1+1: Protected Microwave Links

Abstract

This paper deals with the methods of increasing the uptime of a single microwave link. Setting up a fully protected radio link implies network element redundancy. The goal of this paper is to define the required redundancy to suffice target service availability measures. It will discuss in detail Ceragon's flagship product, the FibeAir® IP-10 designed with resilient functionality. This paper will show that protecting the radio will increase availability twofold; however, describing how this is not complete if protection does not include the controller, network and line elements as well. The main focus of this paper is on Ethernet. Since Ceragon radios use Native^2 technology, all is applicable for TDM only or for mixed usage of TDM and Ethernet. Radio and software availability are out of the scope of this document.

Why microwave availability is special?

Microwave radios require exceptional protection planning due to the nature of the installation:

1. **Top of the tower:** In Telecom towers there are stringent limitations and procedures for maintenance climbing, scheduled and unscheduled
2. **Tower locations:** Microwave radios are often installed in remote locations practically increasing MTTR (Mean Time To Repair/Recovery)
3. **Mission critical:** Application type or just the mere number of subscribers served by a radio link

In mobile backhaul, mobile base stations incur built-in service coverage and protection schemes. This is why microwave links are often not protected as the availability of the radio link and the base station are added together. To increase service availability, network planners add a network level protection such as mesh or ring, or apply adaptive radio techniques, but this topic is outside the scope of this paper.

To summarize this section, microwave radios are designed with built in redundancy to allow operators and service provider to meet their availability targets. The overall expected downtime is a function of failure probability and the average time it takes to recover a link, which is expected to be longer in many radio deployments.

Built in redundancy

There are five levels of link related redundancies:

1. Outdoor/All indoor radio unit level
2. Indoor modem unit protection
3. Port level protection
4. Line protection
5. Complete network element function protection (Switch or TDM Cross connect)

Ceragon applies all the above mentioned five levels of protection in the FibeAir IP-10. The following is a brief analysis of the different levels.

Traditional 1+1 radio protection

The basic radio protection scheme is the 1+1. Most radio units offer this option at the radio level. 1+1 in the radio world translates into radio redundancy: Two identical radio units, creating a single radio link with a single leased spectrum. The reason for that is in addition to the net time it takes to repair or replace the faulty unit, one needs to take into account travel time to the site with the correct spare parts and the time it takes a qualified technician to climb and perform the replacement at height. Hence, recovery time may be quite lengthy. In addition, legacy radios suffered from relatively low MTBF. In case of radio unit failure, the hot standby radio kicks in instantly and maintains the service to the site. This should happen within 50Msec to be as non service affecting, as possible. Switchover may also be managed remotely in case of suspected link malfunction, or for routine maintenance procedures. When climbing is logistically complex, costly or time limited, radio planners tend to choose an all-indoor 1+1 configuration to easily reach availability targets.

Ceragon approach for 1+1 radio protection

Traditional 1+1 radio configuration does not include equipment and facility protection, while Ceragon's product line offers this component. Ceragon system-on-a-chip based radio units with no wire-bonding, enjoy excellent MTBF levels. This level of hardware reliability is comparable to the reliability of indoor units; therefore exceeding availability goals meaning operators can aim for complete indoor unit and line protection capabilities as well. The line protection is achieved by having two ports on two separate indoor units, located either in a single rack or on two different rack units.

To alleviate single point of failure at hubs or aggregation sites, the operators split the connection to the network elements, traditionally to an ADM (Add Drop Multiplexer) in TDM networks or to an Ethernet Bridge/switch/Router for packet networks. This is performed either by using a 'Y' cable to split the signal from a single port on the external network element towards the two ports on the indoor unit, or by applying a protection mechanism on the network element such as APS 1+1 or LAG. Thus two cables connect the two assigned ports on the indoor radio with the two assigned ports of the network element. Obviously this simplifies maintenance work allowing unit and cable replacements without affecting traffic.

Migration to Ethernet challenges

The shift from TDM to Ethernet at cell sites brings multiple Ethernet ports at a cell site or any other access nodes where microwave is used for the backhaul. Operators would like to use a simple and low cost Ethernet switch or cell site gateway for local traffic aggregation and service handover. This network element may also handle traffic arriving from other network nodes in a radio chain or ring. In these cases the Ethernet switch becomes a single point of failure. The alternative is to deploy a costly, fully protected Ethernet switch. Ethernet is also more vulnerable to network disruptions as some of the protocols require a relatively long time to converge thus increasing the need for protection.

This is exactly where the FibeAir IP-10 integrated and protected networking functions become useful as its 1+1 configuration may also include a license for an integrated Ethernet service protection.

Ethernet Configurations

There are two possible configurations for an Ethernet connection: Single or dual interface to the switch router. Depicted in Figure 1.

