AVIAT NETWORKS

MIGRATING UTILITY NETWORKS TO SMART GRID WITH HYBRID RADIOS

CHOOSING THE RIGHT MICROWAVE PLATFORM

This paper explores the migration strategy for Utility networks to migrate to Smart Grid via Hybrid Radios by reviewing the technology choices that are available to support legacy TDM and IP-based services. Network migration should also consider the many demands such as seamless migration, increased capacity, security, and interoperability. Hybrid networks that can transport native TDM alongside native IP are the best solution to successfully tackle the many requirements for Smart Grid networks.

EVOLUTION OF UTILITY NETWORKS

The modernization of the electric grid is facilitating Smart Grid practices by utilities to effectively utilize renewable energy sources, demand response and distributed power. In addition to modernizing the electric grid, utilities must improve their communications infrastructure for Smart Grid to become a reality.

The need for improved monitoring, analysis, control, two- way communication and coverage is driving more complexity and growth in utility networks as they transition to Smart Grid. Combine these expansions with increasing security standards, network capacity concerns and cost issues means the direction for network evolution is not immediately clear.

What is clear is that the traffic requirements in utility networks are becoming more advanced. To support real-time, two-way digital communications, an IP-enabled, communication pipeline must be established.

Currently, utilities still have a large base of TDM infrastructure. While TDM may be prevalent for some time to come, Smart Grid's need for increased capacity, network management and monitoring to include a wide range of access devices and technologies is demanding that a common, reliable infrastructure is used. To meet these evolution requirements, an IP/MPLS solution is poised to become the basis for utility Smart Grid networks going forward. This paper explores these issues, their impact on utility microwave networks, and investigates options for next generation microwave evolution.

MIGRATION TO IP/MPLS

IP networking is a globally accepted and universally known communications protocol offering the desired functionality and flexibility for Smart Grid applications. IP offers a number of considerable advantages for utility networks as they evolve to Smart Grid. IP networks are more cost effective, easier to deploy, and support higher capacities than traditional TDM networks. When combined with MPLS, IP networks can deliver TDM-like predictability, redundancy and security capabilities. MPLS simplifies traffic management of legacy and IP services to meet the QoS requirements to prioritize critical traffic while offering the scalability to support emerging technologies.

UTILITY NETWORK NEEDS

- High Redundancy – transport and interface
- Flexible throughput for TDM and IP traffic
- Cost effective migration to IP
- Scalable TDM and IP interface

In addition to higher throughputs and lower cost, IP/MPLS networks provide convergence capabilities to ensure multi-application networks can be combined onto a single physical infrastructure – ensuring true interoperability, rather than just connecting disparate networks.

With MPLS, "circuit switched" behavior can be introduced into IP by establishing label switched paths (LSP) across the network. In this way, MPLS can be described as a "virtual networking" solution to meet the Smart Grid vision of running multiple applications over the same physical infrastructure.

TDM equipment needs upgrading to support new applications and endpoints. Despite the drive towards IP, the installed base of legacy TDM equipment will not be replaced overnight. Solutions for evolution of utility networks will need to support and extend the useful life of deployed TDM equipment while enabling the fast, efficient migration to all-IP networks.

Microwave networks will need to support the seamless evolution of these networks while delivering IP/MPLS capabilities to achieve network convergence, capacity and cost saving objectives.

