CERAGON WHITE PAPER

Enabling Rural Broadband Services with Wireless Backhaul

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This paper will discuss the technical challenges of building rural broadband networks and how high capacity wireless backhaul solutions can be utilized to alleviate them. Subsequently we will outline a range of solutions to enable potential service providers and systems integrators to offer reliable and affordable services across a variety of deployment scenarios.

Introduction:

Rural Broadband has recently become one of the most discussed topics in the telecommunications market. Almost overlooked by the broadband revolution until recently, rural markets are now becoming more attractive thanks to a host of national incentive plans. Perhaps the most publicized of these plans in the Obama administration led 7.2B USD Stimulus Fund that pledges to support broadband services for rural communities, but other governments are also pushing forward broadband initiatives, such as Australia's government for instance declared a 43B AUD (32B USD) fiber to the premise project in April 2009.

Setting up a network in and to rural areas has its challenges. Having to haul traffic over long distances, operators often find it hard to justify network setup cost when reaching remote communities with low population density. Moreover, these networks sometimes have to bridge over geographical barriers such as mountains, forests, lakes, swamps or deserts a fact that drives up deployment costs for traditional wired (fiber/copper) solutions.

Today, however, wireless solutions such as highcapacity pointtopoint microwave, help to simplify deployments while driving down set up and maintenance costs. Allowing for quick installation and fast time to market, these solutions are changing the entire Rural Broadband business case. And together with government funding plans, they help make Rural Broadband an attractive investment for both competitive as well as established carriers.

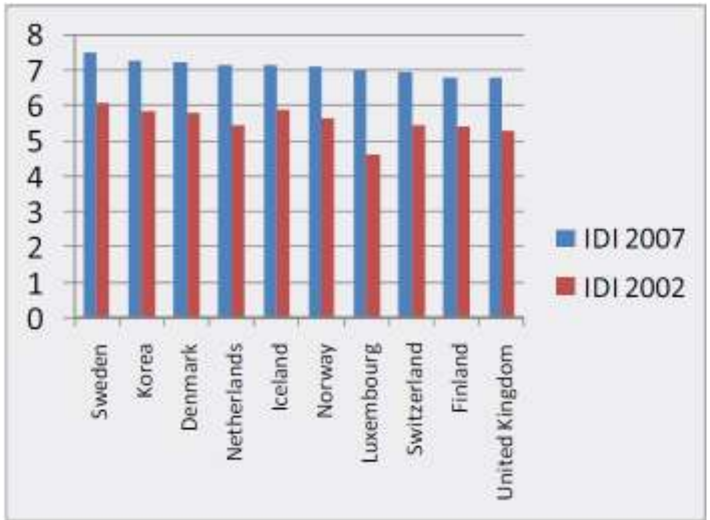

Figure 1: Top 10 ICT[1] Development Index (IDI)

The Top 10 ICT Development Index (IDI) is a relatively good position to be in. However developed countries often cannot sustain this position on the national level average. In rural areas of Germany and Italy for example, around 12% of the population have no access to broadband services. A rather similar picture emerges in other developed countries. Recent announcements by governments in 2009, shown in Table 1 below, indicate that there is an increasing interest in providing better access to communications in rural communities.

Country	Government Incentive for Rural Broadband (in USD)
Australia	$ 32 billion
USA	$ 7.2 billion
European Commission	$ 1.3 billion
New Zeeland	$ 850 million
UK	$ 400 million*
Canada	$ 192 million
Germany	$ 190 million

Table 1: Government Incentive for Rural Broadband (in USD)

Source: Intl. press

1 ICT Information and Communication Technologies. ICT access, use and skills such as households with a computer the number of Internet users; and literacy levels. ITU: Measuring the Information Society The IDI 2009 Edition

Rural Broadband Opportunities: Government Funding

In some areas unique business and operation models can thrive in the outskirts even without incentive plans. In other cases, Government intervention plays an important role in the proliferation of Rural Broadband networks and services. According to Pyramid Research, WiMAX (wireless broadband access) projects in urban areas takes less than 5 months to reach ROI, compared to 18 months in rural areas. Overall, urban projects provide 8 times higher return on investments than rural deployments. But if government support is in place - reducing or even eliminating setup costs Rural Broadband initiatives can flourish and profit.

