

InfiNet Wireless solutions for Small Cell Backhaul

Application Notes





Introduction

The initial drive of the mobile network operators was to provide availability in terms of coverage for the voice services. This is still an important aspect that implies improving or providing coverage at locations where macro cell installation is not feasible and cedes place to the small cells. On the other hand, nowadays, people are driven by the need for data services at high speeds. For this reason, operators have appealed to the small cell technology in order to offload the traffic of the macro cells and provide hot spots in dense urban areas. Heterogeneous networks, or HetNets where macro cells are complemented by small cells, have significantly emerged on the market. Along with this new architecture rose the debate about the need for a suitable backhaul to connect the small cells with the operator's backbone or Point of Presence (for example an aggregation macro cell). The scope of this paper is to present the small cell backhaul requirements and to highlight the features and capabilities of the **InfiNet Wireless** products which are fit to these demands.

Small cells overview and classification

A radio access equipment suitable for small cells is usually characterized by a low RF transmit power, a short range and a reduced weight and size compared with the macro cells equipment. Except for the femtocells which can be also user/enterprise deployed, the small cells are generally managed by mobile network operators. Key attributes small cell versus the key attributes of macro cells:

Attribute	Small cell	Macro cell
Transmit power	Low power - typical range: 200 mW ~ 4 W	Higher power - typical range: 20 W ~ 40 W
Coverage	Short range: 10 m ~ 3 km	Long range: from 1 km up to 100 km in rural open areas;
Form factor	Small - compact and light	Larger and heavier
Location/ Mounting point	Dense urban areas mainly for capacity: street furniture, shops, train stations, buildings, etc Rural areas mainly for coverage	Roof tops, pylons, special rooms for equipment
Installation cost	Low - up to 10 times lower	Higher
Installation complexity	Reduced - ideal plug-and-play, with no special skill requirement. Very short deployment time	High - requires qualified personnel. It takes longer time to deploy.
Management	Automatic or low complexity - tend to be self-optimizing and self-learning	Complex - requires deeper knowledge; LTE macro cells include also SON features
Backhaul connectivity	Difficult - being close to the end user, in dense areas, it is difficult to connect with the backhaul	Easy - backhaul connectivity does not have space and location constraints

[Table 1 Small cell attributes]

- Macrocell coverage
- Microcell coverage
- Femtocell coverage
- Picocell coverage



[Figure 1 Smallcells and macrocells coverage range]

