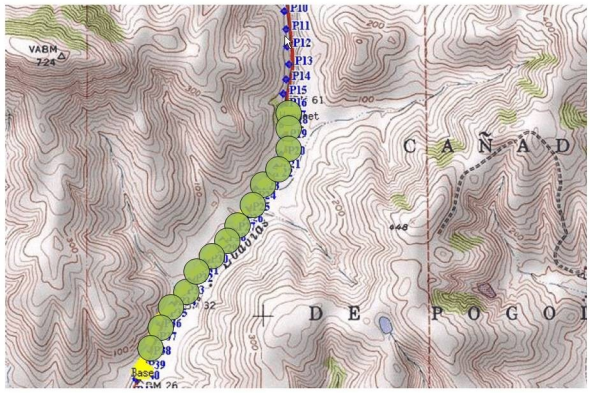
A New Approach to Outdoor DAS Network Physical Layer Using E-Line Technology



A white paper describing a new physical layer technology for wireless mobile networks with dramatically lower cost.

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Corridor Systems
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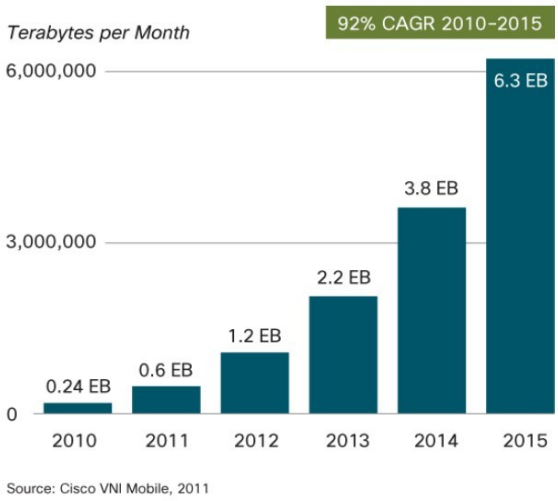
Introduction

This paper introduces a new physical layer technology, E-Line™, as the basis of a distributed antenna system (DAS) network for wireless mobile service providers. Emphasis will be placed on the comparison of this method to existing optical fiber-based techniques rather than a thorough exploration of the new technology itself. Our main goal is to illustrate that, compared with traditional methods, E-Line offers a far less complicated installation process, less equipment to deploy, and much simpler network upgrades in the future.

Background: Mobile Traffic Explosion Driving DAS Demand

Mobile data traffic growth is creating unprecedented demand on existing networks and is led by Smartphone adoption as well as dramatic increases by laptops, netbooks, and other devices as mobile video, web, data, and broadband are increasingly utilized. As service providers deal with these new challenges, the laws of physics quickly impose an important consequence: As data rates increase, wireless path length must decrease, and thus, for a given geographical coverage, a much larger number of smaller cell sites will be required. DAS networks are uniquely positioned to address this challenge.

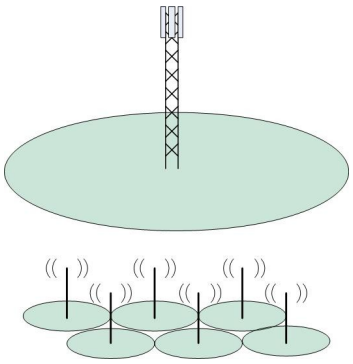


MOBILE DATA TRAFFIC FORECAST

Driving small-cell wireless network architectures

Distributed Antenna Systems

A **DAS** network consists of spatially separated antenna nodes that provide wireless service. As illustrated in the figure, the idea is to split the transmitted power among several antenna elements to provide coverage over the same area as a single antenna but with reduced total power and improved reliability.



