HUGHES
NETWORK SYSTEMS

The Universal Radio: A Single Broadband Wireless System Serving Both Point-To-Point AND Point-To-Multipoint Applications

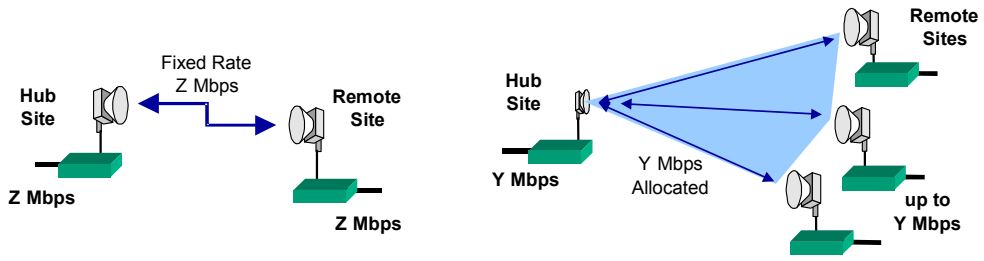
January 2003

A White Paper for Telecommunications Service Providers
Using the AIReach® Broadband 9000 System

This AIReach Broadband White Paper introduces the Universal Radio, a new concept in broadband wireless access (BWA) and cellular backhaul systems. It also shows how the first in this new class of product, the HUGHES AIReach 9000, serves this need at rates up to 30 Mbps (9400 series) or 45 Mbps (9600 series). This paper's intended audience is the technical and business staffs of telecommunications service providers who are considering taking advantage of the AIReach 9000 System for broadband wireless systems.

1.0 Introduction

The industry has generally categorized broadband wireless systems into two types: point-to-point (PTP) and point-to-multipoint (PMP). These types are depicted in **Figure 1-1**, accompanied by a table listing their major characteristics:



PTP ***PMP***

Two points and two radios/link	Multiple points and 1.x radios/link
Dedicated spectrum and bandwidth	Shared spectrum and bandwidth
Narrow beam antennas	Narrow beam antennas on remotes, wide beam on hub
Total radios needed: 2 x number of links	Total radios needed: 1 + number of links
Hardware driven	Software driven
Payload transmitted on fixed, clear channel	Payload processed and transmitted on shared channel

Figure 1-1. Main Characteristics of PTP and PMP Broadband Wireless Systems

Note that if the number of remote units in a PMP system is only one, it assumes many of the characteristics of a PTP system.

2.0 The Universal Radio

By definition, a Universal Radio is one that *operates in either a PMP or PTP mode* and assumes the full characteristics of each mode when doing so. That is, when operating in PTP mode, the Universal Radio operates as a deterministic clear channel, and when in PMP mode, it operates with many remotes serviced by a single hub radio. In PMP mode a statistical element is (typically) introduced to the transport. *In addition, all factors considered, the costs of procuring and operating Universal Radios in PTP mode should be comparable to those of static or nonuniversal PTP radios.*

"A Universal Radio … assumes the full characteristics of each (operating) mode…"

A Universal Radio converting from PMP mode to PTP mode will:

Use narrow beam antennas on both ends of the link to achieve the longer range associated with PTP systems

Dedicate spectrum and bandwidth to a single site

Converting the other way, i.e., transferring from PTP to PMP mode, the hub site is equipped with a wide beam antenna (a simple antenna change), and spectrum is shared or divided across multiple users.

3.0 Coexistence of PTP and PMP Modes

Just as distinct PTP and PMP systems currently coexist in a single network and at a single hub site, these modes of a Universal Radio must also coexist and be functionally independent. Operational coexistence is shown in **Figure 3-1**. The figure depicts a hub site operating with two frequencies in PMP mode and one in PTP mode. The use of narrow beam antennas at the hub in the PTP mode provides for a longer operating range than that available in PMP mode.

"…advantage of a Universal Radio – instead of making investments in two distinct types of radio systems, investment now can be made in just one system"

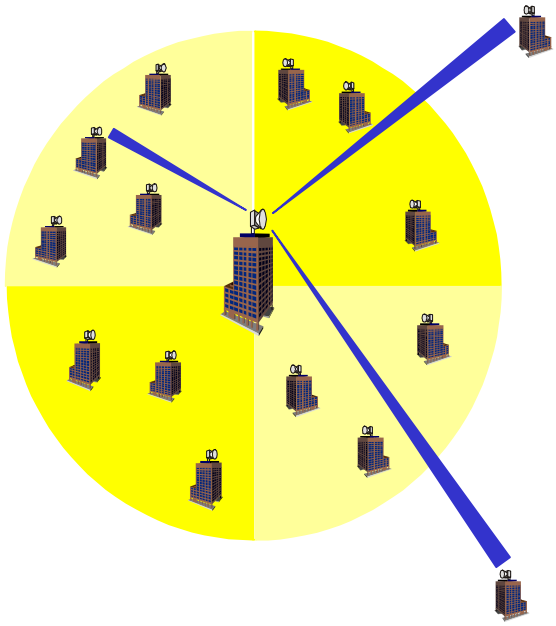


Figure 3-1. Operational Coexistence of PTP and PMP Modes of a Universal Radio System