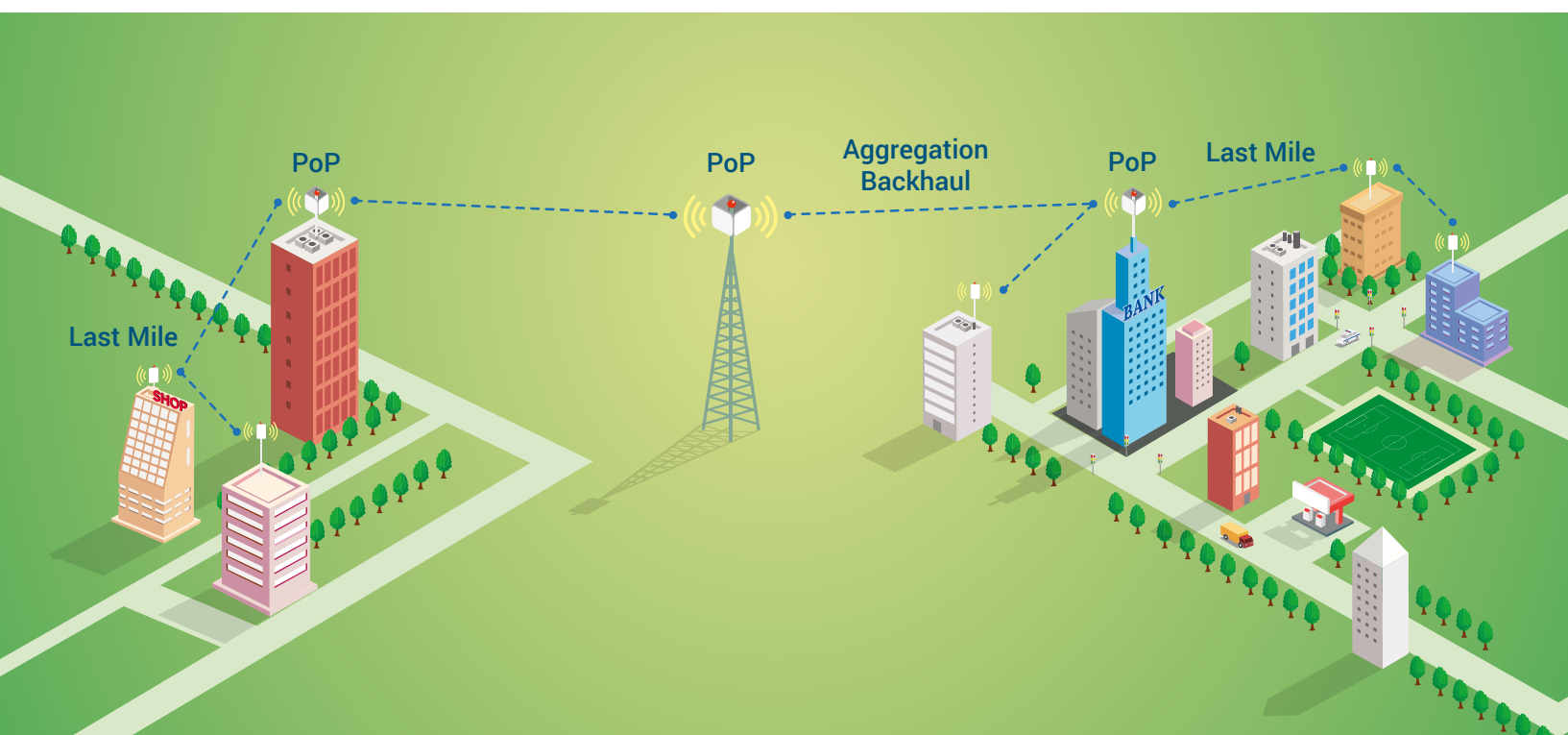
The classification of the small cells can be made at a first glance based on their coverage range, resulting into a specific terminology: femtocells for the shortest range small cells, picocells, metrocells and micro-cells. A more insightful classification is based on the reason that determines the necessity of a small cell installation and it can be for: increasing the capacity, extending the coverage or improving the user QoE (Quality of Experience). The table below provides additional details about this type of classification:

Small cell motivation	Classification	Basic backhaul requirements
Capacity	Targeted Capacity Hot Spot	Has both coverage and capacity high demands - NLOS may be required Availability is not a tight constraint, being in the coverage of a macro cell
	Non-targeted Capacity Hot Spot - for QoE	Availability and coverage are more relaxed Requires high capacity
Coverage	Coverage Hot Spot	Availability has to be very high, but the capacity demand is more relaxed

[**Table 2** Small cell classification]

Backhaul with InfiNet Wireless solutions

The scope of the small cell backhaul is to provide connectivity from street level up to the core backbone by accomplishing the capacity and QoS demands. Taking into consideration the specific characteristics of the small cells and of the served traffic, several aspects need to be brought into discussion as requirements for the small cell backbone.



[Figure 2 Small cell backhaul]

A straight forward classification of the requirements results from depicting the backhaul topology:

- ▶ **LAST MILE** - this is the segment that is directly connected to the small cell, restricted by difficult access. The small cells are usually installed in dense areas, at street level, where positioning any new equipment has many limitations. Wireless solutions are more suitable, as cabling is usually not possible. Additional constraints refer to the form factor of the equipment - it has to be compact, to integrate well in the existing architecture by having a pleasant design, it must be light in weight and easy to install. A last point to consider would be the possibility of using NLOS capable equipment as some small cells have to be installed in specific areas with no direct visibility to the next hop or PoP.

▶ **AGGREGATION** - the aggregation segment which makes the connection with the core network, has constraints in terms of distance, capacity and availability. Because traffic from several nodes is aggregated on the same link, availability and capacity have to be high. Also, in order to cover longer distances until the backbone, long distance links have to be implemented.

InfiNet Wireless offers Hi-End solutions for backhaul connectivity, prevailing as one of the best solutions for both Last Mile and Aggregation segments. Featuring a small form factor, robust design, easy deployment, operating in the sub 7 GHz spectrum and designed with modular license upgradeable capacities, the R5000 InfiNet units are best fit for the Last Mile implementations. For providing increased capacities and availability over long distances, the R5000 InfiLINK 2x2 PRO and InfiLINK XG products are most suitable and can be seamlessly integrated into any type of network. Among the overall advantages it is worth mentioning the short deployment time and the cost effectiveness of the solutions that offer the one of the best price-quality balance.