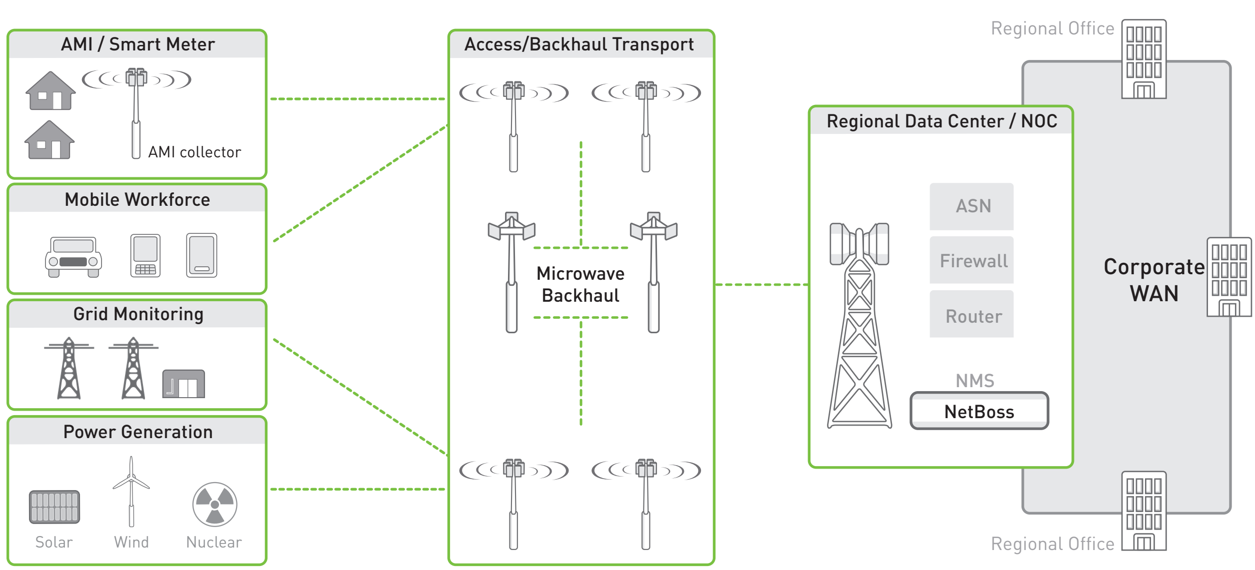

Figure 2. High level network architecture for a next generation utility network built with IP/MPLS and microwave transport.

WHAT SMART GRID MEANS FOR YOUR MICROWAVE NETWORK

The evolution of utility networks to Smart Grid places many new demands on existing microwave platforms.

- Rapid build-out of new sites and coverage areas. The rollout of more coverage areas and last mile access technologies like WiMax increases bandwidth requirements and will require new sites (a complete overlay network is unlikely in many cases and new sites will need to be developed). With the majority of Smart Grid traffic being latency-sensitive in nature, it is important for microwave systems to be deployed in a fast, efficient manner and be interoperable with existing sites and traditional systems.
- Need for seamless migration to IP. Existing utility TDM-based networks will not be replaced overnight and new upgrades will need to gracefully and cost effectively, evolve to the all-IP Smart Grid networks of the future. In addition, the new microwave systems will need to support the converged MPLS architecture. Support increasing capacity demands. In terms of microwave transport, WiMax and subsequent high capacity data applications bring new high-capacity transport requirements to existing TDM-based microwave networks.
- Support legacy TDM interfaces and infrastructure. In many utility networks, TDM infrastructure will continue to be used for some time to come, mainly due to the costs of moving to IP technology. Microwave platforms will need to continue support transport of native TDM applications, and interface with legacy TDM infrastructure equipment; supporting existing reliability and QoS service level agreements.
- Support enhanced QoS requirements. Ability to prioritize traffic under emergency situations becomes more important in a multi-application, multi-user environment. Microwave platforms will need to support latest feature set.
- Support increasing capacity demands. In terms of microwave transport, high capacity data applications bring new high-capacity transport requirements to existing TDM-based microwave networks.
- Improve interoperability within networks. Improved interoperability with other applications is a top priority. By migrating towards IP, networks can more successfully achieve their Smart Grid goals because of the standards-based nature of IP, and the wide availability of equipment choices and network expertise to ensure successful deployment.
- Single view network management. Smart Grid deployment is fueling new management needs for utilities. Utilities will need to manage not just legacy TDM equipment, but also new access networks and customer premise devices that are not yet on the market. By migrating to IP, utilities can deploy element, network and service management on a single platform to achieve maximum efficiency.

MICROWAVE SOLUTION OPTIONS TO SUPPORT EVOLUTION

The selection of radio technology for the replacement of analog RF backhaul solutions, currently used in some utility networks, required some finer consideration. Three available options for microwave platform architectures, considering are reviewed tradeoffs and abilities for each to meet the evolutionary needs of Smart Grid networks.

