on low SNR could still be affected.

The solution to the above described problem is to GPS synchronize all units that are collocated in the same place with the Repeatit SyncMaster. The SyncMaster ensures that all backhauling links and PtF base stations transmits exactly at the same time. More importantly, they also receive at the same time, which means each receiver only has to be protected from the other unit's Rx power levels. These are normally between -45 and -80dBm, which means sufficient isolation between the radios can easily be obtained with good antenna separation. Well worth noting is that Repeatit's synchronization solution does not affect system throughput or latency.

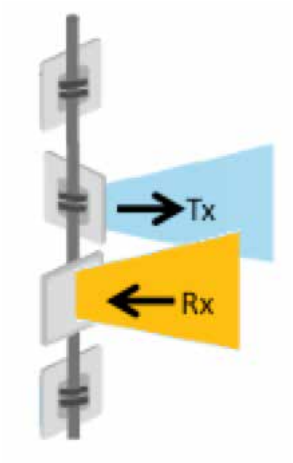

Figure 1 - Channel sharing

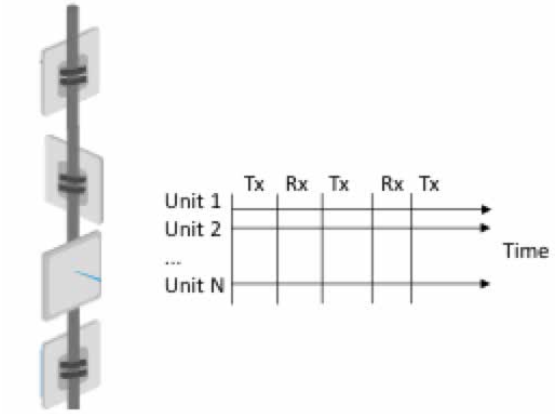

Figure 2 - Link operation under SyncMaster control. The same SynchMaster solution is used for both PtP and PtF equipment. Inter-site synchronization is also supported.

The practical result of using the SyncMaster is that a lot of equipment can co-exist on the same channel in the same site. Channels are also synchronized between sites if needed. The figure below illustrates this concept where channel X is used both to interconnect two sites with a PtP link and to provide PtF systems from both the sites. In this configuration, the two SyncMasters are phase shifted 180 degrees. This means when all units in site A transmits, the units in site B are receiving and so forth.

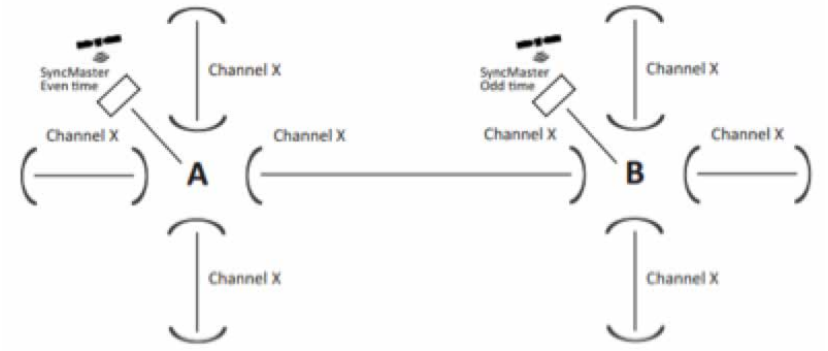

Figure 3 - Two sites using the same channel for both PtP and PtF connectivity. The two SyncMasters ensure inter/intra site functionality.

Needless to say, this approach is extremely spectrum effective. It allows for much better overall performance and system throughput and it effectively increases the likelihood also for other systems to perform at the same site.
When combined with the MultiFlex PtF solution, this means that a network that previously was configured with 16 or 32 links (operating on different channels) to for example a big number of surveillance cameras would now be able to use just one or a couple of MultiFlex Base Stations, and they can all operate on the same channel. This results in tremendous spectrum efficiency and very high likelihood of high and sustainable performance even in very noisy and interfered environments.

Summary

As described in this document, the SyncMaster is often the difference between taking control or losing control over a site. It allows the network owner to use much fewer channels and be spectrum efficient, and both link equipment and multipoint (PtF) equipment can use the same SyncMaster to achieve this.

Operating in unlicensed frequency bands means restrictions in output power and potentially high interference levels. To make your installation tolerant to interference and noise, make sure to plan out the network carefully with Line Of Sight (LOS) and free Freznel zones where possible. Although Repeatits Trinity PtP and PtF solutions work excellent even without the SyncMaster, we always recommend to add it in all locations that are subject to interference to improve link performance and spectrum efficiency.

Figure 4 - SynchMaster and Trinity PtP and PtMP links in operation.