The following sections will walk through the details of each requirement imposed by the small cell backhaul particularities, by pointing at the same time the solutions and capabilities featured by the **InfiNet Wireless** products.

Wireless solution: implications of using sub 7 GHz spectrum

It is well known that a wireless solution can offer more flexibility and lower costs. Compared to a wired solution, wireless brings much shorter deployment time with reduced complexity, lower costs, easy maintenance, scalability in case of adding new equipment and flexibility when deciding to reposition the network elements. Cabling might not even be viable, especially in the particular case of the last mile connectivity for small cells in dense areas.

What is to consider for wireless is the used frequency spectrum and its implications:

Type	Pros	Cons
Sub-7 GHz	Easiest deployment NLOS is available	Reduced spectrum resources leading to limitations in capacity and interferences
Microwave (until 60 GHz)	Higher capacity Interference free band	Only LOS Very short links Vulnerable to weather conditions
E-Band (70-80 GHz)	High capacity License is not expensive	Only LOS Vulnerable to weather conditions

[Table 3 Wireless solutions comparison]

Using below 7 GHz spectrum is desirable for its advantage of supporting NLOS, as higher frequencies are prone to absorption and are not suitable for this scenario.

The **InfiNet Wireless** solution is based on the InfiLINK XG product operating in the 3 GHz, 4 GHz, 5 GHz and 6 GHz bands and on the InfiLINK 2x2 PRO product operating in the 3 GHz, 5 GHz and 6 GHz bands. Using both licensed and unlicensed spectrum, it offers LOS and NLOS high quality connectivity. It can reach capacities of up to 500 Mbps in the 40 MHz bandwidth and a spectral efficiency net superior of up to 14 bps/Hz, being capable to sustain the demands for the small cell backhaul data rates. Additionally, MIMO and OFDM/ Cyclic Single Carrier modulation offer resilience to interferences, corroborated to the robustness of the transmission in bad weather conditions compared to the high frequencies. Special interference mitigation techniques are also implemented.

INSTALLATION AND COMMISSIONING

The installation and commissioning need to be quick and simple. InfiNet products are very easy and fast to deploy, have included a visual antenna alignment tool and require no in depth skills. The radio link is setup automatically and just a basic Web configuration has to be applied in order to make the equipment functional. Management is also without effort, one person can monitor all the devices from an already existing centralized NMS (network monitoring system) or using the proprietary InfiMONITOR.

FORM FACTOR

The reduced form factor of the small cells and their location impose similar demands for the backhauling devices: it has to be light equipment, with a good looking design and suitable for integration in an existing scenery. InfiNet units come in compact and small shape, with variable weight (1 ~ 6.4 kg) and dimensions (24 ~ 60 cm) depending on the technical specifications of the model and whether it has integrated antenna or not. For longer distance backhaul, on the aggregation segment, or in rural areas, the units with the larger form factors and external antennas are more suitable. For the last mile connectivity, the models with integrated antennas can be used.



Figure 3 Street mounting of the InfiNet Wireless units

POWER

Compared to the macrocells, small cells have both transmit and consumed power at much lower levels. An RBS (macrocell base station) will consume from hundreds of Watts to few KWatts and transmit with 20 to 40 W, as opposed to a small cell that consumes few tens of Watts and transmits from mW to few Watts levels. Also, because of the specific locations in crowded places, power over Ethernet is most often imposed. **InfiNet Wireless** units are low power consumers at a maximum around 30 W, supporting Power over Ethernet and have power transmission levels at a maximum value around 500 mW.

COST

The costs for the small cell backhaul have to be lower compared to the macro cell backhaul.

InfiNet Wireless offers cost effective solutions, easy to install and that can be maintained by only one person from a centralized location. “Pay as you grow” software upgradeable features are included and the products are developed in a modular way, offering the possibility to choose the closest solution to the actual needs. The short and easy installation is further completed by the increased reliability of the products, reflecting closely the “install and forget” concept.

Overall, the acquisition, installation and maintenance costs versus the performance of the products converge towards a very good price-quality balance.

ROBUSTNESS AND RELIABILITY

Weather-proof equipment is required for any type of backhaul. InfiNet products have proved to work properly in the harshest conditions over the years. The units are enclosed in a rugged aluminum cast IP66/IP67 compliant, have the normal temperature range of -40 °C to +60 °C and also the extended temperature range of -55°C to +60°C and contain a built-in surge protector.