Stelera Wireless for example is a US operator that already deploys high capacity wireless services to residential and business subscribers. With funds from the US Department of Agriculture, Stelera set up an independent HSPA broadband access network and opted for Ethernet microwave solutions to backhaul subscribers' traffic.

Another innovative player is the Australia based WiMAX operator Allegro. The company built a profitable business case serving rural businesses. Focusing on underserved businesses in Queensland, Australia, Allegro has developed a lean operational model for WiMAX access, using protected Ethernet microwave for aggregating and backhauling highspeed data traffic.

Rural Broadband Challenges

There are many technologies that fit the requirements of serving the 1st mile: xDSL, cable-modem, xPON, WiMAX and HSPA/LTE. All these technologies can be used in remote areas, depending on the specific business case, regulation and population density. Yet regardless of the technology selected for the 1st mile, the main issue in Rural Broadband projects is how to transport data capacity to and from the broadband access site. This backhaul connection to the access node should be able to carry at least 50Mbps to the nearby point of presence (PoP), and typically even more.

Generally speaking, operators can choose one of two options to deliver high capacity voice and data traffic over long distances: Fiber or Point to Point microwave. While fiber has an obvious advantage in terms of capacity, it often does not fit the bill for rural applications being either too costly or too time consuming to deploy. Microwave on the other hand offers carriers shorter set¬up cycles and faster time to market. Taking advantage of such high¬capacity solutions, they can bridge over any terrain, and benefit from a variety of CAPEX and OPEX reductions, as summed up in Table 2 below.

	Microwave	Fiber
Capacity	Requires spectrum	Limitless
Distance	Cost per link. Some incremental cost with the distance	Pay per feet/meter
Terrain	Any	Becomes costly when trenched in Mountains, Desert, swamps, rocky plains or Jungles
Climate	Some time might need to select protected all indoor installation for the active equipment	Limits on Aerial fiber optic cable installation
Accessibility	Need access only to the end points – two base stations for example	Trenching can be tricky if there is no access for vehicles along the path
Time frame	Instant after licenses and site acquisition	Right of way, and construction works may take a while and increase linearly with distance

Table 2: CAPEX: Building Backhaul networks in rural areas

It is important to note that while the costs of maintaining fiber are relatively low, capital expenditure runs linear with distance, and is exponential with terrain roughness. Moreover, fiber is susceptible to floods, fiber cuts and even assets stealing. When we look at distances stretching beyond 3 miles (5 kilometers), fiber total cost of ownership including the potential upside of the fiber assets, exceeds that of microwave.

The advantages of microwave do not go unnoticed. A recent survey by research group Maravedis reveals that 33% of the top 22 WiMAX operators use only Microwave for their backhaul. Others take a hybrid approach, mixing fiber when available with Radio, or building radio trunks as a protection path the main fiber link.

Supporting mix service portfolio – Legacy, Voice and Data:

Some Rural Broadband networks are put in place to deliver data¬only services, hence placing a strong emphasis on capacity increase. However, there are cases in which legacy voice services need to be maintained alongside data. In other cases monitoring systems of power, water and government facilities utilize the network as well. Providing for a proper class of service is therefore vital to the success of the service provider's business case.

Supporting a Mixed-Services Portfolio

As already mentioned, most Rural Broadband networks stretch over long distances and serve areas that are far from the main communication and service hubs. Distance means that repair crews are not always at hand and that spare parts cannot always be delivered within a few short hours. Here are some of the main issues that service providers need to consider when designing their radio backhaul network:

a. **1+1 Resiliency:** High availability is important in any telecommunications network. In rural areas where an alternative service is not likely to be available and where replacement of malfunctioning equipment may take time, it is even more so. By using a protected 1+1 radio scheme or advanced network topologies (as discussed further in this document) Rural Broadband service providers can design fault tolerant networks and ensure high service availability.