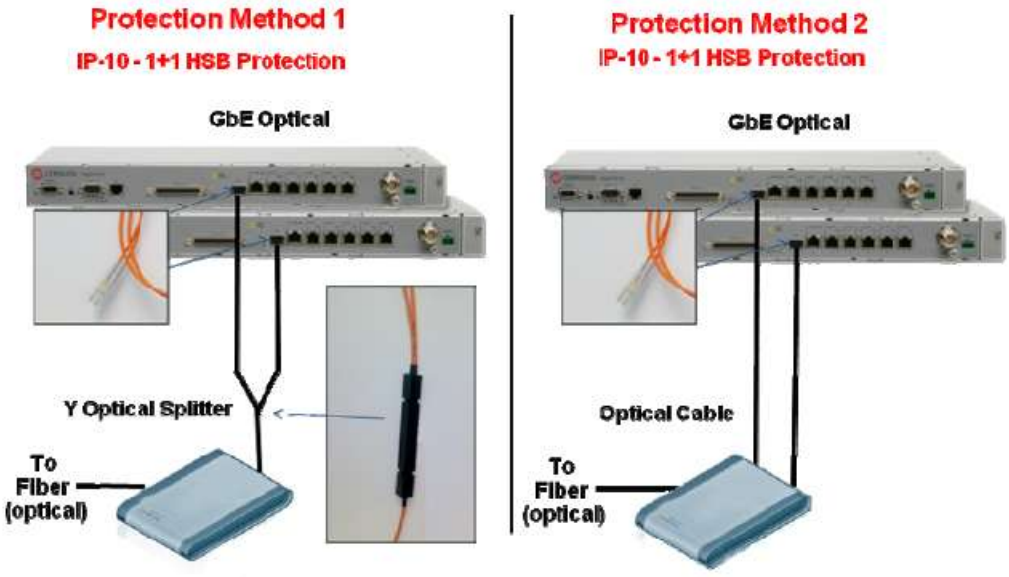


Figure 1: Supported connectivity options

Single GE/FE interface to the Switch/Router:

- Optical splitter/combiner (or Y-cable for FE) used to connect to each pair of FibeAir IP-10 units
- Switchover in MW link is transparent to Switch/Router with the exception of <50msecs traffic interruption

Dual (redundant) GE/FE interface to the Switch/Router:

1. Static Link Aggregation group (or equivalent) needs to be configured on the Switch/Router interfaces connected to the FibeAir IP-10 units
2. Any FibeAir IP-10 unit in "back-up" state disables the Ethernet interface towards the Switch/Router which causes the Switch/Router to send all traffic over the Ethernet interface connected to the "active" FibeAir IP-10 unit

3. Any failure detected in the radio link or Ethernet interface will trigger switch-over to the “back-up” unit with <100msecs traffic interruption on the radio link
4. The Switch/Router needs to detect the switch-over and start sending traffic over the interface connected to the new “active” unit only

Similar configurations for hybrid (Native[2]) topologies or TDM based networks (DS1/E1 or OC-3/STM-1) with an external ADM are also applicable.

FibeAir IP-10 protection concept

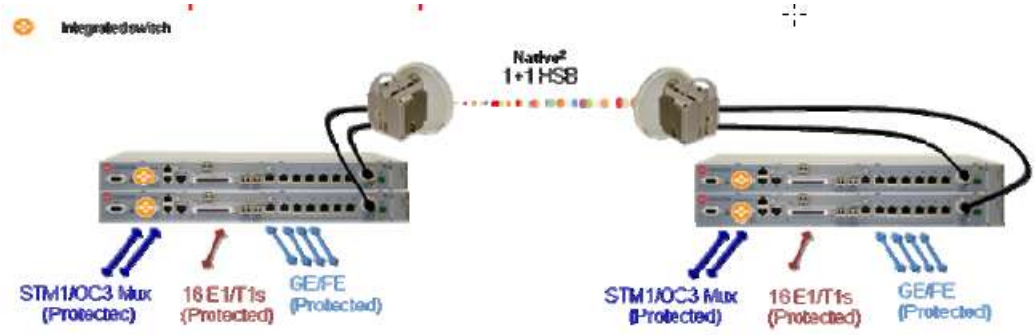


Figure 2: 1+1 HSB link with DS1s/E1s + OC-3/ STM-1 Mux interface + multiple Ethernet ports (5FE + 2GbE)

FibeAir IP-10 design's concept was to create a single unit for stocking purposes, serving all required configurations, whether 1+0, 1+1, 2+0 or even complex nodal configurations.

