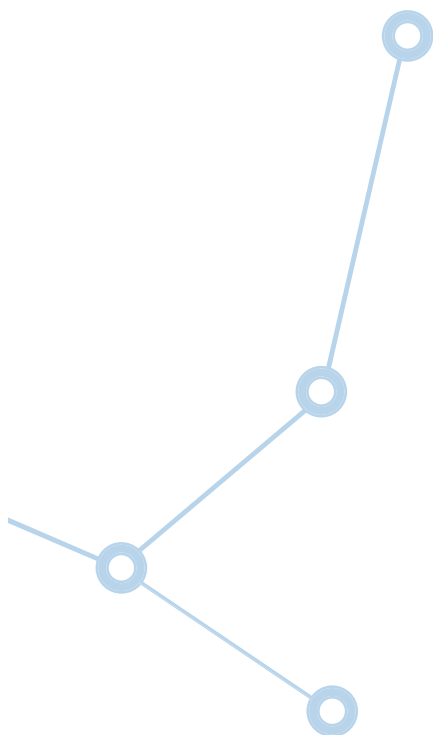




TDM Backhaul Over Unlicensed Bands

ADVANCED RADIO TECHNOLOGY FOR
NATIVE WIRELESS TDM SOLUTION IN SUB-6 GHZ



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1 ABSTRACT

Backhaul of TDM trunks is one of the major challenges encountered by carriers, mainly in terms of OPEX and CAPEX. Traditionally, operators chose either wire-line or licensed band wireless (Microwave) solutions as the typical way to go.

To meet the growing demand for bandwidth while minimizing costs, carriers are continually seeking new methods for backhauling. Obviously, using Microwave radio links in unlicensed bands for backhaul might have significant advantages with respect to the OPEX and CAPEX requirements. These advantages may include ease of installation, low maintenance, excellent radio propagation and cost effective prices.

Any viable solution intended to realize these benefits must address the major challenge of operating in unlicensed bands: overcoming un-expected interference. Meeting this challenge requires a robust wireless system with built-in mechanisms capable of addressing the interference issue. This is especially important when transmitting TDM traffic, since TDM is relatively intolerant of network performance degradation.

RADWIN has become the leader in native TDM wireless solutions for the unlicensed bands, primarily due to its proprietary algorithms dealing with unlicensed band "clutter".

This document describes the challenges of delivering carrier grade TDM backhaul over the unlicensed bands, along with the methods chosen by RADWIN to meet them.

2 UNLICENSED BAND CHALLENGES

Carriers look for high quality TDM transport that can reliably deliver services for heavy duty applications such as cellular backhaul. The required "quality" is commonly referred to as "Carrier-grade TDM" with the following characteristics:

- High Service availability (e.g., 99.999%)
- Low Bit Error Rate (BER)
- Short Latency
- Clock Accuracy (low values of Jitter and Wander)

These desired characteristics should be addressed when aiming to provide a Native TDM wireless transmission solution in the unlicensed bands. Specific mechanisms must be derived in order to maintain such required level of performance and prevent network performance degradation. When working in unlicensed bands, the challenge is not simple to address.

The unlicensed bands offer free usage of hundreds of MHz of unregulated spectrum in which,

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there can be no kind of coordination imposed on its users. Uncoordinated use gives rise to a number of interference scenarios, which in turn affect service availability and BER.

Further, the Time Division Duplex (TDD) nature of the unlicensed bands may cause long delays leading to severe throughput degradation with increasing range. Moreover, the TDD scheme affects the accuracy of the TDM clock.

Performing accurate clock recovery for TDM is considered to be the most challenging issue that needs to be addressed in this context. Since the TDD radio clock is not synchronized with the TDM clock (the latter being embedded in received TDM data), TDM clock must be reproduced at the remote side of the link. The challenge is even greater in the event of interference.

Only a system designed from the ground up to address TDM issues in unlicensed wireless bands, can achieve carrier grade TDM performance.

Alternative solutions, employing TDM over Ethernet rely on the Ethernet protocol design to overcome network congestions caused by jitter distribution. This assumption is based on wire-based networks characteristics. Wireless systems are subject to interference-based radio congestion that can be handled by the Ethernet protocol as well. However, TDM transmission also requires a constant rate and jitter that cannot be met by the Ethernet protocol. This makes Ethernet-based solutions less suitable than native-TDM ones for wireless TDM transmission.

The following section describes several algorithms and methods built into RADWIN radio protocol. These algorithms are the prime mechanisms that enable RADWIN radio products to deliver Carrier-grade TDM in the unlicensed bands.