b. **Operations: Network operations** model should allow for “zero touch” and factor in very high MTTR (mean time to recovery). It alsoBut in order to minimize the chance for failure, the microwave operations model calls for needs to include a more proactive approach and of preventive maintenance procedures. Therefore, The individual radio system in use must therefore feature high MTBF (mean time between failure), come equipped with built¬in protection, and allow for simple remote monitoring and system recovery.

c. **Truck rolls:** Aside from initial installation truck rolls are to be avoided as much as possible. Implementing a reliable radio system that is easily managed and can be remotely upgraded significantly reduces the amount of time that skilled technicians spend on the road and at the remote site.

d. **Warehousing:** Deployed over long distances, Rural Broadband networks are typically stretch far from the carrier’s main warehouse. In order to reduce their dependency on on-site warehousing, carriers can implement a license based single unit stocking strategy. Additionally, the use of compact, modular and light weight equipment will make shipment and stocking easier and less expensive.

Microwave Radios

Rapid development in radio technologies makes the business case for Rural Broadband justifiable even without government intervention.

The unlicensed option: The unlicensed spectrum domain, sub 6GHz, can be utilized in rural areas where interferences are unlikely to occur. Mid capacity radio links (50Mbps) can serve as access connections to businesses, school campuses and government facilities. This option is low-cost, easy to install and can be used to provide adequate capacity for supporting data services with a mix of legacy and Ethernet traffic.

The licensed spectrum option: The licensed spectrum domain is separated into two low and high frequency groups. The low frequency group uses the spectrum between 6 and 11GHz and is more focused on long haul, high capacity transport to rural access nodes. The high frequency group utilizes the 13¬38 GHz spectrum and is more oriented towards medium and short haul applications.

Taking advantage of low frequency radios operators can easily build long haul links that span over 20Miles/30Km per hop and may reach up to 80Miles/130km with more careful planning. Such high capacity links can be chained together to create radio trunks for networks spanning thousands miles over virtually any terrain. Long haul radio technology is already tested and proven having been in service for years carrying real-traffic in applications ranging from broadcast TV through controlling and monitor of gas pipes, water systems and power grids, to military applications.

Today, radio solutions offer operators a reliable technology for long haul transport. Accompanied by new high capacity techniques, microwave radios can now be utilized as a cost-efficient alternative to fiber, and serve the growing need for broadband services in rural communities.

Advanced radio Techniques

Higher modulations serve to increase the radio link throughput. In the past, higher modulations caused the radio link to be more sensitive to noise, thereby reducing its overall availability. Modern radios however solve this limitation on two levels. One, improving the overall system gain by increasing the power of the Transmit unit and, more importantly, by improving the Receiver sensitivity through enhanced digital signal processing; The other, by applying adaptive techniques to optimize the power, error correction schemes and modulation. As a result, new radio solutions enable higher capacities per any given spectrum slice. The service availability can be improved further by applying ACM[2] enhanced with QoS mechanisms.

Diversity is another aspect of radio technology. Diversity comes to solve a common phenomenon called Multipath[3] in which signals are impacted by atmospheric or geographical distortions and deflected. The result of Multipath is that the deflected signals reach the receiver and mix with the desired signal at random phases (see Figure 2).

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[2] Adaptive Coding & Modulation 3 The term "Multipath" comes to describe the multiple paths that a radio signal may follow between transmitter and receiver

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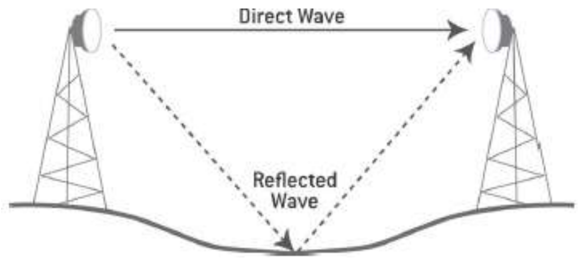

Figure 2 - radio signals sometimes travel in different paths from transmitter to receiver

Modern radios come with built in Space and Frequency Diversity functions. Space Diversity is implemented by placing two receivers (with 2 separate antennas) on a single tower. The signals are recovered using one of two optional techniques: Baseband switching[4] and IF combining[5]. Frequency Diversity uses a single antenna with two simultaneous frequency channels. The receiver with the strongest signal "assumes control", ensuring continues high quality transmission. Both these schemes are depicted in Figure 3 below.