NOISE IMMUNITY AND INTERFERENCE MITIGATION

Being implemented usually in crowded areas, the small cell backhaul needs to have very good noise immunity and techniques designed for interference mitigation. **InfiNet Wireless** offers products with high gain integrated antennas and link optimization using DFS or Instant DFS technology that performs intelligent wireless scanning and switch in real time to a clean frequency when the current level of interference for the used frequency is increasing. Additionally, Automatic Transmit Power Control helps to maintain the optimal signal level for very good performance while reducing the overall interference.

OFDM together with MIMO, used by InfiLINK 2x2 PRO, are well known advanced techniques for counteracting the problems caused by interferences, providing both high capacity and very good signal quality.

InfiLINK XG uses Cyclic Single Carrier modulation together with MIMO and ensures superior adjacent channel rejection and noise immunity. Unlicensed bands permit also operation in split-frequency (H-FDD) for InfiLINK XG.

COVERAGE

Coverage in terms of last mile refers to flexibility and in terms of aggregation to distance. Using frequencies up to 6 GHz, **InfiNet Wireless** units provide flexibility in choosing the location for the installation and have very good performance in NLOS scenarios. For longer distances, high gain antennas provide connectivity in good conditions, with very few capacity loss up to 100 km when longer air frame duration is used.

CAPACITY

Capacity is a very important factor for the small cell backhaul, as many applications are intended to offload macro cells, provide high data rates to users in specific locations or for special events. InfiLINK XG product offers a capacity of up to 500 Mbps using a 40 MHz bandwidth, while InfiLINK 2x2 PRO can sustain up to 280 Mbps for the same bandwidth. The low frequencies used, ensure no sudden drops in capacity because of precipitations.

DELAY

Delay is another aspect that needs to be considered. According to the 3GPP 23.203 standard for LTE, each service class requires a certain maximum end-to-end delay for sustaining the quality of service. Live gaming is the most demanding with about 50 ms delay requirement, followed by voice and IMS signaling with 100 ms requirement. For a small cell backhaul, a delay below 10 ms is considered to be accepted. InfiLINK XG product specifications include a constant delay between 0.5 and 3 ms depending on the air frame duration. R5000 series products feature also very low values for the delay, around 3 to 5 ms.

SECURITY

Both physical and information security are mandatory. **InfiNet Wireless** units have the proprietary air protocol. All units are password protected and support secure connectivity methods using HTTPS and SSH. Regarding network security, the units are protected against the network data storm/ flood.

SPECTRAL EFFICIENCY

According to 3GPP, a small cell requires in average 25% more spectral efficiency compared to a macrocell.

InfiNet Wireless products are designed to maximize the throughput using as few spectrum resources as possible, for this reason the InfiLINK XG product can provide a net superior spectral efficiency of up to 14 bps/Hz, while the InfiLINK 2x2 PRO offers up to 7 bps/Hz.

AVAILABILITY

The availability refers to the ensured time interval for which the link is functional and it is expressed in percentage of nines. For the aggregation segment and for the last mile intended for coverage not spots small cells, the availability is crucial to be very high, reaching up to 99.999%. In the areas where macrocell coverage is also available and the small cells are intended mostly for capacity, the availability is more relaxed and it can go down to 99% without impacting the user Quality of Experience.

InfiNet Wireless units can sustain a 99.999% availability rate over distances longer than 30 km.

SYNCHRONIZATION

Two aspects related to synchronization are mandatory for UMTS and LTE systems:

- ▶ Frequency synchronization for accurate system operation and to follow the regulations of the spectrum allocation
- ▶ Time synchronization for TDD UMTS, TDD LTE and to support advanced techniques like eICIC and carrier aggregation.

Synchronization can be achieved by distributing a frequency or packet-based time reference. In the case of packet based synchronization methods, QoS is also very important because delay and jitter will affect the accuracy of the reference packets.

In order to sustain the synchronization requirements for UMTS and LTE systems, **InfiNet Wireless** units have full support for internal synchronization either via built-in GLONASS/GPS receiver (at InfiLINK XG), or via a TDD synchronization hub (with embedded GPS/GLONASS receiver and active antenna, for InfiLINK 2X2) which provides GNSS-based timing reference, intra-site and inter-site synchronization, geo-positioning information and UTC time.

QoS

Whether it is dictated by the requirements for synchronization or for sustaining the specific traffic classes, the QoS awareness of the small cell backhaul is essential. **InfiNet Wireless** products have full QoS support by implementing up to 17 priority queues, by being aware of the 802.1p standard and by supporting IP ToS and DiffServ. Full voice/RTP support is available alongside with an advanced traffic shaper for reducing delay, jitter and packet loss. Delay as low as 0.5 ms are achievable in order to sustain the most demanding applications.