3 OPTIMIZING SOLUTIONS

3.1 OPTIMIZED ARQ ALGORITHM

ARQ (Automatic Repeat-Request) is the algorithm responsible for ensuring data integrity (commonly measured by BER) by using acknowledgments and retransmissions after certain timeouts. By continuous measurement of received data quality and retransmissions of data in case of possible errors, high data integrity may be preserved, yet, at a price of delays and delay jitter. Retransmissions degrade the TDM performance which is intolerant to delays. Ethernet-based radios (as well as systems employing TDMoIP) commonly use standard ARQ, since they are designed to handle the distributed jitter that may be caused by the retransmissions. As described above, TDM protocols are less tolerant, requiring constant jitter.

Alternatively, some implementations do not use ARQ at all so as to avoid the above negative effect. This approach results in lower delay and a more accurate clock, but is not robust to interferences. As described above, interference is an inevitable part of unlicensed bands and

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therefore, not employing mechanisms such as ARQ severely degrades TDM traffic integrity.

The real challenge when transmitting TDM in unlicensed bands is therefore to find an acceptable trade-off between data integrity and delay to meet carrier-grade requirements.

The RADWIN radio protocol uniquely utilizes an optimized proprietary ARQ for TDM traffic (Ethernet-oriented ARQ is used for Ethernet traffic). The optimized ARQ algorithm dynamically adjusts its parameters according to the BER level and the system current delay by measuring the remote side jitter buffer and accordingly, performing retransmissions. To this end, the RADWIN ARQ algorithm balances up to 12 retransmissions (enabling error-free TDM service) with typical latency of less than 8 milliseconds. By dynamically setting the ARQ parameters, TDM traffic integrity is maintained, without degrading the quality of the TDM clock.

3.2 ADAPTIVE MODULATION

The type of modulation and rate used to transmit data has a direct impact on both the link reliability and the service availability. For Ethernet-based wireless systems, robustness is achieved by the transport layer protocol (TCP/IP protocols). The radio protocol, therefore, has to take care only of the spectrum efficiency (deliver more Bit/Second/Hertz). By contrast, a native TDM wireless system has to maintain balance between high availability and high efficiency, since the TDM is more vulnerable to link degradation caused by interferences.

Whereas transmission using a lower possible modulation scheme (e.g., BPSK 1/2) yields the best robustness, transmission at high modulation (such as 64 QAM) enables higher capacity and shorter transmission times (of the same amount of data) and thus less exposure to interference.

In short, for some scenarios, selection of lower modulation might yield the best TDM quality while on other scenarios the higher modulation may yield the best performance.

RADWIN radio protocol selects the best modulation, dynamically, for each frame (every 1.25 msec in RADWIN 2000 product family). Protocol selection aims for best performance, taking into account the propagation and quality of the radio channel, the current interference and the minimum rate required to deliver the TDM service.

3.3 CLOCK RECOVERY

This section describes RADWIN superior clock recovery mechanism over unlicensed bands. The Clock Recovery algorithm is responsible for reproducing the input TDM clock at the remote end of the link. This requirement is unique to TDM and does not apply to Ethernet-based systems.

The quality of the recovery is defined by standards such as G.823 and G.824. Typically,

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TDMoIP applications use algorithms designed to recover the clock over standard networks, but are not optimized for unlicensed TDD wireless links. TDD makes the recovery more complex since the output packet rate is determined, not only by the input TDM packet rate, but also by the radio frame duration. Moreover, unlicensed bands suffer from random interference which, again, changes the timing. Clock recovery mechanisms for systems operating in unlicensed bands must tune their parameters dynamically as a function of the radio channel quality, level of interference and system/link delays, to ensure clock synchronization and recovery at the remote end, and therefore to enable Native TDM to be transmitted.

The RADWIN radio protocol algorithm is designed to reproduce the clock over the RADWIN link. The algorithm uses RADWIN's proprietary air interface protocol for transmitting the clock over the link, taking into account both RADWIN's ARQ and Adaptive Modulation algorithms to optimize the results. The clock recovery is done per TDM trunk separately, thereby, allowing carrier class grade for multiple TDM services or networks. This is useful in scenarios where backhaul infrastructure is shared by various networks (for example, 2G and 3G, or several operators sharing sites), and each network has its own independent clock.

4 CONCLUSION

TDM backhaul over unlicensed bands is a "best fit", cost-effective solution for operators seeking to deploy rapidly without being dependent on wired infrastructure. Although there are technical challenges to turning it into a service grade solution, dedicated TDM-oriented radio technology can overcome most of them to deliver carrier grade TDM service.

RADWIN products are equipped with the algorithms designed to ensure robustness, low delay with excellent clock delivery and recovery over the unlicensed bands. The Native TDM characteristics embedded in RADWIN radio protocol, along with its Ethernet capabilities, allow RADWIN products to be the ideal solution for carriers needing a TDM backhaul solution now, and who in the future, may need a seamless migration to Ethernet based backhaul solution as they evolve to pure next generation IP networks.