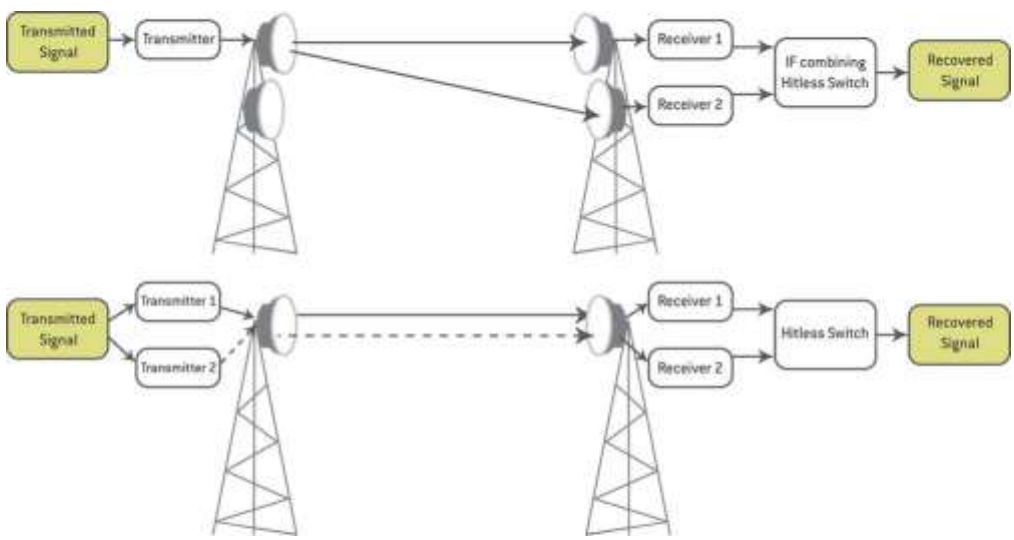

Figure 3: Space and Frequency Diversity Implementation

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[4] *Baseband switching: each receiver detects the signals independently, but the output is selected dynamically from the higher quality one. Switching between receivers must be hitless/errorless*

[5] *IF combining: signal recovery is done by combining both signals in phase with each other to maximize the signal to noise ratio.*

Advanced network topologies to sustain service availability

Survivability is a major broadband service attribute in rural surroundings. Apart from a

1+1 resiliency, operators can utilize a number of advanced network topologies in order to build out robust networks at a relatively low cost. The following paragraphs review two such tactics: protected Ring topology and protected E¬LAN/E-LINE.

