REACT technologies

Access/One®

Wi-Fi infrastructure Enabling Vehicles in Motion

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The industry's highest performance fast-roaming wireless mesh

Dynamic real time next WiFi pole selection & switch-over

Introduction

Access/One® network architecture described in this paper illustrates how the Strix solution provides wireless mesh infrastructure for the transportation industry. This solution is specifically implemented on-board trains and along the tracks for the purpose of video surveillance, voice communications, telemetry and passenger services (Internet access, etc.). The technical merits of the proposed approach and a deployment methodology is provided, however, it is not the intention of this document to provide detailed design guideless as every deployment must be considered individually.

Solution Overview

Utilizing components of Strix Systems current product line which offers:

- The ability to rapidly architect and customize a solution based on local terrain.
- Relatively low cost of deployment
- Proven scalable and fully distributed network architecture
- Support for multiple management methods
- The ability to achieve performance requirements

The solution will:

- Provide WiFi coverage for mobile platforms (trains, busses, trucks, shuttles, ferries, trams).
- Support medium to high travel speeds of <= 280 km/hr (<= 174mph)
- Allow Internet and enterprise VPN access to passengers; support surveillance (webcams, proximity control) data and control systems - "WiFi on wheels/steroids" – TAN (Train Area Network).

Strix Access/One® Platform Description

Strix Systems Access/One is a complete wireless system, supporting multiple radio frequency technologies; 802.11a, 802.11b, 802.11g, - all within an intelligent, secure and scalable mesh network architecture. The architecture is also future-proof to allow easy introduction or addition of new radio technologies.

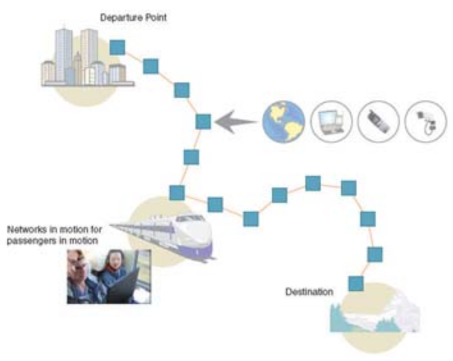
Strix Systems offers outdoor (OWS) and indoor (IWS) wireless system product lines. The Access/One Network OWS is a high-performance wireless mesh networking system that is specifically designed for outdoor deployments. With its multi-radio, multi-RF and multi-channel capabilities, the OWS utilizes advanced algorithms to deliver high throughput over multiple hops from the core to the edge of the network. It intelligently self-tunes, self-configures and self-heals to optimize the overall performance and availability.

The Access/One Network® IWS is a modular indoor node that seamlessly integrates with the OWS.

The OWS and IWS products offer multiple 802.11 radios. Differing significantly from traditional wireless Access Point solutions, the OWS/IWS network nodes may be thought of as being similar to an Ethernet switch/router except without wires. The Node's role within the system is determined by the mix of Modules within the Node itself and its position in the mesh network. Each Node contains all the required functionality for connectivity, security and management. No additional software or hardware is required.

Unlike most Access Point offerings that merely provide a wireless extension for the last "hop" to the user, Access/One is a truly distributed wireless solution, much like today's Internet. It allows both the user links and the backhaul links to be wireless, making the inconvenience and costs associated with pulling cable a thing of the past. Strix's design enables the creation of ad-hoc networks where nodes respond to changes in the environment while maintaining a reliable network connection. Speeds of up to 108Mbps are supported over the backhaul links, using Turbo A or Super G, making it an acceptable alternative to wiring.

In addition, auto-discovery and self configuration functionality allow initial deployments or subsequent modifications to the network to be a trivial exercise. When powered up, each Node self-discovers its role in the network and maintains that configuration until it detects a change or finds a better path, at which point it dynamically adjusts.



Use of a mesh topology instead of a traditional hub and spoke architecture ensures that there is no single point of failure in the network and so in the case of Node failures, removal, or replacement, the network simply self-adapts to the change through its self-healing capabilities.

Strix mesh architecture utilizes multiple dedicated 802.11a radios in an OWS/IWS node to form a backhaul link to the next OWS/IWS node that provides the shortest path (best roundtrip delay) to the wired network. All available links are monitored and the path will dynamically change if the better one becomes available. Roundtrip delay is a weighted function of the actual delay, RF Module load, radio channel signal-to-noise ratio and other factors. A single association is maintained at any given time. The mesh is optimized for wireless-device-to-wired-network (Internet, servers) or similar communications scenarios.

Management of the platform is provided through a Web-based interface which supports a centralized view of the distributed network. The Modules, the Nodes and the network may also be managed through SNMP or a command line interface (CLI).