The summary of the **InfiNet Wireless** product features is listed below.

Key feature	InfiLINK XG	InfiLINK 2x2 PRO
Frequency range	2.0 - 3.0 GHz 3.0 - 4.0 GHz 4.0 - 5.0 GHz 4.9 - 6.0 GHz 6.0 - 6.425 GHz	3.1-4.0 GHz 4.9-6.0 GHz 6.0-6.4 GHz
Coverage	LOS and NLOS Distance up to 100 km or more in LOS open areas	LOS and NLOS Distance up to 80 km or more in LOS open areas
Tx power	Up to 27 dBm (500 mW)	Up to 27 dBm (500 mW)
Power	Up to 30 W consumption, Proprietary PoE	Up to 20 W consumption, Proprietary PoE
Capacity	500 Mbps in 40 MHz	Up to 280 in 40 MHz
Spectral efficiency	Up to 14 bps/Hz	Up to 7 bps/Hz
Synchronization	Built in GPS receiver	Via external synchronization hub
QoS	4 priority queues "Strict" and "weighted" modes 802.1p	17 priority queues "Strict" and "weighted" modes 802.1p, IP ToS, DiffServ, custom L2/L3-based rules Traffic shaping Voice/RTP aware
Delay	0.5 - 3 ms (depends on air frame)	Average 3 ms
Robustness and Reliability	Dust and moisture protection, IP66/IP67 compliant; lightning protection incorporated; -40 °C to 60 °C temperature range	

Table 4 InfiNet Wireless product capabilities

Practical implementations

Among the many successful implementations supported by **InfiNet Wireless** over the years, two practical solutions with relevant demands will be presented below.



ENFORTA Russia

Enforta is the number one company in Russia that offers wireless-based broadband telecommunication solutions, with a footprint covering over 70 million people and operating in 78 of Russia's largest cities. The demand involved a large scale deployment backhauling, in diverse and extreme climate conditions, by sustaining the high availability, reliability and capacity requests.

After performing trials for different backhauling solutions, Enforta chose **InfiNet Wireless** products for having met the best with their requirements:

- ▶ A cost-effective, scalable network was deployed in the 5.15 ~ 5.35 GHz band. The flexibility of the InfiNet products for configuration, deployment and bandwidth/frequency allocation reduced both the costs and installation time
- ▶ A high capacity InfiLINK point to point solution was adopted, to support the high throughput demands over long distances
- ▶ High availability of the backhauling was successfully proved, along with the best support for the different QoS requirements
- ▶ Coverage was also provided in remote suburban areas
- ▶ Operation in diverse geographic topologies and under extreme weather conditions was ensured



Z-NET Hungary

Z-Net is a mid-sized regional W-ISP provider in Hungary. The requirement from Z-Net was to implement a second layer of high capacity wireless backhaul, using 5 GHz links to connect the regional hubs to the core backbone. **InfiNet Wireless** products were chosen as being the best solution to accomplish the specific demands:

- ▶ As close to 100% availability as possible, while sustaining very high speeds
- ▶ Provide regional backhauling routes using 5 GHz wireless spectrum to reach the local PoPs
- ▶ Ensure minimum 200 Mbps in full duplex - InfiLINK 2x2 300 Mbps PtP links were implemented
- ▶ Ensure the lowest latency over the network
- ▶ To operate in different geographic in climatic conditions
- ▶ To offer a competitive price solution, with efficient and flexible deployment

Conclusions

Small cells represent the best solution for providing increase in capacity under the coverage area of a macrocell. Since base stations cannot be supplemented in dense areas and almost all possibilities (modulation techniques, MIMO) for increasing their capacity have been exploited, there is only one solution left: to increase the number of radio network equipment by using small cells. This way, multiple small cells are being deployed under a macrocell, leading to higher sustainable throughputs and higher spectral efficiency. **InfiNet Wireless** products offer the best in class spectral efficiency values, able to support the need of small cells.

Another important aspect to remember is the necessity for using NLOS. As the installation of the small cells is performed at street level, it is most likely to encounter obstacles (buildings, trees) between the cell and the nearest PoP. **InfiNet Wireless** products operate in bands below 7 GHz, being ideal for NLOS scenarios with superior performances.

As a summary, all the points mentioned in the current paper, demonstrate that a small cell backhaul can be successfully implemented using **InfiNet Wireless** products.