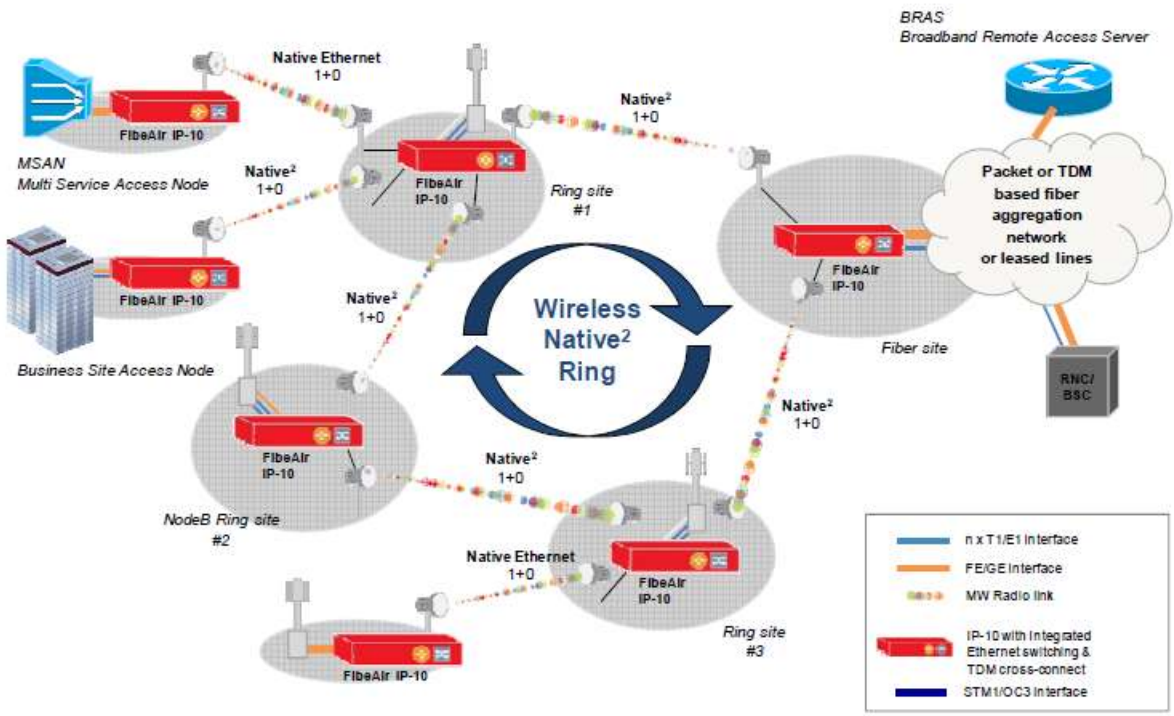

Figure 4: Cost-efficient, protected Native2 rings for rural broadband backhaul with FibeAir IP-10

Built-in Ring protection both for TDM – UPSR/SNCP and Ethernet Ring Optimized RSTP

Ring protection is a common protection scheme. In essence, rings serve the Access node (wireless or wireline) from two separate paths, thereby reducing the probability for a connection failure. As networks migrate from TDM-only to Ethernet, there is need for radio rings and radio equipment that can maintain protection over both networks. Such Hybrid rings that support both Native TDM and Native Ethernet are also referred to as Native2.

Using TDM and Ethernet integrated rings offers 5 opportunities for cost savings:

1. Lower failure probability – hence less support calls and less urgent truck rolls
2. Shorter distances between network nodes compared with star and tree topologies

3. Helps to reduce equipment count across the network since the ring acts as its own backup and eliminates the need for additional backup equipment (for example 1+1)

4. Enables capacity usage of both sides of the rings at steady state

5. Allows the utilization of a single network element for stocking, management and training

Protected E-LAN/E-LINE services

"A protected service scheme such as the one depicted in Figure 5 can be used in order to increase availability of the service by creating multiple protection levels at the network. This scheme ensures continuous service delivery even in the unlikely event of multiple failures at different points of the network.

The example shown in Figure 5 presents use case of an operator providing broadband services along a remote highway. Though its basic services include mobile voice, the focus in this case is using 3G HSPA NodeBs to deliver broadband services to consumers and business residing in the area. As shown in diagram, high capacity Ethernet radios are in place to deliver sufficient bandwidth to each cell site. Each radio link is equipped with high transmit power RF units in order to bridge over long distances. Operators who choose to implement this type of network scheme can utilize split mount radios in most cases, and take advantage of all-indoor configuration where geographical conditions dictate it.