This coexistence is an important attribute and advantage of a Universal Radio – instead of making investments in two distinct types of radio systems, investment now can be made in just one system. This simplified approach has significant advantages not only in capital expenditures but also in costs associated with sparing, training, network management, and other operational considerations.

4.0 Hedging to Capture PMP Economics

The introductory section highlighted that the number of radios needed for a PTP system is 2 x number of links while the number of a PMP system is only 1 + number of links. Clearly, this sharing of radios and spectrum is the basis of the key economic advantage of PMP systems.

In practice, many PTP systems have been applied where a PMP system would have seemed more appropriate. The two driving factors in this application are: PMP limited capacity and uncertainty as to traffic generation. In the first situation, many PMP systems have limited capacity. Some even operate with carriers offering less than 10 Mbps. In the second instance, there is often uncertainty about the level of traffic that a customer or remote site will generate. In the face of this uncertainty, some PTP systems have been installed as a cautious move, especially since they often offer significantly more capacity than most PMP systems.

However, if a Universal Radio's PMP mode offers high capacity, then a deployment strategy involving *hedging* can take place. Hedging is risk mitigation, and its goal is to be able to capitalize on the more cost-effective PMP mode, without foreclosing the ability to (readily) convert to PTP mode if traffic levels consume the radio's full capacity. To take advantage of hedging, the PMP system must have sufficient capacity not only to handle the first site but to also address the needs of others that occur in the PMP coverage area. In this way, there is a high degree of operational confidence that the economics of PMP will be realized. Note that hedging is only practical if the cost of the initial configuration of the PMP mode is on a par with that of PTP systems. This requirement – low initial cost of deployment – is what prevents many PMP systems from effectively serving as Universal Radios.

"This requirement – low initial cost of deployment – is what prevents many PMP systems from serving as Universal Radios."

Hedging is shown in **Figure 4-1**. Service is brought to an initial site, A, whose traffic requirements are within the capacity of the Universal Radio system. Accordingly, A is served in PMP mode rather than by a PTP solution. As business expands and a second site, B, is secured, if its needs can be served by the in-place PMP carrier, then this occurs. In this manner, the total number of radios applied is three instead of the four that would have been required with PTP solutions. By extension, there can be many more sites added within the coverage area provided capacity is available. In this manner, the PMP economics have been achieved. However, it is important that if the traffic requirements at any site increase substantially, the hedge or option remains available to serve that site in PTP mode with changes *only* at the hub site. The more capacity the Universal Radio offers, the greater the opportunity to hedge and to gain the economic advantages wrought by PMP solutions. Regarding the latter, it should be noted that HUGHES AIReach 9000 systems offer 30 or 45 Mbps of payload capacity for either PTP or PMP applications, and they have a uniquely scalable hub architecture. Therefore, the AIReach 9000 offers outstanding hedging opportunities.

"The more capacity the Universal Radio offers, the greater the opportunity to hedge and gain the economic advantages wrought by PMP solutions."

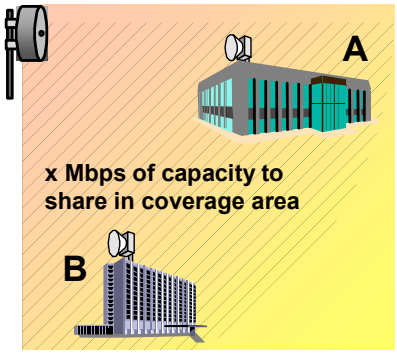


Figure 4-1. Hedging. Site A Is Served in PMP Mode Anticipating Sufficient Capacity to Serve Site B.

5.0 Model of a Universal Radio: The HUGHES AIReach 9000

The HUGHES AIReach 9000 is the world's first Universal Radio. Some of its major characteristics, as applied to the 9400 series, include:

Radio/carrier capacity (PTP and PMP): 30 Mbps (payload)

Bandwidth: ITU 14 MHz, North America, 12.5 MHz

Example operating ranges with 30 cm/12-inch antennas, rain zone K, 0.99995 availability:

26 GHz, 3.7 km/2.3 mi. 28 GHz, 3.9 km/2.4 mi.

Range extension option, same parameters, but using a low order modulation:

Extended Range Option, 15 Mbps (9 DS1s or 7 E1s)

26 GHz, 5.1 km/3.1 mi. 28 GHz, 5.3 km/3.2 mi.

These ranges, along with PMP ranges for the same assumptions/conditions for two modulations (QPSK, 16-QAM), are shown in **Figure 5-1**, assuming rain zone K, 0.99995 availability, and the use of 30 cm/12-inch antennas in PTP mode. Higher gain antennas would increase the distances. In fact, this is apparent in the figure where the higher gain of the antennas operating at 28 GHz overcomes the additional rain fade loss associated with the higher frequency. Therefore, under this scenario, the operating range at 28 GHz is a little greater than at 26 GHz.