To setup a 1+1 configuration, the following is required:

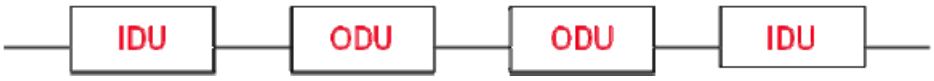
1. 2 FibeAir IP-10
2. 2 RFU (Either RFU-C, RFU-HS or RFU-HP)
3. 2 rack unit spaces on both ends of the link[1]

On top of the radio and line protection for multiple DS1s/E1s, OC-3/ STM-1 and Ethernet ports, FibeAir IP-10 1+1 unique value proposition is its ability to provide Ethernet services and TDM Cross Connect protection. FibeAir IP-10 offers an Integrated Ethernet switch enabling multiple local Ethernet interfaces support. This integrated MEF 9 and 14 certified switch can be used to offer protected E-Line or E-LAN services at the site, offloading local equipment and enabling flexible network topology planning.

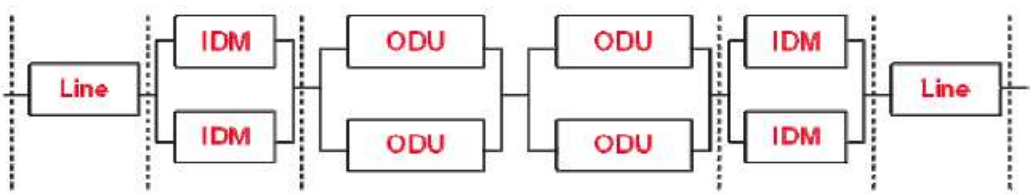
[1] optional rack unit might be required for customers who prefer to use a protection panel

Impact of redundancy measures

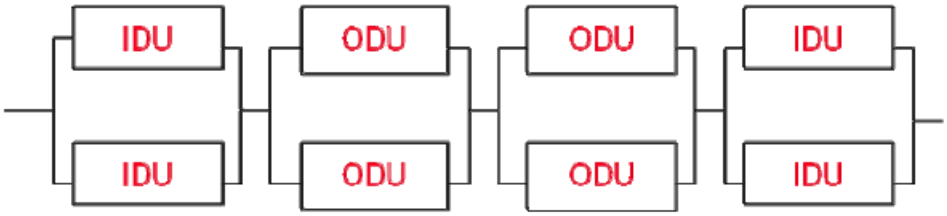
Every level of protection and redundancy improves availability, reduces operation cost and increases customer satisfaction. This should be measured against the associated cost in hardware, power and space. In this paper we evaluated 3 different configurations where ODU denotes an Outdoor Unit, IDU denotes an Indoor Unit and an IDM denotes Indoor Modem. The line unit describes a separate interface or network unit that is common for both radios in a protected radio only system:



1. No redundancy



2. Radio redundancy (Radio unit and modem – split configuration)



3. Complete redundancy (Network element, interfaces and radio)

The respective MTBF and availability figures per configuration are depicted in Table 1

	No protection	Radio only	Complete
MTBF in Years	12	25	63
Availability (MTTR=3 hours)	99.997%	99.999%	99.999%
Availability (MTTR=1 day)	99.977%	99.989%	99.996%
Availability (MTTR=3 days)	99.932%	99.967%	99.987%

Table 1: expected MTBF availability per configuration

Calculation

Based on a Reliability Function:

$$R(t) = \int_0^\infty f(t)dt$$

Where *f*(t) - PDF (Probability Density Function) Function. While the Failure Rate is distributed exponentially

$$R(t) = \exp(-ht)$$

and *h* represents failure Rate

Average Availability (MTTR) is defined as MTBF/(MTBF+MTTR). Note this comes on top of the radio derived availability figures that are an orthogonal discussion to reliability.

Values used for the calculation are common MTBF figures for modern radio and networking equipment. It is used here only to demonstrate the additional availability achieved by equipment redundancy in a radio link.

The above calculation is not taking into account the additional benefits of ongoing implicit maintenance simplicity due to site cable and units redundancy.

Summary

Making sure service is available in today's competitive market is one of the major goals of an operator's network planning team. This is also known to have an impact on churn, revenues and especially on operational expenditures. New technologies and products enable configuration of cost effective protected microwave links and networks, targeted to withhold the most extreme deployment scenarios, including:

1. Redundancy covers failure of all control and data path components
2. Local Ethernet & TDM interfaces protection support via protection-panel / Y-cables
3. <50mSecs switch-over time
4. Protected E-Line or E-LAN services

The modular FibeAir IP-10 was designed to handle these exact conditions. Featuring a single network element type the FibeAir IP-10 is simple to manage and upgrade and allows for easy storage of radio and indoor units.

About Ceragon Networks

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. Visit Ceragon at www.ceragon.com.