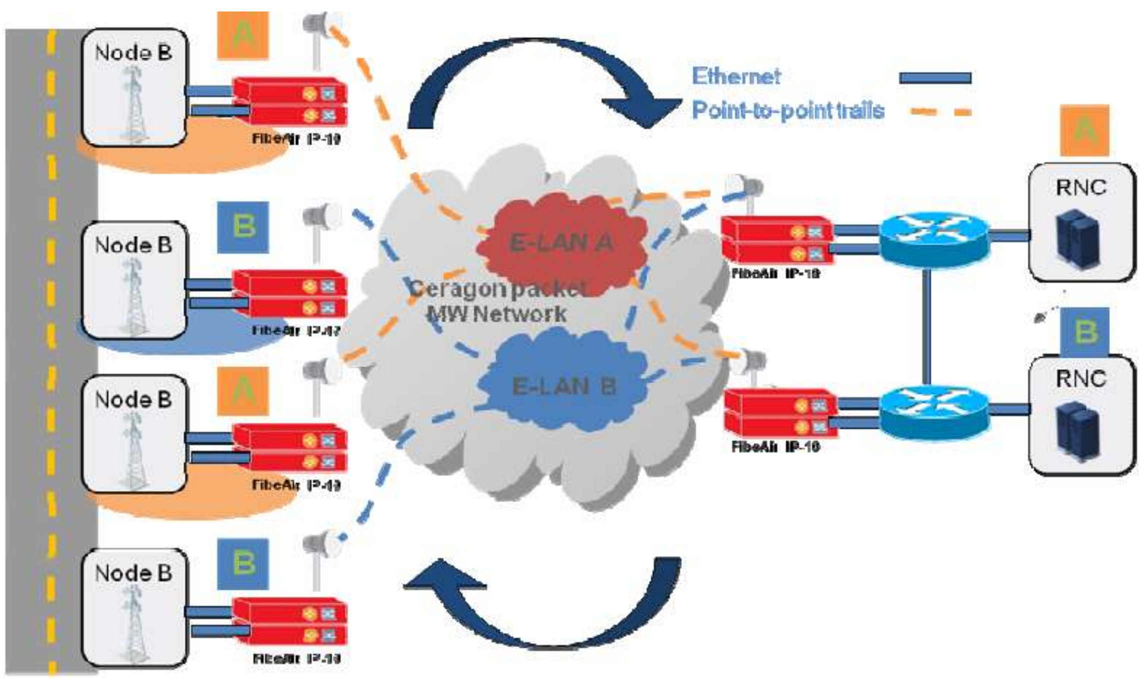

Figure 5: Full protected rural highway access backhaul

The use case discussed above offers four levels of service protection:

1. Overlapping service coverage: Network A NodeB's cover also the service area of Network B. In case of a base station failure, communication can still be delivered using an adjacent node B.

2. Radio Redundancy: Each radio unit is completely redundant – both in terms of its networking functions and of its radio functions (1+1 for radio and networking). Any failure will trigger a hitless switchover to secondary hot standby equipment.

3. Protected E-LAN Service: The radio units provide an end to end E-LAN service. To enable protection, the radio Ethernet cloud is composed of two separate ELAN services.

4. Router redundancy: Redundant routers select traffic to the RNC. In a case of failure either at the router and RNC site, all traffic will be re routed to the protected site.

Conclusion

In light of governments funding plans, Rural Broadband applications are getting more and more attention from both incumbent as well competitor carriers. Rural Broadband does not come without challenges. However, high-capacity microwave solutions make it easier and more cost effective to deliver high-speed internet services to businesses and communities that until recently had limited or no access to the information highway. These solutions combine TDM and Ethernet functionality along with advanced networking features while ensuring network resiliency and minimum maintenance. Thus, advanced microwave systems help operators meet current and future network requirements, facilitating quick deployment, and ensuring lower CAPEX/OPEX and a positive ROI model.

ABOUT CERAGON

Ceragon Networks Ltd. (NASDAQ: CRNT) is the premier wireless backhaul specialist.

Ceragon's high capacity wireless backhaul solutions enable cellular operators and other wireless service providers to deliver 2G/3G and LTE/4G voice and data services that enable smart-phone applications such as Internet browsing, music and video.

With unmatched technology and cost innovation, Ceragon's advanced point-to-point microwave systems allow wireless service providers to evolve their networks from circuit-switched and hybrid concepts to all IP networks.

Ceragon solutions are designed to support all wireless access technologies, delivering more capacity over longer distances under any given deployment scenario.

Ceragon's solutions are deployed by more than 230 service providers of all sizes, and hundreds of private networks in more than 130 countries.

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