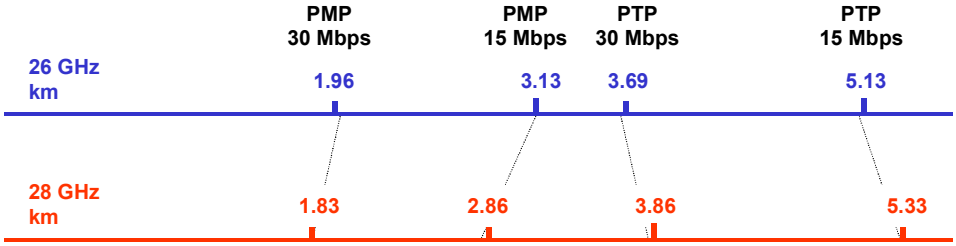


Figure 4. Ranges for Hughes AIReach 9400 Series Universal Radio in PMP and PTP Modes.

Figure 5-1. Ranges for HUGHES AIReach 9400 Series Universal Radio in PMP and PTP Modes

The AIReach 9000 in PTP mode also possesses the same scalability characteristics of any static PTP radio system, that is, it can deliver all the service that needs to be installed is one hub radio and one remote radio per link. *Therefore, the HUGHES system meets the critical initial-deployment cost requirement for a Universal Radio.* In addition, AIReach, even in PTP mode, offers something that few static PTP systems can – meaningful customer interface ports. This is the equivalent of offering integrated customer premises equipment (CPE).

Integrated CPE is applicable to the AIReach 9000 in both PTP and PMP modes. While many PMP systems offer lower speed customer interfaces, it is uncommon in PTP systems although at times T1/E1 ports are exceptions. Interfaces available on the AIReach 9000 are

shown in **Table 5-1**. Note that the unique scalable architecture of AIReach 9000 permits virtually any interface or set of interfaces to be available at both ends of the link (remote and hub terminal ends). No other broadband wireless system offers this degree of operational accommodation to your needs.

Table 5-1. Integrated Interfaces for PTP or PMP HUGHES AIReach 9000

Interface	Key Characteristics
E1/T1	TDM; ATM; IMA; Frame Relay
10/100BaseT	
DSL	SDSL; G.SHDSL
E-3/DS3	TDM/ATM
STM-1/OC3	sm or mm, ATM

With this set of interfaces a highly competitive range of services can be offered. Additionally, for the cellular backhaul application, note that AIReach offers the critical E1 ATM IMA and STM-1 interfaces required for UMTS. Note also that the AIReach 10/100BaseT interfaces at remote and hub terminals make the system IP-Ready should an operator desire to operate using only IP at Layer 3.

The HUGHES AIReach 9000 is known for its strength as a high-capacity PMP system. Some of its lesser known applications in PTP mode are depicted in **Figure 5-2** and **Figure 5-3**.