Basic Assumptions

Train speed: 174 miles/hr (280 km/hr)

WiFi Pole spacing:
Distance between poles (linear):
Minimum: 1/4mile = 1200ft (400m);
Maximum: 2 miles = 10960ft (3,218m)

(Note: Spacing could be farther depending on Line of Sight)

Max distance Pole to Rail tracks: 100ft (33m)

Pole height:
Minimum: 10ft (3.3m)
Maximum: 30ft (10m)
Near line-of-sight between poles reduces the number of “WiFi Poles”, where as curves or tunnels may require more frequent WiFi Poles. Minimum train egress antenna height above ground: 10ft (3.3m)

Note: These values are for reference purposes only. The distances between poles will depend on many factors. Among them: antennae used, country and transmit power regulations, train configuration, topography, tunnels etc…

Example Solution

Strix proposes the creation of a 3-tier network as follows:

Tier-1 Network
The Tier-1 is an 802.11a based wireless transport network which will run along the railroad track the entire length of the desired coverage/service area. This network is created by installing mesh nodes and the corresponding antennas on the poles that exist along the track. Many of these nodes on this Tier-1 network will be entirely wireless. Some, at railways stations and possibly a few more along the route will be wired, i.e. have an Ethernet connection to a Fibre, Satellite, DSL, E1, etc. All data traffic will hop across the wireless backhauls to the nearest wire.

All backhaul links are AES encrypted which allows private information transport throughout the Tier- 1 Network.

On every train (convoy) there will be a node called the **Mobile Node** that is part also of the Tier-1 Network. This node is responsible for connecting the train to the nodes along the railroad performing fast roaming associations.

Tier-2 Network
The Tier-2 network will be an on-board intra-train and mainly consists of several OWS or IWS wireless nodes and a Layer 3 gateway among other equipment. One OWS/IWS node will wirelessly link the nodes located in the carriages/cars to the gateway (this gateway would be a router that supports NAT and other features) and on the other side of the gateway the OWS node Mobile Node would be used to backhaul to the 802.11a radios located outside near the track. These nodes would most likely be mounted in the main engine or dinning car. As carriages are linked together prior to departure, this Tier-2 network will discover the neighboring nodes and configure itself to ensure there is connectivity through the entire length of the train. Such connectivity will be preserved until carriages are unlinked or train configuration changes.

Tier-3 Network
The Tier-3 network will provide 802.11g access to the services. This access can be used by passengers or other applications such as video surveillance and telemetry equipment aboard the train. The traffic is wirelessly meshed back through the Tier-2 network and then over to the Tier-1 network, and, finally, to the wired networks.

Tier-1 and Tier-2 networks are transparent to the users. Users will always connect to the nearest stationary 802.11g node in their carriage and will not be aware of the high speed hand-offs that are happening behind the gateway.

The auto-configuration and self healing features of the product will minimize the deployment efforts and costs. Each Tier of the network is intelligent enough to configure its nodes limiting the administration intervention to simply replacing equipment if required.

Switchover and Other Timing Issues

Dataflow Interruption
Learning bridges (comprising wired infrastructure) take time to learn the location of each PC with packets traversing the network. In a fast moving platform (train) with a number of PCs sending/receiving data while network connection “hops” from one WiFi pole to another, packet stream destined to a client whose WiFi network connection has hopped will continue to flow to the wrong destination. This happens until the bridged network has learned the new location (connection) of the PC – yielding constant interruption in end-user data flow.

The Access/One network resolves this problem. Each backhaul automatically advertises (upon connecting to new AP) its entire bridge table effectively advertising on behalf of all known backhauls and PCs behind it. This automatically and dynamically readjusts (as it updates) the bridged network. In fact, this approach of updating appropriate bridges will allow virtually uninterrupted end-user data service.

In the architecture proposed here, the Tier-2 network is attached to the train’s IP Gateway (because it is an IP router) and only the train’s IP Gateway will be advertised through the bridge network making the ‘hopping even more transparent to the end-users.

Dynamic Real-Time Next-WiFi Pole Selection and Switchover

In order to accommodate timely switchover (and re-association) between WiFi poles, constant background scanning (by the Train’s OWS Egress node) needs to be performed and optimized. As the speeds increases, switchover time becomes an issue – for example, at 120miles/hr with a distance of ½ mile between poles there are only 15 seconds to complete switchover and re-association. That will be the time that the train takes to move from a node to another.

The Access/One network resolves this problem as each backhaul already performs background scanning (in order to perform self-healing and self-tuning). With the default setting, a WiFi channel is scanned every 5 seconds, which is sufficient for stationary mesh networks. Additionally a cached list of candidate APs is kept to allow real-time switchover between APs.

Decreasing the configurable scanning interval as well as the number of scanned channels (<5 seconds recommended) will further improve switchover time. In other words, one should limit the number of allowed operating 802.11a channels to 4 or fewer for this particular application. The background frequency scan interval will depend on the distance between poles and the speed of the train.

Detailed values for these parameters are beyond the scope of this document and will be the focus of a future document focusing on detailed design considerations.

All of the enhancements detailed above should yield a typical switchover time between WiFi poles over the Access/One system of about 80-150 msec.

For Further information on this exciting solution, please contact React Technologies.

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