TDM-ONLY RADIOS

TDM radio technology has been used since the introduction of microwave radios to carry mission-critical traffic, such as Synchronized Phasor Measurements, for utilities. In utility systems, TDM (PDH and SONET/SDH) is a well-proven synchronous technology used efficiently for time-slot transport.

TDM-ONLY radios have TDM backplanes and modulate TDM for RF transmission. While effectively supporting TDM, these TDM-ONLY radios do not support native IP over microwave transmission and therefore do not support high capacity throughputs offered by next generation IP-based radios. These radios encapsulate IP packets over TDM, and are typically bound by upper throughput limits of 155Mbps or less.

IP-ONLY RADIOS

Packet Microwave systems are often referred to as all-IP, but really they should be called IP-only, in that they support native Ethernet/IP transport but lack any native TDM capability. Instead, these systems are primarily designed for green-field IP networks, where there is no legacy network in place. This is ideal for new broadband networks, but in practice most utility networks have substantial TDM traffic for legacy infrastructure.

While these platforms are designed to support high capacities of IP traffic, they generally don't support TDM well. Forcing the emulation of all existing TDM traffic over IP, these radios mandate a change to the way all existing TDM traffic is being transported thus creating a very disruptive evolution path.

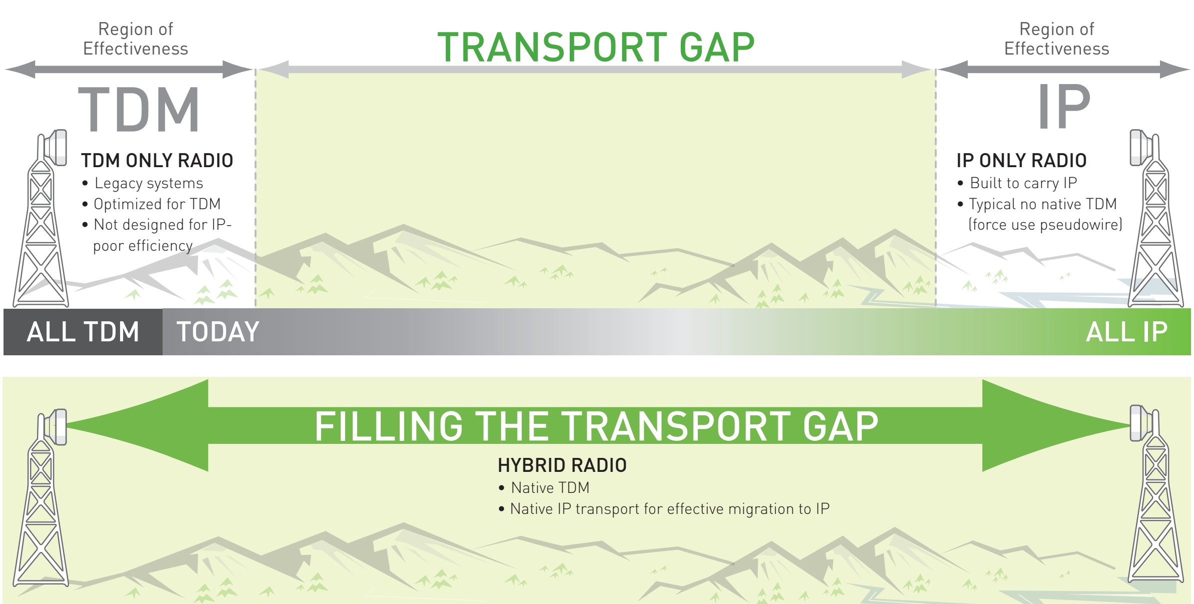

Figure 3. Landscape: Network migration plans and today's microwave systems

PSEUDOWIRE LIMITATIONS

In addition to the disruptive nature of IP-ONLY radios as a migration solution, pseudowire emulation of TDM over IP has tradeoffs to consider. Depending on frame size, emulated TDM over IP with pseudowire will add either latency or overhead to TDM traffic. For the vast majority of applications, pseudowire is an ideal migration solution. For latency-sensitive applications such as video surveillance, or network synchronization circuits, network engineers need to pay close attention to the delay budgets and impacts of using this technology.