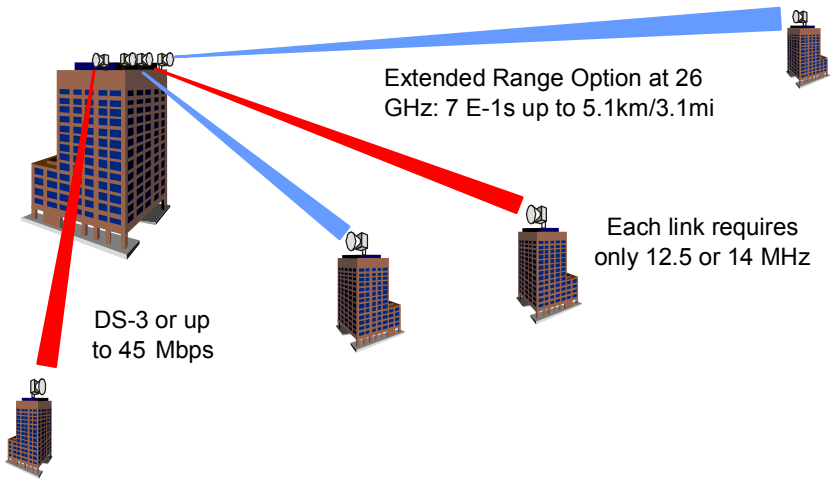


Figure 5-2. Up to 45 Mbps Point-to-Point Radio

Figure 5-2 depicts the AIReach 9000 operating in PTP mode as a narrowband radio at 45 Mbps or at a North American DS3 rate. It is narrowband because it only occupies a maximum of 14 MHz. If North American standards apply, this amount is only 12.5 MHz. The figure also depicts the extended range feature. Recall that with extended range, a lower order modulation is used, which decreases capacity but increases range. Note that other AIReach radios could be operating in PMP mode on different frequencies in this same geographic area. *AIReach 9000 also features a frequency-change-on-the-fly capability so that the frequency plan can be changed from the centralized network management station without any site visits.* This capability further facilitates the transition between the two operating modes.

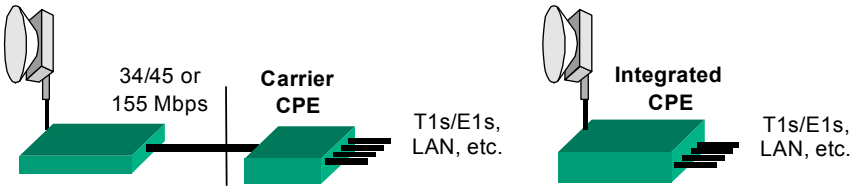


Figure 5-3. Remote Site Options Provisioning

Figure 5-3 highlights options to provide the actual customer interface. As necessary, carriers can furnish a distinct piece of equipment or take advantage of the integrated CPE features of AIReach 9000, which offers cost and network management advantages. This will often mean the elimination of a "separate box" as CPE and the attendant simplification that occurs.

Figure 5-4 depicts a solution to a significant problem in many urban areas: the shortage of available spectrum. This is a variant of using AIReach 9000 as a narrowband radio. The obvious advantage is the major reclamation of spectrum and the resulting ability to increase revenues by serving more customers.

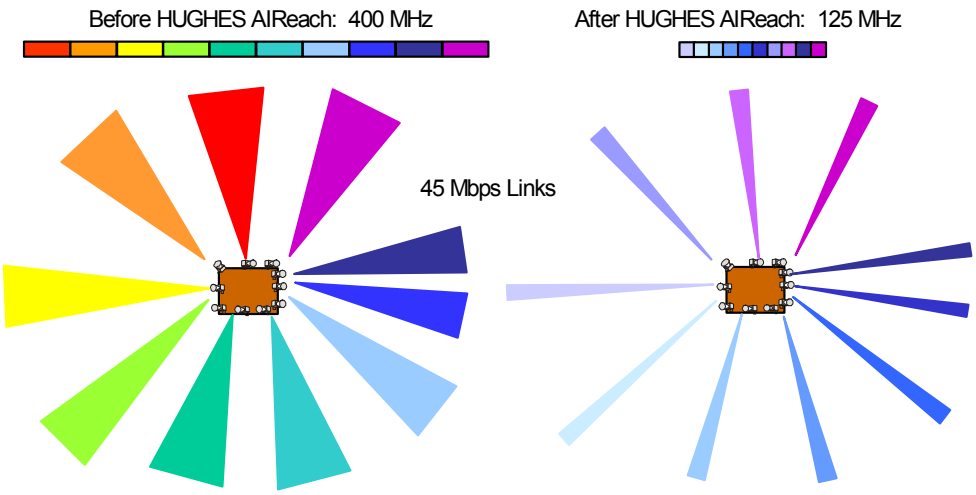


Figure 6. Spectrum Recovery Using the AIReach® 9000

Figure 5-4. Spectrum Recovery Using the AIReach® 9000

6.0 Summary

This paper has introduced a class of product called the Universal Radio. Rather than force operators to manage distinct PTP and PMP systems, the Universal Radio can operate effectively in either PTP or PMP mode. Changing between modes is simple, essentially just changing antennas at the hub and making notations in the network management system.

The important operational and deployment concept of *hedging* has been introduced. Hedging is a process in which customers are initially served using the Universal Radio's PMP mode if possible. Other customers in the same coverage area are likewise served if possible. In this way, the underlying economics of PMP are realized, and if conditions change, sites can always be converted to PTP mode. Two conditions help make hedging possible: The PMP mode must offer high capacity (e.g., 45/30 Mbps) in and of itself and deploying this mode must also be as cost-effective as deploying PTP radios at the outset.

By virtue of its high capacity and unique, scalable hub architecture, the HUGHES AIReach 9000 has been introduced as the industry's first Universal Radio. In addition, AIReach Broadband offers several other advantages including high spectral efficiency and a range of cost-effective integrated CPE options.