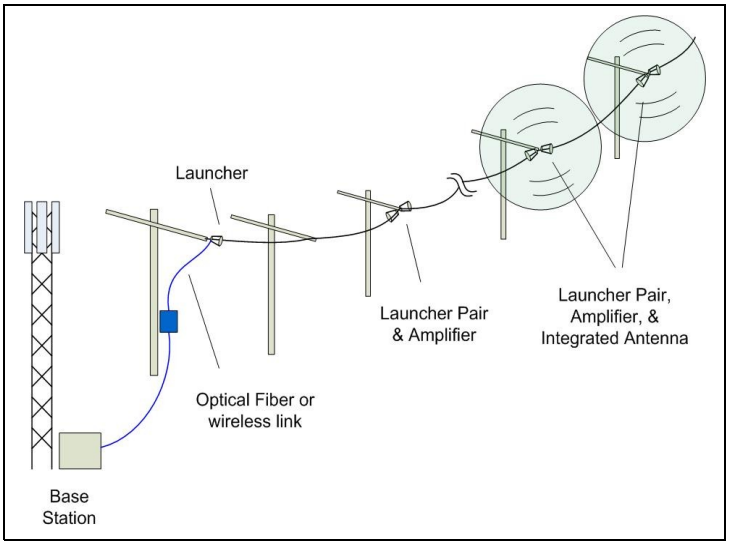
DAS CONCEPT

Implementing an E-Line DAS Network

An E-Line DAS network incorporates two elements: 1) a broadband transmission line over existing power lines and 2) inexpensive integrated antenna nodes. This method makes use of a newly discovered mode of propagation that is supported by a single, uninsulated conductor. Unlike traditional techniques for broadband transport, a surface wave transmission line (SWTL) is used to enable unprecedented transmission-line performance when coupled onto standard, utility-grade power lines. Compared with traditional electrical techniques, E-Line has excellent frequency coverage (20 MHz - 20 GHz), lower attenuation than coaxial cable, flat group delay, and low distortion. Even though this is a new technology, a broadband network for virtually any mobile communication frequency band is surprisingly easy to implement.

Unlike other power line communication methods such as IEEE P1901 Broadband over Power Line (BPL), E-line technology operates at native communication frequencies and does not have interference issues with amateur radio or other RF services.

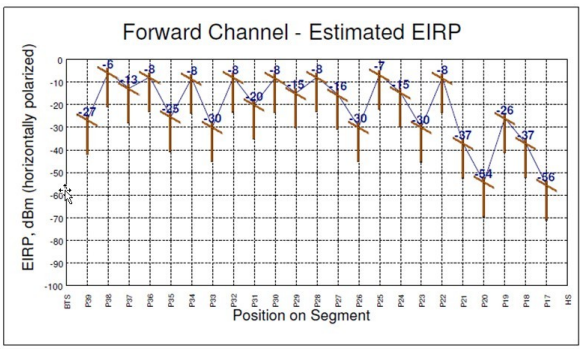
The native wireless frequency band from the mobile base station is launched over any utility-grade power line with either a fiber optic or wireless link for high-voltage isolation. At 300-yard increments (~6/mile), a launcher pair and small-signal amplifier are used to maintain signal quality. At each of these nodes, an integrated antenna is used to establish a small RF footprint for connectivity to a mobile device. As for any RF system, by maintaining an adequate S/N ratio, multi-mile DAS networks can be implemented.



E-LINE DAS NETWORK DIAGRAM

System Performance

Extensive field evaluations conducted over a fully operational energized power line confirm full broadband system performance as well as practical operational considerations. Existing medium-voltage power distribution lines have been used with no disruption to service during installation and also have been used under full functional testing. System operation evaluations have been performed in both unlicensed ISM bands (2.4 /5.3 GHz) and in licensed mobile wireless bands (850 MHz /1.9 GHz). In addition, a 'corridor' of RF connectivity was created capable of supporting 4G wireless handsets for hundreds of meters on either side of the power lines.