HYBRID RADIOS

These state-of-the-art radio platforms are designed to support native transport of both TDM and IP. Hybrid microwave systems combined the traditional features of TDM transport with the ability to transport Ethernet/IP traffic natively over the same radio path. These systems enabled Native Mixed Mode transport of both TDM and Ethernet traffic, so that networks can support the transport of new IP-enabled deployments alongside their legacy infrastructure.Hybrid platforms include all the capabilities in the below diagram.

Hybrid radios deliver the following benefits to utility networks:

TRADITIONAL TDM FUNCTIONALITY

New IP Features Hybrid radios combine traditional radio features of TDM (high power/system gain, low latency, high reliability) with new capabilities delivered by IP (higher capacity and throughput, carrier-class QoS, lower cost) all in the same platform. In addition, hybrid architectures enable multiple deployment options (split mount, all indoor, all outdoor) with a common nodal based indoor unit. This reduces network complexity and ensures the same solution can be used across all frequencies, capacities and network applications.

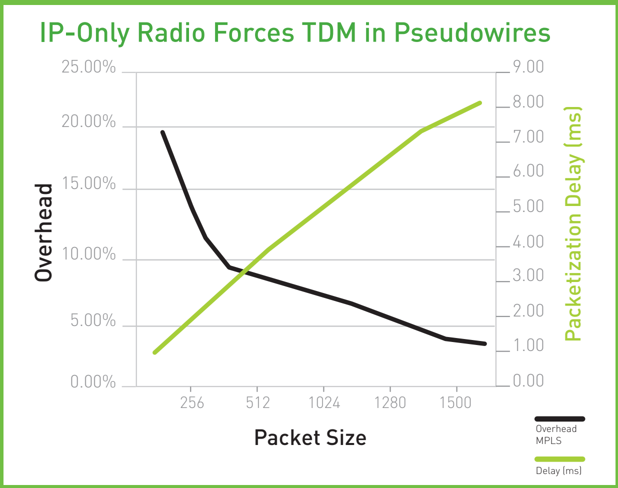

Figure 4. Packetization delay using TDM over IP

COMPARING HYBRID AND IP-ONLY RADIOS

This chart compares packetization delay and overhead for varying packet sizes using typical SAToP encapsulation. Packetization delay is the one-way latency introduced by the process of encapsulating TDM frame into IP packets. It does not include switching, modem, over-the-air and any possible delays introduced by the IP network including queuing and serialization.

For a transport to carry 32 DS1s of traffic, an additional 7.5Mbps of extra bandwidth or a total of 55.5Mbps, is needed to accomodate the 15% overhead.

By implementing statistical multiplexing, header compression and preamble suppression , this bandwidth for the DS1 traffic will be reduced.

SMOOTH NETWORK MIGRATION

Even though they retain the TDM transport capability, Hybrid systems support the same Next Generation Packet Microwave transport features, with high throughput and low latency, along with integrated Layer 2 switching. Hybrid radios simply add side-by-side processing of TDM data, without any encapsulation of Ethernet/IP over TDM and without emulation of TDM over Ethernet/IP.

Hybrid systems are ideal for networks needing a gradual migration path to all-IP and retain a large amount of TDM traffic support, which will not be decommissioned any time soon. Hybrid systems enable networks to seamlessly introduce IP transport at their own pace, without disruption of TDM-based voice services, for low cost and low risk network evolution. As shown in the above figure, hybrid systems have flexible bandwidth allocation to be configured as all-TDM or all-IP as the networks evolve.
In addition to supporting the native transport of both TDM and IP traffic, new Hybrid platforms offer pseudowire capability for encapsulation of TDM in IP. Supporting multi-transport technology options in a single platform, Hybrid radios offer all the functionality of IP-ONLY radios - PLUS native TDM transport.

INTEGRATED MPLS AND QOS

As with other packet radios, hybrid platforms support MPLS and QoS functionality. MPLS routers can be connected directly into the radio platform via Ethernet and QoS can be maintained across the entire microwave network. This critical functionality can be delivered by hybrid platforms to ensure the vision of a consolidated multi-department, multi-application utility network built on IP/MPLS can achieved.