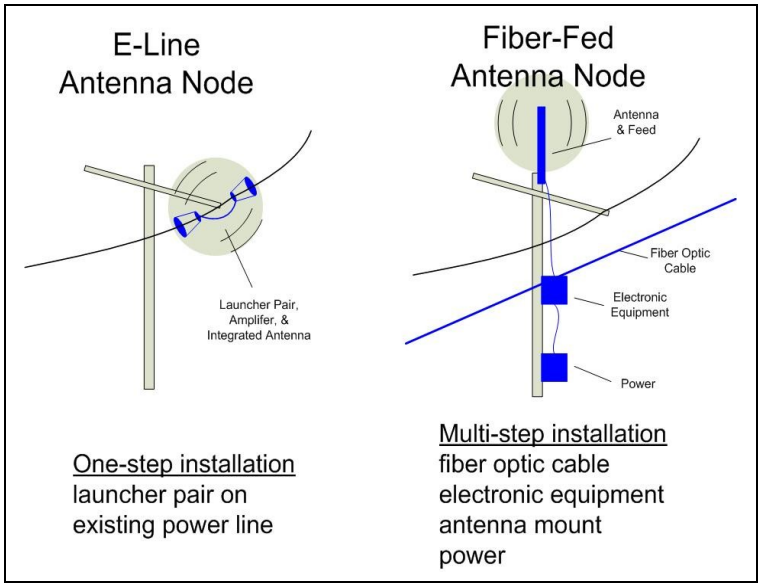


ESTIMATED EIRP ALONG FIELD TRIAL

Antenna Node Comparison

The comparison between traditional fiber-fed DAS networks and E-Line is best initiated at the antenna node. E-Line active components are simply mounted onto an existing utility power line. No other physical attachments or specialized installation expertise is required.

In contrast, traditional DAS installations require a multi-step process involving installation of fiber optic cable, antenna mount, electrical equipment, and power tap. This is in addition to any new right-of-way and new construction permits.



Comparison with Existing DAS Networks

The following table illustrates the core differences between a traditional fiber-fed and new E-Line–fed system. In any implementation, many other practical considerations need to be considered in addition to these items.

	E-Line DAS Network	**Fiber-Fed DAS Network**
Antenna node connection to Base Transceiver Station (BTS)	Existing overhead utility power line	New fiber optic installation (underground or aerial)
Antenna node placement	Utility power line only	Utility poles, street lights, traffic signals, nearby buildings, and other structures
Node power for active components	Coupled energy from power line	Tap/transformer or alternative source at each location
Installation expertise requirements	Utility-certified personnel	Utility-certified personnel fiber optic cable certified
Future network upgrade (2G to 3G to 4G to ?)	No upgrade to physical layer required	Upgrade required on all data/protocol-dependent components

Practical Considerations

INSTALLATION OF E-LINE ANTENNA NODE

FIELD TRIAL SEGMENT

The E-Line surface wave transmission line operates directly on high-voltage utility power lines, requiring properly certified personnel for all installation and maintenance operations. Furthermore, regulatory and use model issues will arise from power utility and communications service providers.

At any connection that crosses a high-voltage boundary (e.g., circuit breaker, autorecloser, base station interface), an isolated data link is required. This can be implemented with either a short fiber optic or wireless link. In a DAS network, the payload will be the native cellular frequency bands. This band of frequencies, the communication data rate, and other system requirements determine the design of a number of key components such as the launcher horn, bidirectional amplification, as well as the high voltage isolation links.

Because E-Line operates at this native communications frequency band with high-speed, bidirectional, frequency and data format–independent transmission lines, the protocol-independent design can accommodate multiple networks (i.e., 850 MHz, PCS, 2G, 3G, 4G, LTE, 5G?, etc.) as well as multiple carriers and services.

Summary

This brief report illustrates how a new physical layer technology, E-Line, can be used with existing overhead utility power lines to augment current DAS network technologies. Dramatic cost savings can be achieved in 3 categories: 1) lower equipment cost—only launchers and their integrated electronics/antennae are required at each antenna node instead of the installation of a fiber optic cable; 2) lower installation cost—launcher nodes are simply mounted to existing utility lines; and 2) lower cost to upgrade, with protocol- and data-independent transmission capability.

Not considered in this paper are the regulatory issues that will arise from the shared use by power utility and communications service providers as well as other aspects such as system reliability, redundancy, operational efficiency, system control, and other important considerations in any communication system.

However, with the inevitable scenario that mobile data traffic will continue its exponential growth, DAS networks are uniquely situated to help open up the bottle necks that wireless users and their service providers face. E-Line technology, with its advantages of low cost and natural synergy with existing overhead power utility lines, is one of the alternatives wireless service providers should consider when faced with the challenge of building their future networks.

About Corridor Systems

Corridor Systems Corporation, founded in 2000, is a privately held company based in Santa Rosa, California. Our mission is to advance E-Line surface wave transmission line technology in as many applications as possible. As high-speed broadband connectivity requirements increase, we believe there will be many important solutions that E-Line will enable. This new technology has great potential for dramatically lower costs and an elegant solution for complex situations where alternatives may not readily exist. We invite you to learn more about us.

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