STRONG SECURITY

With the migration to IP, networks just became less secure. New microwave platforms will need to deliver enhanced security features to deliver TDM-like reliability. Features like secure management over unsecured networks with support for standardized protocols; payload encryption and integrated RADIUS client capability all are required for an additional level of security for wireless networks. Hybrid radios can provide these necessary features.

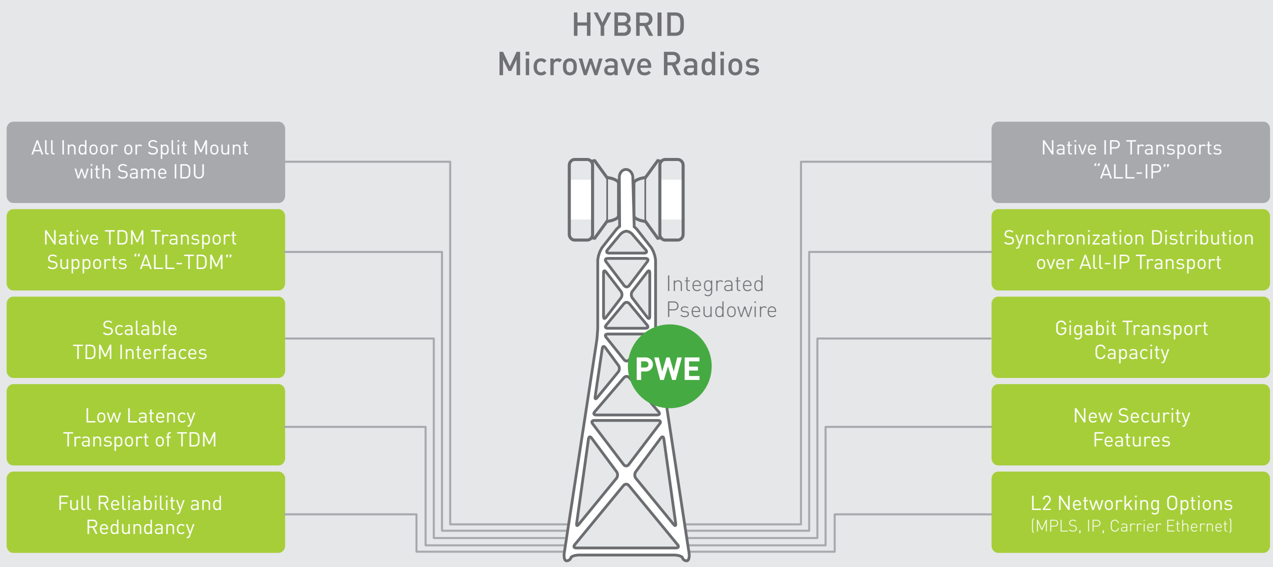

Figure 5. Hybrid radio platform benefits

SUMMARY

Smart Grid is driving upgrades to utility networks, which is placing new requirements on traditional microwave transport platforms. Legacy microwave systems are not sufficient to support the capacity, connectivity, protocols and cost requirements of these new converged networks.

New HYBRID radio platforms best support needs of today and future utility networks. Utilities need to lay a solid foundation with transport technologies that support smooth evolution while delivering on the promise of Smart Grid.

CAPABILITY	TDM ONLY	IP-ONLY	HYBRID
High TDM throughput	YES	NO	YES
High System Gain	YES	NO	YES
Low TDM latency	YES	NO	YES
High Redundancy	YES	YES	YES
Scalable TDM interfaces	YES	NO	YES
High IP Throughput	NO	YES	YES
Synchronization in All Packet Network	NO	NO Risky Packet Sync	YES Keeps TDM Sync
Easy migration to IP without antenna upgrade	NO	NO	YES
MPLS or Carrier Ethernet Support	YES	YES	YES
All indoor or split mount options with commun IDU	NO	YES	YES
Integrated pseudowire	NO	MAYBE	YES

Figure 6. Comparison for three microwave solution options

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